Development Impacts of High-Speed Rail: Megalopolis Formation and Implications for Portugal's Lisbon-Porto High-Speed Rail Link

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ABSTRACT

High-speed rail (HSR) has been gaining acceptance worldwide with development of rail technology and rising concerns over climate change and congestion in airports and on roads. The implementation of high-speed rail lines also plays an important role in reshaping the travel patterns and activities of people and consequently change the ways cities develop. An interesting indirect implication of HSR is the potential for megalopolis formation created by fusion of multiple cities linked by HSR.

An overall consensus is present in the existing theoretical literature as to what development impacts may be from the HSR investment, including the importance of the resulting agglomeration externalities and formation of megalopolises. However, the complexity of the issue leaves the questions about the causal effect of HSR on economic growth open. This thesis studies the existing empirical evidence and experiences of HSR corridors in Japan, France and Germany to explore qualitatively the phenomenon of "megalopolis" formation as a result of a HSR link, and the evidence of economic development effects on urban areas along these corridors.

Portugal among other countries is also planning the deployment of a HSR network in the near future as an effort to stimulate the country's economy and to integrate with the rest of the European Union. The findings and lessons from the case studies are applied to Portugal's proposed Lisbon-Porto HSR corridor. Several possibilities of future scenarios of megalopolis forms and the associated impacts are discussed and analyzed. As a result of improved accessibility and increased interaction between the cities stimulated by HSR, emergence of a megalopolis is possible in different forms along the planned Lisbon-Porto HSR corridor. The critical factor for the formation of a megalopolis is the increased interaction between the cities driven by newly generated traffic and increase in the number of one-day trips. These new travel patterns within a megalopolis may lead to either creation of new economic growth or redistribution of economic activity. The spatial distribution of growth is non-uniform, which may essentially lead to potential winners and losers from HSR. This research is intended to be of value to policy-makers in the railway industry.

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Table of Contents

1 INTRODUCTION 13

1.1 MOTIVATION 14
1.2 RESEARCH QUESTIONS 15
1.3 METHODOLOGY 16
1.4 STRUCTURE 17

2 LITERATURE REVIEW: REGIONAL DEVELOPMENT IMPACTS OF HSR 19

2.1 ECONOMIC DEVELOPMENT EFFECTS OF TRANSPORT INVESTMENTS IN GENERAL 19
2.1.1 Economic Geography: Agglomeration Benefits and Regional Disparities 21
2.2 ECONOMIC DEVELOPMENT IMPLICATIONS OF HSR INVESTMENTS 25
2.2.1 Studies of Economic Development Effects of HSR on Local Level 27
2.2.2 Studies of Economic Development Effects of HSR on Regional and National Levels 28
2.3 PHENOMENON OF MEGALOPOLIS FORMATION 30
2.3.1 Concept of “Megalopolis” in Economic Geography 30
2.3.2 Role of HSR in “Megalopolis” Formation 33
2.4 HSR FINANCING APPROACHES: INTERNATIONAL EXPERIENCES 34
2.5 SUMMARY 37

3 HIGH-SPEED RAIL IN PORTUGAL 39

3.1 CURRENT RAILWAY SYSTEM 39
3.2 PLANS AND EXPECTATIONS FOR HSR 43
3.3 THE EU OBJECTIVES AND VISION 50
3.4 LISBON-PORTO HSR CORRIDOR ANALYSIS 55
3.5 SUMMARY 65

4 JAPAN: SHINKANSEN SYSTEM 67

4.1 COUNTRY BACKGROUND 67
4.2 DEVELOPMENT OF THE SHINKANSEN SYSTEM 72
4.3 TOKYO-OSAKA (TOKAIDO) SHINKANSEN CORRIDOR 77
4.4 SUMMARY 95

5 FRANCE: HIGH-SPEED TGV SYSTEM 97

5.1 COUNTRY BACKGROUND 97
5.2 DEVELOPMENT OF FRENCH TGV SYSTEM 101
5.3 PARIS-LYON TGV SUD-EST CORRIDOR 110
5.4 SUMMARY 125

6 GERMANY: INTER-CITY EXPRESS (ICE) SYSTEM 127

6.1 COUNTRY BACKGROUND 127
6.2 DEVELOPMENT OF GERMAN INTER-CITY EXPRESS (ICE) SYSTEM 131

6.3 COLOGNE (KÖLN) -FRANKFURT ICE CORRIDOR 136
6.4 SUMMARY 150

7 LESSONS LEARNED AND APPLICATION TO PORTUGAL: LISBON-PORTO HSR CORRIDOR 153

7.1 CROSS-CASE COMPARISON 153
7.2 EMERGENCE OF MEGALOPOLISES 160
7.2.1 HSR – "The Sustainable Mode" 165
7.3 ROLE OF INDUCED DEMAND 168
7.3.1 "Paradox" between Growth and Environmental Sustainability 170
7.4 POTENTIAL FOR MEGALOPOLIS FORMATION IN LISBON-PORTO CORRIDOR 170
7.4.1 Regional Development Effects on Urban Areas 180
7.4.2 Minimizing Negative Effects of HSR on Small Urban Areas 180
7.5 IMPACTS ON NATIONAL LEVEL 182
7.6 SUMMARY 184

8 CONCLUSIONS 187

8.1 BACKGROUND 187
8.2 SUMMARY OF FINDINGS 187
8.3 CONCLUSIONS FOR PORTUGAL 190
8.4 DIRECTIONS FOR FUTURE RESEARCH 192

BIBLIOGRAPHY 195

APPENDIX I: TEMPLATE FOR CROSS-COUNTRY COMPARISON OF HSR SYSTEMS 205

APPENDIX II: LIST OF REPORTS ALREADY ASSEMBLED BY RAVE 207

List of Figures

Figure 1.1: Research Stages 17
Figure 2.1: Banister and Berechman's (2001) Illustration of Necessary Sets of Conditions 20
Figure 2.2: The Efficiency of Cities as a function of size, sprawl, and speed 23
Figure 2.3: Influence of the HST on urban areas (van den Berg and Pol, 1998) 25
Figure 2.4: The New Metropolis: Rethinking Megalopolis 33
Figure 2.5: Time-Space diagram of Lisbon and Porto, with the Economic Magnitudes 34
Figure 3.1: Map of Portugal's Conventional Rail Network 41
Figure 3.2: Institutional Structure of Railway System in Portugal 42
Figure 3.3: Planned HSR Network Axes in Portugal 46
Figure 3.4: Financing sources for Lisbon-Porto and Lisbon-Spanish Border links 48
Figure 3.5: European HSR Network (2009) 51
Figure 3.6: Shrinking of Temporal Distance in the Trans-European Transport Network 52
Figure 3.7: South-West European HSR Link (2008) 53
Figure 3.8: The EIB Project Cycle 55
Figure 3.9: Lisbon-Porto HSR Corridor Stations 56
Figure 3.10: Compatibility of Lisbon-Porto HSR line with Conventional Rail System 57
Figure 3.11: Political Map of Portugal: Regions and Districts 60
Figure 3.12: Alfa Pendular and Intercity Rail Service Schedules for Lisbon-Porto Route (2010) 63
Figure 3.13: Trips generated by mode on Lisbon-Porto Corridor (2003) 65
Figure 4.1: Map of Transport Networks in Japan 69
Figure 4.2: Institutional Structure of National Railway System in Japan 71
Figure 4.3: Map of Shinkansen Network by Company of Operation 71
Figure 4.4: Maps of Shinkansen Network Routes (left) and Shinkansen with Regular Conventional Rail Routes (right) 74
Figure 4.5: Planned Shinkansen Lines (2005) 75
Figure 4.6: Tokaido Shinkansen and Conventional Lines Operated by JR Central 78
Figure 4.7: Tokyo-Osaka Shinkansen Route with all intermediate stations (2009) 79
Figure 4.8: Stopping Patterns of Tokyo-Osaka Shinkansen by Train Type (2009) 81
Figure 4.9: Population of Major Urban Areas along Tokyo-Osaka HSR Line 82
Figure 4.10: Time-Space Chart for Commuting Times from/to Tokyo by mode 90
Figure 4.11: Time-distance diagram of major cities in Japan based on Maglev train travel time 90
Figure 5.1: Map of Transport Networks in France 99
Figure 5.2: Institutional Structure of National Railway System in France 100
Figure 5.3: TGV Network Maps: Existing and Planned TGV Lines by Year of Completion (left) and TGV and Conventional Rail Networks (right) 105
Figure 5.4: Radial HSR Network in France and Population Densities Distribution 107
Figure 5.5: Map of Paris-Lyon TGV Sud-Est Line 111
Figure 5.6: Map of French Provinces affected by TGV Sud-Est Line 115
Figure 5.7: Time-Space Chart for Commuting Times from/to Paris by mode 122
Figure 6.1: Map of Transport Networks in Germany 128
Figure 6.2: Current Organizational Structure of German Railways Company 130
Figure 6.3: Institutional Structure of National Railway System in Germany 130
Figure 6.4: Chronology of HSR Development in Germany 132

Figure 6.5: ICE Network Maps: ICE Lines by Speed in 2008 (left) and by Capacity of ICE Rail System by Speed (right) 133
Figure 6.6: Map of Cologne-Frankfurt ICE Line 137
Figure 6.7: Location of Montabaur ICE Station 138
Figure 6.8: Political Map of Germany 141
Figure 6.9: Time-Space Chart for Commuting Times from/to Frankfurt by mode 148
Figure 6.10: Destination of the Surveyed Commuters (in%) 149
Figure 7.1: Country Comparison of Population Sizes and GDP per Capita (2009) 154
Figure 7.2: HSR Models according to relationship with conventional services 156
Figure 7.3: Fundamental Chain of Development Impacts of HSR through Megalopolis Formation 160
Figure 7.4: Japan Megalopolis Formations: Tokyo-Osaka HSR Corridor 163
Figure 7.5: France Megalopolis Formation: Paris-Lyon HSR Corridor 164
Figure 7.6: Germany Megalopolis Formation: Cologne-Frankfurt HSR Corridor 165
Figure 7.7: Greenhouse Gas Emissions by Mode for EU-27 Countries 166
Figure 7.8: Net Growth versus Relocated Growth 169
Figure 7.9: Time-Space Chart for Commuting Times from/to Lisbon: existing modes and HSR 171
Figure 7.10: Possibilities of Megalopolis Forms 173
Figure 7.11: Scenario 1 – Lisbon-Porto Megalopolis 176
Figure 7.12: Scenario 2 - Lisbon-Oeste-Leiria and Porto-Aveiro-Coimbra Megalopolises 177
Figure 7.13: Scenario 3 – Hybrid Megalopolis 178
Figure 8.1: Possibilities of Megalopolis Forms 188
Figure 8.2: Feedback Effect of HSR Investment on Transportation Strategy 192

List of Tables

Table 2.1: % Productivity gain from 10% reduction in all driving times..... 22
Table 2.2: Applying the New Appraisal to CrossRail (UK Department for Transport, DfT, Calculations)..... 24
Table 2.3: Metropolitan hierarchy in the U.S..... 32
Table 2.4: Financing Strategies of first HSR Lines by Countries..... 35
Table 3.1: Planned HSR Axes in Portugal..... 46
Table 3.2: Main Urban Areas along the Lisbon-Porto Corridor..... 60
Table 3.3: Current Travel Times for O-D city pairs between Lisbon-Porto by mode (2010), before HSR..... 62
Table 3.4: Modal Split on Lisbon-Porto Route, before HSR..... 64
Table 3.5: Mode Share by Trip Purpose, before HSR..... 64
Table 4.1: The Main Shinkansen Lines Deployed..... 76
Table 4.2: Evolution of Train Travel Time and Frequencies of Tokyo-Osaka Shinkansen Services (1964-2009)..... 79
Table 4.3: Tokyo-Osaka Shinkansen Travel Time and Frequencies: listed by Train Type (2009)..... 81
Table 4.4: Smaller Cities Served by Hikari and Kodama Trains along Tokyo-Osaka Corridor..... 85
Table 4.5: Travel times for city pairs by mode (in minutes) (2010)..... 88
Table 4.6: Change of Population and Economic Indices in cities on Tokaido line..... 94
Table 4.7: Information exchange industries employment growth (%) in regions with population increase (1981-85)..... 94
Table 4.8: Employment of cities with stations and neighboring cities without stations..... 95
Table 5.1: Approximate Frequencies of TGV trains (2010)..... 113
Table 5.2: TGV Fares by Origin-Destination (second class fares, in Euros) (2010)..... 113
Table 5.3: The Rhone-Alps province versus the Paris region..... 115
Table 5.4: Market Shares by Mode on Paris-Lyon Corridor: Before and After the HSR..... 119
Table 5.5: Travel times for city pairs by mode (in minutes)..... 120
Table 5.6: Growth of business travel (1980-1985)..... 122
Table 6.1: Frequency of Service of ICE and Other Rail Services (IC or RE)..... 139
Table 6.2: ICE Fares by Origin-Destination (second class fares, in Euros)..... 139
Table 6.3: Cologne-Frankfurt Corridor Traffic Market Shares by Mode and Trip Purpose (%): Before and After . 145
Table 6.4: Travel times for city pairs by mode (in minutes)..... 147
Table 7.1: Country Level Comparison..... 154
Table 7.2: Corridor Level Comparison by Country: Before HSR..... 155
Table 7.3 (Part 1): HSR Corridors Comparison by Country: After Deployment of HSR..... 158
Table 7.3 (Part 2): HSR Corridors Comparison by Country: After Deployment of HSR (PART 2)..... 159
Table 7.4: Greenhouse Gas Emissions (grams per passenger-km)..... 166
Table 7.5: Expected Travel Times for O-D city pairs between Lisbon-Porto by mode (in minutes), after deployment of HSR..... 172
Table 7.6: Cities located along the planned HSR corridor: directly served and not served..... 175

1 Introduction

Attractiveness of high-speed rail (HSR) has been growing around the world with development of rail technology and rising concerns over climate change and congested airports and roads. Leading pioneers in HSR in the 20th century were Japan, France and Germany. More countries have turned to HSR to meet their transportation needs in the last two decades, including Spain, Italy, South Korea and Taiwan. In early 2008, "there were about 10,000 km (6,214 miles) of new high-speed lines in operation around the world". The network is still "growing at a very fast pace in many more countries" [1] and "25,000 km of new lines by 2020" [2] are projected worldwide.

HSR development has progressed rapidly in Europe as part of the European Union's (EU) Trans-European Transport Networks (TEN-T) program.[3] The European Union places a great emphasis on development of railways, especially those involving high speed as a more environmentally sustainable alternative to replace short-haul air travel and contribute to further integration of Europe. The total length of the planned TEN-T high speed network is 30,000 km (18,641 miles).[4]

Portugal is also among the EU members planning to join the trans-European HSR network as part of the South-West European High-Speed Rail Link, which is ranked as one of priority projects in the TEN-T program. The construction of the project will ensure connection between the Iberian Peninsula countries, Portugal and Spain, with the rest of Europe "without the need for reloading"[5] due to gauge differences.

The proposed HSR deployment in Portugal is intended to begin in 2010, with priorities being the 297 km (185 miles) Lisbon-Porto link and 206 km (128 miles) Lisbon-Madrid link (distance to the Spanish border only). Rede Ferroviária Nacional (REFER) and Rede de Alta Velocidade (RAVE), two state agencies, are jointly responsible for planning and implementation of the HSR construction and its operation. The implementation of Lisbon-Madrid (Lisbon to the border with Spain) line has begun and is scheduled to open in 2013. The Lisbon-Porto line was initially scheduled for completion in 2015; however, it may be postponed in light of the current financial crisis and Portugal's high budget deficit.[6]

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

[2] Ibid

[3] Sichelschmidt, H. 1999. The EU programme "trans-European networks" —a critical assessment. *Transport Policy*, 6, pp. 169-181.

[4] European Commission Transport, Official Website. Retrieved on 02/12/2010 from http://ec.europa.eu/transport/infrastructure/networks_eu/rails_en.htm.

[5] High Level Group on the Trans-European Transport Network. 2003. Report. TREN-2003-00960-02-00-EN-REV-00 (EN).

[6] DN Economia. 2010."Governo pára quatro estradas e reavalia linha do TGV." Article, February 2. Retrieved on 03/15/2010 from http://dn.sapo.pt/inicio/economia/interior.aspx?content_id=1484454 on 02/02/2010

Portugal considers the project to be an effort to stimulate the country's economy and to integrate with the rest of EU. According to the study conducted by RAVE (2008), the investment in HSR construction will generate in the long run an "accumulated increase of EUR 121 billion in GDP" and lead to the creation of 56,033 permanent jobs.[7] HSR is also anticipated to stimulate by improving accessibility and travel time, contributing to the overall GDP. These results establish the importance of the investment in the country's economic performance.

1.1 Motivation

The implementation of new high-speed rail lines plays an important role in reshaping the travel patterns and activities of people and consequently changing the ways cities develop. Apart from the goals of increasing transportation infrastructure capacity and providing a "green" transport alternative, the motivation to develop HSR system for many countries has also been promotion of economic growth and regional development. Traditionally, the direct economic impacts of HSR and other transport investments are assessed through a benefit-cost analysis (BCA). However, there are also indirect or wider development impacts that the traditional BCA may not capture. These impacts are the main focus of the thesis.

An interesting indirect development implication of HSR is the potential for *megalopolis* formation. HSR connects multiple cities at *high-speed* of 200-300 km/h (124-186 mi/h) and leads to fusing them into an integrated economic urban complex – *megaregion* or *megalopolis*. The Chubu Economic Federation (CEF) of Japan introduced the term "Extra Huge" Economic Zone (EHEZ) as a concept similar to *megalopolis* while "evaluating the impact of a HSR investment" servicing the Tokyo/Osaka corridor.[8] The megalopolis can have major economic impacts in terms of larger labor markets, larger commercial markets, expanded individual daily activity zones, and so forth. Ross (2009) presents a megaregion as a framework that can be better and more effective than cities alone in "meeting the economic and social challenges".[9]

There are a number of existing studies that assess the economic development implications of transport investments in general. Banister et al. (2001) examines whether transportation investments yield any "additional development benefits" at the regional and local levels besides the direct gains from travel-time savings. Puga (2001) and Krugman (1991) explore the effect of "reduction in transport costs" on "the spatial location of economic activities." Puga also notes that transport infrastructure improvements are one of the main instruments for "reducing regional inequalities." Prud'homme (1997) links the size of the city's labor market to the city's productivity. The larger the labor market, both the firm and the employees have higher probabilities of getting what they want. A larger labor market also justifies and facilitates specialization of workers and jobs thus increasing productivity. Considering this theory, the megalopolis may offer a larger labor market relative to the existing labor markets of Lisbon and Porto, and therefore contribute to increased productivity.

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[7] Rede de Alta Velocidade (RAVE). 2008. Os Efeitos Fiscais do Investimento na Rede Ferroviária de Alta Velicidade. Versão Síntese do Relatório Final. January.

[8] Ishii, M. 2007. Flexible System Development Strategies for the Chuo Shinkansen Maglev Project: Dealing with Uncertain Demand and R&D Outcomes. S.M. Thesis, Engineering Systems Division, Massachusetts Institute of Technology. Cambridge, MA..

[9] Ross, C.L. 2009. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC, p. 5.

The development impacts from the HSR may also be negative. For example, the HSR can disadvantage the smaller urban areas located between the main HSR stations. Puga (2001) notes that "a better connection between two regions not only gives firms in a less developed region better access to the inputs and markets of more developed regions," but also can harm them by reallocating economic activity to the richer regions. This is also true for cities. Therefore, we will draw upon international experiences to understand what the improved accessibility from the HSR means for the economic activity, labor markets and distribution of development impacts in the small cities by answering the following questions:

- Will the cities lose their labor, markets and economic activities to large cities by having gained better accessibility, either because of increased competition or because of relocation of these activities to bigger cities?
- Does being pulled into an integrated economic zone – megalopolis – disadvantage small cities or on the contrary, benefit them?
- What are the situations when small cities are not the biggest losers and what can be done to protect them when they are?
- What could be done to mitigate the harm and the isolation of smaller urban areas from the rest of the country?

These impacts are directly relevant to Portugal. This thesis will specifically focus on the newly planned Lisbon-Porto HSR corridor that will connect the country's two biggest cities with non-stop travel time of 1 hour and 15 minutes. The link will also serve the four intermediary cities of smaller sizes such as Oeste, Leiria, Coimbra, and Aveiro. This research will study the potential for creation of a Portuguese megalopolis between Lisbon and Porto, and identify the potential impacts of HSR on the distribution of economic activity within this megalopolis, toward the goal of developing policies maximizing the benefits and minimizing the negative effects of HSR on the areas not served by the network.

1.2 Research Questions

The objective of this thesis is to inform Portugal of the potential effects of the HSR on the concentration of economic activity within the megalopolis in the case of Lisbon-Porto high-speed corridor. It is anticipated that the research outcomes will assist Portuguese stakeholders to design policies maximizing the gains from the ongoing and future HSR projects. The research work in this thesis is intended to contribute to the future projects and proposals developed under the Transportation Systems focus area of the MIT Portugal Program and other HSR research initiatives.

The questions posed in the research are:

1) How do the large economic zones formed by HSR networks change the economic development of the connected cities due to time savings and other development factors induced by HSR?

    a) What is the level of impact of these changes on the development of urban areas based on experiences of existing systems?
    b) Does the integration to HSR network lead to smooth integration of small cities to the

global economy, or does it disadvantage them economically?

c) Who benefits and who loses from a HSR network: what are potential advantages and/or detriments for large and small cities?

2) What is the possibility of megalopolis formation between cities of *Lisbon and Porto* in Portugal due to HSR?

   a) What would be potential effects of the megalopolis on the development of large and small urban areas, both connected to and outside the new HSR corridor?
   b) What would be the distribution of the economic activity within this megalopolis?

The following main research question is examined in this thesis:

> *Will HSR deployment in Portugal form large economic zones or megalopolis that will change the development patterns of the connected cities, both small and large, due to time savings and other wider development factors induced by HSR, both positive and negative?*

1.3 Methodology

A case methodology was applied to analyze the phenomenon of megalopolis formation and the economic development effects resulting from HSR deployment worldwide. The approach was largely qualitative and descriptive supported with quantitative analysis of existing empirical evidence and synthesis of the relevant literature. Cases were based on studying the situations in countries that have had experience with the functioning HSR system for a period of time that is sufficient to allow for the development effects of HSR to occur. Figure 1.1 outlines the research process. In Stage 1, empirical evidence was collected through review of models already developed in the literature that estimate the impact of HSR on location of activities and regional development; and key indicators for measuring economic effects of transportation investments were identified.

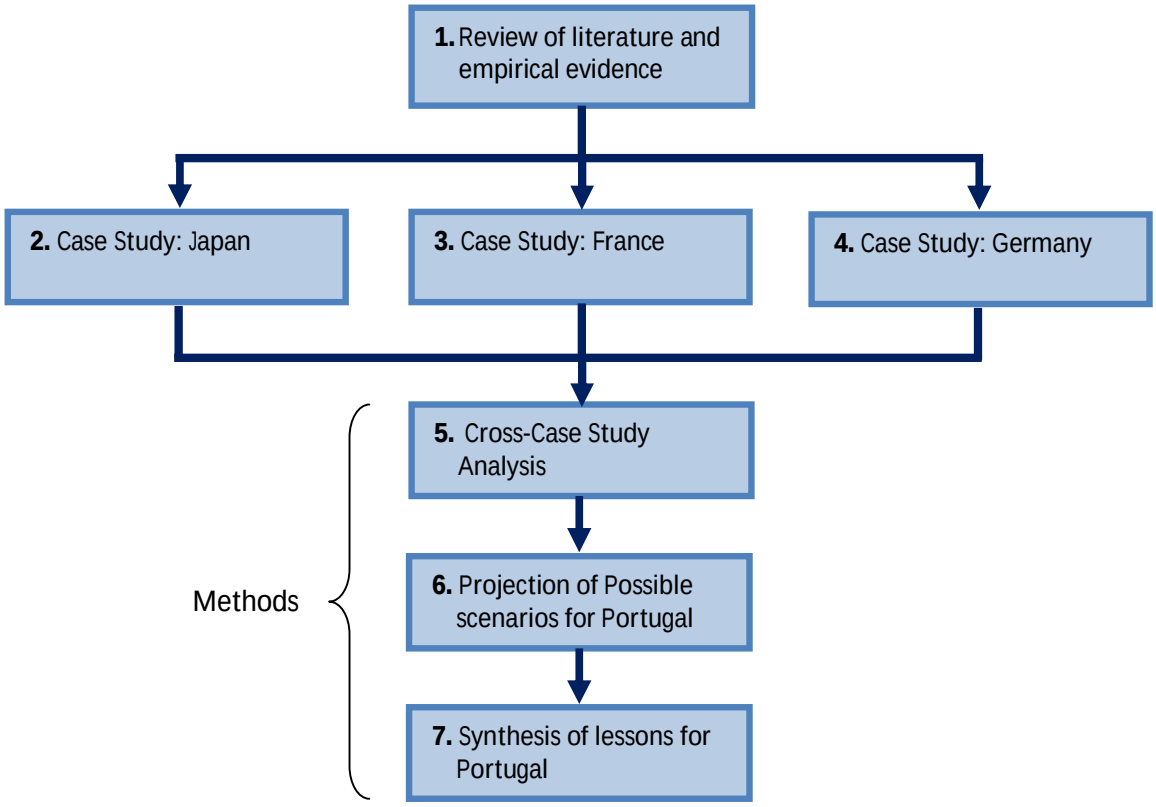
In Stages 2-4, cases of experiences in Germany, France, and Japan were studied before and after deployment of HSR. These country studies aimed to:

- Ascertain the phenomenon of megalopolis formation as a result of HSR deployment, and determine the possibility and magnitude of associated development effects.
- Analyze in detail the regional economic impacts of a HSR link on cities, large and small, connected and not connected to the network.
- Based on the specific country context, lay out the lessons learned for Portugal, thereby feeding into the next phase of research.

The cases will be structured around the following aspects:

- Status of inter-city conventional railway network in a country pre-HSR deployment.
- Competing modes and modal share in a country's corridor of study pre- and post- HSR.
- Studies done in a country that raised issues of megalopolis and regional development prior to deployment of HSR and proposals made to address them, if any.

Figure 1.1: Research Stages



- Actual outcomes post-HSR: the expected outcomes with respect to regional development that occurred as a result of HSR or did not occur, and unexpected outcomes.
- Existing empirical evidences on how HSR affected the regional development and distribution of growth among large and small cities.

In Stage 5, the case study findings and empirical evidence were analyzed and compared. In Stage 6, we applied these findings to Portuguese context to project possible scenarios of megalopolis formation and development impacts from HSR deployment in Lisbon-Porto corridor. In Stage 7, we synthesized the lessons learned for Portugal's HSR.

1.4 Structure

In addition to this introductory chapter (Chapter 1), this work is organized in seven other chapters. The thesis begins with literature review of regional development impacts of HSR investment and the concept of megalopolis in Chapter 2. The overview of the railway sector and plans for HSR system development in Portugal and specifically for the proposed Lisbon-Porto HSR link is presented in Chapter 3. The latter illustrates the current situation in the corridor before HSR deployment. Three sets of country case studies on development impacts of HSR are presented in three chapter: Japan's Shinkansen case study in Chapter 4 focuses on the experience

and impacts of the HSR link between Tokyo and Osaka; France's TGV system case study in Chapter 5 explores the development impacts of the Paris-Lyon HSR corridor; and Chapter 6 presents a case study of Germany's overall ICE system and impacts from the deployment of HSR line between Cologne and Frankfurt. Chapter 7 includes a cross-case comparative analysis, and lays out ideas on possible scenarios of megalopolis formation and development implications for the planned Lisbon-Porto high speed link in Portugal. Associated summary of findings, conclusions and recommendations as well as possible implications for Portugal's transportation strategy conclude this thesis in Chapter 8.

2 Literature Review: Regional Development Impacts of HSR

Development impacts of HSR may differ across different spatial scales, starting from effects on areas around stations to the effects on regional, national, and international levels through integration of metropolitan areas leading to potential creation of *megalopolis*. This chapter provides a review of general literature on HSR as well as the current state of research on the economic development impacts of HSR and other transport infrastructure investments on local/city, regional, national, and international levels. It also discusses existing theories defining the concept of *megalopolis* and how it relates to transportation investments.

Recent developments in the Unites States regarding the implementation of HSR, who is at the same starting point as Portugal, have inspired us to also discuss the financing approaches used by the countries with existing HSR systems to implement their first line.

2.1 Economic Development Effects of Transport Investments in General

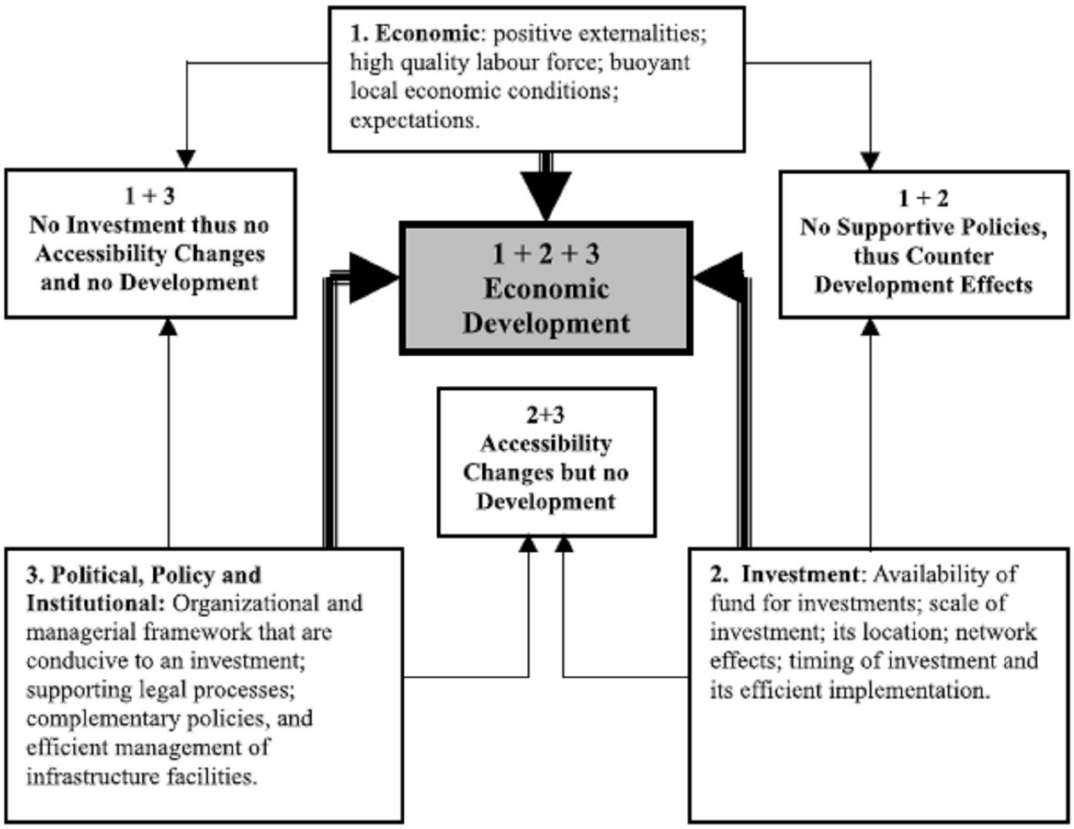
A number of studies have been completed assessing the economic development implications of transport investments in general. Transportation literature distinguishes between two types of impacts of transportation: direct and indirect. Direct impacts result from travel time savings and reductions in transport costs in the short-term, and these impacts are usually included in the traditional benefit-cost analyses of construction of transport infrastructure. Indirect impacts encompass the long-term implications such as economic growth, productivity, employment level, labor markets and agglomeration effects resulting from changes in accessibility and proximity induced by transport investment. Indirect impacts are more complex to account for in benefit-cost analysis as there are double-counting issues (e.g., travel time savings already capture some of the economic benefits). Radopoulou (2010) reviews the different methods and "software" that exist in the transportation literature on "evaluating economic impacts" of HSR, and recommends a "screening model" for evaluating the viability of implementing HSR in Greece.[10]

Banister and Berechman (2001) address the key question of "whether transport infrastructure investments" promote "additional development benefits" and economic growth at the urban and regional levels in developed countries. According to the authors, for the economic development to occur, transport investment alone is not a sufficient condition "but it acts in a supporting role when *other conditions* are at work". The conditions that must be present, as illustrated in Figure 2.1, are: (1) "positive *economic externalities*" such as agglomeration and labor market economies, good quality highly skilled labor force, etc.; (2) "*investment factors"* such as availability of funds for the investment, network effects (e.g., missing links in the network, etc.), and timing of the investment; and (3) "*political factors"* defining the right "policy design" that enables facilitation of decisions on local and national levels and maximizes the gains from transport investments. Authors emphasize that "policy-making is the crucial factor in

[10] Radopoulou, S. 2010. High Speed Rail in Greece: Methods for Evaluating Economic Impacts. S.M. Thesis, Transportation Program. Massachusetts Institute of Technology, Cambridge, MA.

realizing economic growth benefits from a transport infrastructure investment." However, neither of these factors on their own can result in economic growth. Combination of any two conditions would lead to the accessibility changes and redistribution of existing economic development only at best but not to additional development benefits.[11]

Figure 2.1: Banister and Berechman's (2001) Illustration of Necessary Sets of Conditions



Source: Banister, D. and Berechman, Y. 2001. Transport investment and the promotion of economic growth. *Journal of Transport Geography*, 9, p. 210.

Puga (2001) and Krugman (1991) explore the effect of "reduction in transport costs" on "the spatial location of economic activities." Puga (2001) notes that transport infrastructure improvements are one of the main instruments for "reducing regional inequalities," as "firms in a less developed region" get "better access to the inputs and markets of more developed regions". He also discusses that the new *economic geography models* or "*location theories"* can help to understand the "relationship between transport costs, agglomeration, and regional inequalities".

[11] Banister, D. and Berechman, Y. 2001. Transport investment and the promotion of economic growth. *Journal of Transport Geography*, 9, pp. 209-218.

Specifically, "reductions in trade or transport costs, by affecting the balance between dispersion and agglomeration forces, can decisively affect the spatial location of economic activities." [12]

However, Puga finds it ambiguous that the reduction in transport costs facilitates convergence of regional inequalities, as smaller urban areas may lose their economic activity to larger already developed cities. With the improved connectivity, the firms in richer regions can easier "supply poorer regions at a distance" and therefore "harm the industrialization prospects of less developed areas". The paper refers to an example by Faini (1983), showing that "the reduction in transport costs between Northern and Southern Italy in the 1950s" led to acceleration of "deindustrialization process in Southern Italy" because the firms lost the protection. [13] According to Krugman (1991), high transport costs disperse the locations of productions to both the core and peripheries, while the fall in transport costs shifts the production into one location, either core or periphery,[14] which contributes to centralization of economic activity in one place.

According to Banister and Berechman (2001), for transport-induced economic growth to transpire, various economies need to be present in various markets, the principal ones being firms' agglomeration, transport network, labor market, land market and environmental quality enhancement. "Merely improving accessibility" (which translates into travel time and higher travel volumes) is not sufficient to generate growth. Accessibility, on one hand, may drive the growth in "economic activity" by increasing "employment and productivity", but on the other hand, it may help one location at the expense of a competing location. Moreover, in most advanced countries levels of accessibility are already high (e.g., highway and conventional rail are in place already in Portugal). So the effect on the system as a whole may be marginal, or it may enhance the existing trends rather than create new ones. The authors also doubt that public infrastructure investment alone can cause substantial increases in new employment as potential savings are realized through increase in productivity of the existing labor force. This also raises a "causality" question of whether transport investment promotes economic growth or growth encourages more demand for transport and thus further investment. [15]

2.1.1 Economic Geography: Agglomeration Benefits and Regional Disparities

Reductions in travel time contribute to improved proximity of urban areas to each other and to major economic centers. Proximity of an area to "economic mass" measured by travel time is an important determinant of the variations in productivity, according to Rice et al (2006) study. The study finds "considerable support for the hypothesis that proximity to economic mass raises income" in the UK. Over 30% of "productivity variation" between regions in the UK is "due to variations in their access to economic mass" centers." The effect is more significant for the lower productivity areas. Cutting travel time to the centers of economic mass from 60 min of driving to 30 min would increase the impact of proximity "by a factor of four". Reducing all driving times in the UK by 10% would raise overall UK productivity by 1.2% and twice this

[12] Puga, D. 2001. European Regional Policies in Light of Recent Location Theories. Discussion Paper Series No. 2767. Center for Economic Policy Research. London, UK.
[13] Ibid
[14] Krugman, P. 1991. Increasing returns and economic geography. *Journal of Political Economy*, Vol. 99, No. 3, pp. 483-499.
[15] Banister, D. and Berechman, Y. 2001.

amount for areas whose access to large population mass is increased the most, holding the qualifications and location of the labor force constant. However, the effects of economic mass proximity on productivity diminish as travel time increases, becoming insignificant at about 80min or above. Table 2.1 displays these findings.[16]

Table 2.1: % Productivity gain from 10% reduction in all driving times

	Average	Minimum	Maximum
UK average	1.21		
North East	0.88	0.53	1.04
North West	1.17	0.94	1.52
Yorks-Humberside	1.34	1.15	1.55
East Midlands	1.44	0.79	1.78
West Midlands	1.40	0.96	1.87
East	1.45	0.36	2.40
London	0.95	0.78	1.14
South East	1.40	1.08	1.76
South West	1.17	0.34	1.72
Wales	1.18	0.55	1.70
Scotland	0.85	0.00	1.69

In very low density areas speeding up transport has essentially no induced productivity effect, hence the low minimum values for Scotland and the South-West, whilst the highest value (a 2.4% productivity increase), is for an area between London and the Midlands.

Source: Rice, P., Venables, A. and Patacchini, E. 2006. Spatial determinants of productivity: Analysis for the regions of Great Britain. *Regional Science and Urban Economics*, 36, pp. 727–752

Boddy et at. (2005) examine the "determinants of regional productivity differentials across the UK regions" using the data for individual business units. They find that disparities in regional productivities can be explained by a "limited set of variables," including "industry mix, the capital employed by the firm, business ownership, the skills of the labor force," and location-specific factors such as travel time from London (proximity to center, London in this case) and population density. The analysis has "important policy implications", specifically related to the effects of travel time, density and agglomeration. The authors find that businesses located in highly dense areas are more productive, and "access to larger markets can bring scale economies". Larger markets provide greater opportunities for "collaboration and interaction with other businesses," networks and contacts, which in turn promote learning and innovation exchange.[17] Therefore, "the overall impact of peripherality" and travel time on regional productivity differentials is important. For example, "the longer the travel time to London, the greater on average the productivity penalty on individual establishments," which can be

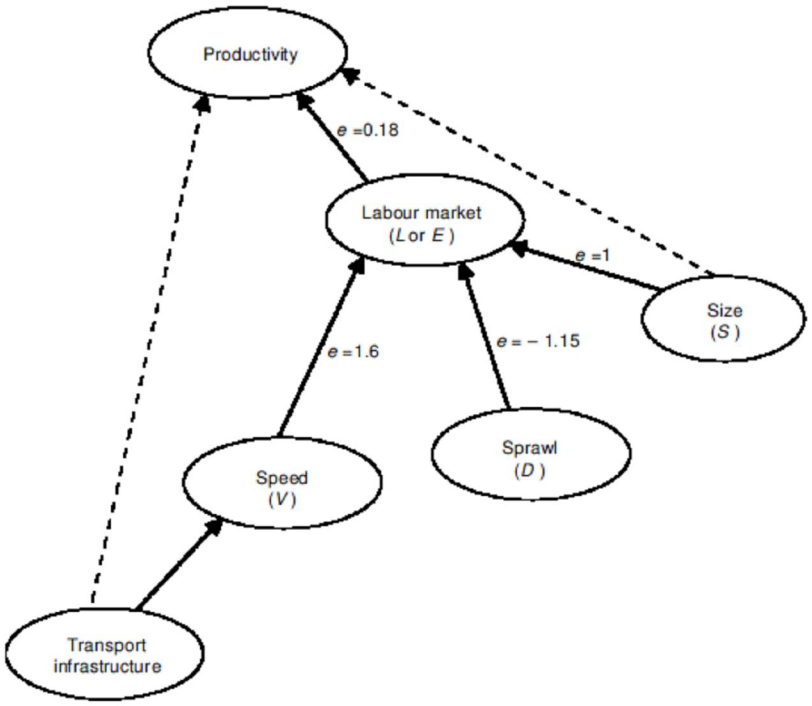
[16] Rice, P., Venables, A. and Patacchini, E. 2006. Spatial determinants of productivity: Analysis for the regions of Great Britain. *Regional Science and Urban Economics*, 36, pp. 727–752.

[17] Boddy M., Hudson, J., Plumridge, A. and Webber, D. 2005. Regional Productivity Differentials: Explaining the Gap. Discussion Paper No. 0515. University of the West of England, Department of Economics Discussion Paper Series. December.

explained by the agglomeration effects rather than simply travel time penalties. Proximity to London was found to have greater agglomeration effects than the population density does. It may also "represent the speed of knowledge diffusion where best practice spreads from the center (London) to other areas at a speed inversely proportional to peripherality."[18]

Prud'homme et al. (1999) links the size of the city's labor market to the city's productivity. Larger labor market widens pool of opportunities of the firm and individual workers, as both have higher probabilities of getting what they want. Larger labor markets thus justify and facilitate specialization of workers and jobs, which in turn increases productivity. Thus the theory (depicted in Figure 2.2) behind this statement is "that the efficiency of a city is a function of the effective size of its labor market, and that this labor market size is itself a function of the overall size of the city, but also of its sprawl" and transport infrastructure, which defines "the speed at which trips are made". [19]

Figure 2.2: The Efficiency of Cities as a function of size, sprawl, and speed



Note: *e*'s are elasticities.
Source: Prud'homme, R. and Lee, C. 1999. Size, Sprawl, Speed and the Efficiency of Cities. *Urban Studies*. Vol. 36, No. 11, pp. 1849-1858, p. 1857.

According to Graham (2007) reaffirms that agglomeration externalities arise from the transport investment by providing evidence that these "agglomeration effects matter", especially for service sectors, and can "make a difference to the benefit-cost calculations" of the transport

[18] Ibid
[19] Prud'homme, R. and Lee, C. 1999. Size, Sprawl, Speed and the Efficiency of Cities. *Urban Studies*. Vol. 36, No. 11, pp. 1849-1858.

investment appraisal. "If transport investment changes the densities available to firms" by reducing travel times or travel cost, then the "gains from agglomeration" are likely to be positive and can be quantified as "wider economic benefits" of transport investment. The author demonstrates "potential magnitude of agglomeration benefits" induced by transport investment using an example of "an ex-ante cost-benefit evaluation" of the Crossrail project in the UK. The evaluation shows that "inclusion of the agglomeration benefits increase the total benefits of the Crossrail project by 25%" (Table 2.2), pointing to "that agglomeration benefits may not be trivial". The paper notes that "not all transport investments or policies" will lead to increase of densities. Some may lower the densities resulting in "agglomeration costs rather than benefits in transport appraisal." For example, "road pricing" policies may decrease "effective densities" for certain types of trips such as commuting trips but increase densities for business trips. Thus, transport policies may induce agglomeration effects that "can reduce or increase the benefits".[20]

Table 2.2: Applying the New Appraisal to CrossRail (UK Department for Transport, DfT, Calculations)

Benefits	*Welfare (£ million)*
Business time savings	4,847
Commuting time savings	4,152
Leisure time savings	3,833
Total User benefits (conventional)	**12,832**
Agglomeration benefits	3,094
Total benefits (new approach)	**15,926**

Source: Graham, D. 2007. Agglomeration, Productivity and Transport Investment. *Journal of Transport Economics and Policy*, Volume 41, Part 3, September, pp. 317–343.

Glaeser el al. (2003) empirically test the implications of the decline in transport costs on "economic geography" of cities and regions. There is evidence of a "decline in transportation costs" over the last century, with a greater degree for goods and lesser for people. However, "in the last three decades" there have been observed some rise in the transportation costs for people moving within a city, which is mainly due to road congestion increases. The authors state that as transport costs of goods decline, the cities do not need to be located near "natural resource or natural transport hubs", but in places where the living and social conditions are more pleasant. Thus, the cities are becoming more "facilitators" of face-to-face "contact between people" rather than production centers. Decrease in travel time (mainly by auto) "has allowed the cities to sprawl and eliminate any tendency towards a single city center". So, Glaeser et al. envision the new future "regional model" in economic geography as the one "without centers and without transport costs for goods".[21]

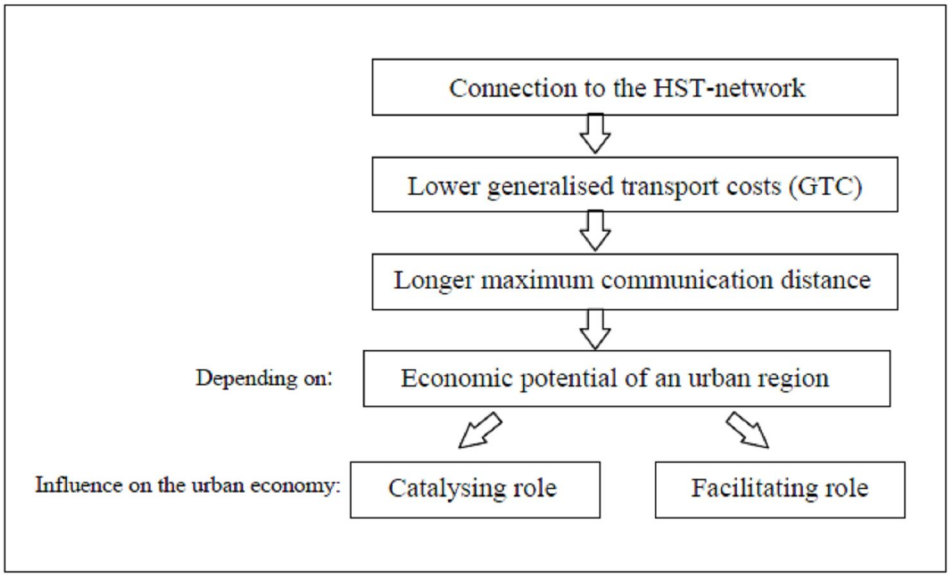
[20] Graham, D. 2007. Agglomeration, Productivity and Transport Investment. *Journal of Transport Economics and Policy*, Volume 41, Part 3, September, pp. 317–343.

[21] Glaeser, E. and Kohlhase, J. 2003. Cities, Regions and the Decline of Transport Costs. National Bureau of Economic Research. Working Paper 9886.

2.2 Economic Development Implications of HSR Investments

Since the implementation of the first HSR systems in Japan and some European countries, there has been an ongoing debate about the impacts HSR has on regional socio-economic development. In general, the HSR systems in most countries tended to connect the most densely populated areas mainly to ensure sufficient traffic demand.[22] HSR services have changed people's travel patterns and affected the mode splits. As stated by Shin (2005), high-speed trains (HST) have socio-economic impacts on areas within 2-3 hours of travel time, since that's the threshold within which HSR is "more competitive than air travel", i.e. the distance of up to 750–800 km (466-497 miles).[23]

Figure 2.3: Influence of the HST on urban areas (van den Berg and Pol, 1998)



Source: Pol, P. 2003. The Economic Impact of the High-Speed Train on Urban Regions. *European Regional Science Association EconPapers*. Retrieved on 06/12/2009 from http://www.ersa.org

The reduced travel time and lower transport costs resulting from the HSR connection may play two roles in the development of urban regions, according to Pol (2003): the effects of HSR may play "catalyzing" or "facilitating" roles, depending on the level of economic potential of an urban region (as illustrated in Figure 2.3). HSR connection acts as a "catalyst" typically in the cities with "low economic growth" by drawing "new activities" and thus causing economic growth. In the "cities with prosperous local economy, which need new infrastructure to accommodate their economic growth", HSR acts as a "facilitator". Most of such cities are major metropolitan centers or capitals that already have "high economic potential" and are often "the

[22] Shin, D. 2005. Recent Experience of and Prospects for High-Speed Rail in Korea: Implications of a Transport System and Regional Development from a Global Perspective. Working Paper 2005-02. Institute of Urban and Regional Development, University of California, Berkeley, CA.

[23] Ibid.

first to be connected to the HSR-network". Thus, the growth of these cities drives the demand for HSR investments to facilitate this growth but not create new growth.[24]

The possible negative development impacts of the HSR are explored as well. Among them is that the HSR can disadvantage the smaller urban areas located between the main HSR stations. Vickerman (1997) and Sasaki et al. (1997) argue that HSR benefits the large cities rather than smaller cities and enforces centralization of growth in major metropolitan area rather than dispersing it to the peripheries.[25] Furthermore, as discussed by Vickerman, "if central and peripheral regions are linked by new or improved infrastructures, obstacles to transport will be reduced in both directions", i.e. the firms in more accessibly and central areas get better access to the markets in less developed regions as well.[26] This may diminish these firms' willingness and need "to maintain branch factories or offices in peripheral areas".[27]

Puga (2001) explores the location theories and confirms that "a better connection between two regions not only gives firms in a less developed region better access to the inputs and markets of more developed regions," but also can harm them by reallocating economic activity to the richer regions. He elaborates that since HSR usually is not suitable for transporting freight, it is thus "unlikely to have much effect on the location of industry," but "may have larger effects on the location of business services and headquarters." The HSR connection may provide an opportunity to the businesses to serve remote locations with more ease, and "may lead to the concentration of business services and headquarters in a few large cities." Some evidence exists that the HSR link between Paris-Lyon "led to relocation of headquarters from Lyon to Paris". Spain is also concerned that "the Madrid-Barcelona high-speed rail line may reinforce the process of headquarters relocation towards the capital." Thus, HSR favors the existing cores (centers of activity), which are the main nodes of the network, and "is unlikely to promote development of new activity centers in minor nodes or in locations in between nodes." Puga explains this by distinguishing two characteristics of HSR: "its strong nodal aspect" as with too many stops HSR is not longer high-speed and its "large sunk costs relative to operating costs." The places located between the main HSR nodes are unattractive locations for production, and "the increasing returns to scale" exhibited by HSR technologies "are unlikely to promote new centers of production even on nodes of the network."[28]

The paper by Vickerman (1997) discusses the issues in evaluation of the HSR network in Europe from the perspective of "competitiveness, network effects and corridor development." It criticizes the development role assigned to HSR by urging "caution in approaches to the evaluation of individual projects." HSR "improves both the competitiveness and cohesion dimensions by, in effect, shrinking the size of geographical space," and increasing accessibility. Europe has indeed become more compact and all regions are closer to each other, but looking in terms of accessibility it is obvious that the biggest gains have accrued to the major access points

[24] Pol, P. 2003. The Economic Impact of the High-Speed Train on Urban Regions. *European Regional Science Association EconPapers*. Retrieved on 06/12/2009 from http://www.ersa.org.

[25] Sasaki, K, and Ohashi, T. and Ando, A. 1997. High-speed rail transit impact on regional systems: does the Shinkansen contribute to dispersion? *The Annals of Regional Science*, 31, pp. 77–98.

[26] Vickerman, R. 1997. High-speed rail in Europe: Experience and issues for future development. *The Annals of Regional Science*, 3, pp. 21-38.

[27] Sichelschmidt, H. 1999. The EU programme "trans-European networks" – a critical assessment. *Transport Policy*, 6, pp. 169-181.

[28] Puga, D. 2001.

on the network. Cities located between the main access points may "suffer a reduction in absolute as well as relative accessibility if they lose current services" (e.g., in Belgium new lines by-pass some major towns). Further, Vickerman claims that the causality of development impacts of HSR is not always clear: "whilst improvements in accessibility reduce transport costs and improve competitiveness for poorer regions, richer regions are better able to afford, and therefore to invest in, infrastructure and thus maintain their advantage." In the long run, "growth in peripheral regions may be depressed if more efficient firms in more central regions are better able to exploit the new infrastructure to widen their own markets at the expense of indigenous firms." [29] So, on average Europe's competitiveness as a whole improves, but the equal distribution of these gains or "cohesion" is "difficult to predict".[30]

Masson et al. (2009) concludes that "HSR is a mode of transportation that only permits the development of activities if it is well anticipated and configured", i.e. HSR implementation alone cannot achieve "positive effects" and must be "boosted" by accompanying "public and private measures".[31]

Several empirical studies assessing the impacts of HSR in different countries on different geographic scales are discussed in detail in the next sections.

2.2.1 Studies of Economic Development Effects of HSR on Local Level

Sands (1993) examines the potential development effects of HSR systems at the urban and station level with an emphasis on California's proposed HSR link. Based on the observed development effects of HSR stations in Japan, France and Germany, the author makes the following general conclusions for California. Specifically, he predicts that land value premiums of 20% might occur around the HSR stations given that adequate transportation infrastructure is provided and development is supported by local public agencies. Stations without adequate transport network connections, specifically without an urban rail link to the local city centers, would experience low ridership levels. Drawing from experiences of Japan, France and Germany HSR stations, Sands recommends that the State agency responsible for HSR implementation take a role in developing the areas around stations, and that this agency must work closely with local transportation authorities to ensure development of adequate modal connections to the HSR stations (accessibility to the stations and smooth transfers between modes). This may require provision of funding to local agencies to make these connections.[32]

Pol (2008) analyzes international case studies for four cities with HSR stations – Amsterdam, Munich, Lille and Rotterdam – to assess "the conditions for the economic effects of the HST". He claims that without any additional investments in the station area development, cities will most likely not have any "spatial changes related to the advent of the HST, or worse, can experience backwash effects". In all city cases, Pol found that "the local authority" plays an important role in the development of stations, but its influence varies across cities: while in Lille

[29] Vickerman, R. 1997.
[30] Vickerman, R. 1995. The regional impacts of Trans-European networks. *The Annals of Regional Science*, 29, pp. 237-254.
[31] Masson, A. and Petiot, R. 2009. Can the high speed rail reinforce tourism attractiveness? The case of the high speed rail between Perpignan (France) and Barcelona (Spain). *Technovation,* 29, pp. 611-617.
[32] Sands, B. 1993. The Development Effects of High-Speed Rail Stations and Implications for California. California HSR Series. Working Paper 566. University of CA at Berkeley, CA.

and Rotterdam station development was led by the local governments, in Munich and Amsterdam this initiative was undertaken by private or other independent actors. Overall, the paper concludes that "investing in [...] the HST station area" can increase the attractiveness of the city and be "a condition for sustainable urban growth catalyzed by the HST".[33]

2.2.2 Studies of Economic Development Effects of HSR on Regional and National Levels

Shin's (2005) paper discusses the regional disparity issues in development in Korea, where most economic activity is concentrated in Metropolitan Capital Seoul Region. The Korean government's policies directed at achieving de-concentration through Korean HSR Korean Train Express (KTX) have not been successful. In fact, reducing regional disparities became more difficult with KTX in place as Korea virtually became a daily-life zone. Therefore, the government's role is vital in ensuring that cohesive policies are in place aimed at boosting regional development, de-concentration of economic activity, and growth of less developed areas.[34]

The evaluation of the predicted accessibility effects of HSR link between Madrid-Barcelona-French border is presented by Gutierrez (2001). The author compares two scenarios of "with" and "without" HSR, by analyzing the effect of the new line on changes in "disparities between cities" on three levels of geographical scale: international, national and corridor scales. The indicators selected to measure accessibility are weighted average travel time, economic potential and daily accessibility. The changes in accessibility inequalities indicated by all three indicators show reductions in existing disparities on international/EU level: by 1.87% in travel times, by 1.37% in economic potential, and by 2.3% in daily accessibility. The spatial distribution of the effects of the new line favors the peripheral Iberian Peninsula, and "when a transport infrastructure mainly favors a peripheral space, it is obvious that it lessens the center-peripheral disparities". The new line is predicted to reduce "accessibility inequalities among cities at the European scale" and corridor level, "but increase inequalities at the national scale." At the national level the cities that have greatest increases in accessibility are already highly accessible without the HSR line. On corridor scale, small and medium-sized cities will obtain greater increases in accessibility than the large ones (meaning that this will induce spreading of economic growth).[35]

Bonnafous (1987) conducted an empirical study on the regional impacts of the TGV HSR between Paris and Lyons based on the surveys carried out before and after HSR inauguration. The emphasis was made on tourism and services industries and their impact on traffic flows. The study is concerned with the connections of the Rhone-Alps region, the second region of France, and its capital city of Lyons and other relatively important cities of Grenoble, Saint-Etiennes and Valence with Paris. The study notes that while transportation between Paris and urban centers in the provinces has improved, the connections between these provincial cities themselves have not changed or even worsened. The survey before the TGV showed that service industry enterprises in the Rhone-Alps region faced a risk "from the 'proximity' of their

[33] Pol, P. 2008. HST station and urban dynamics: Experiences from four European cities. Chapter 4. *Rail Development: Impacts on Urban Dynamics.* Ed. Bruinsma et al. Physica-Verlag Heidelberg.
[34] Shin, D. 2005.
[35] Gutierrez, J. 2001. Location, economic potential and daily accessibility: an analysis of the accessibility impact of the high-speed line Madrid-Barcelona-French border. *Journal of Transport Geography*, V. 9, Iss. 4, pp. 229-242.

powerful Parisian competitors." The post-TGV survey revealed a drop in the overnight stays in hotels, increase in the business journeys from Paris to the Rhone-Alps region by 52% for the purposes of selling or buying services, while the residents of Rhone-Alps have increased their trips to Paris by 144% for the same purposes. As for relocation of the enterprises, the TGV connection was not the key factor on choice of location. "The availability of TGV was regarded as a 'bonus'", but not a requirement. Its importance was given greater weight when other spatial constraints were considered.[36]

Tanaka et al. (2009) presents the post-assessment of the 127.6 km (79 miles) southern segment of the Kyushu Shinkansen line in Japan, carried out by the Japan Railway Construction, Transport and Technology Agency. The post-assessment confirmed that the Kyushu Shinkansen line had a positive impact on the economy. More specifically, the line widened the area of economic activity, streamlined business activities through reducing business travel costs, provided access to wider business opportunities, allowing a more efficient collection of information and simplified the organization of business meetings and negotiations. The business survey revealed that majority companies were affected positively, with less than 5% responding to have had negative impacts form the new line. Shinkansen also has influenced the change in travel behavior of the public as rail traffic share increased from 41% to 71% since 2004 and air traffic share decreased from 42% to 72% in the area between Fukuoka and Kagoshima cities. Overall, 20% of riders switched from air and 25% - from auto. By trip purpose, 33% of business travelers switched from air and 35% of leisure travelers changed from auto to Shinkansen. The new demand induced by the new line was estimated at 17.8% of the total demand. The number of commuters for work and school from smaller cities to Kagoshima City increased substantially, with the number of rail commuters reaching 11 times the pre-HSR levels in 2007.[37]

A study conducted by Atkins consulting company (2008) for the UK Department for Transport (DfT) and Scottish Government provides a very brief overview of the HSR prospects in the UK, including the line extensions from England to Scotland, HSR technology and segregation of HSR from conventional rail, productivity benefits, mode shift, environment and fundability. There is growing concern about the "*differentials in economic growth* between the North and the South of the UK and *how transport investment can assist in reducing the gap*". Most businesses demand good access to markets and HSR line "would make Scotland a more attractive location for inward investors, enhancing the major city region status of the Glasgow/Edinburgh axis." While improving north-south transport links is "a necessary enabling factor in reducing productivity gap", it is not sufficient "without other economic development measures." In order to maximize agglomeration benefits and support the higher value business development outside London the HSR stations need to be located in city centers, according to the author. The study also notes that "cities with more extensive financial services and research sectors will benefit more quickly from a HSR connection than those without." Thus, to take full advantage of the wider connectivity of HSR link and achieve real benefits, cities or regions must be willing to change their economic development, planning and transport policies.[38]

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[36] Bonnafous, A. 1987. The regional impact of the TGV. *Transportation.* 14, pp. 127-137.

[37] Tanaka, Y. and Monji, M. 2009. Post-Assessment of the Kyushu Shinkansen Network in Reference to the Proposed United States High-Speed Railway Project. Transportation Research Board Annual Conference, Session 212. Paper No. 10-1092. Washington, DC.

[38] Atkins. 2008. High Speed Rail in the UK. Written Submission. October 17.

A report by Steer Davies Gleave (2002) tries "to provide an assessment" of the ways "in which rail makes a contribution" and "attaches values wherever possible" to justify "for the spending on the railways" in the UK. The study "identifies a wide range of external benefits that the railways bring to the country as a whole, and to individual sectors of the population and the economy." In particular, the following impacts on the economy have been determined:

- Rail "enables the economy of London and other major cities to function and grow" by enhancing their "international competitiveness".
- It supports the "growth of regional cities" through promoting "the spread of economic benefits out of London and enabling key growth centers such as Birmingham, Leeds and Manchester to provide services nationally and serve the expanding workforce that their growth requires".
- It supports "regeneration of regional cities […] by providing access to jobs from surrounding areas of high unemployment" to regions such as Nottinghamshire, the Cardiff Valleys, etc. Business users can travel fast from "city centre to city centre" while "working during the journey".
- It impacts "land use" and density – "without rail there would be enormous pressures for dispersed lower density developments".
- "Rail is major industrial sector in its own – 130,000 jobs with an employment multiplier are six times greater within the manufacturing industry".
- It is "an important component in tourism – one of the largest sectors in the UK economy – bringing in over 1/3 of London's domestic visitors and heavily used by overseas tourists traveling to other cities and some of the more remote parts of the UK economy, which rely on tourism for much of their income."[39]

We can formulate the expected economic impacts of the HSR theoretically; however, empirically these impacts are "not measurable", according to Pol (2003). It is very difficult to "directly link accessibility changes with economic development" as there are many other factors influencing this relationship. "Economic changes can occur over a relatively long time period, during which many other urban elements change". HSR creates "opportunities for economic renewal and/or growth", but it is "impossible - ex-ante as well as ex-post - to determine the exact relationship between the advent of the HST and regional-economic changes".[40]

2.3 Phenomenon of "Megalopolis" Formation

One of the interesting economic development implications of HSR is the potential for megalopolis formation, resulting from a fusion of multiple cities into an integrated economic urban complex enabled by shrinking of the travel time distances and costs. We explore the concept of "megalopolis" as it is defined in the existing literature.

2.3.1 Concept of Megalopolis in Economic Geography

The opinions on the definition of the term "*megalopolis*" had differed among geographers and this debate still continues. Historically, the term first dates back to 371-368 BC, and refers

[39] Steer Davies Gleave. 2002. The Case for Rail. Final Report. London. June.
[40] Pol, P. 2003.

to the name of "a city in the Peloponnese". The city of Megalopolis was known for its "grandiose scale" but it fell in the late Roman period of history. Since then, the term has been used by geographers in different ways and has carried different connotations. One of its uses in the academic literature is reflected mainly in the works of Patrick Geddes (1915) and Lewis Mumford (1938), who referred to it to "denote an overlarge city doomed to destruction"[41] In 1961, Jean Gottmann introduced the new use of the term to "denote a large and highly connected" urbanized zone stretching along the Boston-Washington corridor in the Northeastern part of the United States.[42] This definition by Gottmann is officially accepted today among the geographers, but is not common outside of the discipline:

> *Megalopolis is "an almost continuous stretch of urban and suburban areas from southern New Hampshire to northern Virginia and from- the Atlantic shore to the Appalachian foothills."*[43]

Gottmann clarified later that his definition did not have a "physical" meaning, but it was... "***a functional definition of urbanization and urban growth***", i.e. megalopolis was "a cradle of a new order in the organization of inhabited space."[44]

Another reference to "megalopolis" in the economic geography literature is made by Jerome Pickard (1962) who built on Gottmann's idea of megalopolis and defined it as follows:[45]

> *"The largest urban region, sometimes called 'megalopolis', extends along the northern Atlantic seaboard from Portland, Maine to Washington, DC. A popular misconception has led to calling this a 'city 500 miles long'. It most definitely is not a single city, but a region of concentrated urbanism – a continuous zone of metropolises, cities, towns and exurban settlement within which one is never far from a city."*[46]

Other terms used in the literature referring to the concept similar to that of "megalopolis" include "mega-city region" and "polycentric urban development" by Hall (2006)[47], "megaplex" by Lang and Knox (2009), and "extended functional region" by Blum et al. (1997). The term of "*mega-city region*" originated from East Asia where it was used to refer to highly urbanized areas such as Tokaido Shinkansen corridor in Japan connecting Tokyo and Osaka. Hall (2006) analyzed the concept in their POLYNET study and defined it as:

> *"…a series of anything between twenty and fifty cities and towns, physically separate but functionally networked, clustered around one or more larger central cities, and drawing economic strength from a new functional division of labor. These places exist both as*

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[41] Baigent, E. 2004. Patrick Geddes, Lewis Mumford and Jean Gottmann: divisions over 'megalopolis'. *Progress in Human Geography*, 28, 6, pp. 687-700.

[42] Prevelakis, G. 2003. The relevance of Jean Gottmann in today's world. *Ekistics*, Vol. 70, Iss. 422/423, pp. 295-305. Athens, Greece.

[43] Gottmann, J. 1961. *Megalopolis: The Urbanized Northeastern Seaboard of the United States*. Book. Twentieth Century Fund. New York, NY, p. 3.

[44] Hall, P. 2009. Looking Backward, Looking Forward: The City Region of the Mid-21st Century. *Regional Studies*. Vol. 43, 6, p. 806.

[45] Lang R. and Knox, P. 2009. The New Metropolis: Rethinking Megalopolis. *Regional Studies*, 43, 6, p. 793.

[46] Pickard, J. P. 1962. Urban regions of the United States, *Urban Land*, April, 3–10.

[47] Hall, P. 2006. *The polycentric metropolis: learning from mega-city regions in Europe*. London; Sterling, VA: Earthscan.

separate entities, in which most residents work locally and most workers are local residents, and as parts of ***a wider functional urban region connected by dense flows of people and information along motorways, high-speed rail lines, and telecommunications cables****. It is no exaggeration to say that this was the emerging urban form at the start of the 21st century."*[48]

Lang and Knox (2009) illustrate the "anatomy of contemporary metropolitan form - the New Metropolis" (see Figure 2.4). The distinct feature of this "*New Metropolis*" is its "polycentric structure" and "clusters of decentralized employment." Metropolis emerges through being bound by "urban freeways, arterial highways, beltways, and interstate highways" as part of a greater "megapolitan region". "*Megapolitan region*" is the term used in the U.S., and is defined as "integrated networks of metropolitan areas, principal cities, and micropolitan areas". The largest by scale "urban complexes in the U.S." such as "pairing between Southern California and Arizona Sun Corridor" are referred to as "*megaplexes*". [49] Table 2.3 shows the "hierarchy of urban complexes" existing in the U.S.

Table 2.3: Metropolitan hierarchy in the U.S.

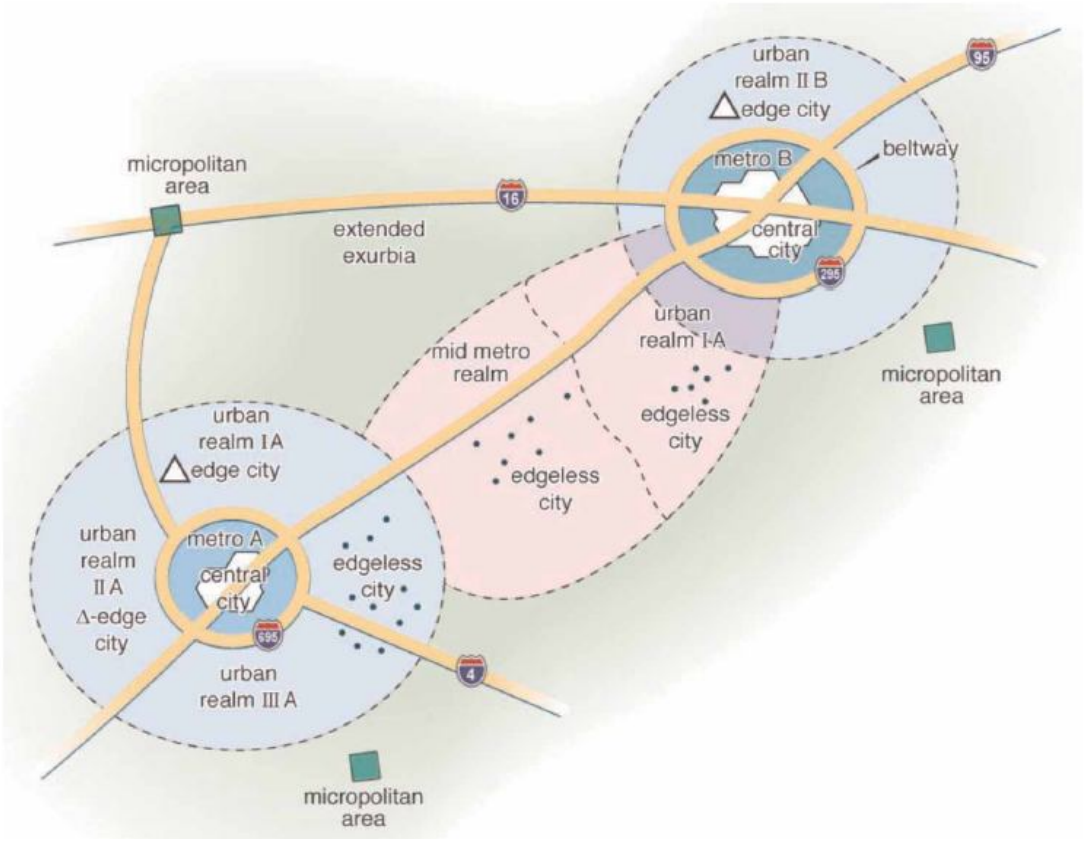
Types	Description	Examples
Metropolitan	Current definition of the Census Bureau	Pittsburgh; Boise
Metroplex	Two or more metropolitan areas that share overlapping suburbs but principal cities do not touch	Dallas–Ft Worth; Washington–Baltimore
Corridor megapolitan	Two or more metropolitan areas with anchor principal cities between 75 and 150 miles apart that form an extended linear urban area along an Interstate	Arizona Sun Corridor (Phoenix–Tucson); SanSac (San Francisco–Sacramento)
Galactic megapolitan	Three or more metropolitan areas with anchor principal cities over 150 miles apart that form an urban web over a broad area that is laced with Interstates	Piedmont; Great Lakes Crescent
Megaplex	Two megapolitan areas that are proximate and occupy common cultural and physical environments and maintain dense business linkages	Megalopolis and Great Lakes Crescent; Sun Corridor and SoCal

Source: Lang R. and Knox, P. 2009. The New Metropolis: Rethinking Megalopolis. *Regional Studies*, 43, 6.

Contant and Nie (2009) build on earlier definitions by Gottman, Hall, Pain and others and define "a megaregion" as "linked network for metropolitan areas that serve as a functional unit for economic activity." The authors claim that a "megaregion" consists of "economic, social and population core" and 'delineates the natural, economic, and social connections between cities, metropolitan areas, and rural places."[50] Ross (2009) presents a megaregion as a framework that can be better and more effective than cities alone in "meeting the economic and social challenges" and responding to economic crises.[51] Campbell (2009) argues though that the "focus on creating […] a competitive megaregion" and economic development may lead to environmentally unsustainable outcomes.[52]

[48] Hall, P. 2009. p. 806.
[49] Lang R. and Knox, P. 2009.
[50] Contant, C. and de Nie, K.L. 2009. Scale Matters: Rethinking Planning Approaches across Jurisdictional and Sectoral Boundaries. Chapter 1. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC, p. 15.
[51] Ross, C.L. 2009. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC, p. 5.
[52] Campbell, S. 2009. The Imperative of Growth, the Rhetoric of Sustainability: The Divergence of the Ecoregion the Global Megaregion. Chapter 7. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island

Figure 2.4: The New Metropolis: Rethinking Megalopolis



Source: Lang R. and Knox, P. 2009. The New Metropolis: Rethinking Megalopolis. *Regional Studies*, 43, 6, p. 791.

2.3.2 Role of HSR in "Megalopolis" Formation

The role of HSR deployment in fusing the urban areas into one integrated economic zone and formation of "megalopolis" are mentioned in papers by Hall (2006, 2009), Blum et al. (1997) and Ishii (2007). Hall (2006, 2009) actually state that railway systems in Europe and in Asia have "achieved an extraordinary renaissance in the form of high-speed trains" such as the Shinkansen in Japan, the TGV in France, the British Inter-City 125s, the Italian Direttisima and others. Hall predicts that in the 21st century, these HSR systems would accomplish "what motorways failed to do: ***to shrink geographical space, and thus tie not only half of Britain, but also much of Europe, into a single polycentric Megalopolis"***.[53]

Blum et al. (1997) hypothesize that "cities that are linked together into a band of cities by means of a high-speed train are transformed to an *extended functional region*". The paper defines the concept of "*extended functional region"* as "a geographical area that shares a common labor market and a common market for household and business services". It serves as "a common ground for a number of important economic and social functions, in particular,

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Press, Washington, DC, p. 132.

[53] Hall, P. 2009. p. 808.

markets for local services, the market for labor and markets to satisfy the demand for proximity." This conceptually is also similar to what we mean by "megalopolis".[54]

Ishii (2007) discusses the formation of "Extra Huge" Economic Zones (EHEZ) between two or more cities as a result of high-speed train connection. This concept was developed by the Chubu Economic Federation (CEF) of Japan for evaluating the impacts of a HSR investment in Japan. Ishii applies this concept to illustrate the formation of EHEZ on Lisbon-Porto HSR corridor in Portugal by comparing current, TGV and Maglev systems (Figure 2.5).[55]

Figure 2.5: Time-Space diagram of Lisbon and Porto, with the Economic Magnitudes

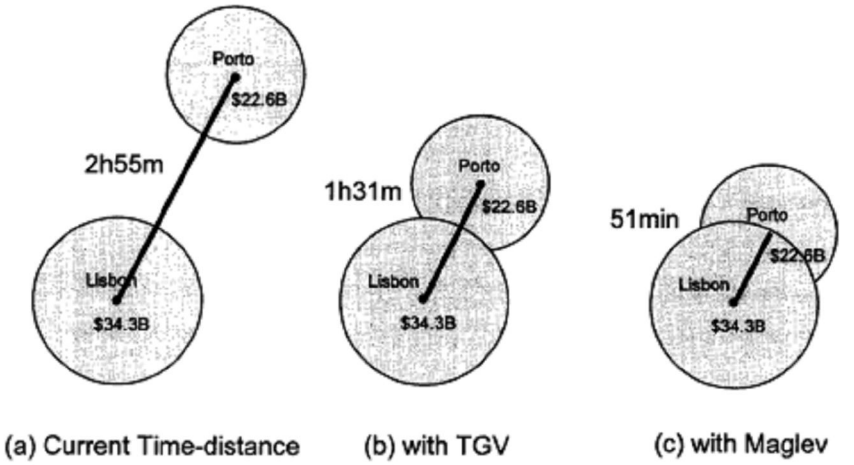

Figure 2-7: Time-distance diagram of Lisbon and Porto, with the Economic Magnitudes. Time-distances are based on the scheduled speeds of railways; current scheduled speed, which is 115 km/h [22], would be 222 km/h with TGV [23], and 400 km/h with Maglev [4]. No stops are assumed in the calculations of travel time with TGV or Maglev.

Source: Ishii, M. 2007. Flexible System Development Strategies for the Chuo Shinkansen Maglev Project: Dealing with Uncertain Demand and R&D Outcomes. Chapter 2. S.M. Thesis, Engineering Systems Division, Massachusetts Institute of Technology. Cambridge, MA, p. 39.

2.4 HSR Financing Approaches: International Experiences

The development of new HSR systems has grown around the world in the last two decades. Today, there are a number of HSR lines planned for construction, including Portugal, China, United States, the Netherlands, Poland, Russia, etc.[56] On January 28, 2010, President

[54] Blum, U., Haynes, K.E. and Karlsson C. 1997. The regional and urban effects of high-speed trains. The *Annals of Regional Science*, 31, pp. 1–20.

[55] Ishii, M. 2007. Flexible System Development Strategies for the Chuo Shinkansen Maglev Project: Dealing with Uncertain Demand and R&D Outcomes. Chapter 2. S.M. Thesis, Engineering Systems Division, Massachusetts Institute of Technology. Cambridge, MA.

[56] International Union of Railways (UIC) High Speed Department. 2009. High Speed lines in the World. Prepared by I. Barron. Updated June 14. Retrieved on 03/15/2010 from http://www.uic.org/

Barak Obama made an announcement on initial allocation of $8bln funding for development of America's first nationwide high-speed rail program. This amount was sliced up among 13 major high-speed rail projects across the country to serve as a down-payment on developing or laying the groundwork with total of 31 states receiving a piece of the funding. The largest share recipients are Florida and California: Florida is receiving $1.25bln for a new HSR corridor between Tampa and Orlando; and California is receiving $2.25bln for its planned HSR project to link 432 km (268 miles) of distance between Los Angeles and San Francisco. With the total cost of the CA network totaling to about $40 billion, the funding does not even cover 10% of the costs.

The announcement has raised concerns about the U.S. approach of spreading the dollars so thin that no investment will be effective in the end. Other countries with existing HSR systems approached the financing of their HSR start-up programs differently. However, it would be fair to note the different geographical scale of the U.S. compared to other countries that already have HSR. While constructing one HSR line in smaller countries may create a cross-country link, the U.S. would require building multiple lines to achieve a cross country connection.

Below are the descriptions of how the countries with developed high-speed rail systems allocated their original funding for launching their respective HSR systems. Since the HSR systems in Japan, France, and Germany are described in detail in dedicated separate chapters (Chapters 4-6), this section provides brief descriptions of HSR deployment strategies in Spain, South Korea and Taiwan. Table 2.4 summarizes the financing information for all countries. (Appendix I presents a template that can be followed as a way of characterizing HSR systems around the world and comparing across the countries).

Table 2.4: Financing Strategies of first HSR Lines by Countries

Country	First HSR line(s) or project	Year Completed	Share of National Government Funding	Other Sources of Funding
Japan	**(1)Tokyo-Osaka**	**1964**	**100%**	**World Bank loan ($80mln)**
France	**(1) Paris-Lyon**	**1981**	**100%**	**--**
Germany	**(1) Hanover-Wurzburg (upgrade)** **(2) Mannheim-Stuttgart (upgrade)**	**1991** **1991**	**100%** **100%**	**--**
Spain	**(1) Madrid-Seville**	**1992**	**100%**	**--**
South Korea	**(1) Seoul-Daegu**	**2004**	**100%**	**--**
Taiwan	**(1) Taipei -Kaohsiung**	**2007**	**0%**	**PPP through syndicated loan**

Spain

Spain launched its HSR network with the development of its first line between Madrid and Seville, which opened in 1992. This 472 km (293 miles) long route operated at speeds up to 300 km/h (186 mi/h). Majority of funding for construction was provided by the national government. The construction of this first line was rushed by the government in order to be completed for the International Exhibition that took place in Seville in 1992.[57]

The motivation for the development of high-speed rail was to enable rail to be more competitive with air and car and promote regional economic development. The geography of Spain is similar to that of France, with long distances between the major cities and little intermediate population. Given the relatively low quality of the inherited infrastructure, Spanish Railways were rapidly losing market share to air and car.

Following the Madrid-Seville line, in the successive years Spain built additional high-speed rail lines: from Madrid to Barcelona in 2007 and from Madrid to Valladolid in 2008. The construction of these lines was based on a national rail plan created in 1987 and national transportation plans created in 1993, 1997, and 2005.[58] The construction of the network was also driven "by Keynesian policies" aimed at creation of employment opportunities in the country.[59]

Korea

The first HSR line in Korea between Seoul and Daegu was completed and put into operation in April 2004. The specially established Korean HSR Construction Authority was in charge of the construction. The Korean High-Speed Rail (KHSR) adopted the French TGV technology, with the maximum line speed of 300 km/h (186 mi/h).

Initially, Korean government took a decision to construct a 412 km (256 miles) long HSR line connecting Seoul and Busan in 1989. The construction started in June 1992 with expected completion in 1998. However, due to financial crisis of summer 1997, the original plan was revised in July 1998 and the project implementation was split into two phases: (1) Seoul-Daegu line and (2) Daegu-Busan line. Thus, the first phase was completed in April 2004 with a delay of 63 months from the originally planned completion date. The second phase is scheduled for completion in 2010.[60]

The project was financed 100% by the Korean government. It resulted in large cost overruns amounting to about $6bln. During the construction, the KHSR faced a lot of opposition from the civil society, environmentalists, cultural heritage experts and religious followers, which also contributed to delays.

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[57] Nash, C. 2008. High Speed Rail Investment: an overview of the literature. Institute of Transport Studies, University of Leeds. Leeds, UK.

[58] United States, Government Accountability Office. 2009. High Speed Passenger Rail: Future Development will Depend on Addressing Financial and Other Challenges and Establishing a Clear Federal Role. Report to Congressional Requesters. GAO-09-317. March.

[59] Nash, C. 2008.

[60] Kao, T, Y. Lai and M. Shih. 2010. Privatization versus Public Works of High Speed Rail Projects. National Taiwan University. Taipei, Taiwan. TRB Session 212. Paper No. 10-2004.

Taiwan

The first HSR service in Taiwan was launched in January 2007 with the completion of construction of a 345 km (314 miles) long high-speed line between Taipei and Kaohsiung. Six stations were constructed new and two were modified to be shared with the conventional railway. Taiwan HSR (THSR) is based on Japan's Shinkansen technology, and its train operating speed is 300 km/h (186 mi/h), with maximum design speed of 315 km/h (196 mi/h).

Taiwanese Government has made a decision to build HSR in 1989 as a response to the growing domestic demand for intercity transportation, and increasing congestion on highways and in airports. After the completion of design studies in 1993, the government chose to privatize the project. The construction was delayed due to lack of proper legislation on privatization. In 1998, the project was finally awarded to private company Taiwan HSR Corporation (THSRC) under a BOT scheme for a 35 year concession, upon which it would be transferred back to the government. Construction started in 2000 and was scheduled for completion in 2005, but was actually launched in 2007 (with a 14 month delay).

The THSR construction was financed through a syndicated loan of $10.1 billion, signed between THSRC and a bank consortium.[61] THSR project had large cost overruns amounting to $1bln. The project is one of the largest privately managed and funded transport schemes to date.

2.5 Summary

Overall consensus is present in the existing theoretical literature as to what development impacts may be from the HSR investment. Some of the economic development implications of transport investments in general highlighted in the literature go beyond the direct gains from travel-time savings and transport cost reductions. These include spatial location of economic activity, reduction in regional inequalities, larger labor markets and increased productivity level. Some of the negative impacts include loss of economic activity by less developed to more developed regions and thus uneven allocation of economic growth.

Studies assessing the development impacts of HSR find that HSR contributes to further centralization and concentration of most economic activity in already developed areas. For instance, HSR line in Spain induced spreading of economic growth and reduced disparities on corridor level but not on national level, according to Gutierrez (2001). While HSR "improves competitiveness and cohesion dimensions by shrinking the size of geographical space" by increasing accessibility and proximity, the biggest gains have still accrued to the major access points, per Vickerman (1997). TGV survey in Rhone-Alps region, according to Bonnafous (1987), revealed that "there were big risks to the enterprises in the service sector from the 'proximity' of their powerful Parisian competitors". Most scholars also agree that no economic growth can be achieved without the necessary set of conditions in place, including the development at the station level, the right policy design and frameworks, etc. The literature on the formation of "megalopolis" as a result of HSR connection has been emerging mostly recently, as the HSR development has grown in the last several decades. Many authors agree on the importance of agglomeration externalities especially in the HSR investments.

[61] Ibid

Nevertheless, the available literature has not yet provided robust results explaining the relationship between HSR investment and economic growth because of the complexity of this relationship and long period of time needed for the growth effects to realize, during which other factors may be or are at play.

The chapter concludes with the review of financing strategies inspired by the recent announcement in the U.S. on first allocation of the funding for construction of 13 HSR and conventional rail projects across the country. All other countries that have successfully implemented their first HSR systems, have concentrated their funding on one strategic corridor, selected either because of capacity problems of the existing services or for other political reasons. All of the systems were also funded from mostly one source, usually the government.

* * *

The next chapter reviews the existing railway system in Portugal, elaborates on the country's plans and expectations for HSR, including financing and decision-making processes, and discusses the current state of the Lisbon-Porto corridor.

3 High-Speed Rail in Portugal

The plans for HSR deployment have been high on the political agenda of Portugal in recent years. The government has finally embarked on construction of the first HSR line beginning 2009-2010, but the implementation has been delayed due to economic slowdown and Portugal high levels of debt. The network of total of 1,010 km (628 miles) of high-speed lines is expected to connect the cities within Portugal as well as to the cities in Spain and increase the integration of Iberian Peninsula with the European Union (EU). This chapter describes the current railway services and plans for HSR deployment in Portugal, and the EU's objectives pertaining to the Portuguese HSR. The last section discusses the current situation and transport alternatives serving the corridor between Lisbon and Porto before HSR, and the cities located along the planned the HSR route.

3.1 Current Railway System

The first railway line was inaugurated in Portugal on October 28, 1856, between Lisbon and Carregado. Gradually, the network was expanded to the South and North of the country and to Spain. Today, Portugal's railway network extends to 2,789 km (1,733 miles), of which 2,606 km are wide gauge (1,668 mm) and 183 km are narrow gauge (1,000 mm) lines.[62] While Portuguese conventional trains are operable in Spain that has the same gauge size, they are not compatible with the standard gauge networks (1,435 mm) in the rest of Europe. In 2004, the Portuguese rail network carried total of 133 million passengers and 9.5 million tons of freight.

The passenger and freight rail operations in the country are under the jurisdiction of state owned enterprise Trains of Portugal (Comboios de Portugal, CP). Established in 1951, CP was initially a private company, but was nationalized in 1975 as a state-owned enterprise. As part of EU's liberalization efforts, in 1997, the Portuguese government separated rail operations from infrastructure: CP was put in charge of the train service operations and the management over the railway infrastructure was transferred to the new state owned enterprise National Railway Network (Rede Ferroviária Nacional Empresa Publica, REFER).[63] The only privately operated passenger rail service in the country is Fertagus commuter rail line in the Lisbon metropolitan area. The rail freight services in Portugal are provided by CP and private operators.

Operations

The primary operator of the freight and passenger trains in Portugal, CP offers the following rail services: long distance Intercity services such as Alfa Pendular and Intercidades (CP Longo Curso); nationwide regional and inter-regional service (CP Regional); commuter rail services between Lisbon metropolitan area and its suburban network (CP Lisboa); commuter

[62] Rede Ferroviária Nacional (REFER). 2009. Network Statement 2010. January. Retrieved on 03/15/2010 from http://www.refer.pt/Documentos/Network_Statement%20_0010_REFER.pdf

[63] Comboios de Portugal, Official Website. History. Retrieved on 03/30/2010 from http://www.cp.pt/cp/

trains between Porto metropolitan area and its suburbs (CP Porto); and rail freight operations (CP Carga).[64]

Portugal's existing form of HSR service - Alfa Pendular - operates between Braga-Porto-Lisbon-Faro at a top speed of 220 km/h (137 mi/h). It is CP's top service that was introduced in 1999; however, it has not been very successfull in terms of speed and traffic demand as the Portuguese had hoped.[65] Alfa Pendular's service frequency from Lisbon and from Porto is 11 trains per day, with only 2 making all intermediate stops[66]

Commuter services connecting Lisbon to the suburbs on Setúbal Peninsula, located to the south across the Tagus River, are operated by private company Fertagus on a 30 year concession, granted in 1999. Fertagus, owned by the Portuguese transportation company Grupo Barraqueiro, is the first and only private rail operator in Portugal. The company pays REFER an infrastructure usage fee.[67] The original revenue projections of the concession proved over-optimistic and demand levels did not reach the minimum band, leading to a revenue shortfall and triggering Fertagus to renegotiate the contract.[68] In 2005, Fertagus and the Portuguese surface regulator (formerly known as DGTTF, currently IMTT) entered the renegotiations. As a result, the concession term for reduced from 30 to 9 years, and "Fertagus was allowed to sell its rolling stock to central government and subsequently lease it back".[69] (Figure 3.1 presents a map of conventional rail network in Portugal.)

Infrastructure

The ownership, management and control over the national rail infrastructure is a responsibility of REFER. REFER reports directly to the State Secretariat for Transportation and Ministry of Public Works, Transportation and Communications (Ministerio de Obras Públicas, Transportes e Comunicações, MOPTC), who is the primary decision-making authority in transportation. REFER also owns 40% share of the state owned company High-Speed Rail Network (Rede Ferroviária de Alta Velocidade, RAVE), created in 2000 to develop a HSR in Portugal. The Portuguese government owns the remaining 60% of RAVE. REFER and RAVE are jointly responsible for the development and implementation of HSR in Portugal. The coordination of the implementation of international axes between Portugal and Spain is carried out by newly created agency Spanish-Portuguese joint venture – High Speed Spain-Portugal (Alta Velocidad Espana-Portugal, AVEP).

[64] Ibid
[65] Nelson, J. 2008. Stuck With the Bill, But Why? An Analysis of the Portuguese Public Finance System with Respect to Surface Transportation Policy and Investments. S.M. Thesis, Transportation Program and City Planning, Massachusetts Institute of Technology. Cambridge, MA.
[66] Comboios de Portugal, Official Website. 2010. Train Timetables. Retrieved on 03/30/2010 from http://www.cp.pt/cp/
[67] Wikipedia. Fertagus. Retrieved on 02/15/2010 from http://en.wikipedia.org/wiki/Fertagus
[68] KPMG. 2005. Commercial and Procurement Options for the Portuguese High Speed Lines. RAVE. December.
[69] Nelson, J. 2008.

Figure 3.1: Map of Portugal's Conventional Rail Network

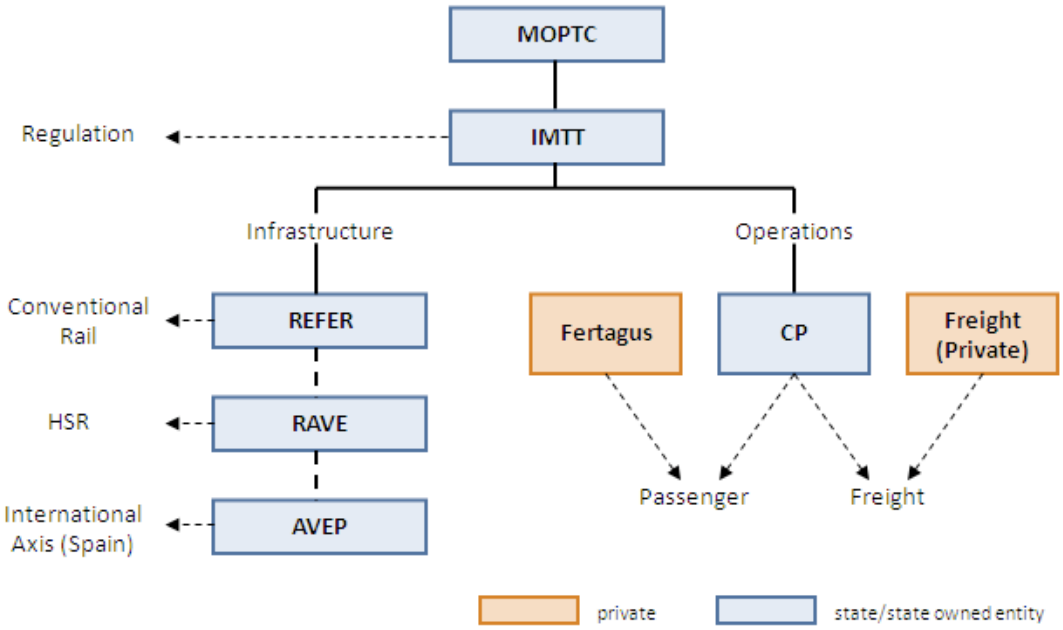
Source: Rede Ferroviária Nacional (REFER). 2009. Network Statement 2010. January. Retrieved on 03/15/2010 from http://www.refer.pt/Documentos/Network_Statement%20_0010_REFER.pdf

Regulation

The Institute of Mobility and Land Transportation (Instituto da Mobilidade e dos Transportes Terrestres, IMTT) is the state regulating agency established in 2007. IMTT combined the former state rail regulator, the National Institute for Rail Transport (Instituto Nacional do Transporte Ferroviário, INTF), the surface transportation and ferries regulators, and the licensing and traffic safety office into one entity. This new entity is part of central government and is responsible for regulating and supervising all transport modes as well as road safety, vehicle registration, and drivers' licenses.

IMTT integrates a functionally independent rail regulatory unit in charge of the economic and technical regulation of the rail sector.[70] In partnership with the existing railway operators, CP and Fertagus, the regulator defines access rights, grants access licenses to operators, approves access charges and regulates railway activities taking into account development, safety, quality and environment.[71] Figure 3.2 presents the institutional structure of Portugal's rail sector.

Figure 3.2: Institutional Structure of Railway System in Portugal



Financing

Existing railway system operates at large losses. Demand forecasts made for the first investment in high-speed rail line, Alfa Pendular, have proven optimistic resulting in higher costs and lower speeds than expected. Hence, the railways are incurring losses, including the

[70] Instituto da Mobilidade e dos Transportes Terrestres (IMTT) Official Website. Retrieved on 03/25/2010 from http://www.imtt.pt/

[71] Rede Ferroviária Nacional (REFER) Official Website. 2010. Retrieved on 03/30/2010 from http://www.refer.pt/en/apresentacao.php

only private operator Fertagus.[72] In 2006, CP's net operating loss accounted for about 193 million Euros and that of REFER's was 201.7 million Euros. In the same year, operating subsidies provided to the two state owned enterprises – CP and REFER – totaled 27 million and 29 million Euros respectively.[73]

Government wants to fully privatize the rail market, but the interest from the private sector is unlikely due to questionable profitability and bounding rail fare regulation. The only private operator Fertagus (with 30 year concession to operate suburban service Lisbon-Praga-Fogueterio shortened to 9 years in 2005) had disappointing 35-50% fewer ridership than was forcasted by the government. The Government is now subsidizing Fertagus' deficit.[74]

3.2 Plans and Expectations for HSR

Decision-making process

Since the early 1990s, the government has been placing greater importance on the development and maintenance of the rail network in Portugal. HSR technology has also been a big policy issue. With France and Germany ahead of the game with HSR functioning at speeds of 300 km/h (186 mi/h), and neighboring Spain operating its AVE since 1992, Portugal also made a decision in 1993 to start development of its HSR network. Currently, one of the key projects in the government's infrastructure program is construction of a HSR link between Porto, Lisbon, Madrid and other Portuguese and Spanish cities.[75]

To start the process, state owned company High-Speed Rail Network (Rede Ferroviária de Alta Velocidade, RAVE) was created in 2000 as a public entity under the ownership of REFER (40%) and the Portuguese government (60%). REFER and RAVE are jointly responsible for the HSR network implementation: RAVE develops and coordinates the needed work and studies, and REFER is in charge of infrastructure investments.[76] In 2001, High Speed Spain-Portugal (Alta Velocidad Espana-Portugal, AVEP) was set up as a Spanish-Portuguese joint venture to coordinate the implementation of international axes between Portugal and Spain. The constituting contract equates AVEP to a commercial company (with fiscal obligations) with a mission that has been defined in political terms at the Iberian Summits. AVEP is headquartered in Madrid and the president of RAVE is also the president of AVEP.[77] AVEP and RAVE coordinate in the matters related to cross-border axis of the HSR.

The first feasibility studies and environmental impact assessments for the three priority axes were launched by RAVE in 2002 and 2006 respectively. The Lisbon-Madrid link was the first axis to be constructed, officially approved in 2006. In June 2007, RAVE proposed and publicly presented a Business Model for the deployment of the network, consisting of a series of

[72] Petkova, B. 2007. Strategic Planning for rail System Design: An Application for Portuguese High Speed Rail. Master's Thesis, Industrial Engineering and Management, University of Groningen. Groningen, Netherlands.
[73] Nelson, J. 2008.
[74] Petkova, B. 2007.
[75] The Economist Intelligence Unit (EIU). 2008. Country Profile: Portugal. London, UK.
[76] Petkova, B. 2007.
[77] Rede de Alta Velocidade (RAVE) Official Website. 2010. Retrieved on 03/12/2010 from http://www.rave.pt/en/tabid/338/Default.aspx

Public-Private Partnership (PPP) projects.[78] In June 2008, the Portuguese government made a decision to launch the first PPP tender process for construction of Poceirão-Caia section of the Lisbon-Madrid axis and issued an official announcement inviting potential bidders. This 165 km (103 miles) long section stretches to the Spanish border. Construction was expected to begin in 2008, however, the award of the concession contract was delayed until after September 2009 for political reasons and upcoming elections. The election results were good news for the HSR project to proceed with the re-election of the Socialist Party Prime Minister Socrates. The contract was finally awarded in December 2009 to one of the two bidders and the implementation is currently underway.[79] Nevertheless, the implementation of the remaining lines, including Lisbon-Porto, has been delayed and the start date is questionable given the financial stress and budgetary constraints currently being experienced by Portugal.[80]

The HSR project has caused a wide-ranging public debate about the need for and possible routings of the high-speed lines. This debate is still on the table. The opponents emphasize the huge cost and commercial failure rates while proponents see the potential benefits that HSR could bring to a region.[81]

Government's Vision for HSR and Motivations

The Portuguese State has important strategic goals for the high-speed lines such as:[82]

- Create a modern, sustainable and efficient transport system with the minimum environmental impact;
- Reduce the country's peripheral position by improving rail links to Spain and to the rest of Europe;
- Contribute to the Atlantic southwest front competitiveness;
- Accelerate the country's economical and technological development, including at the regional level;
- Contribute to a better modal distribution, both for passenger and freight, and encourage a modal shift to rail from air and road; and
- Increase mobility and competitiveness of the country's port, airport and logistics systems.

Overall, the HSR in Portugal is expected to double the mobility at the national level and within the Iberian Peninsula. The government reinforces the importance of international connections and envisions that the new HSR will connect to and integrate with the interoperable

[78] Rede de Alta Velocidade (RAVE). 2008. Announcement for PPP expression of interest for Lisbon-Madrid link. Retrieved on 03/12/2010 from http://www.rave.pt.

[79] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

[80] DN Economia. 2010. "Governo pára quatro estradas e reavalia linha do TGV." Article, February 2. Retrieved on 03/15/2010 from http://dn.sapo.pt/inicio/economia/interior.aspx?content_id=1484454 on 02/02/2010

[81] Petkova, B. 2007.

[82] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

Trans-European Transport Network (TEN-T), a central component of the European policy.[83] The country expects that the improved mobility will trigger mode shift from road and air to the railways, increasing the rail market share from 4% in 2003 to 26% by 2025.[84].

The launch of the HSR implementation in Portugal was mainly motivated by the lack of line capacity on the existing inter-city. The HSR will also allow freeing some capacity on the conventional lines for freight traffic, as both Portugal and EU seek for ways to reduce truck traffic on the roads. After the opening of the HSR system, Portugal plans to continue operating its existing conventional passenger services in those areas that will not be served by the high-speed system.[85]

Expected Socio-economic Impacts

Several studies assessing the socio-economic impacts of the three priority links – Lisbon-Madrid, Lisbon-Porto and Porto-Vigo – have concluded that the investment would result in positive effects on all regions of Portugal. A study by Pereira, A. M. and J.M. Andraz (2007) found that Lisbon and regions in the north would gain the most benefits from these three HSR lines, however, the middle size urban centers would also gain more influence. The same study estimated the following long-term economic and budgetary effects:

- "56,000 new permanent jobs" will be created;
- private investments will increase by 126 billion Euros;
- GDP will grow by 121 billion Euros;
- "cumulative increase in tax revenues" will reach 64 billion Euros. [86]

Planned high-speed lines

During the 2003 Iberian Summit the five lines for the new Portuguese HSR network were announced, and in June 2004, the Cabinet of Ministers of Portugal approved this new network. It constitutes one national link Lisbon-Porto (297 km/185 miles) and four international connections into Spain: Lisbon-Madrid (203 km/126 miles to the Spanish border), Porto-Vigo (100 km/62 miles to the Spanish border), Aveiro-Salamanca (170 km/106 miles to the border), and Evora-Faro-Huelva (240 km/149 miles to the border).[87] Table 3.1 provides details on each line and Figure 3.3 presents a map of the whole planned network.

[83] Lourenco, N. and Santos, A. 2005. Ananálise Demográfica E Socio--Económica Dos Corredores Da Alta Velocidade. Padrões De Distribuição Da Acessibilidade À Alta Velocidade Ferroviária. Presentation by SociNova Cabinete de Investigacao em Sociologia Aplicads, Universidade Nova de Lisboa, Faculdade de Ciencias Sociais e Humanas. Lisboa, Portugal, December.

[84] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

[85] Nelson, J. 2008.

[86] Rede de Alta Velocidade (RAVE). 2008. The Portuguese High Speed Rail Projects: General Overview and Status of the Project. LNEC, Lisbon, Portugal. September 23.

[87] Barrón, I. 2009. High Speed lines in the World. International Union of Railways (UIC) High Speed Department.

Figure 3.3: Planned HSR Network Axes in Portugal

Source: Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

Table 3.1: Planned HSR Axes in Portugal

Lines	Length (km/mi, to Spanish border)	Speed in km/h (mi/h)	Expected Launch Date	Traffic (Pax/Freight)
Lisbon-Caia(-Madrid)	203 km/126 mi	350 (217)	2013	Mixed use
Porto-Valença(-Vigo)	100 km/62 mi	250 (155)	2013	Mixed use
Lisbon-Porto	297 km/185 mi	300 (186)	2015	Passenger only
Aveiro-Almeida(-Salamanca)	170 km/106 mi	250 (155)	Undetermined	Mixed use
Evora-Faro-Vila Real de SA(-Huelva)	240 km/149 mi	250 (155)	Undetermined	Mixed use
TOTAL HIGH-SPEED LINES LNEGTH	**1,010 km/628 mi**			

Sources: International Union of Railways (UIC, 2009), Rede de Alta Velocidade (RAVE, 2010), Ministry of Public Works, Transport and Communications (MOPTC, 2010).

The Lisbon-Madrid, Porto-Vigo and Lisbon-Porto have been selected as three priority links. All the lines in Portugal with the exception of the Lisbon-Porto axis are planned to be built as mixed use to carry both freight and passenger traffic. Lisbon-Porto will be the only non-mixed use link dedicated to passengers.

Locating stations of HSR in the center or outside of urban areas is a debate in Portugal and will have a significant impact on the ridership. Placement of a HSR station in the city center and close to other modal services will ensure access and better ridership on the HSR. Central station location will also make HSR more competitive with air, as it would provide city-center to city-center service with limited inter-modal transfer needs. The final decisions of Lisbon-Madrid and Lisbon-Porto alignment and station locations have been made through numerous studies by consulting firms. All feasibility studies and environmental impact assessments for the Lisbon-Madrid axis have been completed. Appendix II lists all the studies completed by RAVE.

Compatibility with conventional rail system

To ensure compatibility with the EU HSR network, the new HSR lines will be built to the European standard gauge size of 1,435mm, different from Portugal's existing rail gauge. However, to integrate the HSR with the existing conventional rail network, the stations will be designed to accommodate both high-speed and conventional trains so that easy connection and transfer between two types of services is allowed. In addition, automatic track gauge changeovers are planned to be installed to allow the circulation of high speed and conventional trains in both networks.

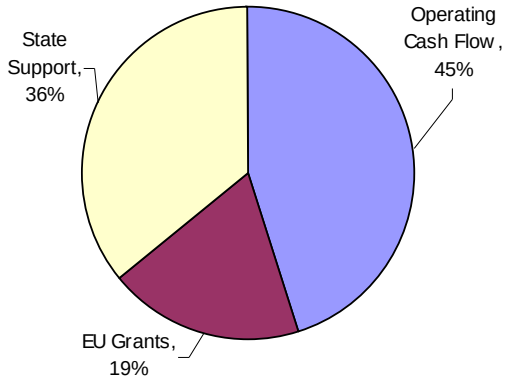
Financing

Entire HSR investment in Portugal is estimated at total cost of 8-10 billion Euros. The sources of financing the investment include the EU grants, European Investment Bank (EIB) loans, private sector and the state. The implementation of the Portuguese HSR construction is planned to be set up as a series of PPP projects under availability payments structure, where the Portuguese state will make periodic payment to a concessionaire for provision of the infrastructure facility, and payments are reduced if the facility is not available for a period of time, or is not being maintained in satisfactory condition. Under this structure the concessionaire does not assume any traffic risk.

The Portuguese government estimates that the Lisbon-Porto and Lisbon-Madrid projects will generate an operating cash flow covering only 45% of the total investment amount (about 6.7 billion Euros), and the EU will contribute 19%. The remaining 36% will require funding support from the Portuguese state (Figure 3.4).[88] Though the current railway system in Portugal is struggling financially, and financial viability of new HSR is uncertain, the decisions of the EU and Portugal are firm.

[88] Rede de Alta Velocidade (RAVE). 2009. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at European Federation of Railway Trackworks Contractors (EFRTC) General Meeting. Porto. June 5.

Figure 3.4: Financing sources for Lisbon-Porto and Lisbon-Spanish Border links



Source: Rede de Alta Velocidade (RAVE), 2009. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at European Federation of Railway. Trackworks Contractors (EFRTC) General Meeting. Porto. June 5.

Lisbon-Madrid Axis

The Lisbon-Madrid HSR line will be 640 km (398 miles) long, including 203 km (126 miles) on the Portuguese side. The line will be built for a mixed traffic use (passenger and freight) with a maximum speed of 350 km/h (217 mi/h). The total required investment for the Portuguese portion is 2.2 billion Euros. This new line will guarantee a transit time between Lisbon and Madrid of around 2 hours 45 minutes. The line will also serve intermediate stations in Évora and Elvas/Badajoz(Caia).[89] The section between Évora and Caia will be built as a conventional line. Freight transport will be limited and impose a weight restriction of 1,000 tons.[90] Considerations are also being made to connect the line to the Lisbon New Airport area near Alcochete, to the east of Lisbon, via a conventional rail link.

The Lisbon-Madrid link has been split by RAVE into 3 sub-concessions: 2 construction concessions and one signaling and telecommunications concession. First request for tenders was announced in June 2008 for a PPP for concessions of engineering, construction, financing, maintenance and provision of 165 km (103 miles) rail infrastructure of Poceirao-Caia stretch (RAVE 1). The section includes a conventional rail component for freight services between Evora and Caia. Proposals were received from two consortiums in 2008, but the final award decision was delayed due to elections. In December 2009, the contract was awarded to the Elos consortium of companies, co-led by Brisa, for a 40 year Design, Build, Finance and Maintain (DBFM) concession. The construction of the section is currently underway and includes 90 km (56 miles) of a new single track freight line. The concession constitutes only the infrastructure but not the train operations. About 50% of total capital expenditures (840 million Euros) are funded through the State and the EU subsidies, 690 million Euros are financed from loans from

[89] Rede de Alta Velocidade (RAVE). 2008. Launch of the International call for tenders – Infrastructure concession for the Poceirao-Caia section of the Portuguese high-speed network. Retrieved on 03/15/2010 from http://www.rave.pt/

[90] Davignon, E. 2008. Priority Project No. 3: "South-West European High Speed Rail Link". Annual Activity Report of the European Coordinator. Brussels. July.

the European Investment Bank (600 million Euros) and other commercial borrowing, and 120 million Euros comes from the consortium's equity. The concessionaire will be repaid through "availability rents with a small demand-related adjustment factor close to 5%". The estimated IRR for the section is above 12%.[91]

A second concession for the section between Lisbon and Poceirao (RAVE 2) is evaluated at 1.93 billion Euros, including the 7 km (4 miles) bridge over the Tagus River in Lisbon (Third Tagus Crossing, TTC) and conventional rail connection to the new Lisbon Airport. The invitation to tender for this section was launched in March 2009 and bids were received in August 2009.[92]

The construction of the Spanish portion of the Lisbon-Madrid HSR link is on schedule. It is financed not through a PPP but through a public procurement. The EIB has provided financing for the Spanish section as well. Even though there is some conditionality between Spain and Portugal on the HSR, Spain has no influence in the speed of implementation of the Portuguese section (which is behind schedule).

The Lisbon-Madrid line is expected to start operating in 2013. It has been predicted to carry 2.7 million trips annually out of total 24 million of forecasted traffic demand in 2015. Economic Internal Rate of Return (EIRR) of the entire project, excluding the TTC, is estimated at 5.9%. The EIRR for the TTC alone is estimated at 20.47%.[93]

Lisbon-Porto Axis

The plans for a high-speed line between Lisbon and Porto were first announced by the Ministry of Transport in 2005. This 297 km (185 miles)[94] link is a national line that will be dedicated for passenger traffic only with a maximum speed of 300 km/h (186 mi/h). It is expected to connect two largest Portuguese cities, Lisbon and Porto, with a journey time of 1 hour 15 minutes for non-stop service. In addition, the line will serve four intermediate stations in Aveiro, Coimbra, Leiria, and Oeste, but not all trains are expected to stop at these stations.

The project requires an estimated investment of 4.5 billion Euros. The Lisbon-Porto link is also planned to be launched as a PPP, split into 3 sub-concessions: two for construction and one for signaling. The forecasts have shown that the line will carry 7.4 million passengers per year in 2015 out of total 46 million of total predicted passenger traffic on the corridor.[95] The EIRR has been estimated at 10.8%.[96]

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[91] Brisa. 2009. High Speed Rail: Poceirao Caia stretch awarded to Brisa co-lead consortium. Presentation. December 13. Retrieved on 04/01/2010 from http://www.brisa.pt/ResourcesUser/Investidores/Comunicados/EN/HSR20091213UK.pdf

[92] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: Business Model. Presentation at Workshop on PPP and High Speed Rail – The Portuguese Experience. Lisbon. January 28-29.

[93] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

[94] Steer Davies Gleave/VTM. 2009. Análise Custo – Benefício da Ligação em Alta Velocidade Ferroviária da Ligação Lisboa – Porto. Relatorio Final. RAVE. March.

[95] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the

The line is initially scheduled for completion by 2015; however, as mentioned earlier its implementation may be postponed due to Portugal's recent budgetary challenges. More detailed discussion of the Lisbon-Porto corridor is included in Section 3.4 of this chapter.

Porto-Vigo Axis

The Porto-Vigo link is a 125 km (78 miles) long HSR line, of which 100 km (62 miles) will run on the territory of Portugal. The line will connect cities of Porto in Portugal with Vigo in Spain in one hour, with intermediate stops in Braga on the Portuguese side and Valenca on the border. Both passenger and freight services will be allowed to operate on this high-speed line at a maximum speed of 250 km/h (155 mi/h).

The investment in the Portuguese portion of the Porto-Vigo line is estimated at 1.4 billion Euros. The line is predicted to carry 1.7 million trips out of total 20 million trip traffic annually on the corridor by 2015. The Economic IRR has been estimated at 2.4%.[97] Initially scheduled for completion for 2013, it has been delayed to 2015. The final completion date is also uncertain for the same reasons as the Lisbon-Porto line.

Aveiro-Salamanca and Evora-Faro-Huelva Axes

The other two HSR links in the pipeline are Aveiro-Salamanca and Evora-Faro-Huelva with lengths of 170 km (106 miles) and 240 km (149 miles) respectively on the Portuguese side only. Both will be international lines connecting to Spain and operate mixed traffic services (freight and passenger) at maximum speeds of 250 km/h (155 mi/h). No investment estimate and launch dates have been defined for these lines as of this moment.

3.3 The EU Objectives and Vision

Trans-European Transport Network (TEN-T)

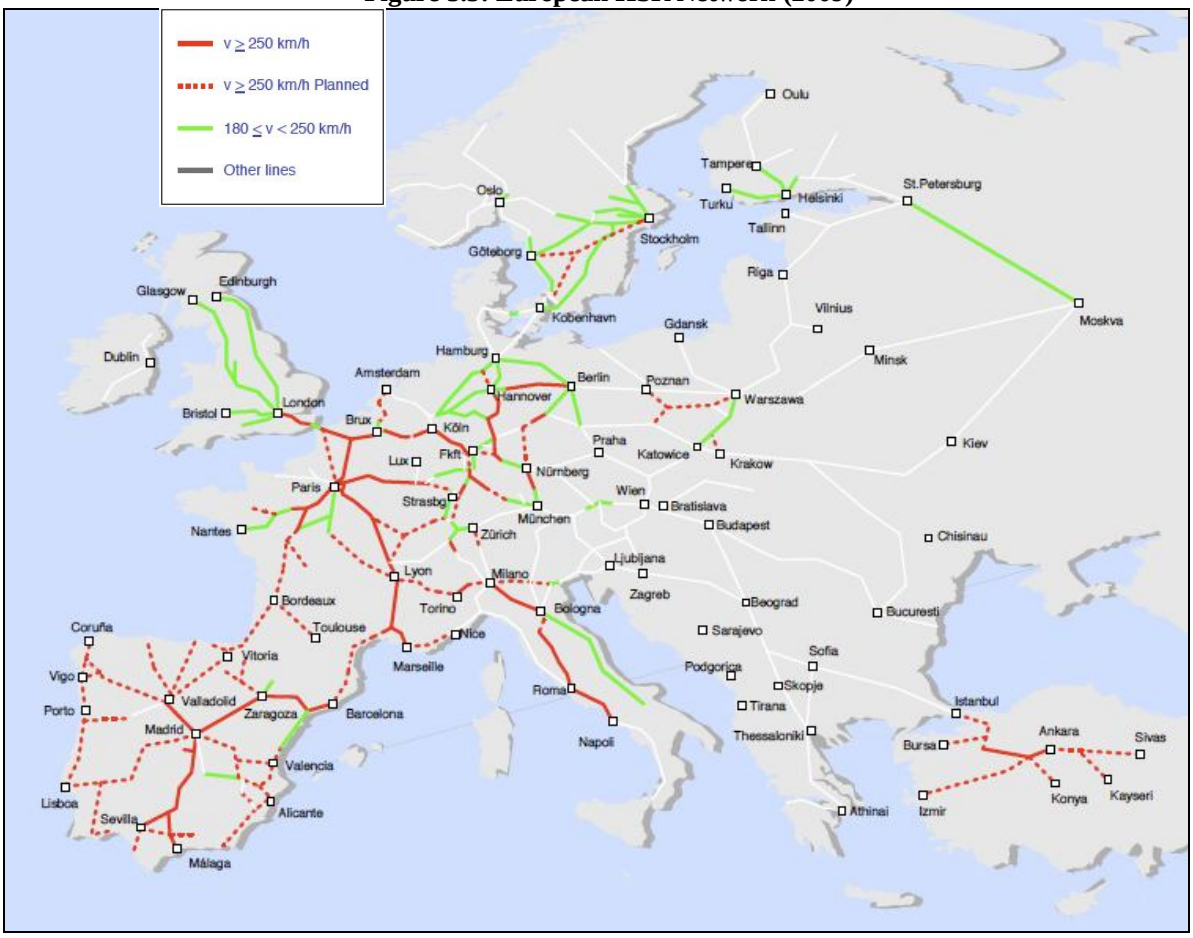
Development of HSR Network across Europe is one of the priorities of the European transport policy for integration and is part of EU's Trans-European Transport Network (TEN-T). The implementation of the TEN is carried out under the Maastricht Treaty of 1993 and its aim is to induce economic development and decrease the regional gaps throughout Europe. The TEN-T plays an important role in passenger and freight movements in the EU. The entire network incorporates all modes of transport and by 2020 is planned to include 89,500 km of roads, 94,000 km of railways, of which 20,000 will be HSR with speeds of at least 200 km/h. The financial support for the TEN-T infrastructure projects is provided through the EU's Structural and Cohesion Funds in some member countries and through loans from the European Investment Bank (EIB). During 2000-2006, the Cohesion Fund has provided about 20 billion Euros for the

Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

[96] Steer Davies Gleave/VTM. 2009.

[97] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

Figure 3.5: European HSR Network (2009)



Source: International Union of Railways (UIC) High Speed Department. 2009. High speed lines in the world. OG/IB Updated September 18. Retrieved on 02/15/2010 from http://uic.asso.fr/IMG/pdf/20091113_d_HIGH_SPEED_LINES_IN_THE_WORLD_MAPS.pdf

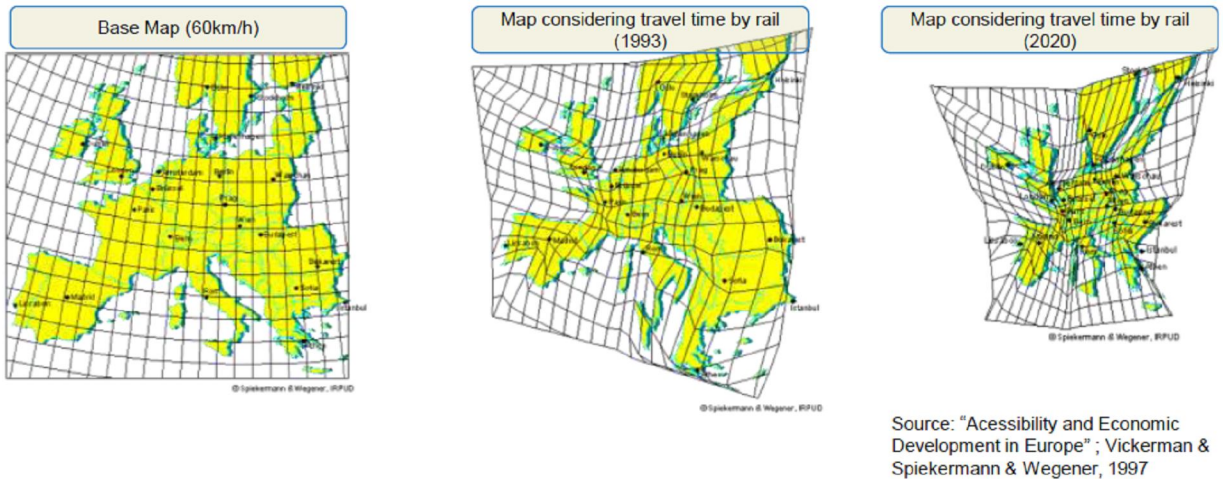
TEN-T projects. During 1997-2006, the EIB has financed about 50 billion Euros in loans to eligible member countries for the TEN-T projects.[98] See Figure 3.5 for the map of the European HSR network as of 2009.

At the broader European level, the most important strategic objectives for high-speed rail are:[99] (i) European integration, in particular improving links to remote regions, such as southern Italy, Portugal, and the countries of Eastern Europe; (ii) relief to the over-crowded air services and to congestion on main rail axis throughout Europe; (iii) improvement of cohesion, competitiveness and single European market; and (iv) sustainable development. Figure 3.6 presents visual demonstration of EU integration.

[98] Lee, Y. S. 2007. A Study of the Development and Issues Concerning High Speed Rail (HSR). Korea Railroad Research Institute and Transport Studies Unit, University of Oxford. Working Paper No. 1020. Retrieved on 01/16/2010 from http://www.tsu.ox.ac.uk/

[99] Rede de Alta Velocidade (RAVE). 2008. The Portuguese High Speed Rail Projects: General Overview and Status of the Project. LNEC, Lisbon, Portugal. September 23.

Figure 3.6: Shrinking of Temporal Distance in the Trans-European Transport Network



Source: Rede de Alta Velocidade (RAVE). 2008. The Portuguese High Speed Rail Projects: General Overview and Status of the Project. LNEC, Lisbon, Portugal. September 23.

According to the Economic Intelligence Unit (2008), one of the mistakes made by the EU in the 1990's, when the EU was financing a number of transport links, was "the failure to link Portugal to the rest of Europe by rail. A high-speed rail link to Spain would not only facilitate Portugal's access to the Spanish market, it would also provide faster access to the rest of Europe".[100] Today, Portugal's planned HSR network is considered part of the 30 TEN-T priority projects. Specifically, these are the South-West European High-Speed Rail Line defined by the European Commission in 2004 (see Figure 3.7 for the map of the line), and the Sines/Algeciras-Madrid-Paris rail freight line. It is expected to integrate the TEN-T and is "classified of high interest by the European Parliament and Commission, reinforcing the rail interoperability in Europe".[101] The South-West European High-Speed Rail project is seen by the EU as "essential for ensuring the continuity of the trans-European railway network". The new network would serve effectively the passenger transport and also facilitate the transport of goods between Europe and the Iberian Peninsula as far as Portugal and Spain,[102] without the need to reload the trains due to gauge size differences between the networks. The need for reloading is seen as detrimental to European rail transport, especially freight.[103]

Given its importance, the HSR project in Portugal is eligible for the EU funding. The EU has provided 19% of investment for both Lisbon-Madrid and Lisbon-Porto links. The rest is to be covered through loans from the EIB, the Portuguese state and private sector.[104]

[100] The Economist Intelligence Unit (EIU). 2008. Country Profile: Portugal. London, UK.
[101] Rede de Alta Velocidade (RAVE). 2008. The Portuguese High Speed Rail Projects: General Overview and Status of the Project. LNEC, Lisbon, Portugal. September 23.
[102] Davignon, E. 2008.
[103] Ibid
[104] Nelson, J. 2008.

Figure 3.7: South-West European HSR Link (2008)

Source: Davignon, E. 2008. Priority Project No. 3: "South-West European High Speed Rail Link". Annual Activity Report of the European Coordinator. Brussels. July.

The role of European Investment Bank

The European Investment Bank (EIB) has been established in 1958 by the Treaty of Rome to serve as a long-term lending bank of the EU to finance strategically important projects. The decisions on lending at EIB are driven by primarily EU policies. One of the priority objectives of the EIB is lending for the projects of the EU TEN network. In Portugal, the EIB has signed

nearly 30 billion Euros of loans during a period of 1981-September 2008 for financing infrastructure (energy, environment, transport, telecom) investments. Of this amount 13.35 million Euros have been invested in multimodal transport projects, including road concessions, airport, etc.[105] In HSR, EIB is financing a 600 million Euro loan to the Elos consortium in the first PPP for construction of the Poceirao-Caia section. Other railway projects in Portugal currently in the EIB lending pipeline are RAVE's Lisbon-Poceirao high-speed link and REFER's Sines-Elvas conventional line:[106]

EIB can finance up to 50% of project costs only, with exception of projects on reduction of carbon emissions, which can be financed up to 75% by EIB (subject to the Credit Committee's approval). The 50% threshold has been set in order not to crowd out other sources of financing. While EIB has no specific country limits on countries, the combined amount of EIB and EU funds cannot exceed 90% of the project costs in "convergence regions"[107] and 75% in non-convergence regions. Portugal is still qualified as a convergence region, with exception of Lisbon and Setubal that are currently in a phasing out stage.[108]

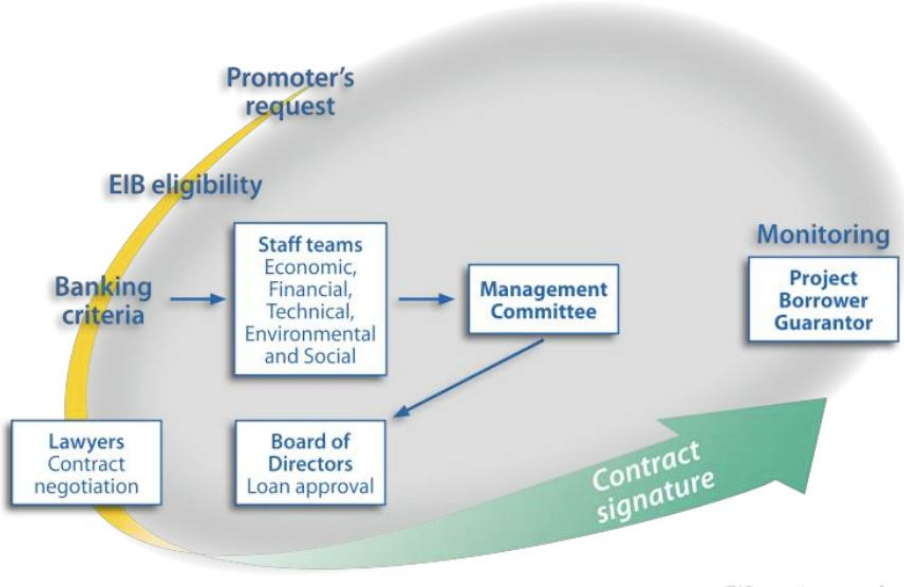
In times of current credit crunch it has been difficult for international capital markets to provide long-term maturities for competitive interest rates, so EIB was requested to fill in this liquidity gap by the Portuguese government and the consortiums bidding for the first Portuguese HSR PPP project on Poceirao-Caia section. Decisions on financial instruments for projects are made by the promoter or borrower (government in the case of Portugal), and the EIB has no preference toward PPPs or other specific financial instruments. Its participation in PPPs is "non-exclusive and non-discriminatory" and is complementary to any other commercial finance sources. Though it lends to the private sector, the EIB closely cooperates with the public sector.

The EIB financing approval follows a project cycle (Figure 3.8). The EIB conducts its own due diligence of each bidder's proposal to ensure the technical, financial, environmental, and legal aspects of the project are satisfactory and in line with EIB's guidelines and EU requirements. Credit proposals are then presented to the EIB Board of Directors for approval before any intention to participate in the financing is issued. All the technical and economic studies are conducted independently in-house by the EIB's own economists and engineers, and the results often differ from those of bidders. The assessment of economic rate of return (ERR) is a key decision factor as (or at times more important than) financial factors such as NPV and IRR of the investment. The ERR estimates have been found to differ most of the time from the bidders' estimates because of EIB's more conservative traffic forecasts. Social and economic benefits of the project play a key role in project selection, thus distinguishing EIB from other commercial investment banks.[109]

[105] European Investment Bank. 2009. Promoting European Objectives. Presentation by Alexandra Almeida, Head of the Lisbon Office. April 2.
[106] Pinto, M. 2010. EIB Support for Rail Projects. Presentation at the Portuguese High Speed Rail Workshop. Lisbon. January 28-29. Retrieved on 03/15/2010 from http://www.rave.pt/en/tabid/389/Default.aspx
[107] EU classifies the EU area into "competitive regions, regions that are phasing out from the funds and the *convergence regions* which are fully eligible for the funding".
[108] European Investment Bank. 2009.
[109] Pinto, M. 2010.

The average project cycle period starting from technical studies up to credit approval is 3-6 months depending on the size of the project, with over 6 months for more complex projects. The fees for technical analysis are paid by the borrower in the form of commission, usually 0.1-0.5% of the total loan amount.[110]

Figure 3.8: The EIB Project Cycle



Source: Pinto, M. 2010. EIB Support for Rail Projects. Presentation at the Portuguese High Speed Rail Workshop. Lisbon. January 28-29. Retrieved on 03/15/2010 from http://www.rave.pt/en/tabid/389/Default.aspx

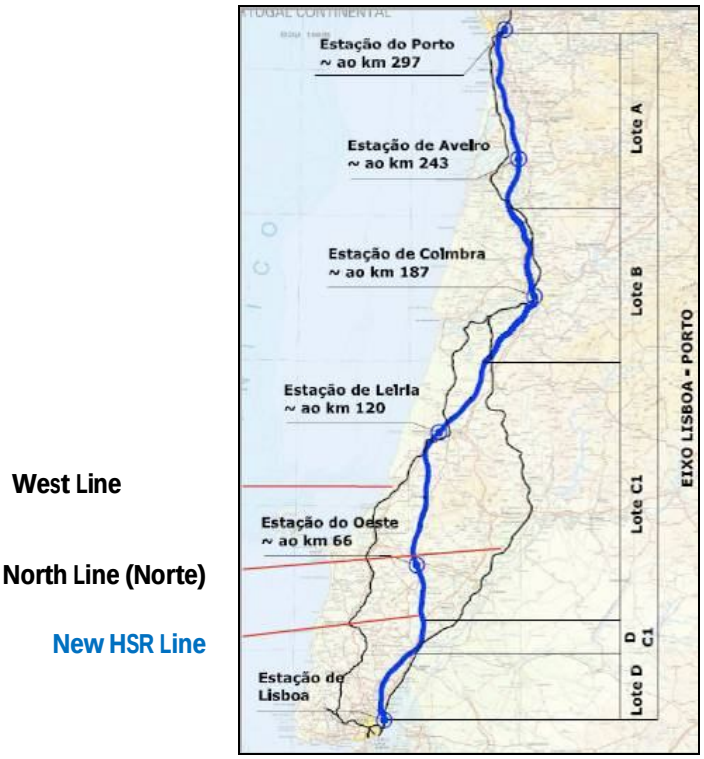
3.4 Lisbon-Porto HSR Corridor Analysis

The 297 km (185 miles) Lisbon-Porto high-speed line will be dedicated to passenger traffic with a maximum planned speed of 300 km/h (186 mi/h). It will connect the two largest cities in Portugal, Lisbon and Porto, with the journey time of 1 hour 15 minutes for non-stop service. The construction of the line was initially scheduled to launch in 2010, and planned for completion by 2015. However, the project has been delayed with potential risks of being postponed due to problems in financial markets and Portugal's budget deficits.[111] The line will serve four intermediate stations: Oeste, Leiria, Coimbra, and Aveiro (See Figure 3.9).

The Lisbon-Porto HSR link is planned to be split into 3 sub-concessions: 2 for construction and one for signaling. The total investment required for the line is estimated at 4.5 billion Euros. The two construction sub-concessions include the Pombal-Porto stretch and the Lisbon-Pombal section. Tender processes for both PPP contracts are expected to be launched in 2010.

[110] European Investment Bank. 2009.
[111] DN Economia. 2010. "Governo pára quatro estradas e reavalia linha do TGV." Article, February 2. Retrieved on 03/15/2010 from http://dn.sapo.pt/inicio/economia/interior.aspx?content_id=1484454 on 02/02/2010

Figure 3.9: Lisbon-Porto HSR Corridor Stations



Sources: Rede de Alta Velocidade (RAVE). 2009. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at European Federation of Railway Trackworks Contractors (EFRTC) General Meeting. Porto. June 5.

Corridor Design and Station Locations

Decisions on the alignment of the line and locations of central stations in Lisbon (existing rail Oriente Station) and Porto (existing rail Campanhã Station) have been already made, according to RAVE. The central stations in Lisbon and Porto will be developed for HSR services directly by REFER and RAVE, while the others are planned to be developed by the private concessionaires as part of PPP deals.

- *Oriente Station* is a modern state-of-the-art site, located about 6 km from Lisbon city center and is linked to the Parque das Nações (the former World Expo 1998 site), and adjacent to the Vasco da Gama shopping centre. It currently houses conventional rail, metro and bus terminals, and will be expanded to become the main HSR terminal in Lisbon.

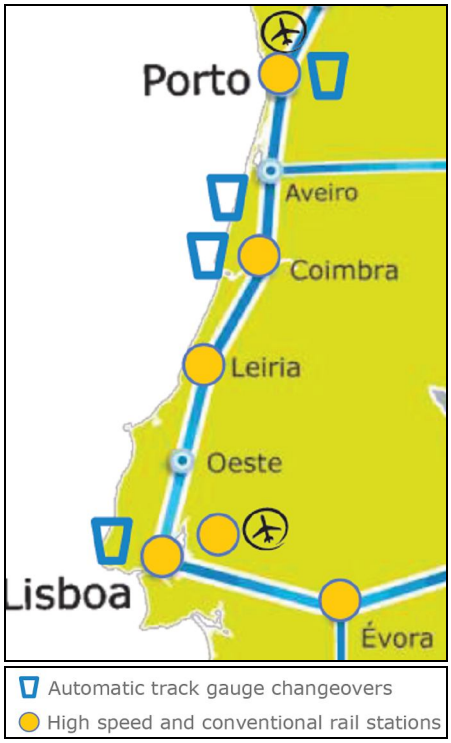
- *Campanhã Station* in Porto is located on the eastern edge of Porto about 2 km from the city center. It is currently served by conventional railways, and is planned for expansion to accommodate HSR services. The station is 3-4 minute walk away from a metro stop serving local urban and regional rail lines and buses.

At the initial stage in 2005, RAVE considered five alternatives for the Lisbon-Porto HSR corridor design. The Ministry of Transport chose to build the new line to the international

standard 1,435 mm gauge to ensure high speeds and compatibility with the EU HSR network. However, to integrate the HSR with the existing conventional rail network, which uses 1,668 mm gauge tracks, the following arrangements have been included in the design of the new HSR lines:

- The approaches to Lisbon, Leiria, Coimbra and Porto stations will be shared by both conventional and high-speed trains to ease connection and transfer between two types of services.
- Automatic track gauge changeovers will be implemented and permit the high speed and conventional trains to run on both track types.[112] Figure 3.10 shows the stations that will have these features.

Figure 3.10: Compatibility of Lisbon-Porto HSR line with Conventional Rail System



Sources: Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29

Portugal's Expectation of Benefits and Costs

Demand forecasts have estimated the total passenger traffic along the Lisbon-Porto corridor to reach 46 million trips per year in 2015, of which 7.4 million is predicted to be

[112] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

captured by the new HSR link.[113] According to the social and environmental study by Pereira, A. M. and J.M. Andraz (2007), "in the first year of operation 3.5 million of passengers will" divert from road to the high-speed trains, thus contributing to total reduction in emissions and traffic accident externalities.[114] With the HSR link, the centers of the two main metropolitan areas in Portugal, Lisbon and Porto, will be separated by less than 90 minutes. The corridor is also expected to improve the proximity between major economic, scientific, technological, and cultural centers, with total access time of less than 90 minutes from each other.[115]

The expected gains on the Lisbon-Porto corridor to be achieved by 2015 as a result of the HSR link have been determined in a demographic and socio-economic study conducted by SociNova of University Nova of Lisbon:

- the new link will allow 52% of Portugal's population to travel between and reach major urban centers with a total travel time of less than 2 hours, and 90% will enjoy this mobility and accessibility within a total of 3 hours of journey;
- the index of purchasing power parity GDP on this densely populated territory will be above the national average levels by about 20 percentage points;
- the income generated in the territory served by the line (for journeys of less than 180 minutes) is estimated to amount to about 60% of total national income;
- the distance traveled will be double the distance traveled now for the same time period.[116]

According to the report by TYCO Engenharia / Holland Railconsult (2006), the indirect benefits from the HSR connection will be created by presence of three conditions: "economies of scale", "international relocation of employment", and "market imperfections". [117] Another study by Steer Davies Gleave and VTM (2009) estimated that the Lisbon-Porto high speed link would yield an Economic IRR of 10.8%. The following conclusions are made by the latter study for year 2030:

- The benefits of the economies of scale or agglomeration are estimated at about 64 million Euros. These benefits are consistent with the theory that significant reduction of travel time between major economic centers in Portugal increases effective density.
- The benefits from the impacts on labor market are smaller than those from agglomeration. They will be derived primarily through the effects on commuting trips.
- The HSR's impact on increase of competition is derived from improvements in facilitation among companies and businesses in different cities as a result of better accessibility and reduced travel times. The value of this impact is calculated to be approximately 26.5 million Euros by 2030.[118]

[113] Ibid
[114] Rede de Alta Velocidade (RAVE). 2008. The Portuguese High Speed Rail Projects: General Overview and Status of the Project. LNEC, Lisbon, Portugal. September 23.
[115] Lourenco, N. and Santos, A. 2005.
[116] Ibid
[117] TYCO Engenharia / Holland Railconsult. 2006. Socio-Economic Cost-Benefit Analysis: High Speed Rail Lisbon-Porto. Technical Note. RAVE. June.
[118] Steer Davies Gleave/VTM. 2009.

Pre-HSR: Urban Areas on Lisbon-Porto Corridor

The Lisbon-Porto route crosses five major Portuguese districts: Lisbon, Leiria, Coimbra, Aveiro and Porto (see Figure 3.11 showing Portuguese political maps). Currently, about 70% of Portugal's population is concentrated in the areas along the Lisbon-Porto corridor. Lisbon and Porto are obviously the two largest and most developed urban centers not only on the corridor but in the whole country. The three of four intermediate nodes that will be connected to the new HSR line are Coimbra, Aveiro, and Leiria urban areas. The fourth intermediate stop, Oeste is a sub-region located in Centro region. The station in Oeste will be a regional one serving the municipalities of Rio Maior, Caldas da Rainha, Santarém and Torres Vedras. Other urban areas located along the route that are currently connected to the Alfa Pendular but will be bypassed by the new HSR are Santarem, Pombal, Vila Nova de Gaia, among others. Table 3.2 summarizes the main characteristics of each city that could potentially be affected by the new service, and maps in Figure 3.11 show the regional division of Portuguese cities.

Pre-HSR: Other Modes Serving the Corridor

Currently, the cities on the Lisbon-Porto corridor are served by three modes of land transport – road, air, and railway. Two types of rail services operate on the route: Alfa Pendular, an upgraded to high-speed line, and conventional (including Intercity and Inter-regional). Table 3.3 provides travel times by currently available modes between the cities that will be connected by HSR.

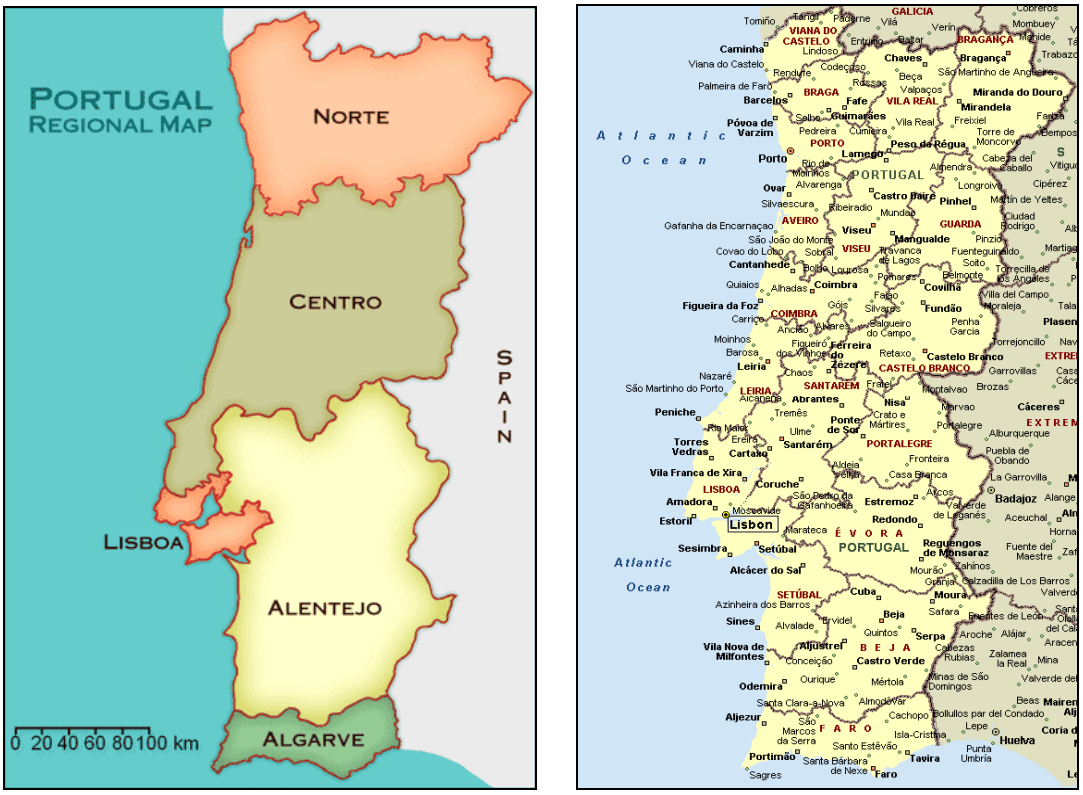
<u>Alfa Pendular HSR</u>

Alfa Pendular trains are a long distance high-speed line operated by CP since the 1990s. Its tilting technology allows the trains to run at higher speeds than conventional ones. Alfa Pendular operates on 1,668mm gauge tracks and can reach its top speed of 220 km/h (137 mi/h) only for three fourth of the journey. The total travel times between Lisbon and Porto vary between 2 hours 20 minutes to 3 hours depending on the number of intermediate stops.

Alfa Pendular trains make two stops in the Lisbon metropolitan area: one in centrally located Santa Apollonia and another in non-centrally located Gare De Oriente. Despite being centrally located, the former station is most inconvenient to access due to lack of metro connection. The latter station is served by the metro and therefore is more accessible. Both stations are within a 10 minute ride from each other on an Alfa Pendular train. The fastest service stops in main stations of Santarem, Coimbra, and Aveiro. The less frequent stops are also made in the cities of Pombal and Vila Nova de Gaia. In Porto, the train arrives at Porto Campanha station, which is not centrally located. It takes 10 more minutes of additional travel time to reach the city center. Fares vary starting from around 24 Euros to 40 Euros for a single one way ride. Service frequency from Lisbon and from Porto is 11 trains per day, with 9 trains running the fast service and 2 making all stops daily[119] (See Figures 3.12).

[119] Comboios de Portugal, Official Website. 2010. Train Timetables. Retrieved on 03/30/2010 from http://www.cp.pt/cp/

Figure 3.11: Political Map of Portugal: Regions and Districts



Source: About.com: Europe Travel. Retrieved on 04/05/2010 from http://goeurope.about.com/od/mapsofportugal/l/bl-portugal-regions-map.htm (On the Left); Google search. Retrieved on 04/05/2010 from http://www.aboutromania.com/maps164.html (On the Left)

Table 3.2: Main Urban Areas along the Lisbon-Porto Corridor

City (Station)	District	Population Size ('000)[a]	Will have HSR station	Served by Conventional Rail?	Served by Alfa Pendular?	Main Sector Focus
Lisbon	Lisbon	2,600	Yes	Yes	Yes	Services
Porto	Porto	1,400	Yes	Yes	Yes	Manufacturing
Oeste	Santarem	390	Yes	No	No	Mixed[b]
Leiria	Leiria	124	Yes	Yes	No	Services/Light Ind.
Coimbra	Coimbra	436	Yes	Yes	Yes	Research/Tourism
Aveiro	Aveiro	73	Yes	Yes	Yes	Tourism/Food Pro
Santarem	Santarem	64	No	Yes	Yes	Agriculture
Pombal	Leiria	59s	No	Yes	Yes	Services
Viva Nova de Gaia	Porto	289	No	Yes	Yes	Tourism/Services
Caldas da Rainha	Leiria	58	No	Yes	No	Services/Tourism
Torres Vedras	Lisbon	92	No	Yes	No	Agriculture

(a) Populations shown for all cities are for metropolitan areas.
(b) Oeste is a sub-region, and the station will be serving Rio Maior, Caldas da Rainha, Santarém, and Torres Vedras municipalities. The population of Oeste is given for entire sub-region.
Source: Statistics Portugal. 2009. Statistical table extracted on 02/23/2010 from http://www.ine.pt

Conventional Rail

Intercity trains run on the conventional North Rail Line (Linha do Norte) connecting Lisbon and Porto with a journey time of 3 hours 50 minutes. Inter-regional trains are also available on the route operating on two conventional railways – West Rail Line (Linha do Oeste) and Linha do Norte. However, traveling from Lisbon to Porto via the Inter-regional service requires train transfers with travel time taking up to 4-5 hours total. Lisbon-Porto Intercity trains operate at a frequency of about 7 trains departing daily from each station.[120] (See service schedule on Figure 3.12).

Road

Auto-Estrada 1 do Norte (A1), constructed between 1961 and 1991, is a principal motorway (freeway) in Portugal operated by Brisa - Auto-Estradas de Portugal, S.A. under a concession as a real toll facility. It links Porto to Lisbon, passing by Coimbra and Leiria in about 3 hours of driving. The motorway stretches for 301 km, and comprises 26 interchanges, 7 service areas and 2 rest areas in Fátima and Oiã.

Two other motorways, A8 and A15, operated by Auto-Estradas do Atlantico also serve some parts of the corridor: The A8 (Auto-Estrada do Oeste) extends south to Lisbon, and Torres Vedras, and north to Caldas da Rainha and Leiria. The A15 goes west to Santarem via Rio Maior.

Air

The two major international airports of Portugal are located on the Lisbon-Porto corridor: Lisbon Portela Airport and Francisco Sa Carneiro Airport in Porto. Portela Airport is located in the city of Lisbon and is one of the largest in Southern Europe. In 2007, 13 millions passengers and 83,000 tons of cargo traveled through the airport. The Portuguese government plans to build a new airport outside of Lisbon urban area and has selected Alcochete as its site, located 60 km (37 miles) from Lisbon. Porto's Francisco Sa Carneiro Airport is located 10 km (6 miles) northwest of the city center and connected to the metro of Porto. Air service is available for domestic flights between Porto and Lisbon, but not to any of the intermediate cities. Lisbon-Porto flight time is 50 minutes in the air, but with consideration of travel time to/from airport, boarding/de-boarding and security checks, the trip takes 2.5 hours total. Small Aerodromes in Coimbra, Leiria and Aveiro do not serve any passenger traffic.

[120] Ibid

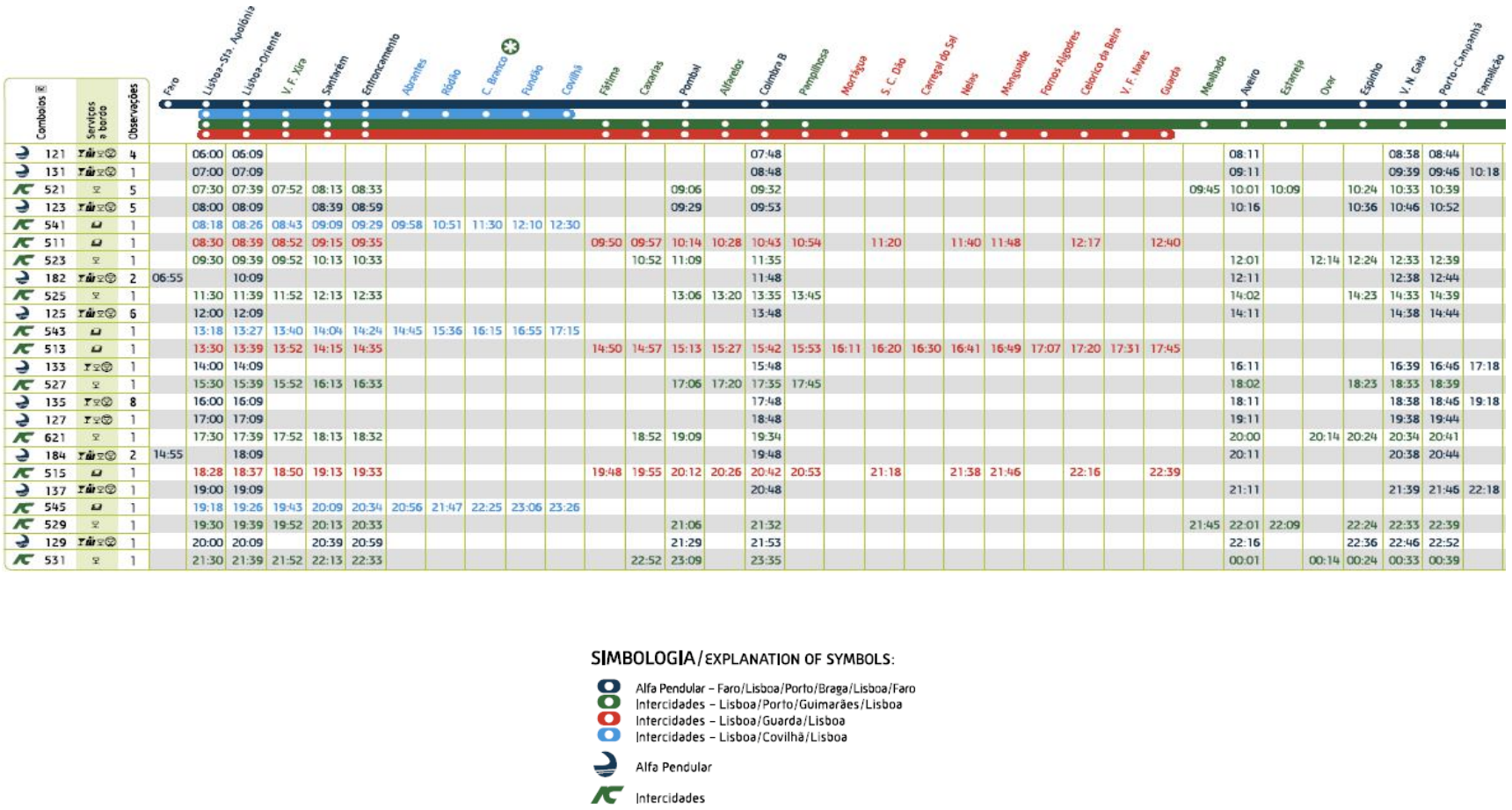
Table 3.3: Current Travel Times for O-D city pairs between Lisbon-Porto by mode (2010), before HSR

	Lisbon				Leiria[1]				Coimbra				Aveiro				Porto			
	AF	CR(IC)	Road	Air[2]	AF	CR(IC)	Road	Air[2]	AF	CR(IC)	Road	Air[2]	AF	CR(IC)	Road	Air[2]	AF	CR(IC)	Road	Air[2]
Lisbon					N/A	N/A	75	N/A	120	135	115	N/A	155	140	140	N/A	165	230	180	140
Leiria[1]	N/A	N/A	75	N/A					N/A	N/A	45	N/A	N/A	N/A	70	N/A	N/A	N/A	100	N/A
Coimbra	120	135	115	N/a	N/A	N/A	45	N/A					38	42	35	N/A	80	95	65	N/A
Aveiro	155	140	140	N/A	N/A	N/A	70	N/A	38	42	35	N/A					42	53	40	N/A
Porto	165	230	180	140	N/A	N/A	100	N/A	80	95	65	N/A	42	53	40	N/A				

Notes:
AF - Alfa Pendular Service
CR(IC) - Conventional Rail Service (Intercity trains)
[1] No direct conventional rail service is available from Lisbon to Leiria; Leiria is not connected to Alfa Pendular.
[2]Air travel times have been calculated approximately by adding to the flight time 90 minutes for travel time from/to city center to/from the airport, boarding and de-boarding pocedures; there are no flights to and between the intermediate cities.

Source: Comboios de Portugal (CP) train timetables, Google directions, Expedia travel search, and own calculations.

Figure 3.12: Alfa Pendular and Intercity Rail Service Schedules for Lisbon-Porto Route (2010)



Comboios	Serviços a bordo	Observações	Faro	Lisboa-Sta. Apolónia	Lisboa-Oriente	V. F. Xira	Santarém	Entroncamento	Abrantes	Rádio	C. Branco	Fundão	Covilhã	Fátima	Caxarias	Pombal	Alfarelos	Coimbra B	Pampilhosa	Mortágua	S. C. Dão	Carregal do Sal	Nelas	Mangualde	Formos Algodres	Celorico da Beira	V. F. Nunes	Guarda	Meadinha	Aveiro	Esgueira	Ovar	Espinho	V. N. Gaia	Porto-Campanhã	Famalicão
121		4		06:00	06:09													07:48												08:11				08:38	08:44	
131		1		07:00	07:09													08:48												09:11				09:39	09:46	10:18
521		5		07:30	07:39	07:52	08:13	08:33								09:06		09:32										09:45	10:01	10:09		10:24	10:33	10:39	
123		5		08:00	08:09		08:39	08:59								09:29		09:53											10:16			10:36	10:46	10:52	
541		1		08:18	08:26	08:43	09:09	09:29	09:58	10:51	11:30	12:10	12:30																							
511		1		08:30	08:39	08:52	09:15	09:35						09:50	09:57	10:14	10:28	10:43	10:54		11:20		11:40	11:48		12:17		12:40								
523		1		09:30	09:39	09:52	10:13	10:33							10:52	11:09		11:35												12:01		12:14	12:24	12:33	12:39	
182		2	06:55		10:09													11:48												12:11				12:38	12:44	
525		1		11:30	11:39	11:52	12:13	12:33								13:06	13:20	13:35	13:45											14:02			14:23	14:33	14:39	
125		6		12:00	12:09													13:48												14:11				14:38	14:44	
543		1		13:18	13:27	13:40	14:04	14:24	14:45	15:36	16:15	16:55	17:15																							
513		1		13:30	13:39	13:52	14:15	14:35						14:50	14:57	15:13	15:27	15:42	15:53	16:11	16:20	16:30	16:41	16:49	17:07	17:20	17:31	17:45								
133		1		14:00	14:09													15:48												16:11				16:39	16:46	17:18
527		1		15:30	15:39	15:52	16:13	16:33								17:06	17:20	17:35	17:45											18:02			18:23	18:33	18:39	
135		8		16:00	16:09													17:48												18:11				18:38	18:46	19:18
127		1		17:00	17:09													18:48												19:11				19:38	19:44	
621		1		17:30	17:39	17:52	18:13	18:32							18:52	19:09		19:34												20:00		20:14	20:24	20:34	20:41	
184		2	14:55		18:09													19:48												20:11				20:38	20:44	
515		1		18:28	18:37	18:50	19:13	19:33						19:48	19:55	20:12	20:26	20:42	20:53		21:18		21:38	21:46		22:16		22:39								
137		1		19:00	19:09													20:48												21:11				21:39	21:46	22:18
545		1		19:18	19:26	19:43	20:09	20:34	20:56	21:47	22:25	23:06	23:26																							
529		1		19:30	19:39	19:52	20:13	20:33								21:06		21:32											21:45	22:01	22:09		22:24	22:33	22:39	
129		1		20:00	20:09		20:39	20:59								21:29		21:53												22:16			22:36	22:46	22:52	
531		1		21:30	21:39	21:52	22:13	22:33							22:52	23:09		23:35												00:01		00:14	00:24	00:33	00:39	

SIMBOLOGIA / EXPLANATION OF SYMBOLS:

- Alfa Pendular – Faro/Lisboa/Porto/Braga/Lisboa/Faro
- Intercidades – Lisboa/Porto/Guimarães/Lisboa
- Intercidades – Lisboa/Guarda/Lisboa
- Intercidades – Lisboa/Covilhã/Lisboa
- Alfa Pendular
- Intercidades

Source: Comboios de Portugal, Official Website. 2010. Train Timetables. Retrieved on 03/30/2010 from http://www.cp.pt/cp/

Mode Shares and Travel Pattern

Current mode share along the Lisbon –Porto route is dominated by road transportation, mostly private vehicles (Figure 3.13). The market share of air mode is the smallest for Lisbon-Porto origin-destination city pair accounting for 13.7% only (Table 3.4). While, both the private car and conventional rail appear to be almost equally preferred choice modes for traveling between Lisbon and Porto (39% and 31.6% respectively), this preference gap increases significantly in favor of cars for trips between the termini points (Lisbon or Porto) and intermediate urban areas. This indicates the trend that for shorter distances, driving remains most preferred. Moreover, as can be seen in Figure 3.13, the trips originating in the cities located between Lisbon and Porto are all road based. Some small share of rail mode travel is observed in Aveiro and Coimbra, and none in Leiria, which can be explained by very limited intercity rail service and no Alfa Pendular line connection to Leiria.

Table 3.4: Modal Split on Lisbon-Porto Route, before HSR

Pair	Private Car	Coach	C. Railway	Plane
Lisbon-Porto	39.1	15.5	31.6	13.7
Lisbon-Leiria	82.7	12.0	5.3	0.0
Lisbon-Coimbra	65.6	16.7	17.7	0.0
Porto-Aveiro	89.4	0.0	10.6	0.0
Porto-Coimbra	64.8	15.7	19.5	0.0

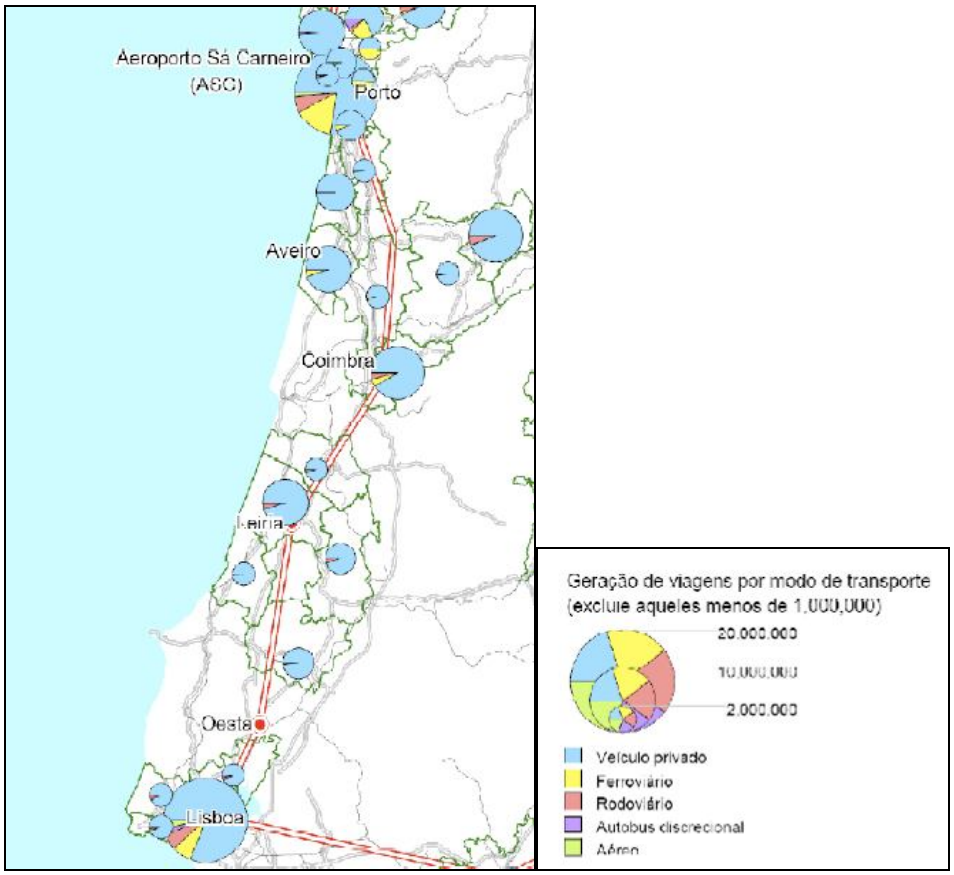
Table 3.5: Mode Share by Trip Purpose, before HSR

Journey reason	Private Car	Coach	C. Railway	Plane
Business	42.0	5.0	33.0	87.0
Commuting/private	27.0	45.0	25.0	3.0
Leisure/holiday	31.0	50.0	42.0	10.0

Source: Carballo-Cruz, F. 2007. High speed rail in Portugal. Presentation at Transport Studies Unit Seminar,?" University of Oxford. Oxford, UK. September 24. Retrieved on 04/01/2010 from http://www.tsu.ox.ac.uk/events/seminar070924

The travel patterns and mode choices differ by trip purpose. 87% of air passengers are business travelers, attesting to the presence of business links between Porto and Lisbon. Only 42% of private vehicle users, 33% of rail passengers and 5% of coach bus riders travel for business. Majority of coach bus and rail users are leisure travelers, which is not surprising. Commuters seem to be mainly choosing to travel by bus, which could indicate to the fact that their zone of daily activity is narrow and limited to the "temporal distance" of a bus ride.

Figure 3.13: Trips generated by mode on Lisbon-Porto Corridor (2003)



Source: Steer Davies Gleave/VTM. 2009. Análise Custo – Benefício da Ligação em Alta Velocidade Ferroviária da Ligação Lisboa – Porto. Relatorio Final. RAVE. March.

3.5 Summary

Portugal has launched the implementation of its first new HSR line in 2009-2010 with the award of a PPP contract for construction of the Phase 1 on Lisbon-Madrid axis (165 km/103 mile Poceirao-Caia stretch). The decisions on alignment and stations for the Lisbon-Porto and Porto-Vigo links have been made. The entire project is planned to be financed under PPP scheme. The Portuguese network is one of the links as part of the EU TEN-T and therefore eligible for EU grants and EIB loan money. However, considerable state support is still required for the projects to proceed. Recent budgetary challenges faced by the Portuguese economy may delay the implementation of the rest of the network. Nevertheless, Portugal and the EU seem firm in their decisions, as of time of this writing.

The 297 km (185 mile) Lisbon-Porto link will be passenger dedicated high-speed line that will connect the country's two largest cities with journey time of 1 hour 15 minutes (non-stop). The line will also serve four densely populated urban areas along the route. Despite well-developed and extensive inter-city railway network serving the corridor, most of the mode share

is dominated by road modes such as private vehicles and some coach buses. The state's expectations from the new link are high and motivated primarily by capacity limitations on the existing conventional network that limit railway's competitiveness and market share. On the national level, Portugal envisions the link to connect country's main urban centers with each other and with the cities in Spain. On the European level, the line is expected to integrate Portugal with the European rail network and ensure cross-border interoperability of Portuguese trains.

* * *

We continue further with case studies of HSR corridor in three countries – Japan, France and Germany – to inform our analysis of HSR in Portugal, which then follows. The next chapter presents the first case study on Japan's Shinkansen system, focusing on the impacts of the Tokyo-Osaka Shinkansen line on megalopolis formation and economic development of urban areas along the corridor.

4 Japan: Shinkansen System

Japan was the first country to build a high-speed rail line in the world. Its first Shinkansen bullet train connecting the 515 km (320 miles) distance between Tokyo and Osaka in 2 hours and 25 minutes was launched on October 1, 1964. Today, Japan remains one of the leaders in HSR technology with the total Shinkansen network of 2,452 km (1,524 miles) connecting major metropolitan areas and carrying over 300 million passengers per year at top speed of 300 km/h (186 mi/h).[121] Having had the longest history with HSR, Japan provides a valuable example of the long-term development impacts of HSR services on urban areas. This chapter describes the overall experience of the Japanese Shinkansen and the impacts of the Tokyo-Osaka high speed link on megalopolis formation and economic development of the cities.

4.1 Country Background

Japan is a chain of islands in East Asia located between the North Pacific Ocean and the Sea of Japan, and comprised of four major islands – Hokkaido, Honshu, Shikoku, and Kyushu– and 6,848 adjacent smaller islands. The tenth largest population in the world, Japan has a total population of 127 million (as of 2009), projected to decline over the next decades. One of the major economic powers, the Japanese economy is the second largest in the world, after the U.S., with total nominal GDP of $5 trillion and third after the United States and China in terms of total purchasing power parity (PPP).[122] While the country's economy is mostly based on private enterprise, the power of the central government remains very strong coming from numerous "required licenses, permits and approvals that tightly regulate business activity and by informal, virtually compulsory, administrative guidance".[123] Japan's capital is Tokyo Metropolis with a 13 million population (35 million in the Greater Tokyo Area) [124]; other major urban centers are Yokohama, Osaka, Nagoya, Sapporo, Kobe, Kyoto, Fukuoka, Kawasaki, and Hiroshima.

Japan has a parliamentary government with a constitutional monarchy, and is administratively divided into 47 prefectures, each overseen by an elected governor, legislature and administrative bureaucracy. The Emperor is Head of State, although his functions are limited and purely symbolic. The bi-cameral Diet (Parliament), comprised of the House of Representatives (Shugiin) and the House of Councillors (Sangiin), is the legislative body of the state. Executive power is exercised by the Cabinet of 18 ministers headed by the prime minister, who also can appoint and dismiss the Ministers. The prime minister is Head of Government elected by a majority parliamentary vote. The Cabinet of Ministers represents the highest level of national decision-making in the areas of financial services, economic and fiscal policy, regulatory reforms, and science and technology. Prefectures and municipal governments are

[121] Central Japan Railway Company.2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf
[122] Central Intelligence Agency. 2010. World Factbook. Retrieved on 02/20/2010 from https://www.cia.gov/
[123] The Economist Intelligence Unit (EIU). 2009. Country Commerce: Japan. Released July. New York, NY, USA.
[124] Tokyo Metropolitan Government Official Website. Retrieved on 05/10/2010 from http://www.metro.tokyo.jp/

financially dependent on the central government and heavily influenced by the Cabinet's decisions.[125]

Japan has one of the world's most developed transportation systems (Figure 4.1) with 26,435 km of railways, 1,203,777 km of roads, 1,770 km of waterways, 128 major ports, and 176 airports.[126] Due to densely populated areas and limited amount of usable land, Japan lags behind in road construction but is advanced in mass transportation development.[127] Japan's subway and rail systems are extensive and efficient. In 2007, the number of passengers traveling by rail totaled 22.84 billion trips, and the volume of goods transported by rail reached 50.9 million tons.[128] Japan's largest port is Nagoya Port. Ferry services provide connections between major and other small islands.[129] The four largest airports are Haneda Airport and Narita International Airport in Tokyo area, Kansai International Airport in Osaka area, and Chubu Centrair International Airport in Nagoya.

The country's passenger transport is dominated by rail and road modes, while nearly all freight is carried by road and water modes. In 2007, the market shares 61.5% of domestic passenger travel was carried by road, 18.7% by rail, and 6.2% by both air and water transport modes. In the same year, only 4.2% of freight was transported by both rail and air.[130]

Japanese Railway Sector

The first conventional rail line in Japan was built between Tokyo and Yokohama in 1872. The Japanese National Railways (JNR), established in 1949, was a fully integrated state-owned entity that was the sole passenger rail operator in Japan. At the time, 80% of Japan's railways were under the JNR and remaining 20% were under the jurisdiction of regional, local and urban railway companies outside of the national government system.[131]

After the initial success of the first high-speed rail line between Tokyo and Osaka opened in 1964, the central government decided to extend the HSR network and enacted the National Shinkansen Railway Development Act in 1970. The Act created a national rail master plan that laid out the vision and goals for the rail system development, including the increase of competitiveness of passenger railway services with air. The master plan has guided Japan's railway expansion ever since.[132]

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[125] The Economist Intelligence Unit (EIU). 2009. Country Commerce: Japan. Released July. New York, NY, USA.
[126] Central Intelligence Agency (CIA). 2010.
[127] The Economist Intelligence Unit (EIU). 2008. Country Profile: Japan. London, UK.
[128] Central Japan Railway Company. 2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf
[129] Wikipedia, Retrieved on 03/20/2010 from http://en.wikipedia.org/wiki/Transport_in_Japan
[130] Japan, Ministry of Internal Affairs and Communications, Statistics Bureau. 2009. Statistical Handbook of Japan 2009. Retrieved on 03/20/2010 from http://www.stat.go.jp/english/data/handbook/pdf/c09cont.pdf
[131] Iwamura, N. 2007. A lean Enterprise Approach for Developing High Speed Rail in Japan and Portugal. S.M. Thesis, Transportation Program, Massachusetts Institute of Technology. Cambridge, MA.
[132] Matsumoto, H. 2007. Shinkansen (Bullet Train) System in Japan. Testimony from Hearing of the House Railroads, Pipelines and Hazardous Materials Subcommittee. April 19. Retrieved on 05/11/2010 from http://republicans.transportation.house.gov/Media/File/Testimony/Rail/4-19-07-Matsumoto.pdf

Figure 4.1: Map of Transport Networks in Japan

Source: The Economist Intelligence Unit. 2010. Country Report: Japan. March. London, UK.

In 1987 JNR went bankrupt due to the large accumulated deficit. The government decided to undertake major reforms and privatize the corporation.[133] Upon the reforms, the JNR was split into six private intercity passenger rail operators based on six distinct geographic regions, as well as one freight operator:

- three fully privatized mainland operators include Central Japan Railway Company (JR Central), East Japan Railway Company (JR East) and West Japan Railway Company (JR West), who operate both HSR and conventional rail lines;
- three operators on the islands are Hokkaido Railway Company (JR Hokkaido), Shikoku Railway Company (JR Shikoku), and Kyushu Railway Company (JR Kyushu).

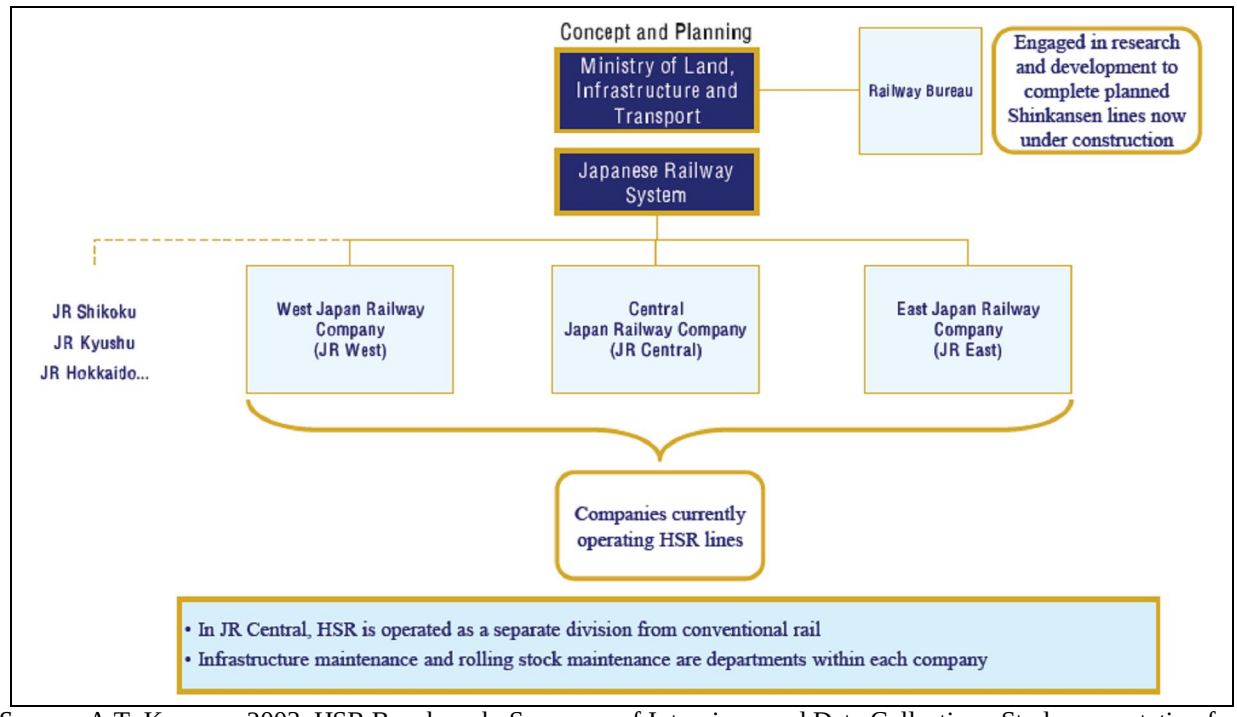
In addition to JR Companies, railway operating organizations also include the local government, private railway companies ("mintetsu"), and companies established between the local government and private companies ("the third sector").[134]

Nowadays, the construction and ownership of the railways in Japan are under the jurisdiction of the independent administrative agency – Japan Railway Construction, Transport and Technology Agency (JRTT). High-speed rail lines built after the 1987 reforms are owned by the JRTT and are leased to the JR companies. HSR lines constructed before 1987 and the conventional lines are owned and operated by the respective JR companies. In 1991, JR East purchased the HSR lines from Tokyo to Niigata and from Tokyo to Morioka; JR Central purchased Tokyo-Osaka HSR line; and JR West purchased the Osaka-Hakata HSR link.[135] (Figure 4.2 shows the institutional structure of the Japanese railway system and Figure 4.3 shows areas of operation by each company.)

The Ministry of Land, Infrastructure and Transport is responsible for strategy development and planning of the railway network in Japan on behalf of the central government. Before the 1987 reform, the funding for the construction of rail lines in Japan was provided through debt incurred by the national government and the Japan National Railways. After the reforms the national government has funded two-thirds and local governments have funded one-third of the construction cost under the Nationwide Shinkansen Railway Development Act.[136] So, in Japan, where the rail sector is mostly privatized, the national government still invests directly in construction of the new high-speed lines because of the lack of sufficient private-sector support.[137] However, “the national government does not provide operational subsidies for HSR passenger operations”.[138]

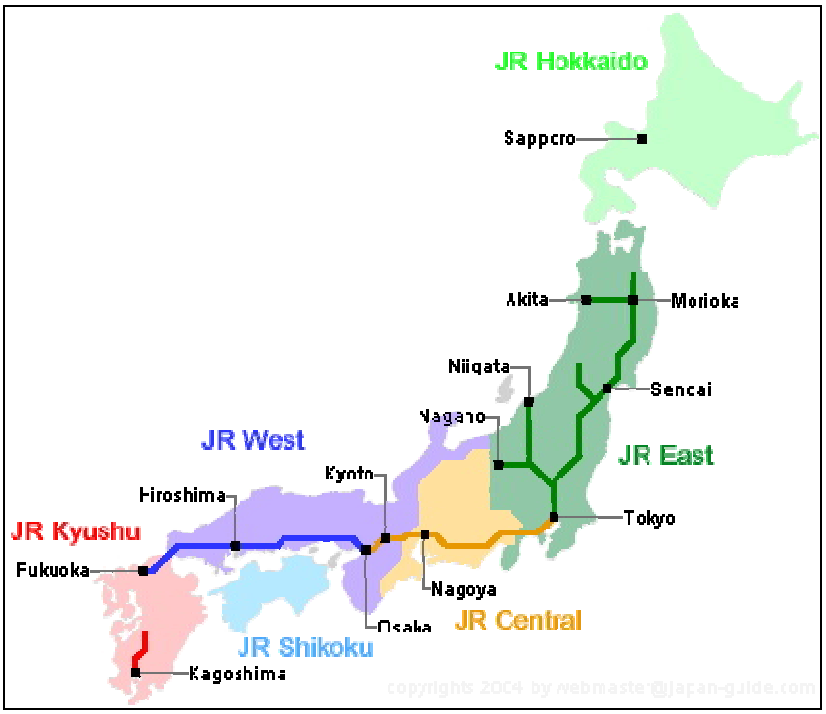
[133] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.
[134] Ibid
[135] United States Government Accountability Office. 2009. High Speed Passenger Rail: Future Development will Depend on Addressing Financial and Other Challenges and Establishing a Clear Federal Role. Report to Congressional Requesters. GAO-09-317. March.
[136] Ibid
[137] Ibid
[138] Ibid, p. 86.

Figure 4.2: Institutional Structure of National Railway System in Japan



Source: A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

Figure 4.3: Map of Shinkansen Network by Company of Operation



Source: Japan-Guide (web). Retrieved on March 25, 2010 from http://www.japan-guide.com/e/e2018.html

4.2 Development of the Shinkansen System

Japan was the first country in the world to build a dedicated line for new high-speed trains, originally starting at speed of 210 km/h (130 mi/h) and reaching 300 km/h (186 mi/h) today. Its first HSR line connecting Tokyo with Osaka (also called Tokaido Shinkansen) was opened in 1964. Japan's high-speed lines are known as Shinkansen, literally translated as "New Trunk Line". The high-speed trains are also called Shinkansen, or sometimes "bullet trains" because of their shape and speed.[139] There are three classes of Shinkansen trains distinguished: Nozomi (speed of hope), Hikari (speed of light), and Kodama (speed of sound).[140] The Shinkansen links the most populous urban centers. In 2003, Japan reached a world record of 581 km/h (361 mi/h) with the test runs of Maglev trains.

The Shinkansen system is managed and operated by four JR Companies: JR East, JR Central, JR West, and JR Kyushu. JR East is the largest passenger railway company in the world, operating a five-route Shinkansen network between Tokyo and major cities in eastern Honshu (mainland). The core of JR Central's operations is the Tokaido Shinkansen linking Tokyo, Nagoya and Osaka. JR West operates the Sanyo Shinkansen, linking Shin-Osaka and Hakata. JR Kyushu operates the Shinkansen line between Kagoshima and Shin Yatsushiro (Figure 4.3).

Decision-Making Process and Motives

The construction of the HSR in Japan was an initiative of the central government. The plans to construct the first Shinkansen HSR line from Tokyo to Osaka date back to the 1940s. With the onset of World War II, the country had to postpone its plans until the 1950s.[141] In 1954, the Japanese National Railway company set up a team to launch a Shinkansen feasibility study. The motivation for the decision was primarily to increase capacity of the Tokaido rail corridor – one of the most densely used corridors in the world at the time – and to achieve major improvements in journey times in order to compete with air. The narrow gauge (3 feet 6 inches) of the original conventional rail lines made it technologically difficult to upgrade the tracks to high speeds, requiring "more effective solutions like HSR".[142] This led to the approval of the construction of a new high-speed line at standard gauge. After the success of the first line, the government made a decision to expand the Shinkansen lines to other highly populated corridors.

The expansion of the HSR system was guided by the National Rail Development Master Plan enacted in 1970. [143] The law required "the creation of a Development Plan for the

[139] Peterman, D., Frittelli, J. and Mallett, W. 2009. High-Speed Rail (HSR) in the Unites States. Congressional Research Service (CRS). Report for Congress. December 8

[140] Shin, D. 2005. Recent Experience of and Prospects for High-Speed Rail in Korea: Implications of a Transport System and Regional Development from a Global Perspective. Working Paper 2005-02. Institute of Urban and Regional Development, University of California, Berkeley.

[141] Petkova, B. 2007. Strategic Planning for rail System Design: An Application for Portuguese High Speed Rail. Master's Thesis, Industrial Engineering and Management, University of Groningen. Groningen, Netherlands.

[142] Ono, H. 1998. The Role of High-Speed Rail in Regional Development. S.M. Thesis, Transportation Program, Massachusetts Institute of Technology. Cambridge, MA.

[143] United States Government Accountability Office. 2009.

Shinkansen Network". The expansion has been since carried out according to this Plan.[144] In addition to increasing the capacity, the decision-making for the expansion was also based on "wider economic considerations such as regional development and equality," leading to the development of Shinkansen line on progressively less busy and profitable routes.[145] Now, in Japan, the Shinkansen is seen as "a spine on which urban and regional development is supported".[146]

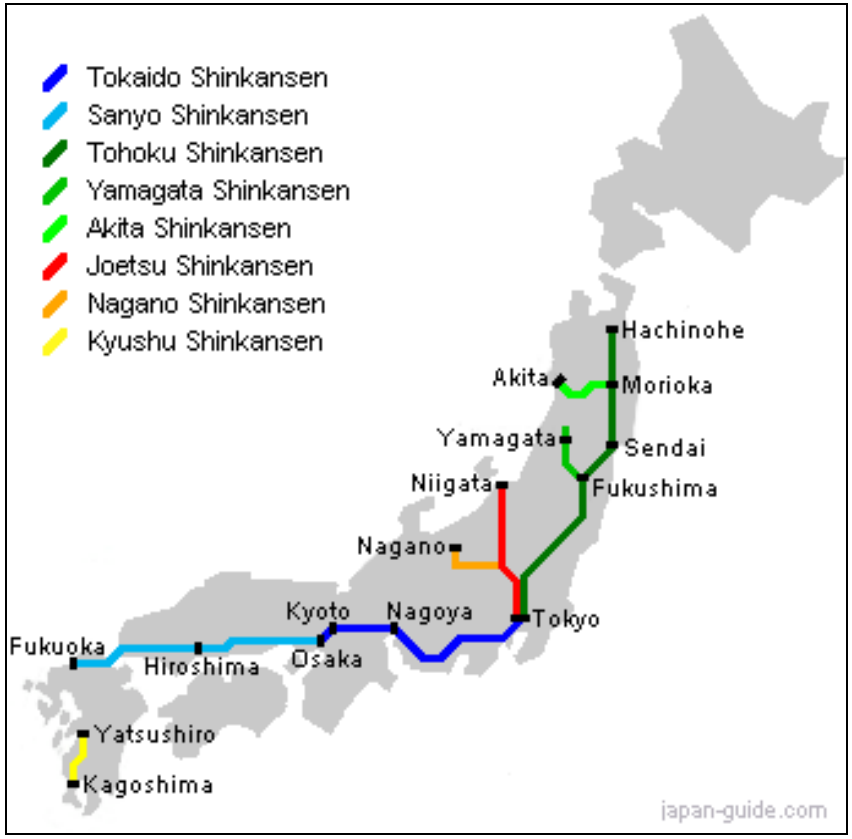
Deployment of the Shinkansen Network

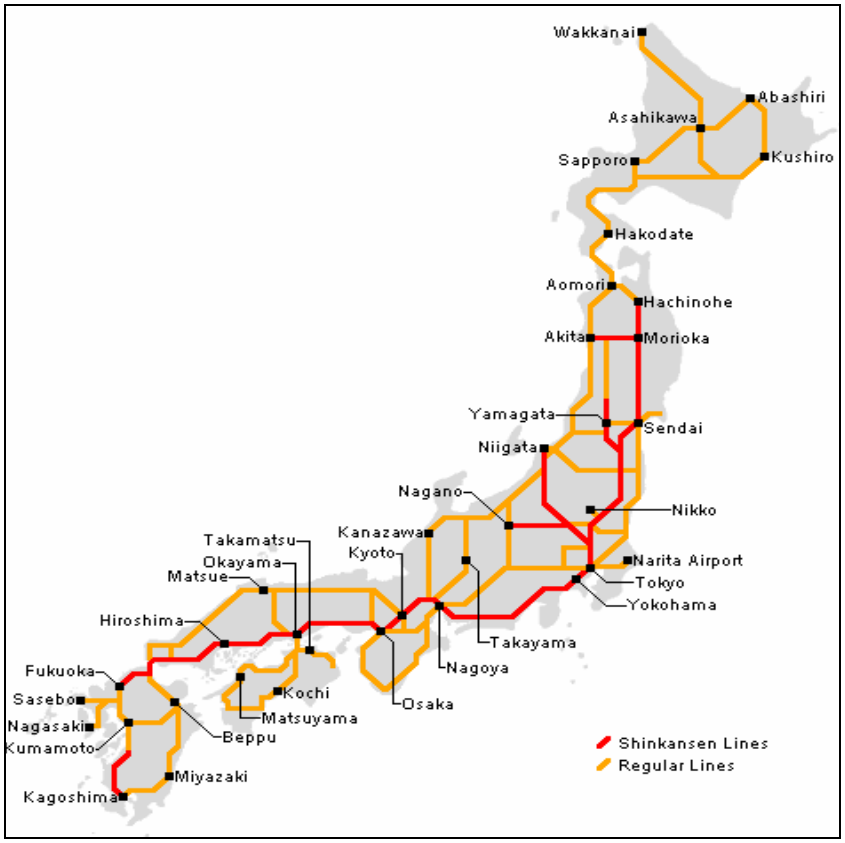
On October 1, 1964, Japan Railways started the operations on the first 515 km (320 miles) long Tokaido Shinkansen line between Tokyo and Shin-Osaka stations with 60 trains per day, just in time for the Tokyo Summer Olympics. The service was an immediate success, carrying 23 million passengers in its first year and leading to demands for its extension countrywide.[147] In 1972, Sanyo Shinkansen line was constructed as an extension of Tokaido Shinkansen from Shin-Osaka station to Okayama. The new service increased the total number of passengers to 500 million. Since then, the Japanese government continued to build high-speed lines throughout the nation until the reforms of 1987. These included the next section on Sanyo Shinkansen line between Okayama and Hakata launched in 1975; and two high-speed lines – Tohoku Shinkansen and Joetsu Shinkansen – completed in 1982. Already by 1976, the total number of passengers carried since the opening of the first line reached 1 billion.[148]

Following the 1987 reforms, "extension of high-speed lines has continued, in part supported by government efforts to stimulate the economy with infrastructure spending during the economic slowdown of the 1990s". [149] The following HSR lines were built after 1987: Nagano (Hokuriku) Shinkansen between Tagasaki and Nagano in 1997, and Kyushu Shinkansen connecting Kagoshima and Shin-Yatsushiro in 2004 (Table 4.1). Today, Japan's Shinkansen system has an extensive network of about 2, 459 km (1,528 miles)[150] and continues to expand. See Figure 4.4 for Shinkansen routes network map (on the left) and Shinkansen network with conventional rail lines (on the right).

[144] Matsumoto, H. 2007.
[145] Nash, C. 2008. High Speed Rail Investment: an overview of the literature. Institute of Transport Studies, University of Leeds. Leeds, UK.
[146] ARUP – TMG. 2001. East Coast Very High Speed Train Scoping Study. Phase 1 – Preliminary Study. Final Report. November. Sydney, Australia.
[147] Shin, D. 2005.
[148] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.
[149] Peterman, D., Frittelli, J. and Mallett, W. 2009.
[150] Lee, Y. S. 2007. A Study of the Development and Issues Concerning High Speed Rail (HSR). Transport Studies Unit, Oxford University Center for the Environment. Working Paper No. 1020. Retrieved on 02/08/2010 from http://www.tsu.ox.ac.uk/pubs/1020-lee.pdf

Figure 4.4: Maps of Shinkansen Network Routes (left) and Shinkansen with Regular Conventional Rail Routes (right)





Source: Japan-Guide (web). Retrieved on March 25, 2010 from http://www.japan-guide.com/e/e2019.html

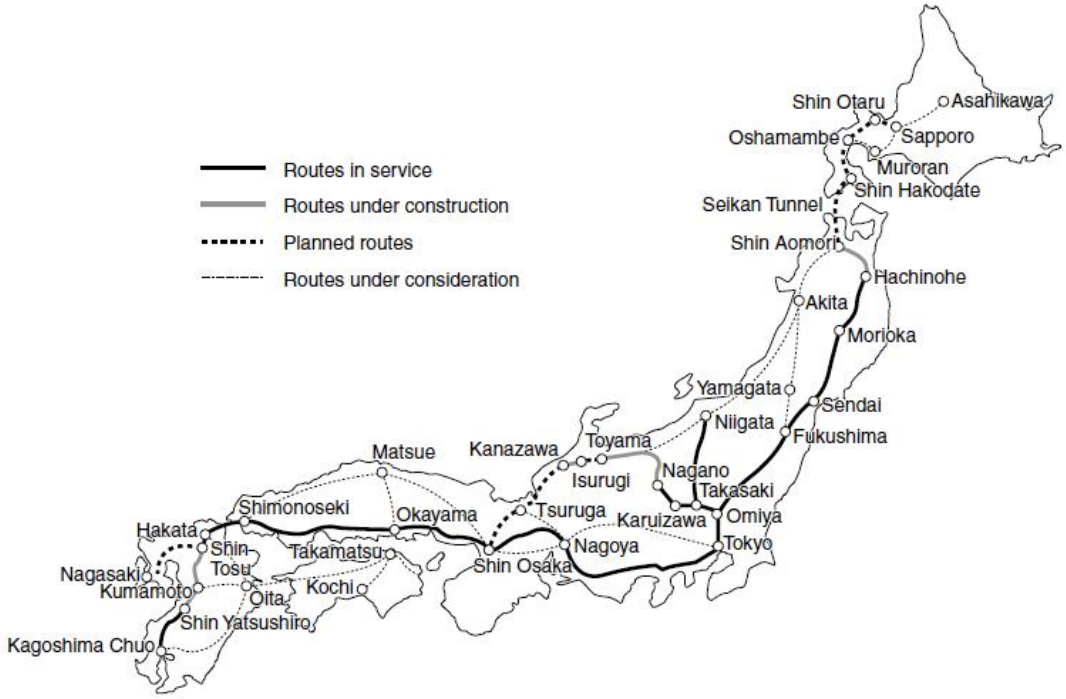
Source: Kent Travel International, Retrieved on 03/20/2010 from http://www3.telus.net/Kent_Travel/jrpass.htm

The following proposed lines are currently under construction and/or development:

- Tohoku Shinkansen extension of 81.2 km (50 miles) from Hachinohe Station to Shin-Aomori to open in 2011;
- Hokuriku Shinkansen extension of 228 km (143 miles) from Nagano to Kanazawa to be completed in 2015;
- Kyushu Shinkansen 130 km (81 miles) section from Yatsushiro to Hakata to open by 2011;
- Kyushu Shinkansen 118 km (73 miles) branch from Shin-Tosu to Nagasaki (Nagasaki Route), construction started in 2008;
- Hokkaido Shinkansen 149 km (93 miles) extension from Shin-Aomori to Shin-Hakodate to be completed in 2016.
- Extension of the Hokkaido line from Shin-Hakodate to Sapporo is under development;
- Extension of Hokoriku line from Kanazawa to Shink-Osaka is in planning stage.[151][152]

A long-term plan for the Tokyo-Nagoya-Osaka corridor is development of a Maglev link, which would reduce current travel times of 2.5 hours to about 1h.[153] The JR Central announced an approximate target date for completion in 2025. See Figure 4.5 for a map of planned lines.

Figure 4.5: Planned Shinkansen Lines (2005)



Source: Kitagawa, T. 2005. Extending the Shinkansen Network. *Japan Transport & Railway Review,* 40. March**.**

[151] Kitagawa, T. 2005. Extending the Shinkansen Network. *Japan Transport & Railway Review,* 40. March.
[152] Matsumoto, H. 2007.
[153] BSL Management Consultants GmbH & Co. KG. 2008. Maglev or High Speed Rail in the Las Vegas to Southern California Corridor. Southern California Logistics Rail Authority. Hamburg, Germany. November.

Table 4.1: The Main Shinkansen Lines Deployed

Line	Start Points	End Points	Length (km/miles)	Operator	Year Opened	Annual # Passengers ('000)
Tokaido Shinkansen	Tokyo	Shin-Osaka	515/320	JR Central	1964	151,320
Sanyo Shinkansen	Shin-Osaka	Hakata	554/344	JR West	1972	63,432
Tohoku Shinkansen	Tokyo	Hachinohe	593/369	JR East	1982	84,833
Joetsu Shinkansen	Omiya	Niigata	270/168		1982	38,294
Nagano Shinkansen (Hokuriku)	Takasaki	Nagano	117/73		1997	10,135
Kyushu Shinkansen Kagoshima Route	Shin-Yatsushiro	Kagoshima-Chuo	127/79	JR Kyushu	2004	4,184

Source: Matsumoto, H. 2007. Shinkansen (Bullet Train) System in Japan. Testimony from Hearing of the House Railroads, Pipelines and Hazardous Materials Subcommittee. April 19. Retrieved on 05/11/2010 from http://republicans.transportation.house.gov/Media/File/Testimony/Rail/4-19-07-Matsumoto.pdf; and Wikipedia. Retrieved on 03/20/2010 from http://en.wikipedia.org/wiki/Shinkansen#cite_note-9

The first Shinkansen line, built in a Tokyo-Osaka corridor well-suited to rail travel, was aimed to expand capacity on an overcrowded rail corridor. From its inception, the line earned enough revenue to cover its operating costs. It also earned enough money to pay back its construction costs. None of the lines built after the 1987 privatization have been reported to produce enough ticket revenue to fully cover their construction costs.[154] The extension of the lines since 1987 was supported by the government as part of the stimulus efforts during the 1990's economic downturn.[155]

The deployment of the entire Shinkansen system has been guided by the National Shinkansen Master Plan adopted in 1970's. The strategic rational of the Japanese Government for HSR deployment included the following two priorities: "to reduce energy consumption and to lessen Japan's dependence on imported oil; and to create new development centers to reduce pressures on large cities by provision of a high capacity fast train for long distance work commuting."[156]

The distinct feature that can be found only in the Japanese HSR system is that high-speed trains never share tracks with conventional trains. Japan has adopted "the *exclusive exploitation model*" for the deployment of HSR lines, "characterized by a complete separation between high speed and conventional services, each one with its own infrastructure". The main reason for choosing this model was "the fact that the existing conventional lines (built in narrow gauge, 1,067 mm) had reached their capacity limits" and building new separate lines allowed implementing the international standard gauge size of 1,435 mm (4 feet 8.5 inch).[157] According to Campos et al. (2007), "one of the major advantages of this (exclusive exploitation) model is that market organization of both HSR and conventional services are fully independent." Alabate

[154] United States Government Accountability Office. 2009. p. 32
[155] Peterman, D., Frittelli, J. and Mallett, W. 2009. p. 8.
[156] ARUP – TMG. 2001.
[157] Campos, J., de Rus, G., and Barron, I. 2007. A review of HSR experiences around the world. Foundation BBVA. Munich Personal RePEC Archive (MPRA). Paper No. 12397. Retrieved on 02/08/2010 from http://mpra.ub.uni-muenchen.de/12397/

et al (2010) mention that "separation from the conventional rail service allowed HSTs to avoid problems derived from the conventional service and its ageing infrastructure."[158] Therefore, there is no compatibility between the HSR and the conventional rail network in Japan.

In addition, Japan built the high-speed lines dedicated to passengers only instead of mixed use because the large "passenger demand and maintenance needs, carried out mainly at night, favored passenger orientation".[159] Thus, all HSR lines in Japan are dedicated to passenger transportation and no freight trains are allowed to run on the routes.[160]

The structure of the Japanese HSR network stretches from north to south along the islands following the linearly located large metropolitan areas. Such structure results in linearly generated traffic demand and thus provides a suitable market for the railway industry. [161] The Shinkansen network has been completed on almost all densely populated corridors in Japan and the focus is now moving on expansion of the Shinkansen network to less dense and less economically thriving regions.[162] While the private sector now plays an integral part in managing and operating the Shinkansen system, the Government still closely controls its planning and development under the National Shinkansen Development Law.[163]

4.3 Tokyo-Osaka (Tokaido) Shinkansen Corridor

The high-speed line between Tokyo and Shin-Osaka (or Tokaido Shinkansen) is a 515.4 km (320 miles) long high-speed line linking Japan's principal metropolitan areas of Tokyo, Nagoya, Kyoto and Osaka. The line runs in parallel to the conventional Tokaido Main Line. After the opening in October 1964, the Hikari high-speed trains Tokyo and Osaka at maximum speed of 210 km/h (130 mi/h) with travel time of nearly 4 hours. The travel time was reduced to 2 hours 30 minutes in 1992 with the introduction of Nozomi service running at 270 km/h (168 mi/h), and further to 2 hours and 25 minutes in 2007.[164] The long-term plan for the corridor is construction of a Maglev link, which would reduce the current travel time to about one hour (planned for 2025 if the project is financed).[165]

The double track Tokaido Shinkansen route has been operated by JR Central (Figure 4.6) since the JNR reforms of 1987. The line is the core of JR Central's operations.[166] It was constructed by former public corporation JNR between 1959 and 1964 at a cost (excluding land costs) of 400 billion yen[167] ($0.92 billion in nominal $US).[168] The financing was provided by the

[158] Alabate, D. and Bel, G. 2010. High-Speed Rail: Lessons for Policy Makers from Experiences Abroad. Research Institute of Applied Economics. Working Paper 2010/03. Universitat de Barcelona. Barcelona, Spain.
[159] Ibid
[160] Ono, H. 1998.
[161] Central Japan Railway Company. 2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf
[162] Ono, H. 1998.
[163] ARUP – TMG. 2001.
[164] Central Japan Railway Company, Official Website. About. Retrieved on 03/25/2010 from http://english.jr-central.co.jp/about/outline.html
[165] BSL Management Consultants GmbH & Co. KG. 2008.
[166] Central Japan Railway Company. 2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf
[167] Kasai, Y. 2000. A History of Development of Japanese Railway Networks. *Japan and the World Economy*, 12, pp.

Figure 4.6: Tokaido Shinkansen and Conventional Lines Operated by JR Central

Source: Central Japan Railway Company. Annual Report 2009. Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2009.pdf

Japanese Government, through bonds issuance and an $80 million loan from the World Bank.[169] The loans were expected to be returned from the passenger fare revenues. The Tokyo-Osaka line became profitable three years after the initiation of its operation. By 1971, the entire initial investment was recovered.

The route was the first newly built dedicated rail line for passenger high speed travel. Its opening was timed to coincide with the 1964 Summer Olympics in Tokyo, which had brought international attention to the country.

Intermediate Stations and Shinkansen Frequency

The service on Tokaido Shinkansen has maintained its reliability (with an average delay of 0.6 minutes). In 1964, the high-speed trains started operating between Tokyo and Shin-Osaka train stations at a frequency of 60 trains/day or 2 trains/hour from Tokyo. Now, the service frequency is total of 323 trains per day for all types of services.[170] From Tokyo to Shin-Osaka, there are 13 trains departing per hour on any given business day[171] (Table 4.2).

89-93.

[168] Alabate, D. and Bel, G. 2010.

[169] Wikipedia. Shinkansen. Retrieved on 02/02/2010 from http://en.wikipedia.org/wiki/Shinkansen

[170] Central Japan Railway Company Official Website. About – Train Diagrams. Retrieved on 03/20/2010 from http://english.jr-central.co.jp/about/_pdf/about_train_diagrams.pdf

[171] United States Government Accountability Office. 2009.

Table 4.2: Evolution of Train Travel Time and Frequencies of Tokyo-Osaka Shinkansen Services (1964-2009)

	1964	2009
Travel time (fastest option)	4 hours	2 hour 25 minutes
Trains/hour from Tokyo (all trains)	2	13 (peak hours)
Trains/day (all trains)	60	323
Ridership/day (total passengers)	61,000	409,000

Note: Data for 2009 is as of April 2009.
Source: Central Japan Railway Company, Official Website. About. - Train Diagrams. Retrieved on 03/20/2010 from http://english.jr-central.co.jp/about/_pdf/about_train_diagrams.pdf

Figure 4.7: Tokyo-Osaka Shinkansen Route with all intermediate stations (2009)

Source: Wikipedia. Tokaido-Shinkansen. Retrieved on 03/25/2010 from http://en.wikipedia.org/wiki/File:Tokaido-Shinkansen.png

There are total of 15 intermediate stations on the Tokyo-Osaka Shinkansen corridor, and one in each origin and destination points in Tokyo and Osaka[172] (Figure 4.7). In 1964, the line served 12 stations only, three of which were built new: Shin-Osaka in Osaka, Shin-Yokohama in Yokohama and Gifu-Hashima in Gifu. All the new stations were built in the peripheries of the cities and were connected to HSR lines only. The remaining stations were existing conventional rail stations located in the city centers.[173]

Shin-Osaka station in Osaka is located about 3 km from the older Osaka Station. The decision was made to build a new station for the Shinkansen in Osaka, instead of using the old existing station, due to the engineering difficulties of running Shinkansen trains into the city

[172] Central Japan Railway Company Official Website. About. Retrieved on 03/20/2010 from http://english.jr-central.co.jp/about/outline.html
[173] Sands, B. 1993. The development effects of high-speed rail stations and implications for California. Working paper No. 566. University of California, Institute of Urban & Regional Development, Berkeley. April.

center of Osaka. The transit rail lines provide convenient connections between Shin-Osaka and other stations around the city center.

Currently, the three types of trains operate on the Tokaido Shinkansen route – Nozomi, Hikari, and Kodama – with varying speeds and varying patterns of intermediate stops. Nozomi is the fastest service running at the speed of up to 300 km/h (186 mi/h) with fewest intermediate stops, serving major cities only, and frequency of 9 trains per hour (Table 4.3). Hikari trains stop at more stations than Nozomi; and Kodama serves all 15 intermediate stations along the route[174] (See Figures 4.8). All Tokaido Shinkansen trains to and from Tokyo make station stops at Shinagawa and Shin-Yokohama.

The following four intermediate stations are located in major urban centers between Tokyo and Osaka and are served by all train types: Shinagawa, Shin-Yokohama, Nagoya, and Kyoto stations. The remaining stations served by the Shinkansen corridor are illustrated in Figure 4.8.

- *Shinagawa Station*, known as the southern gateway to Tokyo, is the first major station after Tokyo Station on the Tokaido Shinkansen route and is a major interchange for trains operated by JR East, JR Central and Keikyu.

- *Shin-Yokohama Station* is a station in Yokohama city, the capital of Kanagawa Prefecture. In addition to the Shinkansen line, it is served by regional and Municipal Subway lines. The Nissan Stadium, the largest stadium in Japan, and the Yokohama Arena are located within a 10-minute walk from the station.[175]

- *Nagoya Station* is a train station in Nagoya, Aichi Prefecture. It is the world's largest train station by floor area (446,000 m²) and houses the headquarters of the Central Japan Railway Company (JR Central). An average of 1,140,000 people uses the station daily during 2005, making it the sixth busiest station in Japan. The station is adjacent to Meitetsu Nagoya Station, the terminal of the Nagoya Railroad, and Kintetsu Nagoya Station, the terminal of the Kintetsu Nagoya Line. It is also connected to three conventional rail lines operated by JR Central and two Nagoya Municipal subway lines.[176]

- *Kyoto Station* is the most important transportation hub in Kyoto. It is Japan's second-largest train station building (after Nagoya Station) and is one of the country's largest buildings, incorporating a shopping mall, hotel, movie theater, department store, and several local government facilities within one 15-story building. The station is served by JR West and JR Central operated rail lines and two transit rail connections.[177]

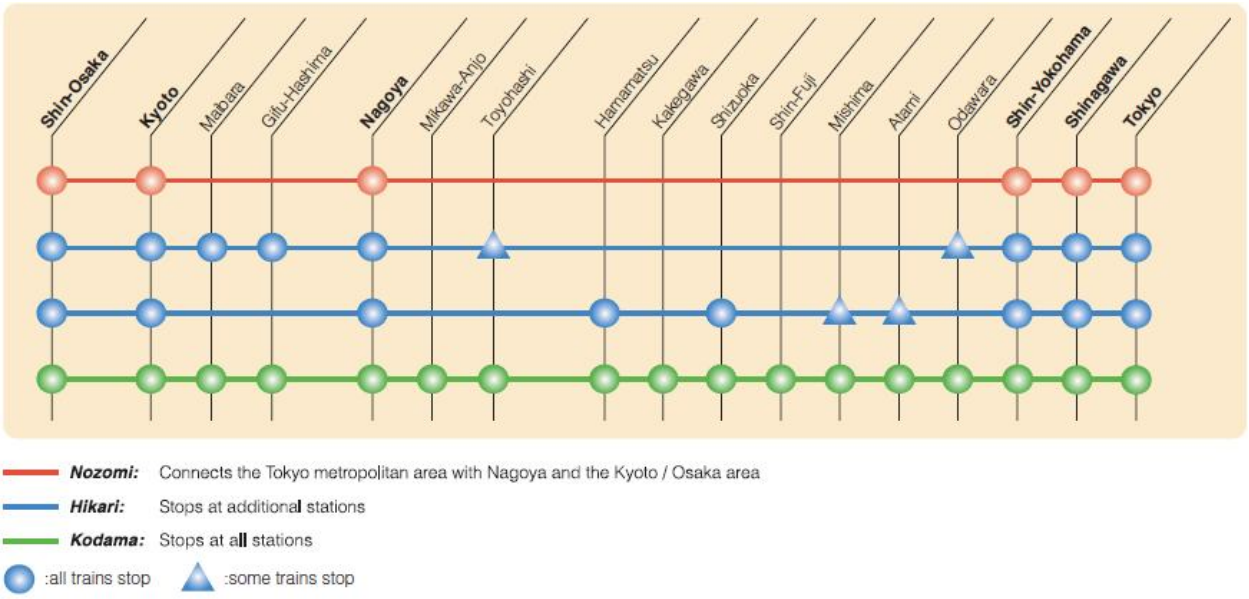
[174] Central Japan Railway Company. Annual Report 2009. Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2009.pdf
[175] Wikipedia. Shin-Yokohama. Retrieved on 03/25/2010 from http://en.wikipedia.org/wiki/Shin-Yokohama_Station
[176] Wikipedia. Nagoya. Retrieved on 03/25/2010 from http://en.wikipedia.org/wiki/Nagoya_Station
[177] Wikipedia. Kyoto. Retrieved on 03/25/2010 from http://en.wikipedia.org/wiki/Kyoto_Station

Table 4.3: Tokyo-Osaka Shinkansen Travel Time and Frequencies: listed by Train Type (2009)

	Travel time	On-way Fare	Frequency	# Intermediate Stops
Nozomi	2 hours 25 min	¥14,050	173 trains/day	4
Hikari	3 hours	¥13,750	66 trains/day	8
Kodama	4 hours	¥13,750	84 trains/day	15

Source: Central Japan Railway Company. 2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf;
Central Japan Railway Company. Annual Report 2009. Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2009.pdf

Figure 4.8: Stopping Patterns of Tokyo-Osaka Shinkansen by Train Type (2009)



Source: Central Japan Railway Company. 2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf

Before the Shinkansen: decision-making

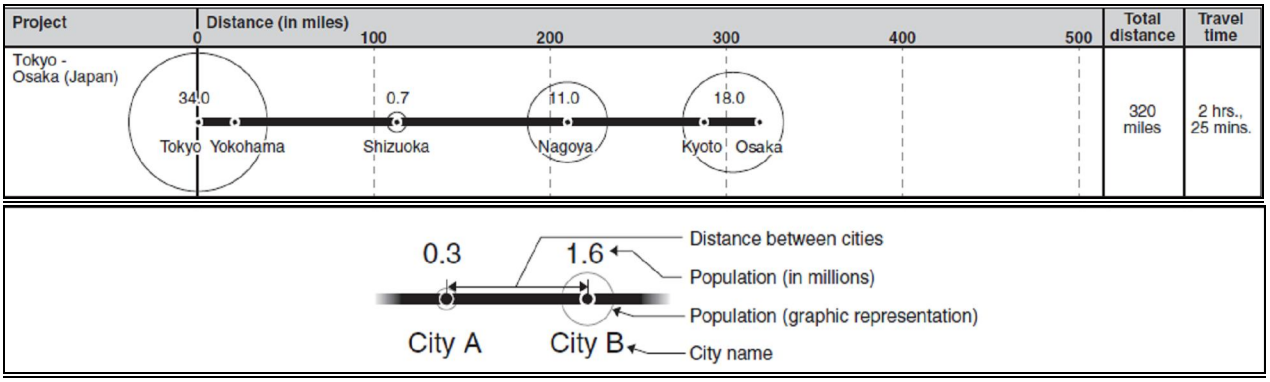
Before the construction of the new Shinkansen line between Tokyo and Osaka, the objective pursued by the early route planners was to reduce the travel time for the 515 km distance between Tokyo and Osaka to three hours. The main policy objective was to promote mobility demand in the corridor due to the rapid economic growth experienced after World War II. The decisions at the high-level emphasized the importance of connecting not only Tokyo and Osaka, but several highly populated areas along a corridor and serve several travel markets,

including commuters and inter-city travelers. A key factor was also the potential for a high number of riders.[178]

Cities along the Corridor

Besides Tokyo and Osaka, the Shinkansen links three other major cities of Japan – Yokohama, Nagoya, and Kyoto. The graphic illustration of population sizes compared across the major cities on the corridor is presented in Figure 4.9.

Figure 4.9: Population of Major Urban Areas along Tokyo-Osaka HSR Line



Source: United States Government Accountability Office. 2009. High Speed Passenger Rail: Future Development will Depend on Addressing Financial and Other Challenges and Establishing a Clear Federal Role. Report to Congressional Requesters. GAO-09-317. March, p. 13.

Tokyo

Tokyo, officially known as Tokyo Metropolis, is the capital and largest city in Japan. It is a metropolitan prefecture comprising administrative entities of special wards and municipalities. Located on the eastern side of the main island Honshu, the population of Tokyo Metropolis is 13 million people. The Greater Tokyo Area, consisting of Chiba, Kanagawa, Saitama and Tokyo prefectures, has a total population of 35 million people and is the largest metropolitan economy in the world by GDP. Central Tokyo area consists of 23 "special wards" that were part of Tokyo City but in 1943 were separated into self-governing municipalities and each given the status of a city. The population of just the Central Tokyo area is 8.5 million people.[179]

Along with New York and London, Tokyo is one of three world financial centers housing Japan's largest stock exchange. It holds 47 of top 500 global companies, which is the highest in the world. The headquarters of several world's largest investment banks and insurance companies are based in Tokyo. It is also Japan's hub for transportation, publishing and

[178] United States Government Accountability Office. 2009.
[179] Tokyo Metropolitan Government, Official Website. Retrieved on 05/10/2010 from http://www.metro.tokyo.jp/

broadcasting industries as well as center for education. According to the Mercer and Economist Intelligence Unit surveys, Tokyo was ranked as the most expensive city to live in the world. [180]

Tokyo is Japan's largest domestic and international hub for rail, expressway, and air transportation, with the two busiest airports in Japan – Haneda Airport (formerly knows as Tokyo International) and Narita International Airports.

Osaka

With a population of 2.5 million, Osaka is Japan's third largest by population size and second most important city. Its nighttime population is 2.5 million, the third in the country, but in daytime the population surges to 3.7 million, second only after Tokyo. It has been the economic powerhouse of the Kansai region for many centuries. It is the capital city of Osaka Prefecture and the heart of one of the largest metropolitan areas in the world with nearly 20 million people. According to the Mercer study, Osaka is the second most expensive city worldwide after Tokyo.[181]

MasterCard Worldwide reported that Osaka ranks 19th among the world's leading cities and plays an important role in the global economy.[182] Historically the commercial capital of Japan, Osaka functions as one of the pulse centers for the Japanese economy. Many major companies in Osaka have moved their main offices to Tokyo; however, several are still headquartered in Osaka, including Panasonic, Sharp, and Sanyo. Osaka is also known for its food and has been often referred to as the "nation's kitchen".[183]

Osaka is served by two airports (Kansai and Osaka International), sea port of Osaka, and international ferry connections to Taiwan, China and Korea, as well as extensive network of conventional, commuter and high-speed rail lines. Two main train stations are Shin-Osaka, built in 1964 to connect to Shinkansen line, and Osaka Station, opened in 1874. Osaka station was one of first railway stations in the Kansai region when the railway between Osaka and Kobe started operating on the conventional Tokaido Main Line. Today, Osaka Station is served by the JR West commuter rail lines and is not connected to the Shinkansen.

Nagoya

Nagoya is the third-largest incorporated city and the fourth most populous urban area in Japan with 2.2 million inhabitants as of 2009. Located on the Pacific coast in the Chubu region on central Honshu, it is the capital of Aichi Prefecture and is one of Japan's major ports. It is also the center of Japan's third largest metropolitan region, known as the Chukyo Metropolitan Area, with population of 8 million people.[184] Nagoya is also the center of Greater Nagoya which had generated nearly 70% of Japan's trade surplus in 2003.

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[180] Mercer. 2009. Worldwide Cost of Living survey 2009 – City ranking. Retrieved on 03/20/2010 from http://www.mercer.com/costoflivingpr#Top_50

[181] Ibid

[182] MasterCard Worldwide. 2008. Worldwide Centers of Commerce Index. Retrieved on 03/20/2010 from http://www.mastercard.com/us/company/en/insights/pdfs/2008/MCWW_WCoC-Report_2008.pdf

[183] Wikipedia. Osaka. Retrieved on 03/25/2010 from http://en.wikipedia.org/wiki/Osaka#cite_note-27

[184] Japan, Ministry of Internal Affairs and Communications, Statistics Bureau. 2009. Population of Japan: Final Report of the 2000 Population Census. Retrieved on 03/20/2010 from

Nagoya and it suburbs are Japan's center for automotive industry, with presence of major Japanese automakers such as Toyota and Mitsubishi Motors and automotive suppliers such as DENSO, Aisin Seiki, Toyota Industries, JTEKT or Toyota Boshoku, Magna International and others. JR Central has its headquarters in Nagoya. Other companies based in the city are in a wide range of industries such as ceramics, machinery manufacturing, production of railway rolling stock including the Shinkansen bullet trains, and production of ice machines and refrigeration equipment. There is also a sizable aerospace, machine tool, materials engineering and electronics industry in the area. Robot technology is another rapidly developing industry in Nagoya.

Nagoya is served by Chubu Centrair International Airport built on the artificial island off shore of Tokoname and by Nagoya Airfield (Komaki Airport, NKM) near the city boundary with Komaki and Kasugai. Nagoya Train Station, the world's largest train station by floor area, is on the Tokaido Shinkansen, Tokaido Main Line, and Chuo Main Line. The Nagoya Railroad and Kintetsu provide regional rail service to points in the Tokai and Kansai regions. The city is also serviced by the Nagoya Subway. Nagoya Port is the largest port by international trade value in Japan. Toyota Motor Corporation uses Nagoya Port for export of their products. [185]

Kyoto

Kyoto, located in the central part of the island of Honshu, has a population of 1.5 million people. Formerly the imperial capital of Japan, it is now the capital of Kyoto Prefecture, and a major part of the Osaka-Kobe-Kyoto metropolitan area.[186] Kyoto is known as the IT and electronics industry center and a popular tourist attraction. Home to 37 institutions of higher education, Kyoto is one of the academic centers of the country.

Many IT company headquarters such as Nintendo, Intelligent Systems, and many others are based in the city. Other key industries in the city area are traditional Japanese crafts run by artisans, kimono manufacturing and sake brewing. Other businesses headquartered in Kyoto include the apparel company Wacoal, the delivery transportation company Sagawa Express and the garage kits maker Volks. In addition, tourism forms a large base of Kyoto's economy. The city's cultural heritages are constantly visited by school groups from across Japan, and many foreign tourists also stop in Kyoto. About 20% of Japan's National Treasures and 14% of Important Cultural Properties exist in the city. In 2007, the city was chosen as the second most attractive city in Japan, in a regional brand survey. [187]

Kyoto Station is the center for transportation in the city. Although Kyoto does not have its own airport, travelers can get to the city via Kansai International Airport and Itami Airport in Osaka Prefecture. The Haruka Express rail service operated by JR West carries passengers from Kansai Airport to Kyoto Station in 73 minutes.

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http://www.stat.go.jp/English/data/kokusei/2000/final/hyodai.htm

[185] Wikipedia. Nagoya. Retrieved on 03/25/2010 from http://en.wikipedia.org/wiki/Nagoya,_Aichi

[186] Wikipedia. Kyoto. Retrieved on 03/25/2010 from http://en.wikipedia.org/wiki/Kyoto

[187] Kyoto City Web. Retrieved o 03/20/2010 from http://www.city.kyoto.jp/koho/eng/databox/sister.html

Yokohama

Yokohama situated on Tokyo Bay, south of city of Tokyo, in the Kanto region of the main island of Honshu, is a part of the Greater Tokyo Area. Yokohama's population of 3.6 million and density of 8,335/km^2 make it Japan's largest incorporated city and second largest city by population in Japan after Tokyo. Since 1965, the city's population has doubled. Yokohama is also a prominent port city of Japan. [188] The city houses the Nissan Stadium, the largest stadium in Japan with a capacity of 72,327 seats, which hosted the 2002 FIFA World Cup final match. The city also features Yokohama Arena and the Shin-Yokohama Raumen Museum.[189] The city has a strong economic base, especially in the shipping, biotechnology, and semiconductor industries. Nissan has announced to move its headquarters to Yokohama city from Chuo, Tokyo in 2010.

In addition to the Shinkansen HSR stopping at Shin-Yokohama Station, Yokohama is also served by conventional rail lines stopping at Yokohama Train Station, with two million passengers daily.[190] The Shinkansen does not pass through Yokohama Station.

Other Cities

Other smaller cities connected by Hikari and Kodama services are listed in Table 4.4 with respective population size and densities.

Table 4.4: Smaller Cities Served by Hikari and Kodama Trains along Tokyo-Osaka Corridor

City	Population (people)	Density (persons/km^2)	Serving Shinkansen Trains
Odawara	198,466	1,740	Some Hikari, all Kodama
Atami	39,755	645	Some Hikari, all Kodama
Mishima	112,078	1,800	Some Hikari, all Kodama
Shizuoka	717,515	508	All Hikari, all Kodama
Hamamatsu	813,369	538	All Hikari, all Kodama
Toyohashi	383,691	1,468	Some Hikari, all Kodama
Gifu	422,061	2,086	All Hikari, all Kodama
Maibara	42,154	223	All Hikari, all Kodama
Anjo	42,154	2,050	All Kodama
Kakegawa	117,858	444	All Kodama
Fuji	254,113	1,040	All Kodama

[188] City of Yokohama Official Website. Retrieved on 03/20/2010 from http://www.city.yokohama.jp/en/
[189] Wikipedia. Shin-Yokohama Station. http://en.wikipedia.org/wiki/Shin-Yokohama_Station
[190] City of Yokohama Official Website. Retrieved on 03/20/2010 from http://www.city.yokohama.jp/en/

Other Modes along the Corridor

Before the Shinkansen

Before 1964, the route between Tokyo and Osaka was served by the local limited express trains called Kodama,[191] which were first introduced on the conventional Tokaido rail line in 1958. This was the first train service of the Japanese National Railways classified as a "limited express", the fastest of train types on the national railway system at that time. The train connected the Tokyo Station with Osaka Station in 6 hours 50 minutes and for the first time allowed the passengers to make a round trip between the two cities in one day. The original conventional Tokaido rail line was narrow gauge 1,067 mm(3 feet 6 inches) and unsuitable for high speeds. It was also operating at capacity.

Similar to French city pairs, the competition from air services between Tokyo and Osaka was increasing fiercely. The flight times for the routes Tokyo-Nagoya and Tokyo-Osaka were 1 hour 20 minutes and 1 hour 10 minutes respectively. The existing rail service with its fastest express trains could not compete with travel time offered by air even if times for travel to/from airport, boarding and de-boarding were accounted for. Therefore, the pressures for increasing the rail speeds were high.

There is no information about what the conditions of the road network were along the Tokyo-Osaka route before 1964. However, considering the distances, the road trips were most likely made from/to Tokyo to/from closer cities, while the distance between Tokyo and Osaka was primarily flown. Assuming the current travel times between the cities by road they would be comparable to those by pre-Shinkansen rail times (see Table 4.5).

After the Shinkansen

The conversion to high-speed rail from other transport modes was much greater for trip lengths below 800 km (497 miles). Consequently, the air service between Tokyo and Nagoya was greatly reduced.[192] Overall, many air routes lost significant market shares to high-speed rail.[193] The rail timings for the trip fell from 6 hours 50 minutes via the limited express Kodama trains on conventional line to 4 hours in 1964 and then further to 2hours 30 minutes in 1992 via the new Tokaido Shinkansen route. Tokaido HSR had succeeded in capturing total of 81% of the air/rail market share from commercial aviation service between Tokyo and Osaka. [194]

Traffic volumes on Tokaido HSR line have been increasing annually, reaching 151 million passengers in 2009.[195] The Japanese Shinkansen is estimated to have diverted 50% of its traffic from existing rail services and 50% from air (mostly), road and induced demand.[196] Demand

[191] Central Japan Railway Company Official Website. About. Retrieved on 03/20/2010 from http://english.jr-central.co.jp/about/highspeed.html
[192] Shin, D. 2005.
[193] United States Government Accountability Office. 2009.
[194] Central Japan Railway Company. 2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf
[195] Ibid
[196] ARUP – TMG. 2001.

forecasts proved to be underestimated. The passengers-km traveled had risen from 11 billion in 1965 to 35 billion ten years later.[197]

Currently, there are also 12 conventional rail lines serving the areas around Nagoya and Shizuoka, and operated also by the JR Central. These lines complement and form a common network with the Tokaido Shinkansen line.[198] The conventional Tokaido Main Line is the busiest along the corridor, and its various sections are operated by different JR companies. Today, there are no conventional passenger trains that operate over the entire length of the line from Tokyo to Osaka (other than certain overnight services). Hence, all intercity trips require several transfers along the way, except Tokyo-Yokohama and Osaka-Kyoto connections (short distance).

According to Japanese government officials, to drive between Tokyo and Osaka – a distance of approximately 512 km (318 miles) by automobile – can cost almost $200 each way, including over $90 in tolls, and between $70 and $105 in fuel costs, depending on the fuel efficiency of the car. This cost compares with a high-speed rail fare of about $130 per passenger. Japan is also covered by a dense highway bus network. Every prefecture and larger city is served by at least one bus company, operating lines to other parts of the country. On major routes, such as the Tokyo - Nagoya - Kyoto - Osaka route, fierce competition has resulted in very low fares.[199]

Unlike in France and Germany, Japanese Shinkansen is not compatible with conventional lines and does not share its tracks with the conventional trains. This is explained mainly due to the gauge size differences between the two networks. Moreover, the high-speed rail in Japan does not connect to any of the airports.[200] Transit and conventional rail lines are interconnected at the stations/nodes with the Shinkansen line allowing easy transfers from one system to another.

Table 4.5 demonstrates comparison of travel times between the major cities along the Tokyo-Osaka corridor by mode.

[197] Alabate, D. and Bel, G. 2010.
[198] Central Japan Railway Company. 2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf
[199] Japan-Guide (web). Retrieved on March 25, 2010 from http://www.japan-guide.com/e/e2019.html.
[200] United States Government Accountability Office. 2009.

Table 4.5: Travel times for city pairs by mode (in minutes) (2010)

	Tokyo				Yokohama[5]				Nagoya				Kyoto[4]				Osaka			
	Rail[1]	Road	Air[2]	Shinkansen	Rail[1]	Road	Air[2]	Shinkansen	Rail[1]	Road	Air[2]	Shinkansen	Rail[1]	Road	Air[2]	Shinkansen	Rail[1]	Road	Air[2]	Shinkansen
Tokyo					25	55	N/A	20	360	285	170	105	540	375	230	140	410	405	160	145-155
Yokohama[5]	25	55	N/A	20					N/A	285	N/A	**85**	N/A	360	N/A	**120**	N/A	395	N/A	130
Nagoya	360	285	155	105	N/A	288	N/A	85					135	120	N/A	**35**	165	150	N/A[3]	**50**
Kyoto[4]	540	375	230	140	N/A	360	N/A	120	135	120	N/A	**35**					40	60	N/A	**15**
Osaka	410	405	160	145-155	N/A	395	N/A	130	165	150	N/A[3]	**50**	40	60	N/A	**15**				

Notes:
-Travel times by Conventional Rail and Shinkansen are estimated averages for the fastest train services with highest frequency and minimum stops.
-The travel times for all modes are from/to the respective Shinkansen stations located in the city centers.
-N/A interprets as "no direct/no connection service provided" for convetional rail and "no airport" exists in the city.
- There are no aorport in Kyoto and Yokohama.

[1]Rail is for conventional rail services. The conventional rail has no direct services between the cities, except between Tokyo-Yokohama and Kyoto-Osaka; all other travel times shown for Rail include multiple transfers.

[2]Air travel times have been calculated approximately by adding to the flight time 90 minutes for travel time from/to city center to/from the airport, boarding and de-boarding pocedures; flights originated in Paris are from Charles de Gaulle (CDG) airport.

[3] There are no flights between Osaka and Nagoya.

[4] The travel time for Kyoto is based on flights from Tokyo to one of the airports in Osaka, that are closest to Kyoto (Kansai International Airport and Itami Airport) and adding 70 minutes of travel time for rail connection to Kyoto (in addition to the 90 minutes for airport boarding/de-boarding).

[5] The travel by conventional rail from Yokohama appears to be via Tokyo only.

Source: self calculated estimates based on the timetables of JR Central Company (http://english.jr-central.co.jp/info/timetable/_pdf/westbound.pdf), Expedia online reservation (www.expedia.com) and Google maps, 2010.

After the Shinkansen: General Impacts

The HSR corridor between Tokyo and Osaka in Japan is a unique case as it passes through one of the most populous regions in the world, with multiple urban areas of several million inhabitants located along the corridor. This corridor attracts the highest number of riders of any high-speed rail line in the world (over 150 million riders annually[201]). This explains the corridor's financial and commercial success beyond the expected forecasts. Tokaido Shinkansen is one of only two HSR routes in the world (along with the French Paris-Lyon TGV line) that "have broken even".[202]

The review of literature by Kamel et al. (2008) mentions that overall economic and social development impacts of Japan's Tokaido Shinkansen railway are mainly the products of the travel time reductions between Tokyo and Osaka, initially to 4 hours and down to the fastest scheduled rail travel time of 2 hours 25 minutes. The high speed is what has created "more opportunities for business and economic development".[203]

Evidence of Megalopolis Formation and Development Impacts

The Japanese HSR, Shinkansen, has changed the people's lives and activities along the Tokaido corridor in a revolutionary way. Specifically, the ground-breaking speed and associated travel time savings have attracted significant new travel demand, illustrated by large annual ridership figures. The reduction in travel time and high service frequencies of Tokaido Shinkansen have provided opportunities never offered by any mode before. Figure 4.10 presents a time-space diagram with the major cities along the Tokyo-Osaka corridor brought closer by the high-speed Shinkansen. Relative to other modes, the HSR's reach has expanded the commute zone to the cities that are over 200 km (124 miles) away from Tokyo. The increase in "intra-organizational" business trips in the services sector and decrease of the overnight stays attest to the enlargement of the people's daily activity zones in terms of physical distance, but within the acceptable temporal distance limits.[204]

Furthermore, the "concept of formation of Extra Huge Economic Zones (EHEZ)" introduced by Japan's Chubu Economic Federation (CEF) as one of the ways to assess the impacts of the Shinkansen investments provides an evidence of a megalopolis or megaregion creation between the cities on Tokaido Shinkansen corridor in Japan.[205] The EHEZ concept was developed by the CEF to make a case for implementation of Maglev trains on the Tokyo-Osaka corridor, which provides even more dramatic reduction of the temporal distance by amalgamating Japan's major urban centers together (Figure 4.11).

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[201] Central Japan Railway Company. 2009. *Data Book 2009*. Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf

[202] Cited by Iñaki Barrón de Angoiti, director of high-speed rail at the International Union of Railways, in Victoria Burnett, "Spain's High-Speed Rail Offers Guideposts for U.S.," *The New York Times On the Web*, May 30, 2009. Retrieved in 03/25/2010 from http://www.nytimes.com/2009/05/30/business/energy-environment/30trains.html

[203] Kamel, K. and Matthewman, R. 2008. The Non-Transport Impacts of High Speed Trains on Regional Economic Development: A Review of the Literature. Locate in Kent Agency. November.

[204] Shin, D. 2005.

[205] Ishii, M. 2007. Flexible System Development Strategies for the Chuo Shinkansen Maglev Project: Dealing with Uncertain Demand and R&D Outcomes. Chapter 2. S.M. Thesis, Engineering Systems Division, Massachusetts Institute of Technology. Cambridge, MA.

Figure 4.10: Time-Space Chart for Commuting Times from/to Tokyo by mode

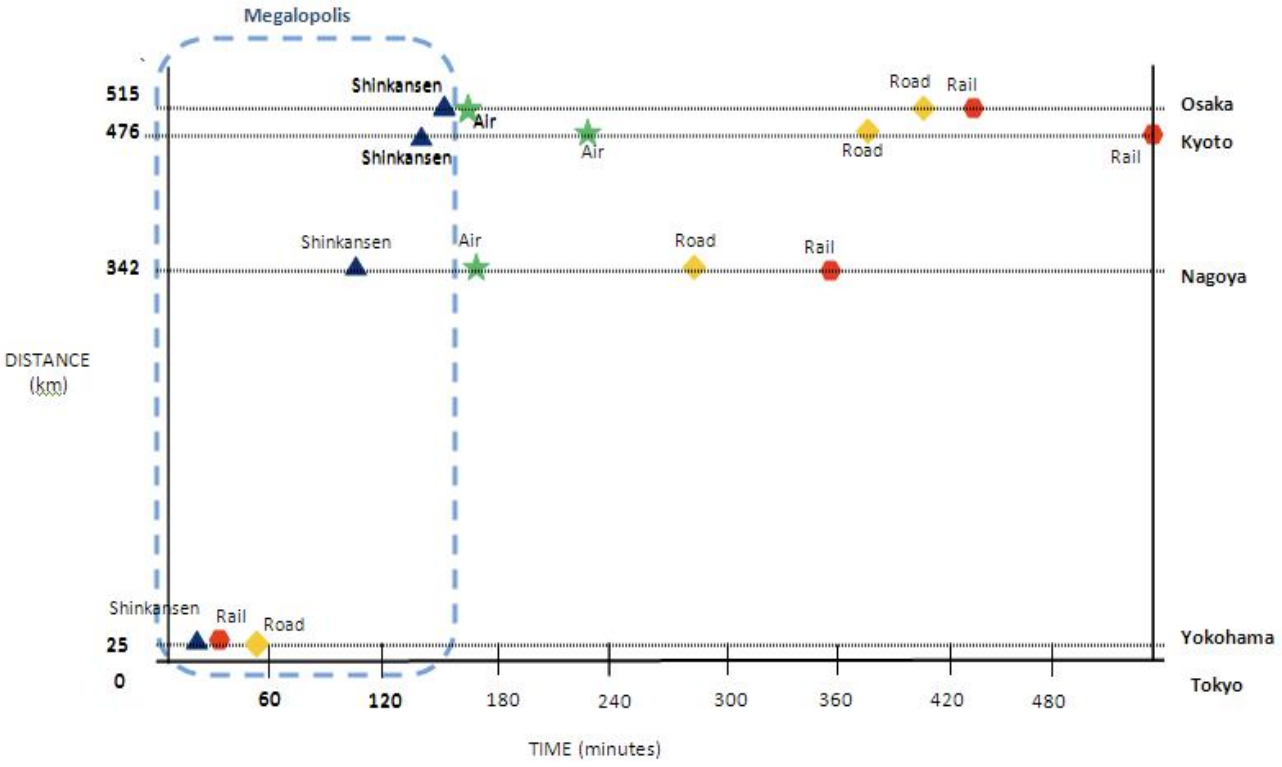
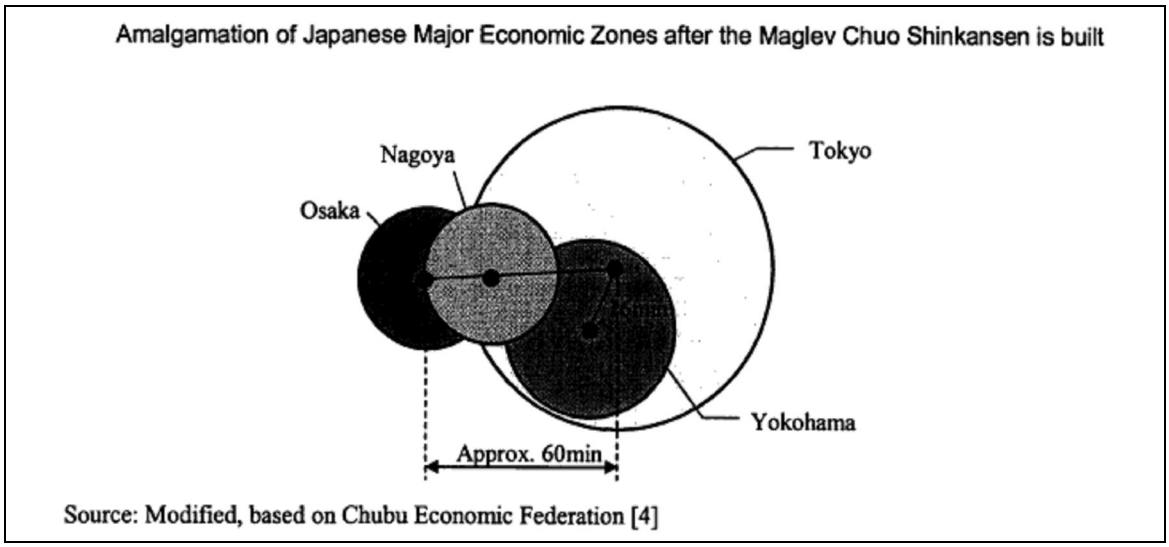


Figure 4.11: Time-distance diagram of major cities in Japan based on Maglev train travel time



Source: Ishii, M. 2007. Flexible System Development Strategies for the Chuo Shinkansen Maglev Project: Dealing with Uncertain Demand and R&D Outcomes. Chapter 2. S.M. Thesis, Engineering Systems Division, Massachusetts Institute of Technology. Cambridge, MA.

Economic Development Impacts

According to Givoni (2006), HSR creates "network effect" by bringing the cities closer and increasing their connectivity because of the travel time reductions it offers. The "network effect" is in turn "the driver for the social-economic impacts."[206] In the transportation literature, the Shinkansen in Japan is often used as a model for discussing the regional development impacts of the HSR. Sands (1993) concludes that "the Shinkansen has had strong development effects in Japan at the regional, urban and station levels".[207] The impacts have been mainly observed in the average annual population growth, increased employment in the "information exchange industries" such as "banking, real estate, education and political institutes", and increase in business and tourism travel between the cities.

Haynes (1997) and Sands (1993) examine the impacts of the HSR on labor markets and regional growth based on empirical studies by Brotchie (1991), Amano and Nakagawa (1990) and Nakamura and Ueda (1989), who found positive correlations between the proximity of a Shinkansen station and regional development, but did not provide any information about the causality of this relationship.[208] Some of the results of these empirical findings are presented in Tables 4.6 – 4.8. Although these figures are often used in discussing the impacts of HSR in Japan, "the real impact of high-speed rail on regional-economic development is still difficult to assess".[209]

Sasaki et al. (1997) assessed whether the Shinkansen led to the reduction of regional disparities and found that HSR lines in Japan led "to regional dispersion of economic activity from developed regions to less developed regions to some extent", but increasing the density of the HSR network did not necessarily contribute to long-term regional dispersion.[210] Furthermore, Haynes (1997) and Sands (1993) argue that along the Tokyo-Osaka corridor "although growth parallels the high-speed train route, most of the route was selected on the basis of expected growth independent of the HST".[211] Hence, the question remains about "the direction of causation: does the Shinkansen cause the increases in growth rates, or is it constructed in regions that are already increasing and thus simply concentrates growth within those region?" Additional detailed analysis of the route is necessary to answer these answers more definitively.[212]

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[206] Givoni, M. 2006. Development and Impact of the Modern High-speed Train: A Review. Transport Reviews. Vol. 26, No. 5, 593–611, September.

[207] Sands, B. 1993.

[208] Willigers, J. 2003. High-Speed Railway Developments and Corporate Location Decisions: the Role of Accessibility. Paper presented at the 43rd ERSA Congress. Jyväskylä, August 27-30.

[209] Willigers, J., Floor, H. and van Wee, B. 2005. High-Speed Rail's Impact on The Location of Office Employment Within the Dutch Randstad Area. 45th Congress of the European Regional Science Association. Amsterdam, August 23-27.

[210] Sasaki, K., Ohashi, T. and Nado, A. 1997. High-speed rail transit impact on regional systems: does the Shinkansen contribute to dispersion? *The Annals of the Regional Science*, 31, pp. 77-98.

[211] Haynes, K. 1997. Labor markets and regional transportation improvements: the case of high-speed trains. An introduction and review. *The Annals of Regional Science*, 31. Pp. 57-76.

[212] Sands, B. 1993.

Impacts on population growth

Overall, the cities with the Shinkansen railway stations along the Tokyo-Osaka corridor grew in population size.[213] In a study by Brotchie (1991), cities connected to the Tokaido Shinkansen HSR registered a 22% higher growth in population size than the cities with no stations but located along the corridor (See Table 4.6).[214] These differences, on the other hand, may simply be a function of the smaller base size of the cities without stations.[215] Also, the HSR aimed to connect the cities that already were predisposed for potential population growth due to other factors (e.g., other transportation linkages, demographics, physical location, etc.).

Impacts on employment and businesses

Japan's Tokaido Shinkansen HSR link, similarly to Paris-Lyon line in France, has mainly "promoted the centralization of economic activities in big cities and favored intra-organizational business trips".[216] Alabate et al. (2010) reviews a study by Plaud (1977) claiming that the service industries became highly concentrated in the cities of Tokyo and Osaka, resulting in the centralization of this sector in the country's major cities. This trend can be supported by the fall in employment in Nagoya following the inauguration of the HST line, "estimated at around 30% down from 1955 to 1970". During the same period, Osaka and Kyoto registered an employment increase of 35%.[217]

Japanese cities serviced by the Shinkansen experienced 16 to 34% higher growth in retail, industrial and wholesale activities than those cities not served by the train by allowing regionally based businesses to have access to the sales and marketing in the major metropolitan areas. Osaka, Japan's second major city, became a new regional center of growth with the expansion of the Shinkansen network to other corridors. In the retail industry, Tokyo has gained the most benefits. Also, since "intra-organizational journeys" have become easier, business travel has increased significantly, however, the number of business overnight stays in hotels in Tokyo and Osaka has decreased.[218]

Regions with good accessibility to the Shinkansen stations also have registered higher growth in employment relative to regions with no direct HSR connection. This trend is observable mainly in the locations like Tokyo and Osaka dominated by "information exchange industries" (business services, banking services, real estate), and with higher education institutes, which registered the highest increase of employees. And on the contrary, presence of large number of manufacturing industries in Nagoya has limited its regional growth even with presence of the HSR station. In addition, "the combination of expressway and the Shinkansen" had a stronger effect on growth rates"[219] (Table 4.7).

As can be seen from Table 4.6, "employment growth in retail, industrial, construction and wholesaling was 16–34% higher" in cities with HSR stations than in those without. Amano and

[213] Alabate, D. and Bel, G. 2010.
[214] Haynes, K. 1997; Sands, B. 1993.
[215] Sands, B. 1993.
[216] Alabate, D. and Bel, G. 2010
[217] Ibid
[218] Ibid
[219] Sands, B. 1993.

Nakagawa (1990) found independently that growth in employment was 26% greater in cities with Shinkansen stations than that in cities with no stations ("1.8% to 1.3% respectively" – Table 4.8).[220] According to Brotchie (1991), "food and accommodation sectors" grew significantly at "both intermediate and termination stations". [221] [222] However, this growth in the cities may be a result of "displacement of activity from elsewhere and should not be interpreted as being indicative of net growth".[223]

Impacts on near station development

The Shinkansen stations that were newly built in 1964 became city centers with transit terminals, hotels, offices, retail, dining and cultural facilities, and parking, and had on average greater effects on the "redevelopment of surrounding areas" than the expanded existing stations at the time. [224] At first, the development around Shin-Osaka station in Osaka was low because it was separated from the city by a river, but eventually, the development was stimulated by initiation of "large-scale development projects", and opening of additional "transportation linkages" between the station and the city center.[225]

In Yokohama, in addition to being a part of residential urban sprawl of the metropolitan Tokyo area, the area around the Shin-Yokohama station had a major inflow of mid-size companies, mainly in the computer software sector. Firms started setting up offices around the station since the mid 1980s after the frequency of the Hikari and Nozomi services had been increased, thus offering shorter travel times to Nagoya and Shin-Osaka.[226] Heavy development of the area around the entrance of the station led to the formation of a new city center in Yokohama.

Impacts on Tourism

Tourism has also showed significant growth following opening of the Shinkansen: rising from 15 to 25% between 1964 and 1975. However, this increase has had mixed effects across the cities on the corridor. The overnight stays decreases due to shorter travel times by HSR affected more the intermediate stops rather than the terminate points of the route.[227] The six prefectures of Tokyo experienced the most increase in the number of tourists.[228]

[220] Haynes, K. 1997.
[221] Ibid
[222] Sands, B. 1993.
[223] Ibid
[224] Shin, D. 2005.
[225] Sands, B. 1993.
[226] Wikipedia. Shin-Yokohama Station. http://en.wikipedia.org/wiki/Shin-Yokohama_Station
[227] Haynes, K. 1997.
[228] ARUP – TMG. 2001.

Table 4.6: Change of Population and Economic Indices in cities on Tokaido line.

	Annual increase[a]					
	Pre-Shinkansen			Post-Shinkansen		
Index	(A1) With station	(B1) Without station	(C1) A1/B1	(A2) With station	(B2) Without station	(C2) A2/B2
Population	2.64	3.39	0.78	1.88	1.55	1.22
Retail	10.10	13.50	0.75	9.96	8.58	1.16
Wholesale	12.90	20.80	0.62	11.63	8.70	1.34
Industrial[b]	13.70	14.20	0.97	9.48	7.81	1.21
Construction[c]	13.80	14.90	0.93	8.01	6.37	1.26

[a] Annual increase is the average of the ten years preceding and following the introduction of the Shinkansen (1964). The period following introduction is lower overall because of national economic stagnation.
[b] Industrial production in area.
[c] Construction in area.
Source: Brotchie, 1991 (based on Hirota, 1984)

Source: Haynes, K. 1997. Labor markets and regional transportation improvements: the case of high-speed trains. An introduction and review. *The Annals of Regional Science*, 31, pp. 57-76.

Table 4.7: Information exchange industries employment growth (%) in regions with population increase (1981-85)

	Shinkansen & expressway (%)	Expressway only (%)
Business services (total)	42	12
Information, investigation, advertising services	125	63
R&D and higher education	27	21
Political institutes	20	11
Other	57	28
Banking services	27	28
Real estate agencies	21	3
Average	22	7

Source: Nakamura H. and Ueda T. 1989. The Impacts of the Shinkansen on Regional Development, in: The Fifth World Conference on Transport Research, Yokohama, Vol. III. Western Periodicals, Ventura, California.

Table 4.8: Employment of cities with stations and neighboring cities without stations

		Year		Change		
Shinkansen	City	1960	1985	Absolute	Percent	Rate
Station	1	21,178	25,873	4,695	22.2	0.8%
	2	26,389	48,404	22,015	83.4	2.4%
Total		47,457	74,277	26,710	56.2	1.8%
Neighboring	1	55,676	78,166	22,490	40.4	1.4%
	2	68,541	120,566	52,025	75.9	2.3%
	3	107,562	111,121	0,359	3.3	0.1%
	4	150,924	223,675	72,751	48.2	1.6%
Total		382,703	533,528	150,825	39.4	1.3%

Source: Amano K. and Nakagawa D. 1990. Study on Urbanization Impacts by New Stations of High Speed Railway. Conference of Korean Transportation Association, Dejeon City.

4.4 Summary

Japan followed an approach to HSR deployment similar to the French one by building new exclusive passenger high-speed lines separated from freight. However, the feature of the Japanese Shinkansen that is distinct from the French TGV system is that it is not compatible with the conventional tracks and conventional trains due to differences in gauge sizes and limited capacity of the traditional rail. The geography of Japan favors the development of rail transport due to shortage of land area for constructing highways. Passenger transport is the dominant market in the railway sector, which explains the non-mixed use and passenger orientation of the HSR rail services. The structure of the Japanese Shinkansen network reflects the country's shape, stretching from north to south along the islands and following the linearly located and largely populated metropolitan areas. The capacity constraints of the existing conventional lines and growing air competition were the main motives driving the decision to construct Japan's first HSR link, while the subsequent corridor decisions also took into consideration the "wider economic" effects such as regional development and equity. The Shinkansen network has provided travel time cuts and high service frequencies that are more competitive than air.

Overall, the Shinkansen in Japan has created benefits for both large and small urban areas. Smaller cities have gained better accessibility and improved proximity to the major economic centers that they would not have had without the HSR. The incremental effects of improved accessibility and reduced travel time brought by the HSR are greatest for the cities that lacked any access to air or conventional rail services before the Shinkansen.

Japan's Tokyo-Osaka Shinkansen, the first HSR line built in the world, focused on linking large urban centers along the most densely populated corridor to ensure the sufficient traffic demand. This explains its wild commercial success and being one of the only two HSR routes in the world (along with the French Paris-Lyon TGV line) that "have broken even"[229] It has had

[229]Cited by Iñaki Barrón de Angoiti, director of high-speed rail at the International Union of Railways, in Victoria

succeeded in capturing 85% of the air/rail market between Tokyo and Osaka from commercial aviation.[230] Some of the key observations of development impacts from Tokaido Shinkansen line are summarized as follows:

- The increases in the number of employees have occurred primarily in banking services, real estate agencies and some other service businesses such as research and development, higher education and political institutes, collectively called the "information exchange industries". Shinkansen has stimulated increase in business trips in the services industry as well as tourism.
- One of the planning policies was the dispersion of economic activity out of the central urban areas such as Tokyo, Nagoya, and Osaka. However, Japan's Tokaido Shinkansen HSR link, similarly to Paris-Lyon line in France, has mainly promoted the centralization of economic activity in Tokyo and Osaka, while Nagoya experienced fall in its employment rates. This can be explained by the mix of the industries prevalent in these cities: Tokyo and Osaka are dominated by the "information exchange" and service industries most favored by the HSR, while Nagoya is a manufacturing industry base on whose development the HSR connection plays a minimal role.
- Overall, the existing empirical studies have found high positive correlations between the Shinkansen deployment and regional development indices such as population and employment at the urban level. However, the causal relationship is not fully revealed to attribute this growth to the Shinkansen, as there may be other factors prevailing in these regions that can support and affect such an impact, and Shinkansen might as well have been connected to these cities in anticipation of an expected growth. Also, "there is evidence that these changes were merely shifts within communities," thus leading to the theory "that the Shinkansen has succeeded to shift growth, not induced it."[231] Therefore, the new growth sometimes has come at the expense of other cities or regions with no HSR linkage.

* * *

The next chapter presents the next case study on France's experience in HSR deployment and the impacts of the TGV line connection between Paris and Lyon on megalopolis formation and economic development of urban areas along the corridor.

Burnett, "Spain's High-Speed Rail Offers Guideposts for U.S.," *The New York Times On the Web*, May 30, 2009. Retrieved in 03/25/2010 from http://www.nytimes.com/2009/05/30/business/energy-environment/30trains.html

[230] Peterman, D., Frittelli, J. and Mallett, W. 2009.

[231] Givoni, M. 2006.

5 France: High-Speed TGV System

France was the second country to initiate the development of a high-speed rail system following Japan in the 1960's, and the first in Europe. Its first Train à Grande Vitesse[232] (TGV) high-speed train connecting the 425 km (264 miles) distance between Paris and Lyon in 2 hours was launched in 1981. Since then, France has been gradually developing its TGV network has become one of the leaders in HSR technology. Today, France has 1,896 km (1,178 miles) of dedicated TGV lines connecting major cities to Paris and carrying 128 million passengers per year (in 2008)[233] at top speed of 320 km/h (199 mi/h).[234] This chapter reviews the background on the French railway sector in general, and discusses the TGV system, focusing on the impacts of the Paris-Lyon HSR link on megalopolis formation and economic development of the cities.

5.1 Country Background

France is located in Western Europe extending from the Mediterranean Sea to the Bay of Biscay and English Channel, and bordering Belgium, Luxembourg, Germany, Switzerland, Spain, and Italy, and is separated from the UK by the English Channel. It is the largest state in the European Union by territory, with a population of 64 million. France is ranked the fifth largest economy in the world by nominal GDP and the eighth largest by purchasing power parity.[235] The largest cities in France in descending order by population size are Paris, Lyon, Marseille, and Lille. The French economy is highly centralized with the central government retaining control and majority ownership over the country's major infrastructure segments, including railway, electricity, aviation, nuclear power, and telecommunications.

France is a unitary semi-presidential republic governed by the constitution of the Fifth Republic of 1958, under which the executive power is shared by both the president and the prime minister.[236] President of the republic is the Head of State elected by popular vote for a five year term, and the Head of Government is prime minister appointed by the president. The French parliament is bicameral consisting of the National Assembly (Assemblée Nationale) of 577 deputies from local constituencies elected by popular vote every five years; and the Senate elected by an electoral college for six years.

The republic is administratively divided into 22 metropolitan and 4 overseas regions, which are also divided into total of 100 departments (département). The departments are subdivided into 342 districts (arrondissements), which are further broken up into constituencies (cantons). Each canton consists of communes (municipality level) that are "the lowest

[232] Translated as "High-Speed Train".
[233] Le Journal du Net. Retrieved on 05/11/2010 from http://www.journaldunet.com/economie/magazine/dossier/les-produits-qui-se-vendent-malgre-la-crise/les-billets-de-tgv-toujours-sur-de-bons-rails.shtml
[234] International Union of Railways (UIC) High Speed Department. 2009. High Speed lines in the World. Prepared by I. Barron. Updated June 14. Retrieved on 03/15/2010 from http://www.uic.org/
[235] Central Intelligence Agency (CIA). 2010. World Factbook. Retrieved on 03/10/2010 from https://www.cia.gov/
[236] The Economist Intelligence Unit (EIU). 2008. Country Profile: France. London, UK.

administrative division" of France. France also has overseas territories in North America (Saint Pierre and Miquelon islands), the Caribbean, South America, the southern Indian Ocean, the Pacific Ocean, and Antarctica, which have varying forms of government ranging from departmental level to "overseas collectivity".[237]

France features one of the densest and most efficient transport networks in the world with 146 km of road per 100 km^2 and 6.2 km of railway per 100 km^2, built as a web with Paris in the center (Figure 5.1).[238] The country has 475 airports, 29,213 km of railways, 1,027,183 km of roads, as well as an extensive marine fleet, 8,500 km of waterways.[239] The French highway network is third largest in the world after the United States and Canada. The 12,000 km long motorway network is privately operated and consists mainly of toll roads. All air traffic is largely centered in the Paris' two main airports – Roissy-Charles de Gaulle and Orly. France is also one of the world pioneers in high-speed railway technology and modern tramway developments. Having long concentrated on developing the capital city's links with the rest of the country, the focus of transport policy has started shifting in recent years to improving long-neglected interregional links.[240]

French Railway Sector

The first conventional rail lines were built radiating out of Paris, connecting France's major cities to the capital. These lines still form the backbone of the French railway system today. The basic structure of the network was completed in the 1860s with more minor lines added later in the 19th century. As a result, the network consisted of a number of disconnected branches extending out of Paris, and consequently Paris was served by trains much better than other parts of the country. For example, to travel from Lyon to Clermont-Ferrand one needed to make a detour via Paris of over 700 km, while the cities were only 120 km from each other. The French railway planners considered it natural that all the lines should pass through Paris, which was viewed as "the undisputed capital of France", unlike Germany, which had many centers competing with each other reflecting a decentralized structure of German railways.[241] In addition, the Paris-centric central government of France with minimal local representation played a major role and greatly influenced the planning process and layout of the railways. Moreover, Paris paid the most investment capital. By 1914 the French railway system had become one of the densest and most highly-developed in the world, and today comprises total of around 29,213 km (18,152 miles) of lines.[242]

The railway system in France has been historically owned and controlled by the government due to the strategic and military importance of the railway. Many lines were constructed for strategic and political needs despite not being economically viable, which the private sector would not have undertaken. In the beginning, the railway lines were leased to private operators, but many of them started experiencing financial difficulties. Thus, in 1938 the socialist government fully nationalized the French rail system and established the state owned

[237] Wikipedia. France. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/Departments_of_France
[238] Wikipedia. Transport in France. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/Transport_in_France
[239] Central Intelligence Agency (CIA). 2010.
[240] The Economist Intelligence Unit (EIU). 2008. Country Profile: France. London, UK.
[241] Wikipedia. History of Rail Transport in France. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/History_of_rail_transport_in_France
[242] Central Intelligence Agency (CIA). 2010.

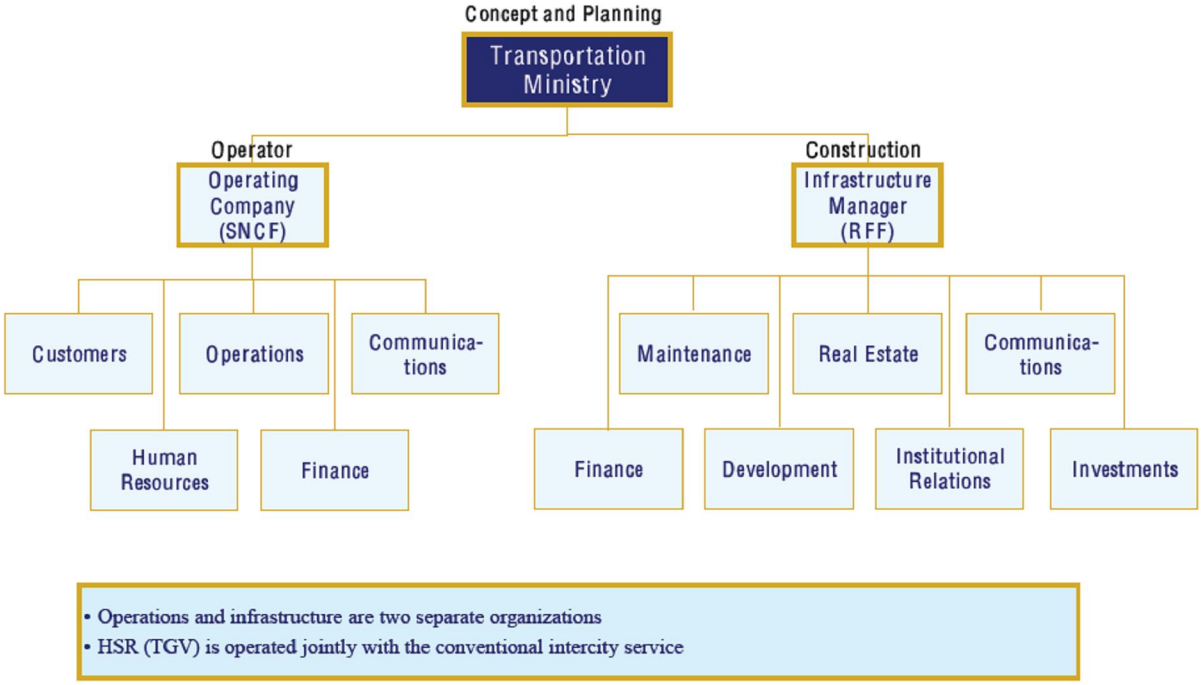
Figure 5.1: Map of Transport Networks in France

Source: The Economist Intelligence Unit. 2010. Country Report: France. February. London, UK. January.

French National Railway company Société Nationale des Chemins de fer Francais (SNCF). In 1977, the SNCF was restructured and the management of the tracks and rail network infrastructure was transferred to a newly created national entity – Réseau ferré de France (RFF). This reform took place under "the European Union directive, which required the separation of passenger operations and infrastructure management".[243] In addition, the ownership of entire railway infrastructure in France, including the high-speed rail network, was transferred from the government to RFF. RFF is also responsible for capacity allocation, contracting, traffic management, and maintenance. The latter two tasks have been subcontracted to the SNCF.[244] Today, the SNCF operates on the national high-speed and conventional rail lines and pays usage fees to the RFF (see Figure 5.2).

The SNCF Group consists of five divisions: SNCF Infra responsible for rail network management, operation, and maintenance on behalf of RFF and engineering of rail infrastructure; SNCF Proximités responsible for local urban, suburban and regional services; SNCF Voyages in charge of long distance and high-speed rail services; SNCF Geodis responsible for freight transport and logistics; and Gares & Connexions managing the train stations.[245]

Figure 5.2: Institutional Structure of National Railway System in France



Source: A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

[243] United States Government Accountability Office. 2009. High Speed Passenger Rail: Future Development will Depend on Addressing Financial and Other Challenges and Establishing a Clear Federal Role. Report to Congressional Requesters. GAO-09-317. March.

[244] Ibid

[245] Société Nationale des Chemins de fer Français (SNCF). 2010. Profile & Key Figures. Retrieved on 05/11/2010 from http://medias.sncf.com/resources/en_EN/medias/MD0006_20100210/file_pdf.pdf

The types of rail services provided include high-speed trains (TGV), regional express trains (TER), and inter-city Teoz conventional trains. The TER trains, operated by the SNCF Proximites within the SNCF Group and other smaller operators, form the backbone of France's regional train services and offer short-distance travel connections to smaller towns at a maximum commercial speed of 160 km/h (99 mi/h). There are 21 regional TER networks throughout France. The inter-city Teoz trains provide long distance services and are run on trunk routes where no high-speed rail trains operate. Conventional Teoz trains operate at commercial speed of 160-200 km/h (99-124 mi/h).[246] The high-speed TGV and inter-city Teoz services are operated by SNCF Voyages. The TGV services are discussed in more detail in the next section.

The Ministry of Ecology, Energy, Sustainable Development, and Spatial Planning is in charge of setting policies, enforcing laws and regulations, and approving and financing rail projects in France. Under the EU legislation of March 2003, the access to rail tracks was opened for freight operators other than the SNCF. The market for passenger rail transport is expected to open for competition by 2010, in accordance with the EU legislation of October 2007.[247]

Nowadays, the funding for railway construction in France comes from a variety of sources, including the national government, provincial governments, RFF, SNCF, and the European Union. France has large national programs relying on national and local funding allocations to build rail projects.[248] The unprofitable rural lines are largely subsidized.[249]

5.2 Development of French TGV System

The first high-speed rail link in France was opened in 1981. France's high-speed trains called Train à Grande Vitesse (TGV), which means "High-Speed Train", were developed during the 1970s by private firm Alstom and the SNCF.[250] The high-speed lines in France, called Lignes à Grande Vitesse (LGV), which means "High Speed Lines", are owned by the state entity RFF and operated by the long-distance rail branch of the SNCF, who is currently the sole provider of domestic HSR operations in France. However, starting 2010 all international HSR lines are being opened for competition from private and public train operators (according to EU directives). It yet remains to be seen whether any competition will follow. The Eurostar and Thalys TGV, of which SNCF is a shareholder, provide international HSR operations to locations in Belgium, Holland, and the United Kingdom.[251]

The TGV serves in the south, west, north and east of France connecting Paris to cities of Lille, Marseille, Marseille and Bordeaux. The TGV technology has also spread to other European countries (Belgium, the Netherlands, Switzerland, Italy) and South Korea.[252] The normal operational speed of the train on the newest high-speed lines reaches up to 320 km/h (199

[246] France, Rail Pass Website. Retrieved on 03/10/2010 from http://www.francerailpass.com/frp/Our-Trains
[247] The Economist Intelligence Unit (EIU). 2009. Country Commerce: France. New York, NY. May.
[248] United States Government Accountability Office. 2009.
[249] Iwamura, N. 2007. A lean Enterprise Approach for Developing High Speed Rail in Japan and Portugal. S.M. Thesis, Transportation Program, Massachusetts Institute of Technology. Cambridge, MA.
[250] TYCO Engenharia/Holland RailConsult (THR) and RAVE. 2006. Socio-Economic Cost-Benefit Analysis: High-Speed Rail Lisbon-Porto. Document No. 00-GA-0-AF-NOT0052-0A. June 1.
[251] United States Government Accountability Office. 2009.
[252] Wikipedia. TGV. Retrieved on 02/02/2010 from http://en.wikipedia.org/wiki/TGV

mi/h). In April 2007, a TGV test train piloted by Eric Pieczak set the record for the fastest wheeled train in the world, reaching 574.8km/h (357 mi/h).[253]

Decision-Making Process

The development of high-speed rail in France was initiated by the French Government in the 1960s, after Japan had begun the construction of the Shinkansen. The Government was highly supportive of technical research for new technologies at the time. In the 1970's, the SNCF began the high-speed train research program to create the world's fastest railway network and proposed the TGV. In 1976 the government allocated funding to launch the TGV project.[254]

Prior to the creation of RFF in 1997, most of the funding for the construction of high-speed rail lines came from the national government (through SNCF). Today, there are a variety of sources, including the subsidies from national government, provincial governments, RFF, SNCF, and the European Union.[255] The HSR deployment is highly supported by the French provinces that try to attract the construction of new lines on their territories by often offering to provide funding. For instance, TGV Est line was funded 32% by the provinces it serves.[256]

The selection and prioritization of the HSR projects are carried out through a political process with consideration of economic, financial and socio-economic evaluations. The evaluations are carried following a feasibility study prior to the HSR line construction:[257]

- *The economic evaluation* is conducted over a period of 20 years to assess the viability of SNCF, comparing the "with new HSR scenario" to a base case of "without the new HSR line". The main profitability indicators used for the assessment are the net profit value (NPV) at a discounted rate of 8 % is adopted, and the internal rate of return (IRR).

- *The financial simulation* evaluates "the effects of the project on the operating and financial accounts of SNCF operations". This assessment is considered important "due to the debt incurred by the company and its objective to achieve financial equilibrium".[258]

- *The socio-economic evaluation.* The earlier mentioned economic evaluation determines the benefits to the investing company only, while the socio-economic evaluation accounts for the benefits and costs to the users and other social and economic impacts, including value of time, impact on other transportation modes, impact on localities, environmental benefits, and economic growth. The socio-economic assessment plays an essential role in providing social justification for the project investment if the economic IRR for the company does not yield viable results.

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[253] Wikipedia. High Speed Rail in France. Retrieved on 02/02/2010 from http://en.wikipedia.org/wiki/High-speed_rail_in_France

[254] Petkova, B. 2007. Strategic Planning for rail System Design: An Application for Portuguese High Speed Rail. Master's Thesis, Industrial Engineering and Management, University of Groningen. Groningen, Netherlands.

[255] United States Government Accountability Office. 2009.

[256] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

[257] Schwob, B. 1995. Economic Justification of the TGV and Development of the High-Speed Rail System. SNCF. France. Retrieved on 02/08/2010 from http://ieeexplore.ieee.org/

[258] Ibid/

The gross value added of HSR investment in France, as calculated by A.T. Kearney analytical study, is that "every €1B investment in HSR generates 10,000 jobs annually". HSR has a 2-6% IRR in financial terms and 12-14% IRR in socio-economic terms, including value of time savings, pollution reduction and congestion relief.[259] Prior to construction, the TGV high speed network lines were evaluated to be very profitable: the TGV Sud-Est was estimated to yield 15% IRR, the TGV Atlantique – 12%, and other projects ranged between 10-13 %.[260]

Deployment of TGV Network

The HSR network in France has been developed gradually during the past 30 years. It was inaugurated with the construction of TGV Sud-Est (or TGV Southeast) line between Paris and Lyon in 1981, proposed after an intensive economic and technical research by the SNCF. As in Japan, the choice of the Paris-Lyon route was motivated by the shortage of capacity on the existing conventional railway route and the growing threat of competition from air. [261]

The success of the TGV Sud-Est led to the creation of an investment plan that provided the funds to construct connections from Paris to other major cities. The network was extended to the West connecting Paris to Le Mans in 1989 and to Tours, and to the North connecting Paris to Lille in 1993. The Mediterranean HSR linked Paris with Marseille in 2001. As part of the trans-European HSR network, Eurostar connected Paris to London in 1994, and Thalys linked Paris to Brussels in 1996.[262] Today, France's TGV network comprises 1,896 km (1,178 miles) of newly built dedicated high-speed lines, with more under construction.[263]

France followed an approach of building new high speed dedicated passenger lines along the congested routes, and keeping the conventional rail services on less crowded routes. From the beginning, the TGV was designed to be compatible with the existing conventional rail network. Therefore, TGV trains can be operated at conventional speeds on the re-electrified sections of conventional tracks. This enables an expansion of the TGV service area to locations, where the construction of new high-speed lines was not practical.[264] The size of the entire TGV network including the TGV compatible conventional lines is about 9,700 km (6,027 miles).[265] The French model, unlike the Japanese and German, corresponds to "the mixed high-speed model", in which, as defined by Campos et al. (2009), "high-speed trains run either on specifically built new lines, or on upgraded segments of conventional lines".[266]

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[259] A.T. Kearney. 2003. Formulating the strategy for HSR in Portugal. Presentation for RAVE. Lisbon, Portugal. June.

[260] Schwob, B. 1995.

[261] Nash, C. 2008. High Speed Rail Investment: an overview of the literature. Institute of Transport Studies, University of Leeds. Leeds, UK.

[262] Masson, A. and Petiot, R. 2009. Can the high speed rail reinforce tourism attractiveness? The case of the high speed rail between Perpignan (France) and Barcelona (Spain). *Technovation,* 29, pp. 611-617.

[263] International Union of Railways (UIC) High Speed Department. 2009. High Speed lines in the World. Prepared by I. Barron. Updated June 14. Retrieved on 03/15/2010 from http://www.uic.org/

[264] Campos, J., de Rus, G., and Barron, I. 2007. A review of HSR experiences around the world. Foundation BBVA. Munich Personal RePEc Archive (MPRA). Paper No. 12397. Retrieved on 02/08/2010 from http://mpra.ub.uni-muenchen.de/12397/

[265] California HSR Authority. 2008. High-Speed Train Systems. Sacramento, CA, USA. Retrieved on02/08/2010 from www.cahighspeedrail.ca.gov

[266] Campos, J. and de Rus, G. 2009. Some stylized facts about high-speed rail: A review of HSR experiences around

TGVs run at speeds of up to 320 km/h (199 mi/h) on new tracks, and at maximum of 220 km/h (137 mi/h) on conventional lines.[267] Overall, HSR in France has increased the average rail speed by 80%.[268] Figure 5.3 presents two maps: a map of the newly built TGV lines by year of completion (on the left) and a map of the new TGV and upgraded conventional rail network (right).

The strategic objectives of HSR deployment in France included increasing rail market share, the creation of a transportation backbone, and the integration with the European network. The political objectives were "connecting all major cities to Paris within 3 hours or less, regional development, and international connectivity".[269] France also pursued a philosophy of "democratization of speed", that promoted HSR as being open to everyone at reasonable fares and made it widely popular with the general public.

The development of HSR network was envisioned as a way "to overcome the limited capacity of conventional lines, where some new investment was needed and more effective solutions like HSR were required"[270] The goals of the French TGV system were focused around meeting the transport needs such as "lowering of transport costs per person/km and increasing the speed of travel" and less on the "spatial re-organization of activity". A secondary goal that emerged during the TGV deployment was to export the French technology and "technical innovation" in the rail industry.[271] Freight rail, unlike in Germany, "is not viewed as a priority"[272] and therefore, operated on the conventional tracks separate from the passenger HSR lines.

The decisions on financing the first TGV lines were made primarily according to their profitability, with an expected 12% minimum financial and social rate of return. This led to the construction of corridors that connected primarily Paris with big cities, from where sufficient traffic demand could be attracted. "The government's centralized and hierarchical decision-making structure led the SNCF to focus on commercial goals" in developing the HST in France partially to prove that public enterprise could be profitable. At the time, the government "did not permit any public debate on how to distribute the HSR network and was immune to any social

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the world. *Transport Policy*, 16, pp.19-29.

[267] California HSR Authority. 2008.

[268] Alabate, D. and Bel, G. 2010. High-Speed Rail: Lessons for Policy Makers from Experiences Abroad. Research Institute of Applied Economics. Working Paper 2010/03. Universitat de Barcelona. Barcelona, Spain.

[269] A.T. Kearney. 2003. Formulating the strategy for HSR in Portugal. Presentation for RAVE. Lisbon, Portugal. June.

[270] Lee, Y. S. 2007 A Study of the Development and Issues Concerning High Speed Rail (HSR). Transport Studies Unit, Oxford University Center for the Environment. Working Paper No. 1020.

[271] ARUP – TMG. 2001. East Coast Very High Speed Train Scoping Study. Phase 1 – Preliminary Study. Final Report. November. Sydney, Australia.

[272] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

Figure 5.3: TGV Network Maps: Existing and Planned TGV Lines by Year of Completion (left) and TGV and Conventional Rail Networks (right)

Source: Wikipedia. France TGV. Retrieved on February 16, 2010 from http://en.wikipedia.org/wiki/File:France_TGV.png

Source: Société Nationale des Chemins de fer Français (SNCF). Presentation by Jean Marie Metzler for the US House of Representatives, Committee on Transportation & Infrastructure Sub Committee on Railroads, Pipelines & Hazardous Materials. Washington, DC. April 19. Retrieved on 03/10/2010 from http://republicans.transportation.house.gov/Media/File/Testimony/Rail/4-19-07-Metzler.pdf

and regional pressures".[273] This in part could have resulted in all the SNCF TGV services being centralized in Paris.

The French TGV network, unlike the German ICE, "has been developed as spokes radiating outward from the hub of Paris," connecting "distant city-pairs with few intermediate stops"[274] (Figure 5.4). All newly built HSR lines link provincial capitals with Paris,[275] with trains running directly from and to Paris with no or maximum one intermediate stop. Additional stops are offered only during very early or late hours. This implies that there are a number of cities along the network that have only one or two high-speed trains stopping in each direction per day,[276] and most travel time saving benefits from the HSR are gained by Paris and provincial capitals. "The preference for connecting only crowded cities means that it is almost always necessary to link them with Paris to justify the investment."[277]

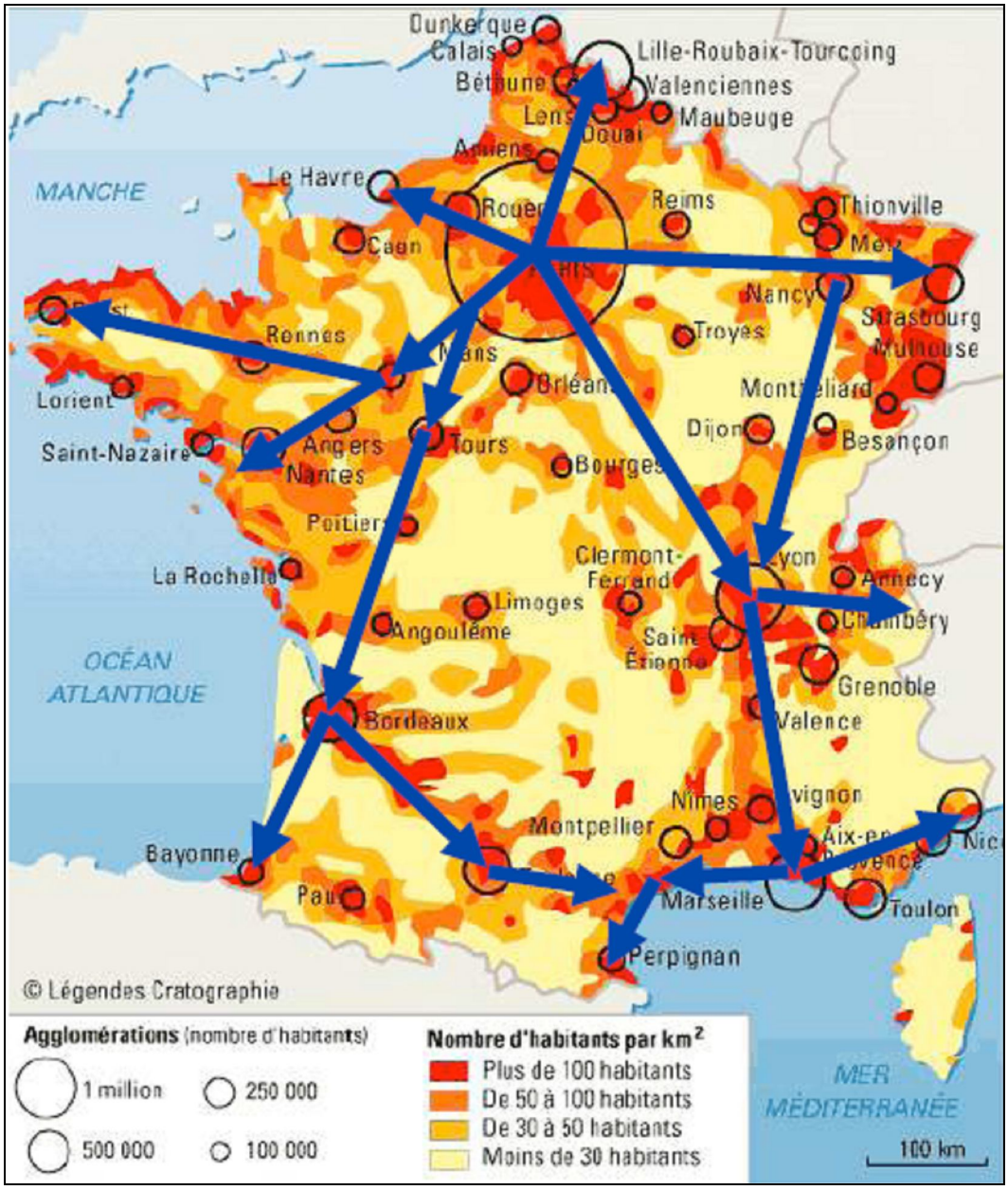
This monocentric structure of the French HSR network, resembling a star shape with the capital at the core in a way similar to the conventional rail network, is a reflection of the country's demographic and urban specificities. As mentioned in the German ICE case study, France has a relatively low population density, few big towns, "long distances between the major cities", and low populated areas outside the major urban centers [278.] The French economy is characterized with great imbalances between nation's capital Paris and the provinces, with "Paris holding a predominant role in French society and its economy"[279] with largest concentration of population and jobs (Figure 5.4).

Overall Impacts of HSR

The dominating position of Paris in terms of every economic, demographic and political aspect has resulted in a centralized "radial" distribution of the HSR services in France, following the pattern of historically evolved conventional rail network. Designed solely for high-speed passenger services and serving the connections with high traffic demand only, the first high-speed lines proved to be a commercial success with net returns exceeding the pre-project estimates (TGV Atlantique had 22% and TGV Sud-Est had 38% net returns)[280]. As in Japan, but unlike in Germany, the French HSR has brought closer in time and space the major urban centers and the capital and "promoted the centralization of economic service activities in these big nodes"[281], especially Paris.

[273] Alabate, D. and Bel, G. 2010.
[274] Peterman, D., Frittelli, J. and Mallett, W. 2009. High-Speed Rail (HSR) in the Unites States. Congressional Research Service (CRS). Report for Congress. December 8.
[275] Verkehrswissenschaftliches Institut (VWI) Stuttgart GmbH and Partners. 2006. Feasibility Study Concerning High-Speed Railway Lines in Norway. Report Phase 1. December.
[276] Ibid
[277] Alabate, D. and Bel, G. 2010.
[278] Nash, C. 2008.
[279] Bonnafous, A. 1987. The Regional Impact of the TGV. *Transportation*, V. 14, No. 2, pp. 127-137, June.
[280] Petkova, B. 2007.
[281] Alabate, D. and Bel, G. 2010.

Figure 5.4: Radial HSR Network in France and Population Densities Distribution



Source: A.T. Kearney. 2003. Formulating the strategy for HSR in Portugal. Presentation for RAVE. Lisbon, Portugal. June 25.

According to Masson et al. (2009) the French TGV had impacts on three different levels depending on the configuration of the line: connection between main large French cities (e.g., Lille–Paris–Lyon–Marseille axis), connection between middle size cities and Paris serving as a "commuter belt" (e.g., TGV Atlantic), and finally, the connectivity and increased proximity between the French capital and other European capitals contributing to greater EU integration

(e.g., Eurostar).[282] Moreover, the TGV also made the remote French regions, such as in the North of France, more accessible to other European capitals. However, Masson et al (2009) argue that "positive effects do not come naturally from HSR implementation but are boosted by accompanying public and private measures" and "HSR will permit development of activities if it is well anticipated and configured". Some claim that after the deployment of TGV services "a pull effect, a kind of centripetal force towards the Paris metropolitan region, has been working for short-distance areas, whereas a push effect—outward from the capital region—has been working for long-distance areas".[283] According to Arduin (1991), "the most important node is the one that benefits most from HST".[284] Indeed, round business trips originating in Paris increased much less than round trips originating at the other city connections with Paris as their destination: 21% versus 156% increase in trips. Therefore, "the region surrounding Paris (Ille du France) has been the one to enjoy the largest increase in its HST supply mainly due to the spatial concentration of population".

Nevertheless, the major big cities with populations over 500,000 such as Le Mans, Vendome, Nantes, Lyon and Lille have experienced some growth mainly due to increases in land values and improved "economic cooperation and exchanges with Paris" stimulated by the TGV.[285] However, Haynes (1997) notes that most of these cities already had relatively "strong local economies with dominant regional roles" and good transport links (e.g., Nantes and Le Mans).[286]

Developments around TGV stations have been more substantial by attracting new businesses (e.g., the Euralille business district near the Lille-Europe station).[287] One of the "interesting policies implemented at the regional level involves the development and improvement of the regional rail services that serve the nodes with HSR stations so that benefits can be spread more widely and overall accessibility be enhanced".[288] As a result, the TGV traffic in main nodes increased more than was expected. However, in the small intermediate cities like Mâcon, Le Creusot, Montceau and Montchanin this policy failed "as the stations located outside the urban areas lacked efficient multimodal connections and dynamic economic area surrounding the station". For example, "in Montchanin the HST link has attracted just four firms, creating 150 new jobs".[289]

Impacts on residential choice and commuting

The study undertaken by Engenharia/Holland RailConsult (2006) concludes that the TGV experience in France has demonstrated that the availability of a HSR connection plays an

[282] Masson, A. and Petiot, R. 2009.
[283] Shin, D. 2005. Recent Experience of and Prospects for High-Speed Rail in Korea: Implications of a Transport System and Regional Development from a Global Perspective. Working Paper 2005-02. Institute of Urban and Regional Development, University of California, Berkeley.
[284] Arduin, J.P. 1991. Las líneas de Alta Velocidad y el acondicionamiento del territorio (High Speed lines and spatial planning). Obras Públicas 22: 22-23.
[285] Alabate, D. and Bel, G. 2010.
[286] Haynes, K. 1997. Labor Markets and regional transportation improvements: the case of high-speed trains. *The Annals of Regional Science,* 31, pp. 57-76.
[287] California High-Speed Rail Authority. 2008. California High-Speed Train Business Plan. November.
[288] Vickerman, 1997.
[289] Alabate, D. and Bel, G. 2010.

important role in the households' residential choices. As a result of the high level of service offered by TGV "people working in Paris have relocated to live at acceptable commuting distances" and commuting pattern increases are observed from cities of Vendôme, Amiens, Lille and Arras, and Lyon. Lille, for example, registered an increase in population since the deployment of TGV station.[290]

Impacts on employment and business development

Overall, the improved accessibility provided by the HSR in France benefited mostly businesses and employment in Paris. In fact, Alabate et al. (2010) summarizes prior studies and states that the TGV "has neither accelerated industrial concentration nor promoted administrative or economic decentralization from Paris". Moreover, the existence of a TGV connection does not seem to be a decisive "factor" in determining office location for the firms. According to the survey of firms in Dijon, 30% considered HSR connection as one of decision "factors", and "only 4 firms from a total of 663 claimed it was a key determinant in their choice of location".[291]

As for impacts of the TGV on employment, they are positive and negative. On a positive side, the TGV led to the relocation of companies within the same region closer to HSR stations and companies outside of Paris became more competitive due to their proximity to Paris enabled by the HSR service. On the negative side, reduction in travel costs from TGV allowed some French companies headquartered in Paris to close their 'back offices' in other cities and extend their Parisian offices instead. Examples of such effects are in Le Mans, where employment decreased. In Lille and Nantes the expected positive impacts on business development and employment were disappointing at least in the short-term. In Lille, "the new office buildings remained empty in the first years and only a few new companies were established". In Nantes, despite the reduced travel times to Paris on HSR, "the impacts on business and employment were almost negligible".[292]

Impact on Tourism Travel

Masson et al. (2009) paper elaborates on the TGV's effects on tourism. Overall, the effects have been positive, and a new group of travelers making round trips on the same day has emerged. Consequently, the volume of overnight tourists decreased across France, which led to some negative impacts on hotels business. However, hotel stays registered an overall increase due to inflow of international visitors stimulated by the trans-European HSR links, but the average length of stay significantly decreased. Almost all business hotels had to be restructured focusing more on leisure travelers. While some hotels went out of business, others adapted to the needs of new emerging customers. The increase in tourist/leisure trips has taken place mostly in direction of France's southern region that has enjoyed the benefits "from an increase in short stay travel within specific non-business markets".[293]

[290] TYCO Engenharia/Holland RailConsult (THR) and RAVE. 2006.
[291] Alabate, D. and Bel, G. 2010.
[292] TYCO Engenharia/Holland RailConsult (THR) and RAVE. 2006.
[293] Masson, A. and Petiot, R. 2009.

Impact on Rail Traffic Share

Since 1981, the HSR in France has doubled the overall rail passenger traffic. During 1999-2004, the passenger traffic carried by HSR increased by 62.5%. One of the distinct features of the French TGV is its high levels of induced traffic, which constitutes mainly leisure trips[294] (49% of traffic generated[295]). The HSR had a more serious impact on short-haul air traffic than road traffic (33% diversion from air and 18% from road[296]), leading to complete cancellation of air services between Paris and Brussels.[297] Currently, the French TGV carries about 128 million passengers per year.[298]

5.3 Paris-Lyon TGV Sud-Est Corridor

The TGV South-East (or TGV Sud-Est) high speed corridor is 425 km (264 miles)[299] long connecting France's two largest cities Paris and Lyon with travel time of two hours. This HSR route follows the alignment of autoroute A5 for 60 km and the road N79 for 15 km. The construction of the line began in 1975 and cost $4 million per km.[300] The line was opened in two stages in 1981 and in 1983 respectively.[301] It was the first operational high-speed line not only in France but in whole Europe. By 1983, with trains operating at speeds up to 270 km/h (168 mi/h) and later up to 300 km/h (186 mi/h), the journey times between Paris and Lyons had been cut from 4hrs 30min to just 2 hrs.

The line as the rest of the French HSR network was built as a separate non-mixed use link dedicated solely to high-speed passenger trains. The TGV Sud-Est fleet was built between 1978 and 1988. There are neither conventional nor freight services operated on the route, except the limited TGV La Poste service carrying mail for the French Post (La Poste) between Paris and Lyon.[302]

The Route and Intermediate Stations

The TGV Sud-Est currently serves Paris and Lyon with no or maximum one-stop service.[303] It starts outside of Paris, and runs directly to the edge of Lyon. To reach the stations in the city centers of Lyon and Paris, the TGV switches to the existing conventional rail tracks

[294] Lee, Y. S. 2007 A Study of the Development and Issues Concerning High Speed Rail (HSR). Transport Studies Unit, Oxford University Center for the Environment. Working Paper No. 1020. Retrieved on 02/08/2010 from http://www.tsu.ox.ac.uk/pubs/1020-lee.pdf

[295] Bonnafous, A. 1987.

[296] Ibid

[297] Ebeling, K. 2005. High-Speed Railways in Germany. *Japan Railway & Transport Review,* 40. March.

[298] Le Journal du Net (web). Retrieved on 05/11/2010 from http://www.journaldunet.com/economie/magazine/dossier/les-produits-qui-se-vendent-malgre-la-crise/les-billets-de-tgv-toujours-sur-de-bons-rails.shtml

[299] The dedicated high-speed line portion is 409 km, and the rest is regular rail track.

[300] Arduin, J. and Ni, J. 2005. French TGV Network Development. *Japan Railway & Trasport Review,* 40. March. Retrieved on 05/11/2010 from http://www.jrtr.net/jrtr40/pdf/f22_ard.pdf

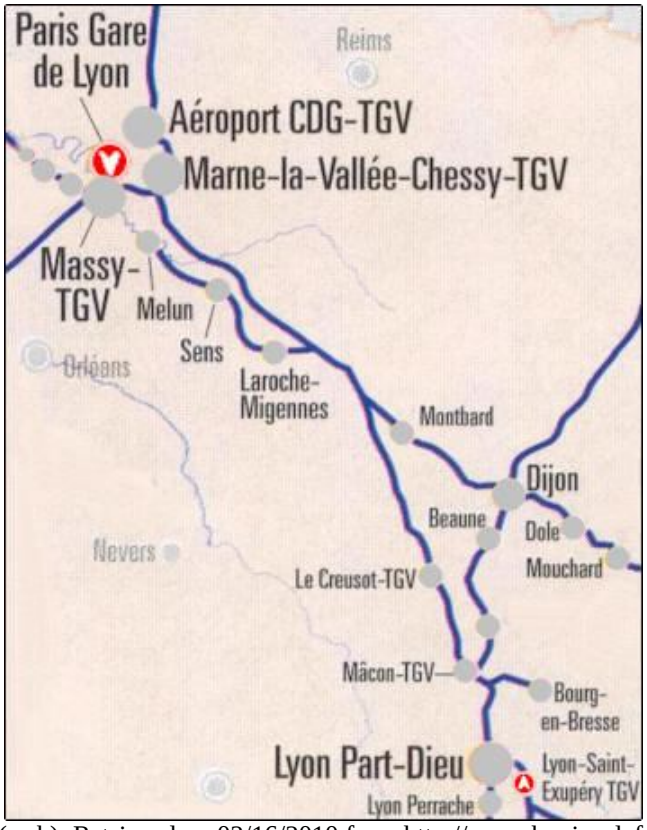
[301] Nash, C. 2008.

[302] A.T. Kearney. 2003. Formulating the strategy for HSR in Portugal. Presentation for RAVE. Lisbon, Portugal. June.

[303] Sands, 1993. The Development Effects of High-Speed Rail Stations and Implications for California. California HSR Series. Working Paper 566. University of CA at Berkeley, CA.

but runs at conventional rail speeds.[304] At about a half way down the TGV Paris-Lyon route, a line branches off to connect to Dijon via the conventional tracks, and continuing on to Switzerland. Once off the Paris-Lyon line, the TGV trains are limited to conventional running speeds. Similarly many trains continue south of Lyon on the existing tracks to the South Coast (Figure 5.5).

Figure 5.5: Map of Paris-Lyon TGV Sud-Est Line



Source: Bonjour La France (web). Retrieved on 02/16/2010 from http://www.bonjourlafrance.com/france-trains/tgv-lyon-bourgogne-franche-comte/paris-lyon-saint-exupery-tgv.htm

The TGV system's compatibility with the conventional rail network eliminated the need for new infrastructure construction to reach existing train stations in the dense urban areas of Paris and Lyon – Gare de Lyon in Paris and Part-Dieu in Lyon. The distance between the two stations is 425 km 264 miles), of which 409 km (254 miles)run on a dedicated high speed (LGV) line and 16 km (10 miles) are on conventional tracks. Avoiding built-up areas between Paris and Lyon allowed building the HSR route that is 87 km (54 miles) shorter than the existing conventional rail (512 km/318 miles)). The route also features no tunnels and provides connectivity to the regular rail network at several points.

[304] Schwob, B. 1995.

The TGV Sud-Est also serves two intermediate stations – Le Creusot or Mâcon-Loché, which were the only stations built new for the corridor. They are basic-looking stations situated away from built-up areas. The service frequencies at Paris and Lyon stations are about 30 trains a day (running almost every 30 minutes). The service and frequencies at intermediate stations vary with mostly non-stop through trains passing between Paris and Lyon and only few making intermittent stops at one of the intermediate stations[305] (Table 5.1). No direct HSR connection is available between Le Creusot and Mâcon-Loché that are only 60 km (37 miles) apart.

Le Creusot Station (Gare du Creusot). This station was opened in 1981 with the inauguration of the Sud-Est HSR line. It is located outside of Le Creusot in the town of Écuisses in the Burgundy (Bourgogne) province and is accessible by road. The majority of TGV Sud-Est trains pass through the station without stopping. The station is positioned between Paris-Gare de Lyon and the southbound station Gare de Mâcon-Loché. TGV journey times from the station to Paris is 1hr 20min and to Lyon – 40min.[306]

Mâcon-Loché Station (Gare de Mâcon-Loché). This TGV station was also built in 1981 along with the new TGV line. It is located in the commune of Mâcon in the Bourgogne province, a few kilometers from the neighboring town of Loché. The station is positioned on the TGV Sud-Est route between the southbound Part-Dieu Station in Lyon and the northbound station Gare du Creusot. Gare de Macon-Loche is connected to the regional railway network via a shuttle bus.[307]

Tables 5.1 and 5.2 demonstrate the TGV train frequencies and fares based on the winter 2010 schedules.

Before the TGV: decision-making

In the 1970s, before the deployment of Paris-Lyon TGV, the conventional rail link joining Paris-Lyon-Medditerannée (PLM) – "the gateway to south-east France" – was experiencing high levels of congestion. [308] The corridor was considered strategically important, serving 40% of the population in France, and was rapidly approaching its maximum capacity limits. To compete with air services, SNCF was also seeking for ways to improve the railway speeds. The existing PLM line had a capacity for running trains at maximum speeds of 160km/h (100mi/h). Different alternatives were considered including an upgrade of the existing line to operate at 200km/h (125mi/h) speeds. However, intensive economic and technical research led to a conclusion that building a completely new line would cost only 40% more than an upgrading the existing line would cost due to the tunnels on the existing tracks. Moreover, an important feature in favor of the new line alternative was that it would allow achieving speeds much higher than 200km/h.

[305] Sands, 1993.
[306] Wikipedia. Gare du Creusot. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/Gare_du_Creusot_TGV
[307] Wikipedia. Gare de Macon-Loche. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/Gare_de_Mâcon-Loché_TGV
[308] Alabate, D. and Bel, G. 2010.

Table 5.1: Approximate Frequencies of TGV trains (2010)

(Number of trains per day in one direction, no connection/direct service only)

	TGV trains
Paris Care de Lyon – Lyon Part-Dieu	30
Lyon Part-Dieu – Paris Gare de Lyon	30
Paris Gare de Lyon – Macon Loche	8
Paris Gare de Lyon – Le Creusot	7
Le Creusot - Paris Gare de Lyon	10
Macon Loche - Paris Gare de Lyon	5
Le Creusot – Lyon Part-Dieu	8
Macon Loche – Lyon Part-Dieu	8
Lyon Part-Dieu – Macon Loche	7
Lyon Part-Dieu –Le Creusot	10

Note: Estimated frequencies based on a week day train schedules in winter 2010.
Source: self calculated estimates based on SNCF TGV train timetables (http://www.voyages-sncf.com), 2010

Table 5.2: TGV Fares by Origin-Destination (second class fares, in Euros) (2010)

		DESTINATION			
ORIGIN		Paris Gare de Lyon	Le Creusot	Macon Loche	Lyon Part-Dieu
	Paris Gare de Lyon		71.30	71.80	83.90
	Le Creusot	71.30		--	27.80
	Macon Loche	71.80	--		13.60
	Lyon Part-Dieu	83.90	27.80	13.60	

Note: TGV fares are based on the SNCF TGV timetables for a weekday in winter 2010. (The TGV service between Macon Loche and Le Creusot was not obtainable via online timetable.)
Source: based on SNCF TGV train timetables (http://www.voyages-sncf.com), 2010

Thus, a proposal was made to build a new separate HSR line from Paris to Lyons. The name Sud-Est was chosen to "emphasize the network effects of the line", which besides serving the Paris-Lyons market was expected to serve the destinations beyond Lyons.[309] The economic evaluation conducted prior to construction of the route served as an economic justification for the investment. Evaluating the project over an operating period of 20 years yielded a positive net profit value at 8% discounted rate and an IRR of 12%, proving a good profitability of the Paris-Lyon high speed link. [310]

The selection of the route alignment and stations was a political process with all the decisions mainly made by the centralized government. Originally, the TGV Paris-Lyon was designed as a "plane on track" with the shortest journey time possible. The design included neither stations nor connections. Subsequently, the stations were added in Le Creusot and Macon, both in Burgundy province, and connections linked to the conventional rail network.[311]

The line passes through six départements, from north to south – Seine-et-Marne, Yonne, Côte-d'Or, Saône-et-Loire, Ain, and Rhône – located in three provinces – the Paris Region (or Ille de France), Burgundy (or Bourgogne), and Rhone-Alps (see Figure 5.6 for political map of France).

Cities along the Corridor

Paris and Lyon are the two largest cities in France, but Paris has a far greater dominance in almost all aspects of economic and social development. As depicted in Table 5.3, while population of Rhone-Alps province, where Lyon is a capital, is "half that of the Paris region, its production is only 1/3 of that of Paris region".[312]

Paris

Paris is not only a dominating city in France but is also one the world's major global cities. The French capital is situated on the river Seine in the Paris Region. The most populated metropolitan area in Europe, it has a population of 12 million (2.2 million within the city of Paris administrative limits) and density of 24,448/km^2 inhabitants (as of 1999 official census). With the GDP of 552.7 billion Euros ($813.4 billion) as of 2008, the Paris region accounts for more than 25% of national GDP.[313] In 2007, the Paris urban agglomeration was Europe's biggest city economy. According to the latest survey by the Economist Intelligence Unit (2010), Paris is the world's most expensive city to live in.[314]

[309] Nash, C. 2008.
[310] Schwob, B. 1995.
[311] LGV 2030 (web). Les lignes existantes et en construction. Retrieved on 03/10/2010 from http://lgv2030.free.fr/ligne1.htm#SudEst
[312] Bonnafous, A. 1987.
[313] Statistiques locales Official Website. Retrieved on 03/15/2010 from http://www.statistiques-locales.insee.fr/carto/ESL_CT_cartethematique.asp?lang=FR&nivgeo=ZE1990
[314] The Economist Online. 2010. "Living Costs in Big Cities." Article. Retrieved on 03/15/2010 from http://www.economist.com/daily/chartgallery/displaystory.cfm?story_id=15659589

Figure 5.6: Map of French Provinces affected by TGV Sud-Est Line

Source: Maps of the World, 2010. Retrieved on 03/10/2010 from http://www.mapsofworld.com

Table 5.3: The Rhone-Alps province versus the Paris region

	Paris region	Rhone-Alps region
Population in 1982	10.07 million	5.02 million
Share of the GNP	27%	9%
Share of the population employed in the service sector (% of the national total)	43%	9.6%
Share of the registered offices of the top 500 French enterprises	77.6%	3%

Source: Bonnafous, A. 1987. The Regional Impact of the TGV. *Transportation*, V. 14, No. 2, pp. 127-137, June

The Paris region is France's primary centre of economic activity. In terms of businesses, the Paris region houses 38 of the Fortune Global 500 companies and a number of international organizations such as UNESCO, the Organization for Economic Co-operation and Development (OECD), the International Chamber of Commerce (ICC) and the informal Paris Club. The Paris region also attracts about 45 million tourists annually. The Paris economy is largely dominated by services industry; however, it still is considered an important manufacturing powerhouse of Europe, especially in industrial sectors such as automobiles, aeronautics, and electronics. Over recent decades, the local city economy has moved towards high-value-added activities, in particular business services. The largest purpose-built business district in Europe is located in Paris.

According to the 1999 census data, out of 5,089,170 persons employed in the Paris metropolitan area, 16.5% were in business services, 13% - in retail and wholesale trade, 12.3% - in manufacturing, 10% in public administration and defense, 8.7% in health services, 8.2% in transport and telecom sectors, 6.6% in education, and the rest of 24.7% in other economic sectors. In the manufacturing sector, the largest employers were the electronics and electrical industry and the publishing and printing industry.[315]

In terms of transport accessibility, Paris is well connected by all modes. The city has six major railway stations – Gare du Nord, Gare Montparnasse, Gare de l'Est, Gare de Lyon, Gare d'Austerlitz, and Gare Saint-Lazare – served by HSR, conventional inter-city trains and suburban rail. Paris is also accessible through two major airports: Orly Airport to the south, and the Charles de Gaulle Airport, which is one of the busiest in the world and is the hub for Air France carrier. A small airport, Beauvais Tillé Airport, located 70 km (43 miles) to the north of Paris, is used by charter and low-cost airlines. The fourth airport, Le Bourget, only hosts business jets, air trade shows and the aerospace museum. Paris also has an extensive road network with over 2,000 km (1,243 miles) of highways and motorways. The city is the most important hub of France's motorway network, and is surrounded by three orbital freeways: the Périphérique, the A86 motorway in the inner suburbs, and the Francilienne motorway in the outer suburbs.

Lyon

Lyon, the capital of the Rhône département and Rhône-Alpes province, is situated in the east-central part of France between Paris and Marseille and has a total population of 488,300 (as of 2007) and density of 9,850/km^2 (25,500/sq mi).[316] Together with its suburbs and satellite towns, Lyon forms the second-largest metropolitan area in France after that of Paris, with the population of 1,748,271 people (as of 2006).[317] Lyon metropolitan area accounts for half of the Rhône-Alpes province's entire population.[318] The city is known for its historical and architectural landmarks and as the culinary capital of France.

[315] Institut National de la Statistique et des Études Économiques, Official Website. Retrieved on 03/15/2010 from http://www.insee.fr/fr/default.asp

[316] Statistiques locales Official Website. Retrieved on 03/15/2010 from http://www.statistiques-locales.insee.fr/carto/ESL_CT_cartethematique.asp?lang=FR&nivgeo=ZE1990

[317] Institut National de la Statistique et des Études Économiques, Official Website. Retrieved on 03/15/2010 from http://www.insee.fr/fr/default.asp

[318] Region Urbaine de Lyon Official Website. Retrieved on 03/15/2010 from http://www.regionurbainedelyon.fr/principal-characteristics-102-2.html

The GDP of Lyon is 52 billion Euros, and the city is the second richest city after Paris. Lyon and its province Rhône-Alpes represent one of the most important economies in Europe and, according to the ECER-Banque Populaire survey, Lyon is ranked 14th favorite city in the European Union among entrepreneurs for the creation of companies and investment.[319]. The city of Lyon is working to attract more new headquarters on its territory.

Lyon is also a major industrial centre specializing in chemical, pharmaceutical, and biotech industries. The city also contains a significant software industry with a particular focus on video games. It hosts the international headquarters of many companies and organizations such as Interpol, Euronews, International Agency for Research on Cancer, Toupargel, Lyon Airports, BioMérieux, and others. The tourism industry is very important for Lyon and it contributed 1 billion Euros in 2007 and 3.5 million hotel overnight stays in 2006. Lyon is a leader in the hotels business in France.

Lyon has two airports: the Saint-Exupéry International Airport and The Lyon-Bron Airport. The former is located 20 km (12 miles) east of Lyon and serves domestic and international flights. The TGV station at Lyon Saint-Exupéry Airport facilitates the air-HSR connectivity, especially with Paris Charles de Gaulle Airport. The Lyon-Bron Airport is a smaller airport located 10 km (6.2 miles) east of Lyon city center and dedicated to General Aviation, both private and commercial. In addition to the station at the airport, the city also has two major railway stations: newer Part-Dieu station serving TGVs and older Perrache station primarily serving regional trains and Eurolines intercity coach buses. Other smaller railway stations operating in the city include Gorge de Loup, Vaise, Vénissieux, St-Paul and Jean-Macé. Lyon is at the heart of a dense road network and is located at the intersection of several highways such as A6 leading to Paris, A7 to Marseille, A42 to Geneve, A43 to Grenoble. The city is now also bypassed by the A46 autoroute. Lyon is served by the Eurolines intercity coach organization.

Le Creusot

Le Creusot is a commune (municipality level) situated in the Saône-et-Loire department south of Bourgogne province in eastern France with a population of 24,441 people (as of 2006) and density of 1,350/km^2 (3,500/mi^2). Formerly a mining town, its economy is now dominated by metallurgical companies such as ArcelorMittal, Schneider Electric, and Alstom. Since 1990's, the town has been developing tourism sector. Le Creusot is also the second educational centre of the Bourgogne province after Dijon.[320] During a period from 1982 to 2007, the town registered a decreased in its population – down from 32,150 in 1982 to 23,800 in 2007.[321]

Le Creusot is served by the regional TER rail service and connected to the high speed TGV network through the Le Creusot-TGV station. The city is near the highway because the road connects via N80 to the A6 motorway in 25 minutes.

[319] European Cities Entrepreneurship Ranking (ECER). 2009. Banque-Populaire Survey. Retrieved on 03/15/2010 from http://www.ecer.fr/resultat_en.html

[320] Wikipedia.Le Creusot. Retrieved on 03/15/2010 from http://en.wikipedia.org/wiki/Le_Creusot

[321] Statistiques locales Official Website. Retrieved on 03/15/2010 from http://www.statistiques-locales.insee.fr/carto/ESL_CT_cartethematique.asp?lang=FR&nivgeo=ZE1990

Macon

Mâcon is situated in the Saône-et-Loire department in the most southern part of the Bourgogne province, 65 km north of Lyon and 400 km from Paris. It is the capital of the Mâconnais district and has a population of 35,393 (as of 2006) and density of 1,309 km^2 (3,390/sq mi). The population trend shows a decrease from 38,404 people in 1982 to 34,469 in 1999, however, it picked up slightly by 2006. The decline in population can be explained by the urban sprawl taking place throughout the Mâconnais district and adjacent areas, leading to lower densities. The population of the metropolitan area of Macon is 61,641 (as of 2006) and the Greater metro area constitutes 104,000 people.[322]

The city is accessed from the major motorways such as A6 linking to Paris and Lyon and A40 connecting to Geneva. In addition to the TGV train station Mâcon-Loché, the city is served by conventional trains from railway station Gare Mâcon-Ville on the routes of Dijon-Lyon and Dijon-Marseille. The city's river infrastructure on the Saône River provides waterway access to the Mediterranean Sea via the Rhône River.

The town's economic activity is dominated by the industrial river port, metallurgy, boating and logistics sectors. Macon is a home of the headquarters of the Chamber of Commerce and Industry of Saône-et-Loire department, the Chamber of Agriculture of Saône-et-Loire, and the Automotive Training Center.

Other Modes along the Corridor

Before the TGV

The Paris-Lyon corridor, prior to deployment of the HSR link, was served by the 512 km long conventional rail line. The line followed a longer route passing through the built-up areas with many stops, including Dijon (see the map in Figure 5.5), connecting Paris to Lyon in 4 hours and 30 minutes. Both intermediate city-stops of Le Creusot and Macon were connected to the regional and inter-city rail services but through different stations. The regional trains also connected directly Macon and Lyon in about 50 minutes. As discussed earlier in the chapter, the corridor was experiencing very high rail transportation demand growth, which it could not absorb, and in the 1970's its capacity reached close to saturated levels.

The route was also served by air flights connecting the Saint-Exupéry International Airport in Lyon and the Paris Charles de Gaulle Airport with 70 minutes of in the air time. Compared to the conventional rail service, air was becoming more competitive and rapidly eroded the Paris-Lyon passenger market share, to which the railways' capacity problems and low speeds contributed even further.

In addition, Autoroute 6 (A6) known as Autoroute du Soleil is a major motorway connecting Paris and Lyon and the areas in between, including Le Creusot and Macon. The travel time from Paris to Lyon by the motorway is 4 hours and 20 minutes; the journey from Paris to either Le Creusot or Macon takes 3 hours and 40 minutes. A6 has been known for its severe traffic jams at bottlenecks such as the Tunnel de Fourvière near Lyon. The motorway

[322] Wikipedia. Macon. Retrieved on 03/15/2010 from http://en.wikipedia.org/wiki/Macon

originates at two points in Paris, Porte d'Orléans and Porte d'Italie, and runs along the two branches, A6a and A6b respectively, merging into A6 in the south of Paris. Being the main link to the holiday destinations in the south of France, the motorway is mostly used by leisure travelers.

Before the introduction of the HSR line, the mode split of the passenger traffic along the Paris-Lyon corridor was 31% air, 40% conventional rail and 29% road. Table 5.4 demonstrates the market shares by mode before and after the TGV Sud-Est.

Table 5.4: Market Shares by Mode on Paris-Lyon Corridor: Before and After the HSR

	TGV Sud-Est	
	Before	After
Plane	31%	7%
Train	40%	72%
Car and Bus	29%	21%
Source: COST318 (1996).		

Source: Nash, C. 2008. High Speed Rail Investment: an overview of the literature. Institute of Transport Studies, University of Leeds.

After the TGV

The inauguration of the high-speed line TGV Sud-Est between Paris and Lyon in 1981 increased the overall competitiveness of the rail services and had a notable impact on other modes serving the corridor. The rail travel times fell almost 50% from 4hrs 30 min on the classic rail route to just 2 hours via the new TGV line.[323] By providing significant travel time savings, the TGV succeeded to "induce a substantial rise in the ridership and modal transfers from road and air".[324] By 1985, the TGV was carrying 15 million people per year. The number of all rail passengers increased from 12.5 million in 1980 to 22.9 million in 1992, 18.9 million of whom were TGV passengers, according to Vickerman (1997).[325] This growth came mainly from the diversion from air (33%), road (18%), and newly generated traffic of 49%.[326] The high level of induced traffic is considered one of the most distinct features of the Paris-Lyon HSR line.

The air travel has been almost fully replaced on this route and the road traffic has been growing at a much slower rate.[327] The SNCF states that its "TGVs have taken the dominant share of the air-rail travel market in several of the high speed corridors", with highest (90%) being in the Paris-Lyon corridor.[328] The corridor's HSR-air traffic share is estimated at 88% as of

[323] Nash, C. 2008.
[324] Schwob, B. 1995.
[325] Vickerman, R. 1997. High-speed rail in Europe: Experience and issues for future development. *The Annals of Regional Science*, 3, pp. 21-38.
[326] Shin, D. 2005.
[327] Petkova, B. 2007.
[328] Peterman, D., Frittelli, J. and Mallett, W. 2009.

2001.[329] Table 5.4 shows the market shares by mode after the Paris-Lyon TGV deployment (1996). More recent market shares by all modes are reported as 2% traveling by air, 18% by road, and 80% by rail.[330]

The standard rail lines operating regional and inter-city trains still serve the corridor. These lines are connected at several nodes to the dedicated HSR lines to allow some TGV trains to run on the conventional tracks in order to access older stations in built-up urban areas. However, TGVs operating on the conventional rail network have to run at conventional speeds, making frequent stops. Although affecting negatively on the travel times, such strategy allows expanding the service area of TGV trains without additional investments in new stations and providing service to more cities.

Travel time comparisons among different modes serving the cities connected by HSR in the Paris-Lyon corridor are presented in Table 5.5.

Table 5.5: Travel times for city pairs by mode (in minutes)

	Paris				Le Creusot[3]				Macon				Lyon			
	Rail[1]	Road	Air[2]	TGV	Rail[1]	Road	Air[2]	TGV	Rail[1]	Road	Air[2]	TVG	Rail[1]	Road	Air[2]	TGV
Paris					N/A	220	N/A	80	N/A	220	N/A	95	270	260	160	120
Le Creusot[3]	N/A	220	N/A	80					N/A	80	N/A	N/A	N/A	115	N/A	40
Macon	N/A	220	N/A	98	N/A	80	N/A	N/A					49-59	55	N/A	25-35
Lyon	270	260	160	120	N/A	115	N/A	40	50	55	N/A	35-40				

Notes:
-Travel times by Rail and TGV are estimated averages for the fastest and direct (minimum stops) trains that are most frequent.
-The travel times for all modes are from/to the respective TGV stations located in the city centers.
-N/A interprets as "no direct/no connection service provided" for convetional rail and "no airport" for air.
-There are no direct TGV connections between Macon and Le Creusot - TGV Sud-Est makes max one intermediate stop at either of two stations.
[1]Rail is for conventional rail services, inter-city (Corail TEOZ) service or regional trains (TER).
[2]Air travel times have been calculated approximately by adding to the flight time 90 minutes for travel time from/to city center to/from the airport, boarding and de-boarding pocedures; flights originated in Paris are from Charles de Gaulle (CDG) airport.
[3] No flights are available from Paris to the airport in Burgundy Region, where Le Creusot and Macon are located (nearest airport is in Dijon).

Source: self calculated estimates based on the timetables of SNCF (http://www.voyages-sncf.com), Expedia site (www.expedia.com) and trip directions on Google maps, 2010.

[329] ARUP – TMG. 2001.
[330] Midwest High Speed Rail Association. 2009. High-Speed Rail: Fact s. Fiction. Chicago, IL, USA. Retrieved on 02/08/2010 from http://www.midwesthsr.org/fact/index.html

After TGV: Megalopolis Formation and Development Impacts

Several empirical studies have been done to assess the impacts of the TGV line on the regional and economic development of Paris and Lyon, with emphasis on business location and development, and tourism. Overall, the line connecting the two strongest economic regions in France, was fully successful technically, commercially and financially, generating the traffic demand and net revenues beyond the estimated forecasts. The line has paid off its construction costs within 11 years and still remains a profit-maker for SNCF.[331]

Evidence of Megalopolis Formation

In the last 30 years since its implementation, the HSR Sud-Est link has gradually brought Paris and Lyons, the two largest urban centers in France, closer by reducing the "temporal distances" between them (see Figure 5.7). The distance is no longer quoted in kilometers but in hours and minutes, with Lyons being only two hours away from Paris. Roth (1990) discusses that the perception of transportation users has evolved and "travel time or 'temporal distances' matter more than the distance traveled," creating "a certain psychological impression of the weight of the trip made." He asserts that "the TGV modifies the spatio-temporal relationships between cities... and as a consequence influences the behavior of potential and actual users", which in turn eventually leads to changes in the "social and economic relationships between"

these cities.[332] The author also makes an interesting observation, that the "psychological weight of a trip" is determined not only by the "temporal distances" but also the quality of the service such as frequency, "comfort", "ease of access", and other factors that "ease" the trip.[333]

One of the fundamental impacts of the Paris-Lyon HSR on the users' behavior is the significant levels of induced traffic it generated, attesting mainly to the increase in business trips made related to the buying/selling of services. Total business travel on the corridor increased 56%, and those made for sale/purchase of services by 112%.[334] Table 5.6 shows the growth of business travel by mode originating in Paris and Lyon between 1980 and 1985. As can be seen, round trips originating in Paris increased much less than round trips originating in Lyons. In addition, the surveys[335] showed that the number of overnight stays by TGV passengers fell after the introduction of HSR from 74 to 46% (between 1981 and 1985).

Thus, the reduced "temporal distance" between Paris and Lyons due to HSR link has led to changes in the mobility patterns of users, and generated new travel with high number of one-day roundtrips. These factors provide an evidence of a formation of a megalopolis or megaregion between cities of Lyon and Paris. However, despite the connection to the TGV, the intermediate cities, Le Creusot and Macon, have not experienced the same levels of interaction with Paris or Lyon. This can be explained by the very low frequencies of HSR services provided in these cities (8 vs. 30 trains/day in Paris and Lyon - Table 5.1).

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[331] Ibid

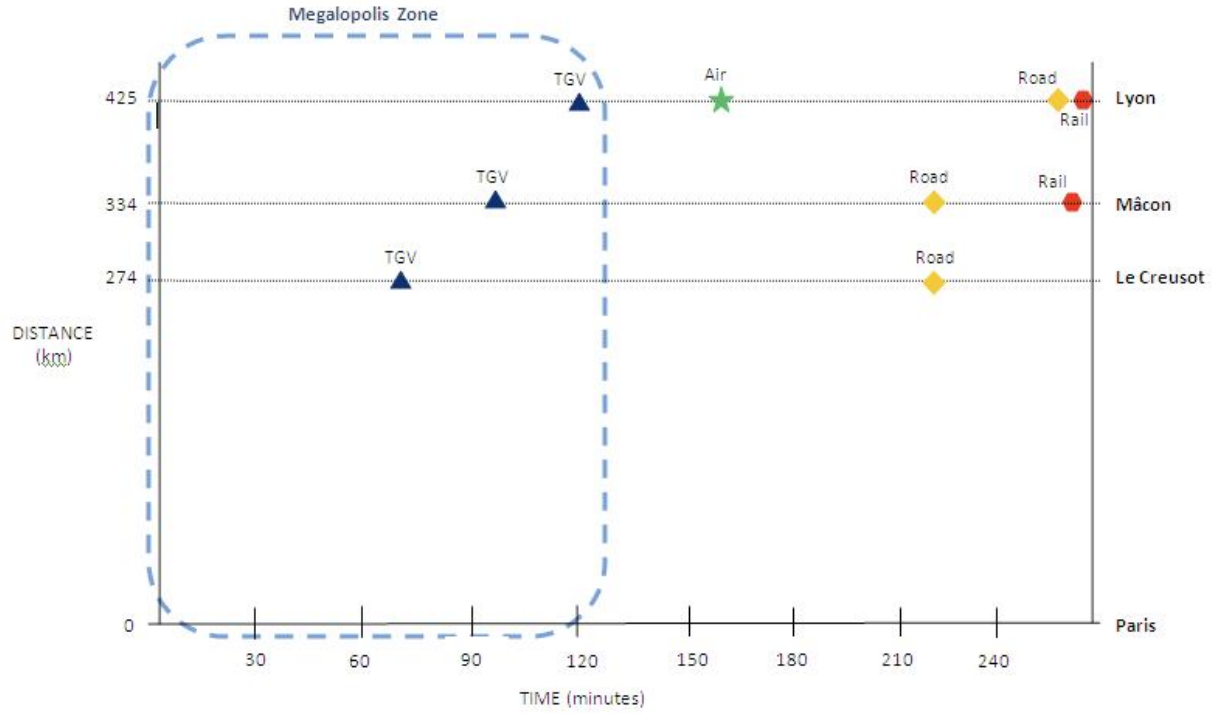
[332] Roth, D. 1990. The TGV System: A Technical, Commercial, Financial and Socio-Economic Renaissance of the Rail Mode. Department of Systems, University of Pennsylvania, Philadelphia, PA.

[333] Ibid

[334] Pieda (Planning, Economic and Development Consultants). 1991. Rail Link Project: A Comparative Appraisal of SocioEconomic and Development Impacts of Alternative Routes. Reading: Pieda.

[335] Bonnafous, A. 1987.

Figure 5.7: Time-Space Chart for Commuting Times from/to Paris by mode



Notes:

- Rail is for conventional (regional and inter-city) trains.
- No air services available to Macon and Le Creusot.
- No direct TGV service is available between Macon and Le Creusot.
- No direct conventional rail link available between Paris-Macon.
- Travel by conventional rail between Paris and Macon involves at least one transfer (via Dijon). Conventional trains serve Macon Centre station in Macon, which is different from the TGV station Macon-Loche.
- No conventional rail service runs between Le Creusot and Paris, and between Le Creusot and Lyon.

Table 5.6: Growth of business travel (1980-1985)

	Mode		Trip Origin		Overall
	Train	Airplane	Paris Region	Lyons Region	
Growth Rate	151%	-46%	20%	86%	56%

Source: Roth, D. 1990. The TGV System: A Technical, Commercial, Financial and Socio-Economic Renaissance of the Rail Mode. Department of Systems, University of Pennsylvania, Philadelphia, PA.

Economic Development

Most benefits of the HSR service supply between Paris and Lyon have been absorbed by the Paris region, "mainly due to the spatial concentration of population". Some positive effects from the HSR connection are also observed in Lyon, mainly "in the form of an increase in economic cooperation and exchanges with Paris".[336]

An empirical study undertaken by Bonnafous (1987) discusses the regional impact of the TGV HSR between Paris and Lyons based on the surveys conducted before and after HSR inauguration with an emphasis on tourism and services industry. Before the TGV deployment, the survey found that the TGV created fears among the service enterprises in the Rhone-Alps province (around Lyon) that their Parisian competitors would expand and displace them. However, in reality the opposite occurred: the Lyon region companies were able to access and expand to the Parisian market mainly in market research, advertising and consultancy areas, thus benefiting from the TGV connection. The fears that Lyon might lose its company headquarters to Paris also did not happen: specialized enterprises, whose markets are outside the regional boundaries or are international, no longer needed to relocate to Paris as it became easily accessible with TGV. So, there is an emerging trend to look for clients in Paris but carry out work in the province with calm and different quality of life. The survey showed that Parisians increased their business journeys to the Rhone-Alps province by 52% for service trade, while the residents of Rhone-Alps have increased their trips to Paris by 144% for the same purposes.[337] It has to be noted that these surveys were conducted two-three years after the inauguration of Paris-Lyon TGV line, and the effects may have evolved further by now.

In case of Macon, some development occurred, which was partially spurred by the HSR connection. Macon registered a 13.5% increase in employment between 1999 and 2006, compared to surrounding cities which have actually lost jobs. This growth can be attributed to the availability of high speed linkages resulting in proximity to the large neighboring economic centers of Paris and Lyon. The decrease in employment in the adjacent cities attests that the relocation of some businesses took place within the province to near the HSR station in Macon. Macon has always been one of the Saône-et-Loire department's major employment areas and attractive for the regional companies, and the HSR link helped to reinforce Macon's already attractive location. On the negative side, the growth in Macon appears to have occurred at the expense of the neighboring cities from where the companies relocated.

The development impacts on the former coal producing town of Le Creusot were not as expected. The town hoped to attract a large pool of companies by its new HSR station and 85 minute time distance to Paris; however, six years after the opening only two companies were situated around the TGV-station.[338] Also, a new TGV station "had almost no local economic impact in terms of new jobs, firms or commercial expansion. This was due in part to its isolated station, poor road access and historical image".[339]

[336] Alabate, D. and Bel, G. 2010.
[337] Bonnafous, A. 1987.
[338] TYCO Engenharia/Holland RailConsult (THR) and RAVE. 2006.
[339] Haynes, K. 1997.

The opening of HSR connection in Lyon helped to attract companies from cities not connected to the TGV HSR network such as Grenoble and Genève. A number of high-tech companies originating from Paris also opened their "back-offices" in Lyon. The companies concentrated mostly close to Lyon's TGV station Gare Part Dieu, which has developed into one of the most important business parks of France. The amount of its office space has increased by 43% between 1983 and 1990. Due to the local authorities' efforts to promote Part-Dieu station development, the area around this TGV station has become "the most sought-after location for office space in Lyon" with "almost 40 percent of the city's total office space", and planned for more. Between 1983 and 1990, the office space around the station was increased 43% (from 175,000 m^2 to 251,000 m^2).[340]

However, it should be noted that "these measures may reflect displacement of activity from elsewhere and should not be interpreted as being indicative of net growth.[341] The development of businesses around HSR station in Lyon has developed at the cost of a lower development in the city's traditional downtown, which has become deserted by companies relocating to near the TGV station. Other negative affects are the experiences by the cities without HSR such as Grenoble and Geneve, who lost their businesses to Lyon.

While the business growth in Lyon can be attributed mainly to introduction of the HSR link, many argue that Lyon's location was already attractive before the TGV started operations, and the TGV was only part of the decision process for businesses to locate themselves at the city's station area. Sands (1993) and Haynes (1997) conclude that the TGV plays a minor role in location decisions of most firms. To the survey of businesses near the Lyon's Part-Dieu Station, only 33% responded that HSR was one of the factors in their location.[342] These companies have indicated that "the HSR station was an important factor, but not the decisive one for setting-up offices in Lyon. Plans did already exist and the TGV subsequently acted as an incentive".[343] Other factors include market proximity, accessibility to the rest of the transport network (road and rail links), and public assistance.

Lyon also experienced a strong growth in tourism business after the introduction of HSR, which has had major impact on the city's economy, but the effects were two-fold. On one hand, while business trips increased, the TGV allowed making these trips in a day, thus reducing the number of overnight stays to the detriment of hotel businesses (length of stay decreased from 2.3 days in 1980 to 1.7 days in 1992). On the other hand, the overall number of visitors for conferences has increased, forcing the restructuring of the hospitality businesses to adapt to new groups of customers. The HSR along with the hospitality infrastructure development and Lyon's "aggressive promotion and communication strategy" have put Lyon "on the tourist map and increased tourist awareness of the city."[344]

[340] Sands, 1993.
[341] Kamel, K. and Matthewman, R. 2008. The Non-Transport Impacts of High Speed Trains on Regional Economic Development: A Review of the Literature. Locate in Kent Agency. November.
[342] Ibid
[343] TYCO Engenharia/Holland RailConsult (THR) and RAVE. 2006.
[344] Masson, A. and Petiot, R. 2009.

5.4 Summary

The radial structure of the French TGV network is an adaptation to the French existing structure, where Paris is a major economic center with the largest population concentration. The HSR network reinforces further the dominating position of Paris and centralized nature for France's political, economic and social developments. Designed solely for high-speed passenger services and serving the connections with high traffic demand only, all TGV lines were built to link provincial capitals with Paris. The TGV's mixed model of railway infrastructure has also enabled efficient integration of the TGV with the existing conventional rail network. The government's goal to achieve the fastest operating speeds resulted in very few intermediate stops on the TGV lines, which led to connecting primarily major cities, with direct services from and to Paris and no or maximum one intermediate stop. Therefore, "the region surrounding Paris (Ille du France) has been the one to enjoy the largest increase in its HST supply mainly due to the spatial concentration of population". Other major big cities connected to the network with populations over 500,000 such as Le Mans, Vendome, Nantes, Lyon and Lille have also experienced some growth mainly due to increases in land values and improved communications with Paris stimulated by the TGV. However, Haynes (1997) notes that most of these cities already had relatively "strong local economies with dominant regional roles" and good transport links (e.g., Nantes and Le Mans).[345]

The Paris-Lyon TGV Sud-Est link connects the two strongest economic regions of France, Paris and the Rhone Alps province, which resulted in high ridership and large revenues. The impacts of the TGV line varied a lot, with some cities and economic sectors benefiting and some losing.

- Paris attracted the most benefits from the connection to Lyon, allowing some of the Paris-based companies to increase the services exchange in the Lyon markets.

- Lyon has also benefited substantially by attracting large pool of businesses, mostly relocated from neighboring cities and within Rhone-Alps province, high number of business tourists, and access to Parisian services market.

- Macon has experienced a small growth of businesses and increase in employment, but it was mainly due to business relocations within Saône-et-Loire department and not from Paris or Lyon.

- Le Creusot did not gain any benefits from the connection as no changes occurred in terms of jobs or commercial expansion.

The significantly high levels of induced travel generated by TGV have contributed to the economic development of the connected cities. However, the TGV mainly resulted in a redistribution of economic activity along the corridor, mainly from cities with no HSR to the cities with a HSR station, and no decentralization of activities out of Paris occurred. Hence, on the national level the growth led to winners and losers.

Thus, as in Japan, HSR in France has reinforced the existing centralization of economic service activities in big nodes and favored business trips. The impact on industrial activities has

[345] Haynes, K. 1997.

been minor. From this case, it appears that HSR spurs additional benefits for the cities that already had a strong economic basis before the connection.

* * *

The next chapter presents the last case study on German HSR system focusing on the impacts of the high speed link on the cities along the Cologne-Frankfurt corridor such as megalopolis formation and economic growth.

6 Germany: Inter-City Express (ICE) System

Germany started developing its HSR network shortly after France. Its first two Inter-City Express (ICE) high-speed lines were inaugurated in 1991, with upgraded links between Hannover and Würzburg and between Mannheim and Stuttgart. In 2002, Germany opened its first newly built passenger dedicated ICE line serving the 177 km (110 miles) distance between Cologne (Köln) and Frankfurt with travel time of 65 minutes (non-stop). Today, Germany has an established network of 1,285 km (798 miles) of ICE lines, serving the major German cities as well as destinations in neighboring countries at top speed of 330 km/h (205 mi/h). This chapter describes the overall experience of the German ICE and the impacts of the Cologne-Frankfurt high-speed link on megalopolis formation and economic development of the cities.

6.1 Country Background

Germany is located in Central Europe, bordering the Baltic Sea and the North Sea, the Netherlands, Poland, and Denmark, and has a population of 82 million.[346] It is the first largest economy in Europe by and the fifth largest in the world by purchasing power parity (PPP), and fourth largest in the world by nominal GDP. Germany's economy is a so-called "social-market" where private companies and markets operate in a highly developed welfare state.[347]

Germany is a federal republic administratively divided into 16 states. Its legislative branch is bicameral consisting of the Federal Council (Bundesrat) of 16 state government representatives; and the Federal Assembly or parliament (Bundestag) of 613 members elected by popular vote every four years. Head of State is the federal president who serves primarily a representative role, and the Head of Government is the chancellor elected for a four year term by the Federal Assembly. The Cabinet or Federal Ministers (Bundesminister) is the main executive branch appointed by the president on recommendation of the chancellor. The 16 states are parliamentary republics and the relationship between their legislative and executive branches is similar to that of the federal system.

Following the fall of the Berlin Wall, Germany underwent reunification of its formerly divided Eastern and Western parts on October 3, 1990, and Berlin was made the capital. Just prior to the reunification, 14 of the East German districts (not including East Berlin) reconstituted themselves, mainly along the old borders, into the five New States. The former district of East Berlin joined West Berlin to form the new state of Berlin. Thus the 10 states are called "old states", and five are "new states" plus Berlin.

Centrally positioned in Europe, Germany is an important transportation hub and features dense and modern transportation networks (Figure 6.1). The lagging transport network in the Eastern part of the country was upgraded significantly after the reunification. Germany has a

[346] Central Intelligence Agency (CIA). 2010. World Factbook. Retrieved on 02/20/2010 from https://www.cia.gov/
[347] The Economist Intelligence Unit (EIU). 2009. Country Commerce: Germany. Released July. New York, NY, USA.

Figure 6.1: Map of Transport Networks in Germany

Source: The Economist Intelligence Unit. 2010. Country Report: Germany. February. London, UK.

total of 550 airports, 33,780 km of railways[348], 644,480 km of roads, and eight ports and terminals.[349] Country's inter-city road network is over 231,000 km long, including about 53,400 km of federal trunk roads, 12,550 km of motorways, and 40,700 km of federal highways. The motorway called the Autobahn network, ranks third largest in the world in its total length with no speed limits on the majority of routes. The country's railway system is extensive and highly developed. In 2007, the number of passenger rail travel totaled 2.2 billion trips, and the volume of goods transported by rail reached 361 million tons.[350] The Federal Government's policy objective is achieving sustainable transport such as environment- and climate-friendly, socially responsible, and economically efficient transport system. Therefore, shifting more traffic to the railways and waterways is one of Germany's main transport policy goals.[351]

German Railway Sector

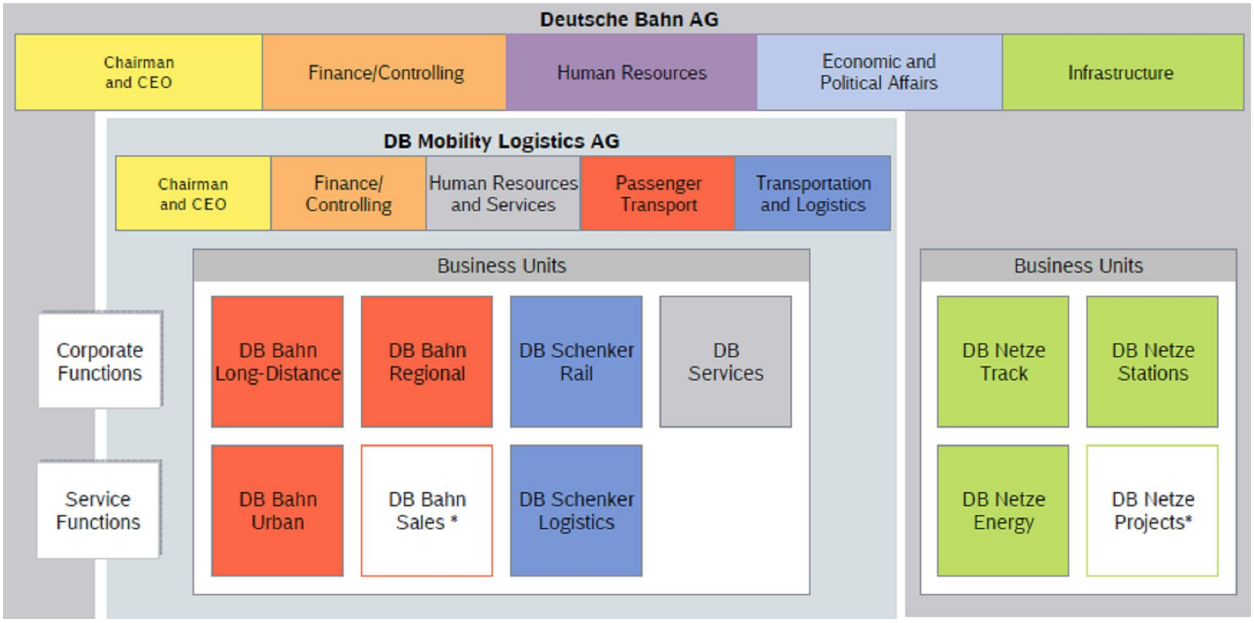
Article 87 of the German Constitution makes rail transport a government responsibility. Before 1993, German railways were under the responsibility of a federal agency Deutsche Bundesbahn. However, in the 1990's, the agency started experiencing financial difficulties that became a serious budgetary burden. To rescue the railways, the German government passed the General Railway Restructuring Act, under which Deutsche Bundesbahn was restructured into a state-owned commercial entity Deutsche Bahn (DB) in January 1994 with the goal of introducing market principles to the sector and enabling greater orientation toward customer needs.[352] Deutsche Bahn AG (DB-Holding) was created as a holding company divided into three broad groups: passenger transport; transport and logistics; infrastructure and services.[353] The railway infrastructure is managed by a subsidiary of Deutsche Bahn – DB Netz (see Figure 6.2 for structure of DB).

The Federal Network Agency newly created in 2006 is the regulator responsible for fostering competition by ensuring fair conditions for access to the railway network, and regulating the pricing structures to prevent the abuse of market power by dominant carrier such as DB.[354] Strategy development for rail sector in Germany falls under the jurisdiction of the Federal Ministry of Transport, Building and Urban Affairs (from herein referred as Ministry of Transport) that is also the owner of DB. Financing of the railways such as construction of new lines and improvements and maintenance of high-speed rail system is done from the proceeds of DB operations and subsidies from the federal budget. (Figure 6.3 depicts institutional structure of the railway system.)

In May 2008, the federal government decided to partially privatize DB, the last major 100% state-owned company in Germany. However, even after the planned privatization, DB would remain under the majority ownership of the German government. The privatization scheme entails the sale of 25% of the passenger, freight and logistics sector to private investors

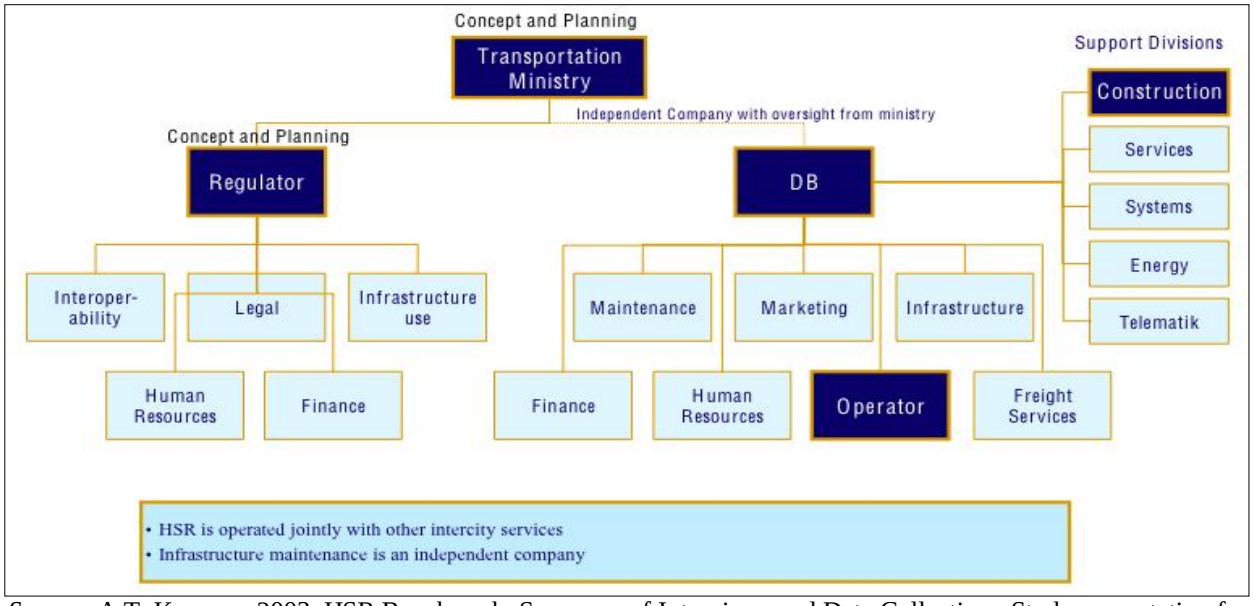
[348] Deutsche Bahn AG. Data provided by Dominik Fuerste of DB AG on 05/12/2010.
[349] Central Intelligence Agency (CIA). 2010. World Factbook. Retrieved on 02/20/2010 from https://www.cia.gov/
[350] The Economist Intelligence Unit (EIU). 2008. Country Profile: Germany. London, UK.
[351] Germany, Federal Ministry of Transport, Building & Housing. Federal Transportation Infrastructure Plan 2003. Retrieved on 04/27/2009 from http://www.bmvbs.de.
[352] The Economist Intelligence Unit (EIU). 1996. Country Commerce: Germany. Released September.
[353] Railway Technology (web). Retrieved on 02/20/2010 from http://www.railway-technology.com/projects/frankfurt/
[354] The Economist Intelligence Unit (EIU). 2008. Country Profile: Germany. London, UK.

Figure 6.2: Current Organizational Structure of German Railways Company



Source: Deutsche Bahn Corporate Presentation, July 2008 (provided by Dominik Fuerste of DB AG).

Figure 6.3: Institutional Structure of National Railway System in Germany



Source: A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

with the government retaining control over 75% of operations and full ownership of the infrastructure.[355] Thus, the federal government would remain the main owner of Deutsche Bahn AG (DB-Holding). The revenues from the share sales would be expected to be used, in equal shares, for the federal budget, for increasing DB's equity capital, and for investments in the railway projects within Germany, including high-speed rail. The initial public offering (IPO) originally scheduled for October 2008 has been repeatedly postponed due to unstable financial markets, and "seems unlikely until at least 2013", according to the Minister of Transport.[356]

6.2 Development of German Inter-City Express (ICE) System

Germany opened its first high-speed rail line in 1991. Its high-speed trains are called Inter-City Express (ICE). The ICE is managed and operated by Deutsche Bahn, and is company's most advanced service category. The ICE serves major German cities as well as destinations in neighboring countries such as Austria and Switzerland that use the same voltage, and the Netherlands and Belgium. The train maximum speed varies between 160 km/h (99 mi/h) and 300 km/h (186 mi/h). Connections are offered at either 30-minute, hourly, or two-hourly headways. The third generation of the ICE has a service speed of 330 km/h (205 mi/h) reaching up to 363 km/h (226 mi/h).

Decision-Making Process

The construction of the HSR in Germany was initiated by the Federal Ministry of Transport, Building and Urban Affairs, who conducted the first study on high speed transport system in 1969-1971. The study was carried out by the associates Deutsche Bahn (German Rail), Strabag Bau-AG and Messerschmitt-Bölkow-Blohm, and served later as the basis of developing the high-speed rail network in Germany. It aimed to answer a question of how to relieve burden from the roads by relocating the traffic to the rail system, and developed solutions for the future transportation system considering the performance and capacity limits of the existing transportation network. The developed solutions were then evaluated based on their impact on the national economy. The study outcome envisioned developing high-speed rail system for freight and passenger transport by deploying independent routes and linking them to the existing transportation system.[357] The initial decision to launch the HSR system had to be approved by both houses of the parliament. The Ministry of Transport is the primary decision maker on the investments in HSR.

The selection process of HSR projects is highly "political and follows the following phases":

1) DB identifies and proposes potential projects them to the Ministry of Transport with justifications based on an economic analysis;
2) The Ministry of Transport, together with the regulator, reviews the plan and provides approval;

[355] Germany, Federal Ministry of Transport, Building and Urban Development, Official Website. Retrieved on 01/28/2010 from http://www.bmvbs.de/en/Transport/Railways-,2077/Railway-reform.htm

[356] The Economist Intelligence Unit (EIU). 2009. Country Commerce: Germany. Released July. New York, NY, USA.

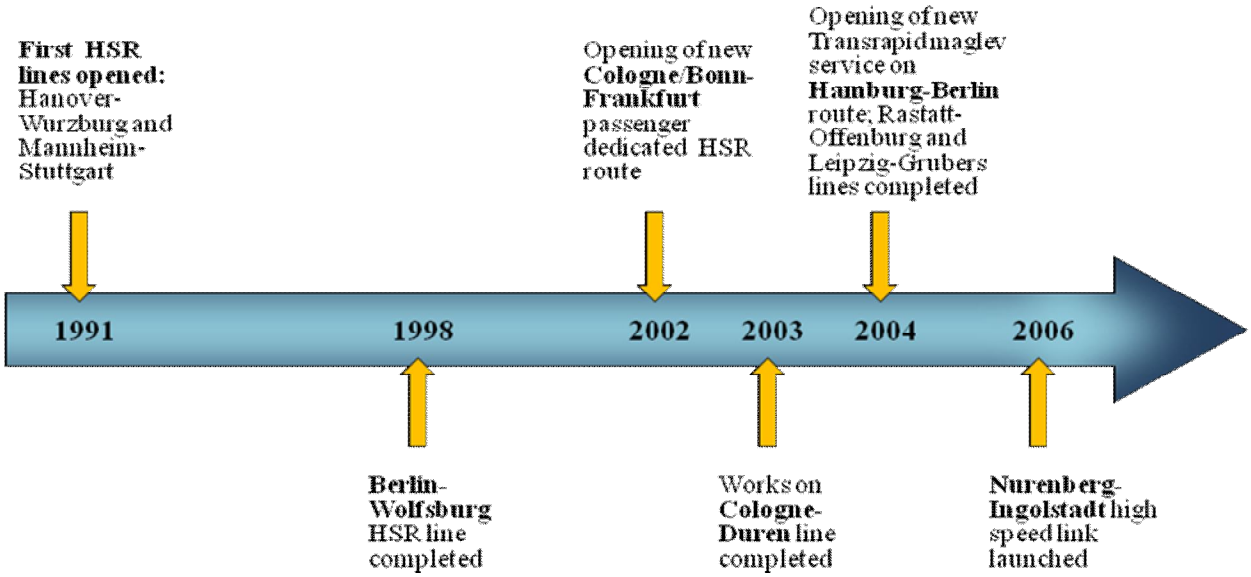
[357] Heinz D. K. 2009. *Inter-City Express – Die Entwicklung des Hochgeschwindig-keitsverkehrs in Deutschland.* Freiburg : EK-Verl. (in German, kindly translated in parts by Kristin Lubowski of Deutsche Bahn, March 2009).

3) The parliament approves the plan, ranks the approved projects and allocates budget.
4) The Ministry of Transport publishes the approved plan and launches studies to begin the implementation of the approved routes that receive funding.[358]

The Ministry of Transport and the regulator supervise the process and manage the government financing process. The selection of routes and station locations is a political decision based on "objective data" (financial and socio-economic benefits) and "subjective criteria" such as regional development, etc.

Deployment of Inter-City Express Network

Figure 6.4: Chronology of HSR Development in Germany

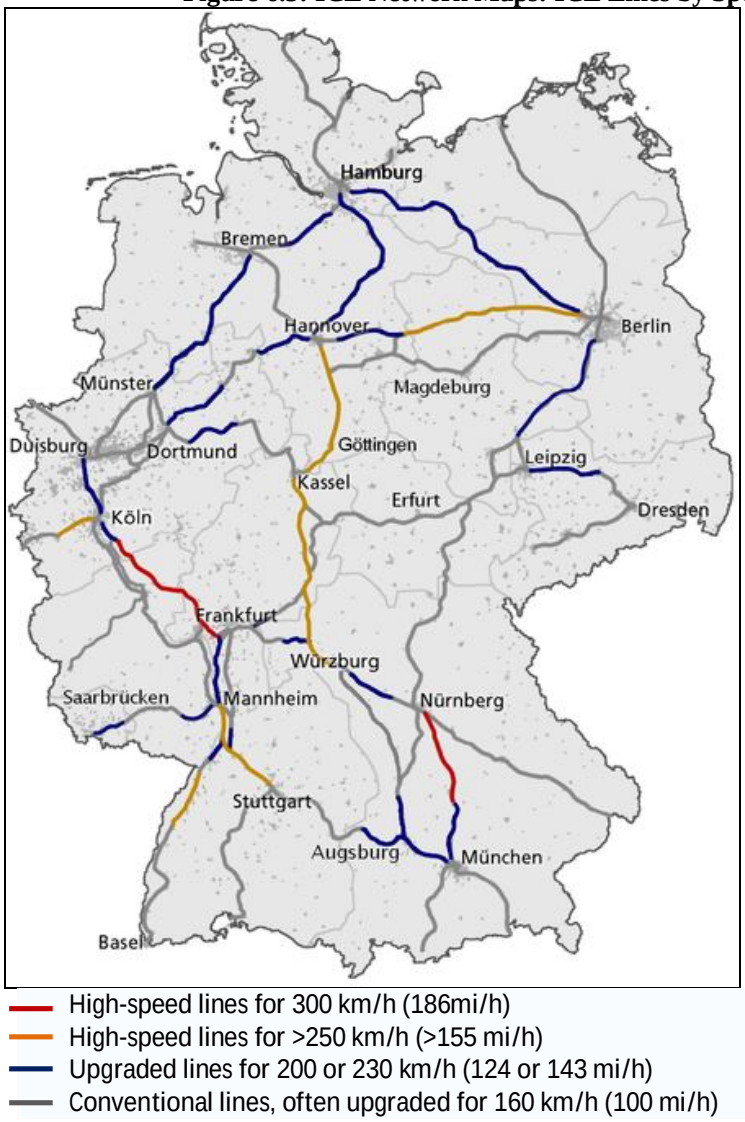


Development of the first German high-speed lines began shortly after that of the French TGV. However, due to significant delays the deployment of the Inter-City Express (ICE) in Germany took place ten years after the TGV network was established. The reasons for the delays were the construction problems given the country's mountainous terrain and the battles for the necessary legal and political approvals.[359] The first ICE trains were the train sets of ICE 1, which came into service in 1989. The ICE network was officially inaugurated on May 29, 1991. Today, Germany has an established 1,285 km (798 miles) long network of high-speed lines. Figure 6.5 presents maps of the German ICE rail network by speeds and by the used capacity of all sections respectively.

[358] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

[359] Dunn, J. and Perl, A, 1994. Policy networks and industrial revitalization: High Speed Rail initiatives in France and Germany. *Journal of Public Policy,* 14, 3, pp. 311-343.

Figure 6.5: ICE Network Maps: ICE Lines by Speed in 2008 (left) and by Capacity of ICE Rail System by Speed (right)



Source: Wikipedia. Retrieved on February 16, 2010 from http://en.wikipedia.org/wiki/File:ICE_Network.png#English

Source : Wikipedia. Retrieved on February 16, 2010 from http://en.wikipedia.org/wiki/File:ICEtracks.png`

The strategic objectives of HSR implementation in Germany were to increase rail market share, create a transportation backbone and the integration with the European network. The political objectives were to "link areas of high population density, reduce environmental pollution, and reduce road congestion."

The ICE was developed based on the Federal Transportation Master Plan.[360]. Germany's initial main goal was to overcome particular bottlenecks in on the original classic rail network and to improve north-south freight traffic. The original rail network in Germany constructed before World War II was oriented mainly to connect west and east. But given the "north-south patterns of industrial cooperation" in Western Germany, the railway network was restructured in order to accommodate these patterns and "to facilitate freight" movements between the ports in the north and industrial territories in the south. [361] That's why the first two new high-speed lines launched in 1991 were linking Hannover with Würzburg and Mannheim with Stuttgart. Following the country's political reunification, "the need to re-connect east and west became an additional priority" [362], which explains why the next links developed were Berlin-Wolfsburg and Nuremberg-Leipzig launched in 1998.

The initial stages of implementation of HSR were characterized by a long "debate between the Ministry of Transport and the railway management centered on the key issue of whether new lines should be dedicated solely to passenger traffic (following Japanese and French railways) or whether mixed passenger and freight traffic would be best". [363] The freight services have been historically the most profit making and, therefore, used by the railway company to compensate for the costly investments in new infrastructure. But this met a resistance from some high level advocates of separating passengers and freight.[364] Cologne-Frankfurt link was the first line newly built and dedicated solely to high speed passenger service, but its implementation had been delayed because of these political disagreements.

> ***Thus, in most instances Germany, unlike France or Japan, did not build a separate HSR network, but rather focused on a "phased approach to HSR implementation" by systematically upgrading existing inter-city rail lines" for multi-purpose freight and passenger use, with the exception of the line between Frankfurt and Cologne.***[365] [366]

Even though most of the ICE German network is designed for shared use by the very high speed ICE trains at 250 km/h (155 mi/h), by conventional Inter-City (IC) trains at 200 km/h (124

[360] ARUP – TMG. 2001. East Coast Very High Speed Train Scoping Study. Phase 1 – Preliminary Study. Final Report. November. Sydney, Australia.
[361] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.
[362] Gutierrez, J. 2005. El tren de alta velocidad y sus efectos espaciales. (Spatial effects of the High Speed Train). Investigaciones Regionales, 5, pp. 199-221.
[363] Ebeling, K. 2005. High-speed Railways in Germany. *Japan Railway and Transport Review*, 40, pp. 36-45, March.
[364] Ibid
[365] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.
[366] Nash, C. 2008. High Speed Rail Investment: an overview of the literature. Institute of Transport Studies, University of Leeds. Leeds, UK.

mi/h)[367], and by freight trains running at lower speeds, the system still offers commercial speed gains of about 60%.[368]

The difference between the German approach from that of French could be explained by "the more geographically distributed political demands of German federal government system and its denser and more evenly distributed population". German "urban structure" is rather complicated with "many more medium sized cities and more complex interactions which leads to the needs for a dense network of services that cannot be tailored to demand in the precise way the French network is".[369] Therefore, Germany's HSR system was structured to connect many hubs with many more stops, while France has a "hub-with-many-spokes" network structure connecting "distant city-pairs with few intermediate stops". Consequently, the "average trip times" of German ICE trains are longer than those of French TGV.[370]

Overall Impacts of HSR

The lack of a dominant metropolitan focus in Germany has led to a more disperse deployment of HSR that is structured around the classis railway network emphasizing upgrades to overcome bottlenecks. Operating freight services on these lines has also been a priority due to strategic importance of freight for the country's heavy industries and political desire to remove freight from roads. Designed for mixed passenger and freight use, the lines have resulted in much higher upgrading and operating costs, but have served to a greater advantage of the connected industrial centers. [371]

According to Vickerman (1997), the polycentric nature of Germany's railway network, which has been historically based on "a complex interlinking network" of connections between many major cities, unlike the "monocentric nature" of the French TGV, "makes it difficult to identify the impact of high speed rail in quite the same way as in France". During the first five years of the new HSR operations the traffic increased from 10 million to 23 million passengers. DB has estimated that "12% of this traffic was diverted from road and air".[372] Compared to the French experience, these figures are rather low, suggesting that a "more patchy introduction of high-speed"[373] lines has not resulted in major shifts in travel patterns as was observed after the deployment of a more concentrated network of TGV on all new lines in France.

The dispersed German multi-purpose HSR system was conceived to spread benefits rather than concentrating them. According to Heinisch (1992), "the main consideration when designing the new lines was not faster passenger traffic, but rather creation of capacity to enable operating the highly profitable overnight freight traffic between the North Sea ports and the industrial areas

[367] Vickerman, R. 1997. High-speed rail in Europe: Experience and issues for future development. *The Annals of Regional Science*, 3, pp. 21-38.
[368] Alabate, D. and Bel, G. 2010. High-Speed Rail: Lessons for Policy Makers from Experiences Abroad. Research Institute of Applied Economics. Working Paper 2010/03. Universitat de Barcelona. Barcelona, Spain.
[369] Vickerman, R. 1997.
[370] Peterman, D., Fritelli, J. and Mallett, W. 2009. High Speed Rail (HSR) in the United States. Congressional Research Service. Prepared for Members and Committees of Congress. December.
[371] Haynes, K. 1997. Labor Markets and regional transportation improvements: the case of high-speed trains. *The Annals of Regional Science*, 31, pp. 57-76.
[372] Vickerman, R. 1997.
[373] Ibid

and consumer markets in Southern Germany.".[374] [375] However, because of the delayed start and slow implementation, the ICE system's development effects are still in their infancy and yet to be realized.

The principal customer segments that have benefited from the introduction of long-distance HSR services are business travelers and commuters due to their higher willingness to pay for a more expensive high-speed service. Price sensitive customers in Germany still use cars, bus, conventional rail or low cost air carriers.

Nevertheless, the HSR services achieved an average increase of 11% in the rail market share.[376] Countrywide, the rail demand has increased by 40% of which 55% was diversion from auto, 40% from air, and 5% newly generated demand. The higher auto diversion is attributed to the shorter distance travel market in which the ICE competes.[377]

6.3 Cologne (Köln) -Frankfurt ICE Corridor

The Cologne (Köln)-Frankfurt high speed ICE corridor is a 177 km (110 miles)[378] long line linking the cities of Cologne and Frankfurt am Main with travel time of 65 minutes for non-stop service. This double track HSR route closely follows the existing Motorway Autobahn 3 (A3) alignment (Figure 6.6). It was constructed between 1995 and 2002 at a total cost of 6 billion Euros, according to DB. The line was planned for completion in 2000, but opened fully in December 2002 after numerous legal challenges and mountainous terrain requiring construction of tunnels. With trains running at a speed of 320 km/h (199 mi/h), this new ICE has reduced the rail journey times from 2hr 15min to just over an hour.[379]

The line was DB's first newly built high speed passenger dedicated track and the only non-mixed use link. Although the initial decision was to build the link as a mixed passenger and freight line, experience from the other lines showed that freight traffic could only be accommodated with severe restrictions.[380] Such restrictions were difficult to implement due to the geological problems and large number of tunnels on the route (along the entire new stretch, there are total of 30 tunnels and 18 large bridges[381]). Due to the steep gradients and sharp curves, the selected railway route is acceptable for high speed passenger-only trains.

Intermediate Stations and ICE Travel Times

ICE 3 type trains started operating between Frankfurt am Main and Cologne (Köln) every 2 hours in November 2000 making alternate intermediate stops at Limburg, Montabaur and Siegburg, and every stop in Frankfurt Airport. The service headways have been increased to 1 hour and less since September 2002.

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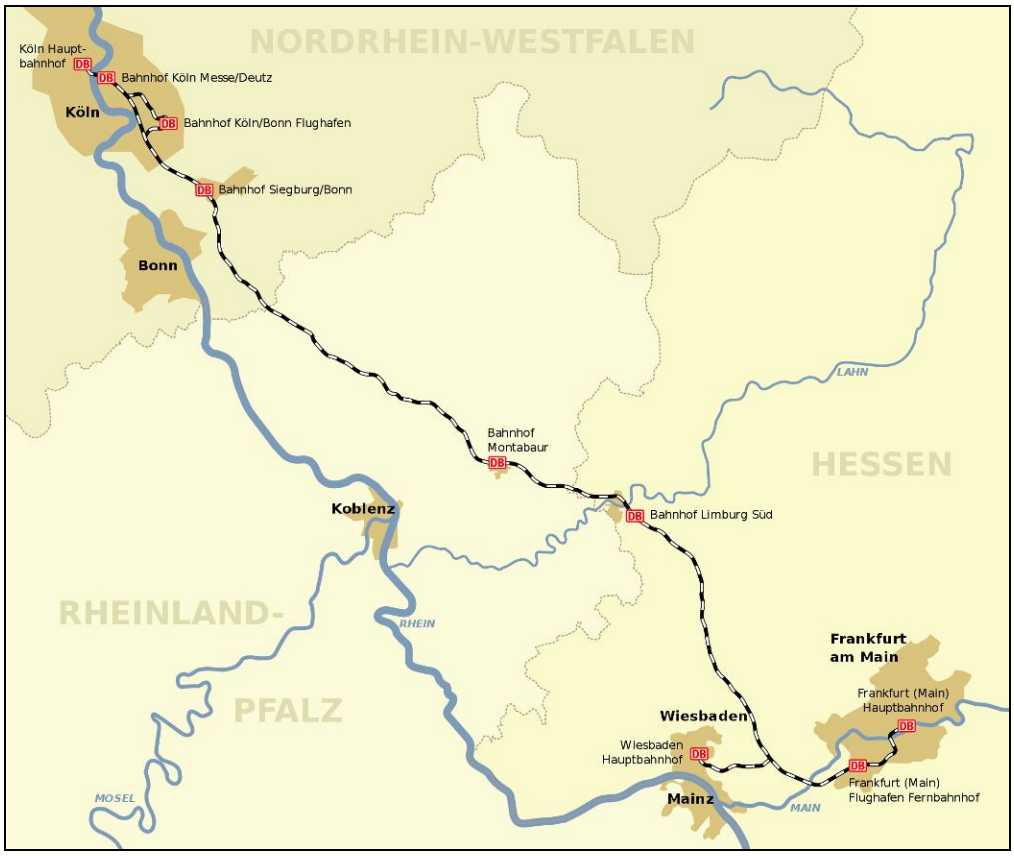
[374] Heinisch, R. 1992. High Speed Trains in Germany. *Rail International*, 23, pp. 23-24.
[375] Alabate, D. and Bel, G. 2010.
[376] Ibid
[377] ARUP – TMG. 2001.
[378] Including the branches to Wiesbaden and to the airport of Cologne/Bonn, the line has a length of about 219 km.
[379] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.
[380] Ebeling, K. 2005.
[381] Deutsche Bahn, Official Website. Retrieved on 02/28/2010 from http://www.deutschebahn.com

Figure 6.6: Map of Cologne-Frankfurt ICE Line



Source: Deutsche Bahn AG. Data provided by Dominik Fuerste of DB AG on 05/12/2010.

Four following new stations were created along the new route between Cologne and Frankfurt: Frankfurt Airport Railway Station, Limburg Sud, and Montabaur. In Siegburg/Bonn the ICE was connected to the existing station served by conventional regional and inter-city rail. The connection of the cities of Montabaur, Limburg and Siegburg to the new line serves as a significant momentum in their economic development. However, the service at each of the stations varies with some non-stop direct trains running between Cologne and Frankfurt and not all ICE trains making stops at each intermediate station.[382]

Limburg Süd ICE Station. This newly built station is located in the area of Limburg / Diez, south of Limburg. South Limburg (or Limburg Süd) is the only station in Germany, served by the ICEs exclusively. The majority of trains pass through the station without stopping. There is no non-stop service connecting Limburg with Frankfurt or Cologne. All ICE trains stopping in Limburg Süd also stop in Montabaur and Siegburg / Bonn.

[382]Deutsche Bahn, Official Website. Retrieved on 02/28/2010 from http://www.deutschebahn.com/site/bahn/de/unternehmen/presse/bauen__bahn/abgeschlossen/koeln__rhein__main.html

Montabaur ICE Station. This modern ICE train station was built during a three year period in the town of Montabaur in the Westerwald district and is shared with the local trains serving the nearby villages (Figure 6.7 demonstrates the location of Montabaur station). The train station is conveniently situated close to the interchange of Montabaur on the A3 motorway. At the opening 350 park and ride parking spaces were made available, which have now grown to 900 spaces and additional 130 paid parking spaces at the bus station (as of August 2006). There are about 15 trains running on weekdays from Montabaur in direction of Frankfurt am Main (airport train station and main train station), the journey of about 80-90 rail miles reachable within about 30-40 minutes of travel time. In direction of Cologne, there are 22 trains offered per weekday covering the 90 km distance in about 30-40 minutes. Being to the south of Limburg station, Montabaur is reachable by the ICE train from Limburg Sud within nine minutes only.

Figure 6.7: Location of Montabaur ICE Station

Source: Westerwaldkreis mbH Economic Development Corporation. Retrieved on 03/02/2010 from http://www.wfg-ww.de/

Siegburg / Bonn ICE Station. The station in Siegburg/Bonn is shared by both high speed ICE and conventional Inter-City trains. The ICE line also connects to Bonn's main railway station by a light rail line within ten minutes. Furthermore, Siegburg / Bonn station is located on the track of Cologne-Siegen and therefore is also served by the Regional Express trains. Since November 2007, the state has become a part of the AIRail system[383], offered in cooperation by DB and Lufthansa airlines. [384] It allows the passengers to check-in and receive boarding passes

[383] AIRail is an integrated intermodal product for air and rail that offers unique service features, such as integrated ticketing and baggage handling (Grimme, 2006).
[384] Wikipedia. Siegburg. Retrieved on 03/02/2010 from http://de.wikipedia.org/wiki/Siegburg

for the Lufthansa flights at the station and take the ICE train directly to their flight at the Frankfurt Airport.[385]

In Cologne, ICE trains also make stops at the Cologne Fair Station (Köln Messe/Deutz) and Cologne Airport Station. Tables 6.1 and 6.2 demonstrate the ICE train frequencies and fares based on the winter 2010 schedules.

Table 6.1: Frequency of Service of ICE and Other Rail Services (IC or RE)

From	To	Intermediate Stops	Frequency (trains/day)	Total Travel Time (minutes)
Cologne Central Station	Frankfurt Central Station	Frankfurt Airport only	7	65
Cologne Central Station	Frankfurt Central Station	Siegburg/Bonn, Montabaur, Limburg Sud, Frankfurt Airport	10	85
Cologne Fair Station	Frankfurt Central Station	Frankfurt Airport only	11	64
Cologne Fair Station	Frankfurt Central Station	Cologne Airport, Siegburg/Bonn, Montabaur, Limburg Sud, Frankfurt Airport	4	91
Frankfurt Central Station	Cologne Central Station	Frankfurt Airport only	8	65
Frankfurt Central Station	Cologne Central Station	Frankfurt Airport, Limburg Sud, Montabaur, Siegburg/Bonn	10	85
Frankfurt Central Station	Cologne Fair Station	Frankfurt Airport only	9	64
Frankfurt Central Station	Cologne Fair Station	Frankfurt Airport, Limburg Sud, Montabaur, Siegburg/Bonn, Cologne Airport	5	91

Source: Deutsche Bahn AG. Data provided by Dominik Fuerste of DB AG on 05/12/2010.

Table 6.2: ICE Fares by Origin-Destination (second class fares, in Euros)

		DESTINATION				
		Cologne (Köln)	Siegburg/ Bonn	Montabaur	Limburg Süd	Frankfurt
ORIGIN	Cologne (Köln)		19	38	45	64
	Siegburg/Bonn	19		31.50	38	59
	Montabaur	38	31.50		19	35
	Limburg Süd	45	38	19		30
	Frankfurt	64	59	35	30	

Source: based on DB winter train timetables (www.bahn.de), 2010

Note: ICE fares cost the same regardless for the non-stop direct trains and for trains making all intermediary stops.

[385] Initially, the AIRail system also included an integrated baggage transport feature, which had been discontinued. Currently, luggage check-in and security checks are carried out at the airport.

Before ICE: decision-making

The routes and station locations for ICE were determined through a highly politicized process. The federal states of North Rhine-Westphalia, Rhineland-Palatinate, and Hesse, through which the line would pass, negotiated intensively with the DB over the route and station locations (See Figure 6.8 showing the states affected by the ICE line). Each state objected to the HSR bypassing the cities on the Rhine, particularly Bonn, Andernach, Koblenz, Mainz, and Wiesbaden. Four other routes were examined that passed through some of these cities. Regional development priorities were one of the criteria for the evaluation of projects and economic impacts during the decision-making. No agreement was reached at the end and the Federal Cabinet agreed on December 20, 1989 to a recommendation of the Transport Minister to adopt the A3 motorway alignment as a route and, among other things, to include a station at Limburg.

Further, the DB consulted with the states and community groups in the area about the specificities such as station locations. Within the state of North Rhine-Westphalia there were many debates about the location of the station to provide access for the Bonn area and to the Cologne-Bonn Airport. The DB decided to build the station in Siegburg and to have a separate line connecting Cologne with the high-speed line to Cologne-Bonn airport. In the state of Rhineland-Palatinate, the DB decided to build a station north of Montabaur, which was only 21km north of Limburg Sud, partly to serve Koblenz, a major city in Rhineland-Palatinate state, via the A48 motorway.[386] In the state of Hesse, the DB decided to build the new station south of Limburg. Routing the line into the old Frankfurt Airport station (now known as the regional station) was not adequate technically; therefore, the DB decided that a separate station would be needed. From there, the line would be extended to connect northbound towards Frankfurt.[387]

The decisions about the route and stations as described above were finalized under the Federal Railway Development Law on November 15, 1993. However, the last legal challenges of the project were not resolved until September 1998. The design of the route was expected to allow trains to cover the distance between Cologne and Frankfurt in 58 minutes, although the current actual fastest time is 65 minutes, due to uncompleted work at rail junctions in Cologne and Frankfurt.

Considering the politicization of the process, the demand forecasts for the project alternatives may have not been entirely accurate and were not the basis for route or station selection. As for the benefit-cost analysis, from the perspective of the DB it yielded a positive ratio because 90% of the infrastructure costs paid by the Federal Government were not included by DB in the cost calculations (only 10% of the infrastructure costs was paid by the DB).[388]

[386] Gough, J. 2003. Neubaustrecke Köln–Rhein/Main. *Modern Railways* (Ian Allen), 60(653), pp. 33-47, February.
[387] Wikipedia. Frankfurt. Retrieved on 02/21/2010 from http://en.wikipedia.org/wiki/Cologne%E2%80%93Frankfurt_high-speed_rail_line
[388] Informal interview with DB staff member on 03/02/2010 at MIT premises.

Figure 6.8: Political Map of Germany

Source: Maps of the World, 2010. Retrieved on 03/04/2010 from http://www.mapsofworld.com

Cities along the Corridor

Frankfurt

Frankfurt am Main is the largest city in the state of Hesse and the fifth largest city in Germany, with a population of 670,000 (in 2008). In 2002, Frankfurt was ranked the richest city in Europe by GDP per capita (74,465 Euros).[389] The city is the centre of the greater Frankfurt/Rhine-Main Metropolitan Region with total of 5.3 million inhabitants. Known as the city of the banks in Germany, Frankfurt is one of the largest employment centers in the country. More than 300 national and international banks, including bank headquarters and stock exchange, are represented here. In addition, the large international companies maintain their offices across different sectors and industries such as media and advertisement, accountancy, management consulting, legal services, telecommunications, internet and software businesses, as well as chemical production. Frankfurt has the highest concentration of jobs in Germany, with over 922 jobs per 1,000 inhabitants (or around 600,000 jobs for 670,000 inhabitants). This can be explained by the high number of commuters working in the city.

The city is accessed from around the world via the Frankfurt Airport, located 12 km (7 miles) from the city centre. The Airport is the busiest in Germany in terms of aircraft movements, passengers boarded and freight traffic. It accounted for 29.7% of all passenger

[389] United Kingdom, Office of the Deputy Prime Minister. 2006. State of the English Cities. A Research Study. Vol 1. London, UK.

traffic in 2006.[390] Frankfurt also features one of the largest train stations in the country – Frankfurt Central Station (Frankfurt Hbf) – serving as a major hub for the high speed ICE and regional trains. Cologne-Frankfurt high-speed rail line extends the ICE service connection to the Frankfurt International Airport.

Cologne

Cologne or Köln with 993,509 residents (as of June 2009) is the largest city both in the Federal State of North Rhine-Westphalia and in the Rhine-Ruhr Metropolitan Area, and the fourth-largest city in Germany (after Berlin, Hamburg and Munich). In 2006, the population density in the city was 2,528 inhabitants per square kilometer. In 2002, Cologne was ranked 14th richest city in Europe by GDP per capita (39, 100 Euros).[391] Cologne is a major cultural and arts center, and is a home to more than 30 museums and hundreds of galleries. It is also known as an important media center within Germany, with several radio and television stations. In addition, Cologne accommodates the main corporate headquarters of the German air carrier Lufthansa and its subsidiary Lufthansa CityLine, and the European headquarters and a factory of major automaker Ford.

Cologne's international airport Cologne Bonn Airport, shared with the neighboring city of Bonn, is the second busiest airport in Germany in terms of freight traffic.[392] Cologne's central train station Cologne(Köln) Hauptbahnhof (Cologne or Köln Hbf) is an important local, national and international hub providing connections for the high-speed ICE rail service as well as conventional IC and Regional Express trains. The city also has another station connected to ICE – Cologne Fair (Köln Messe/Deutz) Station.

Montabaur

Montabaur, situated in the Westerwaldkreis district or country of Rhineland-Palatinate state, has a population of 12,486 (as of 2008). It is an old historical town with numerous tourist attractions. In spring 1993, Chairman of the German Railways and Minister of Economy and Transport of the state of Rhineland-Palatinate agreed on the establishment of a railway station in Montabaur. The agreement also entailed the commitment of the DB to provide hourly ICE train service in Montabaur until 2007, and then adjust according to the use after 2007.

Montabaur also built an industrial park near the station to serve as a center for a new district between the station and the existing settlements. The municipality of Montabaur expected in the 1990s that the development of a 51 hectare area would provide living place for up to 4,000 people and work places for up to 2,000 people.

Montabaur is a known for being home for the headquarters of the leading internet services provider of Germany – United Internet.[393] In addition, the following companies from diverse sectors of economy have offices in this town: Volkmann & Rossbach Traffic Safety Systems (engineering and construction), Deco Glass (services), Ursa Chemie (cosmetics and chemical production), Kloeckner Pentaplast (packaging film production), Metallwerk Elise hut

[390] The Economist Intelligence Unit (EIU). 2008. Country Profile: Germany. London, UK.
[391] United Kingdom, Office of the Deputy Prime Minister. 2006.
[392] The Economist Intelligence Unit (EIU). 2008. Country Profile: Germany. London, UK.
[393] Wikipedia. Bahnhof Montabaur. Retrieved on 03/02/2010 from http://de.wikipedia.org/wiki/Bahnhof_Montabaur

(manufacturer of small caliber ammunition), Academy of German Cooperatives ADG (consulting), and Schmidt Consulting & Distribution GmbH & Co KG (solar power systems).

Limburg

Limburg (officially Limburg an der Lahn) is the capital of Limburg-Weilburg district in the state of Hesse. It is populated by 33,648 residents (as of June 2009). After the decision was made by the Federal Cabinet to route the new ICE line parallel to the A3 motorway on December 20, 1989, it was also decided to include an intermediary stop in the region of Limburg. The state of Hesse was also firm in its demands to have a railway station on the state's territory. In March 1990, the prime ministers of both federal states and the Federal Minister of Transport of Germany signed an agreement confirming "that a stop in the area of Limburg was essential". After having considered three different alternatives for station locations in around Limburg, the selection was made in favor of Limburg Sud, south of Limburg.

The town is a home to the following local businesses[394]: Blechwarenfabrik Limburg GmbH, Bona GmbH, Federal Publishing, Harmonic Drive AG, Hydro GmbH, Glashütte Limburg Gantenbrink GmbH & Co. KG, MOBA Mobile Automation AG, Mundipharma, Soda-Club, Tetra Pak, Vectus traffic ltd, Nassau New Press, Buderus Kanalguss GmbH, Bimatec Soraluce-milling technology GmbH, and Kreissparkasse Limburg.

Siegburg

Siegburg is a city in the district of Rhein-Sieg-Kreis of the state of North Rhine-Westphalia. It is located on the banks of the rivers Sieg and Agger, 10 km away from the former capital Bonn and 26 km away from Cologne. It has a population of 39,564 (as of December 2008). [395] The ICE station Siegburg / Bonn located in the city of Siegburg serves both cities Siegburg and Bonn. The location of the station was on purpose chosen to provide access to the ICE for Bonn. The new development around the station has provided 3,000 square meters of floor space and 1,200 square meters for commercial and other services.

Other Modes along the Corridor

Before the ICE

Traditionally, before the HSR deployment, "the Cologne-Frankfurt route was one of the shortest distances flown in Germany, as their airports were only 136 kilometers apart". During the period of 1990s to 2001, the passenger traffic varied "between 150,000 and 170,000 annually," including both the passengers making a connecting flight in Frankfurt and those ending their trip in either Cologne or Frankfurt. In the 1990s, "20-25% of passengers flying between Frankfurt and Cologne were origin-destination passengers on this city pair". In the 1990s, there were "four to seven daily" flights serving the route, "with an average aircraft size between 105 and 133 seats".[396]

[394] Wikipedia. Lumburg Sud. Retrieved on 03/02/2010 from http://de.wikipedia.org/wiki/Limburg_Süd
[395] Wikipedia. Siegburg/Bonn. Retrieved on March 2, 2010 from http://de.wikipedia.org/wiki/Siegburg/Bonn
[396] Grimme, W. 2006. Air/Rail Intermodality – Recent Experiences in Germany. *Aerlines Magazine*, e-zine edition, Issue 34.

The route was also served by well-developed conventional railways such as long-distance Regional Express (RE) and long-distance national Inter-City (IC) rail. Both services ran on the traditional Rhine-Valley route, which followed a longer winding path from Frankfurt to Cologne, bypassing the hilly and mountainous areas (Figure 6.6). The IC trains made less frequent stops and connected Frankfurt to Cologne in 2 hours and 30 minutes, while the RE with more frequent local stops would take much longer. The route is known for its beautiful scenery across the Rhine Valley. The intermediary stops along the route were not easily accessible from Montabaur and Limburg.

In addition, the 192 km section of Autobahn 3 (A3) federal motorway connects Frankfurt and Cologne and the smaller regions between. The travel time from Frankfurt to Cologne by the motorway is 115 minutes. The A3 is a major connection between Rhine-Ruhr area and southern Germany, resulting in heavy traffic. Consequently, most parts of the motorway are three lanes in each direction.

The mode share before the ICE was dominated by road transport (57.1%) and rail (42.2%), with air carrying only 0.7% of total traffic in the corridor. By trip purpose, about 70% of all business trips were made by road versus 28.4% by road and only 1.5% by air. Private trips were split almost half and half between rail and road modes and none were made by air (see Table 6.3 with traffic market shares on Cologne-Frankfurt corridor by mode and trip purpose before and after the launch of ICE services).

After the ICE

The inauguration of the high-speed line between Cologne and Frankfurt in 2002 had a dramatic impact on the demand for air services. The rail timings for the trip fell from 2hr 15min via the classic Rhine Valley route to just under an hour via the new ICE route. Comparing this to the travel time by air, taking into account the transfer time to the airport, check-in, security clearance, boarding and de-boarding times, competitiveness of air services on this city pair seemed questionable. Indeed, the number of available seats on the flights was reduced from 250,000 to slightly more than 100,000 annually, and frequencies were reduced to a maximum of four flights per day with a smaller average aircraft size of 73 seats. The number of passengers decreased from more than 150,000 to just 50,000 annually.[397] Eventually, all the flights on the Cologne-Frankfurt axis were completely discontinued by the German national airline Lufthansa.[398] Lufthansa decided to integrate the ICE services into its route network, and have the ICE substitute for its flights on the Cologne-Frankfurt route. The HSR service now offers the Lufthansa passengers a dedicated reserved carriage and provides the onboard service comparable

[397] Ibid

[398] Givoni, M. 2006. Development and Impact of the Modern High-speed Train: A Review. *Transport Reviews.* Vol. 26, No. 5, pp. 593–611.

Table 6.3: Cologne-Frankfurt Corridor Traffic Market Shares by Mode and Trip Purpose (%): Before and After

Before the ICE (2001)

Trip Purpose	Rail	Air	Road	Total
Business	12.7	0.7	31.3	44.7
Private	29.5	0.0	25.8	55.3
Total	42.2	0.7	57.1	100.0

After the ICE (2005)

Trip Purpose	Rail	Air	Road	Total
Business	29.4	0.0	36.5	65.9
Private	36.8	0.0	29.2	65.9
Total	66.2	0.0	65.7	131.9

Note: Percentages are presented relative to year 2001.
Source: Deutsche Bahn AG. Matrix Analysis by Martin Thust of DB AG. Provided on 04/15/2010.

to that of a typical European short-haul flight. Thus, "Lufthansa's aircraft environment is almost replicated by the train service."[399]

The long-distance Regional Express (RE) and inter-city national (IC) rail services have remained after the implementation of the ICE and are still in service on Rhine-Valley route. Moreover, the conventional rail serves different towns and provides more frequent and more local stops compared to the ICE. Current travel times by different modes between the city pairs located along the new Cologne-Frankfurt ICE route are presented in Table 6.4.

Currently, the traffic on the Autobahn 3 has decreased due to diversion to the ICE, which follows the alignment parallel to the A3 and therefore is visible from the highway. Partly, it was a success of the intermediate stations that encouraged diversion of commuter traffic from road to rail by providing park and ride facilities. The Frankfurt am Main and Cologne Airports have not been affected by the loss and still remain among the busiest airports in Germany. Travel time comparisons among all modes serving the cities along the Cologne-Frankfurt corridor are presented in Table 6.4, including the air travel times before the ICE was introduced.

As can be seen in Table 6.3, the increase of 50% in the total rail market share came mainly from the newly generated business traffic. Share of business travelers in the corridor increased from 28% in 2001 to 44% in 2005. The overall traffic in the corridor increased 31.9%, while the share of road declined from 57.1% in 2001 to 49.8% in 2005. Thus, the increased demand was mostly captured by rail. According to DB AG, almost all traffic from the conventional IC rail shifted to the new ICE, especially business traffic, as the difference in the fares between the ICE and IC trains is not significant but time savings are significant.

[399] Givoni, M. and Banister, D, 2007. The role of the railways in the future of air transport. *Transport Planning and Technology*, Vol. 30, No. 1, pp. 95-112.

After ICE: General Impacts

The new ICE line effectively links two of Germany's most active economic regions, the Rhine-Main area (population 3 million) and the Rhine-Ruhr region (population 10 million). Direct economic and socio-economic impacts are evaluated regularly such as impacts on pollution, congestion, environment, etc., however, there seem to be no official studies assessing the indirect impacts of this particular corridor such as on regional development, labor markets, etc.

"The city pair Cologne-Frankfurt seems to be a perfect example of the benefits from a shift from short distance air services to high-speed railway."[400] This ICE route not only supports air travel as a feeder to long distance flights, but also has raised the competitiveness of rail against short haul flights and cars. The ridership on the Cologne-Frankfurt line has been growing, and the DB expects passenger numbers to more than double by 2010 to around 20–25 million from current 9 million. Limburg accounts for about 2,500 people using its ICE station daily, and between 2003 and 2005 this number grew by 32% and is expected to grow further. In Siegburg, since the commissioning of the station, the number of passengers has also been increasing steadily, totaling to 20,000 passengers per week in 2005, which was an increase of 40% from 2004.[401]

Evidence of Megalopolis Formation

According to Blum et al. (1997), the HSR link serves two purposes: to "potentially substitute for an air connection between two major cities (or rather CBDs) at long distance with a direct train connection"; or to link "together many cities and CBD's, hence, creating a new type of region with a high intra-regional accessibility". In the latter case, the HSR "binds together cities in a band, where each pair of cities is at a time distance of between 20 and 40 min, i.e. a time distance that allows daily commuting." Blum and Haynes (1997) argue that such a connection "gives rise to a band of cities and, hence, creates an extended functional region formed like a string of pearls". Germany is an example where "a number of cities are connected in exactly this manner by a high-speed train". "In the German case we could speak not only of bands of cities but rather of a network of cities connected by high-speed trains."[402]

Cities of Montabaur and Limburg located exactly between two major agglomerations – the Rhine-Main area and the Rhine-Ruhr conurbations – have become more reachable to the traditional employment center-cities in these conurbations such as Cologne, Frankfurt, and Wiesbaden (another large city in the state of Hesse) since the deployment of the connection to the ICE high speed services. The ICE line has moved the cities closer in space-time thus integrating them into a large megaregion or megalopolis. Frankfurt has been a large commuting destination for work and business trips by road and conventional railway modes but from much closer distances given the lower speeds of these modes. With the high-speed service, within the same travel time of up to one hour, the vicinity of reach has been expanded and now Montabaur,

[400] Grimme, W. 2006.
[401] Wikipedia. Siegburg/Bonn. Retrieved on March 2, 2010 from http://de.wikipedia.org/wiki/Siegburg/Bonn
[402] Blum, U., Haynes, K.E. and Karlsson C. 1997. The regional and urban effects of high-speed trains. The Annals of Regional Science, 31, pp. 1–20.

Table 6.4: Travel times for city pairs by mode (in minutes)

	Cologne (Köln)				Siegburg/Bonn[3]				Montabaur				Limburg Süd				Frankfurt[4]			
	Rail[1]	Road	Air[2]	ICE	Rail[1]	Road	Air[2]	ICE	Rail[1]	Road	Air[2]	ICE	Rail[1]	Road	Air[2]	ICE	Rail[1]	Road	Air[2]	ICE
Cologne (Köln)					21	30	N/A	14	N/A	60	N/A	35	N/A	75	N/A	46-56	150	115	100	62-70
Siegburg/Bonn[3]	30	30	N/A	16					N/A	45	N/A	19	N/A	60	N/A	30	N/A	100	N/A	65
Montabaur	N/A	60	N/A	37	N/A	45	N/A	19					N/A	20	N/A	9	N/A	60	N/A	44
Limburg Süd	N/A	75	N/A	48-55	N/A	60	N/A	30	N/A	20	N/A	9					N/A	45	N/A	33
Frankfurt[4]	150	115	100	63-70	163	100	N/A	65	N/A	60	N/A	44	N/A	45	N/A	32				

Notes:

-Travel times by Rail and ICE are estimated averages for the fastest and direct (minimum stops) trains that are most frequent.

-For Cologne(Koln) and Frankfurt origin and destinations are respective Central Railway Stations (Hbf), located in the city centers.

-N/A interprets as "no service provided" for conventional rail and "no airport" for air.

[1] Conventional rail services, Inter-City (IC) service or Regional Express (RE).

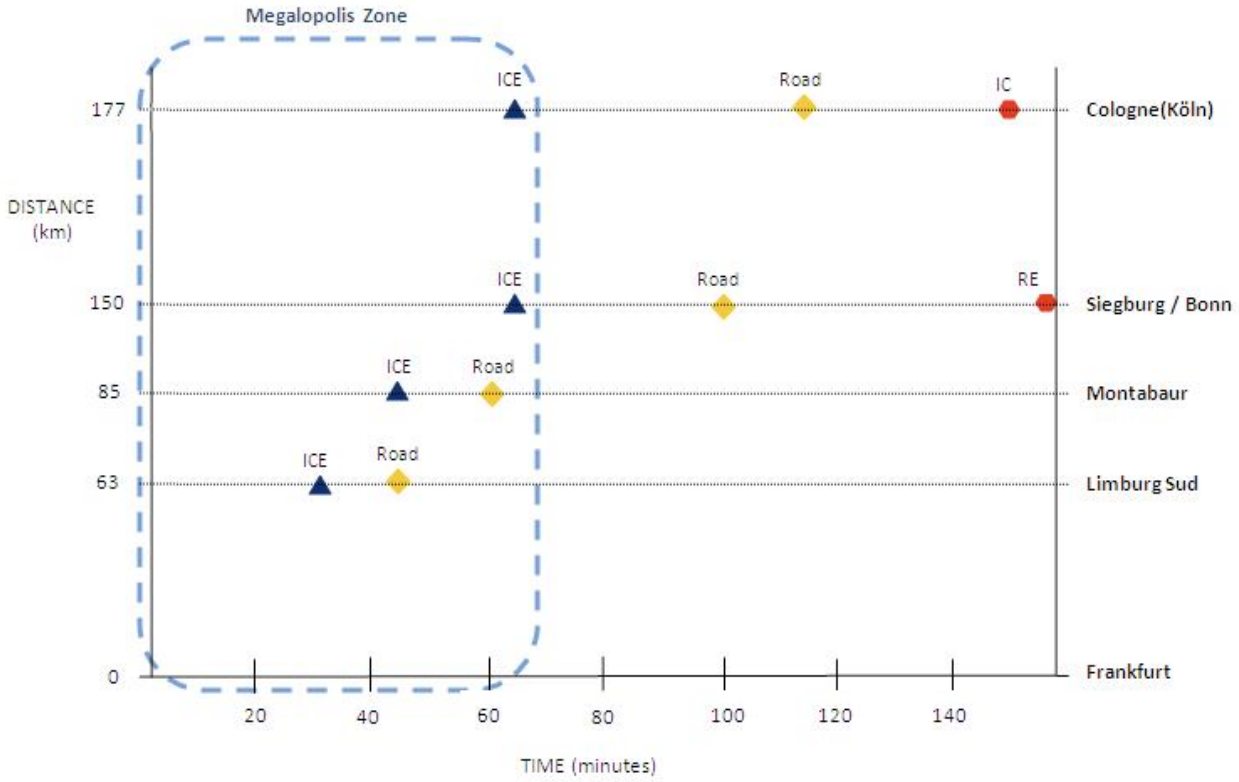
[2] Figures represent the air travel times before ICE deployment - air service has been discontinued between Frankfurt and Cologne since ICE; air travel has been calculated approximately by adding up flying time plus one hour for airport boarding and de-boarding procedures.

[3] Siegburg/Bonn Rail travel times shown to and from the city is for RE trains (no IC service is provided).

[4] Frankfurt Rail travel times shown to and from the city is for IC trains only.

Source: self calculated estimates based on the winter timetables of DB (http://www.bahn.de) and trip directions using Google maps, 2010.

Figure 6.9: Time-Space Chart for Commuting Times from/to Frankfurt by mode



Limburg and Siegburg are within an acceptable time-space "zone" of reach to Frankfurt. Figure 6.9 demonstrates time-space chart for the ICE trains and other modes for travel from the cities on the corridor to Frankfurt).

Increased Commuting Traffic

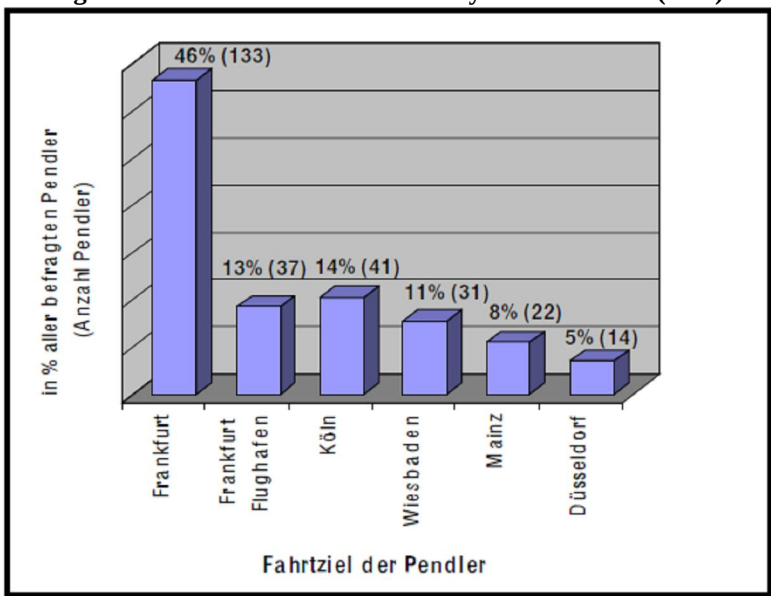
Montabaur and Limburg have always been the central points of commuter trips from the Westerwald and the Limburg regions. Despite their proximity to large metropolitan areas, the regions around Montabaur and Limburg have preserved a rural character, with a high quality of living and affordable land prices and rents that make them attractive for migration inflow.[403] The ICE connection has reinforced and accelerated this migration process and showed its effect already a few months after the opening of the stations. This statement can be supported by the results of the survey of commuters in Montabaur and Limburg carried out by Nina Demuth (2004) with the support of the Westerwaldkreis mbH Economic Development Corporation in 2004.[404] The survey infers that the ICE train stations in Limburg and Montabaur are used primarily by commuters to travel daily to work places in Frankfurt, and that "the attractiveness of the ICE has triggered the increase in urbanization development around the ICE stations."

[403] Demuth, N. 2004. Der ICE Als Pendler- und Vorortzug? Die ICE-Bahnhofe Montabaur und Limburg –Iimpulse fur Wohnstandortwahl, Wohnsiedlungsentwicklung und berufliche Mobilitat. Diplomarbeit, Universitat Trier.
[404] Ibid

Frankfurt as a major employment market, and, therefore, is an important hub for commuters from Montabaur, Limburg, and surrounding area. Being one of the largest job centers throughout Germany, Frankfurt attracts 80% of daily commuters on the ICE line from Limburg and about 60% of commuters from Montabaur[405] (Figure 6.10 shows destinations of the surveyed commuters). This can be explained by the fact that the ICE services have higher frequency and better connectivity options offered in direction of Frankfurt from the Montabaur and Limburg ICE stations, especially during rush hours.

The increase in the commuting patterns from these small towns may be a result of the inflow of new residents stimulated by the availability of a high speed access to the large centers. About 20% of the Montabaur ICE commuters and about 15% of the Limburg ICE commuters responded to the survey saying that they moved to these towns from the neighboring large metropolitan areas such as Rhine-Ruhr conurbations and Cologne/Bonn because of the ICE and the improved speed and accessibility it offers.

Figure 6.10: Destination of the Surveyed Commuters (in%)



Source: Westerwaldkreis mbH Economic Development Corporation. 2004. Der ICE als Pendler- und Vorortzug? Ergebnisse einer Befragung von Berufspendlern am ICE-Bahnhof Montabaur. Retrieved on 03/02/2010 from http://www.wfg-ww.de/neu/Seiten/nina_demuth_kurzfassung.pdf

Some other interesting observations from the survey are:

- 95% of respondents answered that they are satisfied with the commuting experience on the ICE and they intend to continue taking the ICE to work, and the reasons for their satisfaction are "a fast and hassle free trip to work and the reliability of the ICE trains."[406]

[405] Ibid
[406] Westerwaldkreis mbH Economic Development Corporation, Official Website. Retrieved on 03/02/2010 from http://www.wfg-ww.de/neu/Seiten/nina_demuth_kurzfassung.pdf

- 75% noted that the frequency of connections could be increased and attract more commuting passengers and solve the limited seating capacity during rush hours. Others noted that expansion of available parking spaces at the Montabaur ICE station is important to ensure further use of the ICE for work trips.

The experts in city planning and housing industries, interviewed during the same survey above, believe that the ICE connection in Montabaur "acts as an amplifier of a trend" that has already started, i.e. people relocating from the core of the metropolitan areas out to Montabaur city and adjacent residential areas seeking higher quality and lower land costs.[407] The main factors in residential choice, per the experts, are distance to the ICE station by road, rent and home costs.

In terms of development effects due to high-speed line connection, Montabaur and Limburg have been affected positively. The population gains, triggered by the ICE railway station, are considered very important for the region's future development. The induced migration is expected to offset the expected loss of population caused by the demographic changes such as decline in natural population growth, and stabilize the population size of Montabaur region and the Westerwald district.[408] In case of Limburg, however, the extent of urbanization development has been moderate. After ICE station inauguration, the municipalities in Limburg region have imposed some restrictive settlement policies to prevent from turning the area into pure "residential bedroom communities."

The history of the ICE train stations is still young; therefore, an economic boom in the cities is not yet observable, except that another "residential suburbanization"[409] is emerging from the nearby metropolitan areas that are now spreading to the regions Montabaur and Limburg as a result of improved accessibility. The cities gained many opportunities by becoming part of high quality ICE network and can still use these opportunities for their positive development.[410]

Concerning the impacts of the ICE on Siegburg, investigations of the Geographical Institute of Bonn University have shown that 90% of passengers travel to and from Frankfurt, and about three quarters of the passengers use the train for business or commuting.[411] The economic development of the Rheine-Sieg region is linked to the increases in real estate investments that are in turn triggered in part by the new ICE connection. Studies at the University of Bonn showed that almost 3% of the ICE-users from Siegburg have chosen to reside in this town because of the ICE connection. The ICE passenger traffic from Siegburg to Frankfurt is expected to continue increasing in the future, since the population in the Rhine-Sieg-Kreis is expected to rise further from the migration inflow.

6.4 Summary

Overall, Germany followed an approach to HSR deployment quite different from those of France or Japan. Germany did not build new exclusive HSR routes, but rather invested in new

[407] Ibid
[408] Ibid
[409] Demuth, N. 2004.
[410] Ibid
[411] Wikipedia. Siegburg/Bonn. Retrieved on 03/02/2010 from http://de.wikipedia.org/wiki/Siegburg/Bonn

sections and upgrades of conventional tracks for high speeds. Therefore, the ICE network is more integrated with the existing conventional rail network due to a more polycentric urban structure and geography of Germany, which has a widespread nature of the population and almost twice the population density of France. Moreover, given the importance of freight transport in the country, almost all passenger HSR lines are of mixed use and share tracks with inter-city passenger rail and freight rail services. This has resulted in much higher upgrading and maintenance costs, but has benefited the industrial centers connected to the network in the North and South. Nevertheless, the ICE network was able to provide substantial speed improvements, and increase rail demand by 40% of which 55% was from auto, 40% from air and 5% - induced.

The exception to the above strategy was the Cologne-Frankfurt high-speed link, which became the first newly built route dedicated for ICE passenger services only. The exception was made mainly due to the geological and technical challenges in the area. Some of the key take-aways from the German experience with the Cologne (Köln)-Frankfurt ICE link can be summarized as follows:

- The ICE trains have completely replaced the air services between Frankfurt and Cologne. This serves as a "perfect example of the benefits from a shift from short distance air services to high-speed railway".[412] The Cologne-Frankfurt ICE route not only supports air travel as a feeder to long distance flights, but also has raised the competitiveness of rail against short haul flights and cars.

- The megalopolis formation is evident between mainly the cities of Montabaur and Limburg and Frankfurt. The ICE line has moved these cities closer in travel time thus integrating them into a large megaregion or megalopolis, and triggering commuting patterns. Daily commuting trips from Montabaur and Limburg to Frankfurt have increased since the ICE line opening. This increase is due to increased residential inflow to Montabaur and Limburg (more moderately to the latter), which has been attracted partly by the new ICE access. Siegburg also registers primarily commuting and business trips with increasing trends due to similar reasons. However, the commuting appears mostly in direction of Frankfurt, and not as much to Cologne.

- In terms of development effects, due to a dispersed nature of the German ICE and traditional railway network, it is difficult to make conclusions about the biggest winners and losers as a result of the ICE link. Moreover, the corridor already had well-developed regional and inter-city rail services to HSR link and therefore, the incremental impacts from higher speed connection on most of the cities may be very small.

    - However, the cities that were not connected to the old conventional railway network, such as Montabaur and Limburg, have been affected positively as a result of improved proximity via the HSR to major centers of Frankfurt and Cologne. The population gains, triggered by the ICE rail access, are considered very important for the future development of the cities and the adjacent regions. The migration "amplified" by the ICE is expected to offset the loss of population caused by the demographic changes, and stabilize the population size of the cities.

[412] Grimme, W. 2006.

- Judging by the commuting patterns, Frankfurt has benefited more than Cologne by attracting more commuters, which can be explained by its much larger labor market compared to Cologne's. However, some people relocating to Montabaur and Limburg could have moved from Frankfurt. Thus, this could have been reallocation of benefits rather than creation of new employment and growth.

* * *

The next chapter presents a comparative analysis of three case study findings from Chapters 4-6, applies the lessons learned to Portugal, and presents ideas on potential economic development impacts of HSR and possibility of megalopolis formation along the planned Lisbon-Porto HSR corridor.

7 Lessons Learned and Application to Portugal: Lisbon-Porto HSR Corridor

Portugal is at early stages of deploying HSR. The contract for the first section of the Lisbon-Madrid HSR line has already been awarded to a concessionaire, but the construction is currently delayed due to budget deficits in the country's economy and external pressures from the EU. Nevertheless, we are curious to see whether the emergence of a megalopolis defined in Chapter 2 is possible in Portugal as a result of HSR; what economic development impacts would be for the urban areas; and whether HSR would lead to decentralization of economic activity from large metropolitan area and a more even distribution of economic activity. The economic development impacts are "less clear, harder to observe and quantify, and therefore are more controversial,"[413] but we can make certain speculations and inferences based on experiences of countries with HSR history. Hence, this chapter presents the cross-case study comparative analysis; assesses the potential for megalopolis formation on the Lisbon-Porto HSR corridor; projects possible future scenarios of the associated development impacts on the urban areas between Lisbon and Porto; and discusses impacts of economic growth on sustainability.

7.1 Cross-case Comparison

Before we make inferences for Portugal based on the experiences of country case studies, we compare these countries with Portugal. First, we make comparison on a country level such as economy, demographics, and conventional railway network structure. Then, we analyze the pre-HSR situations on a corridor level with the current pre-HSR situation on Lisbon-Porto corridor. Third, the post-HSR situations are compared across the corridors, which serve to present some ideas about possible effects in Portugal. The comparisons are presented in Tables 7.1-7.3.

Country Level Comparison

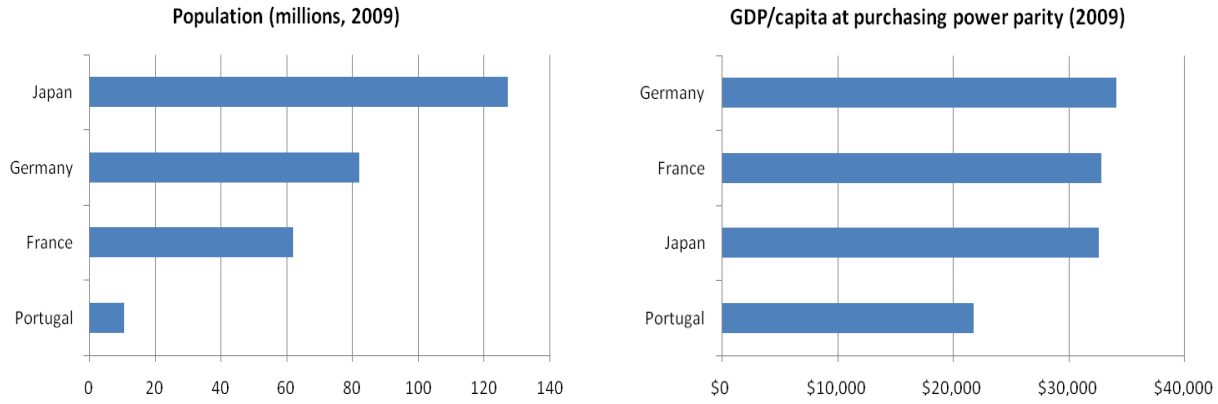
In economic and demographic parameters Portugal ranks behind the case study countries, especially in the population size (Figure 7.1 and Table 7.1). Japan, France and Germany with relatively similar levels of income per capita have stronger economies than Portugal, but Japan leads as the most populous and dense. With 10.7 million inhabitants Portugal's density (114 persons/km^2) compares to that of France (113 persons/km^2).

The Portuguese urban system resembles more the French monocentric urban structure with one dominating capital city concentrating the most economic activity and population (Table 7.1). However, unlike France, the structure of the conventional rail network in Portugal is not as centralized and consists of a few hubs with spokes extending mainly to the north and to the south of the country. It is important to mention that Portuguese railway network size and density are significantly smaller than those of case study countries. As for freight transport, it is considered of strategic importance for Portugal, similarly to Germany, with a view of shifting freight from

[413] Givoni, M. 2006. Development and Impact of the Modern High-speed Train: A Review. *Transport Reviews.* Vol. 26, No. 5, 593–611, September.

the roads to rail. For either France or Japan rail freight is not a priority. In France, "freight is considered only on under-utilized lines and international connections".[414]

Figure 7.1: Country Comparison of Population Sizes and GDP per Capita (2009)



Note: Population for France is excluding the overseas territories.
Source: Central Intelligence Agency (CIA). World Factbook estimates (https://www.cia.gov/).

Table 7.1: Country Level Comparison

	Japan	France	Germany	Portugal
Density (persons/km^2)	336	113	230	114
Year of joining the EU	N/A	1957	1957	1986
Urban Structure (Monocentric or Polycentric)	Polycentric (linear)	Monocentric (radial)	Polycentric (dispersed)	Monocentric (linear)
Structure of conventional rail network	Many hubs and spokes	One hub and spokes	Many hubs and spokes	A few hubs and spokes
Railway Network Size (conventional and HSR lines)	26,435km (16,426 mi)	29,213km (18,152 mi)	33,780km (20,990 mi)	2,789km (1,733 mi)
Importance of freight transport	No	No	Yes	Yes

Note: Density for France is excluding the overseas territories.

Despite Japan being a non-EU country, there are some parallels that can be drawn between Portugal and Japan. Japan has no land surface border with any country and therefore, is in a more isolated and remote position than Portugal is. Moreover, at the time of initiating construction of its first HSR line in 1959, Japan's economy was still in the reconstruction stage following the post-WWII damages. Financing of Japan's HSR was supported by the loan from the World Bank to the government, similarly to the European Investment Bank (EIB) supporting

[414] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

the Portuguese HSR by extending loans (see the discussion about EIB's role in Chapter 3, Section 3.3).

Corridor Level Comparison by Country: Before HSR

Portugal's Lisbon-Porto corridor has similar characteristics of the pre-HSR situation to all three selected case study corridors. All the studied corridors were served by three modes of transport – air, conventional rail and road – and connected two major metropolitan areas at two ends of the line. In cases of Japan's Tokyo-Osaka and France's Paris-Lyon corridors, air was emerging as the biggest competitor of rail offering lowest travel times. But in the Portuguese case the biggest competitor appears to be road (total 55% market share of traffic between Lisbon and Porto captured by private car and bus coach), as was observed in Germany's Cologne-Frankfurt Corridor (57% traffic was carried by road before HSR). All the corridors in Table 7.2, except Cologne-Frankfurt, pass through the most densely populated regions of the respective countries and include capital cities. Due to historically strategic reasons, the existing conventional rail tracks in both Portugal and Japan are non-standard gauge size, unlike Germany and France. Despite the differences, the pre-HSR rail services operating on all the four corridors have similar issues of capacity constraints.

Table 7.2: Corridor Level Comparison by Country: Before HSR

	Tokyo-Osaka Corridor (Japan)	**Paris-Lyon Corridor (France)**	**Cologne-Frankfurt Corridor (Germany)**	**Lisbon-Porto Corridor (Portugal)**
Conventional rail line existed in the corridor	Yes	Yes	Yes	Yes
Gauge size	Narrow non-standard	Standard	Standard	Wide non-standard
Capacity constraints	Yes	Yes	Yes	Yes
Cities not served	Yokohama	none	Montabaur, Limburg	Oeste
Total travel time	6 hours 50 min	4 hours 30 min	2 hours 15 min	2 hours 45 min (AF) 3 hours 50 min (IC)
Competing modes and modal split (if available)	Air, rail, road	Air (31%), rail (40%), road (29%)	Air (0.7%), rail (42.2%), road (57.1%)	Air (13.7%), rail (31.6%), road (54.6%)
Mode with lowest travel time b/w termini city centers	Air (2 hours 40 min)	Air (2 hours 40 min)	Air (1 hour 40 min)	Air and AF (2 hours 20 min)
Most densely populated corridor in the country	Yes	Yes	No	Yes
Major urban centers located along the corridor	Tokyo, Osaka, Yokohama, Nagoya, Kyoto	Paris, Lyon	Frankfurt, Cologne	Lisbon, Porto
Cities with airport connections	Tokyo, Osaka, Nagoya, Kyoto	Paris, Lyon	Frankfurt, Cologne	Lisbon, Porto

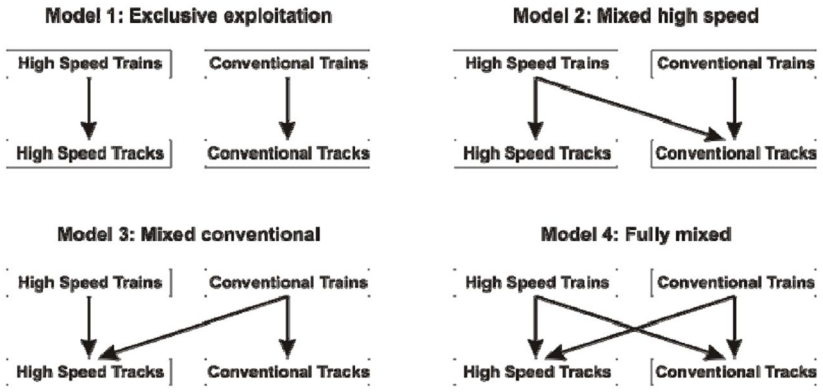
(a) AF – Alfa Pendular; IC – conventional Intercity service.
(b) Oeste is a sub-region, and the station will be serving cities of Rio Maior, Caldas da Rainha, Santarém, and Torres Vedras municipalities, which are all currently connected to the conventional rail service.

Corridor Level Comparison by Country: After HSR

One of the major stated motivations for each country including Portugal to build the HSR link in the studied corridors was increasing the route capacity (see Chapters 3, 4, 5, and 6). All the analyzed corridors were built as new high-speed passenger dedicated tracks not shared with freight or conventional trains. This is also an approach followed by Japan in developing its entire Shinkansen system. However, on the entire HSR network level, Portugal is more similar to Germany in prioritizing the freight rail and planning to construct HSR tracks of mixed freight and passenger use. Nevertheless, the link between Lisbon and Porto is expected to be a passenger dedicated high-speed line.

In terms of compatibility of the HSR system with the conventional network, the distinct feature of the French Paris-Lyon corridor is the compatibility of TGV rolling stock with the conventional tracks. This model is referred to by Campos et al. (2007) as a "mixed high-speed model". Germany overall follows a "fully mixed model", also according to Campos et al. (2007), which allows shared use of ICE tracks by ICE and conventional trains, and ICE trains can run on conventional tracks. The only exception in the German network is the Cologne-Frankfurt HSR corridor, which is the first newly built dedicated line. The entire Japanese Shinkansen, including the original Tokaido line, is not compatible with the conventional railway network because of non-standard gauge size of conventional tracks. Campos et al. (2007) calls it the "exclusive exploitation model".[415] The latter is the model that Portugal plans to follow because of also the non-standard gauge of its existing rail tracks. The types of models of HSR and conventional rail relationship defined by Campos et al. (2007) are illustrated in Figure 7.2.

Figure 7.2: HSR Models according to relationship with conventional services



Source: Campos, J., de Rus, G., and Barron, I. 2007. A review of HSR experiences around the world. Foundation BBVA. Munich Personal RePEC Archive (MPRA). Paper No. 12397. Retrieved on 02/08/2010 from http://mpra.ub.uni-muenchen.de/12397/

[415] Campos, J., de Rus, G., and Barron, I. 2007. A review of HSR experiences around the world. Foundation BBVA. Munich Personal RePEC Archive (MPRA). Paper No. 12397.

To ensure integration with the conventional railway, some stations on the three studied corridors are shared with other rail services, but these are usually the stations that existed before HSR deployment and were upgraded to accommodate the high-speed trains. The newly built stations such as Montabaur and Limburg Sud in Germany and Shin-Yokohama and Shin-Osaka in Japan are exclusively served by HSR and no conventional rail feeding services are linked to these new stations. On the Lisbon-Porto HSR line all stations, except Aveiro and Oeste, are planned to be shared by both HSR and conventional services.

Another important feature of the case study corridors is the frequency of HSR service. Japanese Shinkansen line between Tokyo and Osaka has a high level of service frequency: 173 trains per day compared to about 30 non-stop (38 total) daily trains on the French corridor and 18 one-stop (32 total) daily trains on the German corridor (see comparison of case study corridor parameters in Table 7.3). In addition, all four major intermediate stops on the Tokyo-Osaka line (Shinagawa, Yokohama, Nagoya, and Kyoto), are served at the same 173 trains per day frequency as Tokyo and Osaka, i.e. all trains stop at these four stations. French TGV favors more the direct non-stop service between Lyon and Paris, with an infrequent intermediate stop made at one station at the most. Cologne-Frankfurt ICE trains also operate more frequently non-stop between the end points, however, the three intermediate stops are served at higher frequency than that of Paris-Lyon TGV.

Table 7.3 presents main physical parameters for each case study corridor and compares them to the planned or expected parameters for the Lisbon-Porto line. These are independent characteristics that have been already decided by the Portuguese authorities and will be fixed after the HSR deployment, with the exception of service frequencies, the decision on which will be made after the deployment. The dependent parameters are the actual transport effects observed post-HSR deployment. Increased capacity and decreased travel time consequently have led to changes in the corridor mode share by increasing the rail share at the expense of air and road. In addition, the new high-speed services have generated new demand on the route. These as well as the development impacts along the corridor constitute the dependent parameters. These parameters can only be forecasted and predicted for the Portugal's Lisbon-Porto case given certain assumptions. Below we try to make inferences based on the actual observations in the case studies to predict megalopolis formation and potential development impacts for Lisbon-Porto HSR corridor.

Table 7.3 (Part 1): HSR Corridors Comparison by Country: After Deployment of HSR
(Part 2 continues on next page)

	JAPAN Tokyo-Osaka Link (actual)	FRANCE Paris-Lyon Link (actual)	GERMANY Cologne-Frankfurt Link (actual)	PORTUGAL Lisbon-Porto Link (expected)[a]
Independent Parameters				
Date of Completion	1964	1981	2002	2015
Route Length (km & miles)	515.4 km (343 miles)	425 km (264 miles)	177 km (110 miles)	297 km (185 miles)
Current top operating speed (km/h & mi/h)	270 km/h (168 mi/h); 210 km/h (130 mi/h) initially	300 km/h (186 mi/h)	320 km/h (199 mi/h)	300 km/h (186 mi/h)
Technology type (trainsets)	Shinkansen	TGV	ICE	TGV
Travel time between route end points (direct service)	2 hours 25 min (4 hours before 1992)	2 hours	1 hour 10 min	1 hour 15 min
Newly built line or upgrade	Newly built	Newly built	Newly built[b]	Newly built
Primary motivation	Increase corridor capacity	Increase corridor capacity	Increase corridor capacity	Increase corridor capacity
Compatibility with conventional rail (track and trains)	Non-compatible ("exclusive exploitation model"[c])	Compatible HST ("mixed high-speed model"[c])	Non-compatible ("exclusive exploitation model")[b]	Non-compatible ("exclusive exploitation model"[c])
Non-mixed use dedicated track or shared with freight/conventional trains	Non-mixed use passenger dedicated	Non-mixed use passenger dedicated	Non-mixed use passenger dedicated[b]	Non-mixed use passenger dedicated
Number of intermediate stops	4 (Nozomi trains) 8 (Hikari trains)	2 (Le Creusot, Macon)	4 (Siegburg/Bonn, Montabaur, Limburg, FRA Airport)	4 (Oeste, Leiria, Coimbra, Aveiro)
Cities with stations shared with conventional trains (regional/intercity)	All except Yokohama and Osaka	Paris only	Frankfurt, Cologne, Siegburg/Bonn	Lisbon, Leiria, Coimbra, Porto
Financing sources for construction	World Bank loan and Japanese government	French government	EC initiative grant, German government	EU, EIB loan, private sector (PPP), government

Table 7.3 (Part 2): HSR Corridors Comparison by Country: After Deployment of HSR (continued)

	JAPAN Tokyo-Osaka Link (actual)	FRANCE Paris-Lyon Link (actual)	GERMANY Cologne-Frankfurt Link (actual)	PORTUGAL Lisbon-Porto Link (expected)[a]
Frequency of least stops service per day	173 (4 stops)	30 (0 stops)	18 (1 stops)	TBD
Frequency at intermediate stops per day	173 (4 stops)[d]	8 (1 stop only)	14-15 (4 stops)	TBD
Dependent Parameters (actual only) – Effects of HSR				
Air/Rail market share	85% rail, 15% air	90% rail, 10% air	100% rail, 0% air	
Ridership per year by HSR	150 million	20 million	9 million	
Level of induced demand	High	High (49%)	Medium (~50%)	
Development impacts (zero sum or net growth) on national scale	Zero sum	Zero sum	Zero sum	

Notes:

[a] Decisions for Portugal have been made and are not changeable for independent parameters; however, frequency is a parameter that may be changed.

[b] German strategy to HSR deployment is generally by upgrading conventional line and tracks are generally shared with freight and conventional trains ("fully mixed model" according to Campos et al., 2007); Cologne-Frankfurt line was the first newly constructed HSR link with dedicated track not shared with freight or conventional trains.

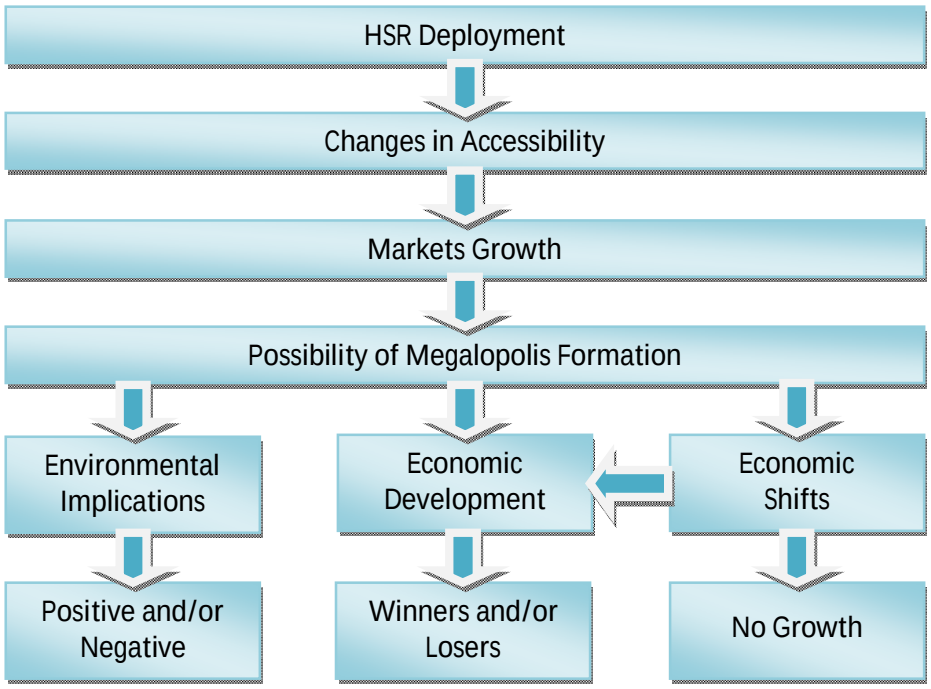
[c] According to Campos et al. (2007) models presented in Figure 7.2.

[d] Japanese fastest HSR service between Tokyo and Osaka (Nozomi trains) stops at least at four intermediate stations. The second fastest service (Hikari trains) makes eight intermediate stops, and the slowest service (Kodama trains) – 15 stops. For comparison purposes above, we are considering the fastest Nozomi train services only

7.2 Emergence of Megalopolises

The expected impact of the high-speed rail investment is changes in *accessibility* through travel time cuts, and increase in mobility options. Gutierrez (2001) defines the "daily accessibility indicator" as the number of possible business contacts (for business trips) and the market potential (for tourist trips). It "measures how much population can be reached from a place (or can reach a place) in a certain travel time limit and the changes in accessible population brought about by a new infrastructure".[416] Since HSR allows reaching more population and more places at a reduced travel time relative to other modes of transportation, we can say that it contributes to the increase of the "daily accessibility indicator". This in turn expands the area of reach and thus access to new and greater markets located within a shorter temporal distance than before (see Figure 7.3 laying out this chain of HSR impacts through megalopolis formation).

Figure 7.3: Fundamental Chain of Development Impacts of HSR through Megalopolis Formation



Through improvements in accessibility to the larger markets for labor, businesses and employment, the areas where these markets are located may fuse economically and functionally into one integrated economic zone, or megalopolis. According to the definition by Contant and de Nie (2009), *megalopolises or megaregions* "are linked networks of metropolitan areas that serve as a functional unit for economic activity," joined by "environmental, cultural,

[416] Gutierrez, J. 2001. Location, economic potential and daily accessibility: an analysis of the accessibility impact of the high-speed line Madrid-Barcelona-French border. *Journal of Transport Geography*, V. 9, Issue 4, pp. 229-242.

infrastructural, and functional characteristics".[417] Hence, HSR contributes to "shrinking of the temporal distance"[418] and removes travelers' psychological barrier to taking a one-day trip for long physical distances.

However, there is no straight-forward way for determining when a megalopolis is indeed formed as a result of HSR deployment, leading to a question of how one would know that a megalopolis emerges. There is no precise process for measuring and identifying the emergence of megalopolis, however, there are certain parameters that could guide us to conclude that megalopolis is formed. Some of these parameters observed in the travel patterns between the cities connected by a HSR line include:

- significant increases in one-day round trips between a pair or group of cities,
- high levels of newly generated induced demand overall,
- induced demand for business trips,
- increase in the number of daily commuters,
- decrease in overnight hotel stays.

It is important to note that these parameters may also be affected by other factors than the HSR infrastructure, therefore, the causal effect is not clear-cut.

Further, HSR by changing the relative accessibility and effectively creating "a different social and economic space" [419] through the megalopolis/megaregion formation contributes to the *economic development*. A larger labor market also justifies and facilitates specialization of workers and jobs thus increasing productivity and contributing to economic growth.[420] However, the spatial distribution of this growth may not be equitable or uniform. "A better connection between two regions not only gives firms in a less developed region better access to the inputs and markets of more developed regions," but also can harm them by reallocating economic activity to the richer regions.[421] Thus, development in one place may occur at the expense of another place, and there may be those who will *lose* and those who will *win* from HSR. There could also be a case when a megalopolis contributes to *economic shifts* through relocation of economic activity from one region to another rather than economic growth, leading to zero sum growth (no growth) or modest economic development (see Figure 7.3). For example, if a country experiences a positive growth, but individually a city not connected to HSR experiences negative growth due to loss of economic activity to the cities with HSR stations, modest development occurs but through economic shifts. There could also be absolute growth observed within the cities that lose economic activity, while relative growth may be negative. The

[417] Contant, C. and de Nie, K.L. 2009. Scale Matters: Rethinking Planning Approaches across Jurisdictional and Sectoral Boundaries. Chapter 1. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC, p. 15.
[418] Givoni, M. 2006.
[419] Ibid
[420] Prud'homme, R. and Lee, C. 1999. Size, Sprawl, Speed and the Efficiency of Cities. *Urban Studies*. Vol. 36, No. 11, pp. 1849- 1858.
[421] Puga, D. 2001. European Regional Policies in Light of Recent Location Theories. Discussion Paper Series No. 2767. Center for Economic Policy Research. London, UK.

changes in spatial development and megalopolis formation also have environmental implications, discussed later in Section 7.3.

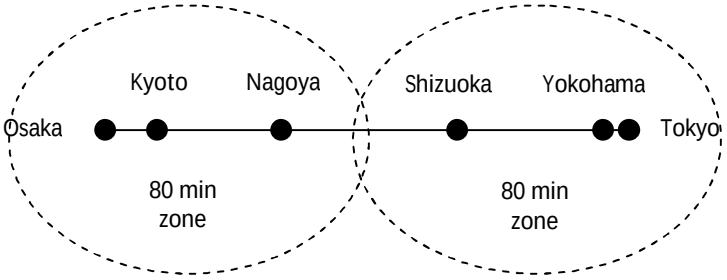
In the case studies for Japan, France and Germany, the implemented HSR routes have changed the relative accessibility and economic space of the urban areas linked to HSR corridor. The time-space diagrams for each corridor shown in Chapters 4-6 illustrate this impact by cities becoming closer to each other and fusing into a *megalopolis*. Based on the case studies, the emergence of the megalopolis appears in two different ways: (1) as a megalopolis formed between one (or both) of the large cities and several small intermediate cities in between along the HSR corridor (observed in the German and Japanese cases); and (2) as a megalopolis formed between the two large cities connected at two ends by a high-speed train, while the smaller intermediate urban areas are excluded (similar to the French Paris-Lyon connection). Both of these megalopolis forms could potentially emerge simultaneously, creating a "hybrid megalopolis", even though it has not been observed in any of our case studies.

Following are the summaries along with the sketches of megalopolis formations (Figures 7.4, 7.5 and 7.6) drawn from the findings detailed in the case studies of relevant HSR corridors in Japan, France and Germany (see Chapters 4, 5 and 6 respectively). The cities that have gained the most benefits and those that have become worse off as a result of the HSR are also listed. The accompanying tables provide detailed information on the main HSR stations such as service frequency, compatibility with conventional rail, direct link to an airport and the industry focus of the station cities. Each of these megalopolises has different magnitudes of impacts on the urban areas located along the corridor.

Japan's Tokyo-Osaka corridor

Based on the findings discussed in Chapter 4, the HSR link in the Tokyo-Osaka corridor has favored the most those cities that specialize predominantly in "information exchange industries" (such as banking services, real estate, R&D, education, and/or political institutes). These cities are Tokyo and Osaka mainly, where employment levels have substantially increased since the HSR deployment. Interaction increased between the cities with the services industry and tourism focus, driven primarily by growth in business and tourism travel from nearby cities. The HSR link also contributed to further centralization of economic activity in major metropolitan areas of Tokyo and Osaka. Nagoya with prevailing manufacturing industry base experienced losses in employment levels as HSR plays a minimal role in the manufacturing sectors of the economy. While positive regional developments such as employment growth occurred in the urban areas along the corridor, the causal relationship with HSR is not clear and there is a theory that the new growth came at the expense of other cities or regions outside of the Shinkansen network. *The one-day trips have increased and overnight stays decreased mainly to/from the intermediate stops rather than between the terminus points, thus leading to a conclusion that two daily activity zones or megalopolises were formed between the cities at two ends of the route, but not between Tokyo and Osaka* (see Figure 7.4). Travel time between Osaka and Tokyo (4 hours before 1992, 2 hours and 25 minutes after 1992) is longer than to major intermediate stops.

Figure 7.4: Japan Megalopolis Formations: Tokyo-Osaka HSR Corridor



Megalopolis 1: Tokyo-Yokohama-Shizuoka
Megalopolis 2: Osaka-Kyoto-Nagoya

Gains: Tokyo, Osaka, Yokohama, Kyoto
No impacts: Shizuoka (Shizuoka is served by Hikari Slower and less frequent trains)
Losses: Nagoya, cities outside of Shinkansen network

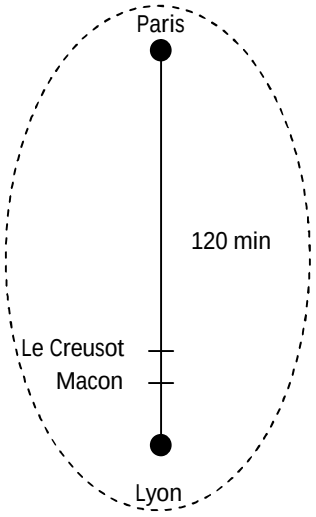
	Tokyo	Yokohama	Shizuoka	Nagoya	Kyoto	Osaka
Frequency (trains/day)	173	173	66	173	173	173
Station served by conventional rail line	Yes	No	Yes	Yes	Yes	No
Connection to airport	No	No	No	No	No	No
Primary industry sector focus	Services	Shipping, Biotech	Services	Manufacturing	IT/Tourism	Services

Source: sketched by the author based on the case study research findings presented in Chapter 4 (drawn not to scale).

France's Paris-Lyon corridor

French TGV further reinforced the existing centralization of economic activity in Paris primarily, according to the findings detailed in Chapter 5. Paris was the biggest winner from the HSR connection to Lyon, allowing some of the Paris-based companies to increase the services exchange in the Lyon markets. Lyon also benefited substantially by attracting large pool of businesses, mostly relocated from neighboring cities and within Rhone-Alps region, high number of business tourists, and access to Parisian services market. Macon has experienced a small growth of businesses and increase in employment, but it was mainly due to business relocations within Saône-et-Loire department and not from Paris or Lyon. Le Creusot did not gain any benefits from the connection as no changes occurred in terms of jobs or commercial expansion. The significantly high levels of new trips generated by TGV have contributed to the economic development of the connected regions; however, it was mainly a result of redistribution of economic activity from cities with no HSR to the cities with HSR station. *The increase in the one-day tourism trips and decrease in overnight stays as well as the growth in intra-organizational business trips between Paris and Lyon attest to the fusion of these two cities into one daily activity zone, i.e. megalopolis* (see Figure 7.5).

Figure 7.5: France Megalopolis Formation: Paris-Lyon HSR Corridor



Megalopolis: Paris-Lyon

Gains: Paris, Lyon, Macon
No impacts: Le Creusot
Losses: cities not connected to TGV

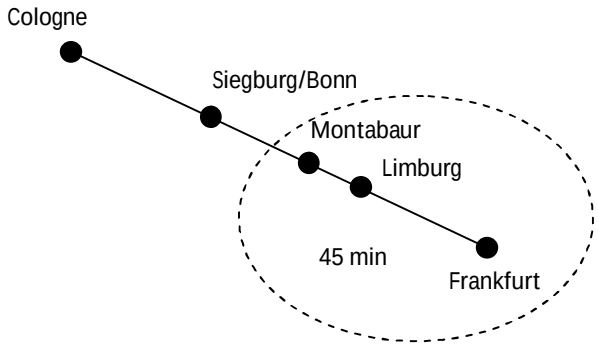
	Paris	Le Creusot	Macon	Lyon
Frequency (trains/day)	38-46	8-10	5-8	38-46
Station served by conventional rail line	Yes	No	No	No
Connection to airport	Yes	No	No	Yes
Primary industry sector focus	Services	Metallurgy	Shipping, Metallurgy	Services/R&D

Source: sketched by the author based on research findings for the case study presented in Chapter 5 (drawn not to scale).

Germany's Cologne-Frankfurt corridor

The findings and evidence from the existing studies on Cologne-Frankfurt HSR corridor discussed in Chapter 6 lead us to conclude that smaller cities Montabaur and Limburg, previously not connected to conventional rail, were affected positively as a result of improved proximity to major centers of Frankfurt and Cologne. *Daily commuting trips from Montabaur and Limburg to Frankfurt have increased since the ICE line opening, thus bringing these cities closer and integrating them into a megalopolis.* This increase is due to increased residential inflow to Montabaur and Limburg, which has been attracted partly by the new ICE access. There is no evidence of a megaregion formed between Siegburg and Cologne as the traffic increase originating in Siegburg is not significant and the trips are mostly taken in direction of Frankfurt, and not as much to Cologne. Frankfurt has benefited more than Cologne by attracting more commuters, which can be explained by its much larger labor market compared to Cologne's. However, some people relocating to Montabaur and Limburg could have moved from Frankfurt. Thus, this could have been reallocation of benefits rather than creation of new employment and growth. As shown in Chapter 6, there is no evidence found supporting the formation of a megalopolis between Frankfurt and Cologne. The increase in travel on this O-D pair comprises mostly those traveling to Frankfurt airport, and not to the city center. This may be explained by the limited business interactions between the two cities, given the differences in their dominating economic activities: Cologne is a cultural and arts center while Frankfurt is a center of finance and banking industry (see Figure 7.6).

Figure 7.6: Germany Megalopolis Formation: Cologne-Frankfurt HSR Corridor



Megalopolis: Frankfurt-Limburg-Montabaur

Gains: Frankfurt, Montabaur, Limburg
No impacts: Cologne, Siegburg
Losses: cities not connected to ICE

	Frankfurt	Limburg	Montabaur	Siegburg/Bonn	Cologne
Frequency (trains/day)	32-33	14-15	14-15	14-15	32-33
Station served by conventional rail line	Yes	No	No	Yes	Yes
Connection to airport	Yes	No	No	No	Yes
Primary industry sector focus	Services	Services	Services	Services	Arts, media, manufacturing

Source: sketched by the author based on research findings for the case study presented in Chapter 6 (drawn not to scale).

7.2.1 HSR – "The Sustainable Mode"

Among the obvious rationales for the HSR being high priority in Japan, France and Germany is the fact that it is considered a relatively more sustainable mode of transportation, especially compared to its main competing mode – air and highway. Shifting traffic from air to HSR has been promoted by policy makers, especially in the EU. EU's White Paper (2001) proposed "revitalizing the railways" and imposing control on "the growth in air transport" in order to reduce congestion at airports and "limit the adverse impacts on the environment" imposed by the air industry.[422] Rail emits significantly lower levels of greenhouse gases (GHG) per passenger-km compared to the private auto and air modes. However, buses beat the rail mode as the lowest emitter of GHG (for non-urban passenger services without congestion). The lower emission levels of buses per passenger-km can be explained by the higher load factor of buses than that of trains. Consequently, calculation of net emissions per passenger-km is highly sensitive to the load factors. Table 7.4 provides estimates of the amount of GHG emitted per

[422] European Commission. 2001. European transport policy for 2010: time to decide. White Paper. COM(2001) 370. Submitted on September 12. Retrieved on 05/06/2010 from http://europa.eu/

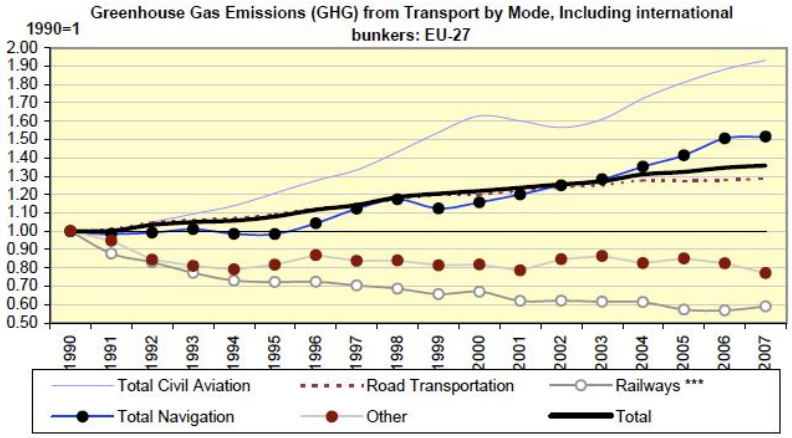
passenger-km for each transport mode.[423] Figure 7.7 illustrates a decrease in GHG emissions from rail mode compared to other modes since 1990 for 27 EU countries combined.

Table 7.4: Greenhouse Gas Emissions (grams per passenger-km)

Transport Mode	Emissions
Rail	150
Bus	75
Private Motor-Vehicle	225
Air	220-240

Source: ARUP – TMG. 2001. East Coast Very High Speed Train Scoping Study. Phase 1 – Preliminary Study. Final Report. November. Sydney, Australia.

Figure 7.7: Greenhouse Gas Emissions by Mode for EU-27 Countries



Source: European Commission DG TREN. EU Energy in Figures 2010. Retrieved on 05/11/2010 from http://ec.europa.eu/energy/publications/doc/statistics/ext_greenhouse_gas_emissions_from_transport_by_mode.pdf

As shown previously in Table 7.3, the two HSR corridors – Paris-Lyon and Tokyo-Osaka – were successful in capturing significant market share from air; and the Cologne-Frankfurt HSR line drove air entirely out of the market in the corridor. HSR has captured 90% of the air/rail market between Paris and Lyon, 85% of the air/rail market between Tokyo and Osaka, and 100% of the air/rail market between Frankfurt and Cologne.

There are also a range of other environmental impacts that result from HSR and can be positive or negative, such as: visual intrusion, energy consumption, air pollution, noise, and land-use. [424] The level of air polluting gases produced in order to provide electricity for HSR depends

[423] The load factors used for calculations in Table 7.4 are not provided by the source. Depending on the load factor values used, the results may alter.

[424] Alabate, D. and Bel, G. 2010. High-Speed Rail: Lessons for Policy Makers from Experiences Abroad. Research

on the energy efficiency of trains and the source used by the electricity generating plant. Therefore, though HSR does not necessarily pollute directly, it still remains an "energy intensive form of passenger transport", and due to its intensive use of electricity it may indirectly contribute to emissions. For example, "if the source of energy is carbon-producing fossil fuels, the level of emissions may exceed that of road transport".[425] Train's energy consumption per passenger may also be greater at higher speeds.

Noise from HSR operations is potentially the most negative environmental impact of HSR. HSR also may cause significant vibration impacts on human and natural environments. However, relative to road traffic noise, "railway noise has been identified as significantly less annoying", because rail noise is "a punctuated event", occurring occasionally, while the highway noise is continuous.[426]

Countries' efforts in addressing sustainability with respect to HSR

The cost of "energy consumption of HSR is 5% lower in France than in Germany", partially because energy is negotiated and acquired directly by the French operators, which creates incentives for energy savings.[427] Japanese Shinkansen "consumes 30Wh electricity per kilometer per passenger. Compared to other transportation facilities, Shinkansen is three times as efficient as the Maglev and six times as efficient as air service".[428] Tokyo-Osaka Shinkansen line produces only around 16% of CO_2 of the equivalent journey by car (a savings of 15,000 tons of CO_2 per year).[429]

France addresses the sustainability issues before the implementation of the HSR projects on the basis of evaluation of the projects' impacts on other transportation modes and impacts on locations and environment.[430] After completion, the TGVs passing near towns and villages in France have caused general complaints about the noise. As a response, France has built "acoustic fencing along large sections of tracks to reduce the disturbance to residents".[431]

Germany evaluates its HSR projects based on direct economic and socio-economic benefits such as pollution reduction, congestion reduction, environmental improvement, connectivity, etc. The Ministry of Environment participates in the evaluation process and strongly supports HSR development considering it as more environmentally favorable relative to other modes.[432]

Institute of Applied Economics. Working Paper 2010/03. Universitat de Barcelona. Barcelona, Spain.

[425] ARUP – TMG. 2001. East Coast Very High Speed Train Scoping Study. Phase 1 – Preliminary Study. Final Report. November. Sydney, Australia.

[426] Ibid

[427] Campos, J., de Rus, G., and Barron, I. 2007.

[428] Taniguchi, M. 1992. High Speed Rail in Japan: A Review and Evaluation of the Shinkansen Train. Working paper No. 103. University of California, Institute of Urban & Regional Development, Berkeley. April.

[429] Wikipedia. Retrieved on 05/05/2010 from http://en.wikipedia.org/wiki/Shinkansen#Competition_with_air

[430] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

[431] Campos, J., de Rus, G., and Barron, I. 2007.

[432] A.T. Kearney. 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for RAVE. Lisbon, Portugal. June 25.

Japan initially did not consider any environmental implications before constructing its first line between Tokyo and Osaka in 1959, because of the lack of time and the rush to complete construction before the Tokyo Olympics in 1964. At the time, the world was also much less concerned about the environment. After the opening of the line, a noise problem in the densely populated areas led to major protests. This served as a good lesson, and in 1975 Japan introduced the environmental criteria to reduce noise pollution in the future corridors such as implementation of noise barriers, "20 m wide environmental zone (both sides of right-of-way), improvements of track ground and basement," and decreased speeds in densely inhabited districts.[433]

7.3 Role of Induced Demand

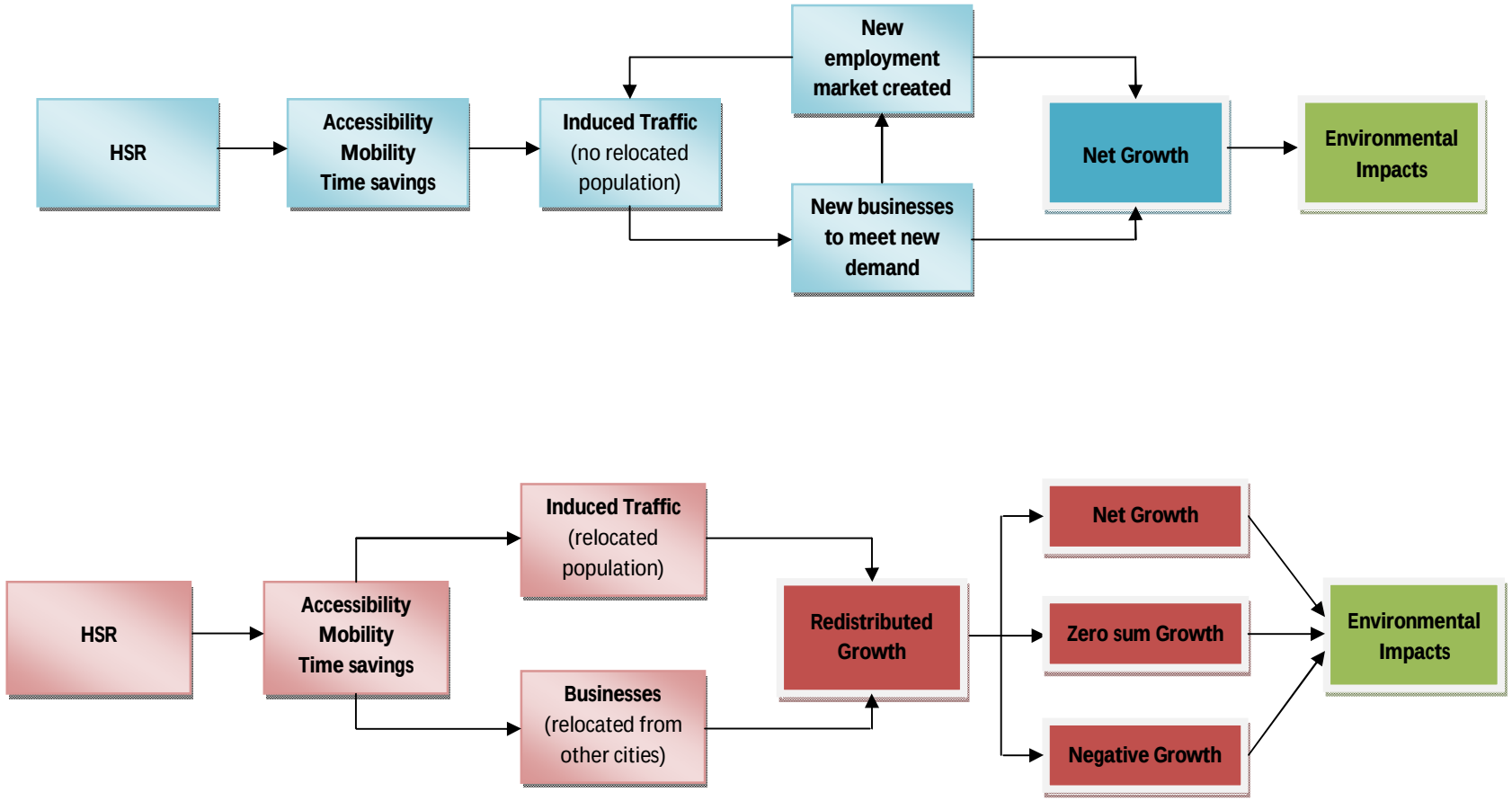
Drawing from the experiences of Japan, France and Germany, on the national level HSR may play a *catalyst role* resulting in new growth, or a *redistributive role* resulting in relocation of economic activity within the corridor, which may result in the overall zero-sum growth, redistribution and some net growth, or even negative growth for some.[434] Net growth is zero-sum if the developments in certain urban areas take place at the loss and expense of other areas and no new growth is generated. The HSR-linked areas become more attractive relative to the unconnected areas leading to relocation of residents and businesses. For example, if businesses or population relocate to Lisbon, because of better connectivity with HSR and proximity to Porto and other areas, and if they travel along the corridor – they would be considered induced traffic from relocated population. The new businesses appearing in Lisbon would also be considered relocated if these businesses moved from other cities to Lisbon after the HSR deployment. Therefore, if the induced traffic is driven from within the relocated population or businesses, the growth it leads to would be at the expense of cities that lost its population, i.e. *relocated (or redistributed) growth*. Both Paris-Lyon and Cologne-Frankfurt HSR corridors generated induced demand of about 50% (see Table 7.3 in the beginning of this Chapter); however, some of it has been a result of inflow of businesses and residents relocating from other parts of the country to the more attractive cities with HSR stations. Thus, on the national level the economic growth was redistributed, at least in part.

Theoretically, net growth may happen when high-speed line *induces* substantial levels of new travel demand, i.e. change the travel patterns of people who otherwise would not have traveled the longer physical distances, but will because of the improved accessibility, mobility and lower travel time offered by HSR. Computing this net growth is difficult as there are a number of other factors that may have greater impacts on growth than HSR. The new traffic induced from within the city (excluding those who relocated to the city from other areas) creates new demand for services and hence contributes to the development of new businesses to accommodate this new demand. The development of new businesses creates new employment opportunities, which in turn contributes to creation of more new traffic (Figure 7.8).

"The source of HSR traffic - whether it is newly generated or attracted from previously existing modes" is an important determinant of the overall net impact of HSR on the

[433] Taniguchi, M. 1992.
[434] Pol, P. M. J. 2003. The Economic Impact of the High-Speed Train on Urban Regions. *European Regional Science Association EconPapers*. Retrieved on 06/12/2009 from http://www.ersa.org

Figure 7.8: Net Growth versus Relocated Growth



environment such as energy consumption and levels of CO_2 emissions.[435] Moreover, the impacts will depend on which mode the traffic has been diverted from. In the case of diverted traffic from road transportation, the impacts will also differ depending on whether HSR has replaced private autos or buses: traffic diverting from buses will result in greater net energy consumption and CO_2 emissions as buses are more energy efficient compared to HST; diversion from cars will lead to decreases in net energy consumption and emissions as cars are more fuel intensive than trains.

7.3.1 "Paradox" between Growth and Environmental Sustainability

The economic development driven by HSR and formation of megalopolises or mega-regions essentially leads to implications on sustainability and environmental conservation. Skeptics claim that creation of "globally competitive megaregion with expanding boundaries through infrastructural megaprojects such as high-speed rail" may emphasize the economic growth over "environmental protection". Campbell (2009) discusses a "paradox between growth and conservation", i.e. the concerns for sustainable development are not usually "compatible" with "growth and expansion", and the problem is exacerbated as megaregions grow. Thus, megaregions or megalopolises "present challenges to sustainable development" because by creating linkages to multiple urban areas they take over "the greenfield exurban and wilderness areas", where these linkages pass through.[436]

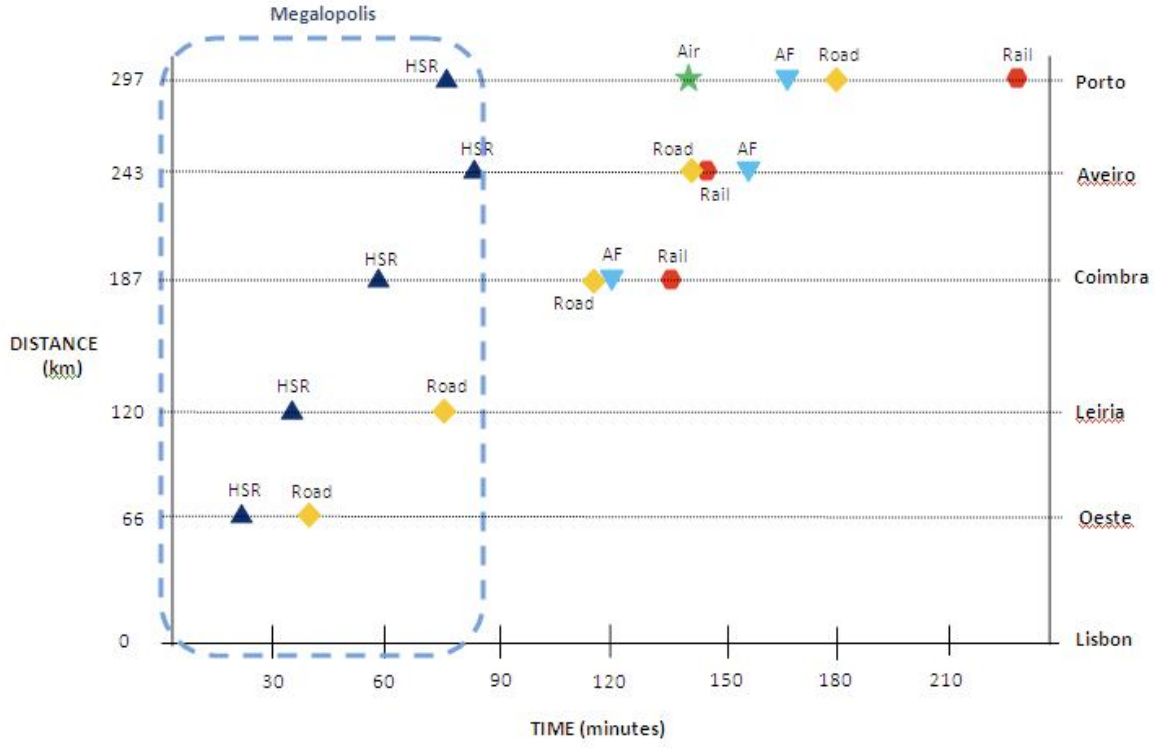
Proponents view megaregions as contributing to "more efficient and compact land use" and that "the implementation of climate change strategies and programs" can be addressed more appropriately within the megaregion "framework".[437] Campbell (2009) notes that "the spatial structure of megaregions" and, hence, the development patterns are "shaped and reflected by its infrastructure networks". Therefore, by controlling the infrastructure – "the direction of megaregions" may be controlled.[438] Ross (2009) also asserts that the megaregion should "become a footprint by which we ensure […] global competitiveness and establish the domestic structures needed to response to a changing environment."[439]

[435] Alabate, D. and Bel, G. 2010.
[436] Campbell, S. 2009. The Imperative of Growth, the Rhetoric of Sustainability: The Divergence of the Ecoregion the Global Megaregion. Chapter 7. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC, pp. 127-139.
[437] Ross, C.L. 2009. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC, p. 4.
[438] Campbell, S. 2009.
[439] Ross, C.L. 2009.

7.4 Potential for Megalopolis Formation in Lisbon-Porto Corridor

The temporal distances between the cities planned to be connected by the new Lisbon-Porto HSR line will be reduced significantly relative to travel times by any currently available mode of transportation. The new link will cut the direct journey time between Lisbon and Porto offered by Alfa Pendular, the fastest rail option in service, by more than half (from 2 hours 45 min to 1 hour 15 minutes for non-stop service). Alfa Pendular's service frequency from Lisbon and from Porto is 11 trains per day, with only 2 making all intermediate stops[440] (see Chapter 3). Even the air travel time between Lisbon to Porto amounting to 1 hour 15 minutes of flight time would be twice as high if the times for check-in, boarding and deboarding procedures are added. The physical distance from Lisbon reachable within a travel time of under 90 minutes does not extend beyond 120 km by car. The high speed link would shrink the entire 297 km (185 miles) corridor within the limits of 90-minute travel time, making it a zone of one-day activity and potentially forming a megalopolis. Figure 7.9 visualizes the time-space distances by mode from Lisbon, and Table 7.5 shows travel times between different city pairs along the planned corridor.

Figure 7.9: Time-Space Chart for Commuting Times from/to Lisbon: existing modes and HSR



Note: AF – Alfa Pendular; Rail – conventional intercity services.

[440] Comboios de Portugal, Official Website. 2010. Train Timetables. Retrieved on 03/30/2010 from http://www.cp.pt/cp/

Table 7.5: Expected Travel Times for O-D city pairs between Lisbon-Porto by mode (in minutes), after deployment of HSR

	Lisbon				Oeste				Leiria				Coimbra				Aveiro				Porto			
	HSR	AF[1]	Road	Air[2]	HSR	AF[1]	Road	Air[2]	HSR	AF[1]	Road	Air[2]	HSR	AF[1]	Road	Air[2]	HSR	AF[1]	Road	Air[2]	HSR	AF[1]	Road	Air[2]
Lisbon					20	N/A	40	N/A	36	N/A	75	N/A	56-59	120	115	N/A	85	155	140	N/A	75	165	180	140
Oeste	20	N/A	40	N/A					16	N/A	35	N/A	36	N/A	75	N/A	65	N/A	100	N/A	73	N/A	140	N/A
Leiria	36	N/A	75	N/A	16	N/A	35	N/A					23	N/A	45	N/A	50	N/A	70	N/A	57	N/A	100	N/A
Coimbra	56-59	120	115	N/a	36	N/A	75	N/A	23	N/A	45	N/A					29	38	35	N/A	34	80	65	N/A
Aveiro	85	155	140	N/A	65	N/A	100	N/A	50	N/A	70	N/A	29	38	35	N/A					17	42	40	N/A
Porto	75	165	180	140	73	N/A	140	N/A	57	N/A	100	N/A	34	80	65	N/A	17	42	40	N/A				

Notes:

AF - Alfa Pendular Service.

HSR travel times to intermediate cities are approximate and may vary depending on number of stops made by a train.

HSR travel time of 75 minutes between Lisbon-Porto is for non-stop direct service.

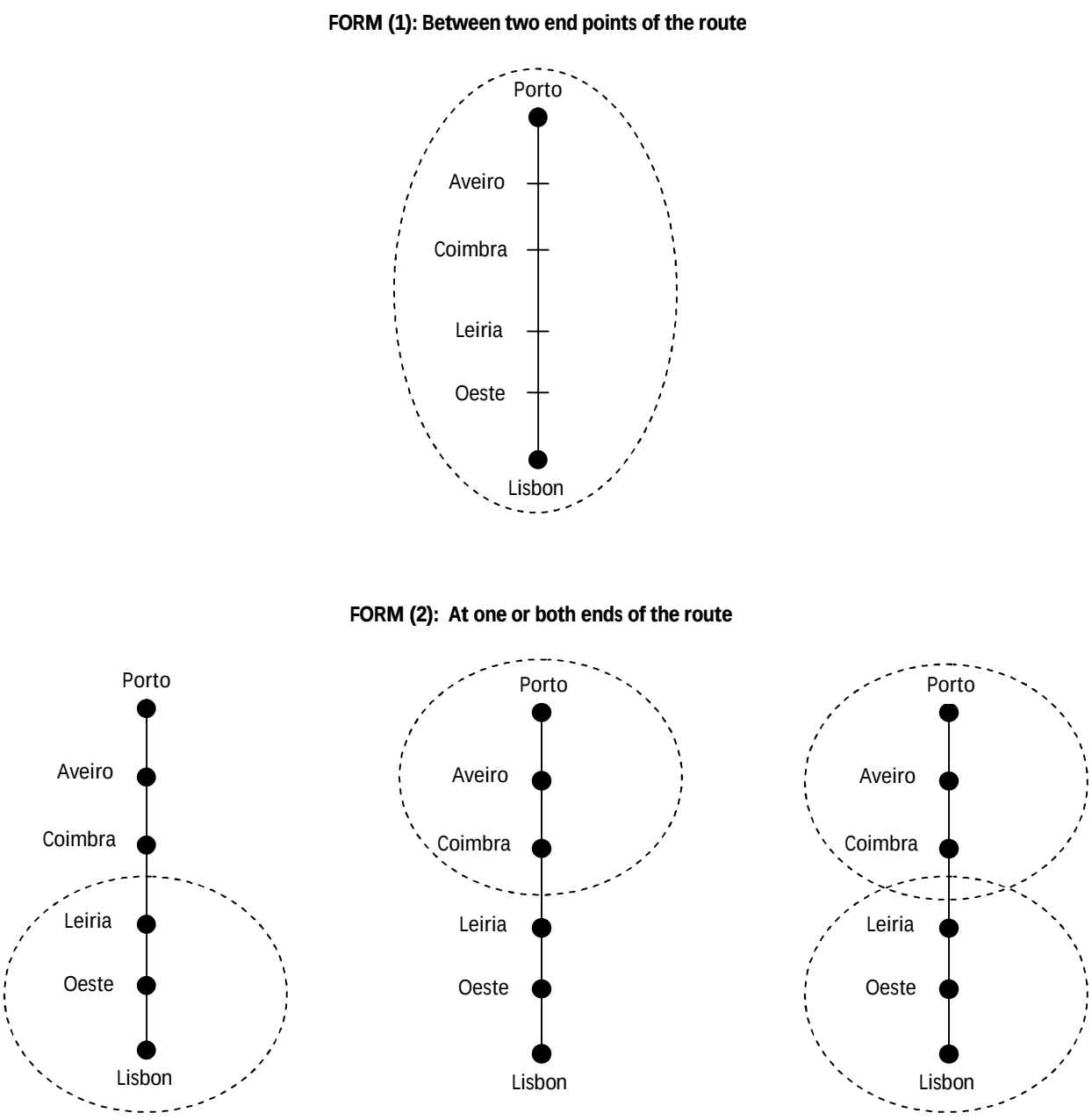
[1] No direct Alfa Pendular service is available from Lisbon to Leiria and to Oeste; Leiria and Oeste are not connected to Alfa Pendular.

[2] Air travel times have been calculated approximately by adding to the flight time 90 minutes for travel time from/to city center to/from the airport, boarding and de-boarding pocedures; there are no flights to and between the intermediate cities.

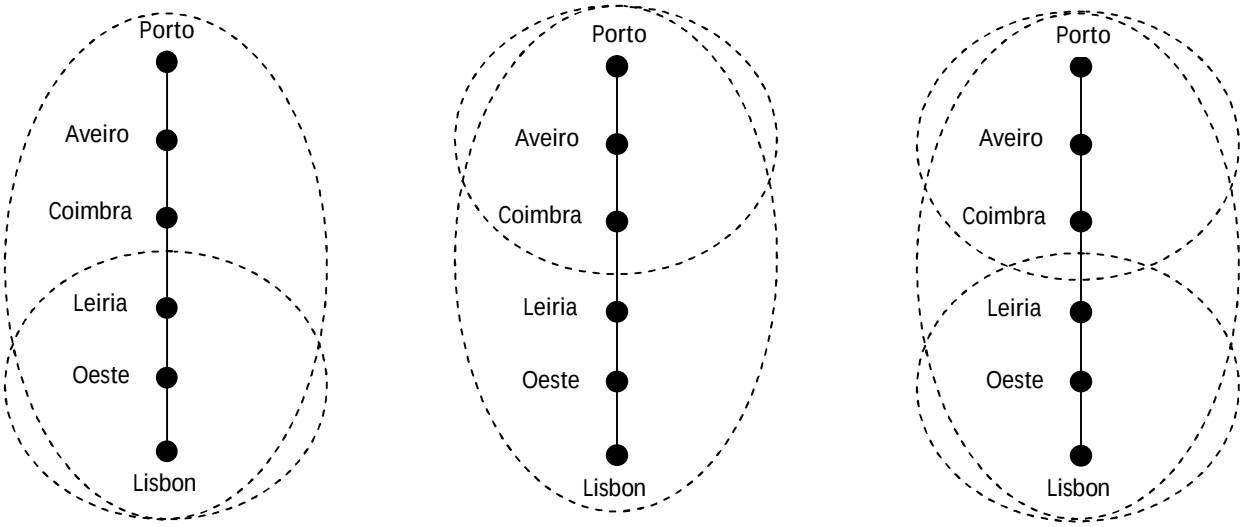
Source: RAVE studies, Google directions, Expedia travel search, and own calculations.

A megalopolis may emerge along the corridor as a result of increased interaction between the cities in two different ways as was observed in the case studies discussed earlier. Applying the same logic, we consider the three possibilities of potential megalopolis formations along the future Lisbon-Porto HSR corridor: (1) megalopolis forming between two main end cities (Lisbon- Porto); (2) megalopolis forming at one of either ends of the HSR routes or both simultaneously (Lisbon-Oeste-Leiria and Porto-Aveiro-Coimbra); and (3) emergence of combinations of both cases in (1) and (2) simultaneously creating a "hybrid megalopolis" (see sketches of various combinations in Figure 7.10). Further, we discuss the fourth possible future

Figure 7.10: Possibilities of Megalopolis Forms



FORMS (3): Hybrid Megalopolis



scenario where a megalopolis is not formed; however, economic development in the urban areas along the corridor may not or may still take place. For each megalopolis form, we also predict which cities may gain the most, lose the most or have no impacts, using the experiences drawn from the case studies.

Description of the current travel patterns and background on the urban areas located along the Lisbon-Porto corridor is provided in Chapter 3. Table 7.6 lists and summarizes the state of the cities that would be affected by the new high speed connection: both the cities that will be directly served by the new line and those located around the corridor that will not be connected to the HSR. The four possible scenarios that may emerge as a result of accessibility provided by the new line and the expected impacts on the urban areas for each scenario are discussed next, drawing on the lessons from the Japanese, French and German case studies. There may be other possible future scenarios (as sketched earlier); however, we are limiting our discussion to only four possibilities.

Table 7.6: Cities located along the planned HSR corridor: directly served and not served

City (Station) connected to HSR	District	Population Size ('000)[a]	Conventional Rail Service	Alfa Pendular Rail Service	Main Sector Focus
Lisbon	Lisbon	2,600	Yes	Yes	Services
Porto	Porto	1,400	Yes	Yes	Manufacturing
Oeste	Santarem	390	No	No	Mixed[b]
Leiria	Leiria	124	Yes	No	Services/Light Ind.
Coimbra	Coimbra	436	Yes	Yes	Research/Tourism
Aveiro	Aveiro	73	Yes	Yes	Tourism/Food Pro

City (Station) not connected to HSR	District	Population Size ('000)[a]	Conventional Rail Service	Alfa Pendular Rail Service	Main Sector Focus
Santarem	Santarem	64	Yes	Yes	Agriculture
Pombal	Leiria	59s	Yes	Yes	Services
Viva Nova de Gaia	Porto	289	Yes	Yes	Tourism/Services
Caldas da Rainha	Leiria	58	Yes	No	Services/Tourism
Torres Vedras	Lisbon	92	Yes	No	Agriculture

(a) Populations shown for all cities are for metropolitan areas.
(b) Oeste is a sub-region, and the station will be serving Rio Maior, Caldas da Rainha, Santarém, and Torres Vedras municipalities. The population of Oeste is given for entire sub-region.

Source: Statistics Portugal, Official Website. 2009. Statistical table extracted on 02/23/2010 from http://www.ine.pt

Scenario 1: Lisbon-Porto Megalopolis

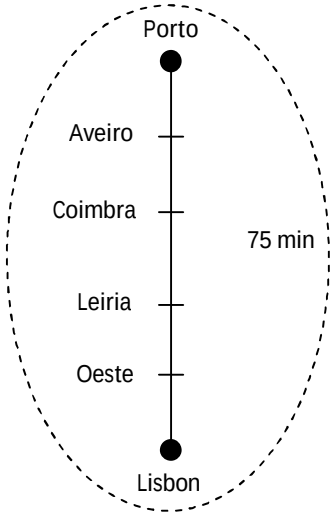
A megalopolis may emerge between the two end points connecting the two largest cities of Porto and Lisbon, similarly to Paris-Lyon corridor. The formation of such a megalopolis would be likely if the frequency at intermediate stops is minimized and more emphasis is placed on the non-stop direct service between Lisbon and Porto. The increase of interaction between these cities may have substantial effects on economic growth on the corridor level, but reinforce further concentration of economic activity in Lisbon thus increasing regional inequalities.

In this scenario we assume that the frequency of service at intermediate stops of Oeste, Aveiro, Coimbra and Leiria will be limited, but relatively high for non-stop service between Lisbon and Porto. This would imply higher average speed leading to substantial travel time cuts for journeys between of Lisbon and Porto (see Figure 7.11). The train frequencies in Porto and Lisbon would be higher than the frequency of currently offered Alfa Pendular service on the corridor. The expected impacts on the urban areas are as follows:

- Porto may not be affected by the HSR connection due to its prevalent manufacturing and industrial sector focus, on which HSR has minimal impact (as observed in Nagoya on Tokyo-Osaka Shinkansen). Better proximity to Lisbon may not yield positive impacts as Lisbon-based businesses may no longer need to expand their offices to Porto.

- Other connected intermediary cities such as Aveiro, Coimbra and Leiria will have modest impacts from the HSR under this scenario since in this scenario the frequency of service would be low.
- Oeste sub-region will be positively impacted. Since the area is currently not served by the conventional rail, the incremental gain from improved proximity to Lisbon will be higher than for the areas already connected to the existing rail network.
- Cities that are not connected to the HSR line will be worst off by losing their economic activity and possibly population to the cities with HSR stations.

Figure 7.11: Scenario 1 – Lisbon-Porto Megalopolis



Megalopolis: Lisbon -Porto

Gains: Lisbon, Oeste sub-region
No/modest impacts: Porto, Aveiro, Coimbra, Leiria
Losses: Cities not connected to the HSR link

	Lisbon	Oeste	Leiria	Coimbra	Aveiro	Porto
Frequency (trains/day)	30	8	8	8	8	30
Station served by conventional rail line	Yes	No	Yes	Yes	No	Yes
Connection to airport	Yes	No	No	No	No	Yes
Primary industry sector focus	Services	Mixed	Services/Light Industry	Research/ Toursim	Tourism/ Food Prod.	Manufacturing

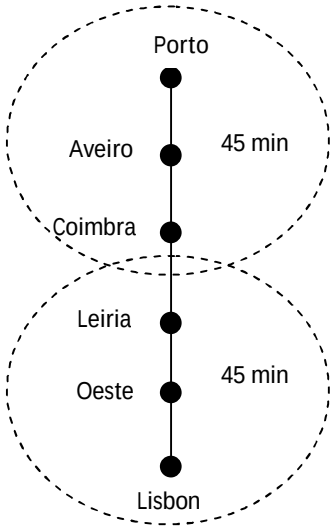
In this scenario, new demand may be induced for trips between Lisbon and Porto mainly among business travelers in direction to Lisbon and not out of Lisbon, as we observed in the Paris-Lyon corridor case. New demand may also be generated out of Oeste sub-region, however, it may be a result of relocated travelers, as attractiveness of Oeste will rapidly increase going from area with no rail connection to area with HSR station.

Scenario 2: Lisbon-Oeste-Leiria and Porto-Aveiro-Coimbra Megalopolises

Two megalopolises may form as a result of the HSR connection between the major end point cities and the closest intermediate cities (similarly to the Japanese and German cases). This scenario would be more likely with the high frequency of stops at intermediate stations, which will increase the total travel time along the corridor, thus promoting interaction between the intermediate cities with the end point cities, but not between the end points.

In this scenario we assume that the frequency of service at intermediate stops of Oeste, Aveiro, Coimbra and Leiria will be same as at the end point stops of Lisbon and Porto. Thus, there would be very limited or perhaps no non-stop direct service between Lisbon and Porto. The higher number and more frequent stops would imply a decrease in the average speed and decrease in the overall travel time savings. This in turn would make the HSR travel between Lisbon and Porto less competitive with other modes. In this scenario, the travelers at intermediate stops would be favored more by travel time savings and more frequent service. The resulting impacts may lead to major economic gains along the corridor and not just in Lisbon (see Figure 7.12):

Figure 7.12: Scenario 2 - Lisbon-Oeste-Leiria and Porto-Aveiro-Coimbra Megalopolises



Megalopolis 1: Lisbon-Oeste-Leiria
Megalopolis 2: Porto-Aveiro-Coimbra

Gains: Lisbon, Porto, Aveiro, Oeste, Coimbra, Leiria
No/modest impacts: none
Losses: cities not connected to HSR network

	Lisbon	Oeste	Leiria	Coimbra	Aveiro	Porto
Frequency (trains/day)	22	22	22	22	22	22
Station served by conventional rail line	Yes	No	Yes	Yes	No	Yes
Connection to airport	Yes	No	No	No	No	Yes
Primary industry sector focus	Services	Mixed	Services/Light Industry	Research/ Toursim	Tourism/ Food Prod.	Manufacturing

- Lisbon being predominantly a service based center will attract additional business and commuter trips from Oeste and Leiria. The increase in commuter trips may be a result of relocation of current Lisbon residents to less costly areas in Oeste and Leiria. Nevertheless, Lisbon businesses will win from expanded catchment area enabled by new HSR.
- Porto being a predominantly industrial center may attract commuting travel from Aveiro and Coimbra, however at a much lower magnitude than Lisbon.
- Aveiro and Coimbra known for their tourist attractions may gain from the increased flow of tourists. Faster travel times provided by the high-speed service may lead to reduction of overnight stays, thus hurting the existing hotel businesses in the areas; however, this loss may be compensated for by the overall growth of tourist traffic.
- Oeste and Leiria will benefit from gaining access to the services market in Lisbon and wider labor market, though at a lower magnitude relative to Lisbon. The incremental positive impact on Oeste with no rail service link available at the moment would be greater than that on other intermediate cities already connected to conventional rail.

- Disconnected cities, such as Pombal, Santarem, Viva Nova de Gaia and others, will be worse off from not being connected and may lose their economic activity to more prospering connected cities.

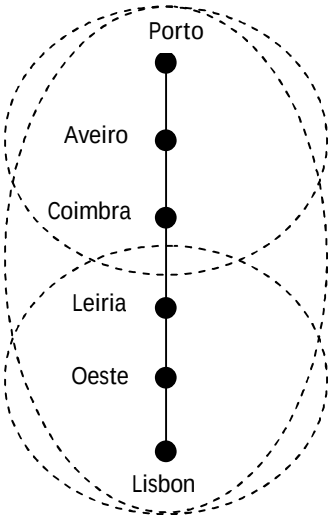
In this scenario, new demand may be induced for trips originating at intermediate stops in direction of Lisbon and Porto for business, commuting and potentially other non-business purposes, similarly to what was observed in the Cologne-Frankfurt case (i.e. increase in commuting travel from intermediate small cities to Frankfurt city center). It may also be possible that this new demand is generated as a result of the large number of businesses and residents relocating to HSR connected cities from the areas not served by HSR.

Scenario 3: Hybrid Megalopolis

The scenarios 1 and 2 are not mutually exclusive and there could be a possibility of both types of megalopolises emerging simultaneously, and forming a combined "hybrid megalopolis". In this case the HSR services would be provided on a relatively frequent basis with stops at intermediate stations, as well as with no stops directly serving the end points of the route. This may promote increased interaction and formation of megalopolises on both levels: one between two end points Lisbon and Porto, one between Lisbon and intermediate cities of Leiria and Oeste, and one between Porto and intermediate cities of Aveiro and Coimbra.

In this scenario we assume the frequency of service at intermediate cities to be greater than that in Scenario 1 but slightly lower than that in Scenario 2, and at the same time, the frequency of non-stop service between Lisbon and Porto to be as high as in Scenario 1. This would imply higher average speed compared to Scenario 2, but lower average speed compared to Scenario 1. This scenario will ensure that substantial travel time savings are provided for journeys between Lisbon and Porto, and simultaneously, the intermediate city stops also gain from travel time savings and improved accessibility (Figure 7.13).

Figure 7.13: Scenario 3 – Hybrid Megalopolis



Megalopolis 1: Lisbon-Oeste-Leiria
Megalopolis 2: Porto-Aveiro-Coimbra
Megalopolis 3: Lisbon-Porto

Gains: Lisbon, Oeste, Leiria, Coimbra, Aveiro, Porto
No/modest impacts: none
Losses: cities not connected to HSR network

	Lisbon	Oeste	Leiria	Coimbra	Aveiro	Porto
Frequency (trains/day)	30	15	15	15	15	30
Station served by conventional rail line	Yes	No	Yes	Yes	No	Yes
Connection to airport	Yes	No	No	No	No	Yes
Primary industry sector focus	Services	Mixed	Services/Light Industry	Research/ Toursim	Tourism/ Food Prod.	Manufacturing

Some of the possible impacts on urban areas may be as follows:

- All cities connected to the HSR line will win, but the distribution of economic gains may not be necessarily homogeneous – i.e. Lisbon and Porto will attract the most benefits, while others will also benefit but at a lesser extent.
- On the other hand, since the accessibility of the intermediate cities will be improved and proximity to the major economic centers will be reduced, there may be a risk of further centralization of Lisbon.
- Businesses in the cities of Leiria, Coimbra, Aveiro, Porto, and Oeste sub-region may face greater competition from their neighbors in Lisbon, or may relocate to Lisbon. Large companies in Lisbon may find no longer a need to have branch offices in the smaller cities located within a daily trip distance by HSR.
- The cities not connected to the HSR line may lose their businesses and population to the connected cities.

This scenario would entail a very dynamic and busy corridor, which would be possible if the level of newly induced traffic is high. Therefore, new demand may be induced from all the cities connected to the new high-speed line. Whether this new demand is generated due to the relocations of businesses and people may raise a question of redistribution of the economic gains.

Scenario 4: No Megalopolis

The Lisbon-Porto HSR deployment may also not result in emergence of a megalopolis. Since the corridor already has well-developed rail services, including the higher speed conventional service Alfa Pendular, the incremental impacts from increased speed on most of the cities may be very small. Even with Alfa Pendular operations, the share of rail traffic is much lower than that of road (private car or coach bus) ridership along the corridor. Therefore, cutting rail travel time in half may not lead to any substantial changes in travel patterns and mode split, generating no or insignificant new traffic. With no induced traffic or no changes in the travel patterns, no increase in the interaction between the cities may take place, and thus no fusion of multiple cities and formation of a megalopolis may happen. However, as discussed earlier, there is no clear-cut way of determining when a megalopolis is formed. One can, however, consider that a megalopolis is formed when some of the following parameters are observed in the travel patterns between the cities: significant increases in one-day round trips between a pair or group of cities, high levels of newly generated induced demand overall, induced business trips, increase in number of commuters, and decrease in overnight hotel stays.

Moreover, no megalopolis formation does not imply no economic development. The development and growth may still occur but without major changes in spatial structure of cities and interaction between them. For example, cities that were not connected to any conventional rail line (like Montabaur and Limburg in Germany) would have positive economic effects from the connection to HSR and HSR station, even if there is no spatial integration with other cities. Also, HSR stimulates economic benefits directly during the construction period (captured mostly by benefit-cost analyses).

7.4.1 Regional Development Effects on Urban Areas

For the cities connected to the Lisbon-Porto HSR line, accessibility will increase, and with even greater magnitude for smaller cities than for large cities, as the latter already have good accessibility levels. The question, however, is not whether accessibility improves for small cities, but rather, what does that accessibility mean for the economic activity, labor markets, and distribution of growth.

The three case studies for Japan, France and Germany (presented in Chapter 4, 5 and 6) confirm the theory presented by Pol (2003) that "new forms of infrastructure" such as HSR "tend to be constructed where there is already much interaction" and "the most intensive interaction occurs among economic key areas", usually capital cities.[441] In all three cases, the decisions to construct the high-speed lines were made mainly to solve limited capacity issues on the existing corridors with high demand for accessibility, and in two cases (Japan and France) capital cities were the first to be connected. Smaller urban areas were connected as intermediate stops mostly because of political pressures. Germany's internal geopolitics such as re-unification between East and West Germany with different capitals and historical presence of several major urban economies led to a more dispersed network of HSR lines.

In all three cases, the cities with already "strong competitive positions"[442] and consequently stronger economic potential have benefited more than smaller urban regions did. Thus, the findings are also in line with Pol's theory discussed in Chapter 2 that HST's "influence on urban areas" depends on the pre-existent "economic potential of an urban region".

The same theory expects the HST to have a "catalytic" effect on cities with lower economic growth, and a "facilitating" effect on already economically prosperous cities (see Figure 2.3 in Chapter 2). However, based on our three case studies, the "catalyzing effect" (i.e. development of new activities in an urban area) leads to net economic growth on a city level but on national level this growth usually occurs at the expense of other urban areas. Hence, the HST may have a third type of effect on the national economy – a redistributive effect – discussed earlier in this chapter.

7.4.2 Minimizing Negative Effects of HSR on Small Urban Areas

Cities not connected to the HSR will be the worst off by potentially losing their businesses, labor market and population to the cities with HSR stations. The impacts of HSR on smaller cities located at intermediate stops may vary, with some benefiting or losing and some remaining as is. Based on the case studies discussed in this thesis, the following factors and strategies to deployment of the HSR lines determine the inclusion of the small urban areas not connected to the HSR in the benefits stimulated by HSR and minimize the potential negative impacts.

[441] Pol, P. M. J. 2003.
[442] Ibid

Compatibility with conventional rail system

Compatibility of French TGV with the conventional rail system has allowed a greater area of reach of TGV trains to the remote areas without the need to invest in high-speed track extensions. For example, TGV trains may reach some remote areas in France without the need to travel through Paris. Lisbon-Porto corridor already has well-developed conventional rail connections. It is currently served by two types of rail services: Alfa Pendular, an upgraded to high-speed conventional line, and conventional (including Intercity and Inter-regional). This existing rail network uses non-standard 1,668 mm gauge tracks, while the new high-speed lines are planned to be built to the international standard 1,435 mm gauge to ensure high speeds and compatibility with the EU HSR network. Therefore, the compatibility between the existing railways and new HSR line will be limited in Portugal, which may lead to disadvantaging of cities connected to the conventional system but not connected to the HSR.

The differences in the gauge size of conventional track make Lisbon-Porto more similar to Tokyo-Osaka Shinkansen corridor. Japan's Shinkansen was integrated with the conventional rail through allowing stations to be shared by both high-speed and traditional trains. This structure ensures provision of *feeder services* to HSR stations from cities not connected to HSR, and the track does not have to be compatible. Portugal plans to integrate the Lisbon-Porto HSR line with the existing conventional rail network by designing the stations to accommodate both high-speed and conventional trains, specifically the stations in Lisbon, Leiria, Coimbra, and Porto, so that easy connection and transfer between two types of services is allowed (these plans are discussed in detail in Chapter 3). In addition, automatic track gauge changeovers are planned to be installed near approaches to stations in Aveiro, Coimbra, Porto and Lisbon, to allow the circulation of high-speed and conventional trains in both networks. If Portugal implements these measures, the potential negative effects on the small urban areas may be minimized. The integration of HSR with conventional network would also generate greater passenger traffic through a network effect.

In addition, the mixed use of high-speed lines by both freight and passenger trains may negatively affect the speed and frequency of the passenger services and increase maintenance needs. The non-mixed used, i.e. separation between freight and passenger services on the HSR lines, would enable faster and more frequent service provision to the intermediate stops.

Frequent stops at intermediate stations

The increased frequency of stops of HSR service at intermediate stations would contribute to regional development and reduction of regional disparities by more equally distributing the benefits of HSR to the smaller urban areas located in between the major centers. However, increasing frequency will lead to lower average speeds, and consequently lower capacity and longer travel times. This in turn may make HSR less competitive with other modes for travel between Lisbon and Porto, especially with air, resulting in little changes in accessibility and mobility, limited generation of new traffic, especially for business purposes, and consequently suppress the overall development benefits that high-speed rail may yield. Therefore, frequency is an important factor for achieving economic development impacts and for ensuring the more equitable distribution of these impacts to smaller urban areas. The trade-off has to be made to balance these two goals.

Adequate access to other modal connections

In addition to current railway network, the cities along and around the Lisbon-Porto corridor are served by other modes of transportation, i.e. roads, transit links, intercity buses, etc. Both Lisbon and Porto have connections to major airports. Integrating HSR with these other modal services is an important factor in improving regional access and maximizing accessibility changes driven by HSR lines. Direct linkages to the airports in major cities also play an important role.

According to Vickerman (1997), HSR is considered a "intermediate level" mode as it serves inter-city trips, and its impacts depend on how well it is connected to local "lower level" (e.g., parking, road, transit, other local transportation, etc.) and to international "higher level" (e.g., international airports) networks. Therefore, provision of adequate access from HSR nodes to other modal networks is critical. No matter how fast the HSR network is, "for firms and individuals in the region, the critical factor will be how easy it is to access that network",[443] especially, in case of peripheral station locations. Similarly to conventional rail feeder services, other modes may extend the HSR's service area to cities not connected to HSR without the need to build high-speed track extensions.

7.5 Impacts on National Level

As discussed in Chapter 3, Portugal has the following strategic goals for HSR:

- Create a modern, sustainable and efficient transport system with the minimum environmental impact;
- Reduce the country's peripheral position by improving rail links between Portugal and Spain, contribute to "strengthening economic and social cohesion" of Europe, and "ensure interoperability" with EU rail networks;
- Contribute to the Atlantic southwest front competitiveness;
- Accelerate the country's economical and technological development, including at the regional level;
- Contribute to a better intermodal distribution, both for passenger and freight, and encourage a modal shift to rail from air and road; and
- Increase mobility "providing new opportunities for attracting investment".[444]

According to the theories of Banister and Berechman (2001), in most advanced countries levels of accessibility are already high; therefore, the impact from new transport investment on the system as a whole may be marginal. Moreover, new investment usually enhances the existing trends rather than creating new ones.[445] Based on this theory, HST construction in Portugal, a developed country with an established transportation system, may not have any development impacts on the national level merely from improvements in accessibility, unless certain

[443] Vickerman, R. 1997. High-speed rail in Europe: Experience and issues for future development. *The Annals of Regional Science*, 3, pp. 21-38.

[444] Rede de Alta Velocidade (RAVE). 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

[445] Banister, D. and Berechman, J. 2001. Transport investment and the promotion of economic growth. *Journal of Transport Geography*, 9, pp. 209-218.

conditions are in place. These conditions, according to Banister and Berechman (2001), are (see Section 2.1 and Figure 2.1 in Chapter 2 for a more detailed review of these conditions):

- "positive economic externalities": "high quality of labor force, buoyant local economic conditions";
- "investment factors": "availability of funds for investments, network effects, timing of investment and its efficient implementation; and
- "political, policy and institutional factors": organizational and legal frameworks conducive to investment, "complementary policies, and efficient management of infrastructure".[446]

Based on these conditions, a question arises whether they are in place in Portugal and whether Portugal will achieve the economic development goals it envisions for HSR. Considering the first condition of economic factors, Portugal's labor force lacks the technical expertise and has low level of education attainments, falling short of the EU average levels. According to the report by the Economic Intelligence Unit (2008), "in 2006 only 27.6% of the Portuguese population aged 25-64 had attained a higher secondary education, the lowest percentage of all EU countries except Malta. Almost 40% of Portuguese children leave school by the age of 14 (the second-highest rate in the EU) and illiteracy rates still rank among the highest in the OECD." One out of ten school graduates continue on to higher education, "compared with an EU average of one in five." [447] However, the government has made investments in education one of the top priorities.

As for "investment factors", the availability of funds for the investment in HSR is currently a challenge for Portugal because of the country's budgetary crunch. Some funds are available through the EU grants, EIB loans and private sector; however, substantial financing support is needed from the government (see Chapter 3 for detailed discussion of the financing issues in Portugal's HSR). This has caused delays in implementation timing, and prospects for construction of the entire network are uncertain at the moment. Regardless the opposition, the Minister of Public Works of Portugal Antonio Mendonca announced on Monday, May 3, 2010 that the Government plans to proceed with the deployment of the first section of Lisbon-Madrid axis and expects the HSR investment to have "feedback and dynamic effects on the economy", "generate many jobs and encourage small and medium-sized Portuguese companies to invest."[448] The final decision will be known at the end of May 2010.

While politically in Portugal there is opposition to HSR, the organizational and legal frameworks are conducive to HSR implementation. The creation of special entity responsible for development and implementation of the projects - RAVE – attests to this fact. Moreover, the EU has been a major driving force and supporter of Portugal's HSR, with the axis in Portugal being part of EU's top 30 priority projects. Thus, the complementary legal and environmental policies and frameworks will have to comply with EU-wide requirements.

In sum, Portugal faces fiscal constraints to proceed with the investment, and its economic conditions may not be optimistic at the moment. On the other hand, Portugal's development

[446] Banister, D. and Berechman, J. 2001.
[447] The Economist Intelligence Unit (EIU). 2008. Country Profile: Portugal. London, UK.
[448] A Bola (online newspaper). 2010. "Ministro defende TGV e novo aeroporto." Article (in Portuguese). May 3. Retrieved on 05/06/2010 from http://www.abola.pt/mundos/ver.aspx?id=203825

may have been slower partially because the country's transportation system has not been well integrated with the rest of the EU and its remote location impeded investments growth from abroad. The HSR will integrate Portugal internationally by providing interoperability with the EU's railway network and removing barriers for people and goods' movements to and from the other EU countries, including Spain. Therefore, relative to the existing status quo, growth should occur in Portugal on the national and international levels through gaining access to Spanish and other EU markets and attracting more investment. Finally, we note that the stimulus effect on Portugal of constructing the HSR system should not be overlooked.

7.6 Summary

Pre-HSR conditions

The way that the urban areas are impacted by the new HSR has to do in part with pre-existing conditions in the cities before HSR, such as:

- The quality, physical characteristics and coverage area of the conventional rail line prior to HSR deployment: gauge size, frequency of service, level of service, number of nodes and stations.
- Strategic importance of freight transport on the corridor.
- Type of industry sectors prevalent in the area: service industry focus would be favored more by presence of HSR than manufacturing focus would.
- Tourist attractions in the area.
- Stations location, connectivity with other rail services, station area development.

Accessibility

All the cities connected to the Lisbon-Porto HSR link will gain better accessibility; however, the benefits to the cities of Lisbon and Porto with good accessibility before HSR will be greater; thus the relative accessibility of smaller urban areas will still be lower compared to that in bigger cities of Lisbon and Porto. Thus, the regional disparities may not be decreased, but on the contrary, may actually increase.

Development Impacts

It is not clear that cutting rail travel time in half will yield significant economic benefits, according to the theories of Banister and Berechman (2001).[449] Even with Alfa Pendular service, the share of rail traffic is much lower than that of road (private car or coach bus) ridership along the corridor.

HSR appears to favor the most urban areas with the dominating service industry focus and the least those with manufacturing concentration. Improved accessibility and decreased travel time offered by HSR may also diminish the willingness of large companies based in Lisbon to keep or open branch offices in Porto or other intermediate cities. Tourism sector will be highly affected by the journey time cuts resulting from HSR connections. According to the case studies, while number of tourist traffic rises, the duration of stay in the cities, specifically overnight stays,

[449] Banister, D. and Berechman, J. 2001.

drops. This may negatively affect the hotel businesses across the cities leading to reduction in employment in the sector.

Megalopolis Formation

Formation of megalopolis seems to be driven mainly by the new group of travelers for commuting or business travel purposes. If HSR on the Lisbon-Porto corridor generates such new demand between the pairs or group of cities, it would lead to the fusion of these cities into one large economic zone and emergence of a megaregion or megalopolis. Lisbon's dominant position as the major economic center in either case will be strengthened further with the expansion of the HSR network to Spain and to the south of Lisbon.

Environmental Sustainability

The environmental impacts from HSR and the economic growth within megalopolises are found to be controversial in the literature. The environmental footprint of HSR is highly dependent on the source of traffic, diverted or induced, and on the load factors of trains. The energy consumption and level of CO_2 emissions produced by HSR is determined by the type of energy source used to generate electricity. The major negative environmental impact of HSR experienced in most countries has been noise pollution and vibrations in the populated areas. There are also concerns that the economic growth occurring within megalopolises or megaregion may overshadow sustainable development as the linkages between multiple metropolitan areas within a megalopolis often pass through the greenfield or wilderness zones.

* * *

The next chapter presents conclusions to the thesis and proposes future areas for research identified during the course of this research work.

8 Conclusions

This chapter summarizes the findings of this thesis and the lessons for Portugal's future HSR system based on three international case studies. In addition, we suggest some future research directions that have been identified during the course of this work.

8.1 Background

HSR is becoming an increasingly important and popular mode of transportation as roads and airports become more congested and GHG levels increase. It took twenty years after the implementation of the first HSR line in Japan until the interest in HSR reached Europe. But it has been in the last several decades that HSR has gained acceptance worldwide, with new lines having been constructed in China, South Korea, and Taiwan, and being seriously considered in the United States and other countries.

The implementation of high-speed rail lines plays an important role in reshaping the travel patterns and activities of people and consequently changing the ways cities develop. This thesis has explored the indirect or wider development impacts that HSR may potentially have on urban areas along the planned Lisbon-Porto corridor. An interesting indirect implication of HSR studied is the potential for megaregion or megalopolis formation - an integrated economic urban complex – created by fusion of multiple cities[450].

In this research, we began with a literature review of two different but related disciplines: transportation literature on economic development effects of HSR investments and economic geography literature focusing on urban hierarchy and concepts of mega-city regions or megalopolis. We then explored empirical studies linking the effects from HSR and other transportation infrastructure to formation of megalopolises. Case studies of international experiences with HSR were undertaken in Japan, France and Germany, focusing on specific HSR corridors: Tokyo-Osaka Shinkansen in Japan, Paris-Lyon TGV in France, and Frankfurt-Cologne ICE in Germany. The objectives of the case studies were to study the phenomenon of "megalopolis" formation along the selected corridors as a result of the HSR link, find evidence of economic development effects on urban areas in the corridors, both positive and negative, and identify the winners and losers. The findings and lessons were applied to the Lisbon-Porto HSR corridor case and the possibilities of future scenarios of megalopolis forms and the associated impacts were discussed and analyzed.

8.2 Summary of Findings

The following are the overarching findings derived from this thesis:

- ***Literature on HSR's indirect development impacts is extensive; however, the question on the real effects of HSR investment on economic development has not been fully exhausted.***

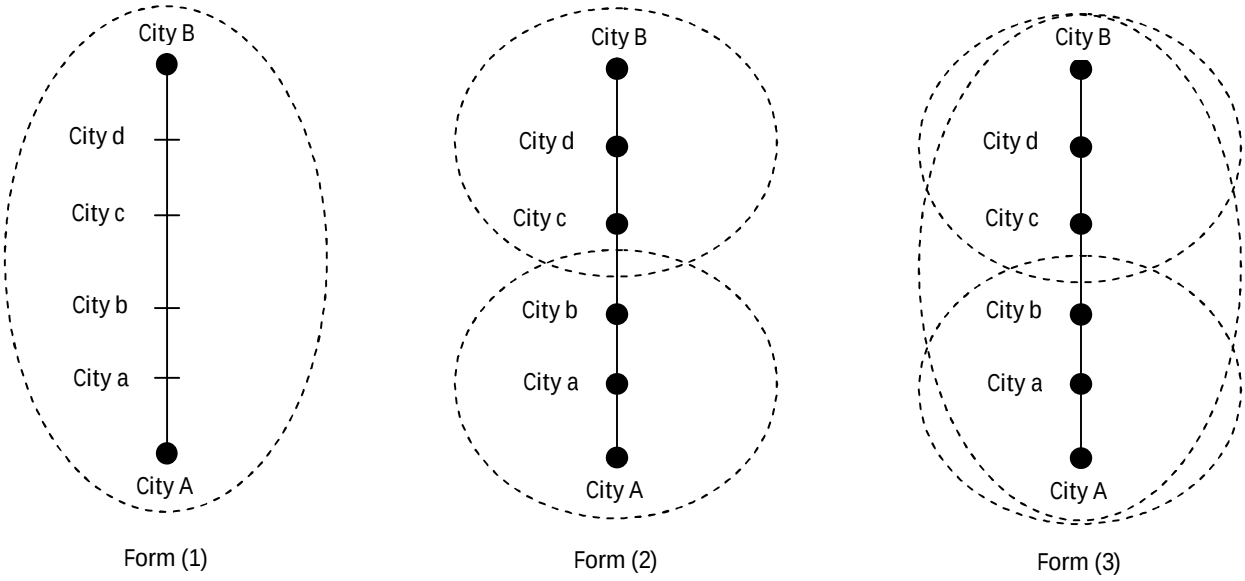
[450] Gottman, J. 1961; Pickard, J.P. 1962; Hall, P. 2006 and 2009; Lang, R. and Knox, P. 2009; and Blum et al. 1997.

A rich literature exists on HSR and there is a general consensus among scholars as to what indirect development impacts may be from the HSR investment, including impacts on spatial location of economic activity, accessibility and proximity to economic mass, labor markets, and productivity. However, the question of the causality between HSR investment and economic growth still remains because of the complexity of this issue, the long-term character of the growth effects, and other factors that may be at play.

- ***HSR investment is associated with potential changes in accessibility and market size, as a result of reduction in travel time and transportation costs, which in turn may lead to economic and functional integration of multiple urban areas by fusing them into a megalopolis.***

The emergence of a megalopolis or multiple megalopolises may occur in different forms as a result of accessibility and proximity to larger markets brought about by HSR. For example, in both Tokyo-Osaka Shinkansen and Cologne-Frankfurt ICE corridor case studies, a megalopolis formation is observed between one (or both) of the large cities at the two ends of the corridor and several small intermediate cities in between. In the case of Paris-Lyon TGV line in France, a megalopolis has emerged between the Paris and Lyon connected at two ends of the route, while the smaller urban areas in between have not been integrated. The emergence of all these megalopolis forms simultaneously could potentially create a "hybrid megalopolis", although it has not been observed in any of the case studies (Figure 8.1 illustrates examples of possible megalopolis forms).

Figure 8.1: Possibilities of Megalopolis Forms



- ***The economic growth stimulated by HSR is not uniformly distributed within a megalopolis, resulting in winners and losers.***

HSR through the megalopolis formation contributes to *economic development*. It may either spur new growth (catalytic role), or contribute to *economic shifts* through relocation of economic activity within the corridor (redistributive role), which may imply some growth, no growth or even negative growth for some. The spatial distribution of any growth is non-uniform, which may essentially lead to urban areas that win at the expense of those who lose from the development.

- ***Role of induced traffic in the generation of economic growth is critical.***

The formation of a megalopolis seems to be driven mainly by the generation of more travel for commuting, business, leisure or other purposes. New growth is more likely to take place when HSR *induces* substantial levels of new demand by changing travel behavior of those who would not have traveled otherwise. However, if the induced traffic is driven from within the population and businesses that relocated from other areas, the growth it leads to could be redistributed at the expense of cities that lost economic activity and population.

- ***The way that the urban areas are impacted by the new HSR is related to pre-existing conditions in the cities before the high speed connection.***

Case study findings have shown that cities with a strong economic base before the HSR construction seem to benefit from the HSR the most, while cities with smaller economies gain to a lesser extent or not at all. HSR tends to favor urban areas with service and information exchange industry foci and less manufacturing and agriculture oriented areas. Other pre-existing factors that may maximize HSR's positive impacts are compatibility with the conventional railway, inter-modal connectivity, tourist attractions, and station location in city center. Cities not connected to HSR line directly are the biggest losers from this development, especially if they are not linked to HSR by conventional feeder services.

- ***The economic development stimulated by HSR within a megalopolis may have adverse environmental implications.***

Proponents view HSR as the sustainable mode, that emits significantly lower levels of greenhouse gases (GHG), especially compared to its main competitors – air and cars. However, amount of polluting gases that HSR is responsible for depends on the source of electricity generation for HSR. There are also concerns that the drive for economic growth occurring within the megalopolises may neglect the needs for environmental conservation, as the HSR linkages between multiple metropolitan areas within a megalopolis often require large areas of new land and may pass through the greenfield or wilderness zones. Depending on these factors, HSR may not be as environmentally advantageous as believed.

- ***Costs of constructing HSR lines are substantial, but are within reasonable limits for infrastructure spending.***

The funding requirements for HSR investments may differ depending on the model of the network (more costly to build a mixed-use than a dedicated line), terrain and geotechnical factors, and the technology selected. Most HSR lines were supported by public subsidy at the

construction stage, but more recently, the private sector has also become involved in HSR investments (e.g., in Taiwan and potentially in Portugal).

- ***Countries approached the financing of their HSR start-up programs differently: by either focusing on deployment of a single line or developing multiple lines simultaneously.***

Most countries with existing HSR systems have followed a single-line approach such as Japan and France, while others have allocated their funding for launching multiple lines such as Germany, who launched two lines at the initial stage. The United States has announced an initial allocation of $8 billion across multiple HSR projects throughout the country (characterized by President Barak Obama as a down payment). However, the differences in the country scales in terms of HSR construction have to be taken into account when comparing these financing strategies.

- ***HSR may be seen as a strategy for national integration.***

HSR can be part of an overall national integration strategy, as by linking vast distances and shrinking physical spaces it may stimulate better cohesion of remote parts of a country. For example, in Germany HSR was seen as an important part for re-unification of East and West Germany.

8.3 Conclusions for Portugal

The previous section summarizes our main findings. We also studied Portugal's most densely populated corridor between Lisbon and Porto. The corridor is planned to be linked by the proposed 297 km (185 miles) high speed line with a non-stop journey time of 75 minutes. The HSR will also connect four other urban areas in between Leiria, Aveiro, Coimbra and the Oeste sub-region. The corridor has an already well-developed railway system in place; however, the current traffic is dominated by road mode, including private auto and buses. Nevertheless, Portugal's expectations from the new link are high. HSR is motivated by capacity limitations on the existing conventional network as well as an effort to stimulate the country's economy and to integrate with the rest of the EU.

Based on the earlier findings, we make the following conclusions for Portugal with respect to potential for megalopolis formation and development implications of HSR, specifically focusing on the proposed Lisbon-Porto HSR corridor:

- ***Emergence of a megalopolis is possible in different forms along the planned Lisbon-Porto HSR corridor as a result of improved accessibility and increased interaction between the cities.***

The temporal distances between the cities planned to be connected by the new Lisbon-Porto HSR line will be reduced significantly relative to travel times by any currently available mode of transportation. The high-speed link has a potential to shrink the entire 297 km corridor within the limits of 90-minute travel time (75 minutes non-stop), making it a zone of one-day activity and potentially forming a megalopolis. If the new HSR line between Lisbon and Porto is successful in generating new demand between the pairs or a group of cities, it could lead to the fusion of these cities into a large or several smaller integrated economic zones and emergence of

one or several megaregions. Between which city pairs or group of cities this megalopolis could emerge would in part depend on the origin-destinations that register the biggest traffic increase.

- ***Regional disparities may not be decreased along the corridor, but on the contrary, may actually increase, resulting in winners and losers.***

All the cities connected to the Lisbon-Porto HSR link will gain better accessibility; however, the benefits to the cities of Lisbon and Porto with good accessibility before HSR will be greater. Thus, the relative accessibility that smaller urban areas will gain from HSR will still be lower compared to the accessibility gained by Lisbon and Porto. In three scenarios, derived for the proposed Lisbon-Porto HSR link in Chapter 7, the cities located at intermediate stops of the HSR route (Aveiro, Coimbra and Leiria) may have either no or some development gains. The cities located along the corridor but not connected to the HSR directly may lose economic activity and population to the cities with HSR stations. Moreover, Lisbon's dominant position as a major economic center may be strengthened further as the HSR network expands to Spain and to the south of Lisbon. However, it is still unclear whether the incremental changes in travel time and accessibility will be substantial enough for the economic growth to take place on the corridor level given that the good connectivity and access to conventional railways in the corridor already exist.

- ***Overall growth should occur in Portugal through gaining access to Spanish and other EU markets, and becoming more accessible to investors from abroad.***

On the national and international levels, the HSR will promote Portugal's integration within the Iberian Peninsula and other EU countries by ensuring interoperability with the European railway network both for passenger and freight movements. The EU will also improve its access to Portugal, which is a south-western gateway of Europe to the Atlantic Ocean. However, the three conditions defined in the theories of Banister and Berechman's (2001) must be in place in Portugal in order to achieve the economic development goals it envisions. For Portugal, these specific conditions include presence of "high quality of labor force", "availability of funds for investment" in infrastructure, and favorable political environment.[451]

- ***Megalopolises or megaregions present the need for planning on a new spatial scale with new boundaries and linkages; and HSR links may be used to shape the direction of megalopolises within Portugal and the EU.***

Knowing the impacts of a megalopolis can help to shape appropriate strategies within a megalopolis framework not only in Portugal, but also on the EU level. For example, "the implementation of climate change strategies and programs" can be addressed more appropriately within the megaregion "framework".[452] Moreover, since transport infrastructure investments such as HSR are essential in linking the urban areas into a megalopolis or megaregion, planning transport links may be used to shape the direction in which megalopolises are developed, specifically with respect to ensuring the development of the intermediate urban areas located in between the main stops, and urban areas not directly connected to high-speed lines. This

[451] Banister, D. and Berechman, Y. 2001.
[452] Campbell, S. 2009. p. 132.

includes the planning of station locations, inter-modal connections and frequency of HSR service that may minimize the negative development effects from HSR and a megalopolis.

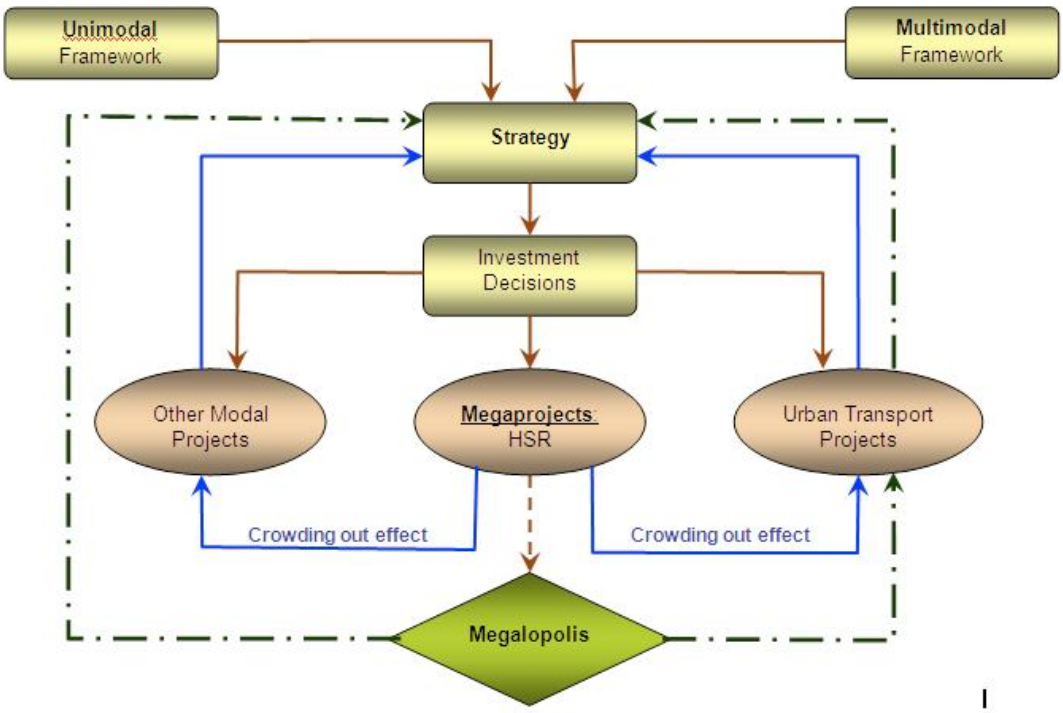
8.4 Directions for Future Research

The following areas for potential future research stem from this thesis work:

- This thesis is based largely on qualitative analysis with quantitative content drawn from previous empirical studies. The assessment of economic development impacts of the HSR on urban areas could be carried out *quantitative*ly, which was not feasible in the scope of this master's thesis due to data and time limitations. If the needed data is obtained for the case studies used in this thesis, one could apply quantitative methods to predict the possible development effects of the HSR investment in Portugal empirically. The modeling approaches that could be used to carry out this analysis are system dynamics, benefit-cost analysis, regression analysis, or difference-in-differences method applied in econometrics.

- Impacts of HSR deployment on *physical and spatial* restructuring on the urban level, specifically changes in land use and station area development, are important issues for Portugal that could potentially be explored. For example, one of the questions could be posed about the possibility of transit oriented development happening around HSR stations, the factors stimulating such development.

Figure 8.2: Feedback Effect of HSR Investment on Transportation Strategy



- The formation of a megalopolis linked by HSR infrastructure and its impacts on economic development of the urban areas will have a feedback effect on the direction of the overall transportation strategy and investments planning, and pose difficult challenges for decision-makers. Experience shows that success of the first HSR line has led many countries to expand their networks further. The experiences of the first lines have also played an important role in determining the routes and cities for the subsequent lines. Changes in travel patterns, emergence of new commuting and other purpose traffic would require rethinking of the existing system to accommodate the changes in the peoples' activities and spatial boundaries. Competition from HSR may also drive other modes out of the markets (e.g., discontinuation of air services in Cologne-Frankfurt route), which in turn will call for changes in the existing infrastructure and development of new solutions ensuring that changes in other modal services do not cut off access to certain areas. (As shown in Figure 8.2, a megalopolis may pose challenges for urban transport investments and affect the strategic objectives at the higher level.) From this we suggest the following directions for future research:

    - The main institutional issues related to megaprojects arise from funding and financing constraints due to not only their high costs but also because of their geographic, physical, financial, and time scale problems. Megaprojects require long term commitment of investments, which creates budgetary constraints or crowding out effect for alternative modal projects of smaller scale, or for even other sectors (for the public sector and private investors). Thus, HSR investment may have *crowding out effect* on the funding availability for other transport projects in Portugal (Figure 8.2). Exploring the research question of what the impacts of the crowding out effect from HSR would be on other infrastructure investments and transportation sector overall could be important for Portugal, especially in light of the country's current budget deficit.

    - The strategy leading to specific investment decisions may be developed on a unimodal basis, i.e. without consideration of other modes, or multimodally, i.e. in a more integrated manner accounting for all modes simultaneously. This relates specifically to the decisions on HSR deployment (as shown in Figure 8.2). Intuitively, the multimodal framework is expected to lead to more informed and effective decisions than unimodal framework, but decisions made multimodally may result in delays or no implementation of larger-scale projects such as HSR. On the contrary, within the unimodal approach with one strong decision-making power, HSR may get deployed faster. The main question that arises is whether multimodalism leads to more effective and sustainable decisions and transportation strategy, or unimodal approach is more appropriate in this context, specifically with respect to costly megaprojects such as HSR.

* * *

As concerns for climate change grow and demands for fast and sustainable transport alternatives increase, high-speed rail networks will continue to expand worldwide. This will call for a need to better understand the role HSR may play in changing people's travel patterns and

forming new economic geographies of cities – megalopolises or megaregions – and how economic development effects of HSR may be distributed within these new geographies. We thank the reader for taking interest in this thesis, and hope that it brings value to researchers and those in the railway industry in Portugal and other countries.

Bibliography

A Bola (online newspaper). 2010. “Ministro defende TGV e novo aeroporto.” Article (in Portuguese). May 3. Retrieved on 05/06/2010 from http://www.abola.pt/mundos/ver.aspx?id=203825

A.T. Kearney. 2003. Formulating the strategy for HSR in Portugal. Presentation for Rede de Alta Velocidade (RAVE). Lisbon, Portugal. June.

--- 2003. HSR Benchmark: Summary of Interviews and Data Collection. Study presentation for Rede de Alta Velocidade (RAVE). Lisbon, Portugal. June 25.

Alabate, D. and Bel, G. 2010. High-Speed Rail: Lessons for Policy Makers from Experiences Abroad. Research Institute of Applied Economics. Working Paper 2010/03. Universitat de Barcelona. Barcelona, Spain.

Amano K. and Nakagawa D. 1990. Study on Urbanization Impacts by New Stations of High Speed Railway. Conference of Korean Transportation Association, Dejeon City.

Arduin, J.P. 1991. Las líneas de Alta Velocidad y el acondicionamiento del territorio (High Speed lines and spatial planning). Obras Públicas 22: 22-23.

ARUP – TMG. 2001. East Coast Very High Speed Train Scoping Study. Phase 1 – Preliminary Study. Final Report. November. Sydney, Australia.

Atkins. 2008. High Speed Rail in the UK. Written Submission. October 17. Retrieved on 12/01/2009 from http://www.parlamaid-alba.org/s3/committees/ticc/inquiries/documents/SubmissionfromAitkins-17thOctober2008.pdf

Baigent, E. 2004. Patrick Geddes, Lewis Mumford and Jean Gottmann: divisions over 'megalopolis'. *Progress in Human Geography*. 28, 6. pp. 687-700.

Banister, D. and Berechman, Y. 2001. Transport investment and the promotion of economic growth. *Journal of Transport Geography*, 9, pp. 209-218.

Barrón, I. 2009. High Speed lines in the World. International Union of Railways (UIC) High Speed Department. Retrieved on 02/15/2010 from http://uic.asso.fr/IMG/pdf/1-4-2_20090614_a_HIGH_SPEED_LINES_IN_THE_WORLD.pdf

Blum, U., Haynes, K.E. and Karlsson C. 1997. The regional and urban effects of high-speed trains. The *Annals of Regional Science*, 31, pp. 1–20.

Boddy M., Hudson, J., Plumridge, A. and Webber, D. 2005. Regional Productivity Differentials: Explaining the Gap. Discussion Paper No. 0515. University of the West of England, Department of Economics Discussion Paper Series. December.

Bonnafous, A. 1987. The regional impact of the TGV. *Transportation.* 14, pp. 127-137.

Brisa. 2009. High Speed Rail: Poceirao Caia stretch awarded to Brisa co-lead consortium. Presentation. December 13. Retrieved on 04/01/2010 from http://www.brisa.pt/ResourcesUser/Investidores/Comunicados/EN/HSR20091213UK.pdf

California High-Speed Rail Authority. 2008. California High-Speed Train Business Plan. November.

--- 2008. High-Speed Train Systems. Sacramento, CA, USA. Retrieved on02/08/2010 from www.cahighspeedrail.ca.gov

Campbell, S. 2009. The Imperative of Growth, the Rhetoric of Sustainability: The Divergence of the Ecoregion the Global Megaregion. Chapter 7. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC, pp. 127-139.

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

Campos, J., de Rus, G., and Barron, I. 2007. A review of HSR experiences around the world. Foundation BBVA. Munich Personal RePEc Archive (MPRA). Paper No. 12397. Retrieved on 02/08/2010 from http://mpra.ub.uni-muenchen.de/12397/

Carballo-Cruz, F. 2007. High speed rail in Portugal. Presentation at Transport Studies Unit Seminar,?" University of Oxford. Oxford, UK. September 24. Retrieved on 04/01/2010 from http://www.tsu.ox.ac.uk/events/seminar070924

Central Intelligence Agency. 2010. World Factbook. Retrieved on 02/20/2010 from https://www.cia.gov/

Central Japan Railway Company. 2009. *Data Book 2009.* Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2009.pdf

--- Official Website. About. Retrieved on 03/25/2010 from http://english.jr-central.co.jp/about/outline.html

--- Annual Report 2009. Retrieved on 03/25/2010 from http://english.jr-central.co.jp/company/ir/annualreport/_pdf/annualreport2009.pdf

City of Yokohama Official Website. Retrieved on 03/20/2010 from http://www.city.yokohama.jp/en/

Comboios de Portugal, Official Website. 2010. Train Timetables. Retrieved on 03/30/2010 from http://www.cp.pt/cp/

--- Official Website. History. Retrieved on 03/30/2010 from http://www.cp.pt/cp/

Contant, C. and de Nie, K.L. 2009. Scale Matters: Rethinking Planning Approaches across Jurisdictional and Sectoral Boundaries. Chapter 1. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC, pp. 127-139.

Davignon, E. 2008. Priority Project No. 3: "South-West European High Speed Rail Link". Annual Activity Report of the European Coordinator. Brussels. July.

Demuth, N. 2004. Der ICE Als Pendler- und Vorortzug? Die ICE-Bahnhofe Montabaur und Limburg – Iimpulse fur Wohnstandortwahl, Wohnsiedlungsentwicklung und berufliche Mobilitat. Diplomarbeit, Universitat Trier.

Deutsche Bahn AG. Data provided by Dominik Fuerste of DB AG on 05/12/2010.

--- Matrix Analysis by Martin Thust of DB AG. Provided on 04/15/2010.

--- Corporate Presentation, July 2008 (provided by Dominik Fuerste of DB AG).

--- Official Website. Retrieved on 02/28/2010 from http://www.deutschebahn.com/site/bahn/de/unternehmen/presse/bauen__bahn/abgeschlossen/koeln__rhein__main.html

--- Official Website. Timetable. Retrieved on 02/28/2010 from http://www. bahn.de

DN Economia. 2010. "Governo pára quatro estradas e reavalia linha do TGV." Article. February 2. Retrieved 03/15/2010 from http://dn.sapo.pt/inicio/economia/interior.aspx?content_id=1484454 on 02/02/2010.

Dunn, J. and Perl, A, 1994. Policy networks and industrial revitalization: High Speed Rail initiatives in France and Germany. *Journal of Public Policy,* 14, 3, pp. 311-343.

Ebeling, K. 2005. High-Speed Railways in Germany. *Japan Railway & Transport Review*, 40. March.

Economist Intelligence Unit (EIU). 2010. Country Profile: France. London, UK.

--- 2010. Country Report: Germany. February. London, UK.

--- 2010. Country Report: Japan. March. London, UK.

--- 2009. Country Commerce: Germany. Released July. New York, NY, USA.

--- 2009. Country Commerce: Japan. Released July. New York, NY, USA.a

--- 2008. Country Profile: France. London, UK.

--- 2008. Country Profile: Germany. London, UK.

--- 2008. Country Profile: Japan. London, UK.

--- 2008. Country Profile: Portugal. London, UK

--- 1996. Country Commerce: Germany. Released July. New York, NY, USA.

European Cities Entrepreneurship Ranking (ECER). 2009. Banque-Populaire Survey. Retrieved on 03/15/2010 from http://www.ecer.fr/resultat_en.html

European Commission DG TREN. EU Energy in Figures 2010. Retrieved on 05/11/2010 from http://ec.europa.eu/energy/publications/doc/statistics/ext_greenhouse_gas_emissions_from_transport_by_mode.pdf

European Commission Transport, Official Website. Retrieved on 02/12/2010 from http://ec.europa.eu/transport/infrastructure/networks_eu/rails_en.htm.

European Commission. 2001. European transport policy for 2010: time to decide. White Paper. COM(2001) 370. Submitted on September 12. Retrieved on 05/06/2010 from http://europa.eu/

European Investment Bank. 2009. Promoting European Objectives. Presentation by Alexandra Almeida, Head of the Lisbon Office. April 2.

France, Rail Pass Website. Retrieved on 03/10/2010 from http://www.francerailpass.com/frp/Our-Trains

Germany, Federal Ministry of Transport, Building & Housing. Federal Transportation Infrastructure Plan 2003. Retrieved on 04/27/2009 from http://www.bmvbs.de

Germany, Federal Ministry of Transport, Building and Urban Development, Official Website. Retrieved on 01/28/2010 from http://www.bmvbs.de/en/Transport/Railways-,2077/Railway-reform.htm

Givoni, M. 2006. Development and Impact of the Modern High-speed Train: A Review. Transport Reviews. Vol. 26, No. 5, pp. 593–611, September.

Givoni, M. and Banister, D, 2007. The role of the railways in the future of air transport. *Transport Planning and Technology*, Vol. 30, No. 1, pp. 95-112.

Glaeser, E. and Kohlhase, J. 2003. Cities, Regions and the Decline of Transport Costs. National Bureau of Economic Research. Working Paper 9886. Retrieved on 12/28/2009 from http://www.nber.org/papers/w9886

Gottmann, J. 1961. *Megalopolis: The Urbanized Northeastern Seaboard of the United States*. Twentieth Century Fund. New York, NY.

Gough, J. 2003. Neubaustrecke Köln–Rhein/Main. *Modern Railways* (Ian Allen), 60, 653, pp. 33-47, February.

Graham, D. 2007. Agglomeration, Productivity and Transport Investment,. *Journal of Transport Economics and Policy*, Volume 41, Part 3, pp. 317–343, September.

Grimme, W. 2006. Air/Rail Intermodality – Recent Experiences in Germany. *Aerlines Magazine,* e-zine edition, Issue 34. Retrieved on 02/20/2010 from http://www.aerlines.nl/issue_34/34_Grimme_Air-Rail_Complementarity.pdf

Gutierrez, J. 2001. Location, economic potential and daily accessibility: an analysis of the accessibility impact of the high-speed line Madrid-Barcelona-French border. *Journal of Transport Geography*, V. 9, Issue 4, pp. 229-242.

Gutierrez, J. 2001. Location, economic potential and daily accessibility: an analysis of the accessibility impact of the high-speed line Madrid-Barcelona-French border. *Journal of Transport Geography*, V. 9, Issue 4, pp. 229-242.

Gutierrez, J. 2005. El tren de alta velocidad y sus efectos espaciales. (Spatial effects of the High Speed Train). Investigaciones Regionales, 5, pp. 199-221.

Hall, P. 2006. *The polycentric metropolis: learning from mega-city regions in Europe*. London; Sterling, VA: Earthscan.

Hall, P. 2009. Looking Backward, Looking Forward: The City Region of the Mid-21st Century. *Regional Studies*. Vol. 43, 6, pp. 803-817, July.

Haynes, K. 1997. Labor markets and regional transportation improvements: the case of high-speed trains. An introduction and review. *The Annals of Regional Science,* 31, pp. 57-76

Heinisch, R. 1992. High Speed Trains in Germany. *Rail International*, 23, pp. 23-24.

Heinz D. K. 2009. *Inter-City Express – Die Entwicklung des Hochgeschwindig-keitsverkehrs in Deutschland*. Freiburg : EK-Verl. (in German, kindly translated in parts by Kristin Lubowski of Deutsche Bahn, March 2009).

High Level Group on the Trans-European Transport Network. 2003. Report. TREN-2003-00960-02-00-EN-REV-00 (EN). Retrieved on 11/25/2009 from http://www.governo.it/GovernoInforma/Dossier/ponte_stretto_messina/2003_report_vanmiert.pdf

Instituto da Mobilidade e dos Transportes Terrestres (IMTT) Official Website. Retrieved on 03/25/2010 from http://www.imtt.pt/

Institut National de la Statistique et des Études Économiques, Official Website. Retrieved on 03/15/2010 from http://www.insee.fr/fr/default.asp

International Union of Railways (UIC). High Speed Department. 2009. High Speed lines in the World. Prepared by I. Barron. Updated June 14. Retrieved on 03/15/2010 from http://www.uic.org/

Ishii, M. 2007. Flexible System Development Strategies for the Chuo Shinkansen Maglev Project: Dealing with Uncertain Demand and R&D Outcomes. Chapter 2. S.M. Thesis, Engineering Systems Division, Massachusetts Institute of Technology. Cambridge, MA.

Iwamura, N. 2007. A lean Enterprise Approach for Developing High Speed Rail in Japan and Portugal. S.M. Thesis, Transportation Program, Massachusetts Institute of Technology. Cambridge, MA.

Japan, Ministry of Internal Affairs and Communications, Statistics Bureau. 2009. Statistical Handbook of Japan 2009. Retrieved on 03/20/2010 from http://www.stat.go.jp/english/data/handbook/pdf/c09cont.pdf

Kamel, K. and Matthewman, R. 2008. The Non-Transport Impacts of High Speed Trains on Regional Economic Development: A Review of the Literature. Locate in Kent Agency. November. Retrieved on 01/22/2010 from http://www.locateinkent.com/images/assets/High%20Speed%20Train%20Report%202008.pdf

Kao, T, Y. Lai and M. Shih. 2010. Privatization versus Public Works of High Speed Rail Projects. National Taiwan University. Taipei, Taiwan. TRB Session 212. Paper No. 10-2004.

KPMG. 2005. Commercial and Procurement Options for the Portuguese High Speed Lines. Rede de Alta Velocidade (RAVE). December.

Krugman, P. 1991. Increasing returns and economic geography. *Journal of Political Economy,* Vol. 99, No. 3, pp. 483-499.

Kyoto City Web. Retrieved o 03/20/2010 from http://www.city.kyoto.jp/koho/eng/databox/sister.html

Lang R. and Knox, P. 2009. The New Metropolis: Rethinking Megalopolis. *Regional Studies*, 43, 6, pp. 789-802.

Le Journal du Net (web). Retrieved on 05/11/2010 from http://www.journaldunet.com/economie/magazine/dossier/les-produits-qui-se-vendent-malgre-la-crise/les-billets-de-tgv-toujours-sur-de-bons-rails.shtml

Lee, Y. S. 2007. A Study of the Development and Issues Concerning High Speed Rail (HSR). Korea Railroad Research Institute and Transport Studies Unit, University of Oxford. Working Paper No. 1020. Retrieved on 01/16/2010 from http://www.tsu.ox.ac.uk/pubs/1020-lee.pdf

LGV 2030 (web). Les lignes existantes et en construction. Retrieved on 03/10/2010 from http://lgv2030.free.fr/ligne1.htm#SudEst

Lourenco, N. and Santos, A. 2005. Ananálise Demográfica E Socio--Económica Dos Corredores Da Alta Velocidade. Padrões De Distribuição Da Acessibilidade À Alta Velocidade Ferroviária. Presentation by SociNova Cabinete de Investigacao em Sociologia Aplicads, Universidade Nova de Lisboa, Faculdade de Ciencias Sociais e Humanas. Lisboa, Portugal, December.

Masson, A. and Petiot, R. 2009. Can the high speed rail reinforce tourism attractiveness? The case of the high speed rail between Perpignan (France) and Barcelona (Spain). *Technovation,* 29, pp. 611-617.

MasterCard Worldwide. 2008. Worldwide Centers of Commerce Index. Retrieved on 03/20/2010 from http://www.mastercard.com/us/company/en/insights/pdfs/2008/MCWW_WCoC-Report_2008.pdf

Matsumoto, H. 2007. Shinkansen (Bullet Train) System in Japan. Testimony from Hearing of the House Railroads, Pipelines and Hazardous Materials Subcommittee. April 19. Retrieved on 05/11/2010 from http://republicans.transportation.house.gov/Media/File/Testimony/Rail/4-19-07-Matsumoto.pdf

Mercer. 2009. Worldwide Cost of Living survey 2009 – City ranking. Retrieved on 03/20/2010 from http://www.mercer.com/costoflivingpr#Top_50

Midwest High Speed Rail Association. 2009. High-Speed Rail: Fact s. Fiction. Chicago, IL, USA. Retrieved on 02/08/2010 from http://www.midwesthsr.org/fact/index.html

Nakamura H. and Ueda T. 1989. The Impacts of the Shinkansen on Regional Development, in: The Fifth World Conference on Transport Research, Yokohama, Vol. III. Western Periodicals, Ventura, California.

Nash, C. 2008. High Speed Rail Investment: an overview of the literature. Institute of Transport Studies, University of Leeds. Leeds, UK. Retrieved on 02/08/2010 from http://www.networkrail.co.uk/documents/About%20us/New%20Lines%20Programme/5880_HSR%20investment,%20an%20overview%20of%20the%20literature.pdf

Nelson, J. 2008. Stuck With the Bill, But Why? An Analysis of the Portuguese Public Finance System with Respect to Surface Transportation Policy and Investments. S.M. Thesis, Transportation Program and City Planning, Massachusetts Institute of Technology. Cambridge, MA.

Ono, H. 1998. The Role of High-Speed Rail in Regional Development. S.M. Thesis, Transportation Program, Massachusetts Institute of Technology. Cambridge, MA.

Peterman, D., Frittelli, J. and Mallett, W. 2009. High-Speed Rail (HSR) in the Unites States. Congressional Research Service (CRS). Report for Congress. December 8.

Petkova, B. 2007. Strategic Planning for rail System Design: An Application for Portuguese High Speed Rail. Master's Thesis, Industrial Engineering and Management, University of Groningen. Groningen, Netherlands

Pickard, J. P. 1962. Urban regions of the United States, *Urban Land*, April, 3–10.

Pieda (Planning, Economic and Development Consultants). 1991. Rail Link Project: A Comparative Appraisal of SocioEconomic and Development Impacts of Alternative Routes. Reading: Pieda.

Pinto, M. 2010. EIB Support for Rail Projects. Presentation at the Portuguese High Speed Rail Workshop. Lisbon. January 28-29. Retrieved on 03/15/2010 from http://www.rave.pt/en/tabid/389/Default.aspx

Pol, P. 2003. The Economic Impact of the High-Speed Train on Urban Regions. *European Regional Science Association EconPapers*. Retrieved on 06/12/2009 from http://www.ersa.org.

Pol, P. 2008. HST station and urban dynamics: Experiences from four European cities. Chapter 4. *Rail Development: Impacts on Urban Dynamics.* Edited by Bruinsma et al. Physica-Verlag Heidelberg.

Prevelakis, G. 2003. The relevance of Jean Gottmann in today's world. *Ekistics*, Vol. 70, Iss. 422/423, pp. 295-305. Athens, Greece.

Prud'homme, R. 1997. Urban Transport and Economic Development. *Keynote speech for the 7th conference on the Development and Planning of Urban Transport in Developing Countries,* New Delhi, Feb. 12.

Prud'homme, R. and Lee, C. 1999. Size, Sprawl, Speed and the Efficiency of Cities. *Urban Studies*. Vol. 36, No. 11, pp. 1849-1858.

Puga, D. 2001. European Regional Policies in Light of Recent Location Theories. Discussion Paper Series No. 2767. Center for Economic Policy Research. London, UK.

Radopoulou, S. 2010. High Speed Rail in Greece: Methods for Evaluating Economic Impacts. S.M. Thesis, Transportation Program. Massachusetts Institute of Technology, Cambridge, MA.

Railway Technology (web). Retrieved on 02/20/2010 from http://www.railway-technology.com/projects/frankfurt/

Rede de Alta Velocidade (RAVE) Official Website. 2010. Retrieved on 03/12/2010 from http://www.rave.pt/en/tabid/338/Default.aspx

--- 2010. Portuguese High Speed Rail Project: Business Model. Presentation at Workshop on PPP and High Speed Rail – The Portuguese Experience. Lisbon. January 28-29. Retrieved on 03/15/2010 from http://www.rave.pt/

--- 2010. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at the Workshop on PPP and High Speed Rail: The Portuguese Experience. Lisbon, January 28-29.

--- 2009. Portuguese High Speed Rail Project: General Overview and Status of the Project. Presentation at European Federation of Railway. Trackworks Contractors (EFRTC) General Meeting. Porto. June 5.

--- 2008. Announcement for PPP expression of interest for Lisbon-Madrid link. Retrieved on 03/12/2010 from http://www.rave.pt.

--- 2008. Launch of the International call for tenders – Infrastructure concession for the Poceirao-Caia section of the Portuguese high-speed network. Retrieved on 03/15/2010 from http://www.rave.pt/

--- 2008. Os Efeitos Fiscais do Investimento na Rede Ferroviária de Alta Velicidade. Versão Síntese do Relatório Final. January. Retrieved on 02/12/2010 from http://www.rave.pt

--- 2008. The Portuguese High Speed Rail Projects: General Overview and Status of the Project. LNEC, Lisbon, Portugal. September 23.

Rede Ferroviária Nacional (REFER) Official Website. 2010. Retrieved on 03/30/2010 from http://www.refer.pt/en/apresentacao.php

--- 2009. Network Statement 2010. January. Retrieved on 03/15/2010 from http://www.refer.pt/Documentos/Network_Statement%20_0010_REFER.pdf

Region Urbaine de Lyon, Official Website. Retrieved on 03/15/2010 from http://www.regionurbainedelyon.fr/principal-characteristics-102-2.html

Rice, P., Venables, A. and Patacchini, E. 2006. Spatial determinants of productivity: Analysis for the regions of Great Britain. *Regional Science and Urban Economics*, 36, pp. 727–752.

Ross, C.L. 2009. *Megaregions: Planning for Global Competitiveness.* Ed. Ross, C.L. Island Press, Washington, DC.

Roth, D. 1990. The TGV System: A Technical, Commercial, Financial and Socio-Economic Renaissance of the Rail Mode. Department of Systems, University of Pennsylvania, Philadelphia, PA.

Sands, B. 1993. The Development Effects of High-Speed Rail Stations and Implications for California. California HSR Series. Working Paper 566. University of CA at Berkeley, CA.

Sasaki, K, and Ohashi, T. and Ando, A. 1997. High-speed rail transit impact on regional systems: does the Shinkansen contribute to dispersion? *The Annals of Regional Science*, 31, pp. 77–98.

Schwob, B. 1995. Economic Justification of the TGV and Development of the High-Speed Rail System. SNCF. France. Retrieved on 02/08/2010 from http://ieeexplore.ieee.org/

Shin, D. 2005. Recent Experience of and Prospects for High-Speed Rail in Korea: Implications of a Transport System and Regional Development from a Global Perspective. Working Paper 2005-02. Institute of Urban and Regional Development, University of California, Berkeley, CA.

Sichelschmidt, H. 1999. The EU programme "trans-European networks" – a critical assessment. *Transport Policy*, 6, pp. 169-181.

Société Nationale des Chemins de fer Français (SNCF). 2010. Profile & Key Figures. Retrieved on 05/11/2010 from http://medias.sncf.com/resources/en_EN/medias/MD0006_20100210/file_pdf.pdf

--- 2007. Presentation by Jean Marie Metzler for the US House of Representatives, Committee on Transportation & Infrastructure Sub Committee on Railroads, Pipelines & Hazardous Materials. Washington, DC. April 19. Retrieved on 03/10/2010 from http://republicans.transportation.house.gov/Media/File/Testimony/Rail/4-19-07-Metzler.pdf

Statistics Portugal, Official Site. 2009. Statistical table extracted on 02/23/2010 from http://www.ine.pt

Statistiques locales, Official Wesbite. Retrieved on 03/15/2010 from http://www.statistiques-locales.insee.fr/carto/ESL_CT_cartethematique.asp?lang=FR&nivgeo=ZE1990

Steer Davies Gleave. 2002. The Case for Rail. Final Report. Prepared for Transport 2000, Association of Train Operating Companies, English, Welsh & Scottish Railways, Railway Industry Association, The Railway Forum, Rail Passengers' Council, and Passenger Transport Executive Group. London. June.

Steer Davies Gleave/VTM. 2009. Análise Custo – Benefício da Ligação em Alta Velocidade Ferroviária da Ligação Lisboa – Porto. Relatorio Final. Rede de Alta Velocidade (RAVE). March. Retrieved on 02/10/2010 from http://www.rave.pt/

Tanaka, Y. and Monji, M. 2009. Post-Assessment of the Kyushu Shinkansen Network in Reference to the Proposed United States High-Speed Railway Project. Transportation Research Board Annual Conference, Session 212. Paper No. 10-1092. Washington, DC.

Taniguchi, M. 1992. High Speed Rail in Japan: A Review and Evaluation of the Shinkansen Train. Working paper No. 103. University of California, Institute of Urban & Regional Development, Berkeley. April.

The Economist Online. 2010. "Living Costs in Big Cities." Article. Retrieved on 03/15/2010 from http://www.economist.com/daily/chartgallery/displaystory.cfm?story_id=15659589

Tokyo Metropolitan Government, Official Website. Retrieved on 05/10/2010 from http://www.metro.tokyo.jp/

TYCO Engenharia / Holland Railconsult. 2006. Socio-Economic Cost-Benefit Analysis: High Speed Rail Lisbon-Porto. Technical Note. RAVE. June. Retrieved on 02/10/2010 from http://www.rave.pt/

United Kingdom, Office of the Deputy Prime Minister. 2006. State of the English Cities. A Research Study. Vol 1. London, UK. Retrieved on 03/05/2010 from http://news.bbc.co.uk/2/shared/bsp/hi/pdfs/07_03_06_english_cities_vol_1.pdf

United States, Government Accountability Office. 2009. High Speed Passenger Rail: Future Development will Depend on Addressing Financial and Other Challenges and Establishing a Clear Federal Role. Report to Congressional Requesters. GAO-09-317. March.

Verkehrswissenschaftliches Institut (VWI) Stuttgart GmbH and Partners. 2006. Feasibility Study Concerning High-Speed Railway Lines in Norway. Report Phase 1. December.

Vickerman, R. 1995. The regional impacts of Trans-European networks. *The Annals of Regional Science*, 29, pp. 237-254.

Vickerman, R. 1997. High-speed rail in Europe: Experience and issues for future development. *The Annals of Regional Science*, 3, pp. 21-38.

Westerwaldkreis mbH Economic Development Corporation, Official Website. Retrieved on 03/02/2010 from http://www.wfg-ww.de/

Westerwaldkreis mbH Economic Development Corporation. 2004. Der ICE als Pendler- und Vorortzug? Ergebnisse einer Befragung von Berufspendlern am ICE-Bahnhof Montabaur. Retrieved on 03/02/2010 from http://www.wfg-ww.de/neu/Seiten/nina_demuth_kurzfassung.pdf

Wikipedia. Shin-Yokohama Station. Retrieved on 03/20/2010 from http://en.wikipedia.org/wiki/Shin-Yokohama_Station

--- Cologne-Frankfurt high-speed rail line. Retrieved on 02/21/2010 from http://en.wikipedia.org/wiki/Cologne%E2%80%93Frankfurt_high-speed_rail_line

--- Limburg Süd. Retrieved on 03/02/2010 from http://de.wikipedia.org/wiki/Limburg_Süd

--- Gare du Creusot TGV. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/Gare_du_Creusot_TGV

--- Transport n Japan. Retrieved on 03/20/2010 from http://en.wikipedia.org/wiki/Transport_in_Japan

--- Siegburg/Bonn. Retrieved on March 2, 2010 from http://de.wikipedia.org/wiki/Siegburg/Bonn

--- History of rail transport in France. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/History_of_rail_transport_in_France

--- TGV. Retrieved on 02/02/2010 from http://en.wikipedia.org/wiki/TGV

--- High-speed rail in France. Retrieved on 02/02/2010 from http://en.wikipedia.org/wiki/High-speed_rail_in_France

--- Fertagus. Retrieved on 02/15/2010 from http://en.wikipedia.org/wiki/Fertagus

--- Siegburg. Retrieved on 03/02/2010 from http://de.wikipedia.org/wiki/Siegburg

--- Departments of France. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/Departments_of_France

--- Transport in France. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/Transport_in_France

--- Gare de_Mâcon-Loché_TGV. Retrieved on 03/10/2010 from http://en.wikipedia.org/wiki/Gare_de_Mâcon-Loché_TGV

--- Le Creusot. Retrieved on 03/15/2010 from http://en.wikipedia.org/wiki/Le_Creusot

--- Macon. Retrieved on 03/15/2010 from http://en.wikipedia.org/wiki/Macon

Willigers, J. 2003. High-Speed Railway Developments and Corporate Location Decisions: the Role of Accessibility. Paper presented at the 43rd ERSA Congress. Jyväskylä, August 27-30.

Willigers, J., Floor, H. and van Wee, B. 2005. High-Speed Rail's Impact on The Location of Office Employment Within the Dutch Randstad Area. 45th Congress of the European Regional Science Association. Amsterdam, August 23-27.

Appendix I: Template for Cross-Country Comparison of HSR Systems

Physical Characteristics

1. Network size: current and expected in the future (in both km and miles).
2. Technology selected for Rolling stock (TGV, Shinkansen, ICE, or new design).
3. Technology selected for Infrastructure/Control system.
4. Maximum speed and average speeds of HSR (in both km/h and miles/hr).

Institutional Structure and Financing

5. Who owns and who operates HSR system?
6. Overall cost: construction, rolling stock and control system (in both local currency and US$).
7. Were any subsidies provided for construction/rolling stock/control system?
8. Fare policies: are any subsidies provided for operations? What percentage of operating costs is paid from fares?

Deployment Strategy and Motivation

9. What was the initial deployment strategy? Focus on one corridor? Build several at once? How was the first line(s) funded? How quickly was the rest of network built?
10. What were the motivations for building HSR lines? Was the need for additional railway capacity one of the important motivations?
11. What other motivations were there? Economic stimulus? International interconnections?
12. Are there plans to extend the HSR network?

Structure of the Network

13. What is the structure of the HSR network: decentralized (connecting "many hubs") or centralized (connecting "one hub with many spokes")?
14. How were decisions made on the cities to be served? Have the HSR stations been placed in major cities only or in smaller cities as well? What combination of express (big city to big city) and local (stops at smaller cities along the way) are offered?
15. Where are the stations located within the cities (city center or outskirts)? What provisions for accessing the HSR stations have been made?
16. Was there an existing conventional rail network prior to HSR deployment? What was the quality and extent of that existing rail network? How does the HSR network interconnect with the existing conventional rail network?
17. Are HSR trains operated on conventional tracks? What benefits accrue from this kind of operations?
18. Are HSR lines mixed use (passenger and freight) or dedicated to HSR passenger services? Are conventional passenger trains allowed to operate on HSR tracks?

Development Impacts

19. Has HSR created any economic growth, i.e. is the growth zero-sum (redistribution of activities and no net growth generated) or is there net growth?
20. How has the HSR service affected air transportation service? Are HSR and air cooperative or competitive or both?

Appendix II: List of reports already assembled by RAVE

1. Benefit-cost analysis of Lisbon-Porto and Lisbon-Madrid high speed lines: an application of the methodology by Ginés de Rus and Gustavo Nombela
2. Benefit-cost analysis of Lisbon-Porto
3. Demographic and socio-economic analysis of the Portuguese high-speed rail corridors
4. Assessment of the business models
5. Study of the viability of the corridors and previous study of the interior links between the Lisbon-Porto and Lisbon-Madrid corridors
6. Economic consequences of HSR network development: effects on the GDP of substituting traffic and traffic growth
7. Economic consequences of investing in the construction of a HSR network
8. Definition of the priority elements of the business model for a HSR network
9. Elaboration of the previous study and project on the execution of a Braga-Valenca link
10. Estimation of the costs of maintenance for the Lisbon-Porto and Lisbon-Madrid HSR lines
11. Strategic logistics for high speed rail cargo
12. Study of urban dynamics in the Chelas-Barreiro corridor
13. Study of the market and socio-economic and financial evaluation of the Lisbon-Madrid link.
14. Study of demand on the HSR corridor
15. Study of the technical, economic, and environmental viability of HSR and current and future demand.
16. Study of the model of exploration of passenger service on the Lisbon-Madrid HSR link
17. Strategic study for the development of HSR in Portugal: benchmark analysis
18. Studies of specific HSR links (various)
19. Technical viability of a HSR link between Porto and Vigo
20. Demand, mobility, and technical assessment of the Third Tejo River Crossing on the Lisbon-Madrid link
21. Study of the technical viability of a HSR station in the vicinity of the existing Oriente Station
22. Economic and financial impact of rail investments on the Portuguese economy
23. Integrated passenger demand model
24. Potential for participation of Portuguese industries in the HSR project

(Rough translations by Travis Dunn, PhD Candidate, MIT, 12/29/2008)