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Master-Arbeit

High-Speed Rail: Economic Evaluation, Decision-making and Financing

eingereicht von Juan Ramon Mir Boqué

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Abstract

This paper will have a close look at the costs of HSR infrastructure and the reasons why they vary so much according to different countries. Not only infrastructural costs will be analysed but also operation, social and environmental costs. Comparison between different European countries will be shown in order to see what are the costs in each one. The comparison will be done amongst the four European countries with more operative HSR lines: Germany, France, Italy and Spain. The benefits derived from HSR will also be shown and discussed.

Although according to European legislation, separation in different institutions (whether public or private) of infrastructure and operation is compulsory; the application of this Directive is being done differently, leading to different financial results. Also, decision-making methods in each of the chosen countries will be analysed and discussed, to see the criteria on which the countries rely on. When exposing the project appraisal methods used, it will be discussed what method is best under each circumstance. Another interesting point is to see what are the most favourable conditions in which to construct HSR, in terms of demand, population density and distance between cities. A close look at how the HSR lines have been financed in each of the study countries will be done, paying special attention to where the funds come from. In addition, social profitability of the infrastructures once they are operative will be analysed in an ex-post evaluation using cost-benefit analysis.

Task

High-Speed Rail Projects: Economic Evaluation, Decision-making and Financing

Construction and operation of high-speed railway lines always goes along with high costs. Implementation or increasing the offered HSR-traffic has to base upon solid decisions. At this, rentability and assuring the financing of that traffic offer are of high relevance. In this master thesis the whole topic has to be described broadly.

Cost components and financing

To do economic valuations, all the different cost components appearing at high-speed rail projects have to be comprised. Examples are: erecting of infrastructure and purchasing train sets, railway operation, maintenance, operational difficulties etc. The author has to itemise these costs, show the context of them and point out their position in the lifecycle of a railway line. The financial responsibility of the different costs has to be allocated to the acting institutions. In addition, the ways of financing the single costs are to point out (e.g. construction of transportation infrastructure).

Based upon this, financing of long-haul passenger transport by rail in different countries has to be analysed. To select the countries, the tutor has to be consulted. European and additional countries with high-speed rail are to comprise. As mentioned above in general, the financial responsibilities of the different institutions for all single cost components in every country have to be pointed out. In addition it is to display, how the railway companies are organised and how there are integrated in governmental structures (incl. discussing the effects of dividing infrastructure operators and train operators according to EU-regulations).

Economic valuation and decision-making

Due to the often extended importance of transportation projects, the decision-making (pro or contra specific projects, consideration of alternatives) has to be broad and comprehensible.

First, the basic alternatives of economic valuation of high speed rail projects are to describe. It is to get clear, what data input is needed for significant valuations and how quality and quantity of the input data influence the results.

Economy is not the only deciding criterion, especially in infrastructure projects, so it is to display, which other criteria are used to evaluate projects. First, the basic methods of decision-making (as a part of economic sciences) have to be described. Based upon this, decision-making methods for investment in transportation infrastructures in the different countries have to be itemised. In Germany, for example, the chosen projects belong to Bundesverkehrswegeplan (BVWP). The choice method for BVWP contains amongst others the determination of a macroeconomic benefit-to-cost-relation and analysis of spatial effectiveness.

So there are two questions to answer for each country:

1. Does an instrument exist for (coordinated) planning of infrastructure investments in the country and what is its design?
2. Which methods are used for project choice?

It is also to discuss, whether and how operation of infrastructure is included in the decision.

Ex-post-analysis

An ex-post-analysis is used to determine economic contexts after realising a project, e.g. after start of train operation on a HSR. First the author has to introduce the method of ex-post-analyses in general. Then an exemplifical analysis is to carry out for some selected high speed railway lines. For selection, the tutor has to be consulted again. It is to attend, that railway lines often are part of a network. An improper separation from the network could lead to false results.

Prof. Dr.-Ing. Wolfgang Fengler

Aims

- Investigate the effects of infrastructure management and operation management separation in independent companies.

- Analyse the liberalization of the railway market processes in some European countries.

- Describe the fundamental reasons of the increasing trend in HSR infrastructure construction in Europe.

- Show the different costs of HSR in different countries.

- Show the beneficial impacts of HSR in different countries.

- Clarify the most suitable conditions for HSR investment.

- Define the guidelines for a proper appraisal of Railway projects.

- Identify the different decision making processes and criteria in the study countries for HSR construction and compare the differences.

- Investigate the financing sources for HSR.

- Investigate the socioeconomic profitability of an already existing HSR line in Europe (Ex-post analysis).

Conclusion summary

Title: High-Speed Rail projects: Economic Evaluation, Decision-making and Financing.

- The rail liberalization has been scarce in all the studied countries as the majority of the railway undertakings belong to State owned companies. This means that very little competition has taken place in the rail market.

- The main reasons for HSR construction vary among the different countries. The main reasons are capacity relief in the saturated railway corridors and political reasons, where no evidence of transport efficiency criteria has been used to justify the investments.

- The average cost per kilometre of HSR infrastructure in the studied countries is 17M €, being the highest costs in Germany and Italy and the lowest costs in Spain.

- Benefits of HSR occur mainly in terms of time savings and not in terms of environmental conservation and development of deprived economic areas.

- The most efficient HSR investments takes place under certain circumstances: when demand is enough to cover operation expenses, when times of travel are competitive with the plane and when distribution of population is congregated in few high density nodes.

- In the four studied countries, three existing appraisal techniques are used: cost-benefit analysis, multi-criteria analysis and the financial analysis. In spite of this, there are differences in how the techniques are used, being Germany the country that takes most care of environmental issues and being France and Spain the countries that give more importance to the impacts on economy when constructing HSR.

- Traditionally, the HSR lines have been financed using Public Budgets and loans, which the governments ask for to banks or other lending institutions such as the European Investment Bank. The new trend is arranging Public Private Partnerships so that efficiency in the construction, operation and maintenance of the HSR increases and also not to stress Public Budgets so much.

- The ex-post evaluation of the Madrid-Seville line clearly shows how this line is non-profitable from the social point of view, being the costs much higher than the quantified benefits. The main problem is lack of passenger demand, which is the main factor to achieve positive social returns from the investment.

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List of Abbreviations

HSR: High-speed railway

EU: European Union

UIC: International Union of Railways

CBA: Cost-Benefit analysis

ERTMS: European Rail Traffic Management System

GSM: Global System for Mobile Communications

SNCF: *Socité Nationale des Chemins de Ferre*

RFF: *Reseau Ferré de France*

RENFE*: Red Nacional de Ferrocarriles Españoles*

ADIF*: Administrador de Infrastructuras Ferroviarias*

RFI: *Rette Ferroviaria Italiana*

DB: Deutsche Bahn

M: Million

TGV: *Trains à Grande Vitesse*

ICE: Intercity Express

AVE: *Alta Velocidad Española*

Km: Kilometre

GDP: Gross Domestic Product

Tn: Tonnes

NPV: Net Present Value

IRR: Internal Rate of Return

FRR: Financial Rate of Return (same concept as IRR)

dB: Decibels

CBR: Cost to Benefit Ratio

SIA: Spatial Impact Assessment

EIA: Environmental Impact Assessment

PPP: Public Private Partnership

VAT: Value Added Tax

CPI: Consumer Price Index

EIB: European Investment Bank

CO_2: Carbon dioxide

MCA: Multi-criteria Analysis

BVWP: *Bundesverkehrswegeplangesetz*

PEIT: *Plan Estratégico de Infrastructuras y Transporte*

ERDF: Euro Regional Development Funds

TEN-T: Trans-European Transport Network

PGT: *Piano Generale dei Trasporti e della Logistica*

PPI: Priority Investment Plan

CIPE: Interdepartmental Committee for Economic Planning

SPV: Special Purpose Vehicle

FS: *Ferrovia dello Stato*

NTV: *Nouvo Transporti Viaggiatori*

DGT: *Dirección General de Tráfico*

1 Introduction

In the past 25 years, railway infrastructure has been constructed at a high rate in Europe following the new European Commission Directives issued in 1990, which aimed to reduce road traffic and air traffic in favour of railway traffic. During the second half of the 20th Century, both passenger traffic and freight traffic in railway had decreased substantially due the rapid expansion of the automotive industry leading to the problems of road traffic congestion, pollution and excessive costs in time delays. In terms of HSR, the European Directives want to achieve high rates of passenger traffic, warranting their security and also achieve high levels of trans-European interoperability; reducing technical boundaries for operation and describing technical standards for the construction of the railways, for example, international track gauges.

HSR has several different definitions, but the most accepted one is the one provided by the International Union of Railways (UIC), which includes the following three: [1]

- Lines that are explicitly built to run trains capable of speeds 250 km/h or over.
- Conventional railway lines that have been upgraded to run trains capable of speeds of 200km/h;
- Conventional railway lines that have been upgraded but because of special topographical circumstances or due to the proximity with urban areas, the speeds must be reduced to certain maximum.

These definitions are wide enough to include the totality of the HSR infrastructure. However speed is not the only factor which has to be taken into account since there are other which can cause trains equipped with high speed technology to slow down, as stated on the third definition above.

The first European HSR line to be operative was the French connection between Paris and Lyon in 1981. Congestion problems in the existing railway line made the authorities start the feasibility studies for constructing a new one instead of upgrading the existing conventional line. Both cities, which are 483km apart, were connected in 2h 20 min. Soon, this line became successful in terms of demand as it carried more than 12 million passengers (Vickerman 2007) during the first year of operation and so the French TGV started expanding rapidly. In 1991, ran the first HSR line in Germany between Hannover and Würzburg, connecting both cities short after German reunification in about 2h. Short after, in 1992, the first Spanish HSR line was opened between Madrid and Seville, covering the 530 km in 2h 55min. Since 1992 onwards, HSR construction has been at a growing trend, and still today there are new projects being studied.

In early 2008 there were in operation around 10.000 km of new HSR lines throughout the world, and globally, including conventional lines also used by the high-speed trains, more than 17.000 kilometres of the railway world were used to provide high speed services to a growing number of travellers willing to pay for lower travel times and higher quality rail transport. In Europe, the average annual traffic is located at 50 million passengers, but has grown steadily since 1981 at an annual rate of 2.6%. The total number of HSR km in operation on Europe is about 6.700. [2]

It is has been discussed whether the construction of HSR lines is always profitable for society and for the managing companies. Due to its high implementation costs, new construction of lines is not always justified in terms of benefits. Solid decisions have to be made in order to approve new construction of HSR, such as sufficient passenger demand, operation costs, and time savings. Furthermore, financial profitability of all stakeholders must be analysed in order to ensure success. Private investors will most likely be reluctant to take excessive risks when investing in such high costly operations, therefore, government decision making will have to consider all the stakeholders involved. Although investigators agree on the need to compare social benefits and costs of transport infrastructure before committing excessive resources to this purpose, the truth is that ex ante appraisals are often not being done and therefore questionable returns appear from these once they start their life cycle. HSR infrastructure involves high investment costs, often irreversible, subject to strong indivisibilities and high risk due to uncertainty of demand. These features show the high cost of taking wrong decisions. Therefore it is important to appraise projects correctly considering all stakeholders during the whole life cycle of the infrastructure. This type of analysis is what is known as the financial profitability analysis.

On the other hand, cost benefit analysis is used to show the economic impact of a project in the whole of "society's" welfare and does not consider financial profitability for stakeholders. It measures benefits and costs of the project for society in terms of resources, which, for many items, the market will be able to provide. Others, such as time of travel, are non directly tradable. Cost-benefit analysis (CBA) is a useful technique, which will be described later in this investigation. It is a fact that this technique is used worldwide, but it has been proved that it is most useful when the CBA links with the incentive system of financing mechanisms. Other appraisal methods used are multi criteria method and the economic impact method. Depending on the country, different methods are used.

Components of HSR infrastructure are by far, more expensive than conventional railway. This is due to the higher quality of the materials used and of course, due to the modern technology implemented. Satellite navigation systems and safety measures take up a considerable amount of the budget in this type of infrastructure. Rolling stock is also an important part of the total costs as well as the operation costs.

On the other hand, benefits of HSR are also taken into account. HSR is known because it reduces travel times and access passenger times. Historically, HSR have been put through in order to reduce congestion in some corridors, either road corridors or conventional railway corridors. Also, reduction in fossil fuel consumption is a HSR characteristic compared to the air transport sector; therefore it is considered an important benefit in terms of socioeconomic profitability.

These extremely high costs of HSR have to be financed one way or the other, and this is the reason why further on in this document, a deeper investigation is carried out. It is interesting to see how, at a slow pace, governments expect to have private financial support so that public budgets are not so much affected by HSR investments. Private participation in projects via concession contracts is believed to increase the projects overall performance, in terms of management and operations.

2 Railway Legal Framework in Europe

2.1 91/440 Directive

This European directive issued in 1991, applies to the management of rail infrastructure and rail transport in all the Member States of the Union. It does not refer only to HSR but to all railway activities taking place. It only applies to railway companies, which provide railway services throughout a country and therefore, are excluded, railway undertakings whose activities take place only at an urban, suburban or regional level. This European directive states three basic points that will have to be complied with:

- Management independence

Governments of the Member States will make sure to take the appropriate measures to warrantee the separation of management, administration and administration accounting. This means, the States will have nothing to do with the assets, accounts and budgets of the railway companies.

The States will make sure that railway companies will adapt their activities to the market and to be properly managed by their own directive bodies. Also, Governments should control their activities so that they provide the most efficient and cheapest services to users.

- Separation between transport operations

Member States should ensure the separation of infrastructure management and transport operations, maintaining income accounts and balance sheets apart. The accounts of the operator and the infrastructure manager will be published separately and there will be no fund transfer between them. Public budgets should also reflect this account separation.
Furthermore, each State will be responsible for the correct development of the railway system (i.e. planning, decision making and finance) always taking to consideration the general needs.

- Access to railway infrastructure

All railway operators affected by this directive will have access to all EU countries infrastructure, not only to provide freight transport but also to provide passenger transport.

The European Transport Commission will monitor the technical conditions for the development of the railway market and will work with each countries EU representatives so that this Directive is complied with. [3]

2.2 95/18 Directive

This Directive sets the criteria for the granting licenses of railway companies of the EU with good reputation, sound financial situations, acknowledged skills of their workers and those in possession of a liability insurance.
This Directive covers the following aspects:

- Each country shall appoint a licensing authority in order to grant the licenses to the targeting companies.

- Railway companies established in the EU will have the right to apply for a license in their own country. The license will be valid throughout the whole EU.

- The license for itself does not give full right to access the infrastructure because several requirements have to be achieved. These requirements are: a security certificate issued by a competent authority in the State to which the infrastructure belongs to, the allocation of the tracks on which the company will be able to operate and the realization of the necessary business arrangements with the infrastructure manager.

2.3 95/19 Directive

The rules for the capacity allocation the railway infrastructure are contained in this Directive. It determines the conditions of utilisation of the infrastructure in terms of:

- The provision in the allocation of the infrastructure

- The collection of royalties from the operator to be able to operate in the infrastructure.

- The obligation of the infrastructure managers to publish a network statement (this is the document that sets out the characteristics of the infrastructure available to the railway companies, and contains information on the conditions of access to it. It details the general rules, deadlines, procedures and criteria concerning the charging and capacity allocation, and any other necessary information to enable application of the operator to use the infrastructure)

- Creating a regulatory organism in every country, which may supervise the development of the operator’s activities and will act as a referee in case of conflicts, especially in the use and royalties for utilization.

These Directives have been applied in all EU countries but with a different degree of compliance and therefore they have been modified and adapted due to the failure in the complete application of its contents (fully achieve the process of liberalisation and free competition). [4]

2.4 First Railway Package

In order to achieve the revitalization of the use of railway in Europe, and to in order to get a transfer of an important proportion of road traffic, to the European Commission issued a series of new Directives which were known under " First Railway Package" on February 2001. These Directives amended the previous ones, taking into account the resolutions written in the White Paper that stated the importance of a full liberalization in the railway sector. The new European Directives were the 2001/12, 2001/13, 2001/14, which added new measures in terms of freedom of access to infrastructure and reduce constraints. A new Directive, 2001/16, later joined these, and addressed issues related with the interoperability of the system. These three directives emphasized the liberalization of services, greater separation of the infrastructure exploitation and the creation of a regulation entity of the railway business.

A brief summary of each of these follows:

- 2001/12 Directive: this goes on, on the 91/440 in the rules of separation between services and management. It defines the infrastructure manager as the one in charge of installation and maintenance as well as the responsible for security issues. It stated the willingness to open the railway service market in 2003 up to 50.000km for the Trans-European Freight Railway Network. Nevertheless, in 2008 the whole European network must be open.

- 2001/13 Directive: it extends the provision of the 95/18, which introduced a licensing system only for international railway operators. Now, it is extended to national rail service providers, ensuring a fair non-discriminatory treatment for all of them.

- 2001/14 Directive: emphasizes on the rules for awarding infrastructure capacity in terms of a more specific definition of railway companies' rights. An independent organism, not related to any operator, will carry out the capacity award. Regarding to the charges on the utilization of railway infrastructure, pricing is calculated on marginal costs i.e. costs related only to the operation of services. Also, charges will be set by independent organisms.

- European Transport White Paper: it stated the prioritization of railway transport to the detriment of road and air transport in order to balance the modal distribution. Also, an important issue was to remove bottlenecks in the railway network and to achieve interoperability in passenger traffic and freight traffic. Security measures were also put forward in the White Paper.[4]

2.5 Second Railway Package

On January 2002, the European Commission issued a series of new laws, which intended to create a common space for an integrated railway area. The main 5 actions describes in these new Directives are all following the guides of the 2001 White Paper and all have to do with upgrading the already stated measures in the past. Again the main objectives were, enhancing security, achieving interoperability, the market opening for freight transport and the creation of a European Railway Agency responsible for coordinating the technical work. A brief summary of each directive is as follows:

- 2004/49 Directive: has to do with security matters in terms of creating a European common security space, describing thoroughly the security systems, which all railway operators should adopt. Its aim is to develop a common approach on safety and creating a common system to regulate the expedition, content and validity of safety certificates. An agency will be created in every Member State responsible of certifying the quality in the railway services and infrastructure. A very important point here is creating common procedures when investigating accidents driven by independent investigating agencies.

- 2005/50 Directive: it modifies and completes with the previous Directives related to interoperability of conventional and high-speed railway systems. At this point, interoperability is defined as the capacity of circulating anywhere in the railway network. Therefore, this Directive is a further step in implementing the European technical railway systems, removing technical barriers that eventually would be against international traffic. It insists in improving the technical interoperability specifications that will be issued by the European Railway Agency and which also force countries to publish a rolling stock register every year. [4]

2.6 Third Railway Package

The third railway package consisted of new European directives orientated towards passenger rights and with the aim of revitalizing international passenger traffic. The railway sector must by 2010 be completely open to international competition in national and international journeys. The new legislation is composed of two Directives, one on the development of the Community's railway through a certification of train drivers and personnel involved in the driving, and a second one regulating on the rights and obligations of rail passengers.

Concerning train driver certifications, it will be compulsory for these to be in possession of a license, which certifies their skills to drive specific trains and their language skills.

Concerning passenger rights, the new Directives stated the conditions of compensations due to delays in the railway service. Alike with the air transportation sector, compensations will be applied in case of severe delays, link loss and cancellations.

Delays between 60 and 119 minutes will be compensated with 25% of the tickets price, and delays beyond 120 minutes will be compensated with 50% of the fare. Compensations will have to be paid within 1 month from passenger's claim.
Other elements in the new legislation include the obligation of railway operators to inform passenger about their rights and duties and not to discriminate the disabled.[4]

2.7 HSR legislation

HSR laws in the European Commission have to do with technical standardization of systems to be able to achieve interoperability within the whole European Union. The Directive underlines the essential requirements covering all of the conditions to be met in order to ensure the interoperability of the European high-speed train network. Member States are obliged to comply with these essential requirements to achieve the objectives of interoperability in Europe. The trans-European high-speed train network is divided into many sub-systems, which are subject to special rules. The European Union implements rules concerning the management of the sub-systems by the Member States. The Directive also defines the allocation of roles and prerogatives of the Member States, the procurement bodies, manufacturers and notified bodies.

2.7.1 ERTMS

Technical systems such as ERTMS (European Rail Traffic Management System) started being deployed in 2009 after a 7-year phase of research and development. ERTMS is a system, which enhances cross border interoperability and signalling procurement by creating a Europe wide standard for train control and command systems. The two main components of ERTMS are the European Train Control System (ETCS), which is an automatic train protection system, and GSM-R radio system that provides voice and data communication between track and train using GSM standard frequencies. ERTMS is being deployed because there are more than 20 train control systems in the EU, making it difficult for trains to cross borders in a safe way. Endowing trains with different signalling and communication systems to be able to operate across borders also means high costs. For example, *Thalys* trains covering the Paris-Brussels-Cologne-Amsterdam line use up to 7 different train control systems. A standardization of these systems will make, not only passenger traffic, but also freight traffic, more efficient. According to the European Union, the ERTMS system will bring benefits in reducing maintenance, enhancing reliability, punctuality and traffic capacity. This will also mean great environmental benefits for the whole Community. [5]

2.7.1.1 ERTMS deployment in Italy and Spain

In Spain, the railway infrastructure manager ADIF has deployed ERTMS in level 1 in the following operating lines:

- Madrid-Barcelona HSR line (650km) (since October 2011, ERTMS level 2)
- Córdoba-Málaga HSR line (155km)
- Madrid-Valencia HSR line (500km)

- Madrid-Valladolid HSR line (197km)
- Madrid-Toledo HSR line (80km)
- Zaragoza-Huesca HSR line (80km)

ERTMS will also be deployed in HSR lines that are at the moment under construction in northwest Spain (Galicia) and the international connection with France via Figueres in the northeast.
Observed benefits since the ERTMS was fully operative in the stated lines above were the achieved punctuality rates above 98% on average in all lines using ERTMS.

Italy has been an early investor of ERTMS, therefore it is nowadays deploying level 2 of ERTMS. ERTMS Level 2 does not need trackside light signals and allows for a significant increase in terms of traffic capacity. The following lines use such traffic management system:

- Rome-Naples HSR line (245km)
- Torino-Novara HSR line (80km)
- Milan-Bologna HSR line (219km)
- Bologna-Florence HSR line (78km)
- Novara-Milan HSR line (40km)

Benefits of such deployment include an increase in tunnel speed in the lines running through the Alps, resulting in a global increase of the share in railway passenger transport up to 48% in detriment of the air transport market share (39%). [6]

3 Rail liberalisation levels across Europe

According to the European directives above explained, European countries should tend to a higher degree of liberalisation in their rail markets, and at some point be similar to one another. Yet, this similarity has not yet been achieved because of the differences existing in the granting of these companies. Different States in the EU give different subsidies to railway companies and this influences the level of deregulation. Some authors state in their investigations that full deregulation and competition lead to higher productive efficiency, in the freight market and in the passenger market. Deregulation helped operators to improve their financial results reorganizing networks, cutting off unnecessary costs, reducing the staff and negotiating new contracts with shippers.

In spite of these conclusions, many countries that have documented non-discriminatory access to railway companies into the system, do not allow this to happen due to high costs in licensing processes. Rolling stock approval represents one of the biggest barriers for companies to access the infrastructure. It is easy to find regulatory institutions to be dependant on each State's Transport Ministry without the necessary resources; therefore, reality differs from what is stated in European legislation.

Nash (2008) studies show three models of deregulation:

- Separation of operations and infrastructure management.
- Separation of basic competences
- Separation of the main holding rail company.

He states that completely unbundled countries could face high transaction costs in the future due to the large amount of operators. Also, the task of governments is key to achieve full separation and full access. They must remove bureaucratic barriers and promote competition, leaving the task of decision making in operations to the private sector. Therefore, governments should only supervise the conditions of entering the market and protect the consumer but not interfere with operational decisions.

3.1 Current monopoly conditions

Germany and Italy are the two European countries that have a greater separation between operation and infrastructure management. In spite of this fact, the major contributor in the management of the network is still the State but in the case of Italy, under different departments: the Ministry of Economics and the Ministry of Transport. In France SNCF (operator) and RFF (infrastructure manager) are economically independent have separate account sheets but are in conflict in two aspects. The first one is in the charging of fees, where an agreement, which satisfies both parts, has not been yet completed and the second; the terms in the contract for which SNCF does the infrastructure maintenance. Quality achievement and finance of the infrastructure maintenance is a matter of conflict between them. In Spain, the owner of infrastructure is ADIF and the company responsible for the operations is RENFE, although they both belong to the same Transport Ministry (*Ministerio de Fomento*), they are under different secretariats and work under a Program Contract, in which states mutual obligations and benefits. Summarizing, in the four countries the owner of the companies is the State under different ministries, which highlights clearly the “dress up methods” used in order to give a separated appearance.

Table 1 shows the ways in which funding of national railway companies occurs in the four countries stated.

Table 1 State and Regional finance in 4 cost types [7]

	Investments	**Network maintenance**	**Services**	**Rolling stock**
Italy	State → RFI (Program contract)	State → RFI (Program contract)	State → *Trenitalia* (Long distance services) Regions → *Trenitalia* (Regional services)	No subsidies before 2009. Regional Governments → *Trenitalia* (from 2010)
France	State → RFF (for non financially profitable investments)	State → RFF (contract subsidies State → SNCF (maintenance contracts)	State and Regions → SNCF (public service obligations)	For regional services, rolling stock amortizations is part of the financial arrangement of contracts.
Germany	Federal State → DBNetz (by law BSchWAG) Regions → DB Netz	Federal State → DBNetz	Regions → DB (for regional services only)	Not subsidized
Spain	State→ ADIF	State→ ADIF	State→ RENFE (public service obligations) Regions→ RENFE (for regional services)	State→ RENFE (about 40% of investments in rolling stock)

As seen on *Table* 1, in Spain is where most governmental intervention takes place as it finances at four levels, investments for infrastructure, operations, maintenance and 40% of the rolling stock. Little amounts of money come from regions, only to pay for the regional services. The Spanish State also covers operating losses accounting for 150M€ per year between 2009 and 2010. The French case shows almost the same as in Spain, where State and Regions co-finance the railway companies to a large extent, except for rolling stock. RFF must, by law, keep SNCF as only client; a clear demonstration of State intervention in the railway sector. In Germany, it is seen that Regions finance the service operations and the State only funds investments in infrastructure maintenance. Italy has also a strong cash input from Sate and Regions but had no finance for the acquisition of rolling stock before 2009. However, after 2010, a 2.000M € State investment was announced to purchase rolling stock. [7]

To have an idea of the amount of money that States and regional governments transfer to their railway companies, table 2 summarizes such amounts in 2007.

Table 2 Public transfers in investment costs and total demand of railway network in 2007. [7], [8]

	Spain	**Italy**	**Germany**	**France**
Infrastructural investments (Million €)	2125	3900	4270	2151
Demand (Million passenger-km in 2007)	21.362	49.780	79.098	81.961
Ratio (€/passenger-km)	0,09	0,07	0,05	0,02

Table 2 shows public transfers in investment costs and passenger demand in the whole railway network in 2007. As seen, in absolute term, Germany is the country with higher transfers to railway managers and Spain is the country with the lowest transfers.

Anyway, to be able to compare between countries, it is useful to pay attention to the ratio; investment in € per passenger-km. Here is where Spain gets the highest transfers of public investment per passenger-km and France the lowest. An explanation to this fact is the high amount of public budget that Spain is transferring for its expansion of the HSR network, despite the low demand rates. Italy and Germany are the countries that have intermediate State transfers for new infrastructure with 0,07 and 0,05 €/passenger-km respectively.

3.2 Evolution of the concessional model

Traditionally, European countries have used concession agreements in order to provide the railway services. This model involved transfers to companies to be included in the annual budgets, often resulting in an inefficient allocation of resources, cost overruns due to additional payments and discrimination to competition due to subsidies. Therefore, this system has evolved towards a contractual model, where contracts of issue, are established between public institutions and railways. The contracts define the terms and conditions of the payments to railway undertakings and therefore use of resources is more efficient. Contracts also regulate the duration of the public funding. With these, Regions are able to have better programming in the acquisition of rolling stock and provide higher quality services. If terms in the contracts are not respected by either of the two signing parties, independent regulatory agencies can act and sanction the party committing the irregularities. Other functions of these agencies include tariff setting and ensuring competition between operators. From 2009 there is in France such an agency called *Autorité de Régulation des Activités Ferroviaires* (Railway-Activity Regulation Authority), which deals with infrastructure charges to operators, access and deals with conflicts when agreements between Public Sector and operators are not reached. In Germany, the regulatory organisms are the *Eisenbahnbundesamt* and *BNetzA;* the first responsible for the timing of technical specifications and the second deals with track charging and sets the non discriminatory rules. In Italy and Spain such agency does not exist as such and the Ministries assume these functions. [7]

3.3 Conditions to access the market

Theoretically as explained before, the market should allow free access to any company willing to provide rail services and that complies with the rules of access, according to European directives. Reality differs somehow on what stated in the Directives due to each country's specific legislation. In Germany is where the hardest conditions to obtain an operating license take place, especially due to technical and trained personnel requirements, although it is the country with more railway operators (see Table *3*). On the opposite side, Italy has the less strict conditions to enter the market, as only a declaration certifying that all requirements are met at the moment of starting operations, instead of an ex-ante certification. The monopoly conditions of Spain and France make it very difficult to access the rail markets for other undertakings that are not public like RENFE o SNCF.

Regarding the access conditions in terms of accessing the use of fixed railway assets such as terminals, stations, depots and maintenance machinery; differences between the four countries are found. It is important to remember that operation means not only the right of using the tracks but also the rest of necessary infrastructure. Many times, this acts as a barrier for accessing the market because it is not easy to manage such high cost assets, and they are strictly necessary to carry out railway operations. The following table summarizes the conditions in every country to access the fixed assets operation.

Table 3 Access conditions to fixed railway assets [7]

	Italy	France	Germany	Spain
Stations	RFI, open to new entrants	Divided into "technical" part (owned by RFF and accessible) and "commercial" part (owned by SNCF)	*DB Station und Service*, open to new entrants	ADIF, open to new entrants
Freight terminals	RFI, open to new entrants Some of them are transferred to *Trenitalia* and access is subjected to its approval	Owned by RFF and rented out to operators, other competitors must apply to use them	The majority is owned by *DB Netz* and rented out to *Railion* (cargo carrier), few private owners, Container terminals are open to new entrants	ADIF, open to new entrants
Maintenance units	RFI, open to new entrants	Light maintenance units for rolling stocks are operated by SNCF but are considered as an essential facility and competitors have access to them.	Open to *DB Netz* and private companies	RENFE, not open
Train depots	RFI, open to new entrants	Owned by SNCF, not open	Open to operators and DB *Dienstleistungen* (Services)	ADIF, open to new entrants

It is seen that France's conditions for entering the operation in train depots and stations is not open to other competitors and therefore can only be operated by SNCF and RFF national companies. In Germany and Italy is where fewer restrictions to enter the fixed assets management occur as the four types have full open access to competition. In Spain, ADIF, infrastructure manager gives full access to competitors but RENFE operator does not give such in the maintenance machinery assets. With this table, the differences in the access conditions to fixed railway assets in the four countries are made clear, being Italy the less restrictive in this sense.

No less important than the fixed assets is the issue of rolling stock purchasing. Rolling stock is one of the most expensive items in the railway companies costs. Not only the purchase of it, but also amortization and maintenance. Normally, state companies do not provide other tendered companies with their rolling stock, being the main reason why new companies will have to purchase it, leading to high costs that they cannot assume This is seen as an important barrier to access the market. This is not the case of Germany, where the Regions (*Bundesländer*) own the rolling stock and lease it to the tendered companies who have accessed the rail market. In Spain, RENFE State Company owns the rolling stock and does not give the chance to newcomers to lease it. Instead rolling stock must be purchased and maintained, incurring in high costs. Of course it is easier to buy rolling stock if the company is granted with public funds, therefore new companies in Spain will have a clear disadvantage. In Italy, like in Spain, trains were financed by *Trenitalia* itself until 2009, when the Italian government started to grant the purchase of rolling stock. The case of France is somewhat like in Germany, where Regions contribute to the rolling stock amortizations according to the contracts existing with the main operator, SNCF.

3.4 Licensed operators and market shares

Market liberalization has led to a growing number of railway undertakings in European countries, although it is not a clear indicator of the level of market opening because many times, the market is not profitable enough for new competitors to enter. Table 4, shows the number of actual companies operating in the four countries being studied.

Table 4 Number of operators and their market shares. [3], [7]

	Licensed operators 2008	**Operating**	**Passenger market share**	**Freight market share**
Italy	49 (many of them of mixed traffic)	16	Less than 1% (2009)	13% (2008)
Germany	350	330	Regional: 15,2% Long distance: < 1% (2006)	19%(2007) 22%(2009)
France	8 (mainly freight operators)	-	0% (2008)	10% (2008) 15% (2009)
Spain	8 (mainly freight operators) (14 by 2011)	-	0% (2008)	5% (2008)

As seen on *Table* 4, most companies are operating in Germany, as it is easier to enter the market than in the other countries. 330 companies operate regularly and take up approximately 15% of the market share in regional services of passenger travel and up to 22% of freight transport in 2008. Passenger market share for Spain and France is very low compared to the other two countries. Only after 2010 there was an opening to other companies only in the international passenger transport. The great majority of operators in these countries (Spain and France) are freight carriers. The number companies operating in Italy is not negligible although not near to Germany’s status. As seen, they take up a relatively high portion of the whole countries freight traffic (13%).

4 Exploitation models of HSR lines.

Although the high-speed rail shares the same engineering principles of transport as conventional rail (both are based on the idea that the circulation on iron rails anchored to the floor allows the circulation of higher weight vehicles by reducing friction and energy expenditure to a minimum),there are also notable differences between the techniques. For example, from an operational point of view, signalling and guidance systems used by each are completely different: while conventional rail traffic is controlled through external electric signals, along with automatic signalling and control placed along the track sides, communication between a high-speed train and the different stages of the path, is performed internally, using an integrated equipment in the driving cab.

Similarly, the electrification is completely different: while most of the new railway high-speed lines require at least 25,000 Volts, conventional rail operates at a lower voltage. There are also other significant differences in relation to rolling stock and commercial exploitation of services. However, mixed exploitation systems between high speed and conventional rail exist. Four exploitation models are identified:

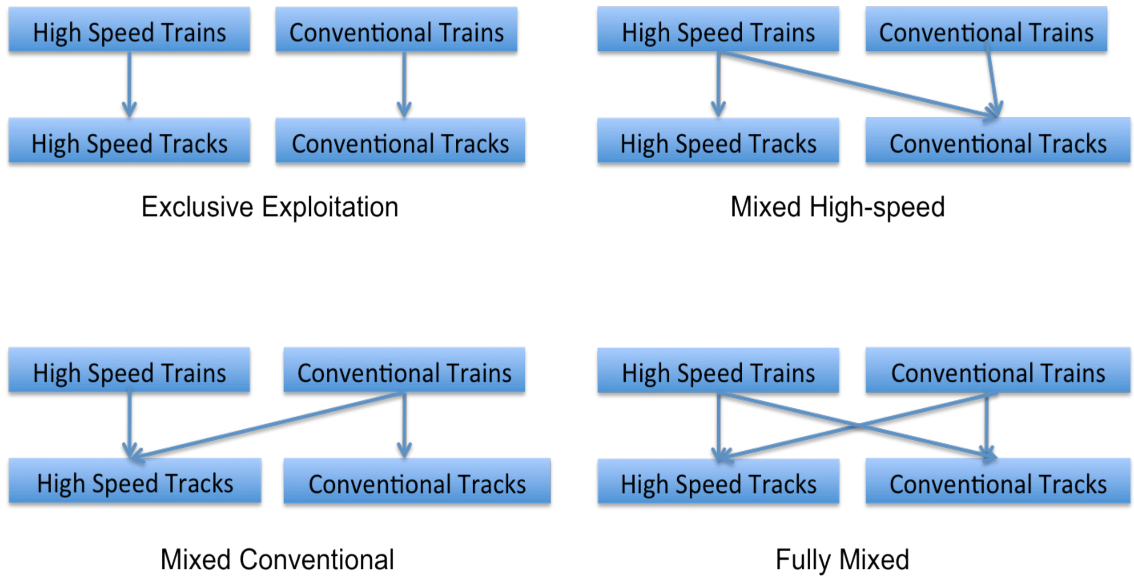


Figure 1 Railway exploitation models [9]

- Exclusive exploitation model: takes place when each type of train (conventional and high speed) travels on specific built infrastructure. Therefore there are no mixed services and this brings a clear advantage: the commercial and administrative organization of services may be independent.

- Mixed high-speed model: in this model high-speed trains travel on exclusive tracks and also in upgraded conventional infrastructure. A clear example of this models' utilization is in France, where since 1981 the new TGV's, were not only running in new built exclusive infrastructure but also in upgraded conventional tracks. The main renewal was the electrification of lines up to 25KV in order to allow high speed trains to travel on the tracks. The main advantage is the considerable reduction of construction costs.

- Mixed conventional model: this takes place when conventional trains and high speed trains are used over new built infrastructure specially built for the second type. This happens in countries such as Spain where a different gauge has traditionally been used in conventional tracks. New built tracks are built in the international gauge (1435mm) so to be able to operate trains in both of them, new technologies in train's bogies had to be implemented. This technology allows bogies to vary their width in order to adapt to both gauges and is mainly used in *Talgo* trains for long distance journeys. This interoperability achievement in trains reduced the cost of rolling stock acquisition as well as maintenance costs, and allowed to offer *express*, intermediate services in certain routes.

- Completely mixed model: this model is used when high-speed trains may use conventional tracks or when conventional trains may be used on new built tracks. This fact means more flexibility in operations, as no track constraints appear to run trains. Of course, each type of train will travel at its correspondent speed. This happens in some Intercity services (ICE) in Germany and in the Rome-Florence line, where at some moments high speed trains use conventional infrastructure and vice versa; especially conventional freight trains may use new built infrastructure for high-speed services during the night, when these services are much less frequent. This intensive use of tracks end up in higher track maintenance costs due to the erosion caused by heavy freight trains. When adopting a mixed high-speed model or an exclusive exploitation model, running of trains is subject to little conditions and may be more intensive utilization. Instead, when using the other two models, the fact that slower trains need bigger time slots to complete the same distance as faster trains travelling on the same tracks, means that planning of services needs to be very accurate. This may be avoided only in sections where duplicated tracks for overtaking exist. Due to the major capacity problems this may cause, the normal operations scheme is: high-speed passenger services occur during the daytime and freight traffic during the night time. Occasionally, high-speed night trains may use conventional tracks.

The decision whether to use one exploitation model or another depends, amongst other factors, in an economic factor. This means that costs of using one or other have to be compared and analysed. These costs comprise, as always, construction and maintenance costs. Other decision factors apart from economic criteria, are listed ahead:

- Characteristics of the rolling stock: when constructing a high-speed line it has to be taken into account that special rolling stock must be purchased. This must adapt to the high-speed specifications and requirements in order to achieve desired speeds and comply with security and technical standards. This type of rolling stock is much more expensive than conventional trains and usually amortization takes place during more than 20 years.

- Public support: it is to be noticed, as explained in previous paragraphs, that HSR lines are being largely granted by governments, which have committed large amounts of public budget for their construction. The reason for this is European Commission's commitment to favour railway transport instead of road transport due to the less consumption of fossil fuels, reduced levels of congestion and higher security. This massive support to HSR may bias decision of external railway operators in favour of offering high-speed services instead of conventional ones. It may also influence decision on which exploitation model to use.

- Growing demand of HSR services: it is a fact that passenger demand on this type of services has grown considerably over the past decade, especially in Europe. Society demands higher quality services in terms of time savings and passenger comfort for mid range hauls. Especially the number of business trips is growing in this type of transport, where one-day trips to cities within a 600-800 km range may be done. The added value HSR offers in terms of comfort, ticket sales, frequencies, time savings etc., is often positively valued by customers. This growing demand together with public grants is a perfect chance for external railway operators to make business and expand their companies, of course when competition is allowed in highly liberalised markets. [9]

5 Costs of HSR lines

Costs of HSR lines may be separated in three main types of costs: Infrastructure costs, infrastructure maintenance costs and operation costs. Also a fourth type of costs appears when the line is operative, like in all transport projects, external costs.

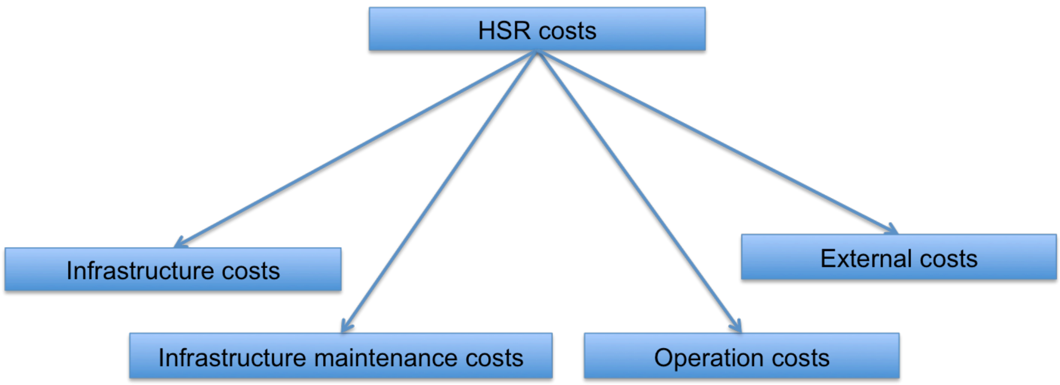


Figure 2 Types of HSR costs (source: author)

5.1 Infrastructure costs

The following table summarizes the infrastructure costs.

Table 5 Types of infrastructure costs

Infrastructure costs	Planning and land costs
	Construction costs

The larger costs are always related to infrastructure costs but these not only refer to the costs of materials and labour, but also to the costs of feasibility studies and land expropriation. These are the previous stage before the start of construction itself and are known under the name of planning and land costs. The magnitude of a HSR project makes it compulsory for public administrations to task for these kinds of previous studies, which include not only technical studies but also economic studies. These try to make accurate estimates the final construction costs, which will be very important for the investor's prediction of their financial profitability. Moreover, land acquisition has to be well taken into account, although land is many times purchased at expropriation cost instead of market value. This means, land results somewhat cheaper than if bought at market price. However, the high length of this type of infrastructure makes these costs arise substantially. The portion land acquisition and feasibility studies represent usually between 5-10% of the investment costs.

Purely construction costs are the costs of infrastructure and superstructure. Construction of infrastructure involves terrain preparation, platform building, tunnelling and viaducts. These costs may vary between 10 to 25% of total investment costs when the topographical conditions are favourable. On the contrary, when topography is harsh i.e., when tunnels and viaducts need to be built, this percentage may duplicate up to 40 to 50% of total investment. On the other hand, superstructure costs involve all elements on top of the platform: tracks, catenaries, signalling elements, electrification, safety installations and communication systems. Also included in this part are stations and train depots used for maintenance of rolling stock, which are considered basic facilities for a HSR line. However, special station architectural designs may increase substantially the cost of superstructural elements, well beyond the minimum for operating purposes. With no special architecture on stations this part of the budget represents between 5 to 10% of investment costs.

The percentages given are general figures but these may vary according to each specific project, subject to terrain characteristics and the pre-existence of conventional infrastructure. If previous infrastructure was present, upgrading of this incurs in less costs than the construction of a completely new line. Attending to this criterion, five type of projects may be distinguished:

- *Large isolated corridors*, which are constructed away from other HSR lines and for specific purposes. A clear example was the Madrid-Seville line, which was built in 1992 because of the celebration of the International Exposition in Seville. At present, this line is being integrated in Spain's south HSR network with connections to Málaga and Córdoba.

- *Network integrated corridors,* which connect to other existing HSR lines, allowing connections to other cities. This is the case of the Paris-Lille line, which was the north extension of the Paris-Lyon line.

- *Smaller extension of major existing lines*, like for example Madrid-Toledo or Lyon-Valence lines, built to provide service to medium size cities in the middle of big corridors.

- *Large singular projects* such as the Eurotunnel, connecting Calais (France) and Dover (UK).

- *Smaller projects that act as complements for the conventional network*, which include high-speed connections to airports and upgrade of conventional railways for high speed services such as in Germany an Italy.

The following table shows the range of infrastructure costs and average costs per km in the four countries being studied in this paper. These costs do not include feasibility studies or terrain preparation.

*Table 6 Average cost per km for HSR lines in service (s) and under construction (c) in million €***.** [10]

	Cost Range/km		**Average cost/km**	
	S	**C**	**S**	**C**
Spain	7,8 - 20	8,9 - 17,5	13,9	13,2
Italy	18 - 25,5	14,0 - 65,8	21,75	39,9
Germany	15 - 28,8	21,0 - 33,0	21,9	27
France	4,7 - 18,8	10,0 - 23,0	11,75	16,5

It can be observed that Spain and France have the lower infrastructure costs per km of new line (between 13 and 16,5 M € on average) because their topography is not as harsh as in the other two countries, therefore less tunnelling and viaducts have had to be constructed. Also, the fact that less concentration of population outside main conurbation exists and so reduces land expropriation costs. On the opposite side, Italy and Germany have considerably higher costs due to construction procedures and due to Italy's mountainous terrain in the north, especially on the Torino-Milan line. In France, construction procedures avoid tunnelling in favour of steeper grades up to 3,5% instead of the standard limit of 1 – 1,5%. This reduces the amount of tunnel and viaduct construction therefore reducing the construction costs. [10]

Further explanations to the cost differences may be:

- Land acquisition costs: in Spain, government land is often free of charge for transport infrastructure projects although these only represent 5% of total cost. In other countries land costs are higher, for example Germany, due to high-density populated areas.

- The differences between the countries' labour costs.

- Environmental regulations: it is known that environmental regulations are more onerous Spain than in Germany for example, where these are stricter. This often causes the increase in track length or tunnel length, raising the final cost of the project.

- Pace of the approval for projects: normally, the longer it takes for the decision makers to process and accept the project proposals the more cost overruns there will be.

- Changes in project specifications after the works have begun.

Figure 3 shows the maximum construction costs per km of infrastructure for the compared countries in already in service and under construction. Note how the costs of the under construction lines are much higher than the existing ones. Anyway, the total average construction costs for these four European countries is 17,3M€ per kilometre of HSR infrastructure.

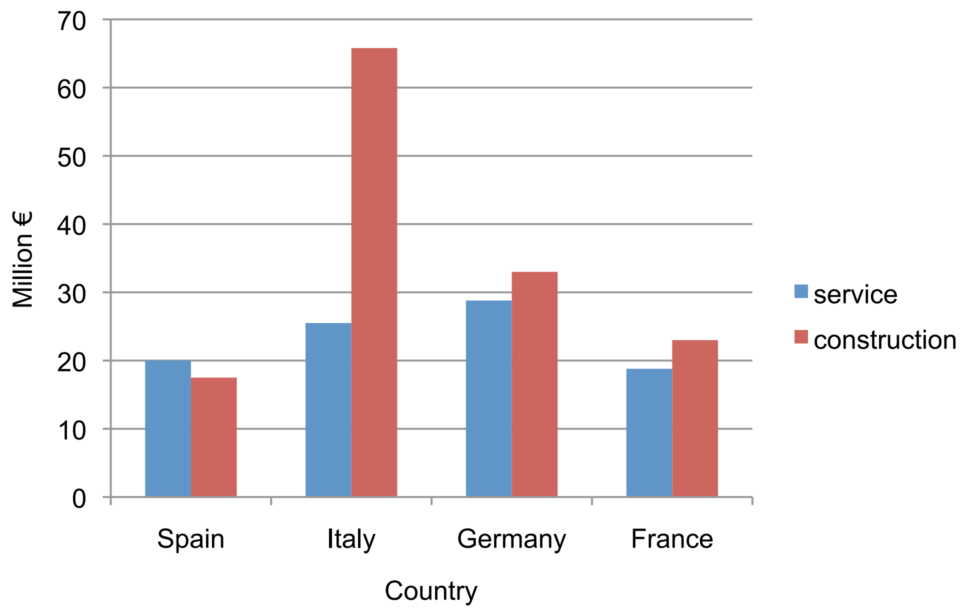


Figure 3 HSR maximum construction costs per km (source: own elaboration from Table 6).

5.2 Infrastructure maintenance costs

Infrastructure maintenance cost are the ones incurred in labour to maintain stations and depots, maintenance operation activities such as energy consumed by specific machinery running along guideways; signalling systems; safety systems and traffic management. These costs are normally fixed cost, which means these operations occur systematically throughout the week according to the company's safety and maintenance standards. Although, track and catenaries maintenance costs are directly proportional to the amount of trains running per day. This means that more train operations involve a higher wearing rate of both infrastructural elements and therefore higher costs. Knowing this, companies have to estimate maintenance costs depending on the number of daily operations that take place. On the other hand, companies' benefits are expected to increase the more railway services they provide, leading to a trade off relation where more running trains provide more revenues but also produce higher infrastructure maintenance costs.

According to UIC (International Union of Railways) the proportions of labour costs compared to the total costs are: 55% for electricity facilities maintenance (catenaries and power stations) and 45% for equipment maintenance (signalling and management systems). The following table summarizes the annual cost per km of single track in some European countries:

Table 7 Cost in € (2002) of infrastructure maintenance per km of single track and year [10]

	Spain		**Italy**		**France**	
km of single track	950,0		492,0		2638,0	
Track maintenance	13.531,0	40,4%	5.941,0	46,0%	19.140,0	67,3%
Electrification	2.986,0	8,9%	2.455,0	19,0%	4.210,0	14,8%
Signalling	8.654,0	25,9%	4.522,0	35,0%	5.070,0	17,8%
Telecommunications	5.637,0	16,8%	-	-	-	-
Other costs	2.650,0	7,9%	-	-	-	-
Total	**33.458,0**	**99,9%**	**12.918,0**	**100,0%**	**28.420,0**	**99,9%**

As seen on Table *7*, highest cost in infrastructure maintenance is the tracks that take on average 40% of the total maintenance cost. In France, this figure is higher, reaching 67% due to intensive track utilization with more train services that in Spain and Italy, especially in the Paris-Lyon line. It has to be considered that Spain most demanded line (Madrid-Zaragoza-Barcelona) is relatively as it opened in 2009 new therefore demand ramp-up has not yet finished and therefore expected level of demand has not yet been achieved. Although Table *7* summarizes infrastructure costs in the whole of the network, not in specific lines. However Spain is the country that incurs in higher costs and Italy the one with fewer costs in this matter. Anyway, the average cost in these three countries is 25.000 € per km of single line, which means that to maintain a 600km line with double tracks, 30M € need to be spent each year.

5.3 Operation costs and rolling stock

Inside this category, rolling stock acquisition, maintenance and utilization are found. The first one is mainly carried out at the beginning of operations when new rolling stock is purchased, but can also be done for renewal when the amortization period is over. Normally, rolling stock with high-speed characteristics is renewed every 20 to 25 years. Therefore railway undertakings must take into account in their cash flows the investments in new rolling stock during the period they are going to operate. The price of rolling stock depends on the contract agreements between operator and manufacturer companies an also in the train capacity. It stands to reason that greater train capacity means higher purchase price. Also technical specifications can affect final price. Operation costs involve personnel training and labour, passenger insurance and energy consumption. All of these will depend on the number of daily trains operating in a line, which at the same time, will depend on the passenger demand. In regard to energy consumption, speed of travel is a factor that determines it. Daily services and operations will be adjusted to demand rates every year, so that tariff revenue covers operations costs. Otherwise, low demand rates and many operations cause operation costs to increase considerably. These costs are usually calculated in €/seat-km, units that relate train capacity and train distance. On the other hand, train maintenance costs which include again, labour and material reposition, are determined by demand, which at the same time determines train distance travelled each year.

The following table summarizes the types of train used in European high-speed services and some of their characteristics:

Table 8 Types of high-speed trains and their capacities. [9].

Country	Type of train	Capacity (seats)	Capacity (seats-km per year)	Max. Speed (km/h)
France	TGV Resseau	377	186.615	320
	TGV Dupplex	510	267.750	320
	THALYS	377	167.765	320
Germany	ICE-1	627	313.500	280
	ICE-2	368	147.200	280
	ICE-3	415	174.300	330
	ICE/T	357	128.520	230
Italy	ETR-500	590	212.400	300
	ETR-480	480	138.240	250
Spain	AVE	329	154.630	300
	AVE S-112	365	175.680	330
	AVE S-103	404	140.970	330

Higher train capacities may be observed in France's *TGV Dupplex* by *Alstom* and Germany's *ICE-1* by *Siemens*, operating since 1995 and 1991 respectively. The faster between both are those in France capable of 320 km/h. Slightly lower capacities can be observed in Spanish trains, *Siemens* 112 and 103 models covering the Madrid-Seville and Madrid-Barcelona lines. Due to lower passenger demand rates, smaller convoy configurations are adopted, although S-103 may carry 141.000 seat-km every year. Convoys with different capacities are used in different lines depending on the times and demand rates.

Table 9 Train operation costs [9].

Country	Type of train	Euros/seat	Euros/seat-km per year
France	TGV Resseau	45	90
	TGV Dupplex	40	75
	THALYS	65	147
Germany	ICE-1	60	124
	ICE-2	35	100
	ICE-3	56	120
	ICE/T	42	120
Italy	ETR-500	58	155
	ETR-480	42	152
Spain	AVE	65	154
	AVE S-112	55	125
	AVE S-103	46	95

In the table above, train operation costs are compared using Euros/seat and Euros/seat-km. The last one includes the cost of the train operations (mainly labour costs). On average, the cost of operating trains in these countries is 51€/ seat, being relatively higher in Spain's AVE, as it has the same costs as the German ICE-1 but with almost half its capacity. When comparing figures with annual Euros/seat-km, it can be seen that on average, France's technology reduces costs between 11 and 25% the costs of operation. Higher costs are observed in Italy's ETR-500 despite its relatively high passenger capacity.

Also energy consumption is taken into account in the operation costs, which depends on each countries specific trainset. Energy consumption varies with speed and number of passengers carried in each haul. At speeds over 300km/h energy consumption increases exponentially but the amount paid for it depends on electricity's price in each country at each moment. In France and Germany, energy is somehow cheaper (between 5 and 10%) not only because they have increased nuclear energy production but also because it is acquired directly by the operator rather than paying canon for infrastructure utilization. This happens mainly in Italy and Spain, where operator is charged by the infrastructure manager for each train that travels on the managers owned infrastructure.

The following table shows train maintenance costs per 1000 km of train operation in each of the countries being studied

Table 10 High-speed train maintenance costs [9]

Country	Type of train	Euros per 1000km
France	TGV Resseau	1,6
	TGV Dupplex	1,6
	THALYS	1,8
Germany	ICE-1	3,1
	ICE-2	1,6
	ICE-3	1,7
	ICE/T	1,7
Italy	ETR-500	4
	ETR-480	3,2
Spain	AVE	2,9
	AVE S-112	3,1
	AVE S-103	3,3

High-speed trains maintenance costs, just as the high-speed infrastructure maintenance costs are not low due to intensive usage and expensive material components (advanced technology). In the comparison above, recently acquired Spanish AVE *Siemens* 103 model used in the Madrid-Barcelona line, shows higher maintenance costs that the rest of competitors in the four countries being studied (3,3€/1000km of train operation). Similar costs, and even higher, are seen in Italy's ETR-500, just as its operation costs. On the other hand, France and Germany's train maintenance costs are relatively lower with averages of 1,9€/1000 km of train operation. These differences may be explained by different maintenance plans, externalization costs and periodicity of new rolling stock acquisition.

Taking the average distance travelled by a single convoy each year as 500.000 km, the annual maintenance costs per unit rises up to 1M €, which yields to 2€/km.

5.4 External costs

External costs (or externalities) are the those which the transport systems generates on the rest of society, or in other words, the costs which lapse on those who have nothing to do with the transport system. This means that all transportation activities, including the railway, will have negative effects on others.

According to INFRAS/IWW studies on transport external costs, in the year 2000, the total external costs in the 17 EU members at that time was (excluding costs of congestion) 650 billion Euros, representing about 7,3% of the EU's GDP. Climate change contribution is the most important cost with almost 30%. Air pollution and accidents account for 27% and 24% respectively, whereas noise represents 7% and landscape effects (barrier effects and visual impact) and other urban effects only represent 5% of total costs. The most striking sector is the road transport sector with more than 87% of all externalities, followed by the air transport (11%) and finally, the railway sector (1,5%) and the maritime transport (0,4%). These figures reflect how railway transport is one of the least contributors to external costs on society. [11]

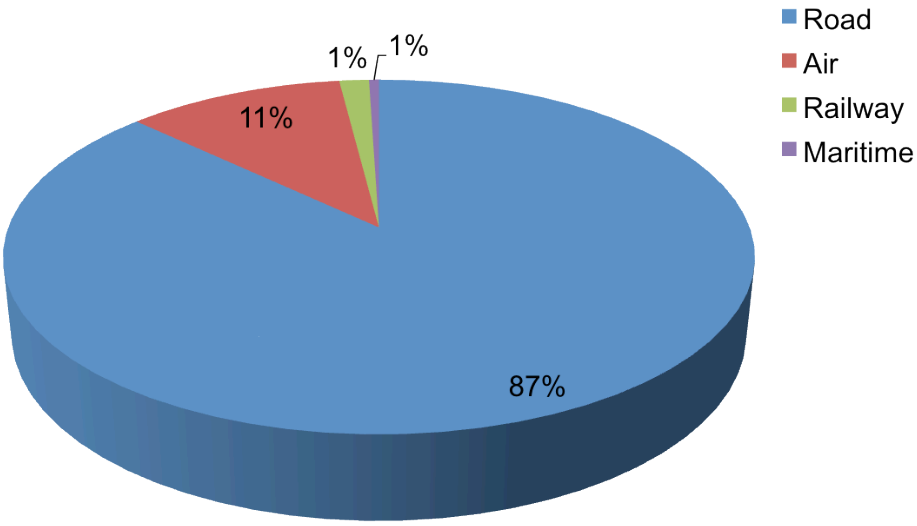


Figure 4 Contribution to external costs by transport mode in the EU (2000). (Source: own elaboration from [11])

First, there are the environmental negative effects such as air pollution, land consumption, barrier effects, visual intrusion and contribution to global warming. In second place there are other negative effects, which the transportation systems may cause on external users such as accidents, congestion (and therefore time loss) and noise. All of these negative effects may be monetized and compared with the benefits an infrastructure can provide to conclude whether its construction is beneficial or rather harmful for society.

5.4.1 Environmental effects

The negative environmental effects of the construction of a new HSR have to be compared with the reduction of the externalities in road and air transport when passengers shift to HSR. The final balance depends on several factors but basically the net effect depends on the magnitude of the negative externalities in HSR compared with the substituted mode, on the volume of traffic diverted and whether, and in what degree, the external cost is internalised (users are charged according to the amount of negative impact they produce with their transportation activity).

The environmental effects of HSR are the same no matter where the line runs through due to electrical energy being consumed by running trains. This kind of energy is mainly produced by petrol, coal and gas combustion; therefore releasing air pollutants and contributing to global warming and upper climate change. However, due to a big diversity in each countries energy primary sources, it is difficult to compare HSR amount of air pollution but the following figures are generally accepted. The volume of petrol consumed by HSR for 100 passenger-km was 2,5 litres (6 litres for car and 7 for aircraft) whereas the amount of carbon dioxide emissions per 100 passenger-km was 4 tonnes, compared with 14 Tn for car and 17 Tn for aircraft. [11]. This can be seen in *Table* 11:

Table 11 Carbon dioxide emission and petrol consumption in three transport modes per 100 passenger-km [11]

Mode of Transport	**CO_2 emissions**	**Volume of petrol consumed**
Road	14 tonnes	6 litres
HSR	4 tonnes	2,5 litres
Plane	17 tonnes	7 litres

However, the big environmental impact produced by HSR is during the infrastructure construction, where big quantity of carbon dioxide is released. It has to be accounted for the production and distribution of materials, such as concrete and steel, as well as all the operation of the machinery involved for construction: tunnel boring machines, bulldozers, and trucks. To compensate for this impact, decades of train operation may be needed, once again depending on the demand rate, on the diversion from other transport modes and on the new traffic generation. Therefore it has to be assessed in an ex post analysis after some years or operation, whether the amount of carbon dioxide emissions produced during the construction compensate for the ones saved in the future. Other factors influencing this evaluation are the number of people affected by the works and the environmental value of the areas affected. This has to be appraised in particular corridors and cannot be evaluated in a whole network. Other factors, which help to understand the little external benefit of HSR in carbon dioxide emissions, are:

- The difficulty in evaluating the environmental costs produced during the operations of the HSR line, subject to variations due to load factors in trains and volume and composition of traffic.

- Other effects such as barrier effects, landscape visual impacts and biodiversity effects might be higher in comparison with the positive effects on global warming, but the social debate nowadays is the one on carbon dioxide emissions.

- If charges for infrastructure use in road and plane do not cover the marginal social costs of this traffic, the diversion to HSR will be beneficial. For the estimation of these benefits, all the externalities, which have been referred to previously (land occupation, noise, global warming etc.) must be valuated in terms of their marginal costs and compared to the taxes that are paid for them.

- A clear and simple example may help to understand the non-efficiency of HSR in order to reduce the global warming effects. The following figures will be assumed in a 500 km HSR line in terms of passenger-trips deviation from other transport modes:
    - Aviation: 20%
    - Cars: 20%

- Conventional rail: 30%
- Bus (long distance): 5%
- Generated traffic: 25%

With these figures and assuming a demand on the first year of 10 million passengers (more or less the minimum for a positive Net Present Value), a reduction of 90.000 tonnes of carbon dioxide would be achieved. Accepting the cost of 30€/tonne of CO_2 (Catalonia's College of Civil Engineering), the amount saved would be 2,7 million €. Compared to the construction costs of this type of transport infrastructure, the saving seems rather low. [12]

5.4.2 Noise

Regarding the noise a HSR line causes, it is difficult to compare and analyse. Of course noise only affects when running through populated areas, therefore in some villages acoustic protection along the tracks have been constructed to lessen this impact. Basically the noise of a train comes from the steel contact between track and wheels, the pantograph and aerodynamic noise and all are proportional to the speed of travel. According to *Levinson et al. (1997)*, a 150m corridor is needed to maintain a tolerable 55dB noise of a high speed train travelling at 280km/h. Usually values lie between 80 and 90dB, which are non acceptable noise levels. [14]

5.4.3 Land Consumption

Also land consumption must be analysed when constructing a HSR line and sometimes must be compared with that of a motorway. On average a motorway consumes 75m of width whereas a HSR line may consume up to 25m. From a capacity point of view, on average a motorway may carry 7650 people per hour and directions of travel (assuming 1,7 passengers per vehicle) and a HSR line may carry 5760 on an 80% load factor assumption. Looking at the total capacity of each infrastructure it seems that a motorway construction is not worthy for a 2000 passenger capacity increase per hour, taking into account that a motorway takes up three times more space. [13]

Table 12 Comparison in land consumption between HSR line and a motorway.[13]

	HSR line	Motorway
Type	Double track	2 X 2 lanes
Width	25 metres	75 metres
Infrastructure capacity	12 trains/ hour and direction	4500 cars/ hour and direction
Vehicle capacity	600 passengers	5 passengers
Total capacity	5760 passengers/hour and direction (assuming 80% load factor)	7650 passengers/hour and direction (assuming 1,7 passengers per car)

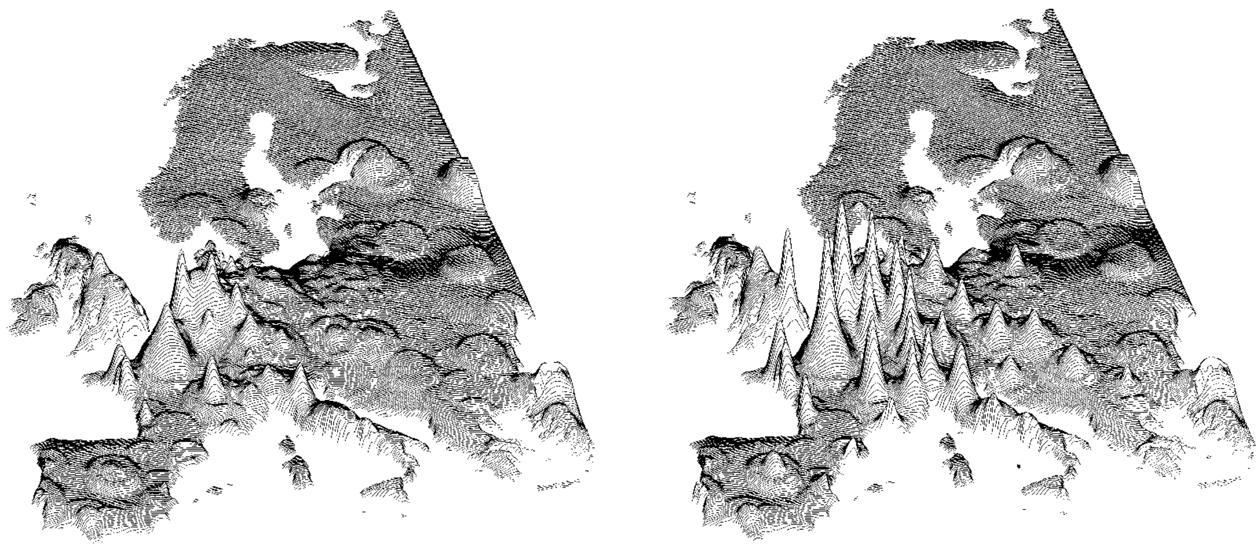
External costs on safety are the ones derived from the price of injuries and death of a person. These vary across countries depending on economic indicators. As far as HSR is concerned, safety standards when constructing this type of infrastructure reduce chance of train collision to a minimum, as very few high-speed train accidents have occurred. Therefore, in the safety aspects, HSR is considered to be positive as it reduces accidents. Nevertheless, safety systems account on a big proportion of the budget for HSR lines. [13]

5.4.4 Effects on Regional inequalities

Government policies in Europe have wanted to minimize territorial economic inequalities between regions. This is the wish of making grow less developed and less industrialized areas, not only the big industrial poles in a country. One of the main pretexts for building HSR is, in fact, this reduction of economical inequality. However, it is not clear yet the impacts in this matter of constructing a new infrastructure.

It has to be taken into account the fact that HSR does not transport freight and therefore this may reduce the potential benefits that HSR could bring to the industrial sector. Normally, the improvement of a transport infrastructure reduces costs of transport and increases the quality of it, therefore inducing new economic activity. Efficient communication between industrial nodes and supply poles (cities) normally lowers these costs but in the case of HSR, which only transports passengers, this does not help this situation to happen. Therefore it is discussed whether European policies of building HSR for lessening regional inequalities is really an effective measure. On the other hand, what HSR has done is to shift service companies' headquarters from the less dense populated areas to the big conurbations. This results in higher costs in the highly populated centres but more advantages in terms of scale economies. Thus, resulting the opposite desired effect.

Figure 5 Daily accessibility by rail (*Source: Vickerman, Spiekermann, and Wegener (1999)*



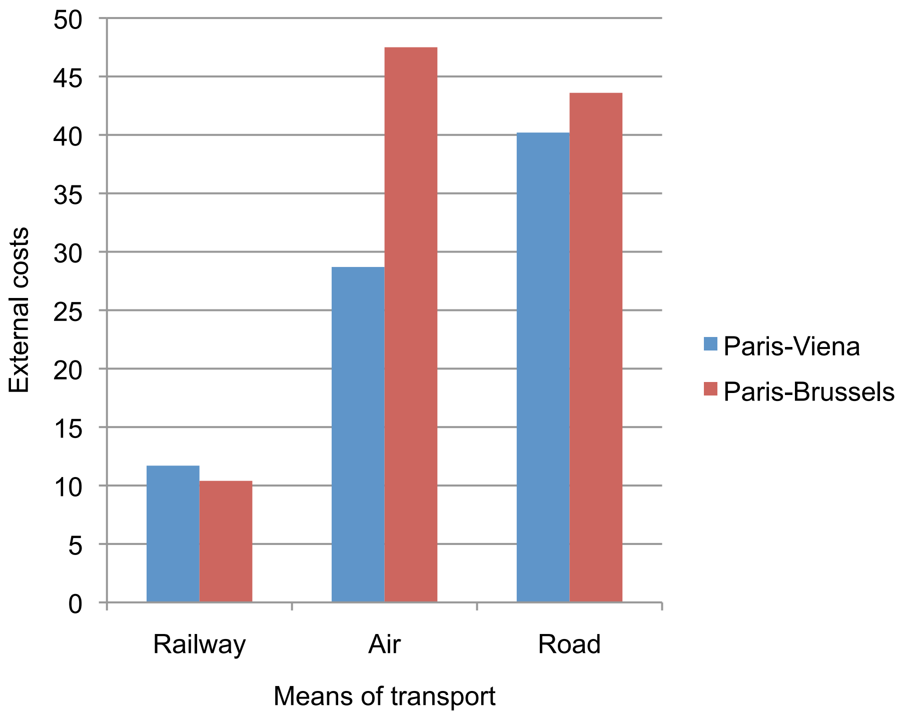
The figure on the left corresponds with 1993 daily access by rail and the one on the right shows the same but in 2010. The height of the surface at each point is proportional to the population that can be reached from that particular point by a return rail trip made during a working day with some minimum stay in the destination. These are normally business trips for which HSR is indeed broadly used. The conclusions at the look of *Figure* 5 results in larger concentration in hubs. It can be seen that access condition to European cores may be twice as much as that of in peripheral areas. When major cities are connected with HSR they get better access to the rest of the territory, whereas in peripheral zones, connections are improved with nearby locations. Another conclusion is that HSR only favours in terms of accessibility the cities that are within the high-speed network (normally at a 3-5 hour travelling distance). On the contrary, cities, which do not belong to the network, will reduce their accessibility and therefore may be concluded that HSR construction will only benefit the highly concentrated activity nodes on the network, and is unlikely to develop economic activity in the less developed areas. [15]

5.4.5 Barrier effects

Finally, the called barrier effect occurs when trains run on urban areas. The main problem is that the railway lines divide land in two sections, creating problems in mobility and communication between both sides. It also conditions the future growth of the city by influencing land use in its edges. This does not only happen with HSR lines but also with conventional rail lines, although in the last case the impact has been minimized by constructing crossings at different levels for pedestrians and for road traffic. In contrast, for HSR, due to the restrictive constraints for its construction, high viaducts or large tunnelling has to be made, increasing the cost of the works.

To summarize, the total external costs between 3 transport modes in two corridors, the following figure is shown:

Figure 6 Total external costs (€) per 1000 passenger-km [9]



The costs include global warming, accidents, noise, environmental pollution and urban effects but do not include congestion costs. As seen on *Figure* 6, for the Paris – Brussels corridor (320 km) the HSR external costs are 25% of those of plane and car due to its high occupation factor, mainly because of business trips between the two capital cities. On the other corridor, conventional railway is responsible for 50% less external costs compared to plane and 75% less than those related to road traffic. The relative advantage of rail transport over plane is reduced as distance increases because big part of external costs caused by the latter is during take-off and landing. This also explains the difference in costs between both corridors in the air transport.

6 Benefits of HSR

Of course, once the investment in HSR has taken place, benefits are expected to come in one form o the other. Some European governments justify enormous economic expenditure with the only pretext of environmental sustainability, but it is not the only benefit of HSR. As seen before, in fact, it is the least important of the benefits provided by HSR. The main benefits than can be observed in this kind of transport are:

- Time savings.
- Generated traffic.
- Higher capacity.
- Reduction of externalities in comparison with other transport means.
- Other economic impacts, such as economic stimulus.
- Increased passenger comfort

When referring to time savings, usually HSR is compared with conventional rail and with other means of transport within similar distance journeys. It is logical that if a train travels at 160km/h or at 300km/h, for the same haul, the time spent by the fast train will be almost half of that needed by the slower one. Also for distances between a certain distance range, high-speed trains are more competitive in door to door journeys than other transport modes, due to lower access and waiting times. Normally high-speed services connect city centres, which means faster access to business facilities than having to travel from an airport for example. As users value access time higher than actual travel time, the perceived cost of travel is reduced for these types of journey.

Another concept of travel costs must appear at this point, it is the value of time. Value of time is quantifying each user’s trip hour in monetary terms. For each country, these values vary according to the transport mode chosen and according to the purpose of travel (business, leisure etc). Differences between countries values of time are established based on economic parameters such as GDP and income. Users mostly value HSR business journeys because, on the train, people are able to perform job related tasks or activities unlike plane or car, making the HSR option more attractive and therefore making their time more valuable. [9], [16], [17]

Latter studies (British Institute for Transport Studies, 2003) on value of time state that this magnitude based on salary rates should vary proportionally to each countries GDP, therefore accounting on the variations of the value of time with the passing of years. With this information, the generalized cost of travel may be easily calculated as the cost of the ticket (out of pocket cost) plus the value of time multiplied by the door-to-door travel time. This generalized cost of travel is responsible for the modal split (choice of transport mode) and may be determining in the demand rates.

When compared to conventional rail travelling at an average of 130km/h, HSR reduces the door-to-door time, on average, between 45 and 50 minutes in a 350 to 400 km journey. However, when the conventional rail is travelling at 160 km/h, HSR saves only 30 minutes time on average due to smaller differences in in-vehicle time, as waiting and access time are the same for these modes.

For car users, the access and waiting time are almost zero but as distance rises, benefits of HSR are evident because it travels, on average, twice as fast. As distances get shorter, HSR advantages over road users diminish due to the proportional reduction in in-vehicle time on the train with respect to waiting and access time.

Comparing with air transport, which is its main competitor, HSR has higher in-vehicle times but may compensate this lack with considerably lowering access and waiting times. As explained before, access and waiting times are valued by users between 1,5 to 2 times as much as in-vehicle time, therefore this may influence the modal choice of users towards rail. Of course, this will depend on the purpose and final destination of the traveller: if the final destination is not in the city centre but in a peripheral area (i.e. not a business journey), plane may be preferable. Also it has to be taken into account at this point, airport security controls and check-in procedures, which may reduce the comfort of the passenger, affecting his final decision towards the train. Another factor, which may influence this final decision of users, may be the comfort of travelling by HSR. Passengers may seat in wide seats, they can work throughout the journey and there are no such security controls as in airports.

Regarding generated traffic, the construction of new HSR lines normally diverts traffic mainly from road transport and air transport. If the charging for infrastructure use on these modes is lower than the marginal cost of the traffic, benefits will be observed. Also, if enough diverted traffic is achieved in the railway line to reduce car and air transport externalities, benefits will occur. Moreover, if diverted traffic is high enough, other transport mode operation costs will be reduced, as the passenger demand will fall. When fewer drivers are travelling in the same corridor in which the HSR line has been built, car maintenance cost and vehicle amortization will be lower, generating a social benefit for those who choose not to use it. [18]

Increasing the capacity of the corridor by building a new line (in this case, a HSR line) will only produce benefits when the corridor has reached it's saturation point, or in other words, maximum capacity has been achieved. If this is the case, the new line will offer more capacity and therefore congestion will reduce in road traffic, air traffic and in the conventional railway services, if these are to exist. The benefit when this occurs is quantified by the net benefit of users plus the net benefit produced due to reduction of externalities on the other modes (accidents, pollution, time savings…). Not only will the expanded capacity benefit the cities that are connected by the new line but also will increase capacities in other connected transport networks, such as the freight traffic. [19]

Also it has to be observed that operating a new HSR line can produce economical benefit to society by providing new jobs and promote economic activity. The operation of the services will need labour force, and so will need all the administrative necessary works to manage the railway undertaking. An example of economic stimulus produced by the HSR line is tourism to a city due to generated trips. The comfort the new line provides as well as the time savings mentioned above, may induce new leisure passenger traffic, promoting tourism in any connected city. However, in the cost benefit analysis, it will have to be made clear whether it is a pure stimulus of economic activity or if it is a simple relocation of labour and economic activity. Similarly to what has been argued in *Effects in regional inequalities*, if the primary objective is to give stimulus to central cities, there is proof that HSR connections produce this effect. Therefore, depending on the policy adopted, this is a beneficial impact on big cities, where the main business activities take place.

7 Development of HSR in the study countries.

During the last decades, the main European countries are constructing HSR (> 250km/h) at a high rate. The following table shows the extension of this kind of infrastructure at the beginning of 2010:

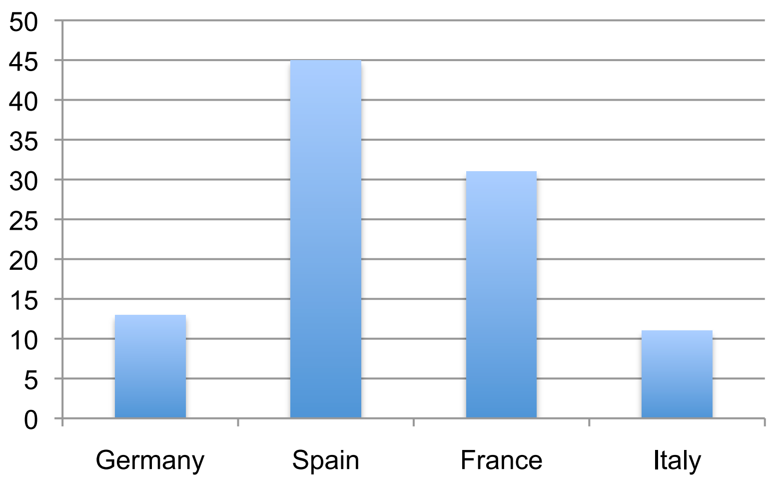
Table 13 HSR in service at the beginning of 2010 [20]

Country	First year of service	Km in service (1)	Km under construction (2)	Km under project (3)	Total (1)+(2)+(3)
Germany	1988	1032	316	599	1947
Spain	1992	1515	2219	1072	4806
France	1981	1872	299	2616	4787
Italy	1992	760	55	395	1210

As seen on *Table* 13, France was the country with more operative HSR lines out the four compared countries, but in fact, Spain is the country which will have the larger HSR network when under project and under construction lines are finished. Italy shows the lowest figure on operative HSR lines.

If we have a look at *Figure* 7 we can see that the ratio of km of HSR in service per million inhabitants, Spain has the highest figure with 42, more than triple than that of Germany and four times that of Italy. France remains at second position in this ranking.

Figure 7 km of HSR per million inhabitants [21]



7.1 France

In France the first HSR line was finished in 1981 between Paris and Lyon with a length of 419 km. The main motivation to carry out this line was the big levels of congestion in road and rail between both cities. Between 1981 and 1992 the demand of this line almost doubled, reaching 19 million passengers. Due to these successful demand levels, the TGV investment plan expanded with new lines between Paris and Le Mans, Tours and Calais. The extension carried on to the Rhone-Alps corridor in 1994 and in the Mediterranean.

The network is a centralized structure, which centre is Paris. The conventional rail has been preserved in order to feed the major HSR lines between cities with lower demands since the expropriation and construction costs for high-speed infrastructure would have been exorbitant. However, TGV transports every year an average of 100 million passengers, being the European country with highest HSR demand.

The economic benefits of TGV have mainly been in Paris, whose trips have risen 144% when it was the final destination. Therefore, Paris has absorbed activity from other minor cities. Nonetheless, Lyon and Lille have also received some positive impacts in their mobility rates via rail. However, the effects on industrial activities and decision on business location have been almost negligible. Finally, after the opening of the Paris – Lyon line, in business trips, the number of people who decided to stay at least one night at destination reduced from 74% to 46%. [22]

Figure 8 TGV France [23]

7.2 Germany

The beginning of commercial high-speed operation is Germany took place in 1988 after some political and topographical problems. The new Inter City Express lines were used to change the networks characteristics, since the German network had been traditionally mainly used in the west-east lines before World War II. After WW II, industrial traffic had started to rise quickly in the north-south corridors of the country, mainly because of freight transport from ports in the north to industrial areas in the south. Hence, the first two

"Neubaustrecken" to be constructed were the Hannover-Würzburg completed in 1994 and Mannheim-Stuttgart in 1991. The main objective was to improve freight traffic from north to south and to solve congestion problems that had been happening during some years. After the countries' political reunification in 1989, east-west corridors were also a priority; hence Hannover-Berlin and Nüremberg-Leipzig were constructed shortly after. [24]

It is important to say that not all railway lines in Germany have been newly built and turned into HSR, but in contrast to other countries, Germany has upgraded many conventional lines to be able to operate at 200-230km/h. These lines correspond to Hamburg-Berlin, Bremen-Münster, Hannover-Dortmund, Berlin-Leipzig, Frankfurt-Mannheim and part of the Nürnberg-Munich line. In addition, in Germany high-speed tracks are compatible with the freight transport (except Frankfurt-Cologne line). Thus, the network is shared between high-speed trains, passenger fast trains and freight trains. The only lines, which are able to achieve 320km/h, are Frankfurt-Cologne and Nuremberg-Ingolstadt

The German multi-purpose HSR system was designed to expand benefits rather than to concentrate them in the networks major nodes (as it is the case for Spain and France). The freight transport was considered more important as it contributed more to productivity and income than the passenger transport. The average increase of the market share introduced by the HSR was 11% and the average revenue for every train-km of the ICE was 1,7 times higher than the average for the other long distance services. [25]. However, Germany's abrupt topography and construction delays ended in high cost overruns as well as operating deficits. Some of these cost overruns were due to the need to satisfy a wide range of policy participants. Therefore, German lines have been more expensive than the French lines. Together with the fact that the average number of users is 67 million a year (much lower than in France), the continuity of HSR investment is being questioned.

The following figures shows Germany's HSR. Red lines are over 300km/h, orange 230-280km/h and blue 200-230km/h (upgraded lines)

Figure 9 Germany's ICE lines [26]

7.3 Italy

High-speed in Italy started with the Rome-Florence line with a length of 240 km that was known as *La Diretissima* and completed in 1992. It allowed speeds up to 250 km/h, but its technical specifications are not formerly those of HSR. The initial plan in Italy was to build a HSR network that was completely independent from the conventional rail services, just as in Spain and France. However, in 1996 a more integral network conception was thought of, therefore *Alta Veloccità* Plans were replaced by the AV/AC plans. These consisted of sharing tracks between HSR and conventional rail, expanding capacity and avoiding conventional rail's degradation. Due to private stakeholders' reluctance to pay for the new line construction, the State railway manager *Ferrovie dello Stato* purchased 60% of the shared investment between the established Public Private Partnership (PPP), *Società TAV.*

The first operating proper high-speed lines were Rome-Naples line in 2005 and the Torino-Novara and Módena-Lavino lines in 2006. Nowadays, the AV/AC (*Alta Veloccità/Alta Capaccità*) gives service to the Torino-Milano-Bolonia-Forence corridors and the Rome-Naples-Salerno corridor.[27]

Just like in Germany, the deployment of HSR in Italy was conceived to spread benefits rather than to concentrate them by linking with the conventional lines. However, these plans caused the costs of construction to shift about 33% of total initially expected costs due to delays and inefficient management of works and contracts. As seen in the *costs of HSR* section, in Italy is where higher construction costs have occurred, due to the reasons exposed in this paragraph, due to its harsh mountainous terrain, high dense populated metropolitan areas and high seismic risk.

Figure 10 Italy's HSR lines [28]

7.4 Spain

Spain's first high-speed trains operated between Madrid and Seville in the inauguration year of Seville's Universal Exposition. The line covered the journey in 2 hours and 20 minutes and was surprisingly not the corridor with the heaviest traffic in the country. Instead, that was the Madrid-Barcelona corridor, linking the two biggest metropolitan areas in Spain. The Spanish Transport Ministry decided to build the AVE (*Alta Velocidad Española*) in international gauge instead of the iberic gauge (1.666mm), which was the traditional gauge used in Spain. In addition, Spain bought the in rail technology from other countries rather than building its own, fact which differs from the other countries mentioned. Regardless of that, the aim of the Spanish government with HSR was territorial cohesion and to favour the economy of the less developed regions of the country. Therefore, in this case, a technical reason responding to transport efficiency criteria (such as reducing congestion) does not exist. Instead it only responds to a political issue.

Although during its first years of operation, the market share for plane between both cities fell considerably, is has been clear that the whole Spanish HSR network is unable to meet demand rates in France or Germany. Even with the Madrid-Zaragoza-Lleida-Barcelona line opened fully in 2008, the total demand rates are lower than expected. In 2007, the first services between Madrid and Valladolid started to operate and also the branch to Málaga. The latest inauguration was in December 2010, the Madrid-Valencia line.

The network configuration is radial, where all lines have origin or destination Madrid. So, in order to travel from north to south (for example, Barcelona to Seville o Málaga), trains used to pass through Madrid's city centre, heavily penalizing travel times. Since 2009, a by-pass was constructed, which reduces travel time in 50 minutes, making the whole journey (Barcelona-Seville) 5 hours and 20 minutes. The journey is completed by plane in 1 hour and 35 minutes and door-to-door time is two times as much in HSR. This together with lower air transport fares makes it unattractive to travel from north to south by high-speed train. [29]

Spain has made of HSR a main priority in infrastructure policy, as stated in the Ministry's Plan for 2020, about 82 billion € will be spent on it. It will convert Spain in the second country in the world with more km of high-speed lines just after China. Therefore, if budget restrictions are not too heavy until 2020, Spain will carry out its HSR construction policy, based on criteria, which do not respond to technical problems.

In 2009, reported passengers that travelled in HSR in the global Spanish network were 16 million. This figure is 15% of that of France and 25% of that in Germany, where the network is smaller. France and Germany have more population density and a more adequate urban structure for HSR passenger transport.[30]

Figure 11 Spanish AVE network in 2011. [31]

8 The Market for HSR

In this section the best conditions for constructing a new HSR line will be discussed. It is important to know when HSR will be the best option amongst all the feasible transport possibilities. The main factors affecting the optimal conditions for the construction of a HSR line will be analysed deeply. These are:

- Journey times and distance
- Competitiveness with other modes of transport
- Demand and capacity
- Distribution of population
- Journey times and distance

Typically, HSR is more advantageous in middle distance journeys than in long journeys or too short journeys due to three reasons: the first one is that for long journeys, the plane is faster, although access and waiting times are larger; the second reason is that for short journeys, conventional train services may reduce time because, many times, HSR will have to serve stations in outside locations, which will make the overall door to door time increase; the third reason is that, also for short journeys, the need of the high speed trains to accelerate to maximum speed will not be comparatively advantageous with respect to conventional rail. Also, energy consumption issues may be observed at this points, where it is arguable that having to spend the energy required for the train to speed up to 300km/h is reasonable for short distances.

Although conventional rail speeds vary widely depending on the country, the typical threshold distance below which HSR is less competitive than this type of rail is 150 km. For journeys between 150-500km, HSR will be more competitive than any other mode. This is because door-to door time travels are considered, where air transport has a clear disadvantage compared to rail. However, when the journey is between above 550 km, normally air transport offers the best conditions for reducing the total time of travel. In spite of this, nowadays there are many airlines competing with HSR in this medium distance ranges. This comparative advantage of HSR in medium-haul market can be seen in the following figure

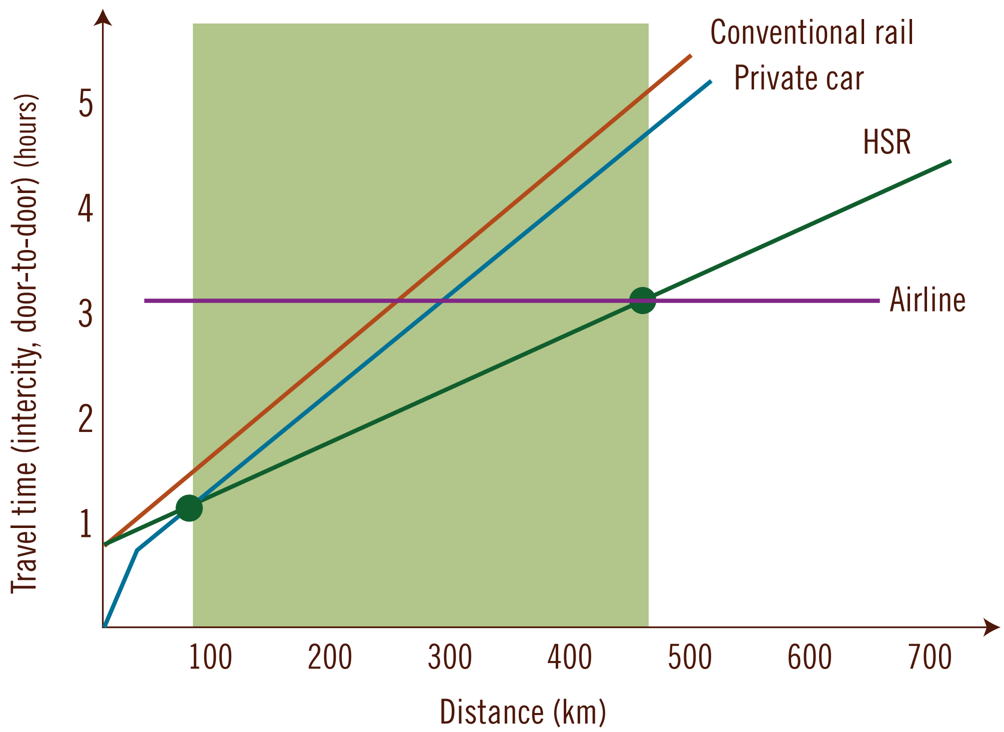


Figure 12 Modal competitive advantage of HSR [9]

A strong correlation between countries that have most of their mainly populated areas within a 400 – 600 km range and the length of their HSR network is observed:

- In France, all major cities except Nice are within 400 – 800 km from Paris;
- In Spain, all major cities are no more than 600km from Madrid.

Apart from this geographic fact, the cases of Spain and France respond to central State communication model, in which the majority of investments in transport infrastructure are made to communicate the capital cities with rest of the country.

On the other hand, Italy and Germany have sufficient cities on the range where HSR is competitive but also, have many others out of this range, which means that the extension of their HSR network are not as vast as in the other two countries. Although having a non-negligible length of HSR lines, they have decided that the best option is to upgrade conventional railway lines to offer reasonable speeds at a much lower cost. It has to be noted that Italy and Germany do not have such centralized States as Spain or France, which means investment will spread out more evenly throughout the whole country's transport infrastructure rather than focusing in the capital cities.

8.1 Competition with other transport modes

8.1.1 Conventional rail.

When comparing HSR with conventional rail, the difference in speed between countries has to be observed. Also, speed varies in different lines in the same country. The most representative speeds are:

160km/h: fastest conventional rail speed, widely used in some British lines. The average time saving of the HSR in this case is 35 minutes for distances between 400-450 km.
130km/h: this is the typical speed for main conventional rail lines across Europe and the time saving produced by HSR is between 45-50 minutes in journeys within 350-400 km.
100km/h: this is speed is most common in Italy and Spain for conventional rail. The time savings could be more than an hour for journeys up to 300 km.

Countries with good conventional rail infrastructure will have fewer costs in constructing HSR lines. The main reasons are that stations to access city centres will already exist and therefore only some upgrading will be needed and therefore many tunnelling works may be avoided. In France, Germany and Italy, this has been achieved as the conventional rail infrastructure allowed the capacity to run the high-speed trains into the cities. In Spain, the poor existing conventional rail access infrastructure has prompted the construction of long urban tunnels, with the high cost of doing so. The best example of this is the 5km tunnel being constructed under Barcelona (Spain) to link the AVE services with the two main urban stations (*Sants* and *Sagrera*), which will be the final linkage of the Madrid-Zaragoza-Barcelona-French Border line. [32]

With respect to conventional rail market shares, the effect of introducing HSR is less clear due to the lack of information provided by the operating companies. As the following table shows, the effect on the conventional rail market shares was reducing dramatically its figures to almost less than 4%. The reasons are that many of them were suppressed as HSR overlapped in the same corridors and also because of the clear reduction of demand.

Table 14 Conventional rail market shares after HSR

Paris-Lyon	Before HSR (1980)	After HSR (1997)
Conv. rail	40%	3%
HSR	0%	70%
Madrid-Seville	**Before HSR (1991)**	**After HSR (2002)**
Conv. rail	16%	1%
HSR	0%	61%
Hamburg-Frankfurt	**Before HSR (1985)**	**After HSR (2000)**
Conv. rail	23%	3%
HSR	0%	48%

8.1.2 Air

Over long distances the main competitor of HSR is air, even more with the creation of the low cost airlines. These have challenged HSR operators to lower their operation and maintenance costs because otherwise, rail market share will decrease rapidly. In France, where typically airlines have issued high fares, HSR demand had increased notably, especially in the Paris-Lyon line (450km), where rail market share rose from 40 to 72% and air market share decreased dramatically from 31 to 7% after the constructions of the HSR line. Of course, this increase in more than 30% is not all direct transfer from plane, but also generated traffic and diverted traffic from road users [18]. In longer lines such as the Paris-Marseille line (700km), the air market share also dropped by an average of 15% by 1997.

Regarding the Spanish line between Madrid and Seville, the air market share after 6 months of construction dropped more than 20% and the weekly flights in one direction did so from 71 to 40%. By 1997 (5 years after finishing construction), the rail market share increased from 16 to 51%, again not being all a consequence of direct transfer from plane but also accounting on diverted traffic from road and generated traffic. [33]

Something similar has happened with the Madrid-Barcelona line (620km), where 2 years after the completion of the line (2010), the air market share was between 14 to 17% lower than that of 2007 (before HSR). The number of passenger flying between both cities lowered 23% in 2010. [34] This data can be clearly seen in *Table* 15:

Table 15 HSR and air market shares before and after the HSR [33] [35]

Paris-Lyon	Before HSR (1980)	After HSR (1997)
Air	31%	6%
HSR	0%	70%
Madrid-Seville	**Before HSR (1991)**	**After HSR (2002)**
Air	40%	8%
HSR	0%	61%
Hamburg-Frankfurt	**Before HSR (1985)**	**After HSR (2000)**
Air	10%	4%
HSR	0%	48%
Madrid-Barcelona	**Before HSR (2007)**	**After HSR (2010)**
Air	56%	40%
HSR	0%	35%

Indeed it is the travel time the key factor to decide between plane and HSR by the look of the following table. It is interesting to note that when the HSR journeys are 3 hours or less, the rail market share was usually above 60% of the combined market for air and rail in 2006.

Table 16 Corridors with the duration of travel and rail share [33]

Corridor (km)	**Year**	**Travel time**	**HSR share[1]**
Paris-London (257)	2005	2h40min	66%
Paris-Amsterdam (514)	2004	4h10min	45%
London-Brussels (204)	2005	2h20min	60%
Paris-Geneva (339)	2003	3h30min	35%
Paris-Brussels (183)	2006	1h25min	100%

It is remarkable the fact that in the Paris-Brussels corridor the HSR market share is 100% for the HSR, with very little airport activity between these two cities. It is observed that as the journey takes more than 3 hours, the market share for HSR reduces significantly as seen on the Paris-Amsterdam and Paris-Geneva corridors. Although the airlines will not exit the market, the only possibility for the air transport is to introduce low cost airline services between these medium haul corridors in order to boost their market share.

In the interaction between low cost airline and HSR, two analysis can be made, national and international journeys. In fact, in the national journeys, Germany is where HSR services have been most affected by the low cost airline competition, due to *Germanwings* competition with the main HSR corridors Hannover –Stuttgart and Hamburg-Frankfurt. In the international journeys, most competition takes place in the Paris-Geneva and in the Paris-Amsterdam as well as in the Cologne-Paris corridors.

Table 17 Air and HSR evolution of the market share in the Paris-London corridor

Company	**Market share**		
	2002	2003	2004
EUROSTAR	58%	58%	66%
British Airways	15%	16%	12%
Air France	13%	12%	10%
Easyjet (low cost)	5%	5%	5%
British Midland	5%	4%	4%
Buzz (low cost)	2%	2%	-
Others	0%	1%	1%

Looking at the figures on the table above it can be said that the operations of low cost airlines did not reduce the demand in the HSR services but, did so, from other traditional airlines that were operating before, such as *Air France* and *British Airways.* Not only did the demand for EUROSTAR services not decrease but it increased to 66% of the market share by 2004. However, the introduction of the low cost airlines has made the rail sector adapt its ticket fares by lowering prices to be able to compete with those of the low cost

[1] With respect to air

companies. For example, in the Paris-Marseille corridor, SNCF has only allowed customers to buy low cost tickets online, being more competitive than before. [36]

8.1.3 Road

In any corridor still the road traffic is the one the takes the major part of the market shares. So it is interesting to see how the introduction of HSR has affected its demand. The following table shows how road market share has evolved after the first HSR services took place in each corridor.

Table 18 Evolution of road markets shares after HSR [36]

Corridor	**Road market share**[2]		
	Before HSR	After HSR	Reduction
Hamburg-Frankfurt	57%	46%	11%
Madrid-Seville	84%	55%	29%
Paris-Lille	50%	50%	0%

As seen on the table above, in the French corridor of Paris-Lille is where HSR made no difference in the road demand, whereas in the Madrid-Seville corridor, the road market share dropped dramatically from 84 to 55%. In Germany, in the Hamburg-Frankfurt corridor, the share for road users reduced 11% after the HSR operations. Therefore, in this section it may be concluded that the road traffic is somehow reduced by HSR but not as much as the air traffic, which is its main competitor, and, at most, the HSR market share with respect to road will be 55% (Madrid-Seville case). [36]

8.2 Demand and capacity

As explained before, HSR infrastructure hives a relief in capacity to all the other transport networks, as it is a high capacity transport system. Actual navigation systems allow the headways in the HSR trains to be approximately 5 to 6 minutes per direction of travel. Considering an average train of 500 seats operating 12 hours a day (120 trains per day and direction), an extra capacity of 120.000 passengers per day (including both directions) can be achieved with HSR. Of course is this would be maximum capacity of the infrastructure, at which the operator would never aim at due to incredible operating and maintenance costs. But it shows how a HSR increases capacity at a very high degree. In fact in Japan, there are HSR trans that have up to 1.600 seats, therefore capacity being tripled than that calculated in the simple example above. With this figures, it is obvious that demand has to exist, and it has to be very high in order to justify investments for HSR.

Capacity has been the main justification for many countries to construct many kilometres of HSR networks rather than speed. A clear example could be Japan where demands are highest, and where HSR has relieved capacity from the existing railway networks. In Italy, the Rome-Naples line will also increase capacity rather than speed. Not only HSR construction provides extra capacity for intercity journeys but also for conventional long distance and regional rail and also freight routes. On he other hand, rather than capacity,

[2] With respect to rail

Spain’s justification was speed, as the central government’s aim in the year 2000 was to connect Madrid with all province capital cities within 4 hours of travel in HSR. Only the Madrid-Seville corridor had congestion in both conventional rail and motorways, before HSR.

The full theoretical capacity above explained (120 -160 trains per day and direction) is only used in the most demanded HSR lines during peak periods. However, demand will be the key factor to operate services at a reasonable proportion of the maximum capacity. The following figure represents the amount of trains per day in different European HSR routes.

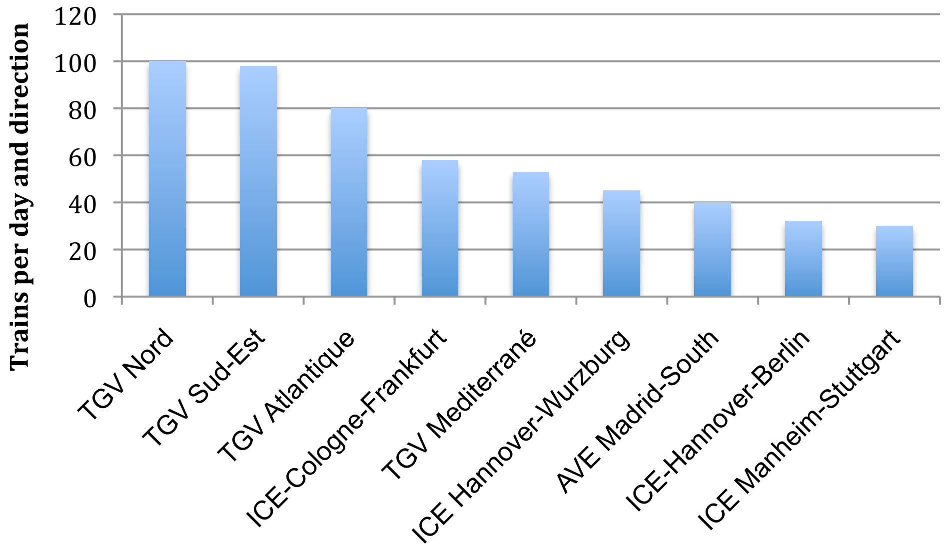


Figure 13 Trains operating per day and direction in different European HSR corridors [37]

It can be observed how at least, there are 30 trains operating per day and direction of travel in the less demanded lines and maximum, there are about 100 trains per day and direction in the TGV north and south east corridors. Therefore is it is clear that France operates the most HSR services due to the high demand rates. The previous figure may be contrasted with the number of passenger per km of line travelling in different European lines in 2010:

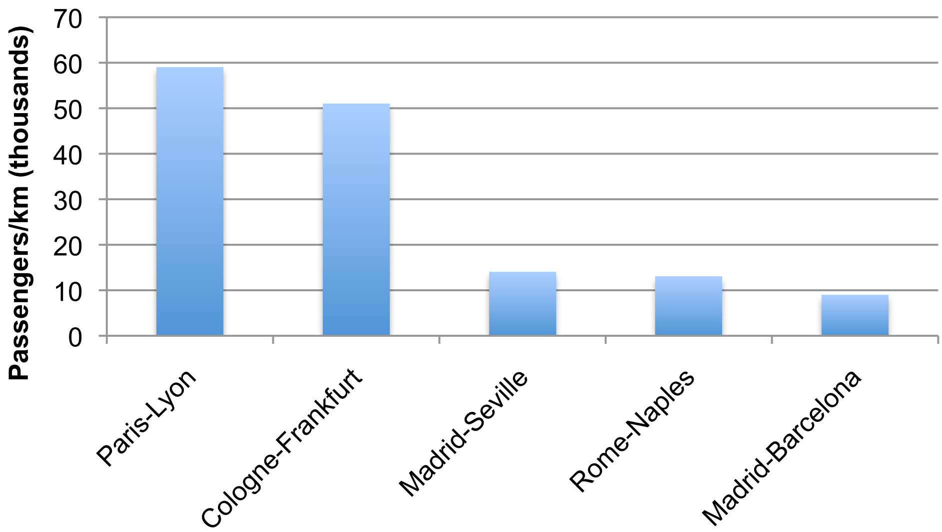


Figure 14 Passenger/km-year in major European HSR lines in 2010 [38]

The Paris-Lyon line, with almost 60.000 passengers per km, and the Cologne-Frankfurt line, are the most demanded lines in Europe, boosting their social returns over profitability thresholds. The Spanish lines and the Rome-Naples line, are the ones that transported less passengers in 2010 with demand rates that lied between 9.000 and 14.000 passenger per km. In the section *Minimum demand thresholds for HSR positive social returns* further on, the minimum demand for a 500 km HSR line to have a positive net present value is discussed in depth (page 67).

8.3 Distribution of population

Another key factor affecting the rail market share is the distribution of population. It is known that rail services will have a greater demand when connecting with high-density population nodes, as it is a high capacity transport mode. HSR can better serve markets such as the ones in France where the majority of population concentrates in the big cities. The Paris-Lyon corridor experiences very high demands and enables to serve nearby population nodes in the middle by having branches off to them. Also, conventional rail helps to feed the main line between smaller cities within the main corridor. In countries such as Germany, where population is spread out more evenly throughout the country than in France, fewer long sections of HSR lines will have very high traffic, therefore the maximum profit of HSR investments cannot be achieved. The case of Spain is similar to the French one but the difference is that the intermediate cities between the main HSR corridors have very low population compared to the main nodes, therefore demand on the main line will be somewhat lower. Italy's case, because of its long and thin geographical nature not only enables high traffic between Rome and Florence but also serves many close medium sized cities, which are not far from the main corridor. The following figures show the countries population density and the 5 larger cities population density. [39]

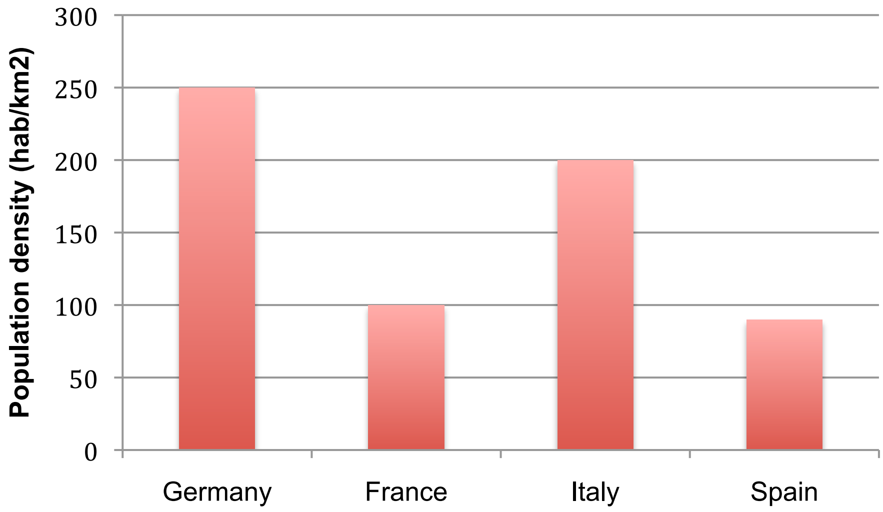


Figure 15 Population density

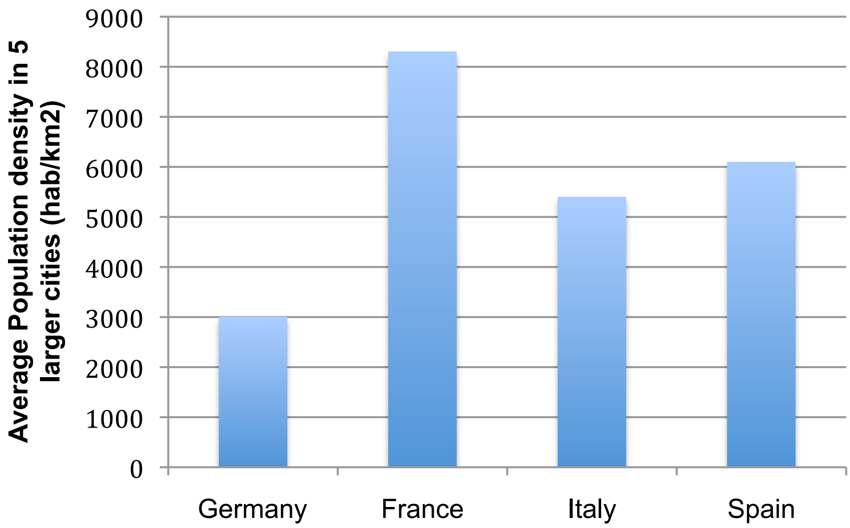


Figure 16 Population density of the 5 larger cities

9 Appraisal of HSR projects

Before starting the construction of HSR line it is very important to proceed to a detailed economic evaluation of the project. Due to the enormous costs, which this transport projects imply, careful studies have to be done in order to see if the resources spent on it have a positive economic return. As it has been discussed in this paper, HSR has a series of beneficial impacts on society but it has to be seen whether these are greater than the cost of the infrastructure and operation during a certain period of time. Investing in HSR has a big opportunity cost for society. This means that the money invested in it cannot be spent in other areas, therefore investments should respond to criteria that make the transport system more efficient, which, at the same time means maximizing the social benefits.

Not only is it important to do an appraisal before the construction of the line but also after a few years of operation. The *ex-ante* (previous) evaluation responds to decision-making criteria, i.e. is it worth spending big amounts of money in a certain infrastructure? Will the investment have good social and economic returns? Once the infrastructure has been built and has been operating for a few years (2-3 years) the ex-post evaluation determines whether initial objectives have been met during this period and also whether the expected beneficial impacts have taken place. Therefore, ex-ante appraisal is a tool to justify investments and feasibility of the project and ex-post is used to see if it has been actually worthwhile.

The following table shows the differences between the ex-ante estimations and the ex-post evaluations of the high-speed network in France. It is seen how some differences appear in some of the lines, especially in terms of demand and costs. Normally, in both cases, demand is overestimated and costs are underestimated. Although differences between the estimated and the real figures are quite significant, the social and financial returns do not differ to that much. Only in the case of the TGV-Nord, where demand was 50% underestimated, big differences appear between the expected and the real returns. Of course, the magnitude of the error in demand estimating is proportional to the difference between expected and real returns.

Table 19 Ex-ante and ex-post results of French TGV lines [18]

		Sud Est	**Atlantique**	**Nord**	**Inter Connection**	**Rhone Alpes**	**Mediter-ranean**
Length (km)		**419**	**291**	**346**	**104**	**259**	
Infrastructure cost	**Ex ante**	**1662***	**2118**	**2666**	**1204**	**1037**	**4334**
(m euros 2003)	**Ex post**	**1676**	**2630**	**3334**	**1397**	**1261**	**4272**
	% change	**+1**	**+24**	**+25**	**+16**	**+22**	**-1**
Traffic (m pass)	**Ex ante**	**14.7**	**30.3**	**38.7**	**25.3**	**19.3**	**21.7**
	Ex post	**15.8**	**26.7**	**19.2**	**16.6**	**18.6**	**19.2**
	% change	**+7.5**	**-12**	**-50**	**-34**	**-4**	**-11.5**
Financial return (%)	**Ex ante**	**15**	**12**	**12.9**	**10.8**	**10.4**	**8**
	Ex post	**15**	**7**	**2,9**	**6.5**	**n.a.**	**n.a**
Social return (%)	**Ex ante**	**28**	**23.6**	**20.3**	**18.5**	**15.4**	**12.2**
	Ex post	**30**	**12**	**5**	**13.8**	**n.a.**	**n.a.**

Traditionally, decision-making in railway projects has been carried out by the Public Administration, particularly by Ministries of Transport that usually have a close relation with the monopolistic railway national companies. This has been the main reason why the allocation of financial resources has often not been the most efficient. Another reason for this misallocation of economic resources is not considering the effects of HSR on other transport modes such as air, road and conventional rail. The transport system has to be seen in an integral way, without excluding other transport modes when appraising HSR projects for example. This is because the effects of building a new infrastructure will be noticed in the other transport modes and vice-versa. The close relation between Ministries and railway national companies has also been the reason for biases in the ex-ante appraisals, where figures have been exaggerated to justify the benefits. These exaggerations are usually in terms of demand forecasting which are usually too optimistic, leading to inefficiency of the system, under exploitation of the infrastructure's capacity and thus, big cost overruns. The new appraisal techniques should substitute the old ones, where independent consultants should evaluate the projects, ensuring the transparency of the figures shown so that the most beneficial decisions for every stakeholder (especially society) are taken.

There are two kinds of economic appraisal in transport projects: financial and socioeconomic. Financial analysis is the one where all stakeholders are accounted for and where cash flows are included. Socioeconomic evaluation is the one that takes into account the benefits that may be monetised for the whole of society and the costs, which the project implies, not including the financial cash flows. Here is where external costs are accounted for.

9.1 Stakeholders in the appraisal procedure.

For the financial evaluation it is important to indentify the different stakeholders involved. Each one will have its own cash flows and its own benefit expectation.

- *Public Administrations*: these are State Companies that normally own the infrastructure. Although nowadays it is common to have public-private partnerships (PPP's) in the form of concessions for some parts of the railway network. In a PPP, assets are partly private and partly public. Concessions are contracts between a private partner and the public sector for the exploitation and conservation of an infrastructure, where the private pays the public administration for the right of exploitation during a definite amount of time. The concessionaire (private partner) has the right to charge users (rail operators, drivers etc) for the use of the infrastructure, by which revenues are generated. However, Public Administrations always reserve the right of property over the infrastructures and almost always participate to a great extent in the financing of the projects.

- *Infrastructure managers*: in some cases these are the owners of the infrastructure, but it may be the case that they are not. When they are different, they should be treated differently in the appraisal procedure since they will have different sources of income (tolls, track charges, taxes etc).

- *Service operators*: recent European legislation states that the market for the operators must be an open one, ensuring competition between them. During project appraisals it is necessary to take them into account, especially in the financial evaluations, as they will have costs and revenues during the process of operation. Tariffs and traffic forecasts are important in this sense for the operators to estimate their financial benefits.

- *Users:* users are a very important part of the socioeconomic evaluation, as they will benefit from the project (time savings and comfort). Also, users are the ones who pay for the service, being directly responsible for the revenues of the operating companies and infrastructure managers. Sadly, railway users have very little influence in the decision-making process.

- *Non-users:* this group is the rest of society, who is always a potential user, but is affected directly by the project's externalities. This group should make clear what external costs they expect from the project and should intervene in the Environmental Impact Assessment (EIA). Therefore, impacts on non-users should be monetised and quantified as much as possible to be able to elaborate the socioeconomic analysis.

- *Other stakeholders:* other stakeholders in the process are: banks (giving loans), construction companies, material suppliers and landowners. Although these stakeholders have normally little influence on the decision-making process, they will absorb a substantial part of the cash flows; therefore they need to be taken into account in the financial analysis.

9.2 The role of evaluation in the decision-making process.

Authorities are to make the best use of scarce public resources. They must bear in mind the fact that technical committees will audit the public accounts during parliament sessions so they must be able to justify investments and demonstrate positive results. Pre-investment assessment will allow clear justification for future investments based on accepted evaluation criteria. After investment evaluation provides feedback on the project's success or failure and is a lesson for politicians on how to invest in future schemes.

Publishing evaluation results make processes clear, transparent and comprehensible. This will make transport projects more irrefutable for fast changing political attitudes, which are not based on technical criteria, for implementing high cost programmes. The fact is that politicians are not very keen on evaluation processes due to the "fear" of failure of their decisions and exposure to public criticism. Laws should include project evaluation as compulsory in order to make sure that public resources are efficiently invested. The failure in doing so may lead to project appraisals not being trustworthy and manipulated to meet the short-term demands of the authorities in charge. This process is dishonest and often too common, where biased evaluations are used to justify pre-established conclusions. [42]

9.3 General guidelines for transport project appraisal.

It is important to carry out a general screening of the project considered to see how much effort, in time and resources, should be put in the appraisal. The following graph shows, in general terms, the costs of the appraisal process depending on the total cost of the project.

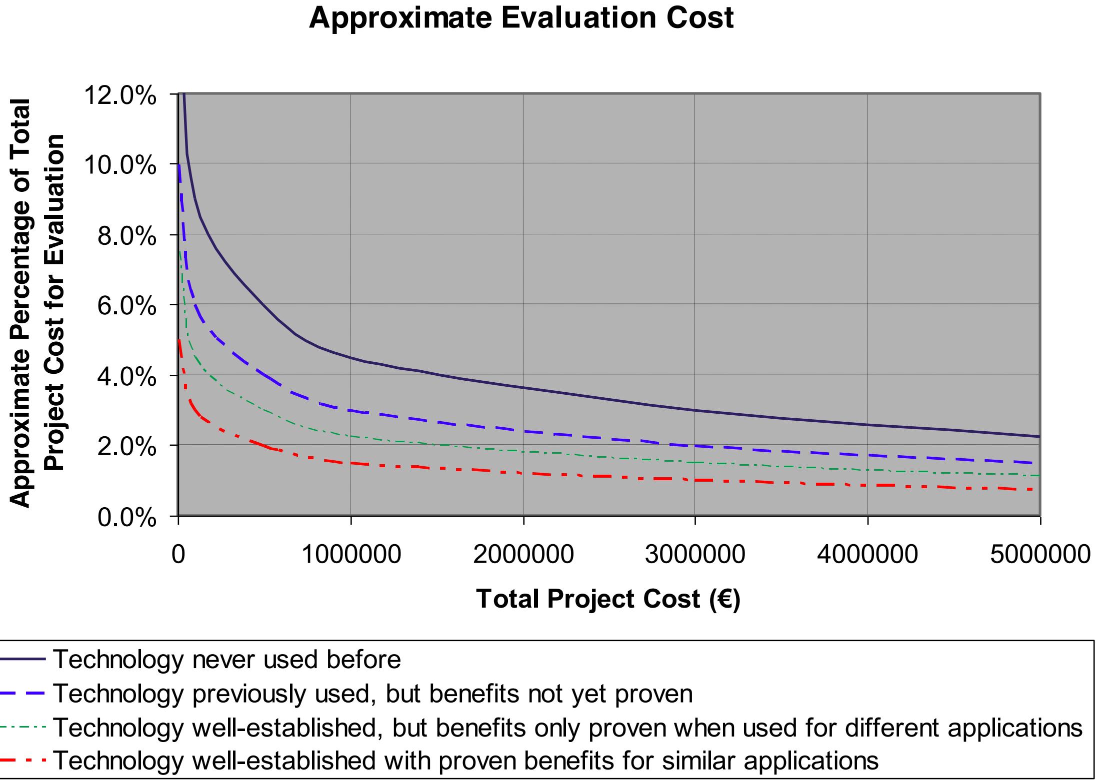


Figure 17 Approximate costs of evaluation in transport projects [42]

As seen on Figure 17, the cost of the evaluation in % is inversely proportional to the total cost of the transport project. For projects with costs above 5M€, the evaluation costs should be around 1-3% of the total cost. In our case, in which we consider HSR, the costs of projects are way above this amount; therefore the cost of the appraisal will always be between these percentages. For project costs under 1M€, costs of evaluation may reach 12% of the total. Furthermore, Figure 17 shows how, in projects where new technology is being implemented, evaluation costs are between 2-6% higher than projects using well-established and proven technology. Figure 17 is only a guideline and only refers to capital costs. However, appraisal costs also depend on the following factors:

- Anticipated benefits of the project and number of set objectives.
- Scale and nature of the project or expected deployments of the application.
- Complexity of the project.
- Level of certainty of expected results.
- Data availability and difficulty at obtaining it.

By looking at the rest of the factors it is obvious that evaluation costs will increase with the number of set objectives, with the complexity of the project and with the non-availability of information about the project during the evaluation. Thus, the importance for companies and administrations to publish clear information in order to cheapen the process.

9.3.1 The screening process

In first place, in order to simplify the selection process of possible projects, it is important to do a quick screening of all the alternatives. This is done before feasibility and pre-feasibility studies are carried out. It is useful to follow the following five steps:

- Be sure that all the projects are clearly indentified in terms of objectives and alternatives.

- Rank the projects in order of priority or most advantageous with simple key indicators so that most unfeasible projects can be easily rejected at the beginning. An example in the railway sector could be "*investment/time saved"*.

- Make sure, for demand-driven projects that the effects that users perceive directly are beyond perception thresholds. This means making time savings and comfort (what users perceive in a more intense way) to stand out from other impacts of the project. If users do not have a clear perception of these, it is likely that a low economic profit will occur.

- Make sure that benefits in one projected are not linked with the benefits in another complementary project, for example, a project in the same corridor. It has to be distinguished, what benefits belong to which project.

- Evaluate if there are barriers to the implementation of the project, such as political ones, ecological ones or physical ones. [43]

9.3.2 Traffic forecasting

All transport feasibility studies need a demand forecast. Demand is the key indicator to success or failure of the project. The demand analysis will not only have to forecast the traffic in the lifecycle of the project, but also the origin of it. Therefore it is necessary to make clear what proportion of each kind of traffic there will be: generated or induced traffic and diverted traffic from the other transport modes. Demand models should be adapted to each type of project and be able to predict demand accurately throughout the evaluation period (normally 30 years).

9.3.3 Alternatives

Transport projects are developed to provide solutions to specific problems. These can be congestion produced by bottlenecks or may also respond to environmental problems. In all transport projects there exist different solutions to solve each problem. Each of these are known as alternatives and should all be properly defined and evaluated. For each project there is a wide range of alternatives, but they should all provide similar solutions (time- savings, comfort, reliability, security etc) to be able to compare them in a reasonable way.

To start with, all projects should have a “do-minimum” alternative, which means guaranteeing the level of service without its excessive deterioration by doing minimum investments. This does not mean “do-nothing”. Instead, in the railway sector, the “do-minimum” alternative implies the renewal of the rolling stock every certain amount of time (normally 30 years) and also the maintenance of tracks, signalling systems and electrification. As its own name indicates, the “do-nothing” alternative does not even contemplate the fact of minimum infrastructure maintenance, therefore it should not be considered as a base case reference scenario. The base case should be clearly defined, as it is the scenario to compare with the new project and from which benefits, such as time saving can be measured. For example, the base case could be an already existing conventional railway line with trains travelling at 160 km/h, in which normal maintenance and renewal of rolling stock investments are carried out during its life.

When a project is interlinked with other performances, for example, in the same corridor, the network effects of the railway mode will cause the interaction of both to distort the final economic appraisal. A way to avoid this is to carry out the global evaluation of the global project and also of each of its individual components to reach optimal project selection. Moreover, it is very important not to double count benefits produced by similar parts of the project. This can be achieved by accurate technical studies that can distinguish between traffics in different branches of the railway project and their net effect on the overall benefits. [44]

9.3.4 Environmental and social aspects

The EU’s transport policy has tended clearly towards higher investments in HSR than in other transport mode’s infrastructure. This is justified by the argument that rail transport has less environmental impact than air and road. This has been discussed in some paragraphs above. Anyway, all environmental impacts during construction and operation period of the line must be included in the appraisal. There are guidelines to assess each impact from a monetary point of view and should be included in the Environmental Impact Assessment. This document is compulsory for al EU railway transport projects and should include the mitigation measures in order to relieve impacts with the real cost of each one. The Environmental Impact Assessment (EIA) also includes different relieving alternatives to lessen the impacts produced, the cost of which will be included in the cost of the project. The appraisal will only consider the costs of the impacts produced after the deployment of the mitigation measures considered in the EIA.

On the other hand there is social externalities, which are even more difficult to measure. The benefits produced by the construction of a HSR line have to be measured carefully since the economic effect is not the same between regions. The major effects are noticed around stations, where land values increase substantially. Also, job generation and economic stimulus are to be observed carefully since a mere redistribution of these may occur instead of net creation of jobs and economic activity. Again, it is important to avoid double counting of these two last factors.

9.4 The financial analysis (microeconomic point of view)

The financial analysis is carried out by each stakeholder's point view in terms of cash-flows of the project and does not take into account the costs or benefits derived by others in the wider community [45]. Each stakeholder should make its own financial analysis to ensure that the project, in which he is investing, has acceptable rates of return. This step of the appraisal is important to ensure the financial sustainability of the project. Financial sustainability is ensuring that each organisation has positive results in cash flows during the whole life of the project or in other words, the organisation has to cover every year at least, the operational and maintenance costs of the project. This means that the organisation must have the ability to obtain funds (grants, revenues etc) in order to ensure the continuity of their activities. [46]

The financial analysis includes:

- Investment costs (infrastructure costs), including expenditure in renewal of infrastructure and rolling stock.
- Infrastructure maintenance and operating costs.
- Vehicle operating costs (operators).
- Revenues for infrastructure managers and operators.

Taxes such as Value Added Tax (VAT) should be ideally included in the financial appraisal because railway projects will produce demand that will pay VAT when purchasing tickets. If demands rates are very high, tax flows may produce an impact in the financial balance of administrators.

In regard to operating costs, the items that are not a proper economic expenditure should be not included in the financial appraisal. These are:

- Depreciation and amortisation of assets.
- Reserves for future replacement costs.

Revenues should be taken into account with traffic forecasts and tariffs. Although the pricing policy may vary during the period of evaluation, a clear estimate should be done to show its impact on the stakeholder's revenues. In regard to subsidies, they should be accounted for in the appraisal but properly separated from operation revenues. Many times, operators and infrastructure managers receive grants and subsidies from state funds so that their revenues are guaranteed because the extremely high maintenance and operating costs may not be recovered only by user payments. It is also important to take into account residual value, (if there is) of the assets at the end of the evaluation period.

This is the value at which the assets (rolling stock and infrastructure) could be sold at the end of the projects life. [47]

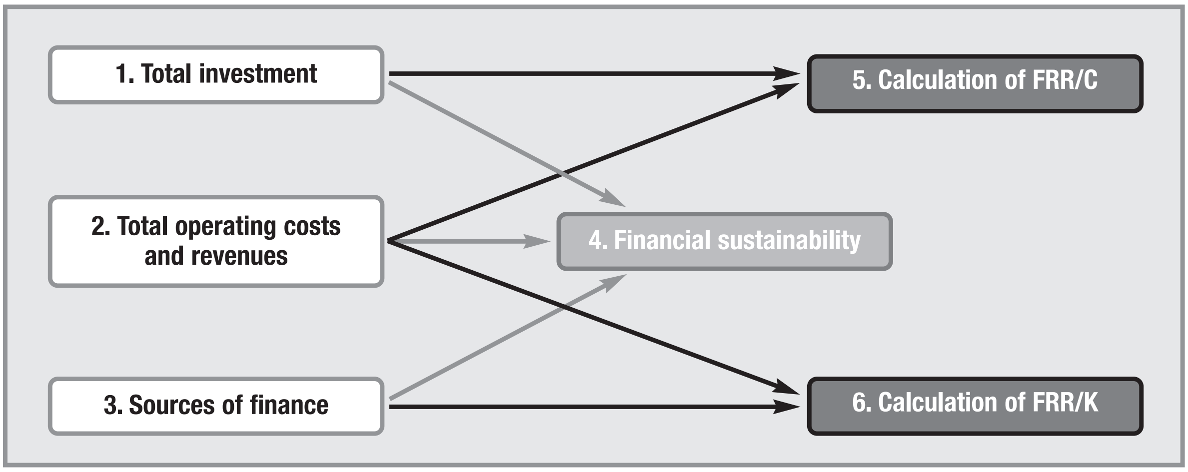


Figure 18 Structure of financial analysis [48]

Normally, the financial analysis is carried out by the operating companies and by the infrastructure managers, since they are the stakeholders, which will have the operating and maintenance costs. It is therefore vital to assess whether they will be able to generate profits to maintain the utility of the infrastructure. When all the costs and revenues are properly analysed per year, the economic profitability indicators of the investment are calculated: Net Present Value (NPV) and the Internal Rate of Return (IRR). The NPV is the net balance between cash inputs and outputs during the evaluation period with a given discount rate. The IRR is the rate, which makes the NPV zero; therefore it is the profitability of the investment during the evaluation period. Therefore, the NPV formula may be written as:

$$NPV = CF_n /(1+i)^n$$

Where;
CF_n is the net cash flow at year n.
i is the discount rate or the opportunity cost of capital.
n is the time of the cash flow.

In the comparison of two projects, the one with higher NPV and higher IRR would be the one to be chosen. When evaluating single projects, when the IRR is higher than the discount rate used, the project is economically worthwhile. [49]

For greater detail see the financial analysis for French operator (SNCF) and infrastructure manager (RFF) for the TGV-Est high-speed line is shown in the appendix. In this financial analysis, the IRR and NPV for each of these stakeholders are calculated, showing financial profitability for each of them. At the end, a simple exercise of how much money would be needed to be borrowed from different lending institutions is made: loans from the European Investment Bank (EIB), short term and long term loans from private banks with higher interest rates. The last graph shows the evolution of cash flows (blue) during the appraisal period and the loans, which would have to be asked for to the different credit institutions. Different demand studies from SNCF were consulted and different assumptions in the price of rolling stock and periods of renewal were made. Infrastructure maintenance costs were also estimated for the 30-year period of the appraisal.

9.5 Cost-benefit analysis (macroeconomic point of view)

Cost-benefit analyses (CBA) are appraisals that show the total costs and benefits of a project to the community or society. In this case, financial cash flows between the various stakeholders in the process are not considered. The concept of “society” or “community” linked to a specific administrative area is subject to discussion because EU regulations do not allow differentiating between EU citizens of different nationalities. This is the reason why socio-economic benefits in the project should not make distinction among users, based on their particular nationality.

The socioeconomic analysis is based on resource costs. Normally these costs can be monetised and the market will provide a value for them. However, others such as time of travel cannot have a value directly assigned to them. Others that cannot be monetised are estimated on the base of willingness to pay from users. Anyway, the objective of the CBA is to the see the project’s impacts on society individuals by summing up costs and benefits provided by the project, and finally assess if the project will be overall worthwhile. In this case, taxes and subsidies will not be taken into account, as they are just resource transfers.

The following table summarizes the costs and benefits that the CBA should include in general terms:

Table 20 Costs and benefits that should be included in the CBA (source: own elaboration).

Costs	**Benefits**
Investment costs	Reduction of travel times
Variable operating costs	Reduction in accidents (safety aspects)
Maintenance costs of infrastructure	Environmental issues
Externalities	Safety
-	Accessibility
-	Integration

Of course, costs and benefits have to be itemized and further disaggregated:

- Travel times for generated traffic: travel times have to be measured for the users, which will use the new infrastructure and compared with the times of travelling in other transport modes before the operation of the line (base case).

- Travel times, safety and comfort of existing traffic: the operation of new HSR line may reduce congestion on the roads, therefore reducing car travelling times; may reduce accidents (due to less number of travelling cars) and thus, increase user comfort on roads. For this, accident reduction rates have to be estimated and multiplied by unit values per accident and casualty.

- Reduction in operation costs for private car owners: If sufficient diverted traffic is achieved, old car travellers will reduce their car's operation and maintenance costs.

- Reduction in CO_2 car and plane emissions and noise.

- Measure and estimate each of the external costs produced by the construction and operation of the new line: CO_2 emissions, noise, land consumption etc. As said before, environmental impact mitigation measures described in the EIA, should be included as part of the investment costs. [50]

As seen in the disaggregation of costs and benefits produced, for the CBA to success, it is very important to have accurate demand estimations not only of generated passengers, but also from diverted traffic to be able to evaluate accurately the benefits produced. Thus, it is important to have accurate demand studies. Also, as discussed before, the choice of the base-case scenario in order to estimate a benefit is very important (for example, the benefits produced by time-savings).

To measure the economic performance of the CBA, or in other words, the output of it, the two indicators explained before (IRR and NPV) are used, as well as the Cost-Benefit Ratio (CBR). The CBR is easily obtained by dividing the sum of benefits and costs during all the evaluation period. If the figure that results is above 1, the project is said to be beneficial as measured benefits are greater than measured costs. Just as in the case of the financial analysis, IRR and NPV are calculated for the whole appraisal period (the time between the first year of construction until the last year of operation) and give the results of whether the project is socially profitable or not using the same criteria. To sum up, *Table* 21 shows the final criteria on which to decide if a project is socially (and financially) profitable.

Table 21 CBA result indicators (source: own elaboration)

IRR	< Discount rate	Project is not profitable
	> Discount rate	Project is profitable
NPV	< 0	Project is not profitable
	> 0	Project is profitable
CBR (only in CBA)	< 1	Project is not profitable
	> 1	Project is profitable

Mathematically, the following equation must be satisfied in order to have positive social profitability:

$$\int_0^T B(H)e^{-(r-g)t}dt > I + \int_0^T C_f e^{-rt}dt + \int_0^T C_q(Q)e^{-(r-g)t}dt\,,$$

where;

B(H) is annual social benefits of the project

C_f is annual fixed operating and maintenance costs

$C_q(Q)$ is annual operating and maintenance costs depending on Q

Q is passenger trips

I is investment costs

T is project life

r is the social discount rate

g is annual growth of costs and benefits that depends on the level of real wages and Q [51]

It is easily identified in the equation that for social profitability to be positive, benefits (term on the left side of the equation) of the project have to be bigger than costs (term on the right side of the equation).

9.5.1 The social discount rate

Choosing the social discount rate is important in this process as it an attempt to reflect how future social costs and benefits should be valued against present ones. The discount rate is the rate used to discount future cash flows to the present value and is a key variable of this process. There is no one single social discount rate set internationally, as it depends, amongst many other factors on capital taxes, capital market imperfections and uncertainties. For the EU is set at 5% since this figure best reflects how investments in the future loose value compared to investments today. [48]

The social discount rate extends the efficiency criterion to the case where costs and benefits occur over time. If the social discount rate is used to calculate the net present value of a project's social costs and benefits over time, a positive net present value indicates the project increases efficiency or raises wealth: it produces enough benefits to fully compensate individuals for the forgone benefits of the resources it displaces from alternative uses. [52]

The following table shows real social discount rates in different countries specified by different financial agencies. Notice that, normally the discount rate is higher in developing countries:

Table 22 Social discount rates in different countries [52]

Country	Agency	Discount Rate (%)
India	World Bank	12
Pakistan	World Bank	15
EU	European Commission	5-6
France	*Commissariat General du Plan*	4-8
Germany	Federal Finance Ministry	3-4
Italy	Central Guidance to Regional Authorities	5
Spain	-	6

9.6 CBA summary: steps that should be followed

To make the procedure clearer, the CBA has been summarized here in 7 steps.

A. Specify the alternative projects.
B. Decide whose costs and benefits account.
C. Catalogue the impacts and select measurement indicators.
D. Monetize all impacts.
E. Account for uncertainty and choose the social discount rate.
F. Perform sensitivity analysis.
G. Rank and select the projects.

A. Specify the alternative projects.

Choose all the possible alternatives for the project being considered and compare them with the base case scenario. Make clear whether an ex-ante or an ex-post evaluation is being done.

B. Decide whose costs and benefits account.

In this step, the scope of the project has to be set. It has to be decided to whom is the project going to benefit or disserve. Depending on the scope of the project, it has to be decided up to which level the appraisal reaches: local, regional or national.

C. Catalogue the impacts and select measurement indicators.

List all the possible impacts (beneficial and non-beneficial) caused by the project. Some are obvious; others may have to be consulted in bibliography. Then decide what the measurement units of each impact will be such as; tonnes of CO_2 / passenger-km, lives saved per year or passenger hours saved per year.

D. Monetize all impacts

Once the list of impacts has been done, they should now be quantified and valued in economical terms. There are tangible impacts such as tonnes of CO_2 or capital and land costs. These have a market value and can be more or less easily obtained. However, when the market prices are not available shadow prices may be used by converting the original into the shadow price, using a conversion factor. Shadow prices are assumed to be the marginal cost of a perceived benefit i.e. how much is a consumer willing to pay for an increase in one unit of a particular benefit [78]. Intangible impacts are for example, values of life, value of time and noise. These may be consulted in specific bibliography for each country.

E. *Account for uncertainty and choose the social discount rate*.

As explained before, the social discount rate is used to value present benefits of future investments, since future payments a worth less than present ones. It has to be chosen depending on the country on which the project will take place (see Table 22). At this point, also time horizon for the project's evaluation must be allocated. At this point, CBA indicators NPV, IRR and CBR have to be calculated to obtain the results of such analysis.

F. Perform sensitivity analysis.

The last step of the CBA is studying how the decision variables (NPV and IRR) vary with the most important variables being considered, for instance, time savings and investment costs. In decision-making it is important to see how robust the analysis has been because robust results mean less uncertainty in the output. If a model is robust means that the analysed variable (IRR for instance) does not vary to a great extent (<10%) with respect to small variations of the other variable being considered. [53]

The following figure is a sensitivity analysis of how IRR varies with investment costs in a CBA of a tram project in Palma de Mallorca carried out by the author. It has nothing to do with HSR but the intention is to exemplify the sensitivity analysis of an outcome from a CBA

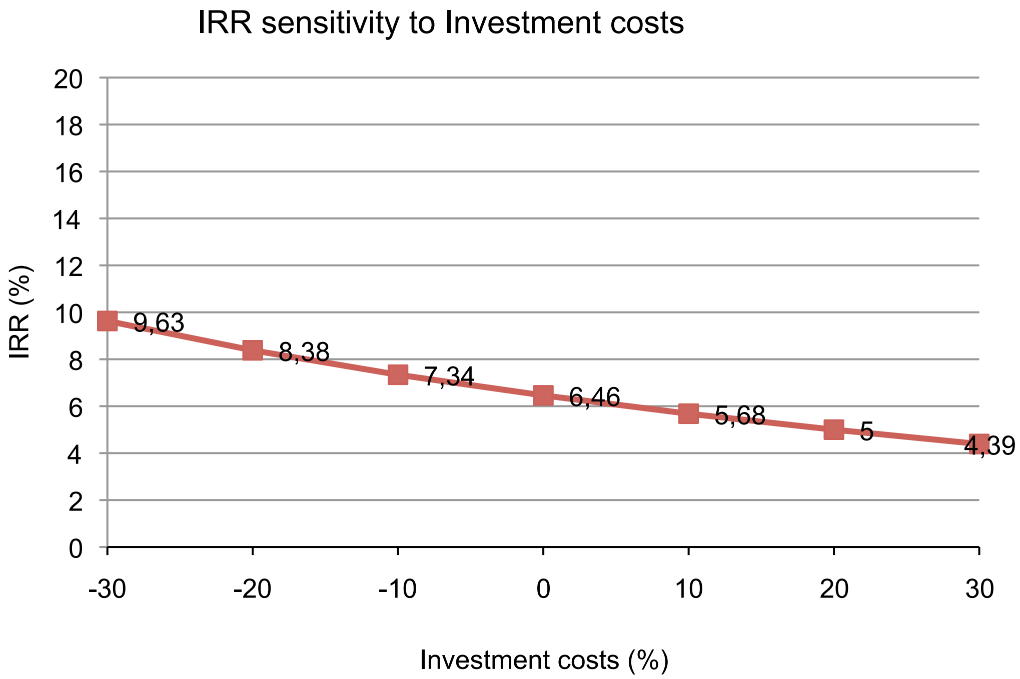


Figure 19 Sensitivity of IRR to investment costs on CBA of tramline in Palma de Mallorca (source: own elaboration)

As the graph shows, the model is quite robust as a 10% variation of the investment cost only implies a variation of about 0,8% in the IRR value.

G. Rank and select the projects

With all the output information of the CBA, it is time to decide which projects are going to be actually constructed from society's welfare's point of view. NPV's, IRR's and CBR's of each project have to be compared and after that decide which project gives the best results. The criteria for this are shown in *Table* 21.

9.7 Multi-criteria Analysis

Multi-criteria analysis (MCA) is a useful way of obtaining an evaluation of non-monetazible effects caused by the project. Also it is useful when data availability is not much, since for CBA data has to be in abundance and great accuracy. Another case when this type of appraisal is used is when it is desired to compare results between similar project alternatives in a simple way. Normally, the outcome results of multi-criteria analysis are slightly more favourable than the CBA.

Some of the effects that could be considered in a multi-criteria analysis could be: social equity, environmental issues, equal opportunities, territorial cohesion, effects on other transport modes etc. Multi-criteria analysis gives a more general assessment than CBA, as it does not quantify each of the issues considered. Instead, each of the effects accounted for are given specific weights depending on the influence they have on the global project's effect. At the same time, a score system has to be set up, establishing a scale of impacts. This can be better explained with a simple example:

Lets imagine that we want to assess the following impacts of the HSR project:

- Territorial cohesion.
- Affection to other transport modes.
- Environmental effects.
- Barrier effects.

The next step is to set up the score system. A simple and useful one could be:

Assessment	**Score**
Critical	-4
High	-3
Moderate	-2
Weak	-1
Null	0
Positive	1
Beneficial	2
Highly beneficial	3

Then the specific weight of the selected criteria should be allocated. The weights are allocated in a subjective, but at the same time, rational way, which the examiner has to decide according to the relative importance of each of the single criteria. In the case that only the effects of the four given criteria should be assessed, the weighing could be:

Territorial cohesion.	0,20
Affection to other transport modes.	0,25
Environmental effects.	0,35
Barrier effects.	0,20

The final score would be calculated by the sum of each weighted effect score, obtaining a final figure, which would be the final assessment grade. If this is done in the do-something and the do-minimum (base case) situations, both projects can be easily compared. The main differences with CBA are that it does not require the use of prices and that the election of criteria is unlimited as it allows to "quantify" intangible elements. [54]

10 Minimum demand thresholds for HSR positive social returns

As it has been discussed before, HSR projects mean extremely high investment and operation costs, hence resulting in high opportunity costs for society. It has been said before that passenger demand in some lines in Europe have not been enough to boost the social profit of the investment, especially in Spain, Italy and in some German lines. Therefore, in order to execute ex-ante appraisals of HSR project it is very interesting to see above which minimum demand threshold will the infrastructure be socially profitable in terms of Net Present Value (NPV). Some studies have been made (*de Rus and Nash 2009*), which show what the minimum demand for a 500 km HSR line should be for a NPV of 0. This means assuming conservative conditions, as NPV = 0 is the value from which the project is considered to be beneficial. Thus, it does not calculate demand thresholds for high project's NPV's, which would be a very optimistic case.

10.1 The model

The model will simplify itself by assuming that benefit generated by the new HSR line only come from time-savings and generated traffic. Relief of capacity, reduction of congestion, environmental benefits and reduction of accidents from roads will not be accounted for in this model, since these factors are very dependant on the condition of the corridor. Therefore the model assumes:

- Fixed costs for construction of tracks, stations and superstructure; signalling systems, and technical equipment for traffic control (I). The range is between 12M€ and 40M€.

- Maintenance and operation costs of the fixed assets that will be considered fixed (C_t)

- Variable operation costs: energy, rolling stock and labour costs. These will depend on the level of demand (C_q).

- Variable annual costs of conventional rail (C_c).

- The average time saving per passenger considered by taking the base case of an existing conventional railway line of 400km travelling at 160km/h, is 35 minutes. If the base case were the same but reduced speed to 100 km/h, the average time saving would be 45 to 50 minutes. Time savings from car users would be even greater, but that from air traffic would be smaller. To summarize, time savings have been considered to be between 30 minutes and 1hour and 30 minutes, including the whole range of possibilities *(Δt)*.

- Values of time will be considered between 15 and 30€/hour. This range includes the different possibilities for reasons of travelling and possible initial combinations of transport modes (ν).

- The avoidable costs from the base case (conventional rail) are assumed to be half of the total costs of the new HSR line (C_t+C_q).

- The social discount rate is assumed 5% as stated by the European Commission (r).

The next table shows the average values assumed in this exercise:

Table 23 Assumed costs for the exercise.

	Cost per unit (thousand €)	Units	Total cost (M€)
Capital costs			
Infrastructure construction (km)	12.000 - 40.000	500	6.000-20.000
Rolling stock (units)	15.000	40	600
Operating costs (per year)			
Infrastructure maintenance (km)	65	500	32,5
Rolling stock maintenance	900	40	36
Energy (trains)	892	40	35,7
Labour costs (workers)	36	550	19,8

The general formula used for the iterations is the one that follows after simplifications:

$$Q_0 > \frac{1}{\nu \Delta t\ (1+\alpha)} \left[\frac{r-\theta}{1-e^{-(r-\theta)\,T}}\ I + C_q + C_t\ \frac{r-\theta}{r}\ \frac{1-e^{-rT}}{1-e^{-(r-\theta)\,T}}\ - C_c\ (1+\alpha) \right].$$

where;

α is the proportion of generated demand;

θ is the annual average growth of net benefits;

T is the time period of evaluation;

Δt is the average time that each passenger saves compared to the conventional mode.

10.2 Results

Under the assumptions of *Table* 23, the following figure shows the minimum passenger demand per year for a positive NPV. The table shows different results depending on different values of the following parameters: infrastructure costs (including rolling stock), time savings (expressed in monetary terms $\nu.\Delta$t), the proportion of generated traffic and the rate at which benefits grow per year.

		Q_t											
		α											
		20%			30%			40%			50%		
		θ											
		2%	3%	4%	2%	3%	4%	2%	3%	4%	2%	3%	4%
I	$v\Delta t$												
12	20	14,9	12,8	10,8	14,6	12,5	10,5	14,3	12,2	10,2	14,0	11,8	9,9
	30	10,0	8,5	7,2	9,8	8,3	7,0	9,5	8,1	6,8	9,3	7,9	6,6
	45	6,6	5,7	4,8	6,5	5,5	4,7	6,4	5,4	4,5	6,2	5,3	4,4
20	20	23,5	20,0	16,9	23,2	19,7	16,6	22,9	19,4	16,3	22,6	19,1	15,9
	30	15,7	13,4	11,2	15,5	13,2	11,0	15,3	12,9	10,8	15,1	12,7	10,6
	45	10,5	8,9	7,5	10,3	8,8	7,4	10,2	8,6	7,2	10,0	8,5	7,1
30	20	34,3	29,1	24,5	33,9	28,8	24,1	33,6	28,5	23,8	33,3	28,2	23,5
	30	22,8	19,4	16,3	22,6	19,2	16,1	22,4	19,0	15,9	22,2	18,8	15,7
	45	15,2	12,9	10,9	15,1	12,8	10,7	15,0	12,7	10,6	14,8	12,5	10,5
40	20	45,0	38,2	32,0	44,7	37,9	31,7	44,4	37,6	31,4	44,1	37,3	31,1
	30	30,0	25,5	21,4	29,8	25,3	21,2	29,6	25,0	20,9	29,4	24,8	20,7
	45	20,0	17,0	14,2	19,9	16,8	14,1	19,7	16,7	14,0	19,6	16,6	13,8

Figure 20 Minimum demands, in millions, for a positive NPV under different scenarios [79]

By looking at the figure extracted from [79], we can see that the most favourable case, where investment costs have been the lowest between the 3 possibilities (12M €/km), with 50% of generated traffic, where the annual growth of benefits is 4% and with the average time saved per passenger is 45 minutes with respect to other modes of transport, the minimum demand for a positive NPV would be 4,4M passengers. However, this favourable case is not what we find in the studied European high-speed lines, where infrastructure costs have been proven to be much higher. A most realistic approach would be looking at the figure that appears in the results for I = 20M €, $\nu.\Delta t$ = 30 min (average scenario), annual benefit growth of 4% and 50% of generated traffic, where the minimum demand that appears is 10,6M passengers in the first year of operation. This shows that for an average European 500 km high-speed railway line, a minimum demand of 10,6M passengers would be needed in the first year of operation for the infrastructure to be socially profitable. As said before, the exercise has been done for a positive NPV, which is not a very satisfactory result, as NPV's are expected to be much higher for better returns. This means the exercise has studied conservative scenarios, and that even the 10,6M passengers observed for an average European scenario could be too low for HSR with higher infrastructure costs (like some cases in Italy or Germany).

If the study had considered the benefits of capacity relief and environmental benefits, the minimum passenger demand could be 10% lower than the 10,6M passengers/year, according to studies made in for the British HSR. 10% is not a significant figure; therefore we may assume that the study above is very accurate.

11 Decision-making in HSR in the study countries

In this section, the type of appraisal used in the four European countries being studied will be compared and discussed and also will the decision-making criteria in each case. Decisions should be made on a technical basis after having studied all possibilities and alternatives, but as results from this section, this is not always the case.

11.1 France

The legal process of HSR project appraisal in France is somewhat complicated. The main legislative framework is the *Loi d'Organisation sur les Transports Intérieurs (LOTI)* where all infrastructure planning is included and where it is stated that all major infrastructure projects should be appraised. RFF, the infrastructure owner, in collaboration with SNCF, define the guidelines to properly evaluate the projects. The process starts with a series of preliminary and pre project studies where different alternatives are considered, and the ones that get through are planned. After choosing the valid alternative, the project is subject to a survey of public utility. This is compulsory if the project is to be funded with public funds. At this point, the Ministry of Transport declares a statement of public utility for the project, which includes a socio-economic analysis of its impacts. Then, a detailed project is drafted and the ways of funding are decided. Finally, the Ministry takes the final decision and implementation can begin.

Although the first HSR projects in France were not formerly appraised in economical terms, more recent projects have been subject to evaluation. The main lines in France that were constructed before the 2000's (Paris-Lyon-Marseille, Paris-Strasbourg, Paris-Lille) were mainly appraised using economic studies concerning wider economic regional impacts. The further secondary lines, which are under planning or construction, have been mainly subject to multi-criteria analysis and cost-benefit analysis, as well as the economic impact studies that were carried out before. The criteria used in the past were general objectives such as national pride and leadership in HSR technology, since France produced its own rolling stock (*Alstom*). The majority of criteria used were only included in the multi-criteria analysis and not in the cost benefit analysis, therefore they did not reflect quantitative results. Therefore decision makers took into account mainly strategic objectives together with, but to a lesser extent, the financial appraisals and transport economic criteria. The most relevant issued in the French appraisals were:

- Higher values of time than in countries such as Spain or Germany were used.

- Tax revenues were counted as benefit.
- The appraisal period is relatively short: 20 years.
- The main indicator used is the Internal Rate of Return (IRR) rather than the NPV.
- Wider economic impacts were also taken into account, such as job creation and regional effects.

However, full cost-benefit analysis is required for HSR projects in France nowadays. The two documents specifying the appraisal criteria are *Circualire Idrac (1995)* and the *Boiteux* report (2001). The first one is more specific towards HSR projects; the second includes all types of transport infrastructure projects. The final assessment is based on the Internal Rate of Return (IRR) compared to the base case of doing nothing, i.e. the project is not constructed. Therefore, today's French evaluations include:

- Net financial profits of the project during its life (financial analysis), which basically means revenues minus costs.
- Net gains in time for passengers.
- Economic losses of other transport operators.
- Impact on tax revenue.
- External costs: noise, emissions, safety and congestion.

Projects with less than 8% social return will not go ahead in France. Notice the fact that only social return is used as a key decision variable instead of considering the cost benefit ratio.

In France, the government considers many other criteria to decide whether to construct the project or not, therefore, even though the project assessment gives high social return, it does not mean the project will be carried out. It is made clear in the *Circualire d'Idrac* the fact that assessment is only intended to inform decision-makers, and will not be the only decision variable for politicians. In French decision-making procedures, economic impact and regional development are very important.

Table 24 Appraisal summary table for France [55]

Appraisal summary			**Notes**	
Appraisal type used	Financial analysis	Yes	Result of appraisal is a CBA including a financial analysis	
	Cost benefit analysis	Yes	Main indicator used is IRR.	
	Multi-criteria	Yes	Multi-criteria is not done explicitly but some factors are considered in the ultimate decision	
Key variables	Discount rate	8%	Also minimum IRR to accept project	
	Evaluation period	20 years		
	Value of time	Road: 8,4-13,2€/h		

		Rail 2nd class: 10,7 - 12,3€/h		
		Rail 1st class: 27,4 - 32,3€/h		
		Air: 45,7€/h		
	Value of life	Private transport: 1 M€		
		Public transport: 1,5 M€		
	Value for serious injuries	Private transport: 150.000€		
		Public transport: 225.000€		
	Value of CO2	100€/tonne		
	Effects	**CBA**	**MCA**	
Environmental issues	Noise	Yes	-	
	Air pollution	Yes	-	
	Greenhouse effect	Yes	-	
	Landscape	Yes	-	
	Biodiversity	Yes	-	
Safety	Accidents	Yes	-	
	Personal security	Yes	-	
Economy	Journey time	Yes	-	
	Rail costs and revenues	Yes	-	
	Other mode costs	Yes		
	Other mode revenues	Yes		
	Performance	No		
	Road congestion	Yes		
	Facilities quality	-	Yes	Not directly but stated in public documents
	Tax revenue	Yes	-	
	Regional economic effects	-	Yes	Not quantified in CBA but stated as political decision criteria
	National economic effects	-	Yes	
	Employment	No	-	
Accessibility	Reduction of barriers	No	-	
Integration	With other transport modes	No	-	

11.2 Germany

In Germany the *Bundesverkehrswegeplangesetz* (BVWP), which in English means The Federal Transport Infrastructure Plan, is the basic framework where all the basic appraisal procedures are contained and it is written by the *Bundesministerium für Verkehr, Bau und Stadtentwicklung* (Federal Ministry of Transportation). Also, the *Bundesverkehrswegeplan 2003: Die gesamtwirtschaftliche Bewertungsmethodik* is a document where specific methods of evaluation are explained, splitting by transport modes and paying special attention to HSR projects.

In Germany all three analysis methods are used: CBA, MCA and financial analysis. The most important one for HSR projects is CBA. The Federal Government recommends this method for all long-distance transport projects and it separates the effects of modal shift and the calculation of costs and benefits. It compares the “with” scenario and the “without” scenario, therefore the base case is again the “do-nothing”. In general terms, the appraisal in Germany includes the following characteristics:

- A formal score method in the multi-criteria evaluations.
- A multiplier is applied to international rail projects.
- Spatial impacts and employment creation.
- The value of time is relatively high.

The MCA is used for environmental assessment via the Environmental Risk Assessment (ERA) and the Spatial Impact Assessment (SIA), when non market prices are not available to be able to monetise the issues: landscape, water, soil, and human health. ERA is supposed to qualitatively take spatial environmental impacts into account, but it is neither combined with CBA nor SIA results. Results are considered separately in a matrix displaying the effects rated by impacts of the categories —very low/ low, intermediate, high and very high. It is assigned to the decision-maker level in the federal transport infrastructure planning process. Explicit weights are given for the use of SIA in order to achieve a combined appraisal outcome. Thus, there are numerical values being done, using a scoring system. The outcome is a combined CBA - spatial impact valuation. This has the main advantage that decision-makers cannot neglect non-monetizable effects. However, the scoring method for MCA is believed to be somewhat subjective because no clear economic rationale is applied to the weightings used. This means that a scoring system may in occasions be created in order to favour some particular interest, mainly the promoter’s interest. Thus, benefits and costs should be monetised as far as possible in the cost benefit analysis.

The final decision whether to construct or not is taken in by *Deutsche Bahn* (DB) and the final decision whether the project is given the money is taken by the Federal Government in response to DB’s decision. As said before, environmental issues have a lot of weight in this decision-making process.

In the summary table for Germany, it can be easily identified what is included in the CBA and MCA for appraisal.

Table 25 Appraisal summary table for Germany [56] [57]

Appraisal summary			**Notes**	
Appraisal type used	Financial analysis	Yes		
	Cost benefit analysis	Yes	Combined results with the MCA. The output is a CBR	
	Multi-criteria	Yes	SIA and ERA	
Key variables	Discount rate	3%		
	Evaluation period	Depend on the lives of the components of project	75 years for tunnels, roadbeds. 25 years for superstructure and signalling.	
	Value of time	Non-commercial travellers: 5,47€/h Commercial travellers: 19,94€/h	The value for business travellers is about four times the value for non-commercial travellers	
	Value of life	1,176 M€		
	Value for serious injuries	87.000€		
	Value of CO2	205€/tonne		
	Effects	**CBA**	**MCA**	
Environmental issues	Noise	Yes	-	Determined by which the target level is exceeded.
	Air pollution	Yes	-	
	Greenhouse effect	Yes	-	
	Landscape	-	Yes	
	Biodiversity	-	Yes	
Safety	Accidents	Yes	-	
	Personal security	No	No	
Economy	Journey time	Yes	-	
	Rail costs and revenues	Yes	-	
	Other mode costs	Yes		
	Other mode revenues	Yes	-	
	Performance	No		
	Road congestion	Yes		
	Facilities quality	-	Yes	
	Tax revenue	No	No	
	Regional	Yes	Yes	Jobs created directly

	economic effects			by construction and operations are included in the CBA. Regional effects are included in the MCA.
	National economic effects	Yes	Yes	
	Employment	Yes	Yes	
Accessibility	Reduction of barriers	Yes	-	
Integration	With other transport modes	-	Yes	Included as objective in the SIA

11.3 Spain

A formal document stating that HSR projects have to be appraised written by the Transport Ministry (*Ministerio de Fomento*) does not exist in Spain. In spite of this, there are several appraisal guides written by Spanish authors that include the evaluating criteria in Spain and the figures that should be used. One example is the "Evaluation Guidelines for Transport Projects" written by the Catalan Civil Engineering College that is widely accepted not only in Cataluña but also in other regions of Spain. The second one is the one written by Florio *et al*. (2003),"Guide for Cost-benefit Analysis of Investment Projects", in which, general appraisal criteria that should be used in transport projects, may be found. Despite the fact of having appraisal guides and set criteria, it is not compulsory to carry out the evaluations by Spanish law. However, the Ministry of Transportation (*Ministerio de Fomento* and) ADIF*,* the national infrastructure manager, are the institutions in charge of writing the infrastructure plan (*PEIT*) and to determine where the investments should be directed to in the railway transport as well as to all the other transport modes. Anyway, economic and social appraisal is carried out in Spain although it has not a relevant effect in the decision-making processes since the political decision was taken in the year 2000 during a parliamentary session: all province capitals should be within four hours of Madrid. The only way to achieve this goal is by HSR. [58]

Since many Spanish HSR projects have been partly funded by European Regional Development Funds (ERDF), CBA appraisals are compulsory following European Directives and are done by following the European Commission's guidelines for cost-benefit analysis for investment projects. However, key variables for the evaluation process such as value of time are not specified in one unique value and therefore they are subject to a great variability depending on the project considered. In this paper, the recommendations of the Catalan Civil Engineering College have been considered.

A distinctive fact in Spain is that increased comfort produced by the new line is explicitly taken into account. In other countries this would be part of specific appraisal (normally urban transportation) and only considered in the case that overcrowding is reduced. In addition, another distinctive Spanish figure is that 30% of all employment created in the construction process is supposed to be new. Also, the salaries of these new created jobs are considered benefits without using any conversion factor. This means using shadow prices in a large extent where market prices do not show the real opportunity cost and are converted to accounting prices.

To summarize, MCA and CBA are used in Spanish HSR evaluation. MCA is used for all the non-monetizable effects, for instance, some of the environmental impacts, whilst the financial analysis is included in the ex-ante CBA as a specific part. All costs and revenues are clearly written down in a 30-year evaluation period considering the “with” scenario and the “without” scenario. The following table summarizes what is accounted for in Spanish HSR appraisals.

Table 26 Appraisal summary criteria for Spain [59]

Appraisal summary			**Notes**	
Appraisal type used	Financial analysis	Yes	Includes estimations on investment, operation and maintenance, sources of financing and returns on capital cost.	
	Cost benefit analysis	Yes	Outcome is CBR and NPV	
	Multi-criteria	Yes		
Key variables	Discount rate	5% or 6%	Recommended by the Civil Engineering College of Cataluña or Transport’s Ministry	
	Evaluation period	30 years	Recommended by the Civil Engineering College of Cataluña	
	Value of time	Depending on the purpose of travel on road and rail: Business: 15,5€/h Work: 10€/h Others: 7€/h	Air travellers: Business: 38€/h Leisure: 18,2€/h If the purpose of travel is unknown for road and rail travellers: 11€/h. Specified by Civil Engineering College of Cataluña not by the Ministry of Transportation	
	Value of life	1,6M€		
	Value for serious injuries	217.000€		
	Value of CO2	28€/tonne		
	Effects	**CBA**	**MCA**	
Environmental issues	Noise	Yes	-	.
	Air pollution	Yes	-	Mode specific. Expressed in vehicle-km.
	Greenhouse effect	Yes	-	
	Landscape	No	No	

	Biodiversity	No	No	
Safety	Accidents	Yes	-	
	Personal security	No	No	
Economy	Journey time	Yes	-	
	Rail costs and revenues	Yes	-	
	Other mode costs	Yes		
	Other mode revenues	Yes	-	
	Performance	-	Yes	Emphasized as a key benefit
	Road congestion	Yes	No	
	Facilities quality	-	Yes	
	Tax revenue	Yes	Yes	
	Regional economic effects	Yes	Yes	Regions with HSR are believed to have increased economic effects
	National economic effects	No	No	
	Employment	Yes	Yes	Included in CBA
Accessibility	Reduction of barriers	-	Yes	Territorial barriers are studied in the MCA
Integration	With other transport modes	No	No	Not quantified in the CBA but is likely to be assumed.

As always, the main outcome of the CBA is a NPV and a CBR but the economic appraisal undertaken is mainly for prioritizing projects, rather than making decisions on which projects to really accomplish. HSR receives great financial support from the Ministry of Transport since accomplishing with the statements of Spanish National Infrastructure Plan (*PEIT*).

11.4 Italy

The general transport plan in Italy is the *Piano Generale dei Trasporti e della Logistica (PGT)* written by the national government every 5 to 10 years. It shows out the main plans for transport infrastructure that are intended to be undertaken. However, not all projects included in the PGT are going to be constructed, but if they are not included, it is for sure that the project will not be carried out. The RFI, the national railway company, also edits the PPI (Priority Investment Plan), which includes all the investments in railway infrastructure and that is close linked to the PGT. The PPI states that each project should have an evaluation but it does not specifically refer to it as a detailed economic appraisal. This gives a glimpse that decision-making in Italy may not be much influenced by the results of the economic appraisal.

The main lines of action that the PGT suggests are:

- Projects have to be energy efficient and environmentally friendly.

- Projects have to be benefit the southern regions of the country as much as possible.
- Reduction of congestion in the main corridors and increase efficiency and productivity.

Apart from these general lines of action, RFI includes the criteria of financial viability and effects on the whole of the railway network for a project to be finally constructed. Anyway, the PPI is annually revised by the Interdepartmental Committee for Economic Planning (CIPE), which is made up by some representatives of regional governments, and has the authority to ask for economic appraisal of the infrastructure projects, if he thinks it is necessary. Many times, he thinks it is not; therefore the evaluation is not done, being clear that there is no formal obligation to do so in Italy. When a project is pulled out, after seeing the preliminary feasibility studies, the CIPE can also carry out its own evaluation.

However, in the projects that are indeed assessed, CBA is the most common tool. Some MCA is included for minor aspects of the projects, but is not widely used for evaluation. It has been difficult to obtain clear information about HSR appraisal in Italy but some authors (Beria, 2007) point out some errors, which have been detected in the appraisal procedure:

- The demand forecasts used do not come from a mathematical model, instead, "comes from a commercial analysis of the transport operator about the slots it would be interested to buy". The model is never included and the demand estimates are based only in RFI passenger data.

- Part of the surplus generated by new traffic in the line is not considered (time savings and money savings).

- The necessity of constructing the project to obtain benefits is taken for granted in the hypothesis section, before even justifying it.

- Benefits are calculated as the difference between the "do nothing" scenario at year 0 and the one with it at year *n.* The correct approach would be comparing benefits with the "do nothing" scenario and with the project at year *n.*

- No relevant study of alternatives is included.

- There are some calculation errors using the trains' load factors that bias the estimation towards the beneficial side of the evaluation, therefore over estimating the benefits.

- The discount rates used for the calculation in the NPV vary from 4% to 8%, showing clear inconsistency and non-uniformity of criteria.

- When CIPE has asked for external project appraisal, it has prioritized user benefits, environmental issues, economic impacts on regions and private investment returns. There is no mention of non-user benefits such as reduced road congestion. [60] [61]

To sum up, the government together with RFI carries out the final decision-making with little attention to what CBA results state. Even so, if the CBA were taken into account, the criteria have not been well defined and the errors found in them would make the decision-making not 100% reliable. Thus, criteria should be more transparent in order to make the appraisal procedure more realistic.

11.5 Comparison between the countries being studied

This section will compare the appraisal procedures in HSR used in the four countries subject to analysis. The main objective is to point out the main differences and commonalities. However, for Italy not all the necessary information has been able to be collected, as sources consulted were unclear.

Table 27 Summary of appraisal methods used in the study countries (Source: own elaboration)

Item	France	Germany	Spain	Italy
CBA	✓ (Only for the recent lines).	✓	✓	(✓) (With detected errors and not always done).
MCA	✓	✓	✓	✓
Other methods	Economic impact and regional development.	Environmental Risk Assessment. Spatial Impact Assessment.	Costs-effectiveness. Economic impact and regional development. Financial analysis.	Global effects on the rail network. Financial analysis.
Impact of results on decision-making	Part of decision-making. Economic impacts on regions are more important.	Used for ranking and prioritization of projects. Used as basis for project inclusion in BVWP.	Used for ranking and prioritization of projects. Results are important for EU project funding.	Little impact. CIPE decides if appraisal is necessary or not.
Appraisal horizon	20 years	Depend on live of components.	30 years.	-
Economic life of railway infrastructure	30 years for rolling stock. 50 years for infrastructure	5 years (tracks and tunnels) 50 years (buildings and structures) 20-25 years (superstructure and signalling).	30 years for rolling stock. 50 years for infrastructure	-

There are some main differences in the institutional set up of the appraisal between the countries but also some similarities in what refers to the methods used. However, slight differences occur in some criteria and in some evaluation parameters.

A. CBA

CBA is the most common appraisal tool used in the four countries although with differences on the way it is applied. In Spain and Italy, the degree of monetization is lower than in the other two countries. Although many of the major components are quantified (investment and operation costs and benefits), the main difference occurs in the environmental issues, where Germany includes the biodiversity and landscape effects and the other countries do not.

As regard for the economic impacts of the project, Germany and France monetize the aspects of regional development and wider economic benefits, such as job creation. In Spain, the wider economic impacts are carried out outside the CBA, therefore not being important for the CBA outcome.

Also different indicators that result from the CBA are used in the different countries. Spain relies mainly in the cost to benefit ratio, as well as Germany, but in this case the final outcome is combined with the numerical results of the MCA. France uses the Internal Rate of Return as a result of the CBA, therefore focusing on the social economic return of the investment. In addition, a minimum IRR of 8% is set for the project’s success.

B. MCA

MCA is used formerly in Germany and Spain, although Germany is the only one that actually gives numerical scores to the issues considered which are then added to the CBA to give a combined result. In France the MCA is done but is only considered when it is difficult to compare between similar projects to finally influence the final decision.

C: Impact on decision-making

In all studied countries, the outcomes of all the appraisal procedures are not the key to proceed to its construction since all decision are taken at governmental level, representing only one input for overall investment decision. Although the results of the appraisals may influence in tight cases where little difference exists between two alternatives, all studies are mainly used for project ranking and prioritization in the national infrastructure plans. In fact, out of the study countries, we could affirm in Germany is where project’s appraisal outcomes is most considered at governmental level.

D. Evaluation period.

Different evaluation periods are considered in the study countries: 20 years in France, 30 in Spain and variable in Germany. The period mainly depends on the lifetime of the infrastructure considered, which varies among countries due to different weather conditions, the degree of utilization and the quality of the materials used. Nevertheless, the longer the appraisal period, greater the value of the aggregate of the benefits will be, even though discounted. This has to be taken into account when comparing social benefits amongst countries, where different social discount rates and evaluation periods are used.

12 Financing of HSR projects

Financing of HSR projects is never an easy task since they are enormous projects, with very high costs and involving many stakeholders. Funding of the HSR lines in the countries of study has mainly been done through public budget, but a trend of mixed, public and private, funding is arising. Projects of such magnitude face a series of challenges to be able to get ahead and turn out to reality. The first challenge is political consensus within major political parties in parliament. Public budgets are approved not only by governmental parties but also with the support of the rest of the chamber. Public budgets have a great part of them being sent to infrastructure funding and this is why decision makers need the outcomes of the appraisals discussed in the previous paragraphs. Another challenge they face is the uncertainties in traffic forecasting, on which highly depend the revenues of the operator and the social profits of the project. Being a stakeholder in this type of projects implies assuming different risk along the lifetime of it: demand risks, construction risk, finance risks or operation risks. Risk is inherent to this type of project as it is related to uncertainty. The long duration of the projects life and the complexity of the works make it easy for problems to come about, especially during construction. These include finishing the works on time without delays, which incur in high cost overruns or technical problems, such as ground subsidence.

Another key issue for the realisation of the project is being able to assure financial sustainability as explained earlier in this document. Positive results in the financial analysis will be the key for private participation in the project's funding. Many times, public funding is not enough and private partners will be needed in order to be able to raise funds and also to share the risks. Nowadays, no stakeholder in a HSR project is willing to bear all the risks; therefore Public Private Partnerships are established. However, The Public Sector will have to ensure good conditions for private participation by unbundling the HSR into key subcomponents, allocating the correct amount of risk by means of contractual condition and by having a strong project organisation, where it is clear what functions is each stakeholder assuming (operation, construction, funding, maintenance etc).

This section will point out how the main lines the analysed countries have been financed. The intention is to have an overview of methods of financing and not a detailed study of each line since every project has used different ways of funding. Also, some key actions for project's funding success will be described.

12.1 Public Private Partnerships (PPP's)

A Public Private Partnership is a public service or private business venture, which is funded and operated through partnership collaboration between government and one or o more private companies. A PPP implies a contract between a public sector authority and a private partner in which the private provides a service and assumes part of the risks in the project. The cost of providing the service is assumed by the private partner by which it will become revenues via users or via government payments. There are two typical PPP structures:

- Where the private sector is given a concession for the operation and maintenance of an infrastructure for which it is paid for by the public sector.

- Where all types of outsourcing activities are carried out by the public sector to the private company, not only operation and maintenance of an infrastructure. [62] [63]

For the European Commission, a PPP shows the following characteristics:

- The relatively long duration of the collaboration between the private partner and the public sector on different issues of a project.

- The methods of financing the project come from complex arrangements between both partners.

- The risk sharing between both partners is stated in the contract conditions.

It is very typical that in a PPP created for the management of an infrastructure, the private partner receives subsidies in the form of a one-time grant in order to make it more attractive for the private investors. Also, governments may guarantee the private company the payment of annual revenues during a period of time. Normally the private partners form a Special Purpose Vehicle (SPV), which is a consortium of companies that will construct, operate, maintain and finance the infrastructure. The SPV signs the contracts with the public sector and is normally made up by a construction company, an operator and a bank (lender) which have to guarantee cash flows during the life time of the project. The SPV will only receive revenues after construction (during operation) and they will depend on the contractual conditions. However, revenues manly come from governmental subsidies or from user payment for the use of the infrastructure. As projects are so big and expensive, it is a risky enterprise and therefore the lending partners in the SPV (banks) will want to carry out an extensive *due diligence* of the projects viability before lending the funds and also a detailed review of risk allocation in the SPV. They will want to make sure that they are sufficiently protected against risk, therefore not assuming big losses if something goes wrong with the project. [64]

The main motivations for arranging these types of contracts with the private sector are that the public sector does not always have the funds in order to finance (construction) such costly infrastructures and therefore means that public budgets are to some extent not much affected. The second motivation is taking advantage of the private sector's expertise and efficiency in managing and operating a big infrastructure. Hence, the private companies intervening in the PPP must demonstrate a wide experience in the activities they have been assigned to carry out. This is the reason why the public sector arranges bidding processes to see which SPV offers the best conditions and reliability in order to assign them the contract. Some conditions, which the private partners are asked for in order to win the contracts, are:

Financial, technical and managerial capacity to build, maintain or finance the project in question.

- Understanding of the commercial issues.

- High level of financial commitment.

- Proven experience in managing, constructing or operating the infrastructure in question.

- Commercial and operation plans must be showed.

- Evidence of adequate financial resources. [65]

The private participation has become a popular action when transport infrastructure is involved. Sometimes, the project is not a *greenfield* project and therefore construction is not necessary, but management and operations will always be and both activities will be allocated to private companies. Therefore the outsourcing actions taking place in the project depend on the type of project and the contractual conditions. The next figure shows the number of PPP contracts in the EU (except UK) by sector.

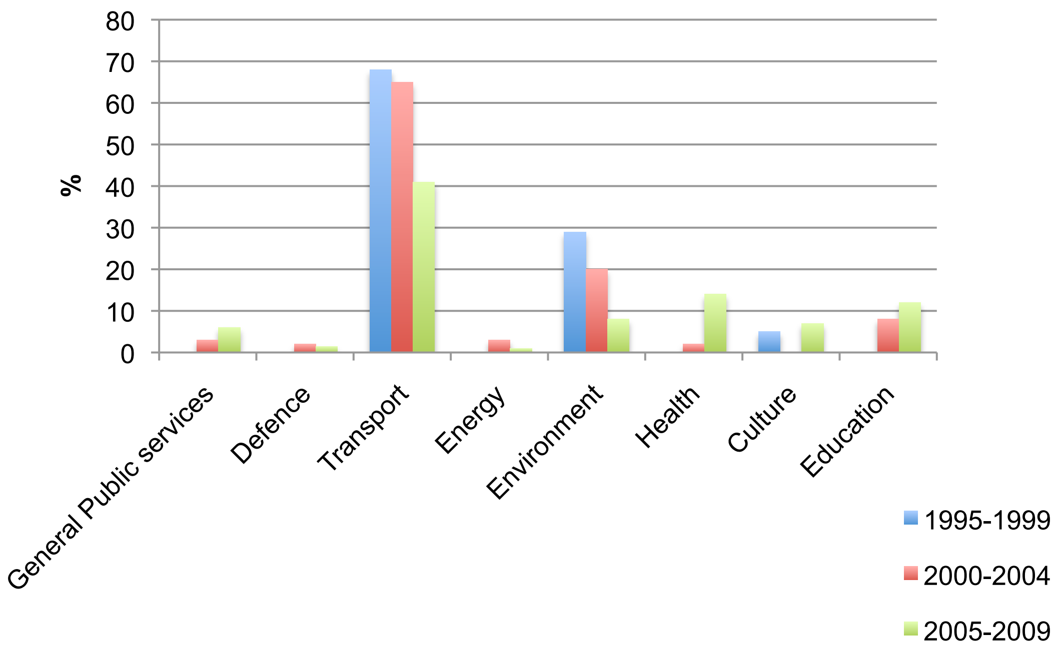


Figure 21 Number of projects (%) by sector involving PPP contracts in the EU [63]

As seen in the above figure, the transport sector involved about 65% of all PPP contracts in the EU during the 2000-2004 period and 40% during the 2005-2009 period, and therefore being by far the sector in which this type of contracts are used the most.

12.1.1 Advantages of PPP contracts.

The main advantages for establishing PPP contracts for infrastructure construction, management and operation are:

- Risk sharing: this means that the risks involved in any of the stages of the cycle of the project are shared between public and private stakeholders. This may occur in a variety of ways:
  - Construction risk is allocated to the private partner when assigned the construction tasks, at a particular schedule and price.

- In design-build-maintain type of contracts, the private partner not only bears the risk of the quality in the works but also has to be able to maintain the infrastructure for a given period of time.
- In demand based concessions, the private bears the risk of traffic on the line and therefore, of revenues being lower than expected initially.

- Advantages in cost, speed of delivery and quality: PPP's are often set up expecting that the private partner's activity during the concession makes the works end faster than if they were managed by the government.

- Less expenditure from public budgets as private capital will be invested in the project.

12.1.2 Disadvantages of PPP contracts.

The main disadvantages of establishing PPP contracts can be summarized as follows:

- Higher capital costs: normally, when a private company wants to have access to credit from lending entities, higher interest rates he will have to pay compared to the public sector.

- Misallocation of risks. This may happen when the bidding process has finished and the private has been chosen by the public sector. At this moment, the private partner has more leverage to negotiate contract conditions towards his favour and therefore may not want to assume so much risk as the government had expected initially.

- Higher transaction costs: these are the costs for all the legal work that has to be done in order to establish the contract. Lots of lawyers, financial analysts and infrastructure experts have to be paid not only to prepare the contract but also during the monitoring process undertaken by the government.

- More difficulty in coordinating all the pieces and stakeholders taking part in the project. Lack of coordination between contract holders during construction and operation may also be the cause of higher costs or quality concerns. [66]

12.2 Finance of the HSR in the study countries

12.2.1 France

French HSR network consists of six major divisions: the TGV-Est, TGV-Sud-Est, the TGV-Rhine-Rhone, the TGV-Atlantique, the TGV Nord and the TGV-Mediterrané (see *Figure* 8 *TGV France*). The extension plan for HSR 2010-2020 expects to invest in the new lines a total of 40 billion € in spite of the restrictions in public budgets expenditure being carried in many European countries. The 2010-2020 plan is aiming at reaching 2000km of new infrastructure in the finalization of the TGV-Atlantique, TGV-Mediterrané and in the Loyre-Bretagne Valley.

As explained in *Liberalisation levels across Europe*, RFF is the Sate railway manager and owner of the infrastructure, which is responsible for the provision of new rail infrastructure (including HSR) and also for the negotiation of contracts for the construction and operation of the lines. The new HSR lines are delivered by RFF to SNCF (national operator) where RFF acts as project manager, allocating the contracts section by section to different private bidders for the civil works. This is done in order to mitigate the risks involved in allocating the construction activity of the whole line to only one partner. Therefore, RFF started to enter PPP's in order to have financial support in the construction of new HSR lines, especially from 2007 onwards, when the Rhone-Rhine and the Bordeaux-Tours lines bidding processes were initiated. Previous to these bidding processes, in 2006, the French law allowed PPP contracts for infrastructures. Before, 2006, scarce participation of the private sector took place in HSR construction. These recent PPP contracts have allowed France to build HSR lines beyond State budget's capacity.

The two forms of involving the private sector in France are:

- The concession model: where operators are allowed to use the infrastructure on payment of track charges to RFF in accordance to the amount of use. This way, the concessionaire assumes the demand risks.

- PPP (*Contrat de Partenariat*): where RFF pays a fee depending on the performance of the private sector and throughout the duration of the contract. In this case, demand risk is taken by RFF.

The PPP model has some main objectives:

- Increase the national rail system in the budget constraint environment like the present one.
- Optimise the public funds with the private finance on the projects.
- Reduce cost and delay overruns by integrating project design, construction and management.
- Transferring part of the risk to the private partners.
- Introducing private expertise in the project's development.

The way RFF gets part of the funds sent to HSR are in the international markets in form of loans and the amount is subject to what RFF can repay back from the revenues of the access charges paid by SNCF. Therefore not all the funds that RFF contributes are equity but also loans from the international markets, which imply the payment of interest rates and therefore making the process even more expensive. These loans are guaranteed by the French State. Also, loans from the European Investment Bank (EIB) and European funds from the Trans European Network (TEN-T) have also been granted to RFF.

Despite the fact of the growing trend of private participation in the provision of HSR, the part of public investment is not all paid by RFF or the Sate. Instead, local and regional authorities also take part in the financing up to certain extents, depending on the length of the line section, which is built on each region. The average participation of these authorities has been between 25-30% of the total construction costs of the TGV up to present. This means that not all the funding effort lies on the State budget, again being a way of not stressing it too much. Another reason for local and regional participation is that, they benefit from the construction of the lines in their territories and the government feels that they should participate in the funding. The following table shows the amount in percentage, which each stakeholder has paid in three sections of the French TGV.

Table 28 funding by source (%) [67]

	TGV-Est	Rhine-Rhone	Loyre-Bretagne
State	39%	31%	32%
RFF	24%	29%	35%
Regional	22%	26%	33%
SNCF	2%	4%	n/a
EU (TEN-T)	10%	8%	n/a
Luxemburg	3%	n/a	n/a
Switzerland	n/a	2%	n/a

The small contributions in the funding by SNCF correspond to the rolling stock purchase through lease commitments.

Is noteworthy the case of the Tours-Bordeaux HSR contract recently signed between RFF and a private partner called *LISEA*, formed by a series of companies which can handle the funding, construction, maintenance and operation of the line. The part of *LISEA* in charge of operation will obtain revenues from charges from users and other operators willing to run trains on their tracks. The contract is a concession that will last 50 years and it was awarded for 7.800M€, the biggest PPP contract ever signed in Europe. The 7.800M€ will be obtained partly from the private partner and part from the public sector. The breakdown of the funding sources and quantities is as follows:

LISEA is providing 3.800M€:

- 772M€ of equity provided by LISEA'S shareholders pre-financed by commercial banks and the EIB.
- 1.060M€ bank debt guaranteed by the French government.
- 612M€ of non-guaranteed bank debt.
- 757M€ provided by *Fonds d'Espargne* and managed by *Caisse des Depots* and guaranteed by RFF
- 400M€ from EIB credit guaranteed by the French government.
- 200M€ from non-guaranteed EIB credit.

Public subsidies provided by French government, regional and local governments and EU funds sum up 3.000M€ and RFF provides from its own equity the 1.000M€ remaining. [68]

12.2.2 Germany

By law, in Germany the State must provide and finance the necessary railway infrastructure that has been included in the transport infrastructure master plan (BVWP). The Federal government will finance investment, including construction, replacement and expansion of DB railway lines. DB is the State owned company that has four further subdivisions, which have the responsibility for maintaining and operating the lines. Hence, in Germany great part of the finance of railway lines comes from the central government, via subsidies or via loans that DB has raised. Also, but to a lesser extent, regional governments can contribute to the finance of HSR. [69]

The main proper HSR lines existing in Germany are the Cologne-Frankfurt and the Nürnberg-Ingolstadt, Hannover-Würzburg, Berlin-Wolfsburg and Mannheim-Stuttgart. Therefore only the costs of these will be considered in this section. These sum up to 21.000M€, of which:

- 35% correspond to Federal government subsidies.
- 32% correspond to interest-free loans.
- 30% correspond to loans with different interest rates.
- About 3% corresponds to EU granting.

These acquired credit obligations by DB and the Federal government have been the usual financing methods. In this sense, very little or almost non-private partner collaboration has taken place to finance, operate and maintain the HSR lines. [70]

On the other hand, EU funding has taken place in some priority projects (TEN-T) in the European network, for example in the Cologne-Frankfurt line that is integrated in the Trans-European railway axis of Paris-Brussels-Amsterdam-Cologne-London, with a 150M€ subsidy. Also in the Nürnberg-Ingolstadt line a EU subsidy of 190M€ was received and in the TGV-Est extension on German territory between Saarbrücken and Mannheim, further 18,5M€ were invested.[80] In regard to EIB loans, the only line that received financial support was the Cologne-Frankfurt, lending up to 800M€. [71]

The following table summarizes the financing sources and amounts for German HSR lines.

Table 29 Sources of funding and amounts for German HSR (source: own elaboration after consulting sources described above)

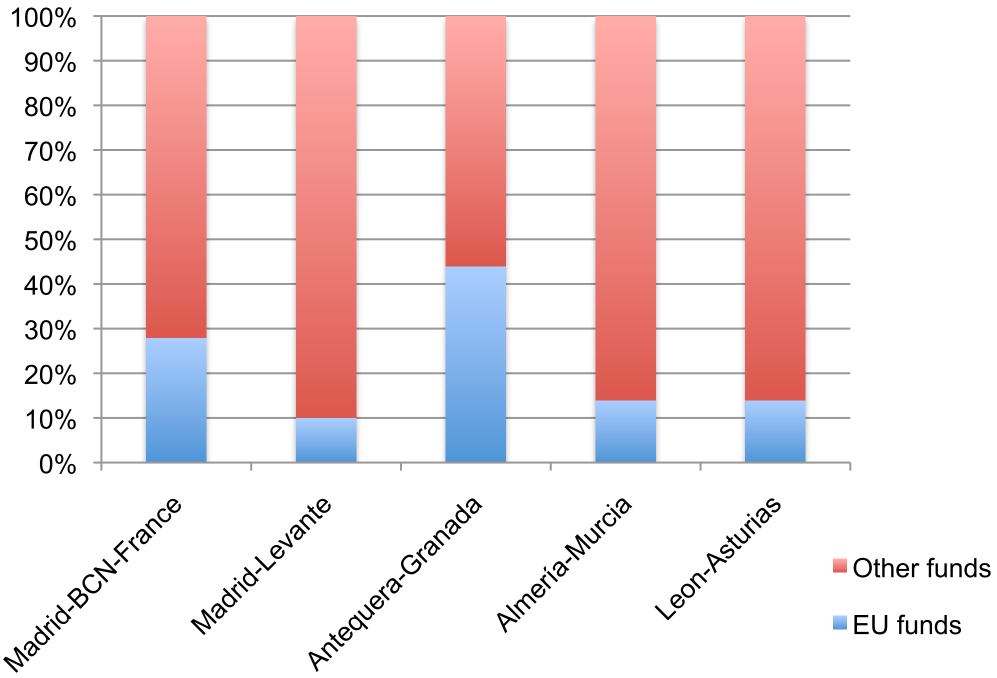
	Cologne-Frankfurt	Nürnberg-Ingolstadt	Hannover-Würzburg	Berlin-Wolfsburg	Mannheim-Stuttgart
Total cost (M€)	6100	3500	7100	2100	2200
Federal subsidies (M€)	1735	1225	2485	735	770
Interest free loans (M€)	1552	1120	2272	672	704
Loans with interest (including EIB) (M€)	2630	1050	2130	630	660
EU (TEN-T) (M€)	150	190	-	-	18,5

12.2.3 Spain

As explained before, by 2010 Spain will be the country with the largest extension of HSR after China. Up to 2008, and excluding the Madrid-Seville line, the committed investment to this purpose is 24.000M€, being the highest amongst the compared countries in this study. By 2020, according to the PEIT, further 29.000M€ will be invested to deliver a total of 10.000km.

Spain's HSR network has the peculiarity of having received many EU funds for its construction. The reasons for this is that many of the Spanish high-speed lines connect somewhat economically deprived areas within the country and also because of the Madrid-Barcelona-French border line, which will be integrated in the Trans-European Transport Network (TEN-T) since it is a cross-border line. The EU funds also come from the Euro Regional Development Funds (ERDF), which aim at stimulating poor regions in European countries and Cohesion Funds, which also aim at reducing economical differences between one country's regions by investing in transport infrastructure. The following chart shows the percentage of EU funds that have been invested in different Spanish HSR lines:

Figure 22 % of EU funding in HSR in Spain [72]



It is important to note that the Madrid-Lisbon line, which was agreed to construct in 2004 by both countries governments, has been cancelled due to recent financial crisis and therefore the projected investment (2.700M€ up to the border) will not take place. As seen on Figure 22, the Barcelona-Figures line that is a part of the Madrid-French Border line has received 28% of EU funding. The Antequera-Granada line has also received a big proportion of EU funds, specifically 44% of the total construction cost. These two regions belong to southern Spain's economically deprived areas considered by the European Commission. The following table is a summary of Figure 22 and also showing the total investment costs for each line mentioned.

Table 30 funding of Spanish main HSR lines [72]

Line	Total Cost (M€)	% in EU funds	EU funds (M€)
Madrid-BCN-France	12.375	28	3459
Madrid-Levante	12.400	10	1223
Antequera-Granada	1355	44	600
Almeria-Murcia	2519	14	348
Leon-Asturias	2391	14	331

Therefore, on average, EU funds have invested 22% of the total committed investment of Spanish HSR, excluding the Madrid-Seville line.

Other sources of HSR funding in Spain also include government's equity (public budgets) and EIB loans for more than 2.000M€. The EIB loans have favourable conditions, which means the interest rates applied are lower than normal bank loans. [73]

In Spain, PPP contracts only involve the construction of the line, as the State companies ADIF and RENFE carry out the operation and maintenance. In this sense, little private investment is being done, therefore increasing pressure on public national budget and increasing the countries' debt. Furthermore, no regional or local contributions to HSR financing are made, which means these authorities have little to say in the planning of the lines, which is done exclusively by the Ministry of Transport (*Ministerio de Fomento).*

The only exception to this non-utilisation of PPP's in Spain is the Figueres-Perpignan line, which is the final connexion between Spain and France in HSR, and that has been put forward by a PPP contract between both countries governments and a private partner. This section is 44km long and includes heavy tunnelling across the Pyrenees. The concession contract includes construction maintenance and operation for a 53-year period that will be carried out by the private company for 1.183M€. 50% of these are coming from France and Spain's government's subsidies and the rest come from the private partners equity (10%) and non-recourse loans (40%), which will be provided by banks in different terms and conditions. [74] [75]

12.2.4 Italy

In Italy the HSR lines connect the northern cities of Milan, Turin and Bologna between them and also is the connection between these northern cities with Florence, Rome and Naples. Today there are more than 800 km of operating lines and about 400km of planned lines to provide connection between smaller southern cities.

Italy's Railway holding is 100% State owned but has had to differentiate between managing company and operations company in accordance with EU directives. The state created *Ferrovia dello Stato (FS)*, the Italian railway holder, and divided into RFI, the infrastructure manager; and *Trenitalia*, the conventional and high-speed operator.

In 1991, the Italian government conceded a 50-year concession to TAV, a partly private partner (40%) that was supposed to be responsible for the design, construction and finance of the entire HSR network. However, in 1997, the Italian government bought the 40% of the private share of the company and turned it into a 100% nationalised company. When the projects are completed, the ownership goes back to RFI but still TAV, preserves the right of charging fees. RFI, in turn, charges *Trenitalia* when this company wants to use the high-speed infrastructure. Furthermore, *Nouvo Transporti Viaggiatori* (NTV) was awarded the licence to perform traveller services in the high-speed tracks during a 30-year period and also the purchase and maintenance of the new rolling stock.

The financing of these companies in Italy is 100% public as the private withdrawal took place in 1997 due to, mainly TAV's private partners inability to manage risk. Therefore TAV gets 60% of its funding from interest free loans and the other 40% are loans from the capital markets which have an associated interest rate, and that are guaranteed by the government. Total project cost estimates for HSR in Italy up to date sum up the amount of 35.000M€, of which 19.000M€ has already been financed. The breakdown of these 19.000M€ is as follows:

Table 31 Funding by source of the Italian HSR network [76]

Italian State equity	5.000M€	25,5%
State guaranteed debt[3]	8.000M€	40,7%
Loans	6.500M€	33,1%
EU funding (TEN-T)	140M€	0,7%

As seen, no other funding other than the one provided by the public sector exists in Italy, where scarce private participation is observed. Anyway the cash flows inputs of the project will be the track access charges, rental of commercial space for shops and restaurants in stations and State transfers to the companies responsible for all areas of the project.

With regard to risk bearing in the Italian HSR network, it has been seen how it was a concerning issue for the private partners to leave the PPP in 1997. Nowadays, with no major private equity for the projects, the risk is distributed in the following way:

- RFI assumes construction and demand risks
- The service operators assume demand risk.
- Italian government assumes credit risk in case of non-payment.

13 Ex-Post evaluation of the Madrid-Seville HSR line [12]

The ex-post evaluation presented in this section will be exemplifying, since no own calculations have been made. Instead, the results are from a study[4] made by *de Rus* in 2010 for the Swedish Finance Department, who wanted collaboration in order to evaluate some planned HSR lines between two major cities in that country. The chosen line has been the Madrid-Seville because it has been operating for 20 years now, since 1992. This 20-year period provides more robust results than other lines that have been operating for much less time, for instance the Madrid-Barcelona line, opened in 2008.

[3] Resorting to State debt is a common financing method used by many countries, where money is borrowed under certain repayment conditions.
[4] *Kingstrom,B and de Rus,G. (2011).Economic Evaluation of the high Speed Rail. Report to the Expert Group for Environmental Studies. Swedish Finance Department)*

As the authors of the study state, demand and cost data in Spain is not easy to obtain, therefore part of the data has had to be estimated. It is remarkable the fact that for Spanish government does not consider the investment as cost but as benefit, labour costs are considered output of the appraisal and relocation of the economic activity is not considered. The output of the CBA carried out is a NPV in 1987 € and deflated by the Consumer Price Index (CPI) according to the National Statistics Institute. The other output is a density probability function of the same NPV. The density probability function is done by means of a risk analysis and it is very useful to see how near the project is of obtaining positive NPV, and therefore being socially profitable. The social discount rate used for this cost-benefit analysis is 5%.

13.1 Costs

- General characteristics and construction costs.

General information about the line is that it is 471km long and works started in 1987 and finished in 1992, although the investment period lasted until 1993. The construction costs were 2.100M€ of 1987 and were distributed evenly during the construction period. This cost does not account for the building costs of stations, planning costs and land expropriation costs. The life of the projected is 50 years although the evaluation period will be 30 years. There will be no residual value of the infrastructure at the end of its life.

- Operating costs

These will depend exclusively on the labour costs of running trains and will be estimated in accordance with the number of trains that are operated per day. The operating costs of trains are estimated to be between 90 and 120€ per seat-km in 2002 Euros. To calculate the total operation costs we need the average number of seats per train (330) and the number of km per year that each train travels, which will be maximum 500.000km.

- Rolling stock acquisition

The cost of the purchase of rolling stock is estimated to be between 33.000 and 65.000€ per seat in 2002. The average life of a train is 30 years. VAT is not deducted from the cost of rolling stock as it is all imported.

- Maintenance costs

These will include rolling stock and infrastructure maintenance. For this study, infrastructure maintenance costs were estimated to be 10.000€/km in 2009 and rolling stock maintenance will be assumed to 3,3€/1000km, since these are directly proportional to the number of km each train travels (up to a maximum of 500.000 per year). VAT for maintenance and operation costs will be:

  - 13% for 1987-1992.
  - 16%for 1992-2010.
  - 18% from 2010 onwards.

For maintenance and operation labour costs a factor of 0,9 will be taken into account for shadow pricing. Shadow pricing is allocating costs to any intangible asset, with no market value, in a production process.

13.2 Demand

Demand is assumed to be constant throughout the day, therefore not considering peak hours. Demand data has only been available for the 1992-2004 period. For the rest of the evaluation period, the demand-income elasticity is considered to be 1; therefore demand estimations will grow linearly with the countries population income evolution. According to IMF and the National Statistics Institute the growth for the period 2010-2015 will be 1% and for the rest of the evaluation period it will vary between 1-4%. The load factor in each train will be 0,7. In the first year of operation, 2,3 million passenger trips were made in the whole line.

The estimation of diverted traffic comes from the total demand estimation per year and multiplied by the percentage of diverted traffic. According to COST 318 (review published by the EU Technical Committee on Transport), these percentages are:

- 45% from air transport.
- 2% from bus users.
- 26% from conventional train users.
- 12% from car users.
- 15% of generated traffic.

13.3 Travel times and value of time

- In vehicle times are taken from RENFE's webpage.
- Values of waiting time are twice the values of in-vehicle time.
- The values of time are gathered from *de Rus* and *Roman* 2006, an ex-post analysis of the Madrid-Barcelona line:
- Access and egress times for HSR, bus and conventional rail are identical

Table 32 Value of access and egress times in different transport modes. [77]

	HSR (€)	Plane (€)	Bus (€)
Egress cost	5,23	8,20	3,80
Access cost	3,33	6,91	3,29

13.4 Benefits

13.4.1 Avoidable costs

These refer to the costs that can be saved from the operation of buses, airplanes and conventional rail with the introduction of the new HSR line.

- The price per km for IBERIA (the air company that used offer more services between Madrid and Seville) is 0,15€ in 2009.
- The bus fares are taken from the main bus operators between the two cities.

- The cost of using cars is taken from the petrol prices net of taxes and depreciation costs from the Spanish Road Association.

13.4.2 Congestion

Estimated hourly demand is taken from the Transports Ministry (2007) data, including average speed of vehicles in the corridor. With the car load-factor and the demand in each demand station, the number of passenger-km may be calculated and therefore the road demand can be distributed through the hours of operation of the HSR. Reduction of speed (without the diverted users) is transformed to time and then compared with the time using HSR. The resulting time is then multiplied by the value of time in the road transport to obtain the monetary benefits of reducing congestion.

13.4.3 Accidents

For the economic valuation of life saving, the statistical monetary value of a life and the number of lives saved due to diverted traffic are needed. The value of life is extracted from IMPACT (2008) including the values for injured (severe and lightly) and the number of casualties avoided per passenger-km is extracted from DGT (2006) (Spanish Road Traffic Authority). Knowing the demand in the corridor (vehicle-km) and the casualty rate, the cost avoidance in life and injuries may be measured.

13.5 Analysis of time savings and generalised costs per transport mode

In this section, a comparison will be made between door-to-door times and generalised cost on the different transport modes assuming the values stated above. The next figure compares door-to-door travel times (in hours) from Madrid to Seville in the different modes.

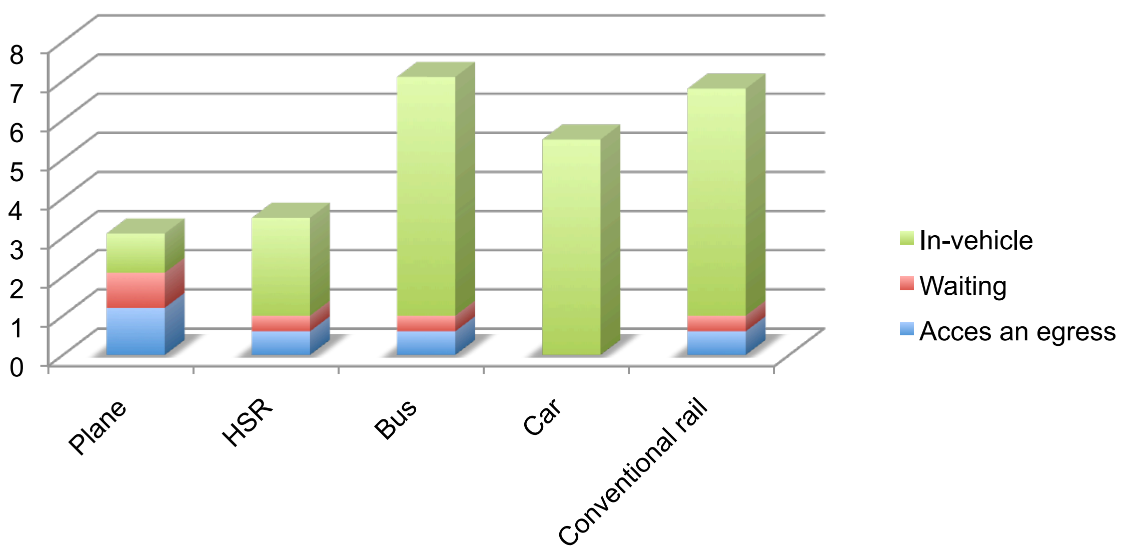


Figure 23 Door-to-door travel times in different transport modes [12]

As seen on *Figure* 23, travelling by air has a lower door-to-door time than HSR, but as regard to the total cost, the high access and egress time for the plane makes the generalized cost of travel in this mode higher than in HSR (remember that the value access times are twice of that of in-vehicle time).

The next figure shows the time benefits in 2010 € obtained from the deviated demand in each transport mode compared to HSR.

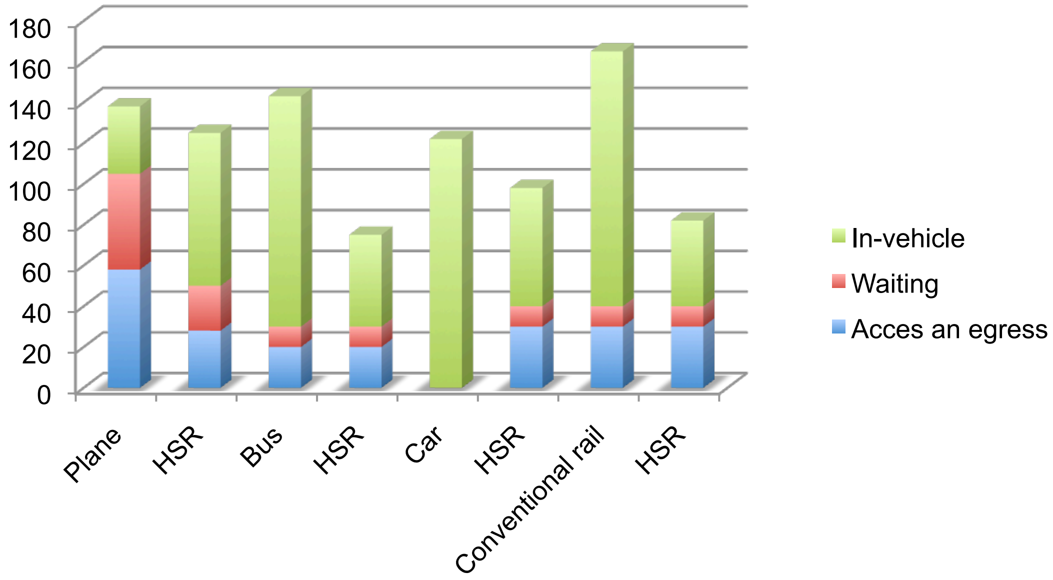


Figure 24 Time savings benefit per passenger-trip [5] *[12]*

Figure 24 shows how the most benefit is obtained from the old conventional rail users that shift to HSR. Although the biggest door-to-door time difference is between bus and HSR, the insignificant 2% diverted demand makes the conventional rail users the most benefited. In addition, although 45% of plane users shift to HSR, the door-to-door time difference is so small that the benefits per passenger-trip of HSR are not that great between these two modes.

The generalised cost of travel is the variable that users use to decide which mode to choose. The generalised cost of travel is the out-of-pocket cost (fares) plus the door-to-door time multiplied by the value of time of travellers. The following figure shows the generalised cost of travel per passenger-trip for the users shifting from the different transport modes in 2010 €.

[5] The graph should be read by pairs i.e. plane-HSR, Bus-HSR etc as it compares each transport modes benefit to HSR.

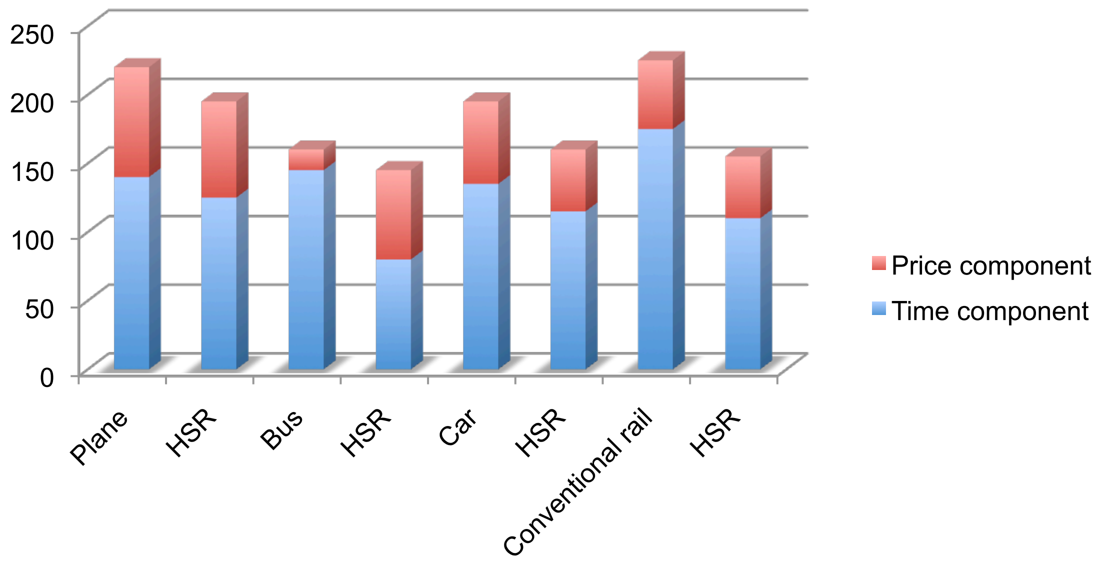


Figure 25 Generalised cost of travel for the users of each transport mode compared to HSR [12]

There is strong modal competition between plane and HSR and Bus and HSR, although for this last one, the difference is in the total travel time. The price component for the air transport is what makes its generalised cost greater than that of HSR. However, price policies in the air sector are subject to external factors such as the cost of fuel or in the case of HSR, to governmental decisions.

The following figure is extracted directly from the ex-post analysis made by *de Rus* (2012) and is where the balance between costs and benefits may be seen. The table summarizes for the 30-year evaluation period and discounts prices at a 5% discount rate until 1987.

13.6 Results of the ex-post appraisal

	Benefits 2010*	%	Discount rate (3%)	25% increase in VOT
Infrastructure Investment	-4,115,670	60.6	-4,462,798	-4,115.670
Infrastructure Maintenance	-562,097	8.3	-882,418	-562,097
Rolling Stock Investment	-318,885	4.7	-434,782	-318,885
Rolling Stock Operation and Maintenance	-1,796,242	26.4	-3,006,700	-1,796,242
TOTAL COST	-6,792,895	**100**	-8,786,697	-6,792,895
Time savings	**1,580,567**	**34.9**	**2,710,696**	**1,975,709**
-Conventional train	1,235,903	27.3	2,120,121	1,544,879
-Car	138,848	3.1	237,971	173,560
-Bus	49,421	1.1	84,676	61,776
-Air transport	156,395	3.5	267,928	195,494
Generated demand	**780,681**	**17.2**	**1,302,319**	**861,224**
Cost savings in other modes	**1,934,446**	**42.7**	**3,166,381**	**1,934,446**
-Conventional train	785,714	17.4	1,287,343	785,714
-Car	391,093	8.6	640,900	391,093
-Bus	12,619	0.3	20,631	12,619
-Air transport	745,020	16.5	1,217,507	745,020
Accidents	**225,813**	**5.0**	**346,791**	**225,813**
Congestion	**6,323**	**0.1**	**11,623**	**7,903**
TOTAL BENEFITS	**4,527,830**	**100**	**7,537,810**	**5,005,096**
NPV (1987)	-2,265,066		-1,248,887	-1,787,800

* Values discounted to 1987 and expressed in thousands €2010. Discount rate 5%. VOT: Value of time

Figure 26 Balance of costs and benefits in the CBA [12]

At the top we can see costs, which have a negative sign and below we can se benefits. Some of them are broken down into constituent parts. Generated demand benefits are considered as the new users willingness to pay and are calculated as half of the difference in generalised costs of travel between the compared modes of transport.

The red figure at the bottom left is the NPV for 1987, which was the first year of construction. It is clearly a negative figure (-2.265M€) expressed in 2010 €, and it is 55% of the construction costs (4.115M€). The reason for this negative NPV is the extremely low demand on the line, where in the first year of operation, only 2,3M passengers used the line and from these, only 1,2M travelled the whole haul from Madrid to Seville o vice versa. In addition, the time benefits (in Euros) generated by the new HSR line were not as great as expected, compared to plane, which still provides the lowest door-to-door time between both cities. Another explanation to the extremely low NPV for this infrastructure are the massive fixed costs (maintenance) and variable costs (operation and rolling stock maintenance), which sum up 35% of the total costs. The fact that maintenance and operation costs are higher than the benefits generated by time savings and generated demand, clearly shows that the line needs a much higher volume of total demand to be socially profitable.

The two columns on the right in Figure 26 are the result of the sensitivity analysis carried out. The analysis consists of, in first place reducing the social discount rate to 3%, and in second place, increasing values of time 25%, with respect to the initial evaluation (first column). In both cases one would expect to obtain a better NPV value, which is in fact what happens, but the NPV's are still way away of being a positive figure. This highlights that the social profitability of the Madrid-Seville HSR line is nowhere near of being a high value, even when favourable conditions for that to happen have been studied.

Lastly, the risk analysis showed in *Figure* 27, shows that the probability of the NPV to be positive during the evaluation period is zero. It has to be noted that not all the exact demand values were used for this CBA, instead many were estimated, therefore this probability distribution may vary slightly using the unavailable real annual demand numbers. Anyway, the maximum result shown in the density function is -1.700M€. This analysis clearly shows the negative social value of this investment.

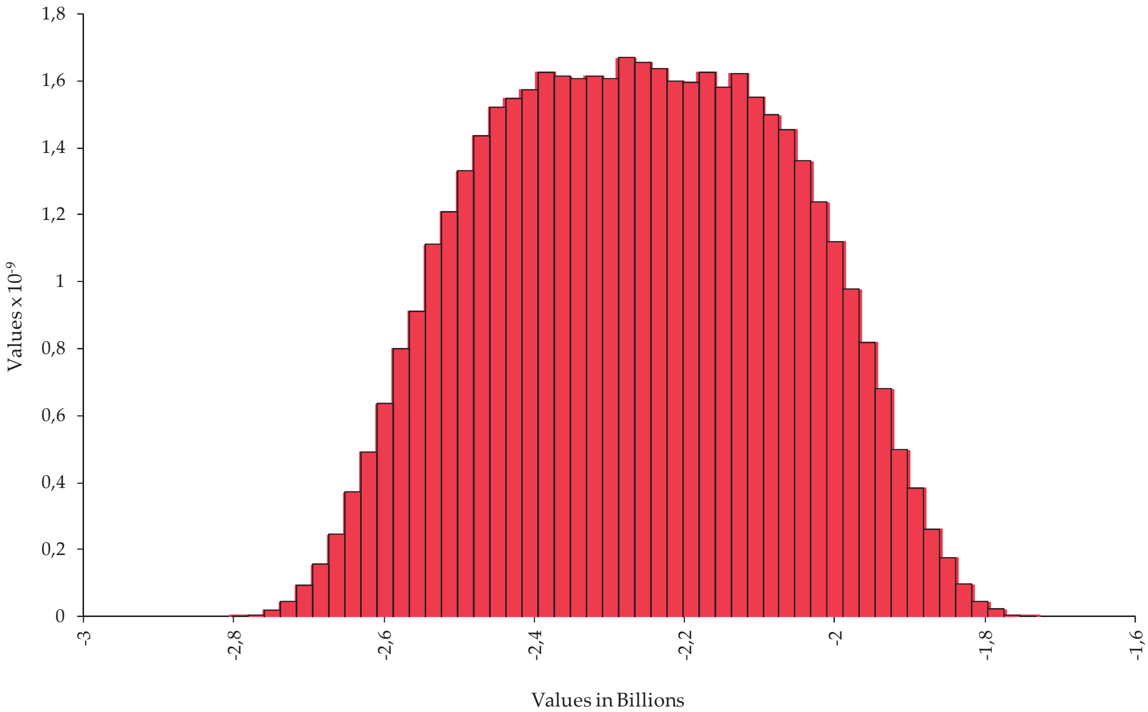


Figure 27 Probability distribution of NPV in the Madrid-Seville line [12]

13.7 Remarks on the CBA of the Madrid-Seville line exposed.

My own remarks on this CBA are the following:

- The analysis has not accounted for any type of environmental benefits derived from the loss of road traffic. This is estimating the amount of pollutants that will be saved from being released to the atmosphere. Instead, they contend that during construction, CO_2 emissions are greater than the amount of CO_2 saved due to the operation of the line during 30 years. In fact, authors say that, from a climate point of view, it would be better to upgrade existing conventional rail lines rather than constructing a new HSR line. Also, no reduction in noise has been evaluated.

- The CBA has not accounted for any impacts on either regional economies or national economies. This means it has not taken into account the job creation during construction and operation of the line and the derived wider economic impacts for the country.

- The IRR has not been calculated although it implies no extra difficulty. Using the same software as for calculating the NPV, the IRR is easy to calculate, as it is the discount rate for which the NPV is zero. The IRR indicates the efficiency or yield of a project in contrast with the NPV, which shows its magnitude or value. In my opinion, both indicators should be calculated in order to have a better global result from the CBA.

14 Conclusions

The conclusions will respond to the issues raised at the beginning of the document, which are the aims of this thesis. The goals of this thesis can be rated as fulfilled. The conclusions will be separated in relation to the aims stated at the beginning of the document and will only reflect the authors deductions from the research that has been carried out.

14.1 Effects of the separation of management and operations in railway companies.

- Although compulsory according to European Directives, proper separation of operation and management in the railway sector has not yet been done in the studied countries. Separation has occurred only to comply with the mentioned Directive; therefore minimum effort has been done for a complete separation in independent companies. All that has happened is separation of accounts of the same undertaking under different commercial names, although both "new" companies still belong to the same global enterprise. This global enterprise is still owned by the public sector, specifically the Ministry of Transport of the studied countries. The basic intention of this separation processes is to achieve liberalisation of the infrastructure i.e. to allow new companies to enter the market and break with the prevailing monopoly conditions until now.

- The direct consequence of this unfulfilled separation of functions in the railway sector is that little liberalisation has occurred. Mainly, State companies operate the railway services. The exception in the studied countries is Germany, where more companies are operating other than *Deutsche Bahn,* mainly because of new entrants in the freight transport sector, which is not subsidized by the State and therefore easier for the newcomer to compete. The rest of the countries have only opened the railway market for freight companies, not for the passenger services. This shows that further liberalisation should take place in order to warrantee full competition in the passenger services market.

14.2 Reasons for the growing trend of HSR construction in Europe

- The main reason that governments give for justifying HSR construction is the capacity constraints that actually appear in the conventional railway networks.
  In France the Paris-Lyon corridor was suffering from important congestion problems before 1981 when the new HSR between both cities was opened, and only 11 years later it achieved 19 million passengers, therefore asserting the justification of capacity.

- In Germany, the main reason for HSR construction or even better, the upgrade of conventional lines to faster lines (not necessarily HSR), was the need for the country to transport freight from the ports in the north to the industrial areas in the south after reunification. Some capacity problems were also used as pretext for the first lines to be constructed (Hannover-Würzburg).

- In Italy, the *Alta Velocittà/Alta Capacità* (upgraded conventional lines up to 230km/h for freight and passengers) was constructed so that a better integration with the conventional lines would expand the railway transport capacity in passenger services. Also, it was thought that the AV/AC would favour the maintenance of conventional lines between cities that were connected by AV/AC.

- In Spain, the main motivation for HSR is the reduction of travel times between Madrid and the rest of province capital cities within less than 4 hours. Therefore, this criterion does not respond to technical transportation issues such as optimization, capacity or integration between transport modes. Also, in Spain, achieving a very extensive HSR network is synonym of technological forefront.

14.3 Costs and benefits of HSR

- There are different costs for HSR construction between the studied countries. The highest average cost per km of line are found in Italy and Germany with 30M€/km and 25M€/km respectively. The lowest average costs are observed in France and Spain with 15M€/km and 14M€/km respectively.

- These big construction costs differences are mainly because of the harsh mountainous terrain in the north of Italy, which implies a lot of tunnelling and viaducts. Also topographical issues make the German costs higher. Political and bureaucratic discrepancies have also induced high cost overruns in Germany, as well as higher land expropriation costs due to densely populated areas. Another reason for these higher costs is the restrictive environmental policies in Germany, which force to take strict environmental protection measures and therefore an increase in the project's cost.

- Regarding infrastructure maintenance costs, France and Spain present higher values than Italy mainly because Italy's technology is not that of the other two countries. AV/AC infrastructure is not as sophisticated (as lower speed is achieved) as the Spanish or French, leading to lower costs.

- Benefits of HSR are similar in all countries in terms of time savings, comfort and more capacity in congested corridors but it has been proved by experience that HSR does not favour the economies of poorer and smaller areas, but it favours the activity suction towards bigger nodes.

14.4 Most suitable conditions for HSR deployment.

The most suitable conditions for HSR deployment are summarized in the following lines:

- HSR is most suitable for medium haul journeys (200-500km) due to lower door-to-door times compared with the plane. Above 550km, the plane achieves advantage over HSR in term of door-to-door time.

- In many important medium distance corridors, since HSR was deployed, air market shares have dropped dramatically in favour of the train. Usually when the journey is 3 hours or less, the HSR takes larger proportion of the market share. Although this does not mean that demand rates are acceptable for HSR, especially in Spain, where high market shares does not mean high demand. With respect to road traffic, the introduction of HSR has reduced the amount of traffic but not as much as in the air transport.

- HSR must be introduced in highly demanded corridors for the project to be socially profitable. Before operations start, the capacity of the corridor must be adjusted to its real demand in order to optimize costs.

  Regarding population distribution, it has been proved that HSR works better when the population is congregated in few high-density nodes, together with the fact that urban areas near the main corridor have intermediate sized population. This way, the main corridor can be fed by branches to and from these medium sized cities. Where this applies best is in France, especially in the Paris-Lyon corridor.

- If demand is lower than 10 million passengers during the first year of operation, an average 500km HSR line with average costs in Europe and assuming conservative conditions of other parameters (operator's annual revenue growth, generated demand and time savings), the NPV will be negative and the IRR will be rather low (lower than the social discount rate), therefore the investment is not socially profitable.

14.5 Decision-making processes and criteria differences within the study countries

- In all countries, France, Germany, Spain and Italy, the three types of appraisal techniques are used for HSR projects. These are, cost-benefit analysis, multi-criteria analysis and the financial analysis. Although the focus and the criteria included in the evaluations vary significantly.

- In Germany, the environmental criteria a largely evaluated and influence the decision-making process to a large extent. Germany is unique since it carries out SIA and ERA in the MCA (qualitative results outputs) for evaluating landscape and biodiversity issues during the project's construction and operation.

- France and Spain's evaluations are more focused to economic impact and regional development. In the case of France, a minimum IRR in the CBA must be obtained in order to put the project forward.

- In Italy, not much information regarding HSR project appraisal criteria has been gathered; therefore the author deducts that is not an extended practice in that country. Research has confirmed that the little appraisal done is erroneous and not accurate. However, financial analysis (cash flows analysis during the life of the project) is somewhat important, just like in Spain.

- Despite of the project appraisals, the final decision is always taken in the Transport Ministry of each country, so it is always a political decision, that may be or may be not influenced by the technical support provided by the appraisals.

- The variables (value of time, value of life, value of a CO_2 tonne etc) used in the appraisals vary across the countries, mainly influenced by economic parameters such Gross Domestic Product or income.

14.6 Financing sources for HSR

- France is the country that has developed the PPP contracts the most out of the four studied countries. As explained, about 55% of the funding for the new projected lines in the TGV-Atlantique comes from private sources. Although the already existing lines have been mainly financed by State funds (about 60%) and regional and local funds. EU contribution to the development of HSR has been substantially low (8-10%).

- Spain is the country that, due to its inclusion in the Euro Regional Development Funds and Cohesion Funds development plan, has had the largest EU finance for its HSR lines (between 10-40%). The rest come from Public Budgets, which many times have to depend on bank loans, therefore increasing Public Debt. Recently a

PPP concession contract has been signed to build and operate the HSR link between France and Spain, which is the first of this type for Spain.

- In Germany, State funds come from loans with interest rates and also from interest free loans. A large proportion of the German funding for HSR comes from the Federal government, with very little proportion of EU funding (about 3%).

- Italy's HSR network (or AV/AC) has also been broadly financed by State funds, which are either State equity or loans (Public Debt). Very small private participation has taken place in Italy and also has received very small proportion of EU funds.

14.7 Ex-post evaluation of the HSR line between Madrid and Seville in Spain.

- The ex-post evaluation of this project is an example of how a project has been undertaken without the necessary ex-ante appraisal, especially regarding demand forecast. Demand rates have to be accurately estimated, because demand is what determines the social profitability of a transport project. Even more when dealing with HSR project where investment costs are extraordinary high.

- A NPV of -2.200M € means that cash flows in terms of costs and benefits to society are totally on the side of the economic loss, therefore being the costs much higher than the benefits that were expected from the project.

- An ex-post appraisal of the Paris-Lyon line has not been presented but with more than 20 million passenger per year, it is clear that social profitability should be high.

- Ex-post evaluations are good to see how a project has performed during a certain period of time and to prove whether initial objectives have been achieved.

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Declaration

I declare that the present document handed in today has been written by myself and no other sources other than mentioned have been used.

Dresden, 13th August 2012.

Signature:

Appendix

SNCF financial analysis (own elaboration).