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Infrastructure Pricing Models for New High-Speed Railway Corridors in Europe

Pricing Model Development for the Lisbon-Madrid High-Speed Line

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Abstract

The railway sector in the European Union has undergone a number of transformations between 1990 and 2010, including separation of infrastructure management from train operations, and implementation of a system where infrastructure users must pay Infrastructure Managers for capacity consumption in accordance to a tariff system. European Commission Directive 2001/14/EC has defined how such tariff systems must be set up and what type of pricing policies are acceptable for use. Pricing in the railway sector in the European Union has evolved since 2001, and most new high-speed rail lines attempt to recover at least a part of their initial investment costs. On the Iberian Peninsula some high-speed rail lines are in operation and many more are in various stages of planning and construction. The proposed Lisbon-Madrid high-speed line is expected to commence operations in 2017. It will consist of 210 km on Portuguese territory and will have three types of services: long-distance, regional, and shuttle to the New Lisbon Airport. After examining tariff systems of key Western European countries, this document analyzes operational characteristics of the proposed line, performs a financial analysis, determining the amount of recoverable funds, and develops a tariff system that considers the line's specificities.

This study first applies existing European tariff systems to passenger and freight demand projections in order to see what systems are more applicable to the proposed line, and to benchmark recovery of initial investment costs. Belgian, Dutch, French, and German systems contain relevant tariff structure components that could be applied in a new tariff structure for the proposed line. After examining the operators' net revenue, the document then estimates the project's net present value. While the project is not able to fully pay back initial investment costs, it is able to pay its maintenance costs during the 40-year operation of the line. Analysis of freight traffic shows that freight could play a part in recovering initial investment costs, but its role is probably more important from a social point of view, (e.g. as a means to decrease pollution on roads). The study then examines the proposed additive tariff structure, which contains three components: two covering marginal costs, and one covering initial investment costs. The study then proposes an innovative tariff concept, where the operator would be charged for a part of the tariff in passenger-kilometers, with rates depending on the origins and destinations of passengers. Finally, the study concludes with a tariff model application and some general observations.

Keywords: Railway infrastructure pricing, railways, high-speed rail, Lisbon-Madrid high-speed rail line, infrastructure tariff systems, railway reform in Europe, tariff schemes, pricing systems, railway cost coverage, origin-destination pricing, marginal cost pricing, full cost pricing, Ramsey pricing

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Acronyms and Definitions

EC – European Commission

ECMT - European Conference of Ministers of Transport

EEC – European Economic Community

EU – European Union

FC – Full Cost

FC- – Full Cost minus governmental mark-ups

HSL – High-speed line

IM – Infrastructure Manager; body responsible for maintaining and developing rail infrastructure within a country

IMTT – Instituto da Mobilidade e dos Transportes Terrestres, I.P. – Portuguese regulator

MC – Marginal Cost

MC+ – Marginal cost + mark-ups

MSC – Marginal Social Cost

NPV – Net Present Value

NS – Network Statement; document that each Infrastructure Manager is required to publish annually that contains information about the IM's rail network

OECD – Organization for Economic Co-operation and Development

Profit – Difference between gross and net revenue

PSO – public service obligation; a subsidized government-contracted service that is considered strategically important, but cannot be sustained by market forces alone;

Revenue, Gross – Revenue not considering costs

Revenue, Net – Resulting revenue after deducting costs

RU – Railway Undertaking (Train Operator); a private or public undertaking whose main business is to provide tail transport services for freight and/or passengers

TTT – Third Tagus Crossing

1. Introduction

1.1. Background

The goal of forming a common transport policy in Europe has been on the agenda as early as the 1950s, during the formation of the European Economic Community. Later, after the foundation of the European Union, the need for common policy became even stronger. In railways, this has led to a number of reforms in an attempt to improve the sector by increasing its competitiveness, efficiency and by creating a level playing field both within the sector as well as between different transportation modes.

A number of reforms (or *Railway Packages*) containing directives have been passed by the European Parliament, leading to a step-by-step reform of the railway sector. Some of the highlights include separating railway operations from railway line management into Railway Undertakings (or RUs) and Infrastructure Managers (or IMs), and gradually opening up the market to limited competition both for freight and passenger services.

With this came a need for a way to charge for infrastructure use. The latest piece of legislation on this issue, European Council Directive 2001/14/EC, established an infrastructure charging framework, and specified implementation guidelines allowing for some leeway in the process. Because the railway industry has historically played different roles in each country, charging schemes vary widely, both in structure and in charging levels. This creates complications for international services that are required to separately obtain certification to operate in each country and to pay for infrastructure use under each country's tariff scheme. This lack of harmonization of tariff schemes creates a problem for services on existing trans-border lines, and remains a challenge for new international services.

1.2. Problem Formulation

This document will consider the construction of a new international high-speed railway line, which requires a high cost recovery rate. The Portuguese part of the Lisbon-Madrid high-speed rail corridor, will be used as a case study and an appropriate infrastructure tariff model will be developed. This document will focus on the question of how to maximize the project's recovery rate and how to structure its tariff system. It is also desirable to harmonize the new Portuguese line's tariff structure with the Spanish one in order to reduce the impact of having two tariff systems on an international line.

1.3. Objective

The main objective of this document is to develop a charging scheme which meets the goals of the new international high-speed rail line. A case study of Portuguese part of the Lisbon-Madrid line will be used. This will be structured in a number of steps. First, an assessment of the current legislative context will be made, along with an examination of the state of the art in railway infrastructure pricing. Second, existing European charging schemes as well as their structures and goals will be considered in order to determine which part or parts are transferable to the Lisbon-Madrid high-speed line. Finally, the document will conclude with an evaluation of how well the proposed tariff scheme meets the goals of the Infrastructure Manager, the concessionaire, the State and the European Commission.

In addition to the objectives stated above a number of key questions will be answered. In analyzing existing European charging schemes it is important to determine which cover line maintenance costs and for those that do, what percentage of initial investment costs are covered. A further analysis of European charging schemes can determine which ones can be transferred to the new international high-speed line. Next, in analyzing the proposed high-speed line, it is important to determine the minimum level of traffic to cover line maintenance costs. Finally, an assessment of the project uncertainties will show potential issues that must be studied further.

This document was developed alongside a research study for RAVE. Although the problem formulation and overall methodology is different, some data that was collected for that study is also being used in this document. (Teixeira et al., 2011)

1.4. Structure

This document will, first, examine the events and history leading up to the railway reform in the European Union. Second, railway reform legislation will be analyzed along with studies that are relevant to the topic. Third, this document will analyze European charging systems, their structure and charging levels. Fourth, this document will examine each charging scheme in more detail and will calculate cost recovery ratios for key European high-speed rail corridors. Finally, the Portuguese part of the Lisbon-Madrid High-Speed line will be examined, and a new charging system will be proposed.

The structure, when divided into chapters, will look as follows:

Chapter 1 defines the problem and describes the structure of this document.

Chapter 2 deals with the state of the art in rail infrastructure pricing in the European Union. This chapter includes analysis of the legislative context as well as analysis of related research.

Chapter 3 examines European tariff schemes of selected countries in great detail. These countries include Belgium, France, Germany, the Netherlands, Spain and Portugal. Charging systems of some special infrastructure projects, such as bridges and tunnels are also presented, as these projects have charging schemes that differ from normal tariffs in their countries' rail networks.

Chapter 4 evaluates financial recovery potential of key European corridors that use tariff systems examined in Chapter 3. This is done by comparing Infrastructure Manager (IM) finances, Railway Undertaking (RU) finances and infrastructure construction costs.

Chapter 5 examines the Lisbon-Madrid high-speed Line project and proposes a charging scheme for the new line. First, this chapter assesses the applicability of other European tariff schemes to the new line. Second, the operator's willingness to pay is established. This sets the upper limit on the potential recovery of funds. Third, new tariff system goals are defined. Finally, a tariff structure is proposed and evaluated.

Finally, Chapter 6 draws some conclusions based on the analysis performed in previous chapters.

2. State of the Art in Rail Infrastructure Pricing in the European Union

2.1. Relevant EU Legislation: pre-2001

Since the foundation of the European community, unifying transportation policy has been a key goal of both the European Economic Community (EEC) and the European Union (EU). As early as 1957 in the EEC Treaty of Rome, common transportation policy was listed as one of the primary goals of the treaty. The next step came nearly thirty years later with a 1985 White Paper proposed the creation of a free internal market and elimination of factors that distort internal competition (EC, 1985). This laid the groundwork for reforms in numerous sectors.

The next policy development came in 1991, with the adoption of the EEC Directive 91/440/EEC *on the development of the Community's railways*. The directive called for an improvement in railway efficiency and development of the sector, specifically by promoting competition. First it mandated that each State separate their accounts (budgets, assets, etc.) from railway undertakings (RUs) and help RUs with restructuring long-term debt, essentially granting RUs the status of an independent government-owned company. Second, the directive called on the States to establish an Infrastructure Manager (IM), an entity responsible for management and operations of the railway infrastructure, but did not mention any specific requirements for such an organization. Third, this directive permitted the RUs to partner with each-other and to establish presence in other states. Fourth, it established the IM – RU relationship, where the IM was required to grant access to RUs on a non-discriminatory basis. Finally, it briefly mentioned that in this relationship, RUs are required to compensate IMs by means of a non-discriminatory user fee, which may "… take into account the mileage, the composition of the train and any specific requirements in terms of such factors as speed, axle load and the degree or period of utilization of the infrastructure" (Dir. 91/440/EEC, Art. 8). This directive was the foundation for the railway infrastructure charging system in existence today.

A 1992 European Commission White Paper specifically addresses EU transportation policy by outlining the goals and underscoring the need for efficiency improvements within each transport mode as well as better interfaces between modes. Other listed goals included promoting sustainability, considering environmental issues, and overall improvement of mobility in the European Union. With regard to railways, the White Paper cited the need for non-discriminatory access to infrastructure. The paper referred to directive 91/440/EEC as a starting point, but cautioned that vague wording would cause the directive to have limited or undesirable results and cautioned that "liberalization already agreed will be very uneven and, in some areas, may give rise to such conflicts that it may not happen at all or at best for a very long time" (COM (92) 494 final, §343)

Another EC Directive, 95/19/EC *on the allocation of railway infrastructure capacity and the charging of infrastructure fees*, expanded on the 1991 directive by defining the role of the Infrastructure Manager. It noted that infrastructure capacity is to be prioritized to public services and to specific types of services on purpose-built infrastructure (e.g. high-speed trains on high-speed rail lines). The directive also refined the specifics of charging mechanisms, stating that the fees may be fixed based on the service type, time of day, market situation and type and degree of wear and tear of the infrastructure (Dir. 95/19/EC, Art. 8). This directive also mandated a balanced IM budget and permitted the IM to make a “reasonable” return on investment.

A 1998 European Commission White Paper noted the diversity in implementation of directive 91/440/EEC in the railway sector and a lack of incentives for charging scheme harmonization, noting the resulting distortions in competition within the European market both within and between modes. The paper proposed a three-step implementation process to tariff harmonization. The first step would introduce compatible tariff structures across different countries and modes. The second step would increase tariffs to the level of marginal social cost (including external costs). Finally, the third step would depend on the first two parts and could include increasing tariff levels beyond marginal social cost (EC, 1998).

2.2. Relevant EU Legislation: from 2001 through Present

In 2001, the *First Railway Package* (directives 2001/12/EC, 2001/13/EC, and 2001/14/EC) was adopted. The package amended directives 91/440/EEC, and 95/19/EC. It opened the international freight market to competition, further refined the definition of access to infrastructure, created priority Trans-European Network (TEN) corridors for freight and passengers, defined EU-wide licensing requirements for train drivers and provided a definition on railway access charges.

Directive 2001/14/EC defined the role of the IM and the framework for infrastructure charges. This directive made it mandatory to publish a Network Statement (NS), containing information about conditions for access, available infrastructure, tariff system, and principles and criteria for capacity allocation, including procedures, requirements, schedule, available services, principles for congested infrastructure and various restrictions (EC 2001/14/EC).

Article 7 of this directive lays out the allowable principles of the charging systems. The principles include:

- Tariffs must be directly related to the cost that the IM incurs for providing services
- A congestion charge may be included in the tariff

- An environmental charge may be included, provided that other modes are charged at a comparable level
- Costs may be averaged over different types of rail services and times
- Infrastructure maintenance charges may be levied during infrastructure maintenance periods
- A capital cost mark-up may be implemented on projects where markets can bear it
- Discounts cannot discriminate against RUs (e.g. cannot be applied to a specific RU) and are permitted only for two reasons:
    - For something that is related to savings incurred by the IM, or
    - For new services, only during an initial start-up period
- A time-limited environmental compensation may be implemented to benefit RUs for unpaid environmental, accident and infrastructure costs of competing modes. In a situation of a single RU, such benefits must be passed on to users
- The directive encourages IMs to set up a performance scheme with bonuses for RU efficiencies and penalties for inefficiencies

This directive also defines the rules for infrastructure access, including procedures for capacity allocation. To date, this has been one of the most significant pieces of legislation in defining the current state of railway infrastructure pricing in Europe.

The *Second Railway Package* (Directive 2004/49/EC, Directive 2004/50/EC and Directive 2004/51/EC, Regulation 881/2004) dealt with interoperability and safety of railway networks, and created a European Railways Agency.

The Third Railway Package (directives 2007/58/EC, 2007/59/EC, and 2007/60/EC, as well as EC Regulations (EC) Nos. 1370/2007, 1371/2007, and 1372/2007) opened the international passenger market to competition, created a uniform standard for certifying train crews and defined RUs' obligations to passengers. EU Directive 2007/58/EC, an amendment of directive 2001/14/EC, opened up the international passenger railway market and clarified the issue of cabotage and public service contracts.

From September 2010, the EC has been considering a modification to these directives by further improving them and by consolidating them into one piece of legislation. Some of the issues under consideration are: access rules for certain pieces of infrastructure (maintenance facilities, freight terminals, passenger information and ticketing facilities), granting rail regulators a more independent and a more powerful role, issues concerning infrastructure costs and their drivers, and providing incentives for investments in interoperability and cleaner technologies.

2.3. Research on Railway Infrastructure Pricing

In 2003, the European Commission led a study (completed in 2004) titled ***EU Passenger Rail Liberalization: Extended Impact Assessment***. This report examined changes in the market after the implementation of the *First Railway Package*. It looked at existing regulatory regimes, attitudes and interests of stakeholders, and at case studies that considered three market-opening strategies: international services with and without a right of cabotage and full market opening for both domestic and international passenger services. The study concluded that the most appropriate approach would consist of opening the market only for international services with cabotage (allowing operators to transport passengers, whose origins and destinations are solely within a foreign country). The report also recommended a better definition of Public Service Obligation-type (PSO) services, regulation of passengers' rights, and some changes in the legislation for access charges so that tariffs for freight and passenger services are consistent. This study has led to the implementation of the Third Railway Package (EC DG-TREN, 2004).

In 2004, most European IMs formed a non-profit association **RailNetEurope**. RailNetEurope's goal is to harmonize the development of infrastructure, products, services, tools and processes in an international context, improve quality of existing rail products and provide legal, technical and commercial information on existing infrastructure. Primarily, RailNetEurope is designed to be a Community-wide one-stop-shop for information that new entrants into the market require. Additionally, RailNetEurope has created a number of tools for both RUs and IMs. PATHFINDER is a tool that handles communication for requests and development of everything related to international train paths, both from an IM and an RU perspective. European Infrastructure Charging Information System (EICIS) allows users to estimate train path price on domestic and international networks. Finally, EUROPTIRAILS allows international train management, delivering real-time data about international passenger trains.

A 2005 European Commission-commissioned a study, ***RailImplement***, looked at the level of implementation of the *First Railway Package*. The study looked at two aspects of implementation: effectiveness of the institutional and procedural framework in place, and market development. It concluded with policy recommendations. The findings of this report stated that not all states have implemented the first railway package, and for those that have, the implementation has not always been effective. The study examined each article of the directives and found varying levels of compliance with directives, as well as diverse ways in which the implementation has taken place. The study found that most countries charged marginal cost rates for using infrastructure. It also concluded that access to terminals and ancillary services was hindered due to discriminatory charging and for other reasons (EC DG-TREN, 2005).

Another study, commissioned by European Conference of Ministers of Transport (ECMT) and by the Organization for Economic Cooperation and Development (OECD) on ***Railway Reform and Charges for the Use of Infrastructure*** was completed in 2005. The study examined in detail the state of the railway industry in Europe as well as each country's tariff levels and concluded that tariffs must: move in a direction that would allow the IMs to balance budgets, send clear signals to RUs, and create international railway corridors that would be prioritized for easy freight movement. The report also noted the need to reduce barriers for international services and recommended harmonization of tariffs across international borders (CEMT, 2005).

A 2005 EC document ***Task Force Track Access Charges*** by *Developing European Railways Committee*, developed in parallel with the OECD study, noted that not all charging schemes were consistent with EU policy objectives. Those found to be inconsistent were not promoting financial stability of IMs, not providing effective price signals to RUs, nor allowing effective competition in the market. It noted that some systems were charging costs that were below marginal, others were cross-subsidizing passenger services with money from freight services in order to reduce PSO costs. This document recommended increasing the role of independent rail regulators, changing the way tariffs are structured, and including renewal costs in tariffs (DERC, 2005).

A 2006 EC-commissioned study, ***SERVERAIL***, examined the implementation of directive 2001/14/EC and the provision of various railway services, such as traction current, services in passenger stations, train formation services, leasing, etc. in railway markets. Additionally, the study looked at market trends for these services. It found broad differences in implementation of the directive and recommended refining the vaguely-worded legislation into something more specific, as well as publishing guidelines for implementation of the directive, and creating common approaches to ensure non-discriminatory access to rail-related services (EC DG-TREN, 2006).

A 2008 update to a 2005 joint study by the European Conference of Ministers of Transport (ECMT) and the Organization for Economic Cooperation and Development (OECD) on ***Railway Access charges in the EU*** examined the state of the art in the implementation of EU directive 2001/14/EC (and its updates) as well as tariff calculation tools, such as EICIS, that have been developed. The update noted that very little change has happened since the original 2005 study, and that previously-set goals were not much closer to being achieved than in 2005 (CEMT, 2008).

A 2006-2008 study ***RAILCALC*** examined current accounting and charging practices of IMs in order to develop a best practice guide and to verify compliance of each IM with the EC Directive 2001/14/EC. The study created a best practice guide for a tariff system. The study recommended a system where at minimum, tariffs cover maintenance and renewal costs on a per train-km, vehicle-km or ton-km basis, taking into account vehicle characteristics and service type. It recommended against charging short-run marginal costs as they do not include track renewal. The study recommended applying mark-up charges as either a fixed or a variable element on a path-km or train-km basis. A performance scheme was recommended for segments with restricted capacity and secondary delay problems in order to minimize network delays. Variable mark-ups were recommended, as they would correspond to initial line costs (Railcalc, 2007-2008).

Other research has been conducted on the topic of rail infrastructure pricing, resulting in numerous papers and theses. These will be referenced in the next chapters as necessary.

3. Analysis of Existing European Railway Infrastructure Tariff Systems

In order to better understand the current state of railway infrastructure pricing in Europe, the history and structure of existing systems needs to be examined in some detail. The first part of this chapter will examine railway tariff structure of Belgium, France, Germany, the Netherlands, Spain and Portugal, as well as charging systems of some special infrastructure projects (bridges and tunnels). The second part of the chapter will look into critical aspects of key European tariff systems, their objectives and priorities. The final part of the chapter will look at trends in pricing of railway infrastructure.

3.1. Tariff System Structure in Key Western European Countries

This part of the chapter will examine tariff systems in key Western European countries, including Belgium, France, Germany, the Netherlands, Spain and Portugal as well as charging schemes for special infrastructure projects such as bridges and tunnels.

3.1.1. Belgium

The Belgian railway Infrastructure Manager, Infrabel, is responsible for administering the country's railway infrastructure. The primary passenger operator in Belgium is SNCB/NMBS. The overall structure is shown in Figure 1.

A. Tariff System: Lines

Belgium uses a multiplicative tariff system, where coefficients for all parts of the tariff are multiplied together, to obtain a final price for the line section in question. A relatively small administrative cost is charged on an annual basis. The tariff includes a basic price per kilometer, which is multiplied by each of the following coefficients related to:

1. Movement priority
2. Line section importance
3. Maximum line section speed
4. Environmental impact
5. Train Weight
6. Time of day
7. Train path customization

1. Movement Priority: *Service Type*

The *coefficient of movement priority* represents the service type and is divided into six categories for high-speed trains; classic international passenger trains; intercity, inter-regional, ICT and rapid P trains; L trains, CR trains and rapid freight trains; slow freight trains and technical trains; and empty trains. Dividing this coefficient into categories allows the Infrastructure Manager to better capture the willingness to pay of each service type.

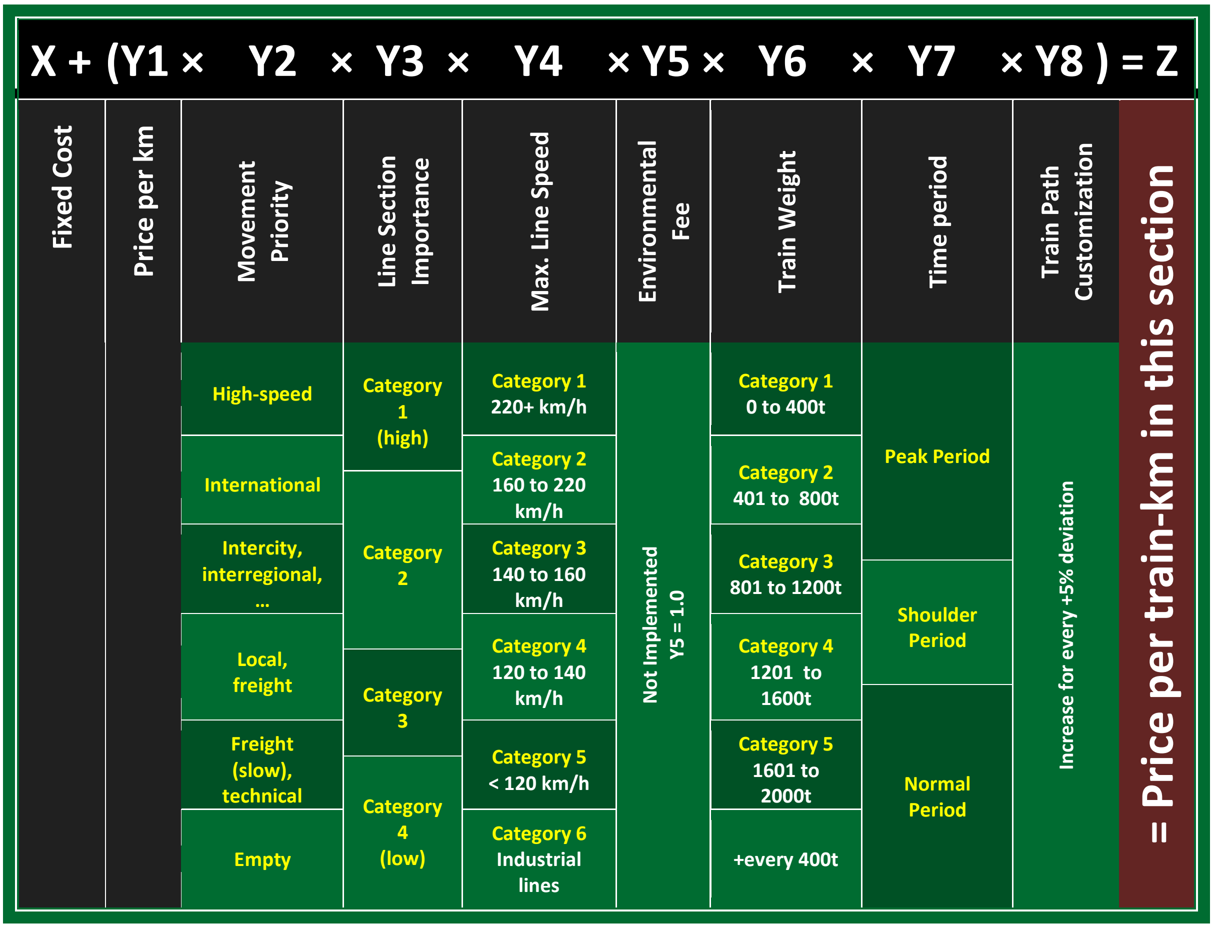


Figure 1: Belgian Tariff System Structure
Source: Infrabel

2. Line Section Importance: Amount of Traffic

The coefficient for *line section importance* is divided into four categories and varies with the importance of the line section in the network, as determined by the IM. This component represents the volume of traffic on a certain line section and allows the Infrastructure Manager assign a value to a certain line segment so as to better correlate demand with available capacity.

3. Maximum permitted line speed: Section Type Coefficient

Coefficient of maximum line section speed divides the network into six categories and places each section in the appropriate category, depending on the maximum allowed speed for that section. This coefficient allows the Infrastructure Manager to convey the available supply of capacity and the value of each section to users, with the main factor being the operating speed.

4. Environmental Coefficient

While present, the *environmental coefficient* is not currently implemented, as directive 2001/14/EC requires similar policy measures to be implemented to all transport modes.

5. Weight Coefficient

The *weight coefficient* is a step-linear coefficient, allowing the Infrastructure Manager to reflect the impact of a train's weight on the track. The system used in the Belgian case has a minimum coefficient for a weight of 400 tons and increments for every additional 400 tons, making the system step-linear. This system does not promote or demote any type of train composition, except for a minimum of 400 tons, a level below which the operator has no incentive to reduce train weight.

6. Time of Day Coefficient

The *time of day coefficient* has three periods and varies not only per line segment, but also per direction, allowing specification of a peak direction on each line section in each time period. Differentiation by time of day allows the Infrastructure Manager to better capture the value of a particular slot, just like the differentiation by amount of traffic per line segment. The Belgian system is divided into three time periods: peak hour, shoulder period and normal period. Each of these periods can be applied to any segment in one or both directions.

7. Train Path Customization Coefficient

The *train path customization coefficient* increases for every 5% deviation from a pre-defined path. This uniquely-Belgian feature penalizes customization of train paths by adding a multiplicative coefficient for path discrepancy. This suggests to railway users the use of standard paths provided by the Infrastructure Manager and penalizes non-standard services. This may have an impact on the "creativity" of railway users in devising new types of services.

While the calculation of the tariff is simple, it is more difficult to determine the origin of each coefficient, which is unlike additive systems, where each part is more clearly defined.

B. Tariff System: Stations

Usage Price (P)	Type of Use (CU)	Station Importance (C)	Time(t)
€ per use	Origin Stop Destination	4 categories	Time of use, above pre-set time limit
Usage Price = P × CU × C + P × 0.2 C × t $^{(1 + 0.01 C)}$			

Figure 2: Belgian Station Tariff System Structure
Source: Infrabel

Station charges in Belgium are also multiplicative. The Belgian tariff system uses a complex multiplicative formula to calculate the cost of using a station, shown in Figure 2. The main part of the charge is determined by a base cost per use, with a multiplicative factor for the type of use (origin, destination or intermediate station) and the importance of a station (divided into four categories). A train is harshly penalized, for using the station for more than a pre-defined amount of time by an additive exponential component that kicks in after the pre-defined stopping time expires. It should be noted that Brussels-Midi TGV, a high-speed station, is in separate category from other station types, even though it is physically part of the Brussels-Midi station. This is because the IM is interested in capturing the higher willingness to pay of high-speed trains.

C. Concepts

Lines: *weight coefficient, service type, customization of train paths, amount of traffic, line type, time of day, environmental coefficient*

Stations: *station importance, type of use, time penalty for overstaying*

3.1.2. France

The French Infrastructure Manager, Réseau Ferré de France (RFF), is responsible for administering railway infrastructure in France. However, it contracts out some of its maintenance duties to SNCF, who is also the primary passenger operator in the country.

A. Tariff System: Lines

The French pricing system has six components which allow the IM to regulate demand levels and to influence the amount of capacity used. Unlike Belgium, which uses a multiplicative system, the French system is additive, allowing for changes to each group of tariff components, while sending a clear message of intent to railways users. Figure 3 shows the structure of the French tariff system.

It consists of three basic parts: a *Reservation Charge*, a *Running Charge* and a flat *Access Fee*, applied only to certain regional trains. The *reservation charge* includes a basic per kilometer fee, which depends on line type and volume of line traffic. It is multiplied by peak factors and a train capacity factor, as well as a factor for originating or terminating a train in Paris. The second part includes the running charge, which is a per kilometer charge that depends on line type. Finally, a fixed market access fee is levied on regional trains, payable on an annual basis.

Reservation Charge

The reservation charge is levied in order to cover capital construction costs. This charge may not be proportional to construction costs of a specific line. Rather, it is averaged over multiple lines of the same type as a way to maximize cost recovery. This charge consists of a basic per-km fee (which depends on the type of line), multiplied by a peak coefficient (which depends on the time of day), a coefficient that depends on the train's origin or destination, and a coefficient that depends on the train's capacity.

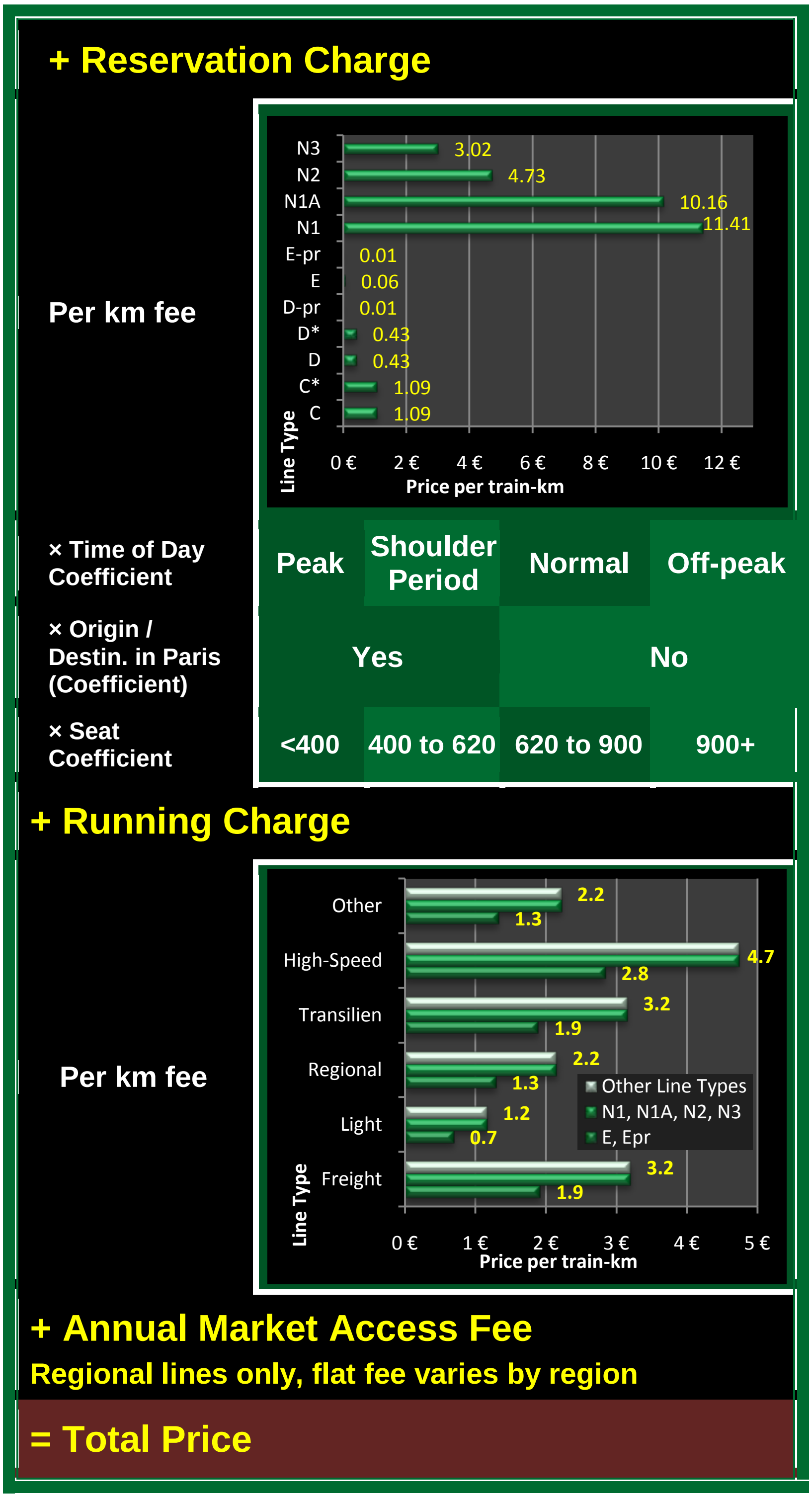


Figure 3: French Tariff System Structure
Source: RFF

Line Type and Amount of Traffic

First, the French system splits its lines into four categories. Each of these categories is then split into sub-categories that depend on the volume of traffic on each line. The categories are: suburban lines (two subcategories: A and B), main intercity lines (five subcategories: C, C*, D, D*, D-pr), high-speed lines (five subcategories: N1, N1A, N2, N3, N4) and other lines (two sub-categories: E, E-pr). A per-kilometer charge is levied on each train, subject to multiplicative factors described below.

Time of Day

Second, the French system has multiplicative factors, allowing for peak period differentiation. There are four types of periods: Peak, Intermediate, Normal and Off-peak. This differentiation allows the Infrastructure Manager to capture the operators' willingness to pay, which is related to the willingness to pay of the operators' customers, during each of these periods. For example, during peak periods, operators' willingness to pay is generally higher due to higher demand for railway services.

Origin-Destination Differentiation

Third, the French system charges a multiplicative factor for trains originating and terminating in Paris. While it may be justified as a way to promote efficient use of capacity in Paris, this concept is a simple way to distinguish between different markets, which corresponding trains serve, allowing the Infrastructure Manager to capture higher willingness to pay for services originating or terminating in Paris.

Train Capacity

Fourth, trains are separated by capacity with multiplicative factors applied to the reservation charge in a step-linear manner (four categories total), based on the number of train seats offered. This, again, allows the capture of revenue based on a train's ability to pay, which is proportional to the number of available seats. This concept also has an effect on efficient network capacity utilization, as with this charge a train operator may have an incentive to run lower capacity trains, depending on charging levels.

Running Charge: Train Type and Line Type

RFF imposes a *Running charge*, which depends on the type of train. This charge is levied on a per train-kilometer basis and covers variable operating and maintenance costs. It is the same on line segments designated as high-speed, suburban and main intercity. Lines designated as "other lines" (categories E and E-pr) have lower levels of running charge fees.

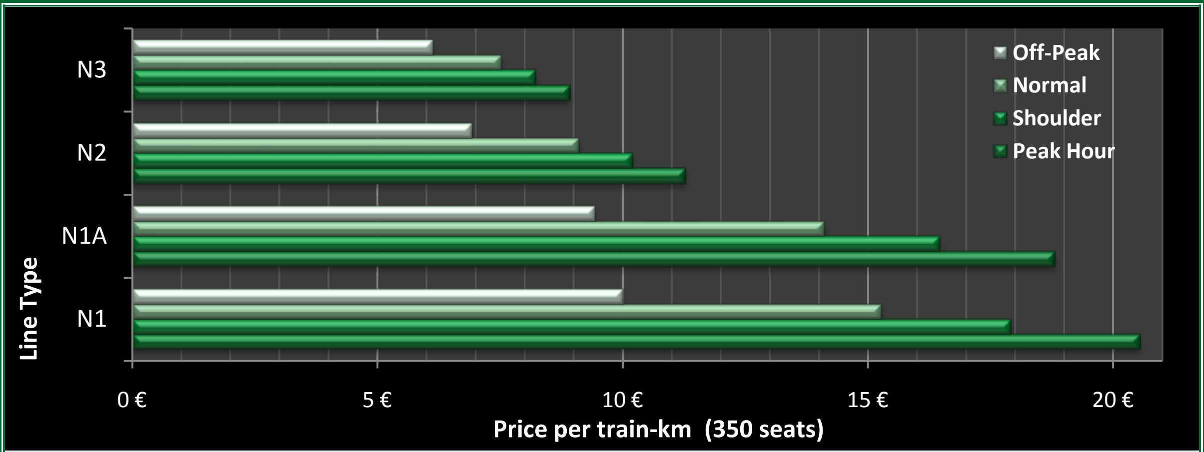
The charge varies by train type and is split into the following categories (from highest to lowest): high-speed, regional (Transilien), freight, regional (other types), others, light/empty.

Market Access Fee

An *access fee* is levied on regional trains and varies by region. Regional services are normally subsidized by regional governments and these access costs are a way to redistribute funds between the State and the Infrastructure Manager, allowing the Infrastructure Manager to fund maintenance and network development projects.

B. Resulting Tariff Levels

The resulting tariff levels for high-speed lines vary greatly between line type N3 (7.53€ per train-km during normal period) and line type N1 (15.28€ per train-km during normal periods). The differences between different time periods are significant. For example, peak period fees are between 9% and 34% higher, and shoulder period fees are between 9% and 17% higher than normal period fees, depending on line type. Figure 4 shows absolute tariff levels for various French high-speed lines on a per-kilometer basis for a high-speed train with 350 seats.



Line Tariff Type: 3 parts

- Three parts in the tariff, with one fixed and two variable parts
- Origin/Destination in Paris coefficient applies only to high-speed lines (Nx)
- Access fee applied only to regional trains
- Stations do not have a fee as they are owned by SNCF (main operator)

Figure 4: Comparison of tariff levels between different line types in the French system
Source: RFF

C. Tariff System: Stations

French stations are owned by the primary operator, SNCF, and are not taxed by the IM.

D. Concepts

The following concepts are in use in France: *line type, amount of traffic, time of day, variation of charges depending on the origin and destination of the train, train capacity, train type,* and *fixed access costs.*

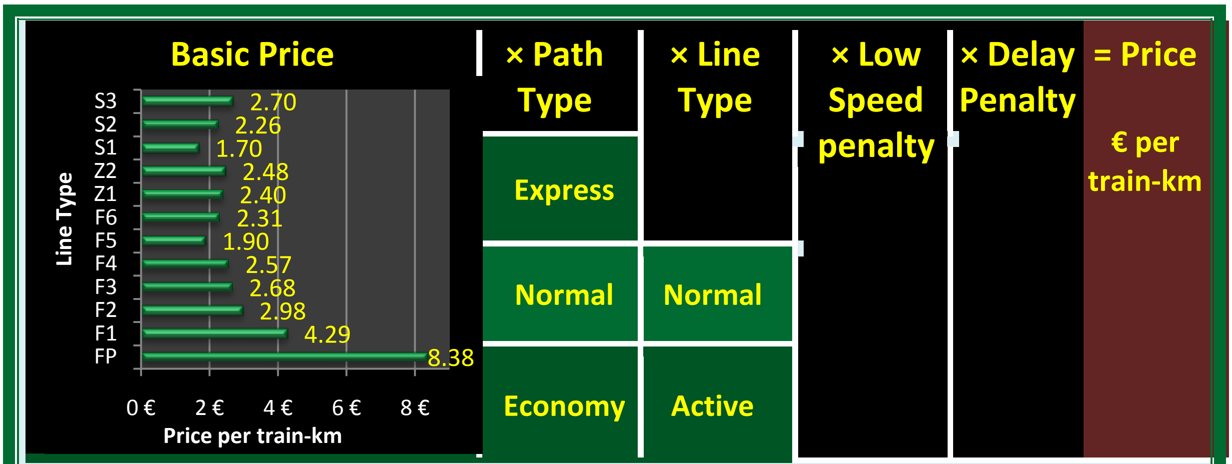
3.1.3. Germany

Deutsche Bahn AG is a German transportation and logistics corporation, which is responsible for both administering the railway infrastructure in Germany and for operating some passenger services. The holding company has several divisions, among which are DB Netze (the Infrastructure Manager), DB Bahn (the long-distance train operator), and DB Regio (regional train operator). As required by directive 2001/14/EC, the Infrastructure Manager's accounts are split form the operators' accounts.

A. Tariff System Definition: Lines

Germany uses a multiplicative tariff system, where trains are separated by line type, volume of traffic, and path type. It includes a performance scheme to discourage delays and low speed operations.

The system, shown in Figure 5, uses a simple tariff per kilometer, multiplied by factors described above. Regional multipliers have been used until recently for regional services, however these have been ruled anti-competitive by a German court. The German system does not attempt to recover capital costs, but tries to promote redistribution of costs to other parts of the system, which may need renovations. (Beria, Quinet, de Rus, & Schulz, 2010)



Tariff per train-km depends on line type (F1 to F6 and FP for long-distance, conventional, and high-speed services; Z1 to Z6 for feeder lines; and S1 to S3 for suburban lines)

Multiplicative factors:

- Path type (Express, Normal or Economy)
- Line type (Normal or Active)
- Low-speed penalty as part of a performance scheme

Figure 5: German Tariff System Structure
Source: Deutsche Bahn AG

Line Type

Lines are divided into three main classes: intercity (seven types), feeder (two types) and suburban (three types). Differentiation between subtypes is determined on a number of factors, including maximum operating speed, number of tracks, availability of electric traction, type of control system and other line factors. The resulting base tariffs are charged on a per-km basis.

Path Type – Service Type

Each path is assigned a type: express, regular, economy or light running. An express train path has the highest multiplicative coefficient and is routed in the most direct way. A regular path involves at least four train pairs per day using a similar route and stopping patterns. These paths generally apply to long distance (including high-speed) trains and local urban rapid transit services. An economy path does not involve regularly-scheduled services, while a light-running path allows movement of traction and work units. This differentiation by path type essentially differentiates the network into different service types.

Amount of Traffic

A line may be designated as *active*, triggering a multiplicative coefficient. This permits the IM to better reflect the value of one line over another, without getting into too much detail over which train slots have higher value, something that would be required with separation by time of day.

B. Tariff System: Stations

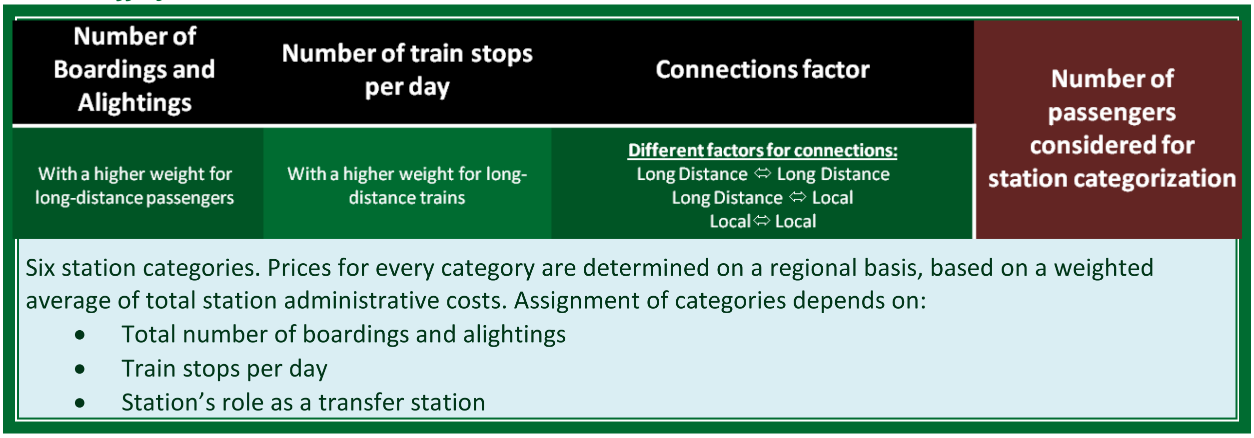


Figure 6: German Tariff System Station Structure
Source: Deutsche Bahn AG

The structure of the German tariff system for Stations is shown in Figure 6. Stations are first assigned a category, based on their importance. The category is determined by the number of boardings and alightings, number of train stops per day, and the importance of the station as a transfer facility. Once the category is assigned, a price is determined based on the total cost of station administration in the region, divided by the number of stations, taking into account each station's category, resulting in a weighted average cost.

C. Concepts

Lines: *line type, service type, amount of traffic*

Stations: *station importance*

3.1.4. The Netherlands

Figure 7: Dutch Tariff System: Lines
Source: ProRail

In the Netherlands, ProRail is responsible for administering the railway infrastructure in the country, while the principal passenger operator is Nederlandse Spoorwegen (NS). Figure 7 and Figure 8 show the Dutch tariff structure for lines and stations, respectively.

A. Tariff System Definition: Lines

In the Netherlands the additive tariff system covers only marginal social costs on non-high-speed segments. The additive system consists of a basic price per kilometer with three line types (based on line importance), a price per ton-kilometer to compensate for the train's impact on the track, and a high-speed surcharge, which is charged to recover capital costs of constructing the high-speed line, added for the 2011 timetable year. The 2010 basic tariff varies between 0.6751€ (line type A) and 0.7319€ (line type C) per train-km. The surcharge for the high-speed line for the 2011 timetable year is 41.53€ per train-km. The high-speed line was constructed under a public-private partnership (PPP) regime and attempts to cover of most of the initial investment costs. (Project Finance Magazine, February 2002)

Line Type

In the case of the Netherlands, line types are separated into three categories, depending on section importance. This differentiation allows the IM to reflect a train's impact on the network capacity.

Ton-Kilometer Charge: Charge for Train Weight

A charge per ton-kilometer can reflect the impact of a train on the railway line, as line maintenance costs are proportional to train load per axle. Because this charge is linear, the railway user has no incentive to maximize or minimize a train's weight.

High-Speed Flat Surcharge

A flat surcharge is levied on the high-speed sections of the network. This charge is levied due to the public-private partnership (PPP) scheme, under which this line was constructed, which requires recovery of initial capital investment costs. The charge per kilometer is very high compared to the normal per-kilometer charge.

B. Tariff System: Stations

There are two types of differentiation in station charges in the Netherlands: by <u>train type</u> (A, B, or C) and by <u>station type</u> (stop, basic, plus, mega or cathedral). Trains that stop at all stops along a line are charged less than trains that bypass some stations, a way to provide separation between local, regional and long-distance markets. For example, a *type A* train must stop at 75% or greater number of stations on its path, while a *type B* train must stop at a minimum of 50% of all stations along its path. A *type C* train does not have any restrictions regarding the number of train stops. The charges vary between 1.32€ and 10.98€ per stop for a type C train with a 20% discount for a type B train and a 25% discount for a type A train. This type of separation effectively decreases the costs of running local and regional trains.

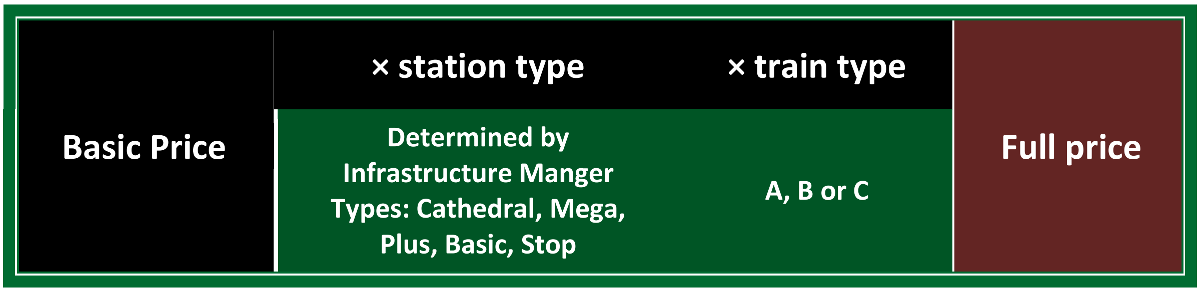


Figure 8: Dutch Tariff System: Stations
Source: ProRail

At the same time, importance of a station as designated by the IM (in this case the stations are divided into five categories) also has an impact on the level of charge.

C. Concepts

Line Charges: *line type, ton-kilometer, high-speed line surcharge*

Station Charges: *train type, station type*

3.1.5. Spain

In Spain, ADIF is the Infrastructure Manager responsible for administering railway infrastructure, while Renfe Operadora is the primary passenger operator in the country.

A. Tariff System: Lines

The structure of the Spanish tariff system is shown in Figure 9. The Spanish additive tariff involves the following variables:

1. **Traffic volume**
2. **Line type:** two types of high-speed lines (V1 and V2) and two types of conventional lines
3. **Service type:**
    a. High-speed service with v_{max} > 260 km/h
    b. Normal service v_{max} < 260 km/h
    c. Freight trains
4. **Time of day:** three periods (peak, normal, off-peak)
5. **Number of seats per train**

The tariff system is divided into four parts:

1. Fixed Access Charge (fixed administrative cost)
2. Reserve Capacity Tariff
3. Operating Tariff
4. Traffic Tariff

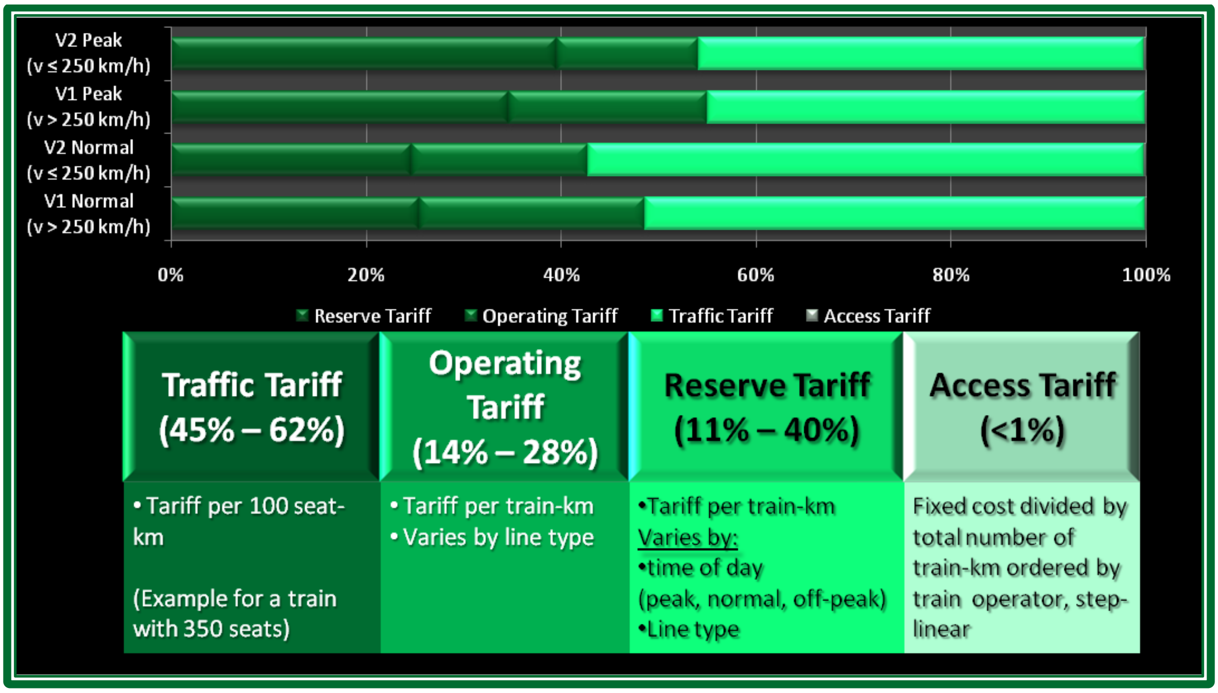


Figure 9: Spanish Tariff System Structure
Source: ADIF

1. Fixed Access Charge

The level of the access charge depends on the number of annual kilometers that a RU orders. The charge is small when divided per kilometer, however if this charge was not graduated, with five different levels of possible capacity consumption, it could potentially act as a barrier to entry into the market for smaller operators or international operators, operating a small number of services, or on a small part of the Spanish territory.

2. Reserve Capacity Tariff

The reserve capacity tariff reflects the availability of a route, which the railway user requests. It is differentiated in three ways: by time of day, by line type and by service type. This part of the tariff makes up between 11% and 40% of the full price. The differentiation allows reflecting the value of a train slot during each of the three time periods. This charge is levied for each train kilometer reserved. The values are between 0.05€ and 3.01€ per train-km on conventional lines and between 0.69€ and 3.65€ on high-speed lines.

3. Operating Tariff

The Operating Tariff imposes a charge for every used train-kilometer. It is also differentiated based on the line and service type. Because the value of a train slot, which varies depending on the time of day, is reflected in the Reserve Capacity Tariff, the Operating Tariff does not use time-of-day differentiation. The values for this fee are between 0.06€ and 0.64€ per train-km for conventional lines and between 0.74€ and 2.14€ per train-km for high-speed lines.

4. Traffic Tariff

The traffic tariff reflects the economic value of offered capacity. It is levied only on high-speed lines and only during normal or peak time periods. It is charged for every 100 seat-kilometers, which effectively means a set per-kilometer charge for each train type. This charge captures each train's ability to pay, which varies with the train's capacity. The values of this tariff are between 0.69€ and 1.35€ for every 100 seat-km.

Variables

Time of Day

The reserve capacity tariff, just as in the French case, allows to reflect the value of a train slot, given that desirability (and ability to pay) of one during peak periods is higher than during off-peak periods.

Service Type

Service type is differentiated in two ways: passenger or freight, and, for passenger service, by speed: greater or less than 260 km/h. Differentiating services with only two steps may influence railway users to run high-speed services at only 260 km/h, when the trains are physically capable of running at higher speeds.

Line Type

Lines are differentiated by type and location: two types of high-speed lines, Mediterranean corridor (between Valencia and Tarragona), and other lines. The high-speed lines are differentiated based on line construction costs.

Train Capacity

Spain differentiates train capacity, charging railway users on high-speed lines for every 100 seat-kilometers. This allows capturing of each train's ability to pay, which depends on the number of occupied seats.

B. Line Tariff Levels

Resulting Spanish high-speed line tariff levels vary between 4.16€ and 10.52€ per train-km for A1 type lines and between 3.85€ and 10.04€ for A2 type lines. Figure 10 compares tariff levels between various high-speed services on different line types.

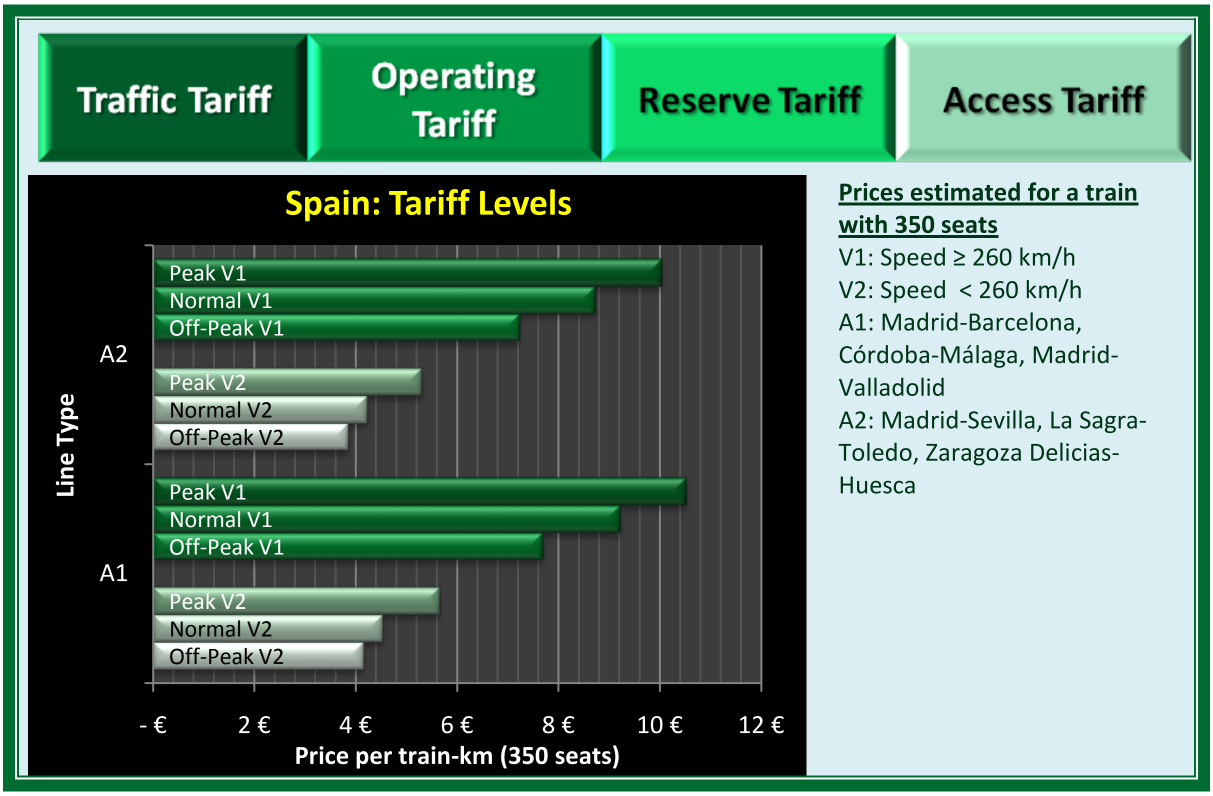


Figure 10: Comparison between price levels of various Spanish high-speed lines
Source: ADIF

C. Tariff System: Stations

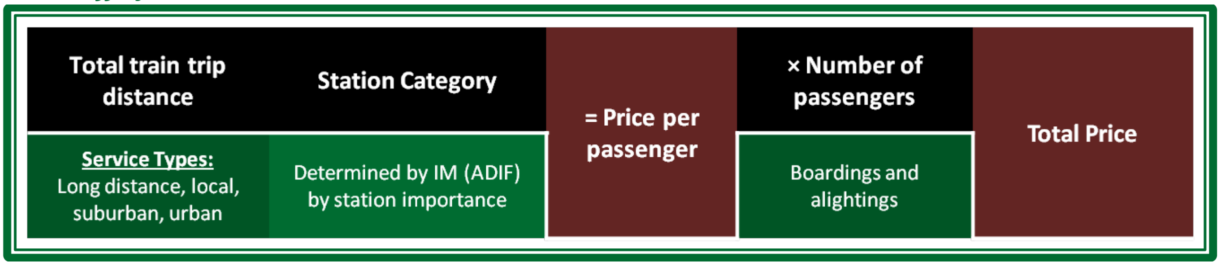
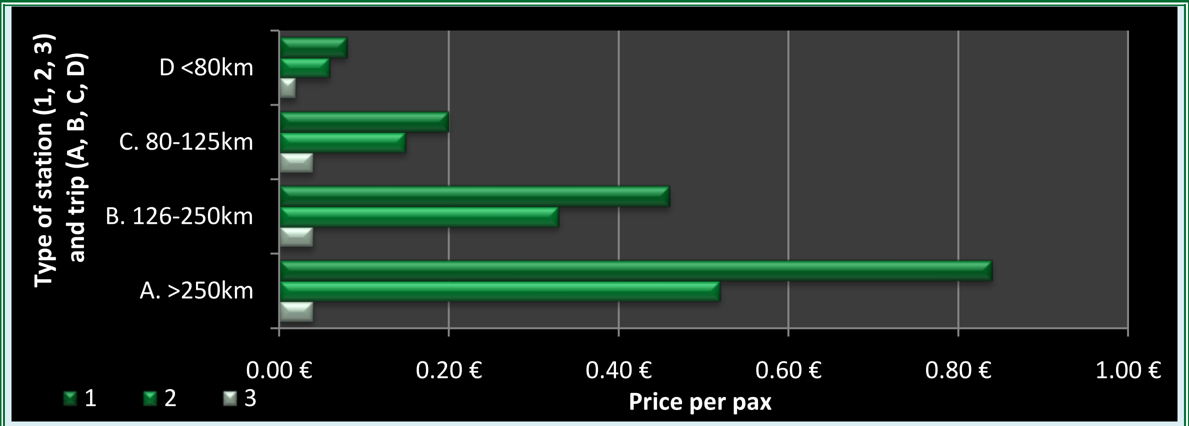


Figure 11: Spanish station tariff system structure
Source: ADIF

Stations have a differentiation in two ways: station category, based on importance, and type of journey. Figure 11 shows the structure of the Spanish station tariff system.

Station type is determined by importance of the station. The price for stations in category 1 (e.g. Madrid – Atocha, Barcelona – Sants, Córdoba – Central, etc.) is between 0.08€ and 0.84€ per passenger, depending on the type of service. In category 2, the prices are between 0.06€ and 0.52€ per passenger. The prices in category 3 are between 0.02€ and 0.04€ per passenger.



Station prices depend on trip distance, trip type and station type.

Station categories:

1. **High Importance**: Madrid – Atocha, Barcelona – Sants …
2. **Medium Importance**: Calatayud, Madrid – Atocha, Suburban stations
3. **Other Stations**

Figure 12: Station charging levels per passenger in Spain
Source: ADIF

The train journey distance is divided into four categories, with limits at 80 km, 125 km and 250 km. The charge is levied per passenger that uses the station. Station stopping fees vary by stopping time with limits at 15, 45, and 120 minutes, with the first fifteen minutes being free. Figure 12 shows various price levels by journey and station type. This differentiation allows capturing of each passenger's cost to the station (their use of facilities) and the value a passenger brings to the station. For example, a long-distance passenger requires more services and facilities, but may also bring more value to the station.

Parking fees at stabling sidings also depend on the amount of parking time, with the first hour being free. After the first hour the following rates are charged: 15.48€ (between 1 and 6 hours), then 2.04€ for each additional hour until 12 hours and 3.01€ for each additional hour until 24 hours, or 38.58€ per day.

D. Concepts

Line Charges: *fixed access charge, time of day, service charge, line type, train capacity*

Station Charges: *station type, length of train journey*

3.1.6. Portugal

A. Tariff System: Lines

The Portuguese tariff system divides the network into homogenous line groups, based on the primary traffic type (freight or passenger) and on the type of traction used (electrified or non-electrified). Tariff groups and levels shown in Table 1.

Table 1: Portuguese Tariff System Price List

Code	Designation/Type	Passenger Paths		Freight	
		Electric Traction	Non-electric Traction	Electric Traction	Non-electric Traction
GH1	**Lisbon Suburban Area** (Sintra, Cascais, and Belt Lines, South line btwn. Campolide and Setúbal, West Line between Cacém and Meleças, Xabregas junction, Sete Rios Jct., Alentejo Line Jct., Barreiro and Pinhal Novo)	1.49	1.46	1.63	1.55
GH2	**Porto Suburban Area** (Minho Line btwn Porto S. Bento and Nine, Douro Line btwn Ermesinde and Caíde, Braga Br. Line, Guimarães and Leixões line, S.Gemil jct.)	1.41	1.40	1.47	1.45
GH3	**North Line** Suburban Lisbon section (Lisbon – Azambuja)	1.23	1.20	1.32	1.23
GH4	**North Line** Btwn. Azambuja and Aveiro	1.4	1.38	1.45	1.41
GH5	**North Line** Suburban Porto area	1.56	1.54	1.61	1.56
GH6	**Electrified** lines, with automatic or telephone signaling, with **mixed traffic <50 trains/day**	1.62	1.45	1.64	1.47
GH7	**Electrified lines** with automatic or telephone signaling, with **predominantly freight traffic**.	1.27	1.14	1.30	1.21
GH8	**Non-electrified** lines, with automatic or telephone signaling, with **mixed traffic <50 trains/day**	-	1.82	-	2.01
GH9	**Non-electrified** lines, with simple signaling, with **predominantly freight traffic**.	-	-	-	-

Source: REFER

B. Tariff System: Stations

Station prices are derived from a model that considers various factors that influence costs of operating the stations, including the number of train stops per day and actual level of station use.

C. Concepts

Lines: *line type*, *service type*

Stations: *Station Importance*

3.1.7. Special Infrastructure Projects

A. Øresund Bridge

The Øresund Bridge links Copenhagen, Denmark and Malmö, Sweden. Constructed in 2000, with a length of 7.845 km, at a cost of 4,038 million Euros, this bridge levies a basic charge of 0.268€ per train-km and a fixed surcharge of 268€ per passenger train and 324€ per freight train on the Danish side. On the Swiss side, the charges are 0.11€ per train-km. The total price per train is a flat fee of 271€ for passenger trains (34.54€ per train-km) and 327€ (41.68€ per train-km) for freight trains. (Banedanmark, 2010) (Trafikverket, 2010)

B. Great Belt Link

The Great Belt Link connects the Danish islands of Zealand and Funen, linking Copenhagen to the European continent. Constructed in 1998 with a length of 6.79 km, at a cost of 2,871 million Euros, the bridge levies a basic charge of 0.268€ per train-km for all trains as well as a flat surcharge of

854€ (125.78€ per train-km) for passenger trains and 791€ (116.59€ per train-km) for freight trains. (Banedanmark, 2010)

C. Lötschberg Base Tunnel

The Lötschberg Base Tunnel cuts through the Alps, connecting Switzerland to Italy. Constructed in 2007, with a length of 34.57 km, the tunnel has a basic charge of 0.309€ per train, same as on the rest of the Swiss network, and a tunnel safety surcharge of 1.543€ per train-km. The full price is 1.852€ per train-km, which totals to 64€ per train. (SBB/CFF/FFS, 2010)

D. Channel Tunnel

The Channel Tunnel links the United Kingdom to France under the English Channel. Constructed in 1994 with a length of 50.45 km, the tunnel has a variable tariff, which depends on the time of day, number of passengers and frequency of service. A per-passenger charge of 16.60€ is levied, with a minimum of 350 passengers. The charge per train that runs on a weekly basis is 77.76€ per train-km (193.96€ per train-km with 350 passengers) for off-peak periods, 86.04€ per train-km (202.60€ per train-km with 350 passengers) during normal hours, and 95.04€ per train-km (211.24€ per train-km with 350 passengers) for peak periods. One-time trains that are planned more than a week in advance have a surcharge of 10% and the same type of trains that are planned less than a week in advance have a surcharge of 15%. Empty trains do not pay the passenger surcharge (Eurotunnel, 2009).

3.2. Critical Analysis of Key European Tariff Systems

This section will first analyze objectives and pricing principles of various tariff systems, then look at how these principles are applied in each country, and finally discuss the most common types of systems in use.

3.2.1. Objectives and Pricing Principles

A. Introduction

One of the goals of EU directive 2001/14/EC was to establish a rail infrastructure tariff system in each country. However the directive left the details of implementation up to individual countries. The fact that each country has different objectives and goals in pricing has not been mentioned yet. Also, the most important question has not been asked up to this point: why have a tariff system in the first place? This section will tackle these issues, looking at the reasons for charging for infrastructure use and also examining each country's system in terms of goals and pricing principles.

B. Purpose

Why charge for rail infrastructure use? This question needs to be answered first. From a physical point of view, rail infrastructure is much more rigid and in order for it to be used optimally, a proper service type mix has to be guaranteed. For example, mixing high-speed and slow speed trains will result in very inefficient use. This can be easily demonstrated on a time-space graph if one compares the aforementioned mix with all trains of the same type (whether all fast or all slow). In the case of the latter two types, a larger number of trains can pass through a given line section than in the case of mixing the two types. Having a tariff system that encourages certain types of services to use certain types of lines solves this problem and organizes the system and promotes efficiency.

Second, one of the main goals of the European Railway Reform as detailed in Directive 2001/14/EC is to encourage competition among RUs while having a separate railway IM who would be responsible for investing in infrastructure (development and maintenance) while selling capacity to RUs. Allowing a scarce resource (capacity) to have zero cost leads to inefficient use and abuse (e.g. hoarding), and distorts competition. (Adler, Nash *et al*, 2003)

C. Economic Pricing Principles

There are a number of economic pricing principles that can be used to implement existing legislation, depending on each country's requirements. The basic division is split between charging marginal costs and charging full costs for infrastructure use.

Marginal Cost Pricing

In the case of railways, short-run marginal costs are additional costs incurred by the IM for adding a train to the network. Long-run marginal costs will include renewals of infrastructure and any other costs that are considered variable in the long run. Charging marginal social costs will maximize social welfare and minimize exclusion of train operators from the network. However, this will leave a deficit that the IM will have to cover, possibly through assistance (subsidization) from the state. Two of the biggest problems with MC pricing are the complexity of marginal cost calculation and the amount of deficit that the IM is left with. A variation on this type of pricing, "MC+," considers additional mark-ups in order to reduce the State's contributions. In this scheme, mark-ups need to be clearly defined and should not exclude operators, who are able pay marginal costs (Nash, 2003).

Full Cost Pricing

Full-cost pricing involves charging the user full costs incurred in provision of services and construction of infrastructure. This approach includes large sunk capital costs that are characteristic of railroad operations, which prevents maximizing social costs, but provides a high recovery rate to the IM and, thus, a low impact of the rail operations on the State's budget. If not properly implemented, full cost pricing may exclude services with lower willingness to pay (WTP). A variation of full cost pricing (FC–) involves a set contribution from the state.

Ramsey Pricing

The Ramsey Pricing concept considers responsiveness of RUs to costs and suggests tying the amount charged to RUs' willingness to pay (WTP). While this theory may leave the IM with a deficit, it attempts to be a second-best approach, better than charging MC in terms of cost recovery and better than charging FC in terms of efficiency. While the directive 2001/14/EC recommends charging "directly-related costs" (best interpreted as short-run marginal costs), it also allows for levying mark-ups, so Ramsey Pricing fulfills the directive's requirements. Including incentives in the tariff systems will send a clear message to RUs regarding the type of behavior expected from them as far as levels and type of traffic (Rothengatter, 2003).

Two-Part Tariffs

A two-part tariff includes a fixed access cost and one or more variable costs. The variable part of the tariff may be implemented both as a multiplicative tariff (with a base price and a number of multipliers) or as a multi-part additive tariff (with each part being multiplicative or additive). Two-part tariffs are one approach to structure public service obligations (PSOs) without having to explicitly declare a concession regime. However, two-part tariffs with a high fixed cost are discriminatory to small operators or operators that operate cross-border services, terminating their service just across the border. This makes spreading the access fee over a large number of train-km difficult and may exceed the RUs' WTP. This type of tariff has been ruled anticompetitive in

Germany, when it was applied to regional services. Such a tariff still exists in the railway regional services in France. A variation of this charge exists in Spain, where the charge is levied using a step-linear function, depending on the number of train-km ordered per calendar year. However, in that case it is considered an administrative fee and its amount is not significant enough to be anticompetitive to small RUs. (Beria *et al*, 2010)

D. Brief Analysis of National Tariff Systems

Belgium

The Belgian tariff system uses a FC– methodology and the IM receives some subsidies from the State. The tariff system sends clear messages to railway users as to available supply and amount and type of desirable demand. The reasoning behind this system, as well as the reasons for coefficient values cannot be determined. The system splits demand, based on ability to pay of each train type and uses an innovative system for stations, imposing a large penalty platform use of long duration.

France

The French tariff system uses a MC+ methodology, levying high mark-ups on high-speed rail services. The tariff system attempts to reflect the real value of each high-speed train slot, by differentiating train type, line type, etc. It effectively prices out regional trains from high-speed lines with very high charges and places high barriers to entry into the market for regional services in each region, forcing competition for the market, rather than in the market. In high-speed services, line categorization by volume of traffic reflects the desirability of one line over another. The system attempts to reflect a train's ability to pay, based on a number of factors, including its capacity.

Germany

The German system, just like the one in Belgium, uses a FC– methodology and sends a clear message to railway users as to what type of behavior offers bigger advantages. Just like in the Belgian system, it does not allow determination of the origin for each coefficient. The German system also does not differentiate based on the time of day, potentially undervaluing certain time slots or overvaluing others. The IM is not required to recover full costs of newly-constructed HS lines, but rather to use revenue from these lines to reinvest in renewal and/or development of the network.

The Netherlands

The Netherlands uses a MC principle, with very low values for its tariffs, allowing it to recover maintenance and administration costs. A high high-speed line (HSL) surcharge allows it to recover initial investment costs (FC). A lack of differentiation of charges based on the time of day may potentially undervalue train slots during peak periods and/or overvalue them during off-peak periods. A high HSL surcharge effectively prices out regional and low-value freight trains.

Spain

The Spanish tariff system attempts to capture the value of each train's ability to pay by using the MC+ principle. It differentiates between high-speed and non-high speed trains by line and train type. The differentiation of train types is not very precise, and may promote RU operations that are suboptimal for passengers and the IM. Fixed costs may keep certain railway users out of the market, such as those operating few services, or those operating cross-border services.

Portugal

Portugal uses a simple system with very low tariffs that are based on the MC principle. Predictably, the cost recovery of such a system is very low. This system does not take into account the time of day, type of traffic and many other factors. The applicability of such a tariff system to a high-speed line would be questionable.

3.2.2. Two Types of Charging System Structures

Directive 2001/14/EC requires each IM to publish a Network Statement that lists information about the infrastructure and about requirements for gaining access to the infrastructure. Section 6 of the Network Statement explains the tariff system and charging levels in detail.

When looking at existing network statements for the 2009-2010 and 2010-2011 timetable years, two main types of systems emerge: multiplicative and additive. The components in multiplicative systems are expressed as product factors. The resulting price (e.g. per kilometer or per use) is a product of each of these factors. In an additive system, the components are added together to come up with a final charge. Each of the components may be broken down into subcomponents and each subcomponent may be calculated in a different way.

Table 2 shows a synthesis of the tariff systems and pricing principles used in Europe.

Table 2: European Tariff System Synthesis

Country	System Type	Pricing Principle
Belgium	Multiplicative	FC–
France	Additive	MC+
Germany	Multiplicative	FC–
The Netherlands	Additive	MC (conventional) FC (high-speed)
Spain	Additive	MC+
Portugal	Multiplicative	MC

3.3. Trends in Pricing of High-Speed Railway Lines

3.3.1. Comparison of Tariff Levels between Countries

In order to better assess existing tariff systems, they will be applied to existing lines, and then compared. The following main European high-speed lines will be evaluated:

- Madrid – Barcelona (Spain)
- Madrid – Seville (Spain)
- Madrid – Valladolid (Spain)
- Madrid – Toledo (Spain)
- Cologne – Frankfurt (Germany)
- Hannover – Berlin (Germany)
- Paris – Tours (France)
- Paris – Lyon (France)
- Paris – Channel Tunnel, and Paris – Lille (France and UK)
- Paris – Brussels (France and Belgium)
- Brussels – Amsterdam (Belgium and Netherlands)

The following evaluation criteria will be used:

Train: High-Speed train with 350 seats (occupancy rate 65%), weighing 400 tons

Departure time: 8:00 AM (results in application of a peak-hour factor in systems that have one)

Service Type: Most appropriate type for a high-speed long-distance train

Figure 13: Comparison of price levels on high-speed lines between European countries
Source: Data from ADIF, DB Netz, RFF, Infrabel and ProRail
Note: Peak Period tariffs, departure at 8:00AM, Comparison: high-speed train - 350 seats, Brussels - Amsterdam uses values from 2011

Average per-kilometer values, shown in Figure 13, were obtained in this comparison: the Netherlands have the highest per-km charge (almost 15€ higher than the next-highest line), due to the high-speed surcharge on the high-speed line. The differences between France and Germany are not great, when the peak period effects of the French system are discounted.

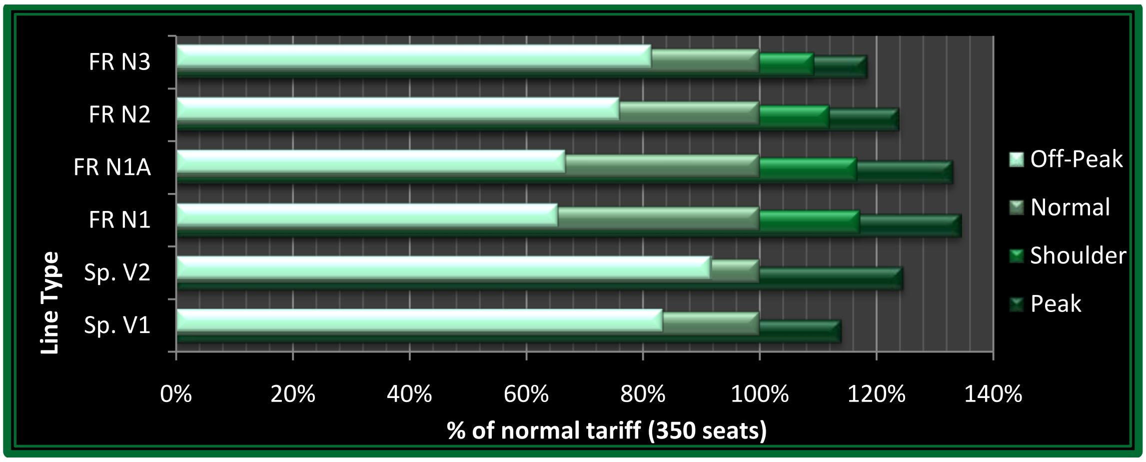


Figure 14: Comparison: French vs. Spanish Charging Levels
Source: Data from RFF and ADIF
Notes: 100% = normal tariff for each line type, Spain does not have a shoulder time period

Furthermore, when Spain and France are compared, as shown in Figure 14, it is clear that France has more variation in its tariffs between peak, normal, and off-peak periods than does Spain. French off-peak tariffs are much lower than those of the Spanish system, and the peak tariffs are much higher. It should be noted: Spain does not have an intermediate period, while France does, and this may explain a part of the difference.

3.3.2. Longitudinal Comparison of Tariff Levels (2007-2010)

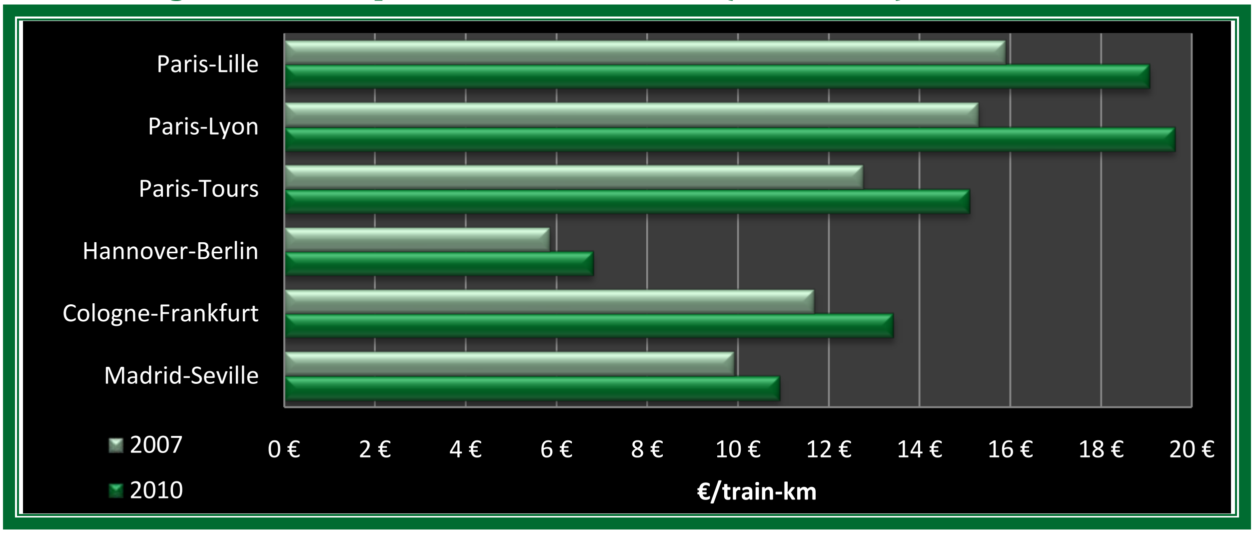


Figure 15: Evaluation of Price Levels on High-Speed Lines (2007-2010)
Source: ADIF, 2008 and Network Statements 2007 and 2010 of respective countries
Note: France overhauled its system between 2007 and 2010 and thus has a higher rate of increase

Between 2007 and 2010 prices have significantly increased on a per-km basis, as shown in Figure 15, and France completely overhauled its tariff system between these two years, adding a surcharge for trains originating or terminating in Paris, which increases the 2010 base price by 25% in comparison to the normal tariff in the same period. The increase in tariff fees leads to the conclusion of an increasing willingness to pay of railway users (on average) and of increased cost recovery figures for IMs.

When the tariff structures are compared, most of the resulting charges are for usage of lines, and, with some exceptions in Spain, the influence of stations on the overall cost is quite limited. In the few cases where the influence of station costs on the overall cost is high, this is mostly due to the shorter length of the line rather than high station charges.

In terms of different tariff principles, more and more high-speed lines are moving to the MC+ with high mark-ups or FC– principle, from a purely-MC principle for HS lines as is evidenced in the Netherlands, which have recently implemented a surcharge on the Dutch part of the Brussels–Amsterdam high-speed line.

4. Financial Recovery Potential of Key European High-Speed Corridors

4.1. Methodology

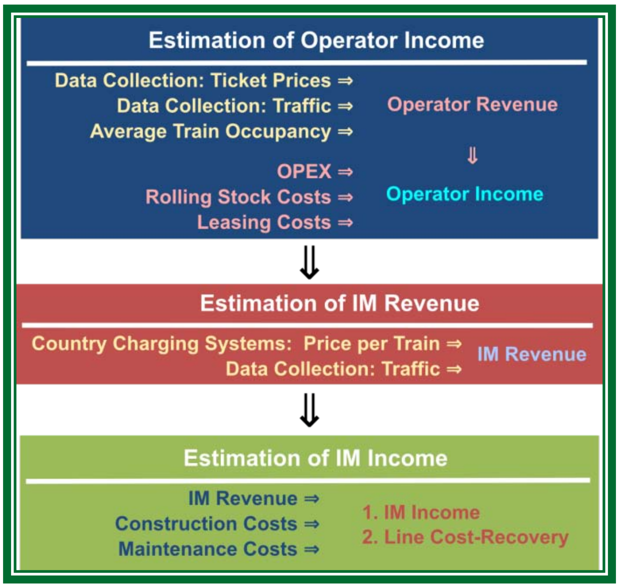


Figure 16: Methodology of estimating financial recovery potential of key European HSLs

The process of examining recovery potential of Infrastructure Managers for key European High-Speed Corridors is an important part in setting the baseline for each country and each tariff system. It presents an estimated picture of existing conditions for lines in question. The process will be divided into multiple parts and is demonstrated in Figure 16. First, operator net revenues will be estimated. This will be done by looking at ticket prices for each of the lines. After being multiplied by an average train occupancy factor, the result will yield gross revenue for each line. After subtracting operating costs, RU net revenues will be determined. Second, IM gross revenue levels for each line will be determined. This process will apply existing tariff schemes and determine per-train gross revenue levels. This will then be extrapolated to annual gross revenues per line. Finally, using estimates for construction and line maintenance costs, IM net revenue levels and investment recovery periods will be calculated for each line, thus estimating each line’s recovery potential.

4.2. Evaluation of Operator Net Revenues

4.2.1. Data Collection of Ticket Prices

In order to assess operator ticket revenue, ticket price data was collected in conjunction with a RAVE research study, using each operator’s website between endpoint origin-destination pairs for each line examined (RAVE, 2011). Many operators now use variability in ticket prices that depends on demand. Prices were collected during two weeks, five days per week, with the lowest available price in second and first classes recorded on each day of data collection, during three time periods: AM peak, midday and PM peak periods for Wednesday and Friday of the following week. This was done to account for different supply and demand levels during each time period, as well as potentially different demand levels (and ticket prices) between Wednesday and Friday. For regional trains that use high-speed lines, but have fixed prices, a proxy price of 50% of the long-distance high-speed full published ticket price was used.

Detailed results of the data collection effort are provided in the appendix. The data shows that dispersal of prices is smaller on Wednesday and that ticket prices for second class are generally higher on Friday. The biggest dispersal of prices was observed on the Paris to London line. First class tariffs have similar levels on both Wednesday and Friday. At times, prices in first class were observed to be cheaper than in second class. Figure 16 shows full and average prices for first and second classes.

It should be noted that for Spain, Club and Preferente classes were both considered as first class, and Turista as second class. For Eurostar services between Paris, Brussels and London, Premier and Leisure/Standard Premier classes were considered as first class, and Standard class was considered as second class.

When compared on a per-kilometer basis, Paris-London has the highest average and full per-kilometer price for both first and second class. Second class prices are also high on the Cologne-Frankfurt and Paris-Brussels lines.

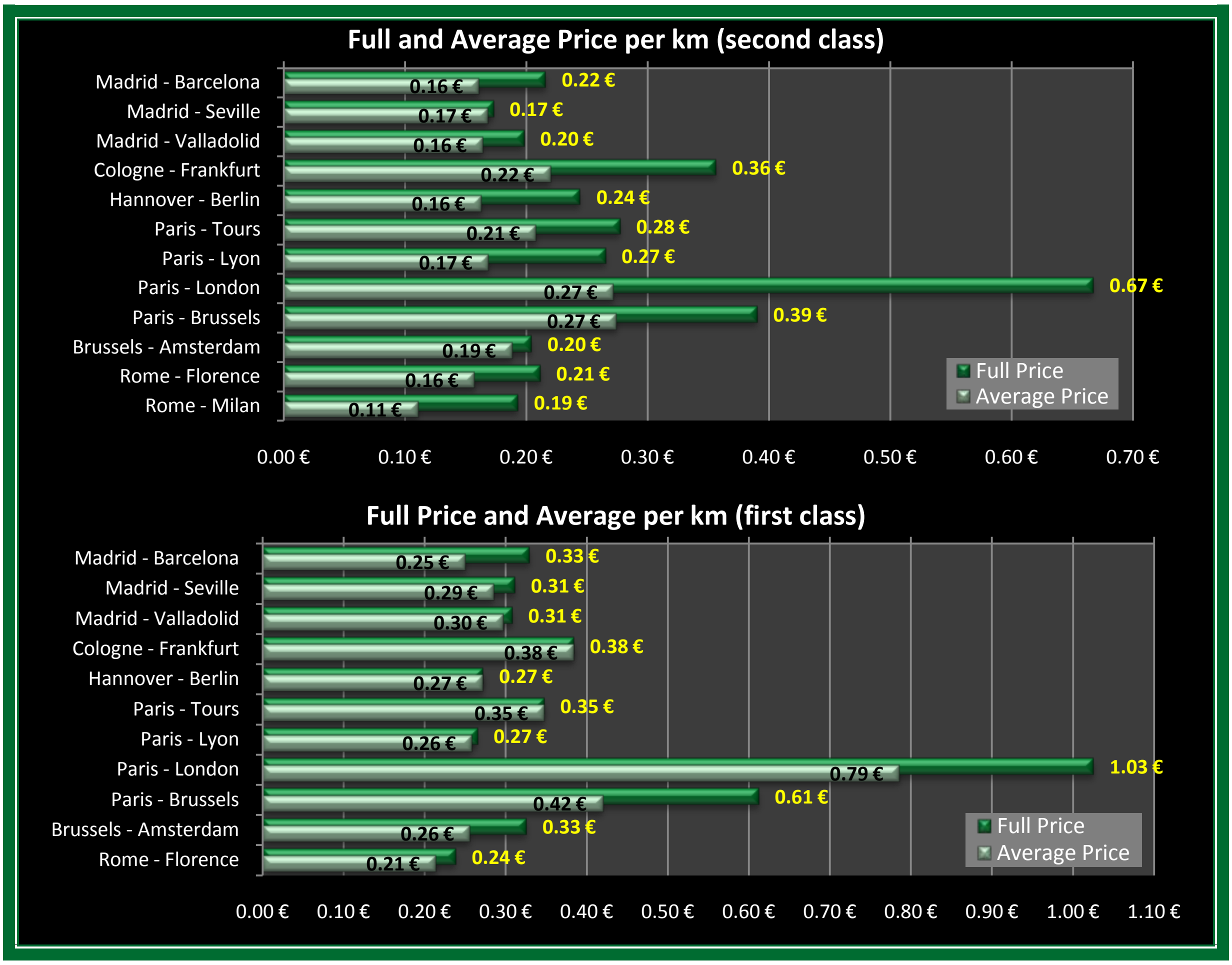


Figure 17: Ticket Price Data Collection Findings: full and average price per kilometer
Source: Data collected within the framework of a research project (Teixeira et al, 2011)

4.2.2. Traffic Data Collection

In conjunction with a research study, traffic data, shown in Figure 16, was also collected and detailed for every time period in question (Peak, Shoulder, Normal, Off-Peak). It should be noted that the number of trains on all French lines is much higher than in other countries as the French high-speed network was one of the first constructed and where demand has had the most amount of time to mature. (Teixeira et al., 2011)

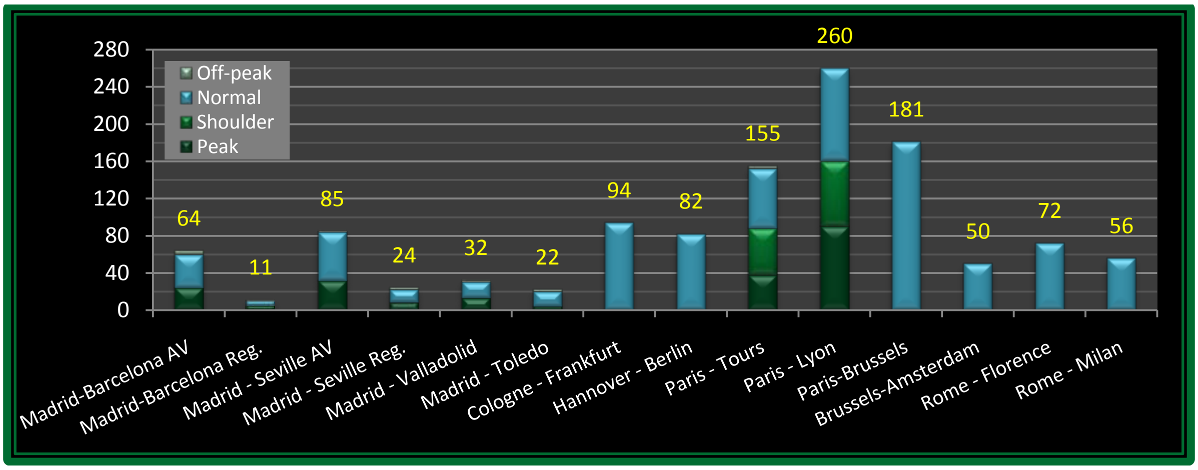


Figure 18: Traffic Volumes on key European HSL corridors (trains in both directions per day)
Source: Data collected within the framework of a research project (Teixeira et al, 2011)

4.2.3. Ticket Sales Gross Revenue

By using the collected ticket price data, gross revenue can be estimated by considering an average occupancy rate of 65% per train. It should be noted that while the average occupancy rate will vary between lines and between different time periods on each line, it serves as a reasonable approximation of the real world occupancy rate (CENIT, Nov. 2006).

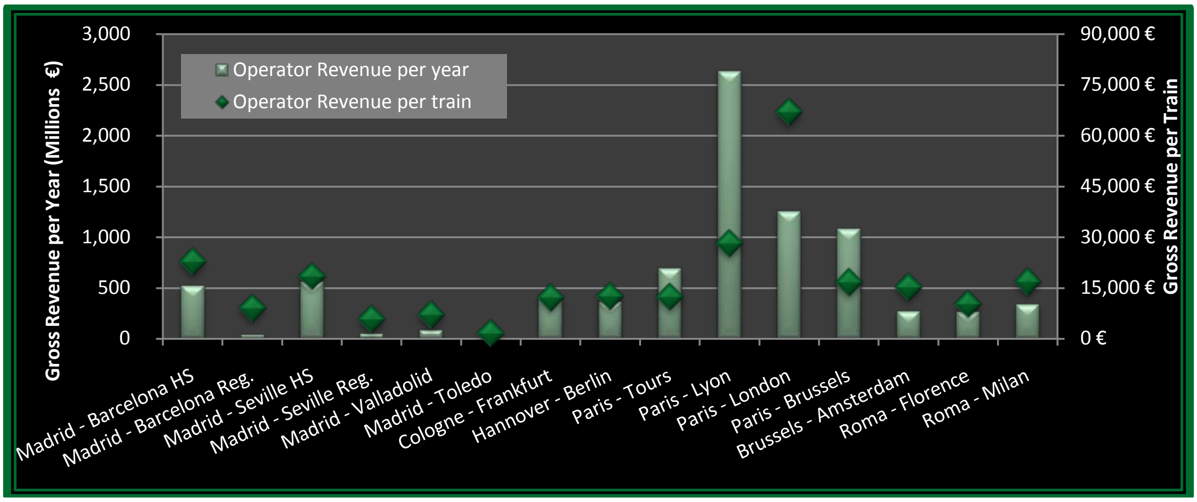


Figure 19: Annual Operator Gross Revenue from Ticket Sales

It is used In order to distribute this average rate between first and second class, the following distribution will be used: two-thirds of the seats in second class, and one-third of the seats in first class (per average distribution of seats on trains being operated on each line). The occupancy considered for second class is 70%, and the resulting occupancy for first class is 55%. Given this information and traffic data described in Section 4.2.2, annual ticket gross revenue can be estimated (shown in Figure 19).

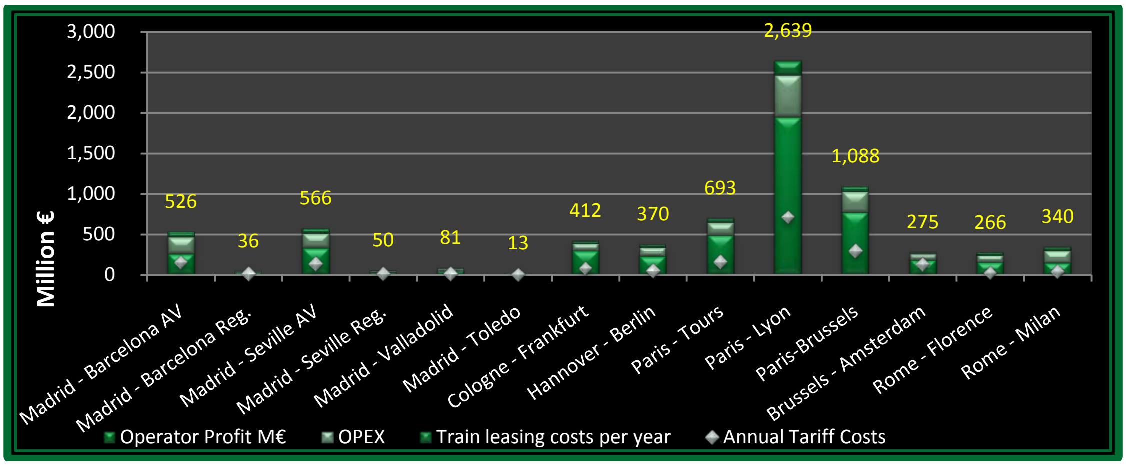


Figure 20: Operator Net Revenue (before paying tariff costs)

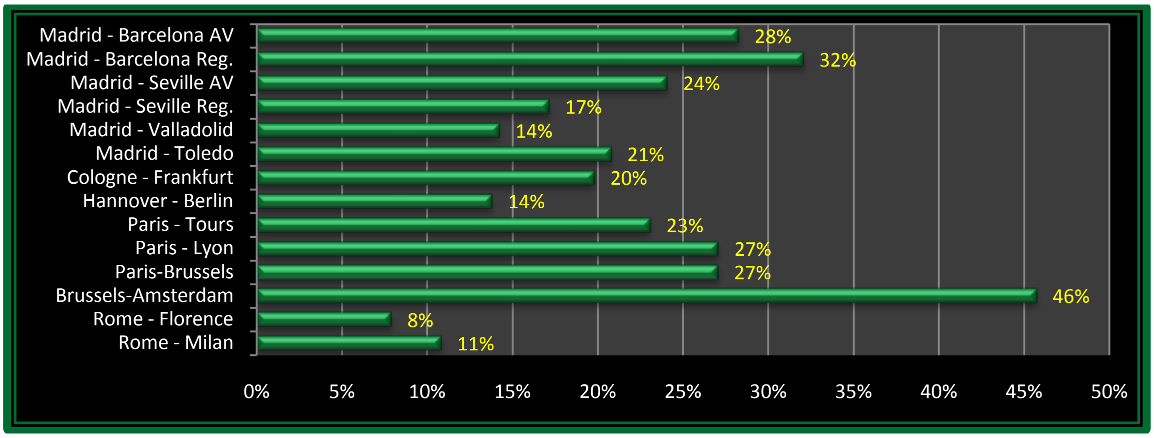


Figure 21: Tariff vs. Operator Gross Revenue

In order to now estimate the operator net revenue before tariff costs, operating costs will be subtracted from gross revenues. Operating costs are estimated at 12.57€ per train-km for long-distance high-speed services and 7.53€ for regional services. Lines using primarily Siemens Velaro or ICE3 train sets have a higher operating cost of 14.04€ per train-km. Trains are considered to be leased on an annual basis with a 6% annual interest rate. The number of annual operating kilometers for each train set is 450,000km for long-distance trains, and 300,000km for regional trains. Rolling stock costs are presented in the appendix (RAVE AVEP, 2008). The results are shown in Figure 20.

Operator net revenue before line tariffs = Operator Gross Revenues – OPEX – Leasing Costs

The methodology behind calculation of tariffs used for this section is discussed in the Section 4.3. Based on these results, the tariff makes up the highest percentage of gross revenues on the Brussels-

Amsterdam line (46%). French and Spanish lines have a ratio between 20% and 30%, German lines have a ratio between 14% and 20% and Italian lines have a ratio between 8% and 11%. The highest level of net revenue on a per-kilometer basis is on all French lines as well as on the Cologne-Frankfurt line, above 40€ per km. This information is shown in Figure 21.

4.3. Infrastructure Manager Gross Revenues

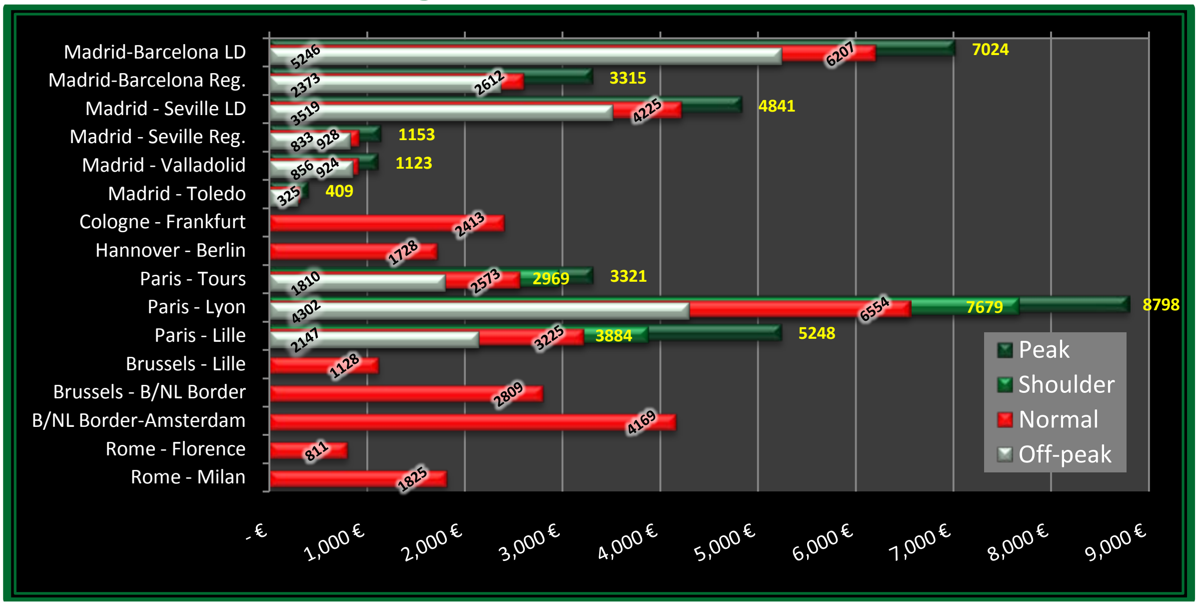


Figure 22: Gross revenue per train

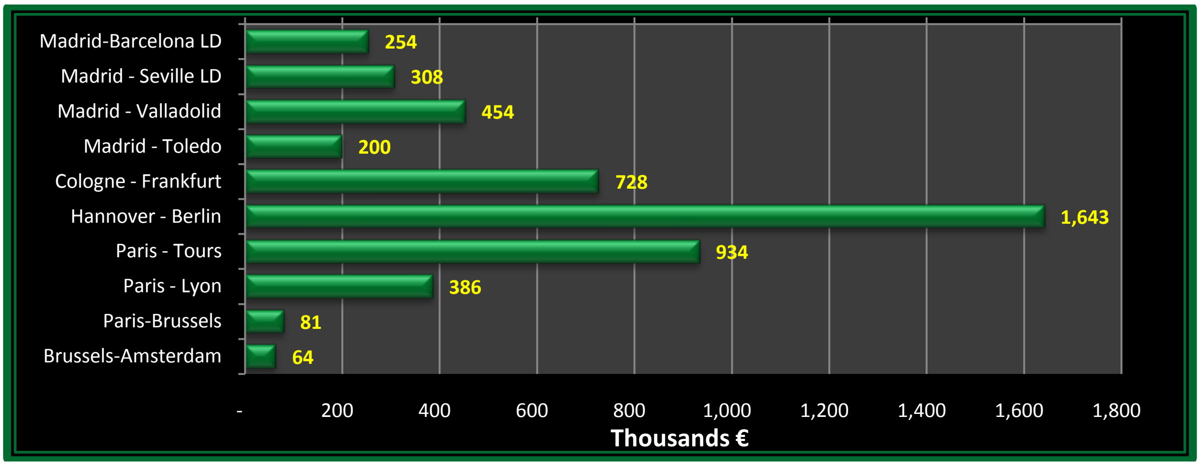


Figure 23: Gross revenue per year per km of line

In this section the tariff levels used are from the 2009-2010 timetable year. Network Statements for each country were used to determine the tariff levels per train. Station costs are included in these fees. For each HSL, the rolling stock considered is typical for the line. On a per-train basis, the levels are lowest in Italy and on some Spanish regional lines and highest in France and on the Cologne – Frankfurt HSL. Gross revenues per train are shown in Figure 22, and gross revenues per kilometer of line are shown in Figure 23.

On a per-line level, the single highest gross revenue line is the French HSL between Paris and Lyon with annual gross revenue of 715 M€. The extremely high traffic level with 260 trains per day contributes to that significantly. The second-highest grossing line was Paris – Brussels with 294 M€. The lowest line was Madrid – Toledo at just under 3 M€. However, given that the line is also the shortest, and a part of the gross revenue is collected along the Madrid – Seville line, this value is justifiable. On a per-km basis, the highest line was again, Paris – Lyon, followed by Paris – Brussels, with the lowest gross revenue per kilometer being on the Rome – Milan and Madrid – Valladolid lines. In the lowest gross revenue lines, the gross revenue levels can be explained by low charges for the Rome – Milan line and service with regional trains on the Madrid – Valladolid line, something that will change then the line gets extended in the near future.

4.4. Infrastructure Manager Net Revenues

4.4.1. Estimation of Construction and Maintenance Costs

Estimates of maintenance costs of 80,000€ and 120,000 €, which are based on previous studies, will be used. (Teixeira, P., Pita, A., 2008).

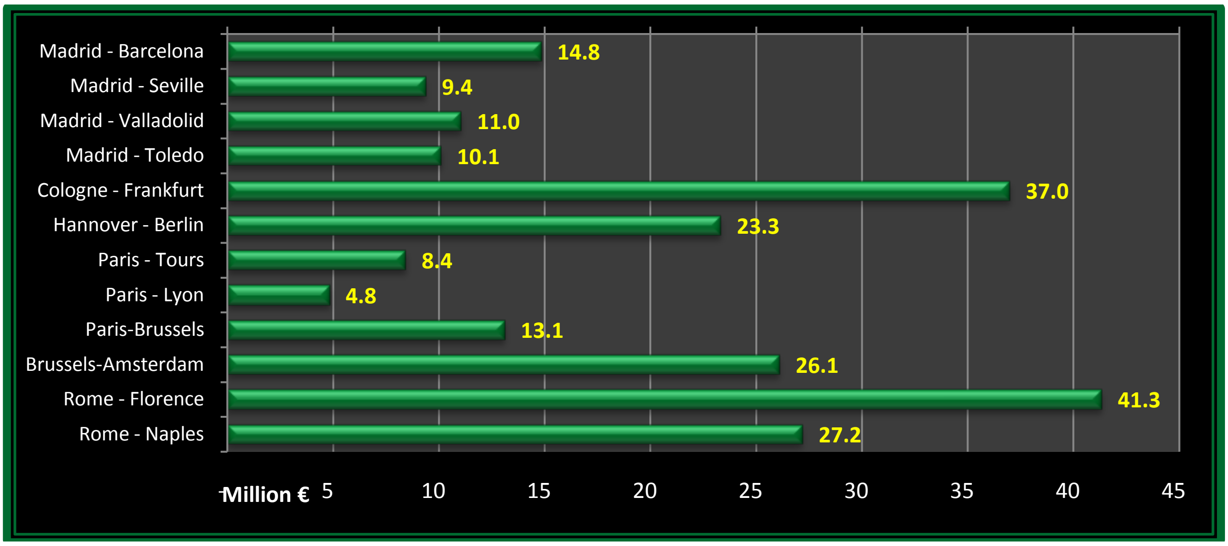


Figure 24: Net Investment Costs (M€/km)
Source: ADIF, DB, Campos and Rus
Note: Figures updated to 2010 using Eurostats inflation data

Figure 24 shows construction costs that were considered for the high-speed lines in question. These costs were updated to 2010 to reflect differences due to inflation. The highest costs can be observed on the Italian lines between Rome and Florence and between Rome and Naples due to difficult terrain and a large number of special infrastructure projects (e.g. bridges and tunnels) required. The Cologne-Frankfurt line was constructed using a new slab-track construction method, as was a part of the Hannover-Berlin line, resulting in a higher-than average construction cost, but lower maintenance costs. A part of the Brussels-Amsterdam route was constructed under a Public-Private

Partnership (PPP) scheme, which may explain the reason for the higher than average costs (Chevroulet, 2010). Costs for Spanish lines include EU subsidies, which have been subtracted from presented amounts.

4.4.2. Cost Recovery Estimates

The resulting IM net revenue levels are presented in Table 3 and detailed recovery figures are presented in the appendix. Two values are considered for maintenance costs: 80,000€ and 120,000€ per line-km. The highest recovery per kilometer is on the French and German lines, followed by Spanish lines. The Italian lines are unable to pay maintenance costs due to low tariffs imposed. The Madrid-Valladolid line is also unable to pay its maintenance costs due to low traffic numbers, as the line is still in the initial phases of operation.

Table 3: Infrastructure Manager Line Net Revenue

	Maintenance Cost			
	Maintenance Only: 80,000 € per line-km	Maintenance and renewals: 120,000 € per line-km	Maintenance Only: 80,000 € per line-km	Maintenance and renewals: 120,000 € per line-km
Line	Total IM Net Revenue (M€ in 2010)	Total IM Net Revenue (M€ in 2010)	Total IM Net Revenue per km (€ in 2010)	Total IM Net Revenue per km (€ in 2010)
Madrid - Barcelona	109.8	84.6	174,305 €	134,305 €
Madrid - Seville	107.1	88.3	227,911 €	187,911 €
Madrid - Valladolid	-2.9	-10.1	-15,969 €	-55,969 €
Madrid - Toledo	1.0	0.2	47,455 €	7,455 €
Cologne - Frankfurt	70.9	65.6	393,974 €	364,174 €
Hannover - Berlin	32.8	23.6	128,448 €	92,648 €
Paris - Tours	142.5	133.7	647,770 €	607,770 €
Paris - Lyon	679.7	662.3	1,562,527 €	1,522,527 €
Paris-Brussels	269.1	256.5	854,435 €	814,435 €
Brussels-Amsterdam	99.6	86.6	306,447 €	266,447 €
Rome - Florence	0.2	-10.2	850 €	-39,150 €
Rome – Naples	-9.2	-32.2	-16,014 €	-56,014 €

The amount of recovered funds by the IM is presented in Table 4. The numbers shown represent the amount that the IM will continue to recover on an annual basis should traffic and tariff levels stay the same. In other words, these numbers show the state of the line today. Since traffic numbers and tariff levels change, the number of years it takes to recover all costs will vary, depending on how demand changes and how the IM responds to these changes with varying tariff levels. The Paris-Lyon line has the highest annual recovery rates, as expected, due to very high traffic volume and very low construction cost. The Paris-Brussels line also stands out as far as cost recovery. Again, Italian lines are unable to pay their maintenance costs under most conditions due to low infrastructure tariffs.

Table 4: Percentage of recovered initial investment

	Maintenance Cost	
	Maintenance Only: 80,000 € per line-km	Maintenance and renewals: 120,000 € per line-km
Line	**%Recovered per year in 2010 / Investment**	**%Recovered per year in 2010 / Investment**
Madrid - Barcelona	1.2%	0.9%
Madrid - Seville	2.4%	2.0%
Madrid - Valladolid	-0.1%	-0.5%
Madrid - Toledo	0.5%	0.1%
Cologne - Frankfurt	1.1%	1.0%
Hannover - Berlin	0.6%	0.4%
Paris - Tours	7.7%	7.2%
Paris - Lyon	32.3%	31.4%
Paris-Brussels	6.5%	6.2%
Brussels-Amsterdam	1.2%	1.0%
Rome - Florence	0.0%	-0.1%
Rome - Naples	-0.1%	-0.2%

4.5. Conclusions Regarding High-Speed Rail Line Cost Recovery

To summarize, most high-speed railway lines can and do cover their maintenance costs, with two exceptions being Italian lines (due to low tariffs) and a Spanish line (due to the line being in the initial phase of operation with low traffic levels). Cost recovery levels vary greatly between lines, but are higher on lines with high traffic volume and high tariffs. In the case of France, all lines have a healthy cost recovery margin, with the Paris-Lyon having the highest recovery rate. Those lines in the initial phase of operation (some of the Spanish lines as well as the Brussels-Amsterdam line) should see higher cost recovery figures after traffic on those lines increases, as is usually the case after the initial ramp-up period.

Lines with higher tariffs generally have higher cost recovery. This is a two-way street, as lines can have higher tariffs because of good economic conditions and certain levels of demand. Lines with lower tariffs may have a lower willingness to pay. A third case, however, may be that the tariffs are set artificially low to allow for cross-subsidization between high-speed and regional services, as seems to be the case with Italy. If the state-owned operator pays low fees for infrastructure use, the remainder of the net revenue can be used to subsidize other services. This allows the operator to request lower subsidy levels when applying for tenders for such services. However, as the high-speed market is opened to competition, such low rates will be unsustainable in the long term. As Italy is one of the first candidates for competition with private passenger operators commencing operations on its high-speed lines, the trend in IM cost-recovery figures may change in the coming years.

5. Considerations for a Tariff System for New International Corridors (Case Study: Lisbon – Spanish Border HSL)

5.1. Context

High-speed railways on the Iberian Peninsula have experienced a boom during the past twenty years. Since 1992, with the opening of the Madrid – Seville high-speed line, the industry has seen the opening of four additional corridors and construction and planning of many more. Some of these lines have been partially funded by the TEN-T program, responsible for improving infrastructure in Europe (EC, 2008).

5.2. The Lisbon – Spanish Border HSL case study

5.2.1. Existing Conditions

The Lisbon-Madrid corridor is served by numerous airlines and bus lines as well as a major motorway. A daily overnight train service is offered in both directions (12-hour trip) through a partnership between the Spanish operator Renfe Operadora and the Portuguese operator CP. (RAVE, 2007). The Spanish IM, ADIF is responsible for railway network operations and management in Spain. Renfe Operadora operates services on dedicated high-speed lines in Spain between Madrid and Barcelona, Málaga, Seville, Toledo, Valencia and Valladolid. The Portuguese IM, REFER, is responsible for operating and managing the railway network in Portugal. CP also operates a premium service on an upgraded conventional line between Lisbon and Porto.

5.2.2. Legislative Setting

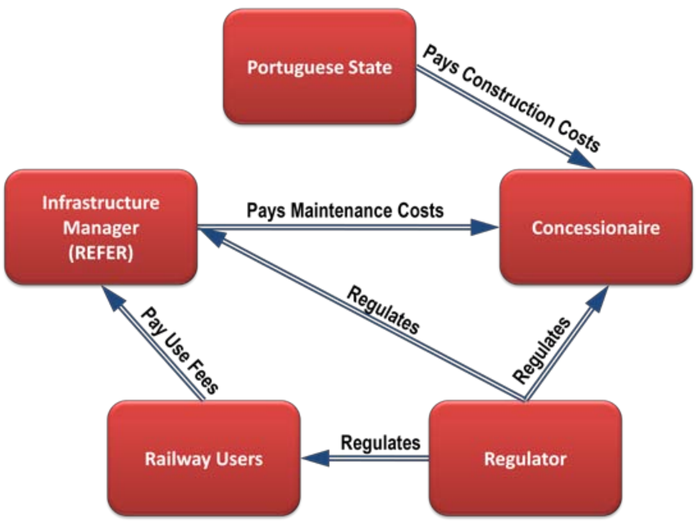


Figure 25: Legislative setting for the Lisbon-Madrid HSL

The proposed line is being funded by the Portuguese State with involvement of private capital. The Infrastructure Manager (REFER) is responsible for paying maintenance costs to the Concessionaire and Railway Users pay infrastructure use fees to the IM. The Regulator (IMTT) regulates the IM, RUs and the Concessionaire. The Concessionaire is responsible for providing capacity and pays penalties for line unavailability. A diagram of the relationships between all entities is shown in Figure 25.

5.2.3. Line Proposal

There are a number of objectives of the proposed HSL. The main is increasing sustainable mobility options. This is proposed to be accomplished by an improvement in competitiveness of the rail transport mode in the Lisbon-Madrid corridor and the reduction of emissions and reduced dependence on petroleum energy that follow from this improvement. Another goal is increasing the competitiveness of the port of Sines, New Lisbon Airport and various logistics systems. Yet another goal is bonding the region together, which will contribute to the region's competitiveness. Finally, the last major goal is integrating the national rail network in the Trans-European Rail Network, to allow for interoperability of both passenger and freight services. (RAVE, 2010)

On the Portuguese side, the proposed line would commence in Lisbon at the Oriente Station, pass over the new Third Tagus Crossing (TTT), and continue east via Poceirão (Lisbon – Poceirão: 35km), Évora (Poceirão – Évora: 88 km) to the Spanish border between Caia and Badajoz (Évora – Caia/Badajoz: 80km). On the Spanish side, the line would start at Madrid's Atocha Station and would continue southwest, passing the regional centers of Talavera de la Reina, Plasencia, Cáceres and would join the Portuguese section in Badajoz. The total line length is 651 km, with the Portuguese part being 210 km, which includes new approaches into Lisbon's Oriente Station. Also, an additional 18-km spur between Poceirão and the New Lisbon Airport will be constructed to provide shuttle services to the airport. (RAVE: AVEP, 2008). The line is planned to allow both passenger operations between Lisbon and Madrid (and intermediate points) and freight operations from the port of Sines. It has been identified as a priority corridor in the TEN-T proposal both for freight and passenger movement (EC, 2008).

Analysis for the proposed line will consist of a concession period of 45 years (2012 – 2057), which includes both a five-year construction period (2012-2017) and a 40-year operation period (2017-2057). Annual line maintenance costs will be considered and the IM will establish a tariff scheme that will determine how much RUs will pay for infrastructure capacity consumption.

5.2.4. Passenger Demand Analysis

Traffic for the proposed line has been estimated by an AVEP study (RAVE, 2008). Three types of services are proposed: long-distance high-speed, regional high-speed and shuttle services between Lisbon and the New Lisbon Airport. Figure 26 shows a distribution of the traffic in terms of train-kilometers, based on a RAVE marketing study with passenger projections. A 65% train occupancy rate is assumed for the traffic profile. The first three years of operation (2017-2019) include a start-up period, where traffic supply is gradually increased from 50% to 100% of the projected levels. The assumed traffic profile from a 2008 study by RAVE is presented in the appendix along with the development methodology.

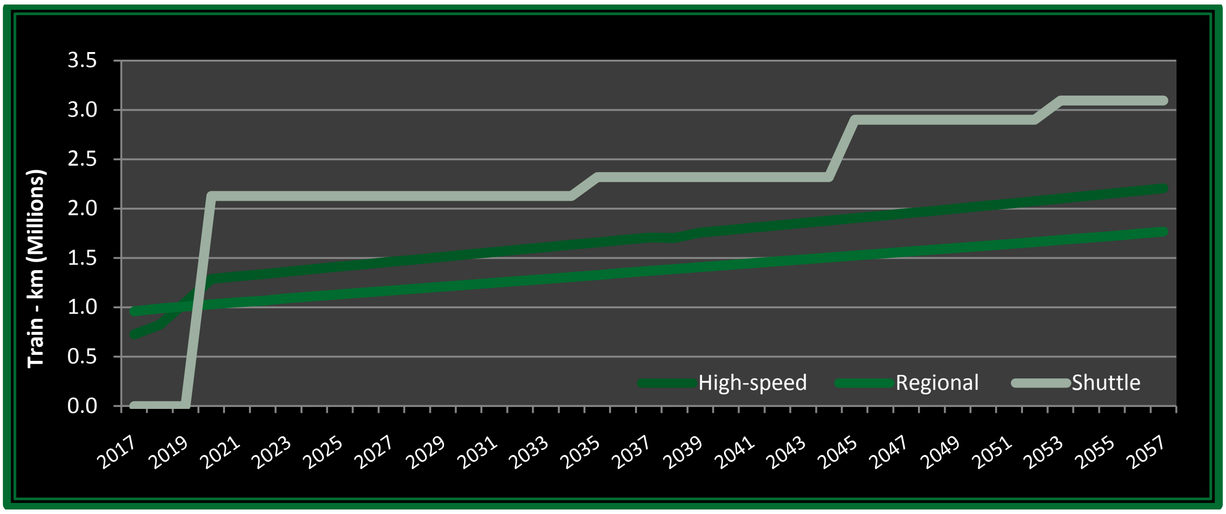


Figure 26: Projected passenger traffic volume for Lisbon-Madrid HSL
Source: RAVE 2008

It should be noted that since this is an international line, subsidies and concessions for train operation are prohibited. Because of this, the State, and the IM face a risk of having lower long-distance traffic numbers than the ones presented above, should passenger demand be less than what is projected, which will lead to lower RU and IM gross revenue. This is an extremely important reason for having a tariff model that provides RUs incentives for increasing traffic. A note of caution on traffic assumptions: the predictions assume a linear increase in rail traffic supply and do not take into consideration the changing demographics of Portugal and Spain, which may have an impact on the demand and the traffic levels, especially after 2045.

5.2.5. Freight Demand Analysis

The proposed line will be designed to allow freight traffic operations, and the Port of Sines is one of the interested parties in using the line for transporting freight. In evaluating demand, a 2008 operational study provided an overview of freight traffic projections, but did not discuss the value of this freight or its willingness to pay. Table 5 shows the total predicted freight demand for the Lisbon-Madrid HSL on the Portuguese territory (RAVE, 2008).

Table 5: Projected Freight Demand

	2013	2018	2020	2025	2030	2050
Million Tons per Year	0.948	1.397	1.522	1.878	2.215	3.815
Trains per day	26	36	38	46	54	88

Source: RAVE, 2008

When examining railway freight tariffs around Europe, the following countries were considered: Switzerland, Denmark and the Netherlands. All price the marginal cost of freight between 0.0018€

and 0.0022€ per ton. Because no data is available about the willingness to pay of the freight on the new line, the Swiss tariff system will be adopted. The assumption is that the value of freight is sufficient to be able to pay its marginal cost of around 0.00217€ per ton-km it will provide a social benefit by potentially reducing the amount of freight traffic on roads.

Because there is no definite analysis for freight value and its willingness to pay, freight demand will not be included in the base scenario, but will be included in one of the scenarios of the sensitivity analysis in section 5.2.9.

5.2.6. Construction and Maintenance Costs

Construction costs are estimated to be 11 M€ per kilometer of line, spread over five years of construction and an annual maintenance and availability cost is estimated to be 120,000€ per km of line, which includes renovations. After the end of the concession, an annual cost for track renewal amounting to 150,000€ per kilometer of line is considered, as it includes long-term renewal expenditures (Teixeira, P., Pita, A. 2008).

5.2.7. Application of Existing Tariff Schemes

In this section, European tariff systems considered in Chapter 3 will be applied to the proposed Lisbon – Madrid line. This evaluation assesses recovery potential for the new line and examines each system for components that can be transferred to the new tariff system, which will be developed later in the document. The following tariff systems will be applied: French N1, French N1A, French N2, French N3, Spanish A1, Spanish A2, German (FP with "active" line designation), Belgian (high-speed with highest speed coefficient), Dutch (HSL line rate with surcharge), and Portuguese (North Line tariff – highest rate for electrified lines). This analysis includes only high-speed and regional traffic and does not include shuttle traffic between Lisbon and the New Lisbon Airport. For each system, high-speed, regional and long distance traffic uses the same tariff where regional tariffs do not exist. Discount rates of 2%, 3% and 4% will be considered for Net Present Value (NPV) evaluation, as these are most appropriate for projects with long-term depreciation periods (ADIF, 2007).

As the shown in Figure 27 and the Table 6, the highest recovery rate of initial investment costs (between 47% and 53%, depending on maintenance costs) can be obtained with the Dutch tariff system, which includes a high HSL surcharge. The lowest recovery ratio is with the current Portuguese system, which has very low tariff levels and is geared more towards conventional traffic which has a lower willingness to pay. The recovery rate of Spanish systems is close to 0% per year, depending on maintenance costs and is below the French one because it uses regional rates for regional services that France does not have. The French and German systems allow a recovery rate of between 5% and 14%, depending on maintenance costs and the Belgian system recovers between -1% and 5% of initial investment costs.

Table 6: Initial Investment Recovery Rates and Line NPVs

Tariff System	Recovery	NPV (M€) Discount Rate 4%	Recovery	NPV (M€) Discount Rate 3%	Recovery	NPV (M€) Discount Rate 2%
France N1	25%	573.73	13%	310.48	18%	420.10
France N1A	21%	474.75	11%	250.76	15%	343.80
France N2	2%	45.97	0%	-7.95	1%	13.26
France N3	-4%	-89.03	-4%	-89.40	-4%	-90.80
Spain A1	0%	-6.57	-2%	-39.59	-1%	-27.20
Spain A2	-2%	-35.83	-2%	-57.25	-2%	-49.76
Germany	24%	552.36	13%	298.05	17%	403.92
Belgium	8%	174.15	3%	69.39	5%	112.08
Netherlands	104%	2,407.95	61%	1,418.62	79%	1,834.97
Portugal	-24%	-555.65	-16%	-371.06	-20%	-450.58
Investment Total @ 11 M€/km		2,310.0		2,310.0		2,310.0

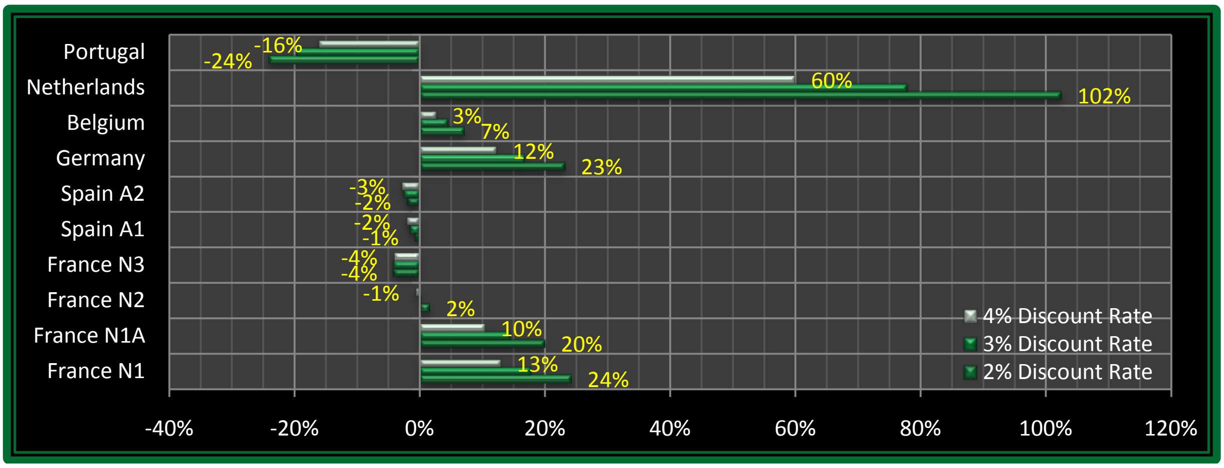


Figure 27: NPV 2017-2057 - updated to 2010

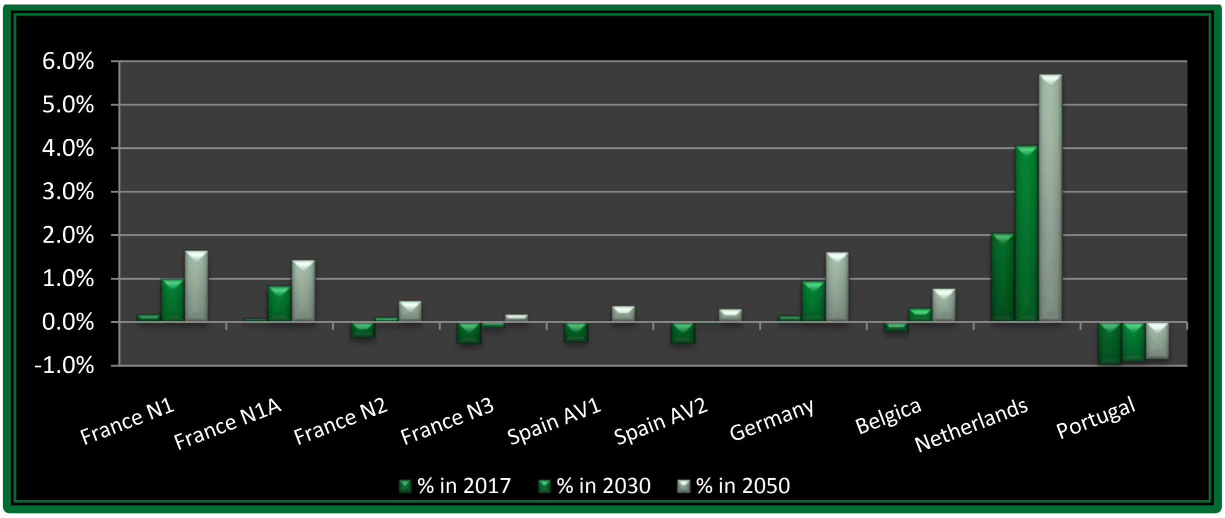


Figure 28: Percent of recovery of initial investment per line per year (% of investment)

It should be noted that the Belgian, Dutch, French and German systems do not have differentiation between regional and long-distance high-speed services and thus the same tariff was applied to both types of services. Figure 28 shows the amount of initial investment costs recovered when each of the systems is applied to the new line in 2017, 2030 and 2050. These numbers are not actualized to 2010.

5.2.8. Boundary Conditions

The boundary conditions need to be approached from both the operator's point of view as well as from the Infrastructure Manager's point of view. From the operator's point of view, there is a maximum that the operator is able to pay. This is determined by market forces and by end users' willingness to pay. From the IM's point of view, maintenance costs have to be met and recovery of initial investment costs is desirable.

5.2.9. Operator Gross and Net Revenues

First, the operator's side will be considered in order to estimate the maximum that the operator is capable of paying for the use of the proposed line. Following this assessment, a sensitivity analysis will be performed in order to assess the stability of the operator's gross revenue. The result of this analysis will be a net present value (NPV) of project.

A. Base Scenario Definition

The base scenario will use traffic numbers defined in the section 5.2.3. Three types of services will use the line: long distance services (using S-112 rolling stock), regional services (using S-130 rolling stock) and airport shuttle services (using shuttle rolling stock). Long-distance services are assumed to operate between Lisbon and Madrid. Regional traffic operates between Lisbon and the Spanish border with an intermediate stop at Évora. Shuttle service operates between Lisbon-Oriente and the New Lisbon Airport. In the base scenario, the traffic increases to just over 2.2 million train-km by 2057 for long-distance services, 1.8 million train-km for regional services and 2.9 million train-km for airport shuttle services. Rolling stock prices and leasing information is shown in the appendix. An operator start-up cost of approximately 16.5 M€ is estimated and will be divided over the first five years of operations (RAVE, 2008).

The average ticket price in Spain discussed in section 4.2.1 was found to be between 0.16€ and 0.17€ per train-km and the price of 0.17€ per train-km will be used for high-speed services on the Lisbon-Madrid line. Regional services will be priced 30% lower at 0.12€ per passenger-kilometer due to lower operating speed and lower comfort levels, which is consistent with Spanish regional service prices. The airport shuttle service will be priced at 12.50€ per ticket, resulting in a price of 0.236 € per pax-km. It should be noted that prices for railway services to the airport vary greatly, from 2.75 € for a single ticket in Zurich, to nearly 28 € for a similar ticket in Stockholm. Prices for airport services generally do not correlate to distance.

Table 7 shows assumptions about rolling stock and operating costs (RAVE, 2008). The rolling stock will be amortized over 25 years using a 6% leasing rate. Operating costs from a 2008 AVEP study will be used. The operating costs are split between Personnel, Catering, Energy, Ticketing Sales, Maintenance/Cleaning and Other Costs. It is assumed that a part of these costs is fixed. An operator gross revenue margin of 10% of operating costs will be considered. An additional gross revenue margin of between 0.25% and 4%, depending on traffic volume, will be applied to operator gross revenue.

Table 7: Assumptions of Operational Parameters

	AV (S-112)	EV (S-130)	Shuttle
Cost M€	23,788,352 €	14,252,052 €	9,910,750 €
Amortization (years)	25	25	25
Leasing Rate (%)	6%	6%	6%
Annual Payment (€)	1,839,224 €	1,101,914 €	766,261 €
Seats	365	299	200
OPEX €/train-km	12.57 €	7.53 €	7.50 €
Personnel	11%	22%	25%
Catering	12%	6%	0%
Energy	11%	8%	10%
Ticket Sales	12%	8%	18%
Maintenance/Cleaning	30%	36%	25%
Other Costs	24%	20%	22%

Source: RAVE AVEP study, 2008

There are numerous ways to evaluate residual value of a project. A seventy-five year depreciation period will be considered on infrastructure from the first year of operation. Thus, the infrastructure is expected to completely depreciate by 2092. A 35-year residual value period will be considered for the evaluation of NPV. Residual value will be calculated in two ways. The first approach (**RV1**) includes continuing operation during the Residual Value period and including IM gross revenue in the residual value of the project. This approach considers maintenance costs of 150,000 € per line-km during the residual value period, as this cost includes long-term line renewal costs. During this period traffic is predicted to increase at the same rate as it did before the end of the concession. The second approach (**RV2**) simply adds the NPV of the depreciated initial investment costs in year 2057 at the end of the 40-year operation period to the NPV of the project up to that point.

B. Base Scenario Evaluation

Figure 29 and Figure 30 show an evaluation of the train operator's net revenue (the difference between gross revenues and costs) and the net revenue per train-kilometer. During the first three years of operation between 2017 and 2020, a higher than average rate of increase in the net revenue can be seen. This is due to the ramp-up period discussed earlier, where traffic supply is increased at a higher rate to reach 100% of projected traffic. Start-up costs also decrease the operator's net revenue during the first years of operation. After the initial operating period, the increase in net revenue is proportional to the increase in the number of train-kilometers for long-distance and regional services. Shuttle services see a consistent increase in net revenue per train-km in steps while service levels remain constant (net revenues per kilometer increase due to an increase in passenger numbers), with decreases in net revenue per kilometer as more service is added.

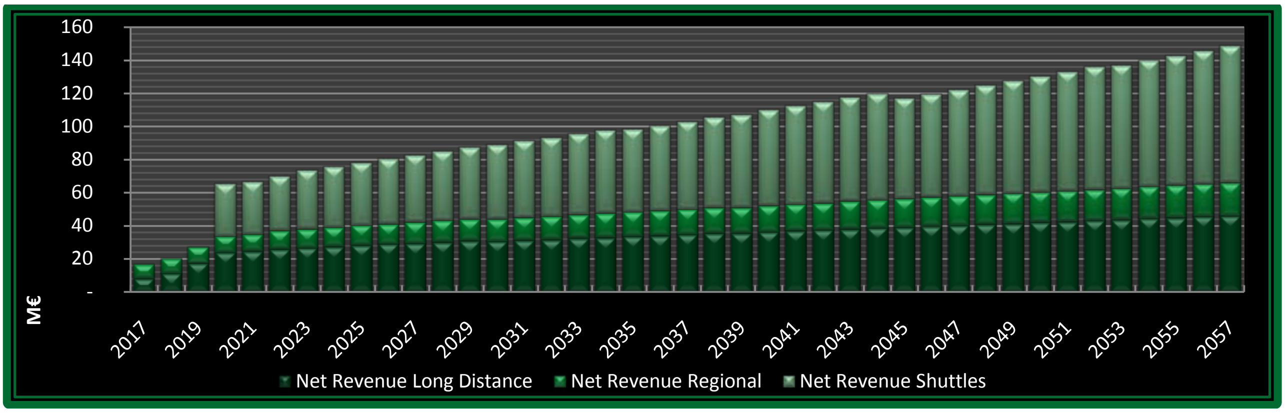


Figure 29: Operator Net Revenue (Gross Revenue - Costs)

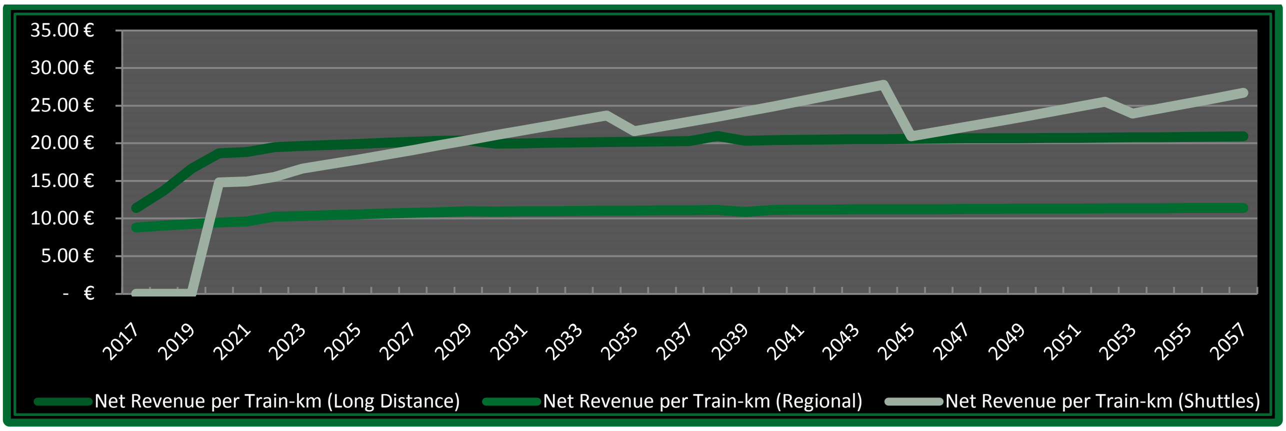


Figure 30: Operator Net Revenue per Train-Km (Gross Revenue - Costs)

Should the entire Operator net revenue be recoverable, the IM net revenue would become positive around 2020 and would continue with a linear increase through 2057 as shown in Figure 31. In 2057, the accumulated total (shown in Figure 32) will be 156.3 M€. The NPV (shown in Figure 33) for the base scenario is -1160.09M€ using a 4% discount rate, -1016.06M€ using a 3% discount rate and -781.83M€ using a 2% discount rate. For calculating a 35-year residual value (shown in Figure 34) between 2057 and 2092 using the RV1 approach, the NPV of the project will be -790.46 M€ using a 4% discount rate, -327.45 M€ using a 3% discount rate and 521.34 M€ using a 2% discount rate. Using the RV2 approach, the residual value is -1,100.96 M€ (4% discount rate), -868.33 (3% discount rate), -412.61 (2% discount rate).

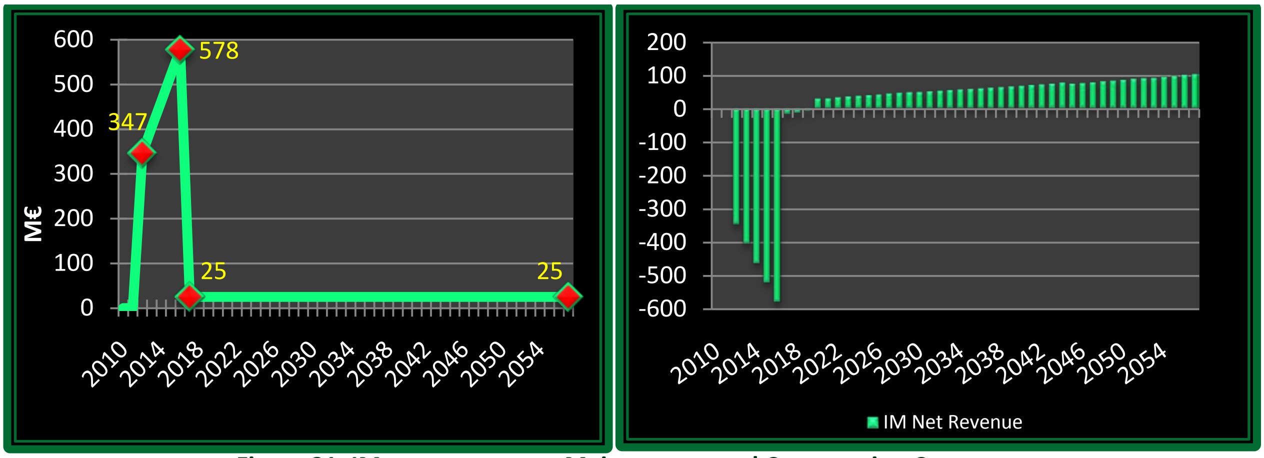


Figure 31: IM net revenue vs. Maintenance and Construction Costs

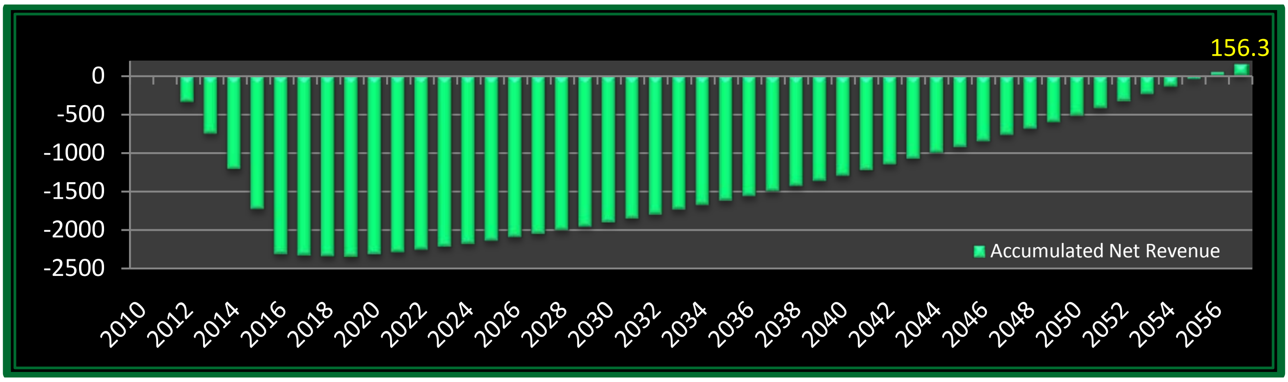


Figure 32: Accumulated vs. Annual IM Net Revenue

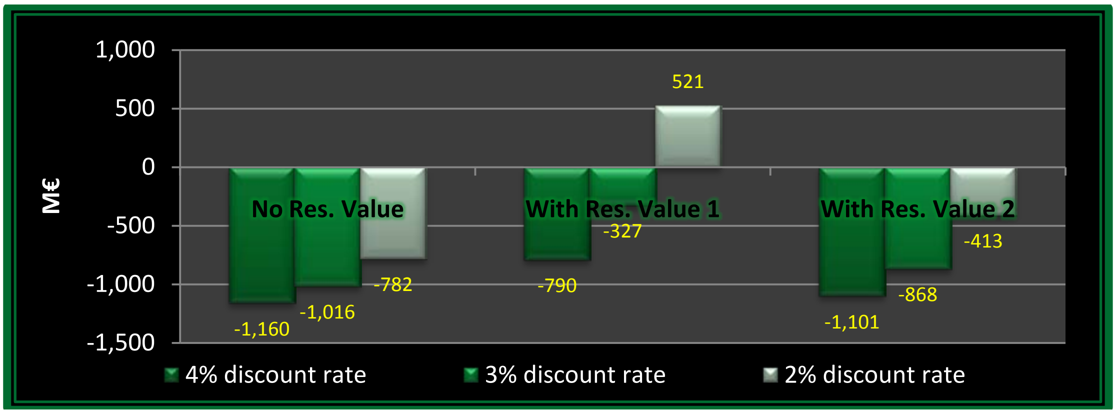


Figure 33: NPV actualized to 2010

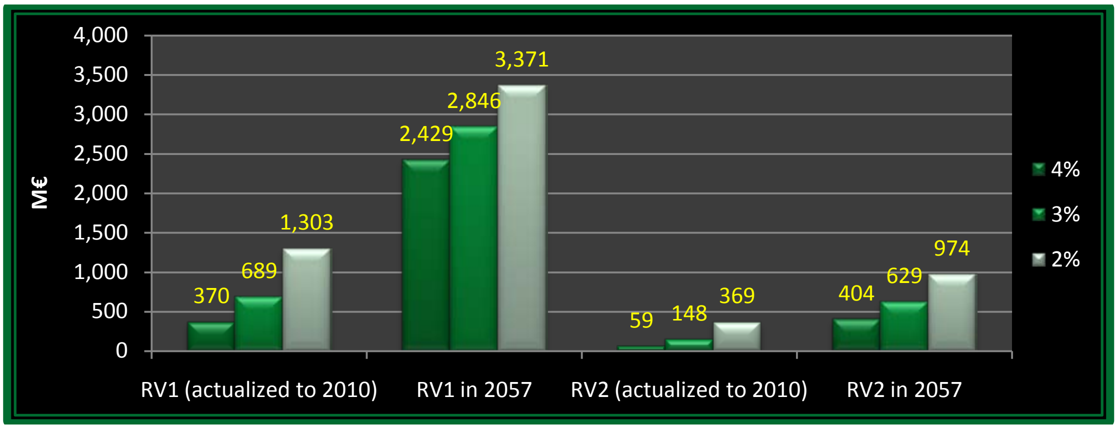


Figure 34: Residual Value

C. Sensitivity Analysis

Table 8: Sensitivity Analysis Scenarios

Scenario	Name	Changes from Base Scenario
1	Base	-
2	No shuttle traffic	0% Shuttle Traffic
3	Freight traffic	100% Freight Traffic
4	25% increase in traffic	+25% LD, +25% Reg, +25% Shuttle traffic
5	Increase in shuttle traffic	+25% shuttle traffic
6	Decrease in shuttle traffic	-25% shuttle traffic
7	25% decrease in traffic	-25% LD, -25% Reg, -25% Shuttle traffic
8	Decrease in maintenance costs	80,000€ per line-km per year, does not include renewals
9	Lower Ticket Prices	LD: 0,13 € / pax-km, Reg: 0,08 €/pax-km;
10	Higher Ticket Prices	LD: 0,19 € / pax-km, Reg: 0,14 €/pax-km;

In order to account for various uncertainties present in the assumptions of the base scenario, a sensitivity analysis will be performed on the base scenario using the most critical variables in the operational model. A total of 10 scenarios (including the base scenario) will be evaluated, and the following changes will be considered: eliminating shuttle traffic, introducing freight traffic, changes in traffic levels, changes in maintenance costs and changes in ticket prices.

Table 8 shows a summary of all scenarios that are being considered.

Scenario 1: Base: Defined above

Scenario 2: No Shuttle Traffic

Shuttle traffic eliminated to account for the uncertainty of construction of the New Lisbon Airport.

Scenario 3: Presence of Freight Traffic

This scenario includes freight traffic gross revenue as defined in Section 5.2.5.

Scenario 4: 25% Increase in Traffic

A long-term 25% increase in traffic across the board (long-distance, regional and shuttle services) is considered to account for a possibility of better than expected traffic growth.

Scenarios 5 and 6: Changes in Shuttle Traffic

These two scenarios consider a sensitivity analysis on the volume of shuttle traffic, with a 25% increase and a 25% decrease in shuttle traffic due to possible changes in construction timeline of the New Lisbon Airport.

Scenario 7: 25% Decrease in Traffic

A long-term 25% decrease in traffic across the board (long-distance, regional and shuttle services) is considered to account for a slower development of demand.

Scenario 8: Decrease in annual maintenance costs to 80,000€ per line-km

A decrease in maintenance costs to 80,000€ per line-kilometer per year is considered between 2017 and 2057. This price does not include renewal costs. During the residual value period, annual maintenance costs remain at 150,000€ per line-km, which includes long-term line renewal costs.

Scenarios 9 and 10: Sensitivity analysis on ticket prices

These scenarios consider changes in ticket prices in order to account for changes in overall economic levels.

Evaluation

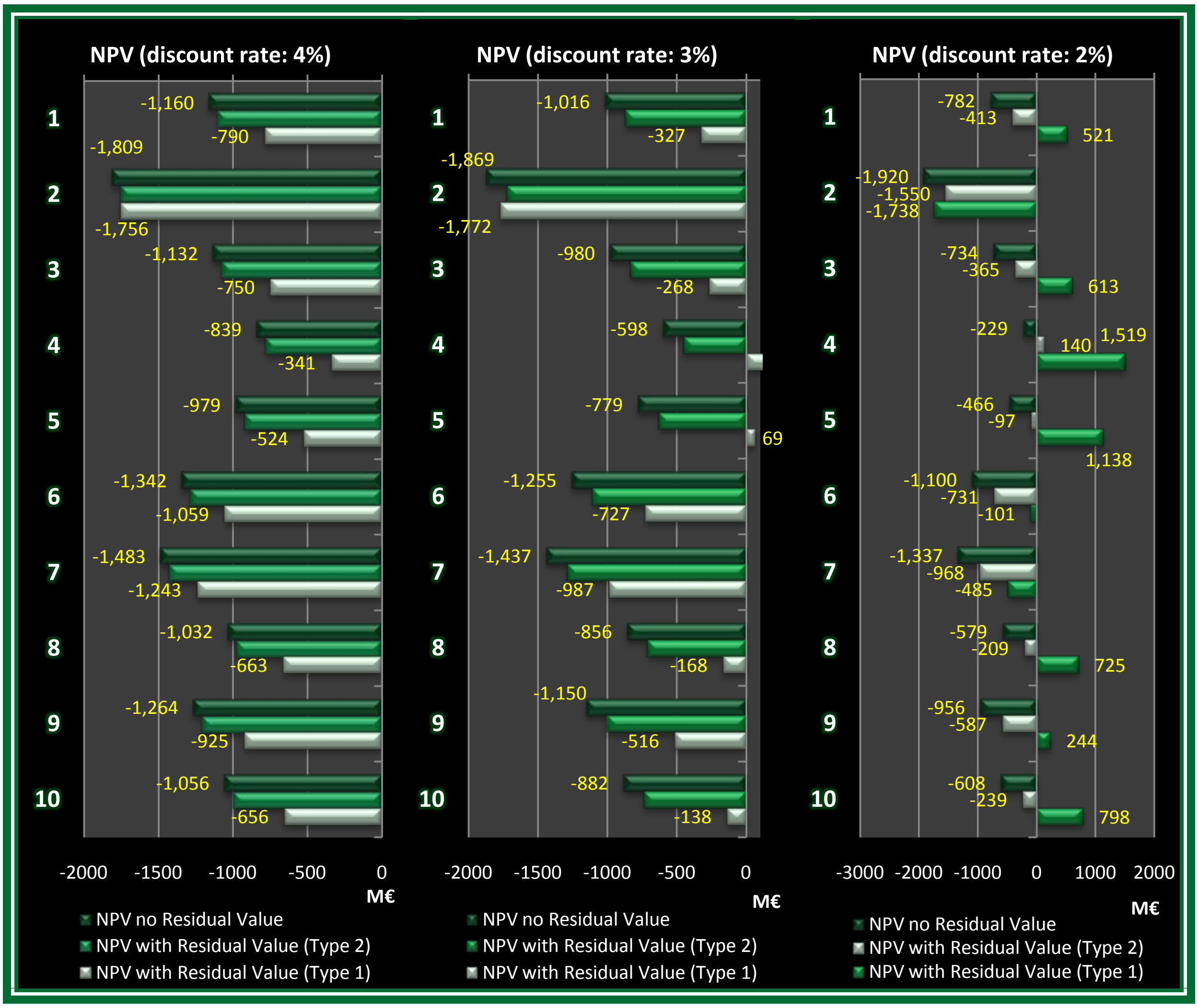


Figure 35: NPV with initial investment costs

In performing an evaluation of all scenarios, the following results (shown in Figure 35) are obtained: the highest NPV is obtained in scenario 4 where an increase in traffic occurs, in scenario 5, which has an increase in shuttle traffic, and in scenario 10, which has higher ticket prices. If the discount rate were to be raised to 3% the resulting NPVs would be lower for all scenarios. Of particular note are scenarios 2 and 3. In scenario 2 shuttle traffic does not exist. This is one of the absolute worst case scenarios. As Figure 36 shows, this scenario still covers maintenance costs on the entire line. Scenario 3 is marginally better than the base as it includes freight traffic. A further study on the freight operators' willingness to pay may lead to a better tariff system, which may improve the bottom line for the IM.

Even though many of the scenarios discussed above have a negative NPV, all are able to cover maintenance costs. Figure 36 presents the NPV of each scenario, without taking into consideration initial investment costs. So long as the NPV is positive in that chart, maintenance costs are covered.

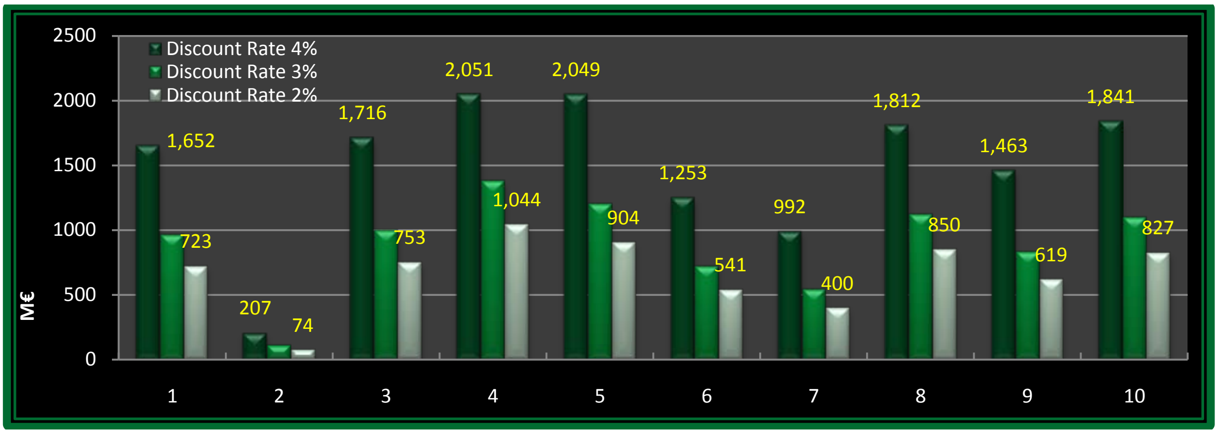


Figure 36: NPV not considering initial investment costs

D. Analysis of the Impact of Freight on the NPV

In analyzing the demand defined in Section 5.2.5, one must take into account that no value for the freight traffic is given. The presence of freight traffic will involve a somewhat higher maintenance cost, especially on a high-speed line. However, it will be assumed that this cost will be paid for by the user as a part of the freight tariff.

Price € per ton	Freight NPV @ 3% (M€)	Total NPV (M€)
0.00100 €	47.4	-968.62
0.00125 €	59.3	-956.77
0.00150 €	71.2	-944.91
0.00175 €	83.0	-933.05
0.00200 €	94.9	-921.19
0.00225 €	106.7	-909.33
0.00250 €	118.6	-897.47

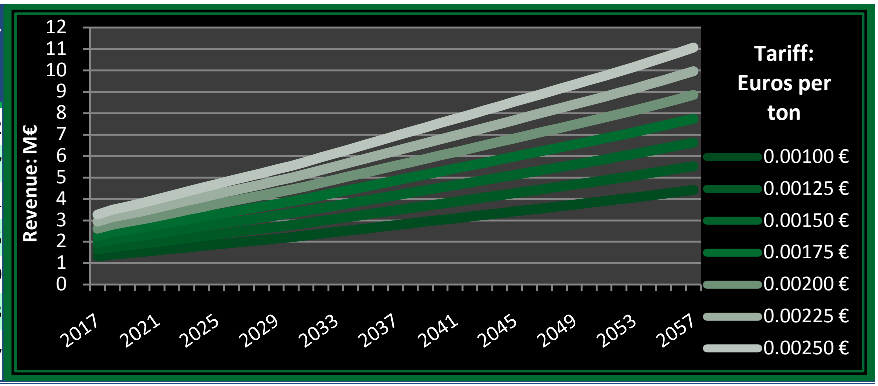


Figure 37: Sensitivity Analysis: Gross revenues from freight operations vs. price per ton

This section will analyze freight operations' impact on the bottom line of the project by using a sensitivity analysis on the freight's value. It will be assumed that freight will be capable of paying marginal costs. The analysis will consider different values (€ per ton) in order to see the impact on the base scenario. The Figure 37 shows the results of the sensitivity analysis in additional gross revenue that the project will receive, should freight be capable of paying the appropriate rate per ton.

First, the NPVs of freight will be calculated, by using the demand figures and prices between 0.001€ and 0.0025€ per ton, in increments of 0.00025€ per ton, for a total of seven cases. A 3% discount rate will be used. The project NPV of the base case with a 3% discount rate (-1,016.06 M€), will then be compared to the NPVs resulting from additional gross revenue with each of the freight prices. Figure 37 show the gross revenue throughout the years as well as resulting net present values from each of the seven sensitivity scenarios. Finally the resulting NPVs are shown. Using the highest price of 0.00250€ per ton of freight the project will see an increase in its NPV of 118.6 M€ to a final value of -897.47M€. The lowest-valued price will result in a 47.4M€ increase in the NPV, to total -967.62M€, all NPV values actualized to 2010.

E. Analysis of the Minimum Amount of Traffic Required to Pay Maintenance Costs

As described in Chapter 4, most of the high-speed lines are able to pay their maintenance costs. In cases where they are not it is either because they are in the initial phase of operation and traffic volumes are not yet high enough, or because a political decision has been made to subsidize line operations. In the case of the Lisbon-Madrid line, the line is expected to pay for its operating costs on average. As traffic is one of the most important variables in this study, it is important to determine the lower bound, below which the line will not be capable of supporting itself during the forty year period of operation.

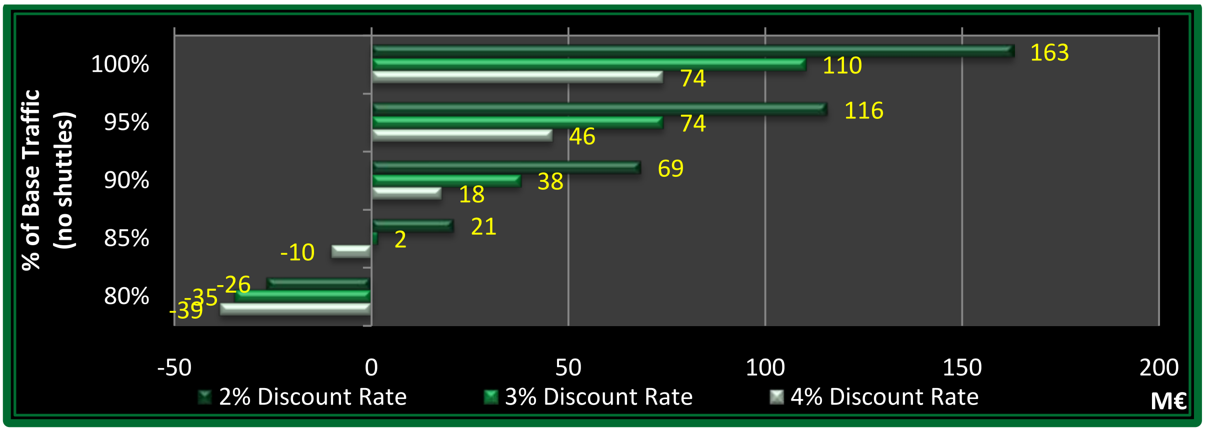


Figure 38: Project NPV (no initial investment considered), maintenance costs of 120,000€ per line-km per yr

This analysis builds on Scenario 2 of the sensitivity analysis in part C of this section. Same traffic growth rate as defined in the Base scenario will be considered for long-distance and regional services. Shuttle services will not be considered, as shuttle traffic depends on the construction of the New Lisbon Airport. It is also desirable to get the minimum amount of traffic required to cover maintenance costs. Traffic values will be reduced until the NPV of the project, not considering initial investment costs, will reach zero. Figure 38 shows the minimum amount of traffic needed to pay line maintenance costs for line maintenance costs of 120,000€ per line-km per year.

Based on this graph, it is clear that at 85% of the base traffic the line passes from positive to negative maintenance cost coverage. This is equivalent to 617,160 train-km for long-distance services and 817,961 train-km for regional services in 2017 and 1,875,963 train-km for long-distance services and 1,502,372 train-km for regional services in 2057. Should traffic fall below the 85% of base level, the line will lose money from operations as maintenance costs will not be covered.

As an analysis of lower maintenance costs of 80,000€ per line-km per year, a lower threshold will be reached. Figure 39 shows the minimum amount of traffic needed to cover line maintenance costs.

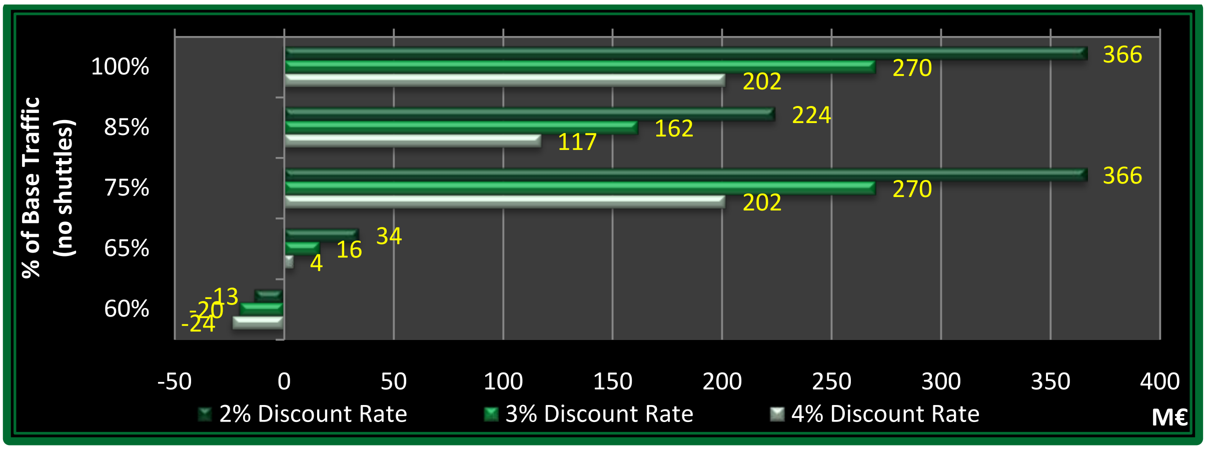


Figure 39: Project NPV (no initial investment considered), maintenance costs of 80,000€ per line-km per yr

It is clear that between 60% and 65% of traffic will be required to cover maintenance costs of 80,000€ per kilometer of line per year. Sixty-five percent of traffic is equivalent to 1,434,560 train-kilometers for long-distance services and 1,148,873 train-kilometers for regional services in 2057.

5.3. Developing an Enhanced Tariff Structure

5.3.1. Goals

Any proposed tariff system must meet certain goals defined by the European Commission, the State government, and the IM. These goals must be in line with current European and State legislation and long-term vision for rail infrastructure.

First and foremost, the goals must include sustaining and improving the rail industry. The European Commission has recommended promoting the rail mode over other modes to increase overall efficiency, decrease energy use and improve sustainability (EC, 2008). On the State level, one of the major goals for the Portuguese railway sector is to improve its efficiency, reduce dependence on State funds, and provide a positive impact on the country. From point of view of the new high-speed line project, the tariff system must contribute to goals set by the European Commission, by the State government and by the project sponsors (RAVE, 2010).

The tariff system that will be developed must be flexible in accomplishing current and future goals of the IM. It must: meet current legislation, allow for efficient auditing and regulation, balance maximization of social benefit and investment recovery and provide incentives for improved productivity and infrastructure use.

In order to accomplish current and future goals, the system must be able to be easily adaptable to future conditions, and thus must be structured in a flexible way, permitting addition of new concepts to its structure. On one hand this means creating a legislative environment that permits relatively easy changes to the structure and tariff levels, while balancing this with a strong regulator who would be able to assess the impact of these changes on previously-set goals. As a counterexample of this, the current tariff system in Spain is a result of a law that needs to be amended to make any changes in the Spanish tariff system (ADIF, 2009). From the point of view of the IM and the State, the initial goal during the start-up period of the line may be to encourage more traffic to use the line, while the goal of the IM after the first ten years of operation may be to maximize gross revenue, or maximize social benefits.

In order to meet current legislation, the system must conform to EC directives mentioned earlier in this document and must be able to meet all laws and regulations of Portugal, including any guidance by IMTT, the regulator.

The tariff system must not be so complex as to prevent auditing the IM and RUs. Creating a charge that is not easily quantifiable or countable (e.g. per-passenger charge at stations without ticket barriers), or one that would have potential for big abuse by either the IM or RUs, would not conform to this goal.

In order to maximize full benefit of the investment, a tariff system must maximize utilization of infrastructure and promote a high level of supply. In other words, high service frequency is required, especially during the initial period of operation, in order to gain mode market share and increase infrastructure utilization.

In accordance with the EC directive 2001/14/EC, IMs are allowed to levy a mark-up on infrastructure where market forces allow it. This mark-up would be used to recover costs associated with infrastructure construction. The mark-up charge must be balanced with the operator's willingness to pay in order to see how much of the initial investment costs can be recovered.

Finally, In order to promote efficient infrastructure use, the tariff system must have built-in bonuses and penalties that send clear signals to RUs about intended IM goals.

5.3.2. Cross-Border Pricing Harmonization: Integration of the New Tariff System with Spanish Tariff System

As this is an international line, it is important to ensure that the tariff systems on the Spanish and the Portuguese sides of the border are harmonized structure, charging levels or both. Given that the Spanish line will not be constructed using a public-private partnership, tariff levels are expected to be lower on the Spanish side than on the Portuguese side. Also, relatively easy terrain that does not require many special infrastructure projects (e.g. bridges and tunnels) means a lower average per-kilometer construction costs for ADIF.

On the Portuguese side, the TTT will have higher costs associated with its construction, and thus will provide an opportunity to differentiate tariff levels between the TTT and the non-TTT segment. This will allow the IM to align the non-TTT segment tariff levels closer to the Spanish tariff, thus ensuring a high level of tariff harmonization.

5.4. Tariff figure proposal

5.4.1. Development Process

As part of the development process of a new tariff system (shown in Figure 40), first a list of concepts will be presented and each of these concepts will be examined in depth. Second, tariff the structure of the system will be defined. Finally, various tariff incentives will be examined their impact on the tariff system and gross revenues will be discussed.

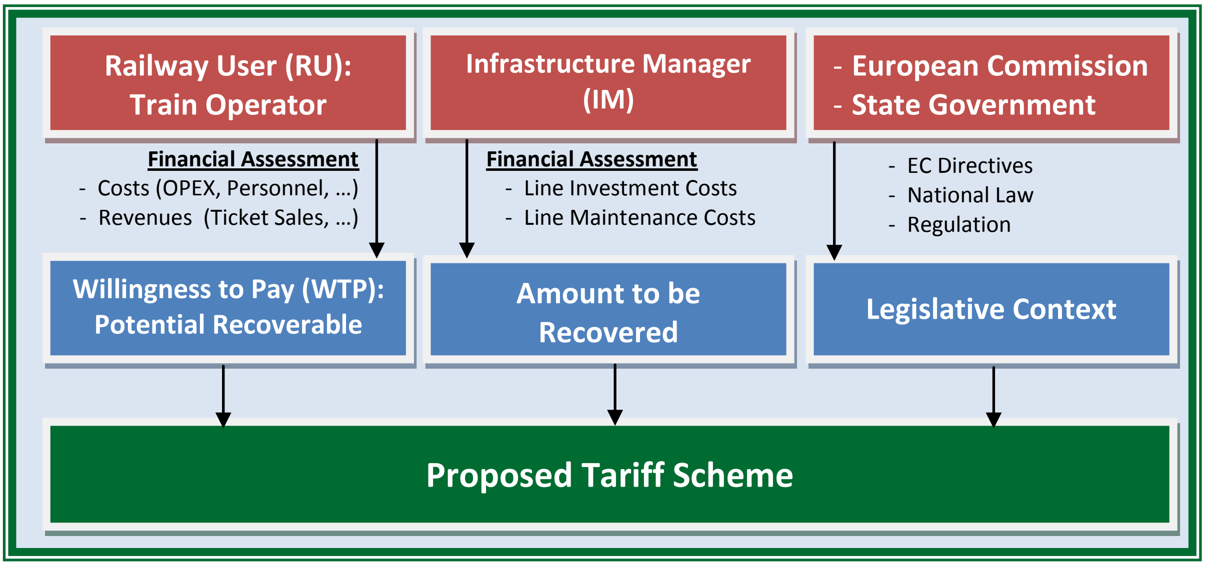


Figure 40: Tariff system development process

5.4.2. Tariff Concepts: Variables

This section will consider possible variables for the proposed tariff model. After, certain variables will be chosen for use in the model.

Line Section by type: this type of differentiation reflects the supply and its operational characteristics (speed, electrification, signaling system, etc.) This concept permits differentiation of supply for each line section and allows recovery of each RU's willingness to pay, which is not necessarily proportional to maintenance costs of each section. This type of differentiation also allows the IM to have influence over the type of path that RUs will choose.

Line Section by traffic volume: by differentiating between lines of the same type by traffic volume on each line, as in France, permits the IM to properly qualify demand for each line type. This results in redistribution of demand between lines with more traffic and lines with less traffic. This type of classification demonstrates the value of each line to RUs and promotes the use of underutilized sections. On the other hand, not differentiating a line by traffic volume results in a cost spread with tariff levels above RUs' willingness to pay.

Line Section by investment or maintenance costs: as a way to better link high construction and/or maintenance costs, an IM may choose to divide a line into sections proportional to their initial construction costs, where a bridge or a tunnel may have a higher tariff level than other line sections, to reflect higher construction costs.

Differentiation by Time of Day: by creating multiple time bands throughout the day and assigning a different value to each, the IM is able to better capture RUs' willingness to pay as it changes with demand throughout the day. For example, passenger demand during peak periods tends to be higher and thus RUs' willingness to pay for capacity is higher. This results in a higher recovery potential for the IM.

Origin-Destination Differentiation: by charging different prices based on the origin and destination of the passengers on a train, the IM is able to capture different WTP for each origin-destination pair. This is a similar concept in how airlines price tickets: flights originating in hubs generally carry a premium, compared to flights originating in secondary cities. Currently this type of differentiation is crudely implemented in France, where high-speed trains originating or terminating in Paris pay more than those that do not.

Train Capacity: given that a train with a higher capacity brings in more revenue, differentiating by train capacity allows the IM to capture the train's higher ability to pay, assuming the same average occupancy rate. This differentiation is implemented in the French and the Spanish system, either with a step-linear increase or using a per-seat fee. Depending on how this variable is implemented, it may have a negative impact on the availability of capacity in the long term, as the RUs may not have an incentive to run longer trains.

Service Type: differentiation by service type allows market segmentation by willingness to pay (e.g. freight vs. passenger; regional vs. long-distance, etc.). This type of differentiation can also reflect different operating costs of the IM (e.g. different levels of capacity use) and also be implemented implicitly (e.g. by maximum operating speed).

Access Fees: using access fees in a two-part tariff generally removes some uncertainties for IMs, related to predicted traffic levels. In some cases, fixed fees can be used to redistribute funds between different levels of government and/or the IM (e.g. regional services in France with high access fees that vary by region). In other cases, access fees are used to recover IM operating costs, as is the case in Spain, where a graduated fixed administrative charge is levied on users, depending on the total number of consumed capacity per year (in train-kilometers). This type of fee is generally used to create an environment with a barrier to entry into the market rather than with competition within the market. Such fees may also be discriminatory toward small or international operators. Current European Commission regulations do not permit the use of such fees on international markets where open access must be permitted.

Train weight: such a differentiation permits cost recovery of a train's impact on the line. This can be used as a basis for the train's marginal cost. There are also other ways to estimate these types of charges such as by studying the impact of a particular train type on track profile.

Diversion from pre-defined paths: this Belgian concept pre-defines a set of paths and charges extra fees for diversion from these paths.

Node concept: a node is defined as a geographic area with a certain level of importance (normally centers of urban areas or large junctions). The RU is charged based on passing through a node. This concept may be used for dealing with congestion problems (as in Switzerland and Italy) and is implemented as a surcharge or a discount, depending on whether the IM wants to reduce or increase the amount of traffic passing through an area.

Station Charges by Station Type: this concept permits charging various rates, based on the infrastructure that is present at a station. For example, the German system defines a minimum level of infrastructure and services that must be present at a station for each station class.

Station Charges by Trip Length: this type of charge is another definition of service type and relates to the amount of services that passengers use, and the amount of revenue they bring in, depending on the type of train they are riding. For example, a long-distance train requires more services than a suburban train, but long-distance passengers are also likely to bring in more revenue to station concessions on a per-passenger basis.

Station Charges by Passenger Volume: this charge is directly related to the size of the station. The more passengers pass through it, the larger it needs to be. This charge is difficult to assess if access control is not implemented at the station.

Station Charges by Stopping Time: this charge is directly related to the capacity that the RU uses. In stations with dimensional constraints, a high surcharge may be levied for trains that stop at a station for more than a certain period of time (e.g. Brussels-Midi TGV).

Station Charges by Type of Use: charging the RUs by type of use (origin, intermediate stop, or destination) is an approximation for the amount of station resources that a given train requires, as well as the amount of passenger traffic that passes through the station.

Station Charges by Service Type: this charge captures a higher willingness to pay of trains capable of paying more. In some cases this may depend on the number of stops a train makes along a line (Netherlands), in others this is more explicitly defined and the charge is levied as a function of passengers that use the station.

5.4.3. Tariff Structure

As discussed earlier, there are two main structure types used in Europe: additive and multiplicative. The proposed tariff structure for this line (shown in Table 9) is additive with multiple parts. The first part will reflect the marginal social costs, the second part will be the mark-up to recover any additional IM costs, and the third part will be used to recover initial investment costs.

Table 9: Proposed Additive Tariff Model Structure

Charge Name	Type	Notes
Marginal Social Cost	Short-term Marginal Cost	• based on train weight • variation by per service type • node congestion charge • environmental charge/discount (future)
Mark-Up	Other Line Management Costs	• per train-km • per service type • varies by time of day
Investment Recovery	Recovery of Initial Capital Investment	• per train-km • varies by service type • varies by time of day • variable discount for total traffic volume on network • OD charges

A. Marginal Social Cost and Mark-Up Charge

The Marginal Social Cost (MSC) reflects cost of the impact of the train on the rail line and any other short-term costs that the IM incurs (including externalities) as a result of having the train use the line. This cost will be calculated on the basis of train weight, or the train's operating characteristics after a study examining these characteristics is performed. In either case, the cost will be converted to a train-km basis and will be differentiated for each service type, as different vehicles have different operating characteristics, and higher speeds generally lead to higher track deterioration (Teixeira, 2008). In later phases of operation, if congestion becomes a problem, the node concept can be implemented (with multiple node types) to better manage capacity. This feature should be included in the MSC price and may be activated at a later point.

An environmental fee may also be added in the future, however EC Directive 2001/14/EC requires that a consistent policy be adopted for all transport modes. This allows the adoption of a policy that would permit giving railway users a discount, based on associated environmental benefits.

The Mark-Up Charge includes medium-range average costs for managing the line. Such costs may include infrastructure expansion, larger line maintenance costs that are not included in the Marginal Social Cost and any other costs related to IM line management.

The total of the Mark-Up Charge and the Marginal Social Cost will make up any and all maintenance and management costs that the IM is liable for. In order to calculate the sum of these two charges, the maintenance costs need to be divided by the total number of train kilometers. However, because in the initial phase of operation the RU will have a lower operating margin and will, most likely, operate fewer train-kilometers, simply dividing the costs by train-kilometers on an annual basis will result in a very high price in the beginning of operation and will penalize the train operator. On the other hand, in later stages of the operation, the train operator is likely to operate more train-kilometers on an annual basis, and thus will have a higher ability to pay these maintenance costs. Thus, averaging these costs over the life of the concession (2017-2057) will permit the IM to recover most of these costs and will not have an adverse impact on the operators during the initial years of operation. This will also serve as an implicit discount to the train operator during the initial phases of operation.

The Mark-Up charge should be levied in Euros per train-kilometer, with differentiation, depending on service type (Long-distance, regional, shuttle) and time of the day (peak, normal, off-peak periods).

B. Investment Recovery Charge

An **Investment Recovery Charge** is levied on RUs and amounts to the remainder of the RUs' willingness to pay. The amount is levied on a per train-km basis and differentiated by time of day and by type of service. The reason for levying this on a train-kilometer basis in the initial phase of the operation is simple: if this amount is charged per passenger-kilometer, or per seat-kilometer offered, there are certain uncertainties that the IM implicitly assumes. In the first case, the IM assumes the risk of low traffic. This does not send any positive signals to the RU regarding desirable traffic levels. In the second case, charging per seat kilometer will have not produce the desired effect of having more traffic in the initial phase. On the contrary, it will tell the RU to increase train load factors and reduce the number of services offered, which will undoubtedly have a negative impact on the line. Another alternative is to have a surcharge for high occupancy factors (at least in the initial phase). This, however, may result in inefficient line operation. For the initial operating phase, this charge is best levied on a per train-kilometer basis.

As the EC directive 2001/14/EC permits discounts during start-up periods, a variable discount can be applied to this charge. This discount would depend on the total number of train-kilometers ordered from the IM, and would vary between 0% and 4% of operating costs of the train operator. The discount would be applied in increments of 0.5% of operating costs (subtracted from the investment recovery charge on an annual basis) for every 500,000 annual train-kilometers ordered from the IM. This amount of train-kilometers is for the total amount ordered from all RUs (only for passenger services). Finally, because of the need to better align this tariff system with the Spanish one, and because construction costs are higher for the line section containing the Third Tagus Crossing (TTT), the tariff system will be divided into two parts: a part containing the TTT between Lisbon and

Poceirão, and the rest of the line, between Poceirão and Caia/Badajoz. The investment recovery charge will be multiplied by a factor, proportional to construction costs of each of the two sections.

As line traffic matures, this charge can be transformed into a charge based on passenger-kilometers, depending on origins and destinations. This complicates things by requiring recordkeeping of passengers and their origins and destinations. The price per passenger-kilometer of such a system would depend on the market's willingness to pay, differentiated by origins and destinations.

C. Station Pricing

Station charges would have three parts, as shown in Table 10. Each of the three parts would have different tariff levels for different service types (Long distance, regional, airport shuttle). This differentiation is in place because passengers using each of these services require a different level of station facilities and spend different amounts of time in a station. For example long distance passengers require more station facilities, but may also, arguably, bring in more revenue, while passengers using frequent suburban services do not require a large amount of station facilities, but also may bring in less revenue to station services.

Table 10: Proposed Station Pricing Model

Charge Name	Type	Notes
Marginal Charge	Short-term Marginal Costs	• per train stop • varies by service
Management Charge	Station Maintenance and Organization	• per train stop • penalty for overstaying (per minute)
Investment Charge	Recovery of capital costs related to station expansion	• per passenger • per stop type (origin, destination, intermediate) • per service type

The first part of the station charge consists of a **station marginal charge**, similar to the one discussed previously for line segments. This charge is based on the added capacity cost of maintaining the station and is levied on a per-train-stop basis. The second part, **station management charge**, consists of two parts. The first is also levied on a per-train-stop basis and covers station management and organization activities. The second part covers an overstay component, and is levied only if the train surpasses a certain station stopping time (depending on the station and whether the stop is an origin, destination or an intermediate stop). After a predetermined time, this part of the charge is calculated on a per-minute basis. Finally, the **investment charge** is directly related to the investment costs of building/expanding the station. This charge depends on the station and is levied on a per-passenger basis, and is differentiated by stop type (origin, destination, intermediate stop).

5.4.4. Origin-Destination Tariff: Further Analysis

A. System Description

A part of the proposed tariff scheme includes the investment recovery charge. The main proposal considers the charge on a per train-kilometer basis, with variation based on service type and time of day. This approach treats all passengers alike and considers that all passengers, on average, have a similar ability and willingness to pay. This is an assumption that is not entirely correct. Passengers traveling between Lisbon and Madrid (two capitals), for example, have a higher ability to pay, than those travelling from Évora to Caia (two regional centers). Furthermore, it can be argued that the ability to pay for passengers in one direction is lower than ability to pay for passengers in the other direction. Using that logic, passengers taking a round-trip from Madrid to Lisbon have a higher ability to pay than those, travelling in the other direction, simply due to a higher economic level of Spain.

Converting the proposed investment recovery fee from a purely per-train-km charge to a charge based on passenger-kilometers and the origin and destination of the trip can help generate more regional passenger demand, as trips between regional stations trips will be priced lower on a per-km basis than trips between main stations. This tariff should be implemented after the initial start-up period when a baseline demand is established.

As a first step for valuing the wiliness to pay of each market, a proxy with four economic levels (high, intermediate, normal and low) will be established. A detailed study would need to be performed in order to determine how to assign and calibrate categories to each city. This approach assumes that tariff savings would be passed on to consumers by the RUs.

Many airlines use such a system to price airline tickets, tying ticket prices to consumers' willingness to pay. As an example, a ticket can often be cheaper for travel between an origin and a destination, traversing an intermediate point, compared with a ticket between the origin and the intermediate point. In another benefit of this system, potential induced demand may increase revenues from this system, compared with a baseline. Because some OD pairs would be charged higher rates than other OD pairs, regional markets could see increased development of demand, as the end users' ability to pay for tickets between regional markets is usually less than that of users traveling between bigger cities and regional endpoints. Furthermore, enhancing this yield management system and creating asymmetric charges, based on round-trips would enhance the ability to capture willingness to pay from markets with higher WTP. For example, a round-trip ticket between Lisbon and Madrid could cost less than a round-trip ticket between Madrid and Lisbon due to different economic levels in each country.

In this system, the burden of proof would be on the RU to show that the passenger did in fact travel between stated endpoints. Otherwise the RU would be charged the maximum passenger-km rate. Other parts of this system could be transferred from the yield management sector of the airline industry.

B. System Application

In order to implement this system, station passenger counters and ticket barriers would have to be established at stations with more expensive categories. This would be required to prevent a passenger from booking a cheaper ticket and boarding or alighting in the middle of the trip.

Based on the four-category proxy above, each city would be assigned a value, from 1(low) to 4 (high) and the corresponding matrix would be used as a basis to modulate passenger-kilometer prices. Table 11 shows a sample value assignment both symmetrically and asymmetrically, resulting in two types of assignments.

After categories are assigned, they are multiplied together to obtain a weight that would be used in assigning a per passenger-km cost. In the symmetric case, the value between origins and destinations remains the same, no matter the order. In the asymmetric case a round-trip to city B, originating in city A may be more expensive than a round-trip to city A, originating in city B. In this example, Lisbon to Madrid has a resulting value of 12, while Madrid to Lisbon has a resulting value of 16.

Table 11: Origin-Destination Pricing, Assignment of Station Categories

Symmetric Assignment of Station Categories		Lisbon	Airport	Évora	Caia	Madrid	Other Spanish Stations
	Cat	4	4	2	2	4	3
Lisbon	4		16	8	8	16	12
Airport	4			8	8	16	12
Évora	2				4	8	6

Asymmetric Assignment of Station Categories		To: Lisbon	Airport	Évora	Caia	Madrid	Other Spanish Stations
	Cat	4	4	2	2	4	3
From: Lisbon	3		12	6	6	12	9
Airport	3	12		6	6	12	9
Évora	1	4	4		2	4	3
Caia	1	4	4	2			
Madrid	4	16	16	8			
Other Spanish Stations	3	12	12	6			

As an example of this system, the year 2030 will be used. In this year, a total of 35.9 M€ are expected to be recovered from the investment recovery fee for long-distance and regional services in the standard tariff system, that does not involve origin-destination pricing. Shuttle services are not considered due to the uncertainty associated with the construction of the New Lisbon Airport. Half of this amount is expected to be recovered. Thus, 17.95 M€ will be divided by a total number of passenger-kilometers, 586,750,788, to get a per passenger-kilometer fee of 0.0306€. This fee will then be weighted by the factors described above to get per-kilometer prices that will be applied to the tariff of the train operator as shown in the Table 12. Because airport services are to be provided by shuttles, they will not be considered in this case. Also, it is worth to note that services between Caia and Spanish stations are also not considered, as these are performed exclusively in Spain.

Table 12: Origin-Destination Prices per Passenger-km

Symmetric Origin-Destination Prices per Passenger-km		Lisbon	Airport	Évora	Caia	Madrid	Other Spanish Stations
	Cat	4	4	2	2	4	3
Lisbon	3			0.028	0.028	0.055	0.041
Évora	1				0.014	0.028	0.021

Asymmetric Origin-Destination Prices per Passenger-km		To: Lisbon	Airport	Évora	Caia	Madrid	Other Spanish Stations
	Cat	4	4	2	2	4	3
From: Lisbon	3			0.028	0.024	0.035	0.080
Évora	1	0.015			0.020	0.035	0.038
Caia	1	0.013		0.011			
Madrid	4	0.035		0.035			
Other Spanish Stations	3	0.031		0.031			

From here, these prices would be applied to the number of passenger-kilometers for each path and the resulting values would be added together for a total recovered amount. Table 13 shows an application of a symmetric model assignment.

Table 13: Passenger-kilometers and gross revenue amount

	Évora	Caia/Badajoz	Madrid	Other Stations
(A) Passenger – Kilometers (2030)				
Lisbon	49,048,933	53,885,582	398,588,175	49,584,744
Évora	0	11,128,035	18,694,073	5,821,245
(B) Gross revenue amount (M€)				
Lisbon	1.4	1.5	22.0	2.1
Évora		0.2	0.5	0.1
Total: 27.7	1.4	1.6	22.5	2.2

Source: (A) RAVE pax-km data; (B) own elaboration

From here, another iteration will be performed, by multiplying the price per kilometer by the difference between the recovered amount and the desired amount to be recovered (27.7 M€ divided by 17.95 M€ to get a factor of 1.544). The price per kilometer will be divided by this factor to get a new price per kilometer and model will be evaluated again with the new price of 0.0198€ passenger-km, resulting in a recovery of 17.95M€.

This type system involves much more data collection and analysis and thus its benefits must be weighted at the prospect of additional gross revenue based on induced traffic. Because of the high start-up costs, establishing this system in a completely new environment may be difficult, given that no traffic data exists to calibrate base valuation of different origins and destinations.

5.5. Application of the Tariff and Sensitivity Analysis

5.5.1. Estimation of Investment Recovery Potential of the Proposed Tariff Model

This section will apply the proposed tariff model to the same conditions as in Section 5.2, using the same traffic values and the same assumptions. There are two parts to this example. The NPV will be calculated, which will allow assessment of the model's initial investment cost recovery levels and resulting tariff values will be presented and discussed.

5.5.2. Numerical Evaluation

In this section, the operator's willingness to pay is once again compared to IM's liabilities of initial investment costs and maintenance. The results are presented below. It should be noted that while the NPV is negative, maintenance costs are always covered, and a large part of the initial investment costs will also be covered by the tariff system. Figure 41 shows the resulting NPV values. This figure includes shuttle traffic.

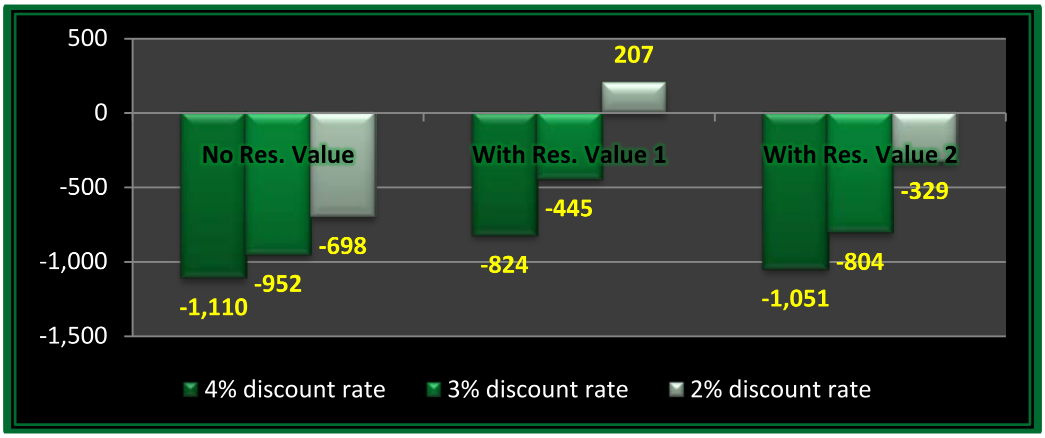


Figure 41: NPV of tariff system application, updated to 2010

As a part of a sensitivity analysis, for a 25% reduction in long-distance and regional traffic, the NPV will decrease between 10% and 15%.

5.5.3. Resulting Tariff Levels

Recovery potential of the model is dependent not only on the total profit, but also on the distribution of gross revenue among different categories of the tariff model. Also, the aforementioned differentiation between the Lisbon-Poceirão and Poceirão-Caia/Badajoz sections would vary as follows: the investment recovery rate on the first segment would be higher than on the second segment. The full values are shown in Figure 42.

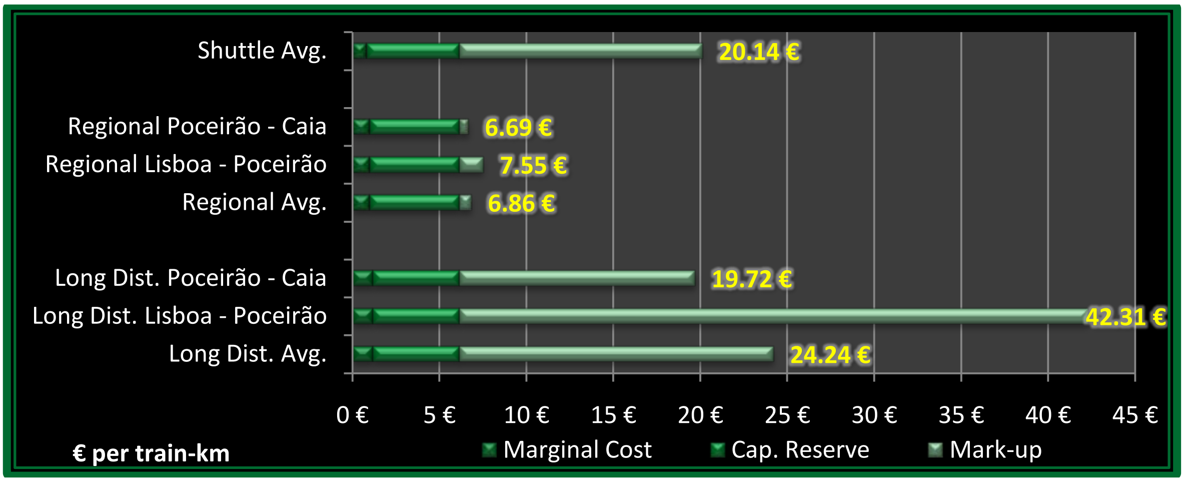


Figure 42: Proposed Tariff Differentiation by Section on Lisbon-Madrid HSL

5.5.4. Assessment of Initial Assumptions and Boundary Conditions

If some of the initial assumptions are not correct, there will be a change in the demand for the RU, and thus a change in gross revenue values for the IM. This section will discuss potential problems that the IM may face and list some of the possible uncertainties.

One of the main uncertainties is the traffic. While numerous market demand studies have been completed, there is always uncertainty on the demand of a new line, not only in the short term (for example due to a changing economic climate), but also in the long term, due to paradigm changes, such as increased competition from another mode that could not have been foreseen. While in the past, many new high-speed rail corridor studies have under-predicted demand by not considering induced travel, there is always a chance that projected traffic numbers have been overestimated. As sensitivity analyses have shown, a drop in demand may have a significant negative impact on line gross revenues, depending on the level of demand change. However, it is unlikely to result in a disastrous outcome for the line as maintenance costs will still be covered and the order of magnitude of the NPV will remain of the same. Furthermore, the NPV (and this document) does not consider other benefits of the new line, which includes regional development, an increase in business opportunities, higher tourism levels, all of which lead to more tax revenue for the State.

Continuing with the question of demand, if the operator finds lower occupancy rates on the line after an initial start-up period, the operator may ask the IM to reduce tariffs, which will reduce the IM gross revenues, or the operator will reduce the amount of service, which will also reduce the IM's gross revenues. Thus the IM has a disincentive for reducing tariffs (more services means higher maintenance costs and lower gross revenue due to lower tariffs), but from a social benefits point of view the State has an incentive in maintaining a certain service level in order to justify initial investment costs.

Should the market necessitate lower ticket prices, the RUs' ability to pay will significantly decrease, and thus the IM's investment recovery charge will also have to decrease. This will result in a longer payback period and a lower NPV value of the project.

This line is designed to allow for freight operations from the port of Sines. The result of this is twofold. First, freight will have to justify its presence by having a high-enough value to pay marginal costs. Second, if the freight's value allows for an additional investment recovery, the IM may potentially recover more of the initial investment costs through investment recovery charges.

6. Conclusions and Further Developments

Railway infrastructure pricing has come a long way since the first pieces of European legislation in the early 1990s. Based on the examination of charging schemes and their cost recovery rates in key European countries, a number of conclusions can be clearly drawn. First, nearly all examined countries are able to cover their line operating and maintenance costs. The exceptions can be grouped into two categories: new lines that are still not constructed to their intended length or that are still in the initial phase of operation (e.g. Madrid – Valladolid), and lines where low recovery rates are due to low tariffs as a result of a political decision (e.g. Italy). In the high-speed sector, the trend between 2007 and 2010 has been to increase line cost recovery up to the maximum potential possible, by passing infrastructure usage costs on to users. This is done either to recover the costs of existing lines or to use the money as an investment in new infrastructure. New lines and special infrastructure projects such as bridges and tunnels are increasingly using innovative financing and project delivery methods such as public-private partnerships (PPPs), requiring high cost recovery levels.

None of the European tariff systems, when applied to the new Lisbon-Madrid line, are optimal to recover full initial investment costs. The Portuguese tariff system is especially inapplicable to the new line, as it does not allow for sufficient cost recovery rates to even cover maintenance costs. However, parts of most charging systems can be used to construct a new system, which meets many of the goals of the Infrastructure Manager, the State, and the European Commission for the new Lisbon-Madrid high speed line.

Based on the presented financial analysis, the proposed Lisbon-Madrid high speed line is capable of paying its maintenance costs and a large part of the initial investment costs. The highest risk to all parties is the uncertainty of the projected level of traffic on the line. Because this is an international line, concessions and operational subsidies are limited by EU law and there is a requirement to maintain open access to any operator that can meet a minimum set of requirements. However, given the experience of other high-speed lines in Europe and elsewhere, traffic numbers are usually under-predicted due to induced demand.

The proposed tariff structure includes concepts from other European lines as well as innovative concepts from other industries, such as origin-destination pricing and is able to capture a high percentage of the operator’s willingness to pay. The proposed tariff scheme’s structure sends clear messages to the operators regarding the amount and type of traffic desirable and provides discounts for higher traffic levels.

Division of the line into two segments, with one containing the new bridge leading into Lisbon, allows the Infrastructure Manager to charge higher tariffs on the section with higher investment costs, passing on the cost directly to users as use fees. This approach also allows harmonization of the tariff levels between the Portuguese and the Spanish sides by aligning the costs on the lower-priced section with the Spanish charging system.

As this line is being designed for passenger and freight operations, capacity for freight operations will depend on the level of passenger traffic on the line. While transportation of freight has high social benefit that includes reduction of congestion on roadways, only high volumes of high-value freight (something that is not forecasted) will benefit the line financially, by providing a significant amount of gross revenue to cover initial investment costs.

Given more detailed information about passenger and freight traffic predictions, as well as operating scenarios, a more detailed tariff rate study can be performed to better define the values for a proposed tariff system, including calibration of peak and off-peak periods and weights for each. Furthermore, a study about marginal operating costs needs to be performed in order to calibrate marginal costs specifically to the track degradation profile of each train type. A more detailed study of tariff harmonization with Spain is desirable, provided that it involves all interested parties. The goal of such a study would be to determine whether an international corridor with a seamless tariff system can be created, and if so, how it would be done.

A more detailed analysis of the tariff scheme based on origins and destinations can be performed to determine appropriate charging levels and the weight of the passenger-km charge versus a flat per-train-km charge.

Finally, a more detailed tariff study could be performed on the Lisbon-Madrid line's evolution. This study would examine traffic levels over time, treating them with uncertainty, and how changes in the line tariff charging system, based on the level of maturity of operation, could be made to capture the highest amount of RUs' willingness to pay.

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[1] CEMT is now known as: ITF – International Transport Forum
[2] DERC is now known as: European Commission's Directorate General Energy & Transport and the Advisory and Regulatory Committee

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8. Appendix

8.1. Ticket Prices

Ticket price data was collected in the fall of 2010. Data was collected during five working days (Monday to Friday) during one week. On each day the ticket price was checked for three time periods (AM Peak, Midday, PM Peak) for Wednesday and Friday of the following week for both first class and second class. This process was repeated twice (two weeks total). Over sixty data points for each line were collected.

Table 14 shows minimum, maximum and average ticket prices for each of the lines considered. Figure 43 contains tables with average prices and the minimum-maximum spread for average prices, Wednesday prices and Friday prices.

Table 14: Ticket Prices - Collected Data

Line	Ticket Prices					
	Second Class			First Class		
	Min.	Max.	Average	Mín.	Max.	Average
Madrid - Barcelona HS	69.00 €	115.00 €	101.32 €	69.00 €	207.00 €	157.37 €
Madrid - Barcelona Reg.			62.00 €			40.20 €
Madrid - Seville HS	48.80 €	81.40 €	79.23 €	122.20 €	146.50 €	134.35 €
Madrid - Seville Reg.			40.70 €			23.07 €
Madrid - Valladolid	21.30 €	35.40 €	29.32 €	28.20 €	55.00 €	53.06 €
Madrid - Toledo	10.00 €	10.00 €	10.00 €			
Cologne - Frankfurt	34.00 €	44.00 €	39.50 €	69.00 €	69.00 €	69.00 €
Hannover - Berlin	39.00 €	62.00 €	41.33 €	69.00 €	69.00 €	69.00 €
Paris - Tours	41.30 €	55.20 €	45.93 €	76.70 €	76.70 €	76.70 €
Paris - Lyon	64.30 €	83.90 €	73.12 €	68.00 €	114.80 €	111.90 €
Paris - London	50.00 €	183.00 €	89.63 €	124.00 €	338.00 €	259.12 €
Paris - Brussels	44.00 €	88.00 €	61.90 €	59.00 €	138.00 €	94.67 €
Brussels - Amsterdam	54.00 €	64.00 €	59.00 €	77.00 €	102.00 €	80.33 €
Rome - Florence	37.00 €	44.00 €	40.97 €	53.00 €	62.00 €	55.70 €
Rome - Milan	49.00 €	89.00 €	63.77 €	97.00 €	114.00 €	100.40 €

Source: Teixeira et al, 2011

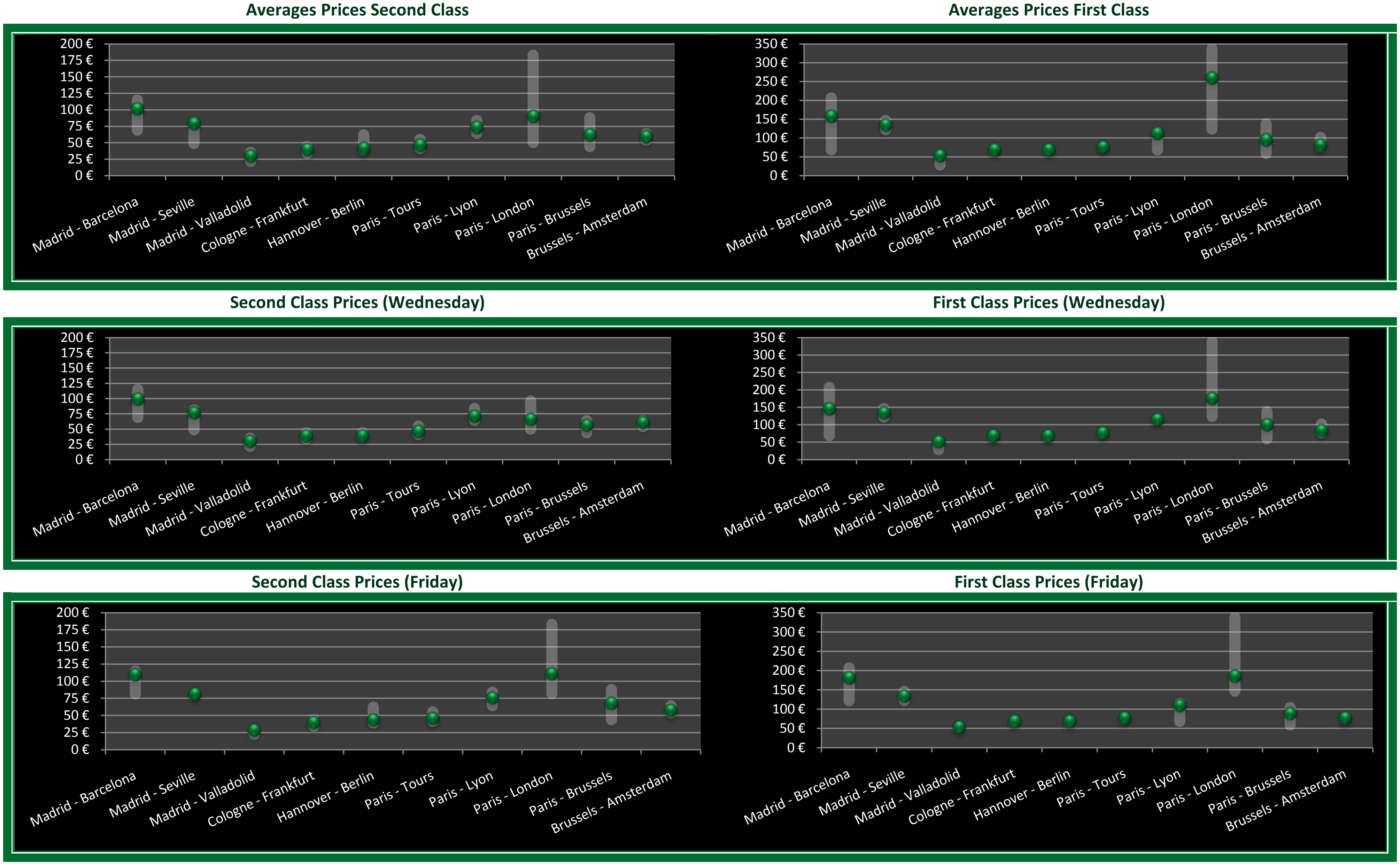

Figure 43: Collected ticket price data
Source: Data collected within the framework of a research project, Teixeira et al, 2011

8.2. Rolling Stock

Rolling stock shown in Table 15 is considered in the evaluation of EU tariff systems.

Table 15: Rolling stock pricing information

Type	Cost M€	Year	Inflation 2003>2010	Cost 2010	Leasing %	Annual payment
Siemens Velaro	24.3	2008	0.20%	24,348,600 €	6%	-1,900,909 €
TGV Duplex	20.88	2003	11.04%	23,185,152 €	6%	-1,633,374 €
TGV Reseau	15.93	2003	11.04%	17,688,672 €	6%	-1,246,152 €
ETR 500	19.99	2003	13.10%	22,608,690 €	6%	-1,563,752 €
S-102	20.5	2008	0.00%	20,500,000 €	6%	-1,603,648 €
S-104	11.783	2008	0.00%	11,783,000 €	6%	-921,745 €

8.3. Infrastructure Manager Gross and Net Revenues

Table 16 and Table 17 show estimates of IM gross revenue based on assumptions considered in Chapter 4, for two levels of maintenance costs: 80,000 € per line-km which considers only maintenance costs, and 120,000 € per line-km which also considers line renewal costs. Annual gross revenue is daily gross revenue multiplied by 360 working days

Table 16: IM gross and net revenues; maintenance: 80,000€ per line-km per year

Line	Km	Gross Revenue/Line	IM Gross Revenue	Investment no EU funds	%Recovered / Investment	Cost Recovery	IM Net Revenue
		Total annual/km (€)		M€/km	per year	Years	€
Spain							
Madrid - Barcelona *	630	254,305 €	174,305 €	14.8	1.2%	85	109,812,362 €
Madrid - Seville	470	307,911 €	227,911 €	9.4	2.4%	41	107,118,085 €
Madrid - Valladolid *	180	64,031 €	-15,969 €	11.0	-0.1%	-	- 2,874,351 €
Madrid - Toledo	21	127,455 €	47,455 €	10.1	0.5%	213	996,550 €
Germany							
Cologne - Frankfurt	180	453,574 €	393,974 €	37.0	1.1%	94	70,915,272 €
Hannover - Berlin	255	200,048 €	128,448 €	23.3	0.6%	182	32,754,148 €
France							
Paris - Tours	220	727,770 €	647,770 €	8.4	7.7%	13	142,509,434 €
Paris - Lyon	435	1,642,527 €	1,562,527 €	4.8	32.3%	3	679,699,438 €
Paris-Brussels							
Paris-Brussels	315	934,435 €	854,435 €	13.1	6.5%	15	269,147,148 €
Brussels - Amsterdam							
Brussels-Amsterdam *	325	386,447 €	306,447 €	26.1	1.2%	85	99,595,143 €
Italy							
Rome - Florence	260	80,850 €	850 €	41.3	0.0%	-	221,120 €
Rome - Milan	575	63,986 €	-16,014 €	27.2	-0.1%	-	- 20,708,000 €

Note: Lines marked with an asterisk are in the initial phase of operation

Table 17: IM gross and net revenues; Maintenance: 120,000€ per line-km per year

Line	Km	Gross Revenue/Line	IM Gross Revenue	Investment no EU funds	%Recovered / Investment	Cost Recovery	IM Net Revenue
		Total annual/km (€)		M€/km	per year	Years	€
Spain							
Madrid - Barcelona *	630	254,305 €	134,305 €	14.8	0.9%	111	84,612,362 €
Madrid - Seville	470	307,911 €	187,911 €	9.4	2.0%	50	88,318,085 €
Madrid - Valladolid *	180	64,031 €	-55,969 €	11.0	-0.5%	-	- 10,074,351 €
Madrid - Toledo	21	127,455 €	7,455 €	10.1	0.1%	1355	156,550 €
Germany							
Cologne - Frankfurt	180	453,574 €	364,174 €	37.0	1.0%	102	65,551,272 €
Hannover - Berlin	255	200,048 €	92,648 €	23.3	0.4%	252	23,625,148 €
France							
Paris - Tours	220	727,770 €	607,770 €	8.4	7.2%	14	133,709,434 €
Paris - Lyon	435	1,642,527 €	1,522,527 €	4.8	31.4%	3	662,299,438 €
Paris-Brussels							
Paris-Brussels	315	934,435 €	814,435 €	13.1	6.2%	16	256,547,148 €
Brussels - Amsterdam							
Brussels-Amsterdam *	325	386,447 €	266,447 €	26.1	1.0%	98	86,595,143 €
Italy							
Rome - Florence	260	80,850 €	-39,150 €	41.3	-0.1%	-	- 10,178,880 €
Rome - Milan	575	63,986 €	-56,014 €	27.2	-0.2%	-	- 32,208,000 €

Note: Lines marked with an asterisk are in the initial phase of operation

8.4. Traffic Data

8.4.1. Regional and Long-Distance Services

In order to develop traffic data, the following procedure was used: first, passenger matrices from RAVE were converted into a line load profile. Based on this profile, and industry-average train occupancy of 65%, the number of annual train-km was calculated. First line load profiles were calculated and the necessary number of trains was determined. Then, using this information, total numbers of train-km and passenger-km per year were calculated. Finally, the numbers were interpolated linearly between the data points, and between 2050 and 2057, the data was extrapolated using a constant growth rate from the 2030-2050 period. A sample passenger OD matrix between stations from the report is shown in Table 18.

Table 18: Matrix of passengers between stations (High-Speed) 2013

Matrix of passengers between stations (High-Speed) 2013 (Source: RAVE 2008) [sample]									
	Lisbon	Évora	Caia/Badajoz	Mérida	Cáceres	Plasencia	Navalmoral	Talavera	Madrid
Lisbon		567,497	392,429	56,905	94,766	43,302	0	15,115	974,511
Évora			195,143	14,156	17,794	7,419	0	4,323	58,694
Caia/Badajoz				197,093	233,522	101,349	0	10,976	628,258
Mérida					257,708	95,523	0	5,129	205,804
Cáceres						239,886	0	0	587,727
Plasencia							0	0	270,234
Navalmoral								0	61,732
Talavera									983,535
Madrid									

Source: RAVE 2008

8.4.2. New Lisbon Airport Shuttle Services

For shuttle services, passenger numbers were converted into an annual passenger-kilometer numbers by multiplying each passenger by 2 (as each makes two trips to access the airport) and by multiplying the passenger numbers by line length. As the line to the airport will not be built until at least 2020, it is assumed that passenger numbers will shift by 3 years from what was estimated (e.g. 2017 to 2020, etc.). A basic service profile was proposed, consisting of 20-minute headways during 15 hours of the day, and 30-minute headways during the remaining five hours of service. This service profile would increase to 20-min headways throughout the day by 2035, then to 15-minute headways during 15 hours of daily service, and 20-minute headways during 5 hours of daily service, and then to 15-minute headways throughout the entire service day. Traffic numbers for New Lisbon Airport Shuttles are presented in Table 19 and Table 20.

Table 19: Lisbon - New Lisbon Airport Shuttle Traffic Assumptions

	2017	2020	2030
Total Annual Passengers (to New Lisbon Airport)	2,214,014	2,471,104	2,920,554

Source: RAVE, 2009

Table 20: Lisbon - New Lisbon Airport Frequency Assumptions

Headway (20 service hrs daily)	2020	2035	2045	2053
15 service hours (e.g. 6AM to 9PM)	20 min	20 min	15 min	15 min
5 service hours (e.g. 5AM-6AM and 9PM-1AM)	30 min	20 min	20 min	15 min

Source: Based on RAVE, 2009

8.4.3. Freight traffic

Table 21 shows the projected freight demand forecast for the Lisbon-Madrid HSL on the Portuguese territory (RAVE, 2008).

Table 21: Freight Traffic Projections

	2013	2018	2020	2025	2030	2050
Million Tons per Year	0.948	1.397	1.522	1.878	2.215	3.815
Trains per day	26	36	38	46	54	88

Source: RAVE, 2008

8.4.4. Traffic Assumptions

Resulting traffic numbers are shown in Figure 44 and Figure 45 in terms of train-kilometers and annual services.

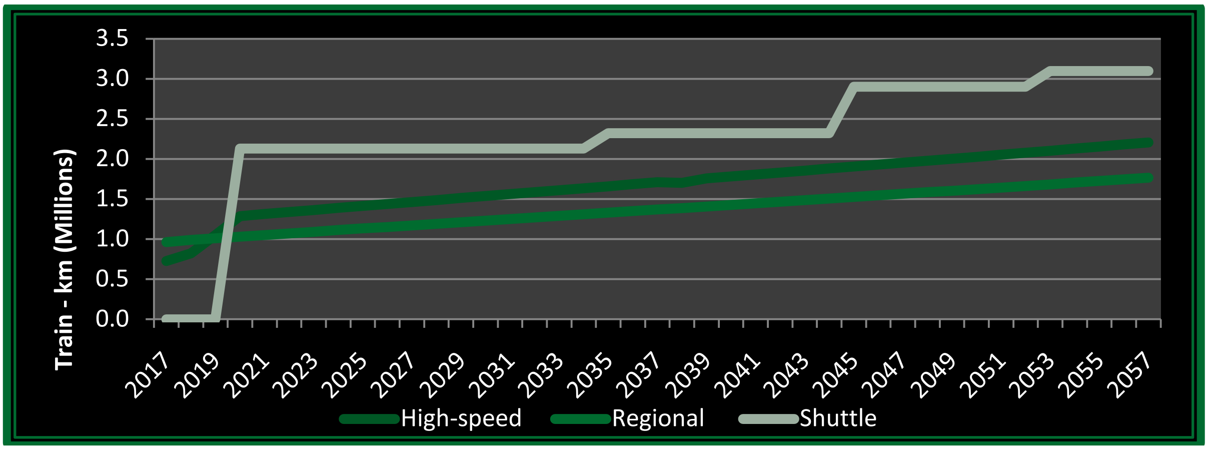

Figure 44: Traffic Assumptions: Train-kilometers per year

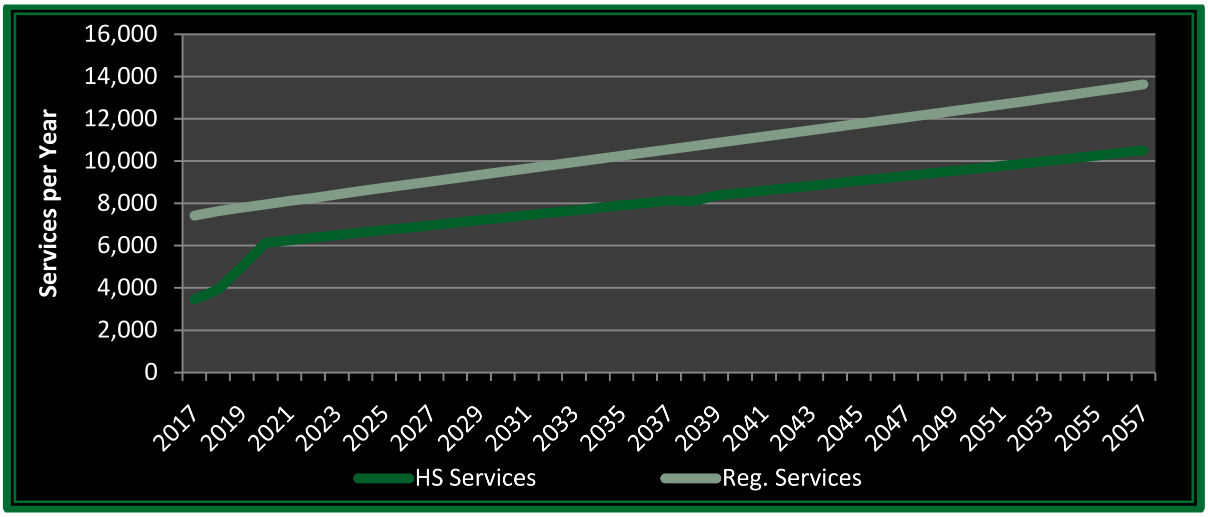

Figure 45: Traffic Assumptions: Services per year