Infrastructure Pricing Models for New High-Speed Railway Corridors in Europe
Pricing Model Development for the Lisbon-Madrid High-Speed Line

1. Introduction

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. 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)

2. Brief History of Railway Reform and Infrastructure Charging in the European Union

In the early 1990s, the European Union has embarked on a series of reforms, designed to open up the railway industry to competition, improve the sector's efficiency and create a level playing field within the sector and between different transportation modes. After the adoption of the EEC Directive 91/440/EEC *On the Development of the Community's railways*, each member state enacted certain reforms, first separating railway sectors' budgets from State budgets, and later – train operations from infrastructure management. In this early stage of reform, the newly-formed infrastructure managers were permitted to levy a fee on infrastructure to offset their management costs. However, details of this new tariff regime were only specified in a European Commission directive 2001/14/EC, dated in 2001. This directive was a part of what came to be called the *First Railway Package*, a series of directives and communications that have since been supplemented by the Second and Third Railway Packages. The *First Railway Package* defined access rules for infrastructure, created trans-European corridors for freight and passenger movement, defined EU-wide licensing requirements for train drivers and provided a definition on railway access charges. The *Second Railway Package* created definitions of interoperability and safety of railway networks while the *Third Railway Package* dealt with crew certification and opened up the railway market to freight and limited passenger competition. Returning to directive 2001/14/EC, it set down rules for Infrastructure Managers to define tariff systems and made it easier for train operators to obtain all information that is pertinent to train operations in any country. (EC, 2001)

Since the implementation of directive 91/440/EEC, numerous studies have been carried out at regular intervals looking both at how to create the best (or second-best) pricing system possible, and at how well the reform, detailed in the directives, was being carried out. While a great deal of debate on the first question continues to this day, studies about the second part noted slow implementation of directives, and as well as a lack of harmonization of tariff structures and tariff levels, leading to a variety of charging systems that use different principles. This was to be expected, as railways served different functions in different countries, and Infrastructure Managers' goals, and funding sources, were different. (EC DG-TREN, 2005)

3. Overview of 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 somehow 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 ideally would not exclude operators that could 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 theory considers responsiveness of RUs to costs and suggests charging operators marginal costs plus a mark-up, so that the total would be at or below 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)

4. Overview of Tariff Systems and Charging Levels in Key Western European Countries

There are two types of tariff system structures in Western European Countries: additive and multiplicative. 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.

Each State has a different tariff structure with different goals and different financial requirements. The tariff structures must not discriminate against operators and must meet goals set by the IM, the State and the European Commission. A number of variables can be used to influence demand, value supply and induce a certain behavior from operators. Tariff systems for lines include variables such as: line type, traffic volume, service type, time of day, performance schemes with bonuses/penalties, train capacity, access fees (two-part tariffs), train weight, node congestion charges, etc. Tariffs can be applied to stations by looking at importance of a station, train service type, passenger volume, train station stop time, and differentiation by use (origin, intermediate station, and destination).

In comparing charging levels, the highest per-kilometer tariff is on the Brussels-Amsterdam line, as the Dutch system includes a very high surcharge for its high-speed line. The next-highest group of lines uses the French tariff system, and includes the Paris-Tours, Paris-Lyon, Paris-London, Paris-Lille, and Paris-Brussels lines. Figure 1 shows different tariff levels on a per-kilometer basis in key Western European countries.

Recent trends have shown that significant price increases have occurred between 2007 and 2010 and that high-speed lines especially have been increasing usage fees, to match the increase in consumers' willingness to pay. In comparing charging levels between 2007 and 2010, the highest increase has occurred in France, where not only have charging levels increased, but the tariff system has been overhauled in order to better capture user willingness to pay. Figure 2 shows the comparison between charging levels of 2007 and 2010.

Figure 1: 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

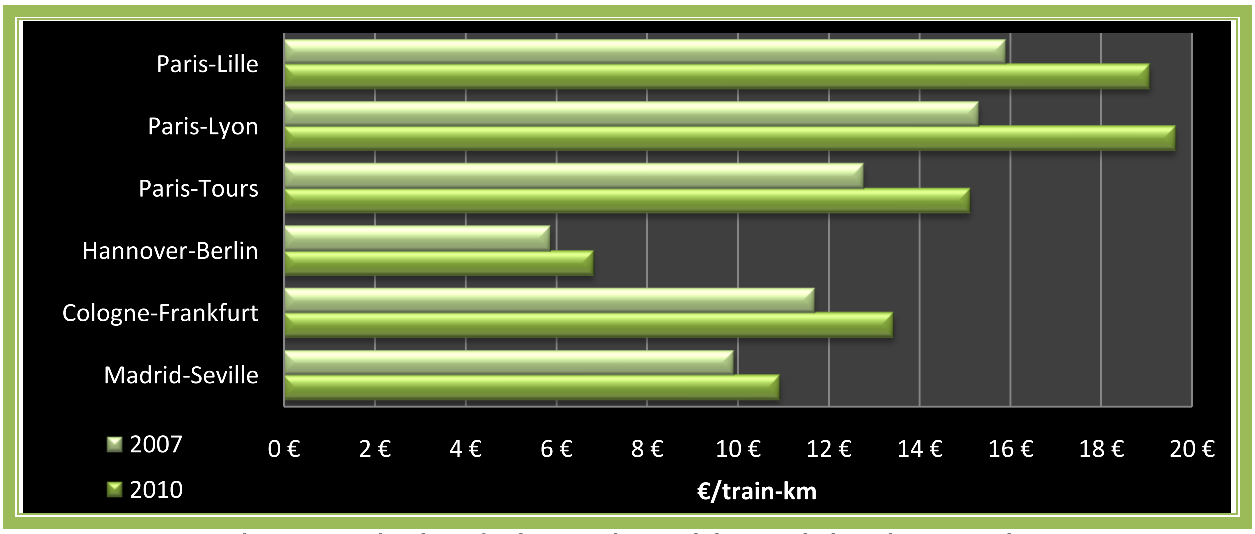

Figure 2: Evaluation of Price Levels on High-Speed Lines (2007-2010)
Source: ADIF, 2008 and Network Statements 2007 and 2010 of respective countries
Note: France overhauled its system between 2007 and 2010 and thus has a higher rate of increase

5. Evaluation of Operator Incomes

In evaluating operator incomes in key Western European high-speed corridors, first, ticket prices were collected and were used together with a 65% average occupancy rate to obtain operator revenues. This provided a basis for calculating operator income. A part of this process involved collecting traffic data for each of the corridors. The highest number of trains was observed on French lines, followed by German and Italian lines. The lowest number of daily trains was observed on the Madrid-Toledo line. This line, however, is a spur from the Madrid-Seville line and acts more as a commuter service than a mainline railway. While the level of operator profit was directly related to the amount of traffic on a line, the percentage of the tariff over the operator profit was highest on the Brussels-Amsterdam line, where the aforementioned high-speed line surcharge increases the otherwise low fee by a large amount.

In looking at Infrastructure Manager revenues, they were also found to be proportional to traffic. Figure 3 shows the Infrastructure Manager revenue per year per kilometer of line. In estimating IM profit, its level highly correlated with traffic levels, and the Paris-Lyon line having the highest profit figures, and highest cost recovery ratios.

It was also found that lines with sufficiently-high traffic levels can cover operating and maintenance costs. The two exceptions were lines in initial phases of operation (either not fully built out, or not operating a sufficient level of traffic) and lines in countries where a political decision has been made to subsidize operations.

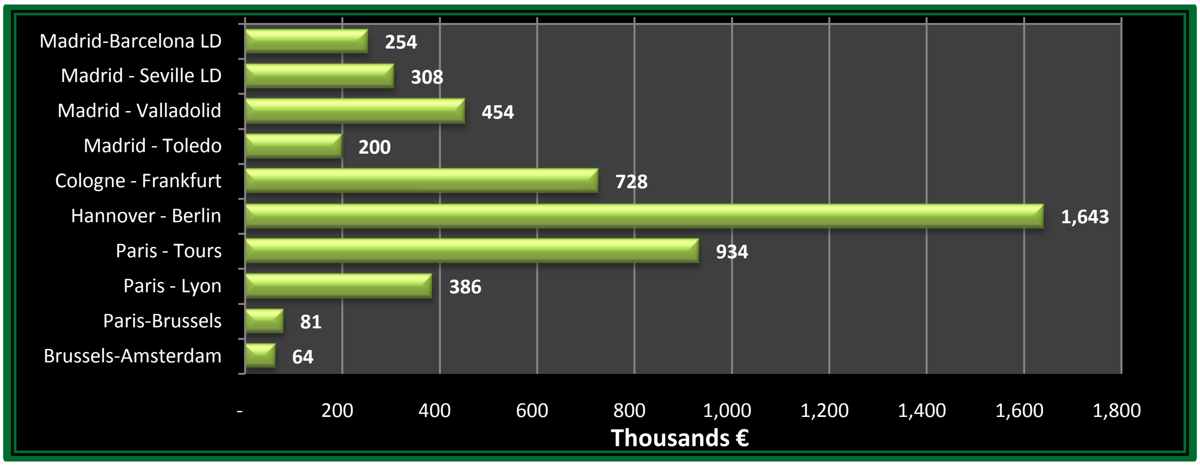

Figure 3: Revenue per year per km of line

6. Tariff System for a New International High-Speed Corridor

The proposed Lisbon-Madrid high-speed line is being funded by the Portuguese State with the involvement of private capital. 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 and Évora to the Spanish border between Caia and Badajoz. On the Spanish side, the line would start at Madrid's Atocha Station and would continue southwest, to join the Portuguese section. Analysis for the proposed line consisted of a concession period of 45 years (2012 – 2057), which included both a five-year construction period (2012-2017) and a 40-year operation period (2017-2057). Annual line maintenance costs of 80,000€ per line-km (maintenance only) and 120,000€ (maintenance and renovations) were considered. The IM is required to establish a tariff scheme that determines how much RUs pay for infrastructure capacity consumption. Three types of passenger services are proposed: long-distance high-speed, regional high-speed and shuttle services between Lisbon and the New Lisbon Airport. Passenger traffic for the proposed line has been estimated by an AVEP study (RAVE, 2008).

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 nor its willingness to pay.

Construction costs are estimated to be 11 M€ per kilometer of line, spread over five years of construction. 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).

When existing tariff schemes are applied to the line, the Dutch tariff recovers the highest amount of initial investment costs (between 60% and 102%, depending on the discount rate). This, however, does not account for the line's ability to pay. This tariff, with a flat surcharge does not tell the operator anything about the desired traffic type and traffic levels.

A base case scenario will be evaluated using a certain set of parameters and costs, and the residual value will be evaluated using two approaches. The first approach (**RV1**) includes continuing operation during the Residual Value period and including IM 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.

Table 1: 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;

A sensitivity analysis is also performed on the base case scenario, looking at key variables that are present 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 1 shows the different scenarios that are being evaluated. The evaluation shows that all scenarios, when considered with a discount rate of 4% are negative. . 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. 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. In order to continue this analysis, a sensitivity analysis is performed in order to determine the minimum volume of traffic that would permit the line to cover maintenance costs. The sensitivity analysis shows that for a maintenance cost of 120.000 € per line-km per year, 85% or higher volume of base traffic is required, while for a maintenance cost of 80.000 € per line-km per year, between 60% and 65% of traffic is required to cover line maintenance costs.

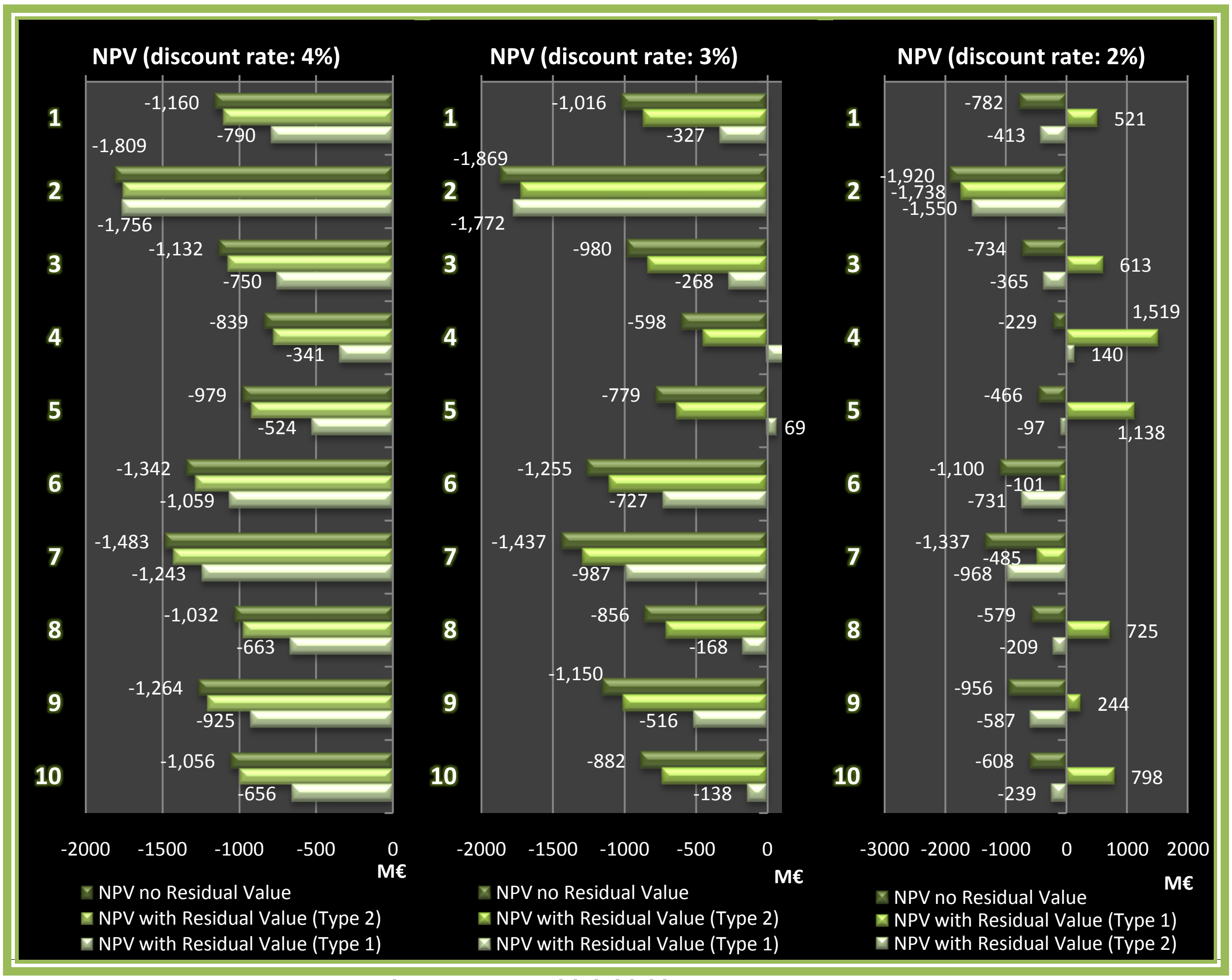

Figure 4: NPV with initial investment costs

7. Developing an Enhanced Tariff Structure

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.

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 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.

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 both in structure and in charging levels. On the Portuguese side, the Third Tagus Crossing (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.

8. Tariff Proposal

The proposed tariff structure for this line 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.

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. In later phases of operation, if congestion becomes a problem, the node concept can be implemented to better manage capacity. 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.

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 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).

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. 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.

After the initial phase of operation is over, converting this charge 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.

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.

Station charges would have three parts. 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).

9. Resulting Tariff Levels

Recovery potential of the model is dependent not only on the total profit, but also on the distribution of 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. As an example, while the average long-distance price per kilometer is 24.24€, the price on the section between Poceirão and Caia would be 19.72€, while the section between Poceirão and Lisbon would have a higher tariff rate at 42.31€ to account for higher construction costs of the TTT.

10. Conclusions

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. 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.

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.

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 revenue to cover initial investment costs.

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