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The Portuguese High Speed Rail Network; Relating Financing to Strategic and Operating Issues

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Abstract

This paper describes the implementation of the Portuguese High Speed Rail (HSR) Network. The business model developed by RAVE for the PPP's related with the HSR infrastructure is described and discussed. Following a recently awarded research project (EXPRESS) aimed at studying the strategic aspects related with the implementation of HSR is presented and its aspects more directly related with HSR operation which could be relevant in a PPP context are discussed.

1. Introduction

Portugal is currently undertaking an important plan for the implementation of a HSR Network foreseen as a component of the Trans-European Transport Network (TEN-T).

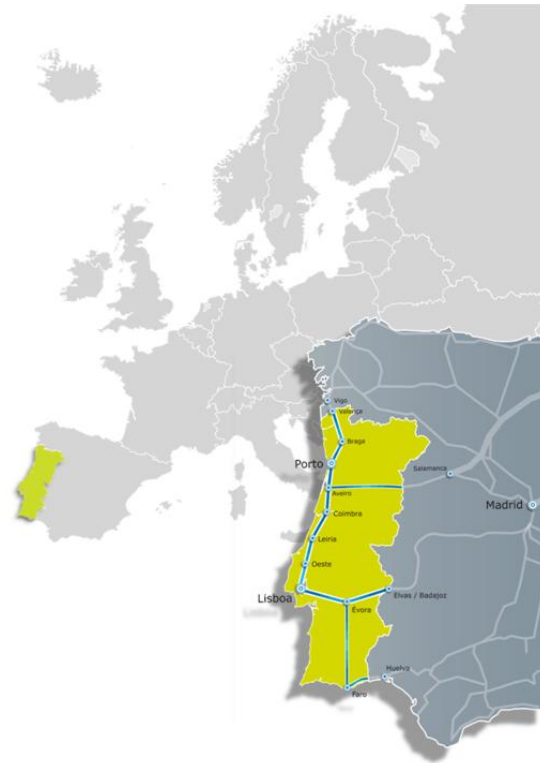


Figure 1 – Portuguese HSR Network

The Portuguese project is comprised of three priority links - Lisbon-Madrid, Lisbon-Oporto, and Oporto-Vigo axes - with a total length of about 650 km and an investment of around € 8 billion, including some significant and costly civil structures such as the Tagus Crossing in Lisbon. When the project is concluded, a large number of Portugal's major cities and the two most important border connections will be linked by high-speed rail.

HSR is viewed by the Portuguese government as a major strategic investment that could bring strong economic benefits and contribute to creating a megapolis in the corridor between Lisbon and Oporto. The importance given to this project goes beyond current transport policies with ramifications in the public policies of research and development. Thus the MIT-Portugal Program (MPP) in the transport systems focus area had a specific line of research dedicated to HSR. Several research projects concerning HSR are underway, mainly related with infrastructure aspects and life cycle costs assessment.

In 2009 under a specific tender integrated in the MPP launched by the “Fundação para a Ciência e Tecnologia” a new research project concerned with HSR, integrating researchers from Instituto Superior Técnico, Universidade de Coimbra and MIT, and having RAVE as a partner was

awarded. This new project is named “EXPRESS - EXploration of Portugal’s high speed Rail and Economic development Strategy Solutions” and deals specifically with strategic aspects related with the development and operation of the HSR network. Some of these aspects are very relevant in the context of public private partnerships (PPP) related to HSR.

The objectives of the present paper are twofold. The first one is to present and discuss the business model developed by RAVE so far for the construction of the HSR Network. The second objective is to present the aspects of the EXPRESS research project more directly related with HSR operation which could be relevant in a PPP context. This paper is organized in the following way. First the business model adopted for the infrastructure construction is presented and discussed. Secondly the EXPRESS project is presented in its more relevant aspects for the implementation and operation of HSR. Finally conclusions are presented.

1 The Portuguese Business Model for HSR Network

1.1 Business Model Concept

In the development of a HSR project, several questions need to be addressed regarding the network shape, the cities to be served, the travel time goals and design speeds, the relation to the conventional rail network and with other transport modes, and many other technical and planning issues.

But as important as the technical questions, the financial and management conditions to allow the implementation of the project must be considered. For that, many other questions need to be answered, such as what should be the role of the public sector and the involvement of the private sector, how to deal with the risks of the project, how to split the project, what type of procurement should be used and how to finance the project?

The set of answers to all of those financial and management questions we refer to as the “Business Model”.

1.2 Strategic Goals

The definition of the Portuguese Business Model was based on four strategic goals:

- **Affordability for the Portuguese State:** the goal is to assure a minimal global cost of the project, namely by promoting the whole lifecycle approach and inducing high levels of competition in the tender process. Other contributions to this goal are the maximisation of the funds generated by the project and European community financing in addition to the maximization of national incorporation;
- **Delivery of the project on time:** the model should give guarantees of fulfillment of the schedule for deployment, through a proper coordination between the entities involved, the articulation of the different stages of the project, a clear allocation of responsibilities and robust bonus and penalty incentive mechanisms;

- **High level of service/quality:** in the end, we want to bring value for rail users, and for that we need quality levels clearly defined and effective monitoring systems. Bonus and penalty incentive mechanisms and the boosting of innovative solutions also have a significant weight in achieving this goal; and
- **Minimization of risks:** minimization of risks must be pursued regardless of who will bear them, but special attention should be paid to the State's exposure. The contractual structure should facilitate the proper risk allocation to the entities or parties best suited to manage them.

These objectives can be achieved in the delivery of the project on time, within budget, with required quality and minimal risk of deviations. Above all, they seek to create value for Portugal, assuring its financial position in terms of charges and risks to be borne with the project and, naturally, to ensure its success on the long run.

1.3 Benchmark Analysis

As it is certain that the business model must be tailored to each case, without blindly import other examples, it is also granted that it is of crucial importance the detailed study of similar experiences, to learn from their successes and mistakes. For the development of the Portuguese Business Model several international projects were analysed, such as the HSL Zuid, the Channel Tunnel Rail Link, the HSL Tour/Bordeaux and HSL Perpignan/Figueras, facilitating the identification of the several factors considered crucial to the success of the project.

The benchmark analysis performed revealed a clear international trend towards more private involvement on large rail projects, namely through the use of PPP.


	France 1980/90 Spain 1980-actual	United Kingdom Decade 90	Holland 2005	Perpignan- Figueras (France-Spain) 2005	Bordeaux- Tours (France) 2007	Brazil 2009
Strategic Role Regulation Planning Establishment of Requirements Articulation of the System	Public	Public	Public	Public	Public	Public Private(PPP)
Financial Role	Public	Private(PPP)	Public and Private	Private(PPP)	Private(PPP)	Private(PPP)
Operational Role Design Build Maintain Operate	Public	Private(PPP)	Public and Private	Public and Private	Public and Private	Private(PPP)
Trend (Reduction of Public Sector risk exposure) 						

Figure 2 – International procurement choices

In fact, besides UK and Portugal, with large experience on this kind of procurement, countries that usually rely on more traditional procurement processes, like Spain or France, are now considering PPP in their high-speed rail projects. Likewise, other countries that are presently starting their high-speed projects, like Russia, Poland, Sweden or Brazil, are considering adopting PPP schemes. As such, the current and future trend for the rail sector has preponderantly kept in the public sphere all responsibilities regarding regulation, planning, establishment of requirements and management of overall systems, while transferring into the private sector all types of responsibilities regarding designing, construction and maintenance of infrastructures.

From the projects analyzed, special mention is due to the Dutch HSL Zuid project, which configured a reference for the rest of the work. The Dutch business model was based on mixed procurement with the substructure contracted in a traditional way and a Design, Build, Finance and Maintenance (DBFM) contract for the superstructure and signaling and telecommunications. The integration risk resulting from separation between substructure and superstructure lead to relevant impacts on cost and schedule. In this case it was difficult to ensure that the substructure contractor met the platform requirements needed for the superstructure provider and forced extra work that resulted on cost overruns and delays. Furthermore, there was some instability regarding signaling technological standards, namely the ERTMS version, leading to additional delays.

1.4 The Business Model

The Portuguese Business Model for HSR was disaggregated in six PPP, with the following key features:

- Five PPP for the design, build, financing and maintenance (DBFM) of the rail substructure and superstructure, excluding the signaling and telecommunications systems, for a 40-years period, with a criteria of geographical segregation of the segments
- A PPP for the design, supply, installation and maintenance of the signaling and telecommunications systems, for 20 years period, for the entire length of the three priorities links of the project.
- Lisbon central station (Oriente station) is to be developed directly by State, through the public infrastructure manager REFER. International Border station, on Lisbon-Madrid axis, is developed directly by both Portugal and Spain. The remaining stations are integrated into the respective PPP for the axes on which they are located;
- The allocation of capacity and the management of circulation are entrusted to REFER, as the managing entity of rail infrastructure in Portugal; and
- At the level of operations, the Portuguese State will proceed to acquire the rolling stock, which it will subsequently allocate to the future operator(s). The definitive model for operations will be defined later.

The Business Model, in what refers to the development and management of infrastructure, may be graphically represented as following:

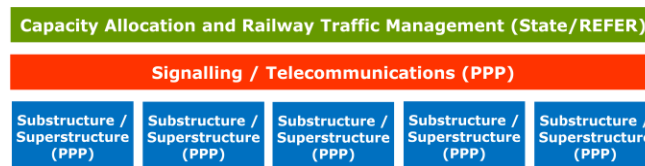


Figure 3 – The Portuguese Business Model

The split of the project in several PPP results in contracts with a size suitable to the market – between 0,5 and 2 billion Euro – which ensures the capacity and attractiveness of the private sector and therefore the existence of strong competitiveness. But still, each PPP remains sufficient big to in order to guarantee efficiency and to minimize the number of transitions Between PPPs and consequently mitigate the interface risk.

In fact, the minimization of interface risk is one of the biggest merits of the Portuguese Business Model. It allows grouping the entire infrastructure in only 8 blocks – the 6 PPP plus Lisbon and Border stations stretches – resulting in 14 physical interfaces (between those 8 blocks and other external parties). With alternative models based on traditional procurement, the average length of sections with independent contracts is always much lower, leading to a much higher number of physical interfaces. For the entire Portuguese HSR project, the traditional procurement could result in about 80 contracts (extrapolating from the average size of contracts in the Spanish case), with equivalent number of interfaces. Besides the risk involved, such number and type of contracts would be much more demanding in human resources.

On the other hand, in the Portuguese Business Model the interfaces were located where they are easier to manage and therefore have less risk. The horizontal interfaces do not represent major concerns. There are few and they are clearly located in convenient spots. As stated before, the vertical interface between superstructure and signaling and telecommunications is common, in Portugal and many other countries. Nonetheless, it is still where the main risk occurs and is the interface that needs much attention.

Vertical integration of substructure and superstructure also aims for the minimization of the interface risk. This option was mainly motivated by the Dutch experience that revealed problems in such integration especially when PPPs were used. No comparable disadvantage was foreseen in the Portuguese case, since the suppliers are generally the same and there isn't significant technological instability.

The development of signaling and telecommunications in a separate PPP is justified by the technical characteristics of equipment, the perceived risk associated with technology and the fact that there are few suppliers of such equipment in the marketplace. The combination of these factors would result in the loss of competitiveness in PPP for the remaining infrastructure. In the Portuguese HSR project, signaling and telecommunications represent less than 10% of total investment but the private sector sees higher perceived risk. So if joined in the same contract with the rest of infrastructure it would amplify the risk premium on the other 90%. With this option it is possible to choose the signaling and telecommunications partners later than the substructure and superstructure partners, allowing for further stabilization of technology. Finally, signaling and telecommunications also have a shorter life cycle when compared to the rest of infrastructure and so it was easier to establish a term contract.

The Lisbon high speed station consists of the upgrading an existing conventional rail station – the Oriente station. The works to be done there will interfere with existing lines and needs to be carefully performed in parallel with intense operation. That particular environment is not suitable for a PPP deal as it implies too many restrictions and risks that are better manageable by the state.



Figure 4 – Lisbon HSL Station – Oriente (simulation)

The option for the border station results directly from its international nature.

Another important option of the Portuguese Business Model is to keep the strategic and planning role within the public sector. That is why the allocation of capacity and the traffic management was entrusted to REFER (the public company that manages the national rail network) .

Moreover, the business model is based on a clear distinction between the infrastructure and operation, which is mandatory in Portugal. This is always a justified option given the fact that those are completely different tasks with distinctive players. This also allows the definition of the business model for operations in a later moment, in harmony with market dynamics resulting from the recent liberalization in the European Union. Finally, it should be noted that when operations covers a broader scope, such as the Portuguese case, it becomes impossible to match the geographic coverage of both infrastructure and operations, resulting in complex issues to solve if covered in the same contract.

1.5 Main Accomplishments to date

The first PPP contract was already tendered and signed. It comprises 165 km of High Speed Line in the Lisboa-Madrid axis, called Poceirão-Caia stretch. The tender process revealed a reasonable competition, a good understanding of the project and business model needs by the bidders; hence, quality proposals were received. The financial structure, with next to 50% of investment in public funds during construction phase, represented a very good equilibrium between short and long term financial effort of the state and allowed the tender process to move forward during the international financial crisis. The deal was closed with reasonable conditions.

But the most impressive outcome so far is the significant cost reductions that the business model provided. The Public Sector Comparator (PSC) exercise points to savings of almost 40% compared to traditional procurement.

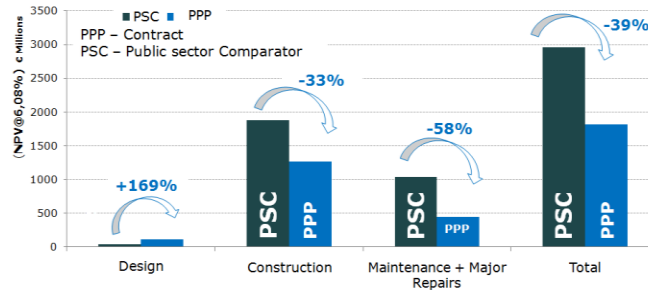


Figure 5 – Public Sector Comparator results

The considerable increase in design costs, also reflecting the higher transaction costs that characterize PPP, were, by far, overcome by huge cost reductions both in construction and in maintenance, repairs and renewals. These cost reductions are even more impressive if we consider that the major production risks were transferred to the private partner as we are using a turnkey contract. Of course there is still a long way to go until the line is ready for service, but these results give us good confidence in the benefits of the business model adopted.

2 The EXPRESS Research Project

The EXPRESS research project aims to study several aspects of the HSR deployment in Portugal which are quite relevant in a PPP usage framework. They include:

- Financial crowding-out effects: We will examine the hypothesis that substantial capital investments and ongoing operating expenses needed for HSR will “crowd out” funds and credit available for other transportation needs. Of particular concern is that funding for urban transportation may be crowded out, causing HSR stations to be less accessible, holding down demand. We will develop and evaluate alternative unimodal and/or multimodal strategy and finance approaches for addressing this crowding-out effect.
- Urban/regional form and megalopolis creation: HSR will have profound impacts on the cities it serves and on the broader region within which it operates. We will study the impact of various deployment approaches on local urban form. For example, the use of HSR for daily commuter trips into Lisbon or Oporto can change the structure of these cities substantially. We will also consider the potential for creation of a Portuguese megalopolis in the Lisbon-Oporto corridor. Also the HSR urban/regional impacts will have implications in the levels of demand attracted by the HSR services, which suggests the existence of a two-way relationship between service demand and spatial impacts of HSR.
- Demand uncertainties and competition / coordination with other modes: HSR deployment will create competition and require cooperation with other modes of travel, including urban transportation, existing conventional rail, and air. We will explore innovative demand forecasting approaches that consider dynamic multi-modal interactions as well as uncertainties in demand forecasts.

- Configuration of freight services on HSR: Using HSR for freight service has the potential to improve the efficiency and sustainability of freight movements while orienting Portugal as an intercontinental freight hub. For example, shipments to the west coast ports of Portugal, such as Sines, could be transported by HSR into the economic heart of the Iberian Peninsula. On the other hand, freight may hinder the ability of the HSR system to provide other expected economic benefits and complicate coordination with other modes. We will explore all of these tradeoffs.

All of these strategic deployment challenges are interrelated and they will affect further developments of business model for the HSR implementation as well as the contracts under preparation, namely the possible crowding out effects.

Each of them will be addressed individually in a first approach and later on in a more comprehensive way combining all these challenges together. For example, the configuration of freight services will affect urban form and megalopolis formation; “crowding out” of funds for urban transportation will affect cooperation with other modes; and so on.

2.1 Financial crowding-out effects

Mega-project are usually plagued with problems (referred to in the literature) that include underestimation of costs, construction delays, and other associated risks and uncertainties (Bruzelius et al, 2002) an important part of them associated with overestimate of future demand and therefore revenues. For instance, some typical issues are: 50-100% cost overruns; demand forecasts overestimated by 20-70%; inaccurate environmental impact forecasts; and unrealized regional and national economic effects. Besides these well-documented problems, the financial implications of megaprojects on the overall transportation strategy and decision-making of *other* modal investments have not been studied in detail. This is a particularly important issue, especially in the current context of credit scarcity.

From a budgetary viewpoint, HSR investment will have a *crowding-out effect* on other investments in transportation, education, and beyond. In the neoclassical model, *crowding out* occurs “when the public sector draws on the pool of resources available for investment,” and private investment is reduced (Rosen, 2005). Similarly, the investment in HSR will limit both public and private sector funding and credit availability for other projects. Moreover, additional investments may be required in existing urban infrastructure that would not have been needed otherwise (e.g., additional transit routes to integrate with HSR stations). This analysis will be made using benchmark techniques using international experiences with HSR in order to characterize and quantify the crowding-out effect on other transportation investments and to ascertain the level of additional urban infrastructure investments required to complement HSR. Currently, the EXPRESS team is studying China, Taiwan, Germany and France. The conclusions drawn from these analyses will be used to develop a suite of strategies for addressing the crowding out effects that might arise due to the implementation of HSR in Portugal

Also, as part of this research, we will consider via case studies whether financing of HSR is inherently different than financing of other transportation investments such as highways, airports and seaports and if there are differences, why they are present. Finally, we will consider the differences in financing HSR projects when the projects may be international in scale, as is true in the EU vs. (almost) isolated systems such as would exist in Japan, the US, China, South Korea and Taiwan.

2.2 Urban/regional form and megalopolis creation

The impacts from HSR on the spatial structure varies from the ones arising in neighborhood areas where stations are located to regional impacts that favor the creation of megalopolises (metropolitan regions up to 200 km) (Coronado et al, 2004). The positive impacts originated from HSR deployment include travel time savings (Banister and Berechman, 2001) reduced transport costs that will impact the spatial location of economic activities (Puga, 2001); and the reduction of regional inequalities (Puga, 2001). HSR can be beneficial for cities with relatively high economic potential and attractive locations by reinforcing existing advantages (Pol, 2003). Moreover, megalopolis creation can improve productivity by expanding labor markets, commercial markets, and individual activity zones (Prud'homme, 2006). In Portugal, a Lisbon-Porto megalopolis is possible, and the economic impact of such a region has broad implications for transportation strategy (Abreu e Silva, 2008). There may also be negative development impacts for smaller cities served by HSR and by cities not served at all. For example, HSR stations in small cities in France did not stop dispersion of economic activity (Facchinetti-Mannone, 2005). The right policy design can ensure that negative effects of HSR are minimized while benefits are maximized (Abreu e Silva, 2008). The spatial impacts of HSR will be assessed using both qualitative and quantitative (modeling) approaches

2.3 Competition and coordination with other modes

A fundamental issue in Portuguese HSR is how attractive it will be in the marketplace for traveler transportation. The system will be very costly and attracting substantial ridership is essential if the project is to make sense.

Of particular interest are the environmental and energy implications of the competition and possible cooperation between, HSR, air and highway modes including buses and automobiles. Some scholars suggest that HSR is a more benign mode environmentally and with respect to energy use; others are less convinced. Our research will consider these issues in the international and Portuguese context.

The way forward in this area is modeling. We hope to use existing models to study these questions, but our early studies suggest we will need to innovate in the creation of new models as well to study the areas of interest in this research.

Models are imperfect representations of reality, which creates uncertainty. In engineering projects, the sources of uncertainties could be functional, geographical, and temporal, and each of

these sources could be decomposed in a hierarchical way (Abreu e Silva, 2008a). Walker, et al. (Walker et al, 2003) point to a generic group of potential aspects where uncertainties can arise: context uncertainties which correspond to the system being modeled (economic/social, technological uncertainties); uncertainties associated with the model formulation, specification, structure or its computational implementation; input uncertainties associated with the description of studied system and external forces that lead to changes in the reference system; uncertainties in the model parameters associated with data sets and calibration methods; and accumulated uncertainties associated with model results. Others consider two types of uncertainties: one associated with inputs and the second associated with specification errors and model parameters (Abreu e Silva, 2008a).

Also, forecasts rarely consider possibilities of cooperation or competition among various modes that could change during the project lifecycle, which could strongly influence HSR demand.

This issue will be addressed in two main ways. The first one will include the construction of dynamic forecasts sensitive to the possibilities of changes in the strategies of competition or cooperation among the various modes of travel as well as the impacts on urban structures and regional economies, behavior of the various stakeholders, and other policies aimed at capturing potential benefits arising from the HSR project. The second aspect is related to the uncertainties associated with the demand models themselves and with the variables used as inputs. These two components should be integrated in a common framework that will be able to tackle demand uncertainties in a dynamic way and at the same time be sensitive to various strategies of the stakeholders involved in the HSR project.

2.4 Configuration of freight services on HSR

Intermodality with rail should produce significant gains by transforming competition between rail, air (EC, 2007), and highway into complementary modes. Coordination between the new HSR line and the conventional line, road logistics platforms, the seaports of Sines and Lisbon, and the new airport could become strategic investments for freight operators (Leal, 2009).

The introduction of freight service on HSR could reduce congestion, accidents, and environmental externalities of freight transportation by diverting traffic from trucks. The economic evaluation of HSR investment has been covered from various perspectives: general assessments (Vickermanl, 1997); cost-benefit analyses of existing or projected lines (de Rus and Inglada, 1997), including in Spain (Beria, 2008), California (Levinson et al, 1997), the UK (Steer Davies Gleave, 2004), and the EU (de Rus and Nash, 2007); and regional effects of HSR investment (Blum et al, 1997).

The introduction of freight-rail services on the Lisbon-Madrid HSR line will open new trade markets and commercial opportunities. Such a system of cost-effective transportation could provide significant public benefits in a key trade corridor by enhancing economic development, improving air quality, and reducing energy consumption. We aim to evaluate alternative freight configurations on HSR that could also influence passenger demand (if for example, passenger trains are delayed by rail freight movements) and also the spatial impacts of HSR.

This research will also use a novel approach developed at MIT called Multi-Attribute Trade-Space Evaluation (MATE) (Nickel et al, 2009) to consider various alternative configurations and operating practices.

3 Conclusions

It is unquestionable that financial and management issues play a crucial role on the success of a HSR project. From the work carried out to design the Portuguese Business Model the following main conclusions may be drawn:

- There is an international trend towards the increased involvement of the private sector, namely through the usage of PPP;
- Experience says that PPP can generate value for money but also requires expertise and needs to be tailored to each situation;
- A complex project like HSR requires, in most cases, to be sliced into several contracts which may represent a delicate task with “interface” risk being introduced;
- The vertical splitting of the project is especially risky and must be carried out taking in account the risk, the competition and the specificity of the different components.

For the definition of the Portuguese Business Model it was most helpful to learn from previous international experiences. Benefiting from past successes and failures, the Portuguese Business Model introduces in the railway scene very innovative concepts, both in terms of private involvement and project splitting. So far, the Portuguese Business Model forecast a significant cost reduction and a large risk transfer to the private sector.

It is expected that the results from the EXPRESS research project could bring important insights for the development of the HSR project in Portugal as well as for other similar projects in different countries. First and taking in consideration the credit crunch that occurred after the 2008 financial crisis, the crowding out effects in public sponsored megaprojects and particularly in PPP’s have become an important issue. By evaluating the possibility of the occurrence of crowding out effects, it will be possible to evaluate the existence of unintended negative impacts derived from the HSR project to the transport sector and to the Portuguese economy as a whole.

The other described research areas of EXPRESS are more relevant to provide insights in to the design of the operation phase of the implementation of HSR in Portugal. We will analyze the aspects that could influence the demand risk and the possible strategies that could be pursued by the several stakeholders that will be involved directly or indirectly in the HSR operation (transport operators, infrastructure managers and regional and municipal public authorities). The project aims to parameterize in more detail the risks associated with the demand and thus the revenues from the operation which are a fundamental aspect in the evaluation of bids for future operations PPPs. Also the analysis of the feasibility of freight services in the HSR network will prove very useful as it could be a basis for further operating revenues and benefits.

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