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Cost–Benefit Analysis in High-Speed Railway Projects: Appraisal of Methodological Approaches and an Initial Social Equity Evaluation, A Case Study

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Abstract: The international literature around the impacts of long-distance rail transport such as high-speed railways (HSR) reveals that social equity impacts have rarely been fully examined or taken into consideration in appraisal. Several methodological and contextual policy factors may have contributed to expanding this gap. As a result, the HSR's potential to act as a transport and land use development policy tool to reduce accessibility inequalities and promote social inclusion remains unexplored in most cases. The present article aims to shed light on current methodological appraisal approaches in order to examine social equity issues around HSR projects, in terms of social sustainability. Further, the research methodology uses an in-depth investigation around one strategic railway project selected in Italy, a country that is investing in HSR. The paper is organized as follows: firstly, there is an introduction that refers to the specific case study. Soon after the paper illustrates the peculiar elements of the cost–benefit analysis of the HSR link Bari–Naples and considers the scientific literature on the issue. Then the novelty of equity considerations is presented in methodological terms and as a result of a concrete consultation process. Finally conclusions close the paper.

Keywords: HSR; railway transport mode; social sustainability; social equity; cost–benefit analysis; evaluation; accessibility

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1. Introduction

The case study from Italy is referred to as the HSR Naples–Bari. The project involves the redevelopment of the current Naples–Bari line through both infrastructural interventions, differentiated for the different sections of the line (speeding up, doubling, and variations to the current route), and widespread technological interventions for upgrading the network equipment with state-of-the-art equipment and systems capable of increasing capacity and speed. The entire work is now estimated to run to a cost of EUR 6.2 billion and it became possible to start it via Law 164 Sblocca Italia approved in November 2014; this entrusted the implementation of the intervention to a commissioner and made the financing concrete. The railway track runs for 150 km between Naples and Bari and completion is expected in 2026. The cost–benefit analysis has been developed and the economic sustainability indicators are positive, which supports the project economically and socially. The results will be presented and analyzed with the novel contribution of its equity and social aspects, which were not included in the original analysis.

Cost–Benefit Analysis of the High-Speed and High-Capacity Bari–Naples Rail Link

The decrease in travel times, the better quality of supplied services, and improved accessibility are the main factors of success for high-speed rail links [1]. The high-speed/high-capacity (HS/HC) rail project in Italy, despite many problems and delays, is a "work in progress" and in the coming years, new sections will be opened. This will have a significant impact on Italy's transportation system, with large reductions in travel times occurring, mainly over medium and long distances (equal to 40–50 percent).

High-speed trains can be used to solve two different accessibility problems. In the first case, where a point-to-point link is dominant, each train is a potential substitute for a road connection between two cities, connecting cities over medium–long distances with a direct train connection. In the second case, where an HS network is dominant, the train system links together many cities and, hence, creates a new type of region with high intra-regional accessibility sharing both a common labor market and a common market for household and business services.

In this section, evidence of the impact of the HSR link between Bari and Naples is provided based on an analysis that has been carried out by the track owner.

2. The Methodology

The methodology that has been adopted is a common cost–benefit analysis (CBA). As it is well known, a CBA is particularly useful for state-funded projects. It is also regarded from an overall national perspective, rather than the perspective of specific stakeholder groups or regions [2,3].

The theory behind this assessment is the theory of value creation. Based on the value creation theory, developed in the 1980s, the aim of the company is to increase its economic value. Investment projects relating to works or services of the public utility can entail significant externalities, both positive and negative, in the local area of reference. The analysis of the process of creating and distributing the value must therefore extend to all stakeholders. This is useful for calculating the economic impact of the work in terms of costs and social benefits, but also for assessing the opportunity to resort to a project involving some of the main stakeholders in the operation [4]. Corporate finance theory has developed multiple approaches to measure the economic value created by a company for its shareholders, with the creation of value and its diffusion becoming the corporate aim of maximizing profit (value-based management). The creation of value is certainly a rational objective oriented to the search for growth in income capacity and risk control, with control consisting of a periodic measurement of the phenomenon to establish the real performance of the company [5].

This theory also associates the value of a company's capital with short-term decisions: a company generates new value when it manages to make the capital invested more than it costs the company itself. The theory of value was created to measure a company's valuation parameters, and the value created can be calculated by subtracting both the fixed costs and the minimum remuneration of the shareholders from the revenue. If the profit remains positive, we are in a case where corporate value is being created.

Based on this definition, explicit reference is made to the importance of "satisfying" stakeholders. In reality, another fundamental aspect is that of providing an index of economic growth in order to guarantee long-term value for both shareholders and corporate well-being.

We further clarify the distinction that underlies the decision-making process of private and public subjects:

- In evaluating private investment projects, decisions are related exclusively to the maximizing of profit;
- In evaluating public investment projects, the decisions of the economic policy authorities are linked to the well-being of society.

As for the public sector, as already mentioned, more than economic growth, reference is made to the growth of the well-being of the community. This well-being can refer to various aspects such as quality of life, education, culture, health protection, and the protection of natural and artistic heritage [6].

The main differences between public and private sector projects can be summarized in the following Table 1:

Table 1. Comparison between private projects and public projects.

	Private Projects	**Public Projects**
Objective	To provide goods or services by profiting	To provide public services, supporting the economy and employment
Funding sources	Private investors and financiers	Taxation, public funds, public-private partnership
Financing arrangements	Individual entrepreneurs, partnerships, companies	Direct payment of taxes, interest-free loans, government bonds, bonds, indirect subsidies, non-repayable loans
Nature of benefits	Monetary	Monetary and non-monetary
Beneficiaries of the project	Mainly entrepreneurs	The collectivity or part of it
Conflict of objectives	Limited	Frequent
Political influence	Nothing	Relevant

With particular regard to the methodology we are going to use here, some of the CBA's peculiarities are introduced.

Cost–benefit analysis originates from the need of the public operator for a calculation tool to define its intervention and in fact, was officially introduced in Italy by the EIF (Employment Investment Fund) in 1988. The idea behind this method is a comparative analysis of benefits; that is, improving collective well-being and costs, in terms of shadow prices of the resources that refer to possible public interventions. This type of analysis is particularly rooted in the branch of neoclassical theory which considers the ideal market situation to be that in which resources are efficiently allocated. From this vision derives the idea according to which any public intervention, other than that strictly necessary to ensure the functioning of the markets, determines a decrease in social well-being and therefore should be avoided. In fact, public intervention in the economy only emerged at the end of the 19th century and mainly concerns the production and distribution of non-rival and non-exclusive public goods (such as justice, national defense, and public order). At the time, intervention in the field of infrastructure mainly referred to work with military or security purposes. Previously the intervention of the state was seen in the field of social goods such as education, health, and infrastructure, much of which was private or provided by private individuals. This raised problems, as we know that the interests of the private entrepreneur diverge from public ones. For these reasons, public intervention spread to prevent or correct any market failures [7].

The first approach to cost–benefit analysis dates back to 1848, the year in which Dupuit, a French engineer and economist, published a work clearly outlining what can be considered the basic principles of this analysis. Subsequently, the analysis was taken up and perfected by Alfred Marshall and the marginalist school. The Marshall Plan developed a coherent theory of supply and demand, production, and marginal utility, and supported public intervention in the economy to improve well-being [8].

In the 1930s, public investment increased significantly with the introduction of the New Deal in the United States. It is no coincidence that almost all the manuals in circulation identify the true origin of cost–benefit analysis very precisely in United States federal legislation. With the Flood Control Act (a law relating to the control of the flooding of rivers) it established for the first time, that in order for a state-funded project to be considered valid, its benefits must outweigh the costs. Since then, cost–benefit analysis has been perfected and progressively adopted in high areas. In the early 1980s, evaluation in Italy acquired a central role in terms of planning for projects. The attempt to focus on public investment assessed by international criteria and as a tool to achieve the objectives of increasing social capital and employment in a phase of severe restrictions on public finance became accompanied by prosperity of interest and activities including the publication of the first evaluation manual for the public administration. The efficiency of this method consists of an ability to identify the effects attributable directly and indirectly to the intervention, to

identify the benefits and costs, and to assign probabilities to random events. Today, this type of analysis finds an application in the evaluation of environmental protection, health care projects, development projects, and other projects whose effects affect the community.

To improve the analysis of the validity of projects, especially in the transport sector, more recently the assessment of equity has been included as an economic–social element normally linked to the accessibility to be guaranteed to the population to an essential service.

Equity can refer to the distribution of impacts (benefits and costs) and whether they are considered appropriate. Transportation equity analysis is important and unavoidable; transport-planning decisions have significant equity impacts, and equity concerns often influence planning debates. Various factors can affect accessibility including mobility, transport network connectivity, affordability, the geographic distribution of activities, and mobility substitutes such as telecommunications and delivery services [9]. Most practitioners and decision-makers are sincere in wanting to achieve equity objectives, but transport equity can be difficult to evaluate because there are various types, impacts, measurement units, and categories of people to consider [10]. To clarify, there are three types of transportation equity:

1. Horizontal equity, concerning the distribution of impacts between individuals and groups considered equal in ability and need;
2. Vertical equity with regard to income and social classes;
3. Vertical equity with regard to mobility needs and abilities.

Ref. [11] argue that equity should maximize average accessibility and minimize the disparities between the lowest and highest groups. Ref. [12] focuses on how unacceptability indexes can improve the public planning process. The Transport Studies Group examines the quality of transport services provided to various groups, while [13] can be seen to identify the ways that planning can better respond to the needs of minor disadvantaged groups (Table 2).

Table 2. Transportation equity indicators.

Increase Access to Mobility	Reduce Air Pollution	Enhance Economic Opportunity
1. Affordability		9. Connectivity to employment, education, services, and recreation
2. Accessibility	6. Air quality and health impacts	10. Fair labor practices
3. Efficiency	7. Greenhouse gas emissions	11. Transport-related employment opportunities
4. Reliability	8. Total vehicle travel (less is better)	12. Inclusive local business and economic activity
5. Safety		

Source: [13].

Our contribution is based on [13]'s paper. We show how it is possible to identify a designed framework to define and evaluate mobility equity and address structural inequities through a planning process that better responds to the needs of disadvantaged people and communities. Ref. [13] identify twelve equity indicators related to improved mobility options, reduced air pollution exposure, and enhanced economic opportunities for disadvantaged groups.

In summary, at present, the economic and social validity of an investment with the use of public resources derives from the comparison between the total and the discounted benefits and social costs, including also the equity elements. Only in the presence of a positive result, the investment will be concretely implemented. Table 3 summarizes the main contributions deriving from the most relevant scientific papers considered in this review. The significant aspects that emerge are grouped under four headings:

1. National impact of the projects;
2. Regional relevance of the contribution of the interventions;
3. Relevance of the stakeholders;
4. Equity analysis.

Table 3. CBA literature review—main relevant contributions.

Authors	National Impact of the Projects	Regional Relevance of the Contribution of the Interventions	Relevance of the Stakeholders	Equity Analysis
Rugiadini	x			
Volden	x	x		
Papagni et al.	x	x	x	
Weerawardena et al.	x		x	
Bennet	x	x	x	
Jones et al.	x	x	x	
Litmat	x	x		x
Di Ciommo			x	x
Creger et al.	x			x
This paper	x	x	x	x

The evaluation analysis of the project closes with the sensitivity analysis which has the purpose of verifying the robustness of the results obtained in the so-called base scenario referred to as the financial analysis and the economic analysis.

The sensitivity analysis consists of repeating the calculation of the indicators by varying the assigned values to the individual elements considered in the assessment itself, in order to identify which forecasts can have a greater impact on the assigned financial and economic–social indicators to the investment: this makes it possible to verify the stability of the valuation with respect to changes in the hypotheses assumed and to identify the "critical" variables of the project, i.e., those that have the greatest impact on financial and/or economic performance.

2.1. Legislation References for Large Projects

In 2008, the European Commission developed guidelines to perform a correct cost–benefit analysis; these became more complex and even mandatory in 2014. The Ministry of Infrastructures, for the same reasons, also issued its own set of guidelines, consistent with the European ones. Together with other tools, cost–benefit analysis is considered the fundamental tool leading to the co-financing of the large projects included in the Operational Programmes of the European Regional Development Fund and the Cohesion Fund. By Large Projects we mean "a series of works, activities or services aimed at carrying out an indivisible action of a precise economic and technical nature, with clearly identified purposes and a total cost exceeding 50 million Euros" (art.100 of the Regulations (EU) No. 1303/2013 [14]. It contains common provisions relating to the European Regional Development Fund, the European Social Fund, the Cohesion Fund, and the European Agricultural Fund for Rural Development, as well as the European Fund for Maritime Affairs and Fisheries. At the EU and national levels there are various rules that impose the obligation to perform an ex ante cost–benefit analysis to evaluate investment projects. The areas identified include:

- Requests for funding from the CIPE (Comitato Inerministeriale per la Programmazione Economica—Interministerial Committee for Economic Planning for strategic infrastructures);
- Feasibility studies for public works based on the tender and on which to establish procedures for competitive dialogue or project finance;
- Substantial modernizations and new plants for electricity generation, industrial production, and district heating;
- The various regional regulations establish the obligation of the CBA within Environmental Impact Studies.

2.2. The Italian Case Study: Methodological Framework for a Transport Investment

The Cost–Benefit Analysis Report on the Naples–Bari route (Figure 1) was developed on the basis of [14,15] in order to provide the information necessary to compile Big Project Documents and access the sources of financing National Operative Programme (NOP) 2014–2020 for projects:

- Variant to the Naples–Cancello line (Figure 2—variante Napoli–Cancello)
- Doubling and speeding up of the Cancello-to-Frasso Telesino section (Figure 2—variante Cancello–Frasso T.)

Figure 1. Naples–Bari route.

Figure 2. Technical sections.

The main aims of these interventions are linked to a decrease in travel times, better quality of supplied services, and improved accessibility affecting population groups' travel choices, as well as new trips not undertaken before the operative supply of new services. The behavioral response varies among different segments of the population depending on their travel needs, which in turn are contingent upon their income, location of residence, and other factors. These elements were analyzed through a consultation process prepared by the Ministry of Infrastructures and Transport before the development of the cost–benefit analysis of the projects [16]. Nevertheless, it has not been included in the final report. What is provided in this paper is an ad hoc analysis focusing on the social equity issues of the current project.

The two interventions mentioned above are de facto sections of a wider Investment Programme aimed at the overall strengthening and redevelopment of the Naples–Bari route, which therefore is considered in its entirety in this CBA. The cost of the Investment Programme of the "Naples-Bari Itinerary" subject of this assessment is estimated at a total of EUR 5524 million (in financial value).

The present cost–benefit analysis has been conducted according to the differential approach; therefore, the evaluation regards the annual flows related to cost–revenues (financial analysis) and cost–benefits (economic analysis). This is determined by the comparison between the scenario "With Intervention" (or "Project Scenario") and the Scenario "without intervention" ("Reference Scenario"). The two analyses, financial and economic, as required by the European guidelines, are drawn up separately but both contribute to the overall results of the project evaluation [17]. In this regard, the European guidelines indicate that:

Firstly, the "CBA compares a scenario with the project using a counterfactual baseline scenario without the project. The incremental approach requires that a counterfactual scenario is defined to show what would happen in the absence of a project. For this scenario, projections are made of all cash flows related to the operations in the project area for each year during the project's lifetime. In cases where a project consists of a completely new asset, that is, there is no preexisting service or infrastructure, the without the project scenario is one with no operations. In the cases of investments aimed at improving an already existing facility, these should include the costs and the revenue/benefits to operate and maintain the service at a level that it is still operable, meaning that Business As Usual (BAU) or even small adaptation investments were programmed to take place anyway (do the minimum). In particular, it is recommended to carry out an analysis of the promoter's historical cash flows (at least for the previous three years) as a basis for projections, where relevant. The choice between BAU or doing the minimum as counterfactuals should be made case by case, on the basis of the evidence about the most feasible, and likely, situation. If uncertainty exists, the BAU scenario shall be adopted as a rule of thumb. If do the minimum is used as the counterfactual, this scenario should be both feasible and credible, and not cause undue and unrealistic additional benefits or costs. The choice made may have important implications for the results of the analysis;

Secondly, projections of cash flows are made for the situation with the proposed project. This takes into account all the investment, financial and economic costs and benefits resulting from the project. In cases of preexisting infrastructure, it is recommended to carry out an analysis of historical costs and revenues of the beneficiary (at least for the three previous years) as a basis for the financial projections of the project scenario and as a reference for the without project scenario, otherwise the incremental analysis is very vulnerable to manipulation;

Finally, the CBA only considers the difference between cash flows with the project and the counterfactual scenarios. The financial and economic performance indicators are calculated on the incremental cash flows only".

It should be noted that the "Without intervention" scenario is not characterized by a general situation of "Do not" with respect to the current situation but considers a trend in the evolution of the infrastructure and economic flows according to the actions already planned and initiated, other than the intervention object of rating.

The effects in terms of cost–revenues in the analysis are therefore associated with the differential traffic flows across financial and economic analyses, which, together with investment spending, allow for evaluating the degree of convenience of the project.

The CBA is conducted on the basis of assumptions about investment costs and contained operating costs in financial analysis.

However, while in the financial analysis, goods and services produced and used in the project are evaluated at market prices actually collected and paid according to a cash criterion, in the economic evaluation analysis this must take place according to the logic of the value that these goods and services have for the community and at an opportunity cost that may not therefore, coincide with market prices.

In addition, some items and prices that appear between the income and expenses in the financial analysis do not reflect the effective use of resources but rather reflect transfers of wealth from one group to another within the community.

With a view to economic analysis, the financial values of investment costs must therefore be eliminated and operate from the elements that constitute simple transfers (mainly taxes, social security charges, subsidies, and other forms of facilitation), as well as expressing values in terms of shadow prices.

For this purpose, a series of conversion factors are used to apply to the financial values which allow for obtaining the corresponding economic values which are relevant for considering social equity issues. The path that led to the choices of options to be considered for the analyses was a consultation path with local authorities and with the territory through agreements and protocols that have been stipulated from 1996 to today. The final choice was the solution that presents the highest socio-economic advantages: in environmental terms, urban re-stitching for equitable purposes and the decongestion of traffic flows.

The indicators that allow for the evaluation of both financial and economic projects are based on the net present value (NPV). This is the algebraic sum of the cash flows originating from a project. This is discounted at a discount rate that takes into account the opportunity cost of the currency during a defined period. It provides the calculation of the value of the net benefit expected by the initiative as if it were available at the time the investment decision was made. In practice, the NPV provides the absolute size of benefits not obtainable from the project.

The formula (1) is:

$$\mathrm{NPV} = \sum_{t=0}^{n} (\mathrm{Benefits} - \mathrm{Costs})_t (1 + r)^t \quad (1)$$

where:

r = discount rate
t = year
n = analytic horizon (in years)

2.3. Financial Feasibility and Economic Indicators

The financial profitability of the investment is assessed by estimating the following indicators:

- Net financial present value (NFPV), or the sum of the annual balances between costs (including costs for investment) and revenues generated by the investment, discounted at a predefined rate (as expressed in real terms);
- Financial rate of return (FRR), or the value of the rate which, applied as a discount to annual cost–revenue balances, makes the NFPV equal to zero.

As for financial analysis, the judgment of convenience or economic–social appreciation of the investment is summarized in a calculation of indices, which, in this case, are represented by:

- Net economic present value (NEPV), or the sum of annual balances between costs and benefits generated by the investment, discounted at a predefined rate;
- Economic rate of return (ERR), or the value of the rate which, applied as a discount to the annual cost–benefit balances, makes the value of NEPV equal to zero;
- B/C ratio, that is, the ratio between discounted benefits and discounted costs.

With particular regard to direct effects, these are the costs and benefits that can be noticed by that part of the community that is directly affected by the project.

For investment projects in the transport sector the direct benefit is typically represented from savings in terms of:

- Time, for which a transport project contributes to the well-being of users if it is able to guarantee a reduction in average transport times compared to the situation "without a project";
- Operating costs, for which the collective well-being is increased to the extent that the project allows and is able to offer an overall cheaper mode of transport than the situation "without a project". Additionally, as for the construction and operation costs of the infrastructure, the operating costs of the different modes of transport are expressed using their economic value, through the application of conversion factors.

Another peculiarity of the economic analysis is given by externalities. These are socio-environmental effects that affect the community as a whole. Economic theory defines externalities as changes in the level of well-being generated by a certain activity, which is not however reflected in market prices. Externalities can be negative (external costs) or positive (external benefits). An external cost, or negative externality, represents a disadvantage or a negative consequence that the activity of an economic agent (or a group of agents) determines towards another agent (or group of agents) if this impact is not compensated for in some way with money from the agent who caused it. Similarly, an external benefit, or positive externality, is the advantage or positive consequence that an activity carried out by an agent (or group) generates in the sphere of one or more other agents; however, they do not pay any monetary consideration for the benefit obtained.

In the transport sector, we agree that most of the externalities are negative (external costs), while there is a broad consensus in terms of considering that the value of possible external benefits is negligible compared to the costs. Above all, the majority of the benefits generated by the transport activity are internalized at the source. Typically, the strengthening of the transport offer induces the example of economic growth (regional, local, national) as it is a benefit explicitly expected from the infrastructural development and therefore directly considered in the decision-making process.

In accordance with the recommendations of [15] and as provided for by practices for investment in transport infrastructure, for the purposes of this CBA the following are valued following externalities: atmospheric pollution, noise pollution, contribution to the greenhouse effect, accidents, congestion.

2.4. Financial Analysis

The method applied is that of discounted cash flow (DCF), which takes into consideration only the incoming and outgoing cash flows; it does not consider provisions, amortization and other accounting items that do not correspond to actual cash movements.

The analysis is carried out from the point of view of the Infrastructure Manager (RFI SpA) and therefore considers the economic-financial effects (in differential terms) that the realization of the Investment Programme involves for business management, in particular:

- Investment costs for the implementation of the Investment Programme;
- Changes in extraordinary maintenance costs aimed at maintaining the infrastructure at a standard level of operation during the forecast period;
- Changes to the operating costs of the infrastructure;
- Toll revenues received for accessing the infrastructure by service operators' rail;

- Sources of funding: the mix of sources is used for the development of indicators and financial profitability of the national capital employed (thus excluding the part inherent in the requested community support) and for the verification of overall "bank" sustainability. The values are considered net of VAT as items that can be recovered by the subject proposer.

The analysis is carried out using constant real prices and therefore a rate is used consistently for discounts expressed in real terms.

Based on the items specified above, annual cash flows are used for the calculation of the evaluation indicators provided for by [15].

The financial analysis also includes:

The determination of the indicators (NFPV and FRR) aimed at assessing the profitability of the financial capital of the national capital, that is, the financial resources made available by national funds (from both public and private sources).

Verification of the financial sustainability of the project, based on the projections of financial flows not discounted; these are aimed at demonstrating that over the entire time horizon, year after year, the project will have sufficient financial resources to cover all expenses related to it.

For the purposes of determining the community contribution, the net revenue method is used, discounted, and applied in accordance with the [18].

Indicators of financial profitability from the investment results (that is "Without the support of the Union") are as follows:

- The net financial present value (NFPV at the discount rate of 4 percent), is equal to EUR −3.714 million.
- The financial rate of return (FRR—6.6 percent).

The indicators show that the net revenues of the project are not able to repay the initial investment (regardless of the sources of financing), therefore it confirms the eligibility of the project in supporting EU contributions.

2.5. Calculation of the EU Contribution and Hypotheses for Other Sources of Financing

Considering eligible costs equal to EUR 367 million, the total for the two interventions of the Naples–Bari route is covered by the application for EU PON 2014–2020 support.

For the purposes of calculating, the financial profitability indicators of the national capital and the verification of banking sustainability, the following hypotheses are considered relative to funding sources:

- Investment spending coverage: the estimated contribution is EUR 316 million, of which: EU support is EUR 237 million
- National co-financing: EUR 79 million; for expenses incurred up to 2018 the collection of the contribution is assumed as for 2019, while for the following years, the collection of the contribution is assumed to be the year following the one of expenditure, up to EUR 316 million.
- The remaining part of the expenditure relating to the entire "sheep Naples" Investment Programme, for an amount of EUR 5207.7 million (including "contingencies"), is financed by national public contributions, considered as collected in the year of support for the expense.

For the purposes of this analysis, the financial profitability of the national capital is evaluated by considering two cases:

A. Invested national capital represented by national public contributions commensurate with expenditure for investments including the "contingencies" part;
B. Invested national capital represented by government grants commensurate with an expense for investments that do not include the "contingencies" part.

We thus arrive at negative indicators, which therefore confirm the admissibility of the project to apply for EU support.

2.6. Financial Sustainability Verification

The analysis of financial sustainability based on projections of non-discounted financial flows, has the objective of demonstrating that the project will have financial resources at its disposal, year after year, sufficient to cover investment and operating expenses during the entire reference period.

The difference between inflows and outflows indicates the expected deficit or surplus accumulated for each year. Sustainability is considered guaranteed if the cash flow generated accumulates positive results (or results that are not negative) for all the years of the evaluation time horizon.

From the analysis of the multi-year plan of the flows, the result shows that the project is financially sustainable: the investment cost is covered by loans of the same amount with operating costs covered by revenues and state subsidies; therefore, overall, the cumulative net cash flow remains positive during the whole evaluation period.

2.7. Economic Analysis

Following the [17], a project is desirable from a socio-economic perspective if the economic analysis demonstrates that the results have a positive net economic present value (NEPV).

The economic analysis requires us to move from a purely private corporate perspective and to consider the effects that the investment introduces for the well-being of the community.

In fact, while the financial analysis makes it possible to arrive at indicators of convenience in relation to the use of resources from stakeholders, an economic analysis makes it possible to assess the net effect of the project in terms of social well-being, for example, to see if it determines the consumption or creation of wealth for the entire community.

According to this view, even investments from a financial point of view that are not advantageous could be socially advantageous as they generate wealth for the community affected by the project.

Through the appropriate adjustment of financial analysis and the monetary quantification of both the environmental and social effects generated by the project, a cost–benefit analysis allows for the possibility of arriving at indicators of the economic convenience of the intervention from a general interest point of view.

This economic analysis aims to assess the increase in well-being of the induced community from the realization of the investment project.

In practice, a number of issues must be checked: whether the investment satisfies public interests such as improvement or not, as well as environmental quality, transport safety, etc. Based on this analysis, decision-making elements related to the commitment of public resources for the realization of investment projects must be offered.

As previously stated, the benefit granted must be considered in "net" terms, that is, as an increase in the balance between benefits and costs generated by intervention with respect to a situation so-called "without intervention".

From the comparison between the situation "without a project" and the situation "with a project", it is possible to derive the differential traffic flows associated with the implementation of the project, divided into railway modes and other methods, for goods and passengers.

The differential flows thus obtained are the basis of the identification and monetary quantification of the direct effects and externalities that, compared with the construction and management costs of the infrastructure, make it possible to determine the indicators useful for assessing the convenience, economic, and social aspects of the project. The basic hypothesis to be considered for the economic analysis, in line with the financial analysis, are as follows:

- Base year for the discounting of flows: 2018, a 30-year time horizon starting from the base year;
- Data expressed at constant prices EUR 2018, consistent with the use of a "real" rate of the discounting of flows;

- Discount rate. As suggested in the "Guide to Cost-Benefit Analysis of Investment Projects"—European Commission DG Regional Policy, 2014, in the present economic analysis, a real discount rate of 3 percent has been used;
- Indexing. For indexing over time, the magnitudes inherent to the externalities and savings of time, parameters based on the annual variation of per capita GDP constant prices: the estimate is based on projections of Italy's GDP by 2020 from Prometeia and on the evolution of the Italian population from Eurostat;
- Conversion factors. The conversion factors used in this analysis have been determined taking into account the indications contained in the Quaderno PON Trasporti 02/2006 and in the [17].

2.7.1. Results of the Economic Analysis

The economic performance indicators of the investment program are shown below:

- The net economic present value (NEPV), or the sum of the annual balances between costs and benefits generated by the investment, discounted according to the default rate (3 percent) is equal to EUR 3218.3 million;
- The internal economic rate of return (ERR), or the value of the rate applied as a discount to the annual cost–benefit balance, makes the NEPV value equal to zero, with the results: 6.8 percent.
- The B/C ratio, that is, the ratio between discounted benefits and discounted costs is equal to 2.3, which corresponds, respectively, to EUR 5609.9 million and to EUR 2388.6 million.

The results of the CBA indicate that the overall Investment Programme considered produces net benefits for the community and therefore can be considered convenient from points of view both economic and social.

2.7.2. Additional Non-Quantified Benefits

The work insists on a densely inhabited area, where the regional capitals of Bari and Naples are included, as well as the provincial capitals of Caserta, Benevento, and Foggia (see Figure 1). The population affected by the implementation of the intervention is approximately 6.2 million inhabitants ([19] for 2017). Furthermore, the two Campania and Puglia regions affected by the infrastructure represent around 10.5 percent of Italian GDP ([20] for the year 2016).

In addition to the direct effects of a transport nature, the subject of quantification in the present context analysis, the realization of this work will produce even more information on the indirect and induced effects of the economic and social fabric.

Indirect impacts include a wide variety of possible effects, including changes in productivity within the transport sector, investments in the supply industry, and productivity changes in other sectors, as well as changes to import and export levels. Moreover, the economic literature also includes other effects, those induced and those that are catalytic. These are given by the increase in final demands due to the expenditure of workers and companies directly involved in transport and infrastructural activities (effects induced) and the set of activities and production facilities generated following the construction of new infrastructure in one certain area (catalytic effects).

In Table 4 direct and indirect effects are presented with regard to this project:

Table 4. Expected direct and indirect effects.

Direct Effects	Indirect Effects—Externalities
Time, for which a transport project contributes to the well-being of users if it is able to guarantee a reduction in average transport time compared to the situation "without a project".	***Externalities***, such as atmospheric pollution, noise pollution, contribution to the greenhouse effect, accidents, congestion.
Operating costs, for which the collective well-being is increased to the extent that the project allows an overall cheaper mode of transport than the situation "without a project". As for the construction and operation costs of the infrastructure, the operating costs of different modes of transport are expressed in terms of economic value, through the application of conversion factors.	***Economic growth*** (regional, local, national) induced by the strengthening of the transport offer.
	Changes in productivity
	Effects on international trade

One key variable concerns the save on travel time. Among the benefits resulting from the implementation of the Railway Investment Programme is to include a time gain in which those railway users directly involved benefit and which is connected to the perception of the value of time.

Considering all the interventions and programmatic actions planned for the development of the complex Corridor Naples–Bari, the objective, shared at various institutional levels is to progressively reduce significant reaching times for long-term relationship distances between Naples and Bari and, more extensively, on the HSR Rome–Bari route. The following values show the targets:

- Naples–Bari: total travel time of about 2 h (non-stop);
- Rome–Bari: total travel time of about 3 h (non-stop).

The following factors contribute to the achievement of these overall objectives:

- Reduction in travel time following infrastructure work already completed (previous connection with Foggia);
- Reduction in travel time directly related to the interventions of this assessment;
- Reduction in travel time expected from the implementation of other investments does not include the Investment Programme covered by this assessment. That is, in addition to interventions into the structure of the services (establishment of non-stop services) or others' actions, in terms of scheduling the timetable.

In particular, the activation of the works present in the Investment Programme may allow for a reduction in travel time for passenger services, both long-distance and regional.

For the monetary valuation of the time saved, reference is made to the values suggested for Italy in [21], considering the average between "short" and "long distance" values, updated to EUR 2018.

As suggested in [17], the time value is indexed over the years based on per capita GDP variations, considering an elasticity of 0.5 for the value of the "work" time and 0.3 for the value of the "non-work" time.

Applying the monetary values of time to the hours saved each year by users of the railway mode, distinguished by different travel reasons, the value of the savings is determined by the time associated with the investment project.

For the purposes of this CBA, time savings are associated with the following:

- The total traffic retained, that is, for the mobility component that would benefit from the railway services for users' own journeys, regardless of improvement of services offered;
- Reduced to 50 percent for the user component acquired from the road.

As an example, the calculation made along the Rome–Bari link, for the year of evaluation (2026), for quantifying time savings resulting from investment, amounts to EUR 35,442,917.00 [16].

On the other hand, another important variable is the evaluation of the greenhouse effect, which is mainly determined by emissions of carbon dioxide (CO_2), as well as from emissions of methane (CH_4) and dinitrogen oxide (N_2O).

For the estimation of car emission factors, reference is made to [22] that, modifying [23], sets a target of 95 g CO_2/vehicle.km for the average level of emissions for new car registrations starting from 2020, with the term extended by one year. Considering the 2016 breakdown of the vehicle fleet of the regions concerned from the itinerary and its evolution over the years, an average value of emissions for 2024 can be estimated as being equal to 138 g.v.km, with the achievement of the target value, an average referred to the entire fleet in circulation, to the year 2035.

In order to consider the evolution of emission factors over time, a linear interpolation was performed up to the year 2035, while for the following years, a decrease in emissions percent of each year was assumed.

Estimating the emission factors of HGV goods vehicles, expressed in g CO_2eq/vehicle.km, was undertaken to refer to the data suggested in [24], in particular, considering the suggested emission values for heavy vehicles in category HGV 16–32 t. equal to 715 g CO_2 eq/v.km (2008 value).

Based on the strategies outlined in the European context the prospective data have been estimated considering a reduction to 2030, which is equal to 20% of the TREMOVE values recorded in 2008.

Emissions in g/vkm per car and heavy vehicle have been multiplied due to the decrease in vehicles.km on the road resulting in traffic scenarios. These have determined the total annual emissions avoidable thanks to the activation of the new railway work and the consequent modal diversion.

For the monetary valuation of cost savings, reference is made to the proposed central value in [24], amounting to EUR 90/t CO_2-eq.per year 2010, derived from estimated values in the literature.

The unit cost of greenhouse gas emissions is very variable over the years as it depends on various elements, such as the technological evolution of the means, the trend of the emissions market, etc.

For the purposes of this analysis, it is assumed that starting from 2010 the value will increase by 2 percent per year up to 2040, a year in which it is estimated as being equal to EUR 163/t, and which then will remain constant for the following years [16].

Further, in accordance with data processed by RFI, the construction of the Naples–Bari connection will produce around 2000 jobs in the direct realization of the work and in the indirect activities connected to it. In addition to this, about 200 employees will be activated in related industries.

The following Table 5 presents the CBA results.

Table 5. Key indicators—financial and economic analyses.

	Million EUR, % and Ratio
NFPV	EUR−3714.00 million
FRR	−6.6%
NEPV	EUR 3218.3 million
ERR	6.8%
B/C	2.3

2.8. Sensitivity Analysis

For the purposes of this CBA, the sensitivity analysis is conducted by modifying the values associated with each single variable and evaluating the effect of this change on NFPV (K) (referred to as the national capital), NFPV and NEPV. Those variables are considered "critical" for which a variation of ±1% of the value adopted in the base case gives rise to a change of more than 1% in the value of the NFPV indicators.

The sensitivity test is carried out:

- For financial analysis: considering the variables relating to all income and expenses ad with the exception of extraordinary maintenance, which is of a negligible amount;
- For the economic analysis: considering not only the financial variables but also the costs economic benefits and the economic benefits that appear to have greater weight in the formation of the NEPV of the base case, and also considering the modal diversion in traffic.

The results of the sensitivity analysis are referred to the changes in the indicators above (or close to) 1%.

The results show that:

- The financial performances of the project are not particularly sensitive to possible fluctuations in the values of the variables estimated in the base case, with the exception of the cost value of the investment which therefore represents the only critical variable for the analysis indicators financial.
- Economic performances are sensitive to some variables to be considered critical, below:

In order of importance:

- Traffic (a variation of 1% determines a variation in the NEPV equal to 2.68%);
- Operating costs of the car (a 1% change in the unit cost per kilometre, determines a change of 1.87% of the NEPV);
- Investment costs (change of 1.21% of the NEPV).

To these elements, it is appropriate to add the operating costs of the railway services. They reach a value very close to 1%.

For each critical variable, the so-called threshold value, i.e., that value in correspondence with which the NFPV indicators become zero.

Regarding the financial indicators, it appears that the cost of the investment should decrease by an unrealistic percentage in order to arrive at positive NFPV values, therefore it is confirmed a decidedly negative financial profile, and therefore compliance with this is even more supported requirement for the eligibility of the project for EU support.

The values indicate that the project would economically fall within the break-even parameters:

- The cost of the project was up to about 86% higher than that defined for the base case;
- Or the operating costs of the railway services reached values more than double those current;
- Or the operating costs of the car were about half of those estimated in the base case;
- Or the reduction of vehicles on the road was approximately 37% lower than the value valued.

The results of the sensitivity analysis make it possible to arrive at a judgment of the good solidity of the project from an economic point of view.

3. Equity Considerations

In the aforementioned CBA, equity is considered during a consultation process, which included stakeholders, but it has not been quantified or presented in the final project report. Therefore, in this paragraph, we shed some light on the equity calculation and present the results of a survey realized on purpose.

Based on this set of indicators we have developed a survey using CATI (computer-assisted telephone interviewing, a telephone surveying technique in which the interviewer

follows a script provided by a software application). Therefore, we have obtained a structured system of microdata collection by telephone that speeds up the collection and editing of microdata, permitting the interviewer to educate the respondents on the importance of timely and accurate data. The selection of potential users of Naples–Bari HS rail services has been based on ACI (Automobile Club d'Italia) members as representatives of potential users switching from cars to trains as estimated by RFI. The survey was developed during the month of October 2019 with 1874 people who travel from Bari to Naples and vice versa.

The structure of the sample is as follows: males represent 67 percent; the remaining 33 percent are females. A total of 82 percent are commuters (also on a weekly base), against the 18 percent who travel for leisure. The income range is concentrated in the class EUR 25,000.00–35,000.00 with 62 percent, followed by those with an income between EUR 35,001.00–45,000.00P accounting for 21 percent. Those selected and who answered (79 percent), provided the following information based on the classification by Creger et al. classification (see Table 6).

Table 6. Transportation equity indicators for Bari–Naples HS link.

Increase Access to Mobility		**% of the Total of the Sample**
1.	Affordability	91%
2.	Accessibility	95%
3.	Efficiency	76%
4.	Reliability	83%
5.	Safety	90%
Reduce Air Pollution		**% of the Total of the Sample**
6.	Air quality and health impacts	95%
7.	Greenhouse gas emissions	98%
8.	Total vehicle travel (less is better)	100%
Enhance Economic Opportunity		**% of the Total of the Sample**
9.	Connectivity to employment, education, services, and recreation	88%
10.	Fair labor practices	45%
11.	Transport-related employment opportunities	79%
12.	Inclusive local business and economic activity	89%

Source: Self elaborations.

The results show interesting indications in terms of impacts on the equity of potential users of the HS railway service. All the characteristics linked to the improvement of mobility access present a widespread appreciation with respect to all indicators considered. These aspects are very important in light of the modal shift because at present the existing railway connection strongly penalizes the population, and precisely on the aspects that are appreciated by those who responded to the survey. The elements to which we are referring to as:

Affordability is strictly related to the rail transport mode and to the location of the rail stations considered. Ninety-one percent of the sample consider this aspect as a peculiarity of the service.

Accessibility refers to the consideration of the HS rail service and if it is considered as physically accessible (available in the neighborhood), accessible to disabled people, accessible to people with various cultures/languages, and accessible without the need for banking or a smartphone. Ninety-one percent are positive about this aspect.

Efficiency reflects the frequency of transit, travel times, and the time spent on board the train. It also includes the availability of parking around the stations, etc., which affects the operative efficiency of the whole service. Seventy-six percent of the sample has this perception.

Reliability refers to the consistency and variability of travel times, as well as the predictability of travel times. Eighty-three percent of the sample consider the service as reliable.

Safety is linked to collision rates and severity, and personal safety issues (harassment, profiling, etc.). Ninety percent consider the HS rail network safe.

The same level of appreciation can be seen from the results of the elements linked to environmental sustainability, and therefore a high sensitivity on the part of potential users with regard to this element is evident. The elements under consideration are as follows:

Clean air and positive health benefits refer to the perception of the reduction of air pollutants and to health improvements due to switching from cars to railways. Ninety-five percent of the sample consider the new service as a generator of these effects.

A reduction in greenhouse gases refers to greenhouse gas reduction which is perceived as possible by 98 percent.

Total vehicle travel links to the perception of reducing vehicles in use given the presence of HS rail transport. It is considered possible by 100 percent of respondents. Finally, with reference to the opportunities for improving economic conditions, there is a good percentage with reference to employment, education, and recreational aspects (88 percent). The service of HS Bari–Naples is not perceived as an opportunity to improve labor practices (45 percent), but rather is appreciated for the chance of generating new job opportunities and developing economic activities (79 percent). We are referring to the possibility of generating new businesses, increasing property values, and benefiting the local community without displacing residents.

4. Conclusions

The cost–benefit analysis of the Bari–Naples rail link provides very useful information on the feasibility of an investment generating significant benefits for society. The contribution of this paper has extended the analysis by considering some useful indicators for including equity within these analyses. This framework provides tools to assess and maximize equity in transportation planning and decision-making to address community-identified mobility needs. The results show a very significant impact on equity in terms of perception. This emerges clearly, considering the three summary aspects of the concept of equity: increase access to mobility, reduce air pollution, and enhance economic opportunity. The methodological suggestion is to always consider social equity involved in high-speed railway projects, but also to enlarge the application field to all the other transport modes which have social relevance.

In evolutionary terms, the analysis could be developed in the future through the application of the multi-criteria decision analysis which could allow us to take into account further qualitative elements deliberately omitted here.

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