Feasibility Studies through Quantitative Methods: The Revamping of a Tourist Railway Line in Italy

Armando Cartenì, Ilaria Henke

Abstract—Recently, the Italian government has approved a new law for public contracts and has been laying the groundwork for restarting a planning phase. The government has adopted the indications given by the European Commission regarding the estimation of the external costs within the Cost-Benefit Analysis, and has been approved the 'Guidelines for assessment of Investment Projects'. In compliance with the new Italian law, the aim of this research was to perform a feasibility study applying quantitative methods regarding the revamping of an Italian tourist railway line. A Cost-Benefit Analysis was performed starting from the quantification of the passengers' demand potentially interested in using the revamped rail services. The benefits due to the external costs reduction were also estimated (quantified) in terms of variations (with respect to the not project scenario): climate change, air pollution, noises, congestion, and accidents. Estimations results have been proposed in terms of the Measure of Effectiveness underlying a positive Net Present Value equal to about 27 million of Euros, an Internal Rate of Return much greater the discount rate, a benefit/cost ratio equal to 2 and a PayBack Period of 15 years.

Keywords—Cost-benefit analysis, evaluation analysis, demand management, external cost, transport planning, quality.

I. INTRODUCTION: THE BACKGROUND

RECENTLY, investments in transportation projects and infrastructures have progressively decreased. The Italian government has tried to change this trend, approving a new law for public contract laying the groundwork for a new look at planning and designing transportation systems restarting a sustainable and rational planning phase [1], [2]. In particular, the Government, after a long phase of sharing with institutional and non-institutional stakeholders, has decreed the "Guidelines for Assessment of Investment Projects". The guidelines incentive the ex-ante evaluation for the new infrastructure and the ex-post evaluation for the project in progress and they are not completed. These analyses must be based on quantitative techniques. In particular, the Cost-Benefit Analysis is the tool proposed for assessing the economic viability (feasibility study) of the investments, in accordance with the Guidelines provided by the European Commission. In addition to the Economic Value, Economic Net Present Value (ENPV) and the benefit/cost analysis (B/C), to identify investment priorities, are nevertheless suggested other investment efficiency indicators. These indicators measure the degree of responsiveness of investment to achieve the strategic objectives identified in the general guidance

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document entitled "Connecting Italy" (annex on infrastructures to the Italian Economic and Financial Planning Document of the Italian Government April 2016).

According to this new law for public contract, in this research, a feasibility study has been carried out through quantitative methods regarding the revamping of a tourist railway line in Italy. A cost-benefit analysis based on external costs estimation and in compliance with the new law for public contracts was performed. Starting from the estimation of the commuters and tourists demand (along the years) within the study area directly influenced by the railway object of revamping (the Municipality of Formia and Gaeta) and potential demand attracted by the new rail service, it was being measured the external costs saved both for users (e.g. travel time saved) and for non-users (e.g. environmental impacts). The Measures of Effectiveness (MoE) estimated were the Internal Rate of Return (IRR), the Net Present Value (ENPV), the PayBack Period, and the Benefit/Cost ratio. Furthermore, a sensitivity analysis was also performed to evaluate the robustness of the results.

The paper is divided into three sections; in the first one, the case the study is described; in the second, the methodology for the Cost-Benefit analysis is reported, while in the last section the main results of the analysis in term of Measure of Effectiveness are discussed.

II. APPLICATION CASE STUDY

As said, the application case study is composed of the Formia and Gaeta municipalities, the area directly involved by the revamping of the railway line object of the study. Formia and Gaeta are two tourist coastal cities of the Lazio Region (Fig. 1), very popular during the summer period. These two municipalities have significant road congestion and pollutant problems. For this reason, the local municipalities have started to revamping the available railway line linking the two municipalities to reduce traffic congestion and environmental (external) impacts and improving the quality of life (welfare).

The tourist railway line object of the study is 9 km long and is part of the national Gaeta-Sparanise railway corridor, one of the most Italian historical line (Fig. 1). Opened in 1892, it was damaged during the Second World War and remained not in operation for many years. The services re-opened in 1954, but due to the boom of the automobile industry of that period, it soon became not used by the transport users until its final closure in 1981. Only in 2008, the revamping activities started, restoring 6 of the 9 km of the line, but before re-opening the line, the works were stopped [4]. Actually, the line is not in operation.

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This railway line represents an important opportunity for the requalification of these tourist territories. This railway service could potentially serve both the commuters (in the winter) and the domestic tourists (during the summer) from Lazio and Campania Regions (Italy).

Fig. 1 The railway line Formia-Gaeta (in red) within the national railway network [3]

III. THE CASE STUDY AND THE MOBILITY SURVEY

The positive impacts (benefits) produced by the revamped railways line Formia-Gaeta, was estimated as the change between the project scenario (the new line) and the Not Project (NP) scenario. They were evaluated according to different perspectives [5]:

− **benefits for users:** potential users of the revamped railway line and the whole transport system users;
− **benefits of non-users:** those who will not use the revamped railway line, but anyway have some benefits from the new construction (e.g. environmental impacts reduction).

Comparing the difference between the overall costs and benefits the economic feasibility of the revamped railway line was performed.

A. The Estimation of Demand Related to the Revamped Railway Line

Many of the activities relating to a cost-benefit analysis are

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potentially subject to so-called "*Planning fallacy*". That is the tendency of the planners to overestimate the effects (positive) of a project in order to legitimize the choice in the construction of a new infrastructure. In order to overcome this phenomenon, in this research many precautionary hypotheses were made, aimed in reducing the risk of benefits overestimation and costs underestimation. One of the precautionary hypotheses was to neglect the induced demand by the revamped rail service [6]. This means considering only the deviated demand from other transport modes (e.g. bus and car) and not the generated demand by the new transport opportunity (increase in transport accessibility). To estimate the deviated demand, it has been carried out a mobility surveys. Between March and August 2016, about 1,000 commuters (who travel very frequently between Formia and Gaeta) and about 420 tourists who visit the beaches of Gaeta, have been interviewed. They have been asked their residential address, the destinations, the gender, the trip purposes and the age. In the second part of the survey, the propensity and the willingness to pay for the revamped rail service Formia-Gaeta, have been also investigated.

Figs. 2 and 3 report the major results: 95% of commuters are willing to use the revamped line paying the same price as they spend today for the trip (e.g. car fuel plus parking price); 59% of tourists confirm they would go several times to the sea in Gaeta if there was a railway line.

Starting from these results, to evaluate the economic feasibility of the revamped railway line it was necessary to estimate, as said, the potential demand (deviated from other transport modes). To do this was applied a transportation system model (explicitly considering transport accessibility variables, [7]) composed in:

- a multimodal supply model (for details see [8], [9]), explicitly considering the interaction among car, train and bus modes;
- an activity-based discrete choice model (for details see [10], [11]);
- both stochastic (for the car mode) and deterministic (for train and bus mode) assignment models (for details see [6]).

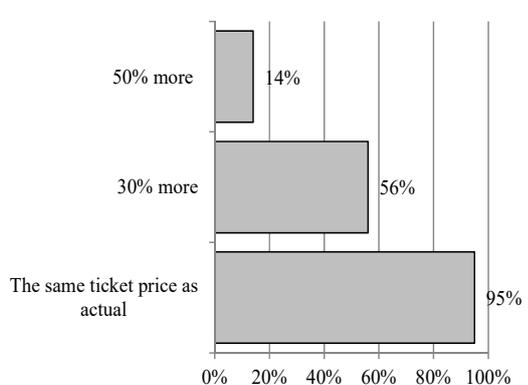The main results of the demand estimation are reported in Table I.

Fig. 2 Willingness to pay for the revamped railway service (in terms of percentage increase of the ticket price)
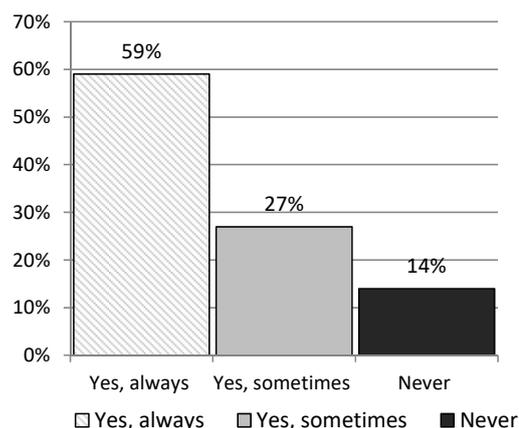
Fig. 3 Percentage of passengers who would increase (always or sometimes) the trip frequency once completed the revamped line

TABLE I
THE ESTIMATED DEMAND FOR THE REVAMPED RAILWAYS SERVICE
(DEVIATED FROM OTHER TRANSPORT MODES)

	Rail users/ day	Rail users/ year	Variation in car usage [Δcar*km/year]
Estimated demand for revamped rail service	6,230	793,658	-5,404,617

B. The Cost Estimation

The costs considered in the analysis are:
- the investment cost (30 million of Euros), which is the realization cost supported during the construction and the first years of service;
- the maintenance and management costs (18 million of Euros), from the first year the line enters into operation and for the whole life period of 30 years considered in the analysis;
- the residual value of the investment (with a positive sign), taking into account that the value of the revamped railways line is higher than the life time period considered for the analysis (e.g. 100 years vs. 30 years).

To exclude taxes and subsidies, all the costs have been multiplied by specific correction coefficients as suggested in [12]. The total estimated investment cost (at 2016 price) is about 25 million of Euros, maintenance and management costs are about 18 million of Euros, and residual value of the investment was prudently fixed equal to 1 million of Euros (underestimating the real value).

C. The Benefits Estimation for Users

The revamped railway line will produce direct and non-direct benefits to users. The benefits directly perceived by the users include travel time savings, while the non- perceived benefits for the users include the savings associated with the reduction of the car maintenance costs.

The estimated benefits for the potential users of the revamped railway are quantified in about 3 million of Euros in the first year of services. Considering a life period of 30 years and a discount rate equal to 3%, at the end of the evaluation period (in 2048), the estimated overall benefits (perceived and not) for the users will be over 596 million of Euros (at

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constant prices).

D. The Benefits Estimation for The Non-Users (External Cost Saved)

The benefits estimation for the non-users (external cost saved) in a cost-benefit evaluation regard the estimations of external impacts (externalities) produced by the project both with respect to the environment (e.g. climate change costs) and with respect to human health (e.g. air pollution and road safety).

The proposed design scenario (revamped railway line) will produce a reduction in the use of private car with significant positive benefits for the non-users in term of reduction in: climate change, air pollution, noises, traffic congestion, and car accidents.

TABLE II
THE BENEFITS ESTIMATION FOR THE NON-USERS

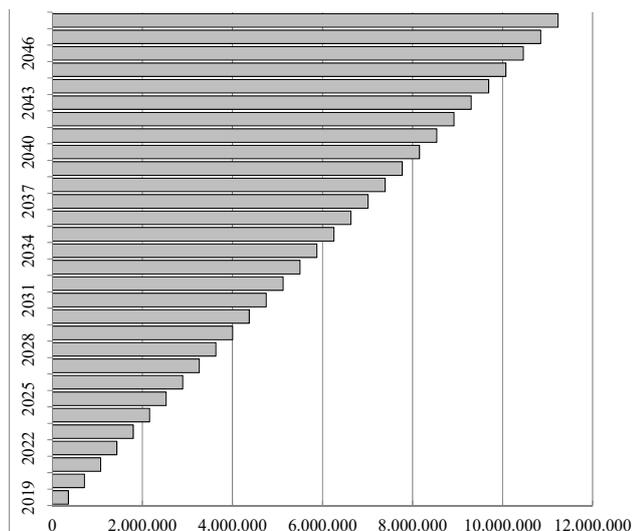| External costs saved	Year 2019 [Euro]	Year 2048 [Euro]
Climate Change	135,547	147,286
Air Pollution	51,935	56,433
Noise	5,179	5,627
Congestion	128,191	139,293
Accident	34,838	37,855
Total	**355,691**	**386,496**

Fig. 4 Cumulative of the benefits estimation for the non-users (Euros)

To estimate the economic value of these benefits (that are in general non-monetary values; e.g. variation in tons/year of climate change emissions), it has been multiplying the amount of car use reduction per year, Δcar*km/year, estimated for the project for a marginal cost (the monetary value of a single unit of car use reduction). The marginal cost used are those proposed by the European Commission [13].

Overall, the average amount per year saved is about 360,000 Euro/year (at 2016 prices) with a cumulative monetary value for all the life period considered for the revamped railway line equal to 11 million Euro (at constant prices).

IV. MEASURE OF EFFECTIVENESS AND CONCLUSIONS

We defined and quantified (in monetary terms) the impacts related to the revamped railway line, the following performance indicators (Measure of Effectiveness - MoE) were estimated:

Net Present Value (NPV): compares the amount invested (costs) in the present value with the future cash receipts from the investment (benefits). It is calculated as:

$$NPV\ (r) = \sum_{t=0}^{Tm} \left(\frac{\sum_j Ben_j^t - \sum_j Cost_j^t}{(1+rate)^t} \right) \qquad (1)$$

where: *rate* is the rate of return (3% as suggested in the Guidelines for Assessment of Investment Projects); *Tm*, is the life time period of the analysis (for this case study was considered 30 years); *Ben_J* are all the benefits (both for users and for non-users) that the revamped railway service will produce; *Cost_J* are all costs supported (investment, maintenance and management);

Internal Rate of Return (IRR) $rate_o$ is the value of the rate of return that null the NPV:

$$IRR = rate_o;\quad NPV(rate_o) = 0 \qquad (2)$$

Benefit /Cost (Ben/Cost) is defined as the ratio between the total benefits and costs discounted at the initial year:

$$\frac{Ben}{Cost} = \frac{\sum_{t=0}^{Tm} \left| \frac{\sum_j Ben_j^t}{(1+rate)^t} \right|}{\sum_{t=0}^{Tm} \left| \frac{\sum_j cos t_j^t}{(1+rate)^t} \right|} \qquad (3)$$

Pay Back Period (PBP) is the length of time necessary to recover all the costs supported (the NPV become positive):

$$PBP = T_{min};\quad NPV(rate) > 0 \qquad (4)$$

The estimation of performance indicators (Measure of Effectiveness - MoE) shows that the revamped railway line is economically feasible for the following reasons:

- the *NPV* is positive and equal to about 27 million of Euros;
- the *IRR* is much greater in the discount rate (around 9% vs. 3%);
- the *Ben/Cost* ratio is approximately equal to 2; and
- the *PBP* is only 15 years.

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