A cost-benefit analysis of the metro Line 1 in Naples, Italy

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Abstract: The metro Line 1 in Naples (Italy), also called "Metrò dell'arte" (art in the Metro), is a high-quality line where many international architects were involved to ensure high aesthetic quality standards for the new stations. The "Daily Telegraph" and the CNN, have defined the new Toledo Station, one of the Line 1 metro station, the most impressive station of Europe.

The aim of the paper was to evaluate, after five years its realization, the economic convenience of the most impressive section of the metro line. A cost-benefit analysis was the evaluation method performed according to both the National and the EU guide lines. The strengths in developing an "ex-post" analysis are: i) the realization and maintenance costs are exactly known (because just spent); ii) the travel demand (passenger moved by the metro line) are counted through the monitoring system and not estimated through models/surveys.

Among the benefits estimated were: travel time and costs saved; hedonic value in using the high-quality metro line; environmental benefit; pollutant reduction; accident reduction; congestion reduction.

Overall, the investment cost was about 897 million euro (price 2000), while the architectural high-quality standards cost was only the 6% of the total (50 million euro). Estimation results show that benefits produced by the hedonic value (perceived quality) of the high-quality stations, in 30 years, are 3.3 times higher than its realization costs with about 164 million euros (price 2000) of benefits, the 12% of the total benefits (1,367 million euro). The benefit/costs ratio (one of the measures of effectiveness used in the analysis) was equal to 1.6, sowing the high socio-economic convenience produced by this transport project.

Key-Words: public transport, passenger satisfaction; evaluation process, cost-benefit analysis, transport quality, railways stations, sustainable mobility, urban sustainability, transportation planning, decision making process.

1 Introduction

Since 1980 an architectural movement, the "Station Renaissance", grows in Europe aimed at improving customer satisfaction with respect to travel attributes such as on-board comfort, perceived safety in railway stations and quality of public transport [1]. This movement has its major originality points in aesthetics, architectural quality, integration with the surrounding landscape and in accessibility and inter-modality between transportation terminals and modes [2]. According to this movement, Naples city (Italy) decided to develop its new metro line according to high aesthetic quality standards [3]. This new Line, also called "Metrò dell'arte"- art in the Metro (Figure 1) is characterized by stations adorned with artworks by many contemporary artists. The idea was to use specific (different) architects for each station, in order to give each station an its own identity. Architects of international fame were involved in the underground project including Zaha Hadid, Rogers, Perrault, Eisenman, Fuksas, Kapoor, D'ascia, Aulenti, Mendini, Podrecca, Siola, Botta E Pagliara, in addition to many young architects from Naples and the Campania region. Some stations of Line 1 have received some international awards; for example, the "Daily Telegraph" and the CNN, have defined the new Toledo Station, the most impressive station of Europe (Figure 2).

In this context, several studies have shown that, the aesthetic and architectural quality, have an important role in mobility choices for the passengers of this Italian case study (e.g. [4], [5], [6], [7], [8], [9], [10]).

From these considerations, on September 2017 (five years after the realization of the new section "Dante-Garibaldi" of the metro Line 1) a cost-benefit analysis was performed to evaluate if the benefits generated by this metro line justify the costs supported over the time. The ex-post analysis implemented, in opposition with the ex-ante evaluations, has less uncertainty (more reliability) and less technical discretion biases, because:

- it is based on the investment and maintenance costs really supported (and not ex-ante estimated);
- the main benefits are measurable and not estimated (es. passengers using the new metro Line);

Furthermore, for developing the ex-post study the main reference technical sources were taken into account, useful for the Italian case study, such as:[11], [12] [13], [14], [15], [16], [17], [18].

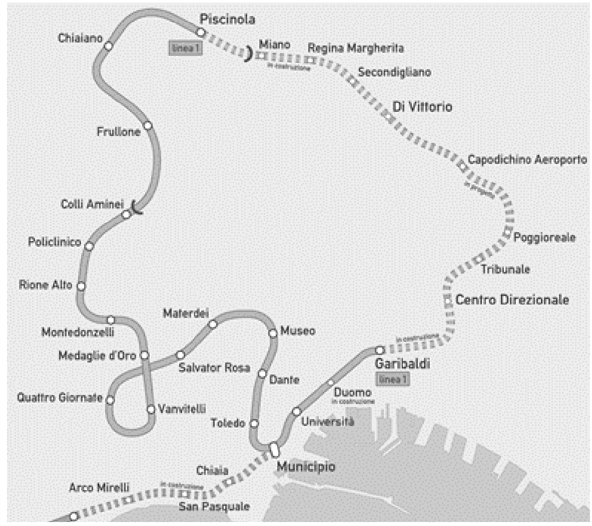

Figure 1 – Route and stations of the metro Line 1 in Naples

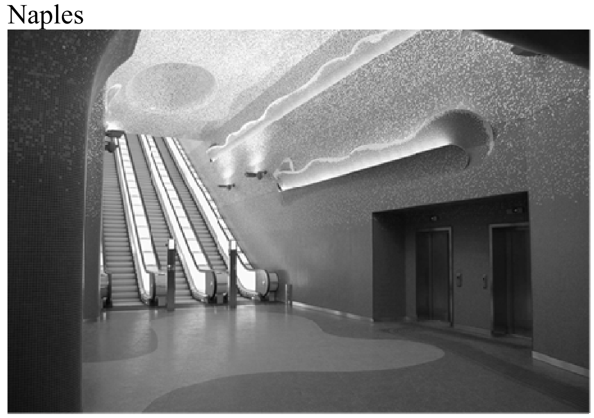
Figure 2 – Toledo station (source Metropolitana di Napoli S.p.A.)

2 Methodology

Recently, the Italian government has approved a new law for public contract aimed in improving a rational national and local sustainable transport planning ([19], [20], [21], [22]).

Following both the national and the EU guide lines (e.g. [13],[14],[15],[16],[17],[18]) a multi-step ex-post study was proposed (Figure 3):

a. Line 1 mobility demand observed and measured (ex post peculiarity);
b. transport study to estimate the impacts produced by the project;
c. costs evaluation (really spent- ex post peculiarity):
   - investment;
   - management and maintenance (ordinary and extraordinary);
   - residual value of the investment;
d. benefits estimation:
   - for the users:

- perceived:
  - the consumers' surplus;
  - the "hedonic value" of the travel (e.g. the aesthetic value of the station, sense of security).
- not perceived:
  - operational costs (e.g. usury and maintenance of the vehicle)
- for non-users:
  - greenhouse gasses emission variation;
  - pollutant emission variation;
  - noise pollution variation;
  - accidents variation;
  - traffic congestions variation;
  - impacts in other sectors variation (e.g. energy market);

e. definition and estimation of performance indicators for project assessment (NPV, IRR, B/C, Pay Back Period).

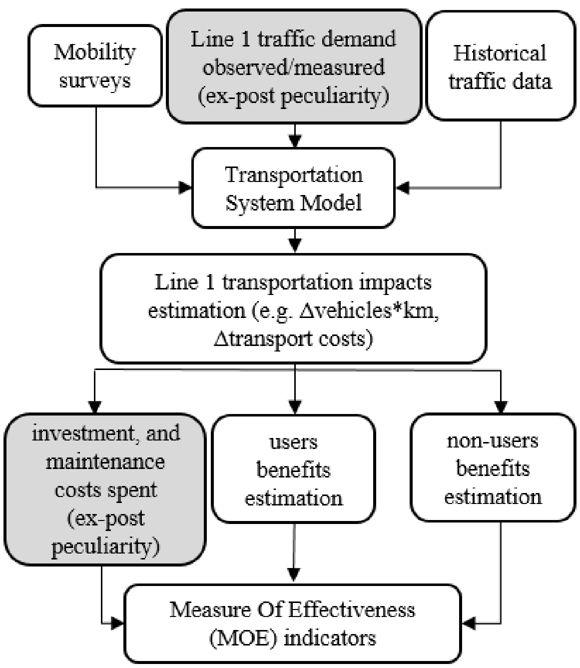

Figure 3 – The multi-step ex post methodology

Some preliminary activities were also performed: analysis time period definition; not-project (NP) scenario individuation; project scenario (P) definition. To reduce the planning fallacy phenomena, two different project scenarios have been simulated: one "optimistic" and one "prudential", based on more or less conservative impact estimation hypotheses. This allowed to estimate an impact "range of variation" instead of an impact "single value".

2.1. The preliminary activities

The analysis time period (sometimes known as temporal horizon) represents the number of years for witch the impacts were taken into account in the analysis. The choice of the time period significantly influences the results of the evaluation process. In accordance with the national guidance lines for the evaluation of investments in public constructions, (D.Lgs 228/2011 Ministry of infrastructures and transport, June 2017), in order to better estimate the impacts produced by the project, a time period of 30 years was considered starting form from the entry into operation of the first station "Università", in 201, of the new line. In detail:

- 1998-2021 is the time period in which there were an investment costs cash flows (source Metropolitana di Napoli S.p.A.);
- 2011-2040 is the time period in which there were the operating and maintenance costs cash flows.

The not-project scenario - NP (or reference scenario) represents the transport configuration in absence of the design solution and with all the "invariant interventions", that are the transport projects already financed or under construction in the study area.

The project scenario includes the new section "Dante-Garibaldi" of the Line 1 and the new art stations:

- Università, opened in 2010;
- Toledo, opened in 2012;
- Garibaldi, opened in 2014; and still under-construction for the external area;
- Municipio, opened in 2015, and still under-construction for the external area.

The section object of the research (Dante-Garibaldi), connects the centre of Naples with the railway station (where regional and AV trains depart).

2.2. The demand estimation

The quality and the accuracy of the quantitative methods used for the demand estimation (passengers that use the new line) has a central and important role in the assessment analysis performed. One of the advantages developing an ex-post study, as said, is that the traffic demand could be measured (observed) and not estimated. In this research the mobility demand was measured through an *had-hoc* survey and through traffic counts. In addition, different other traffic data available have been also used. The source used for the study were:

- last 3 years overall passengers' demand/year (source: company mobility in Naples called "Azienda Napoletana Mobilità -ANM S.p.A".) regarding all the stations of the Line 1 (ex-post peculiarity);
- 2017 monthly and daily passengers demand entering in all the stations of the Line 1 (source: company mobility in Naples ANM S.p.A.) (ex-post peculiarity);
- historical estimated origin-destination (OD) matrix concerning Line 1 trips (from all the stations to all the other stations of the line);
- ad-hoc survey carried out from November 2017 to February 2018 for the study (ex-post peculiarity);
- traffic counting in term of passengers entering/exiting the stations, carried in November 2017 and February 2018 (ex-post peculiarity).

The OD (Origin-Destination) matrix represent the daily (and annual) number of journeys originated from all the station *O* toward all the other station D. The sum of the elements of the i-th row is the number of trips generated by the i-th station. The sum of the elements of the j-th column is the number of trips attracted by the j-th station. Finally, the total number of journeys interested the new line is the sum of all the elements of the matrix (for per daily and for annual time period).

The analysis of this matrix was necessary to identify the level and the spatial distribution of the passenger demand related to the new Line 1. The estimation methodology of the OD matrix consisted in an optimization procedure aimed at jointly using all available source data.

The result of the OD matrix estimation was reported in the next figure. Overall, it is estimated that Line 1 is, on each weekday, affected by an average of 154 thousand journeys (round-trip) which correspond to approx. 26 million passengers/year.

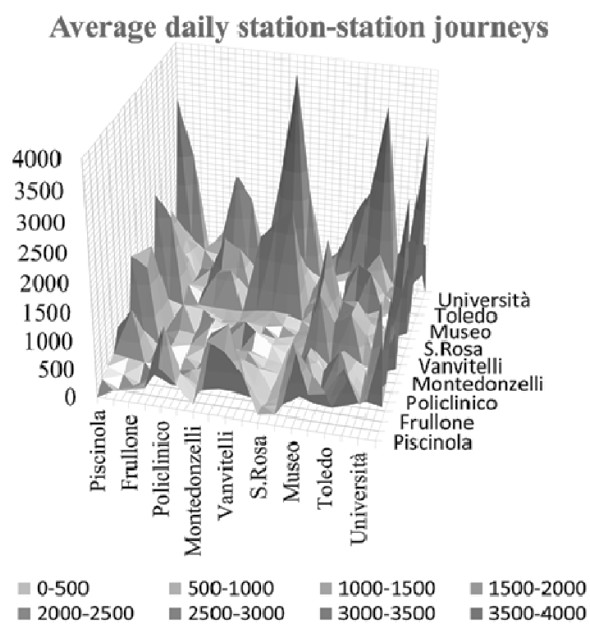

Figure 4 - Metro Line 1 origin-destination (OD) matrix graphical representation

It is noted that the OD pairs with the greatest number of passengers/days are Garibaldi-Vanvitelli (with 3.2-3.7 thousand passengers/day) and Garibaldi-Toledo (with 3.3 and 3.0 thousand passengers/day).

Overall, Dante-Garibaldi section is affected by over 25.5 million journeys/year (round-trip) equal to about 56% of the overall passengers of the Line 1.

Additionally, the demand of tourists visiting art stations was also estimated. Overall, it has been estimated that in one year the tourists who visit the art stations are 176 thousand (0.8% of total travelers / year) of which 50 thousand (28%) have chosen to use Line 1 for the sole purpose of visiting its stations.

Furthermore, through the mobility survey performed, it was estimated how many passengers of the new section "Dante-Garibaldi" of the line 1, in absence of this infrastructure, would had used private cars for their trips.

Finally, to estimate the Δvehicles*km saved in using the new line, an ad-hoc transportation system models was implemented starting from the results of previous research on this case study (for details see [8], [24], [25], [26], [27]).

The results show that the average annual Δvehicles*km saved is of 59.282.422.

To estimate the trend effect produced by this new metro service, a macro-economic model was also performed. This aggregate model allows to estimate the percentage variation of the passenger demand in function of the trends of the main socio-economic and macro-economic variables (GDP, population, fuel/gasoline price and toll).

2.3. The costs evaluation

In the ex-post study, all costs supported were considered. During overall time period, these costs consist in: investment costs, operative costs; ordinary and extraordinary maintenance costs. Furthermore, because of the analysis time horizontal (30 years) is lower than the "economic life" of the project (the new metro line), a residual value of the investment was also considered. This value, because of represents an income for the project, was taken into account with a positive sign in the cost-benefit analysis. 30% of the total investment cost is the residual value considered according to a "prudential way" of analysis (Table 1 and Figure 4).

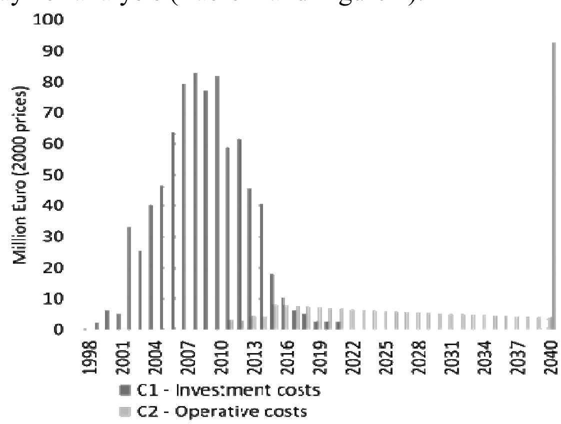

Figure 4 - Investment costs (2000 prices)

	Fiscal corrections	Constant prices (€ Excluding VAT)	Constant prices and with fiscal corrections (€ Excluding VAT)
C1 – Investment costs	0,91	1.146.602.768	1.043.408.518
C2 – Operative and maintenance costs	0,88	14.641.824	12.884.805
C3 – Residual value of the investment	0,88	343.980.830	302.703.131

Table 1 - The economic costs of the project (constant prices and fiscal correction)

As suggested by the reference texts for economic assessment (e.g. UVAL, 2014), the costs to be considered in the analysis require of fiscal corrections and corrections attributable to non-fiscal market imperfections.

2.4. User benefits estimation

The impacts (benefits) for the users of the transportation system were estimated as differences between the project scenario and the non-project scenario.

2.4.1. The consumer Surplus

The benefits for the transport users were estimated through the "consumer surplus" variation (with respect to the no-project scenario). According to a behavioural approach, and following the random utility theory ([28]), the consumer surplus variation (ΔSP) can be estimated summing the travel time variation (mean and standard deviation, $\Delta time$ + $\Delta dev.st.$) and the monetary cost variation ($\Delta cost$) weighted according to reciprocal substitution parameters, the value of time - VOT ($\Delta gen.$ cost generalized transport cost variation):

$$\Delta SP = \Delta gen.cost = VOT * (\Delta time + \Delta dev.st.) + \Delta cost$$

where:

- $\Delta time$, is the travel time saved relative to the transport mode (alternative) available (e.g. Line 1 vs. bus line);
- $\Delta dev.st.$, is the standard deviation relative to the measured/estimated travel time variation;
- $\Delta cost$, is the monetary cost variation between the transport mode alternatives (e.g. metro ticket vs. fuel cost and car parking).

Starting from these considerations, through an ad-hoc transportation system model implemented for the case study (for details see [8], [18], [19], [20], [21], [22], [23]), the consumer surplus variations (between the project and non-project scenario) were estimated.

Furthermore, different value of time (VOT) were considered for the different purposes (e.g. work, study, leisure, sport, others).

Overall, the average estimated generalized transport cost saved is about 4 Euros/trip with a standard deviation of 3.5 Euro/trip (Figure 5).

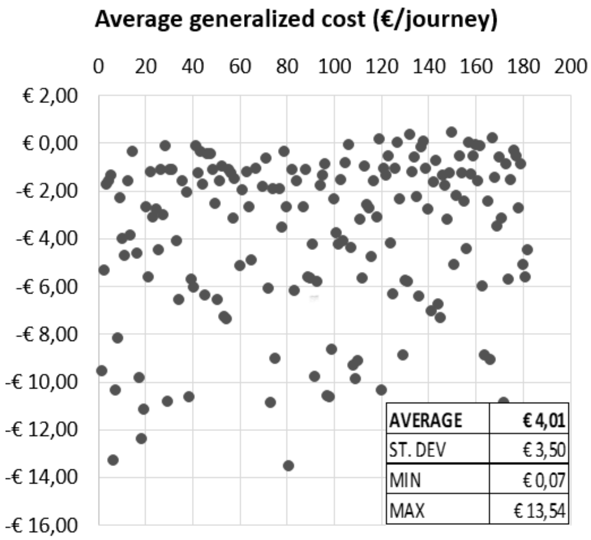

Figure 5 - Generalized transport cost variation produced by the construction of the Dante-Garibaldi section of Line 1 in Naples, Italy (monetary value/trip)

The total users benefit estimated (total consumer surplus variation), for all the time period of 30 years and a discount rate *r* equal to 3%, is over 1.1 Euro billion (2000 prices).

2.4.2. The hedonic value of the art stations

Scientific evidences showed that effects of the aesthetic and architectural quality of the stations have a central and significant role in the perception of the quality from the public transport users and influence their mobility choices. In particular, researches carried out for the case study analysed (e.g. [4], [5], [6], [7], [8], [9], [10]), showed that economic value of railways stations quality is about 43 cent per journey: in other words a user is available to wait until up to 6 minutes more or to walk until up to 9 minutes more in order to get to a beautiful station. Given the peculiarity of the case study, in the current cost-benefits analysis, this hedonic value was considered. The benefit estimated for the hedonic value are quantified in over 160-200 M€ (2000 prices) for the overall time period.

In the following Figure 6 results of total users' benefits estimation were reported (consumer Surplus + hedonic value variations).

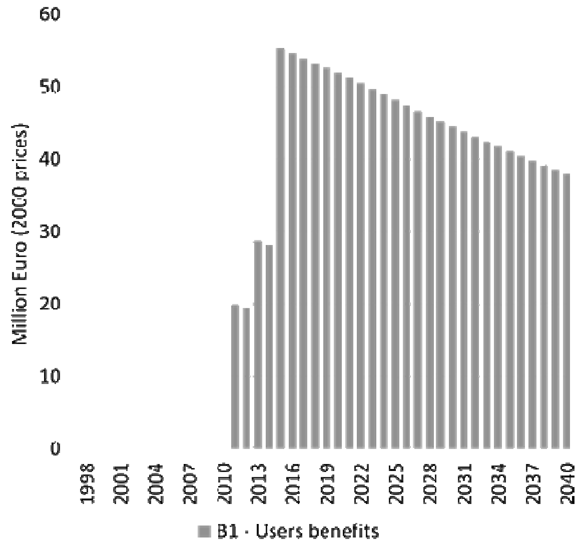

Figure 6- Estimation of benefits for transport users (Euro at 2000 prices)

2.5. Non-user benefits estimation (externalities)

A significant part of the cost-benefit evaluation regards the estimation of external impacts (externalities) produced by the project both on the environment (e.g. climate change costs) and on the human health (e.g. air pollution and road safety).

As mentioned in section 2.2, these impacts were estimated starting from a mobility survey aimed in estimating the number of the actual users of the metro line 1 that would use the private car in absence of the line. Starting form this value, through the transportation model estimated, the total number of vehicles*km saved was quantified.

To estimate the economic (monetary) value of the non-user benefits, Δvehicles*km saved was multiplied by a marginal cost, obtaining the yearly externality saved. These marginal costs has been estimated through the unit rates proposed from the European Commission [16], weighed according to the Naples vehicle fleet distribution [28].

The total external impacts (externalities) estimated was about 70 M€ (2000 price).

2.6. Definition and estimation of the performance indicators

Once all the impacts (benefits and costs) were quantified (in monetary terms) the socio-economic convenience of the project was evaluated through the estimation of some measure of effectiveness - MOE:

- Net Present Value (NPV) which transfers the various effects *j* (impacts) relative to a single project *i* to the beginning year, according to the defined time period T:

$$NPV_i(r) = \sum_{t=0}^{T} \left(\frac{\sum_j B_j^t - \sum_j C_j^t}{(1+r)^t} \right)$$

- Internal Rate of Return (IRR) defined as the discount value r_0 which invalidates the NPV estimated in the time period T:

$$IRR_i = r_o;\ NPV_i(r_o) = 0$$

- Benefit/Cost (B_i/C_i) as the ratio between the absolute-value of the benefits and costs discounted at initial year:

$$B_i / C_i = \sum_{t=0}^{T} \left| \frac{\sum_j B_j^t}{(1+r)^t} \right| \Big/ \sum_{t=0}^{T} \left| \frac{\sum_j C_j^t}{(1+r)^t} \right|$$

- Pay Back Period (PBP) that is, the minimum number of years T_{min} beyond which a positive NPV is verified (return of the investment):

$$PBP_i = T_{min};\ NPV_i(r) > 0$$

Both an optimistic and a prudential scenario were considered in the estimations in term of more or less prudential hypotheses regarding the externalities estimation.

The estimation of these MOE indicators allows to conclude that the new section "Dante-Garibaldi" of the metro Linea 1 is socio-economically feasible because: the NPV is 0,5-0,8 Million €, the B/C is 1,6-1,9 and the Pay Back Period is 18-20 years.

Discount rate *r*	3%
NPV	0,5-0,8 Million €
B/C	1,6-1,9
IRR	6,0-6,7%
PBP	18-20 years

Table 2 – Cost-benefit MOE indicators: optimistic (higher values) and prudential (lower values) estimations

It is interesting to note that the benefits produced by the perceived hedonic value of the metro line is about the 12% of total benefits. Furthermore, this hedonic value is 4-5 times higher (in 30 years) than the costs spent for all the high aesthetic and architectural standards used for the new "art stations" of the metro line 1, underling the economic convenience of this king of architectural standard for transportation terminals.

3.0 The sensitivity analysis

Finally, to verify the strength of the results obtained, an accurate sensitivity analysis was also performed. This allowed to evaluate the reliability of hypotheses performed in the analysis. This analysis is crucial for all the "weaker" hypothesis, that are the ones with the major discretion and minor reliance of the evaluations. Such sensitivity analysis consists in applying variations in positive and negative (e.g. +10%, +20%, +30%) to the hypothesized parameters/indicators/discount rate and evaluate if, and in what measure, the estimated MOE change (e.g. NPV and IRR).

For the performed sensitivity analysis, the following phases were implemented:

- definition of the critical variables, that is those with an elasticity higher than 1, for which for a "*X*" variation of these variables a percentage variation (in an absolute value) " greater than *X*" was observed for the NPV;
- definition of the "*pessimistic scenario*", that is a hypothetical scenario in which some critical variables, opportunely combined, produce a null NPV.

Among the critical variables individuated, those with the highest elasticity with respect to the NPV are: the discount value *r* (Figure 7), the consumer surplus variation (Figure 8) and variation of hedonic value estimation (Figure 9). As shown in the figures, even to applying large (negative) variations in the estimates of these variables (unrealistic variations) the NPV is always positive, confirming the robustness of the analyzed project scenario.

Furthermore, also the "*pessimistic scenario*" estimated (for which the NPV is null) was unrealistic. Only considering an overestimation of the consumer surplus of the 40% and an overestimation of the hedonic value of the 30%, the NPV is null.

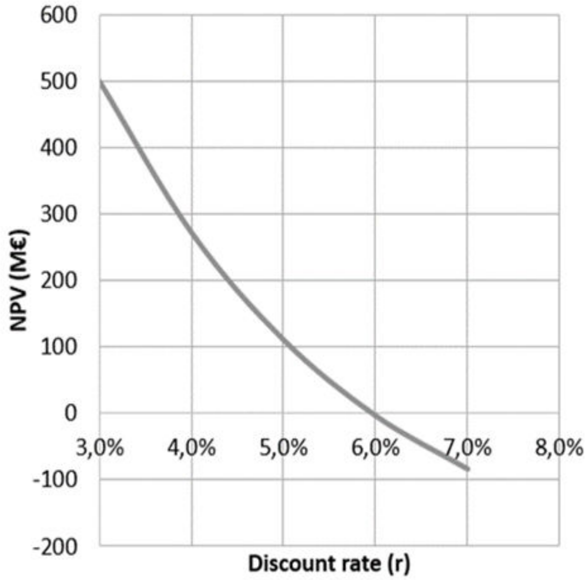

Figure 7 - Sensitivity analysis: elasticity of the NPV with respect to the discount rate *r*

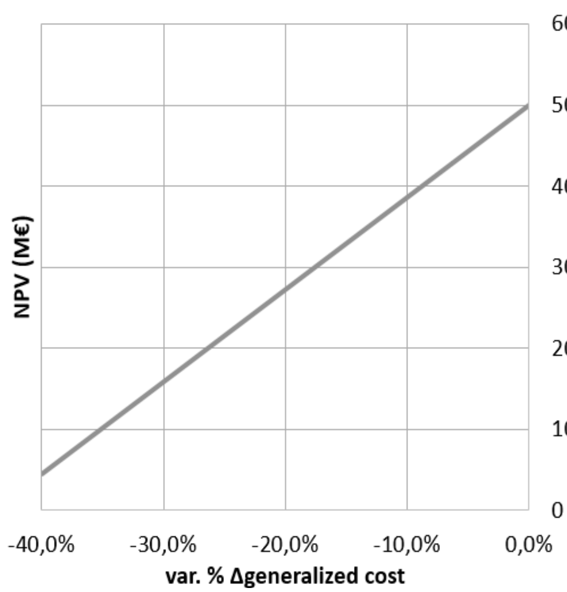

Figure 8 - Sensitivity analysis: elasticity of the NPV with respect to generalized transport cost variation (consumer surplus)

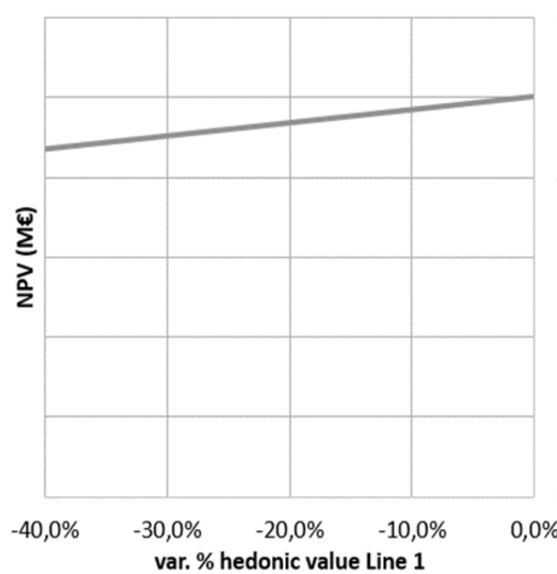

Figure 9 - Sensitivity analysis: elasticity of the NPV with respect to the hedonic value of metro Line 1

References:

[1] Kido E.M., Aesthetic aspects of railway stations in Japan and Europe, as a part of context sensitive design for railways, *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 6, 2005, pp. 4381-4396.

[2] Edwards B, The Modern Station, *London:E & FN Spon*, 1997.

[3] Cascetta E., Cartenì A., A quality-based approach to public transportation planning: theory and a case study, *International Journal of Sustainable Transportation, Taylor & Francis*, Vol. 8, 2014, Issue 1. DOI: 10.1080/15568318.2012.758532,

[4] Cascetta E., Cartenì, A., Carbone A., The quality in public transportation. The campania regional metro system [La progettazione quality-based nel trasporto pubblico locale. Il sistema di metropolitana regionale delia Campania]; *Ingegneria Ferroviaria*, 68 (3), 2013, pp.241-26.

[5] Cascetta, E., Cartenì, A., A quality-based approach to public transportation planning: theory and a case study; *International Journal of Sustainable Transportation*, 8(1), 2014a, pp.84-106.

[6] Cascetta, E., Cartenì, A., (2014b); The hedonic value of railways terminals. A quantitative analysis of the impact of stations quality on travellers behaviour; *Transportation Research Part A: Policy and Practice*, 61, pp.41-52.

[7] Cascetta E., Cartenì, A., Henke I., Stations quality, aesthetics and attractiveness of rail transport: empirical evidence and mathematical models [Qualità delle stazioni, estetica e attrattività del trasporto ferroviario: evidenze empiriche e modelli matematici]; *Ingegneria Ferroviaria*, 2014, pp. 307-32.

[8] Cartenì, A., Galante, G., Henke, I., The catchment area of high architectural railways stations: an application of the Graham scan algorithm; *WIT Transactions on the Built Environment,* 2014.

[9] Cartenì, A., Galante, G., Henke, I., An Assessment Of The Accuracy Of Models In Predicting Railway Traffic Flows: A Before And After Study In Naples; *WIT Transactions on Ecology and the Environment*, 191, 2014, pp.783-794.

[10] Henke, I., La variazione di accessibilità a seguito della realizzazione di una linea metropolitana ad elevati standard architettonici; *Inu Edizioni*, 2015.

[11] Cartenì, A.; A cost-benefit analysis based on the carbon footprint derived from plugin hybrid electric buses for urban public transport services. *WSEAS Transactions on Environment and Development*; Volume 14, 2018, pp. 125-135. ISSN / E-ISSN: 1790-5079 / 2224-3496.

[12] Carteni, A., Henke, I., External costs estimation in a cost-benefit analysis: The new Formia-Gaeta tourist railway line in Italy. Conference Proceedings; *17th IEEE International Conference on Environment and Electrical Engineering* and 2017 *1st IEEE Industrial and Commercial Power Systems Europe, EEEIC / I and CPS Europe,* art. no. 7977614, 2017.

[13] Ministero delle Infrastrutture e dei Trasporti (giugno 2017); *Linee guida per la valutazione degli investimenti in opere pubbliche* - D. Lgs. 228/2011.

[14] European Commission; Guide to Cost-Benefit Analysis of Investment Projects, 2014.

[15] Regione Lombardia, Interventi infrastrutturali: linee guida per la redazione di studi di fattibilità, 2014.

[16] Ricardo-AEA DG MOVE, Update of the Handbook on External Costs of Transport. Final Report. *Report for the European Commission*, 2014.

[17] Unità di Valutazione degli investimenti pubblici – UVAL, Lo studio di fattibilità nei progetti locali realizzati in forma partenariale: una guida e uno strumento, 2014.

[18] HEATCO - Developing Harmonised European Approaches for Transport Costing and Project Assessment; Deliverable 5: Proposal for Harmonised Guidelines, 2006

[19] Cartenì, A., De Guglielmo, M.L., Pascale, N., Calabrese, M, An adaptive rational decision-making process for developing sustainable urban mobility plans; *International Journal of Civil Engineering and Technology*, 8 (7), 2017; pp. 1147-1156.

[20] Cartenì, A.; Urban sustainable mobility. Part 2: Simulation models and impacts estimation; *Transport Problems*, 10 (1), 2015, pp. 5-16. ISSN 1896-0596

[21] Cascetta, E., Cartenì, A., Pagliara F., Montanino, M.; A new look at planning and designing transportation systems: a decision-making model based on cognitive rationality, stakeholder engagement and quantitative methods; *Transport Policy* 38, 2015, pp. 27–39.

[22] Cartenì, A., Urban sustainable mobility. Part 1: Rationality in transport planning; *Transport Problems*, 9 (4); 2014, pp. 39 - 48. ISSN 1896-0596.

[23] Cartenì, A., De Guglielmo, M.L., Pascale, Congested urban areas with high interactions between vehicular and pedestrian flows: A cost-benefit analysis for a sustainable transport policy in Naples, Italy; *Open Transportation Journal*, 12 (1); 2018, pp. 273-288.

[24] Cantarella G.E.; de Luca S., Cartenì A.; Stochastic equilibrium assignment with variable demand: theoretical and implementation issues; *European Journal of Operational Research,* Volume 241, Issue 2., 2015, pp. 330–347.

[25] de Luca, S., Cartenì, A., A multi-scale modelling architecture for estimating of transport mode choice induced by a new railway connection: The Salerno-University of Salerno-Mercato San Severino Route [Un'architettura modellistica multi-scala per la stima delle ripartizioni modali indotte da un nuovo collegamento ferroviario: il caso studio della tratta Salerno-Università di Salerno-Mercato San Severino]. *Ingegneria Ferroviaria,* 68 (5), 2013, pp. 447-473.

[26] Bifulco, G.N., Cartenì, A. and Papola, A., An activity-based approach for complex travel behaviour modelling; *European Transport Research Review*, 2(4), 2010, pp. 209-221.

[27] Cartenì, A., Updating demand vectors using traffic counts on congested networks: A real case application; *WIT Transactions on the Built Environment 96*, 2007, pp. 211-221.

[28] Cascetta E., Transportation System Analysis: Models and Applications, *Springer,* New York, 2009.

[29] Sources ACI, su http://www.aci.it/laci/studi-e-ricerche/dati-e-statistiche/autoritratto.html (last access December 2017).