CRITERIA FOR OPTIMIZING A ROAD NETWORK

Francisco Javier Regalado López
PhD Candidate, UPC, Spain
José Magín Campos Cacheda
Associate Professor, UPC, Spain
Sergi Saurí Marchán
CENIT, Spain

ABSTRACT

Cost-benefit analysis (CBA) is the most widely used tool for appraisal of transportation infrastructure projects, but there isn't generalize guidelines about its implementation, there can be found different approaches that suit the perspectives of each evaluating entity. This document, it shows three different guidelines that used in practice for transportation infrastructure projects, in which there are some different costs and benefits considered informing decision makers about the project appraisal. The costs and benefits with market values have been the predominant ones in the CBA, but there is a transition to use without market values, however, there are no generalized methodologies, so more research will be needed.

1. INTRODUCTION

The constant growing world population causes a greater demand for transport infrastructure that are pressured by the increase in users, causing the need for improvements or new infrastructure projects, the problem is limited financial resources (Jones et al., 2014).

Efficient transport infrastructures are essential for the proper financial and social functioning, helping to increase productive capacity and promoting development; their economic impact can be transformative, in particular for those with a low income level (Feick & Roche, 2013; Younis, 2014).

In the last decades, studies have been carried out on the social impact of having access to mobility, with topics such as the role of transport in social exclusion, the importance of accessibility, the interface between social capital and transport, the effect of transport on human well-being and how it influence the actions of decision makers in a region (Lowe et al., 2018).

Transport infrastructures are key in ensuring the accessibility of passengers and goods, helping to shorten distances and time. The other side of the coin is the negative effects such as the investment, becoming physical barriers, the congestion and noise. Active planning minimize negative externalities and enables the shift towards a sustainable transport infrastructure, which is necessary to steer development in a better direction (Banister, 2011; Koglin & Rye, 2014; Meunier et al., 2014).

Countries invest in transport projects as new infrastructure, upgrade, maintenance or repairs to the transport network. The common denominator among these types of projects is that they are the outcome of public sector decision-making at different levels of government and, sometimes, at the international level. Despite the important technical and economic dimension, investments in transport infrastructure may represent partial political statements of objectives, prioritization of financing and target users (Berechman, 2009).

The ability to choose the best projects according to transportation needs, relies on the quality of data used, the tools for its evaluation and choose the correct variables that lead to guidelines for solving public management problems of decision making (Broniewicz & Ogrodnik, 2020).

The term transportation project evaluation is used to describe the formal procedure for determine the net social benefit of different transport project alternatives that may be of different nature, objectives, costs and benefits (Berechman, 2009). To get an idea about whether planning is heading towards a correct development, different tools and models help to analyze transportation projects in order to estimate their benefits in monetary terms (Laird & Venables, 2017), there is an increase interest in knowing the benefits of a more social nature (Johansson et al., 2017).

Within the European context, the most used tool for the evaluation of transport projects is the Cost Benefit Analysis (CBA), in which it is very clear the variables to be used when it comes to direct impacts that are easily translated into monetary terms, but not much with indirect impacts where there are no market values available. The Multicriteria Analysis (MCA) is an alternative that can use variables without market value, is being used to a greater extent as a complement, or as a comparison in the evaluation of projects with the CBA (Bristow & Nellthorp, 2000).

This document intends to show the costs and benefits taken into consideration in three different contexts, making known the actuality of centralized guidelines of the CBA for transport infrastructure projects, as it is the most used tool to evaluate projects and thus know possible areas of opportunity for improvement or updating.

2. EUROPEAN CONTEXT

The transport infrastructure for the European Union (EU) is essential since it is a single market, so it must have a solid transport network that links its members, without it the internal market would be affected. For this reason, all levels of government have addressed the resolution of the dilemma that exists between policies that promote economic growth and consequently the generation of more transportation infrastructure projects and environmental policies that require reducing environmental impact (Villa et al., 2020).

The global economic recession has affected investment in transport infrastructure since 2008, the percentage of the Gross Domestic Product (GDP) allocated to infrastructure projects is at the bottom, that remember the limited resources despite current transportation needs (OECD, 2019).

Investments have focused on improving the quality of transport, accessibility, mobility and safety, while covering the demand (European Commission, 2014). Despite limited resources and the need to allocate them in the best way, it has been shown that project evaluation tools have had little relevance during the decision-making process and are often seem as tedious obstacles to get the investment required for the project (European Parliament, 2019). Another problem is the enthusiasm in the CBA, the evaluator may be too optimistic about key parameters of the project, causing the projected benefits to be less or impossible to meet (ECA, 2018).

Country	CBA	MCA	QM	QA	NA
Austria	x	x	x	-	-
Belgium	x	-	x	-	-
Cyprus	x	x	-	x	-
Czech Republic	x	x	-	-	-
Denmark	x	-	-	-	-
Estonia	x	-	-	-	-
Finland	x	-	x	-	-
France	x	-	-	-	-
Germany	x	-	-	x	-
Greece	x	-	-	x	-
Hungary	x	x	-	-	-
Ireland	x	-	x	x	-
Italy	x	-	-	-	-
Latvia	x	-	-	-	-
Lithuania	x	-	-	-	-
Malta	x	-	-	-	-
Netherlands	x	-	x	-	-
Poland	x	x	-	-	-
Portugal	x	-	-	-	-
Slovak Republic	x	x	-	-	-
Slovenia	x	-	-	-	-
Spain	x	x	-	-	-
Sweden	x	-	-	-	-
Switzerland	x	x	-	-	-
UK	x	x	x	x	-
Total	25	9	6	5	0

Table 1: Type of analysis by country in road project appraisal. Ref: Adapted from (Odgaard et al., 2005)

The role of the tools for project evaluation is inform to decision makers about relevant data, in this way it will be possible to prioritize projects from the same program, choose the best solution alternative for a problem, know the social benefits of the project and above all choose if it is the right time to make the investment.

The most common tool of evaluation in the EU member states are the CBA and MCA, in some cases the CBA is complemented with the MCA to get a quantitative or qualitative evaluation to include other impacts that are not monetized for technical reasons or policies (Bristow & Nellthorp, 2000).

In 25 European countries, table 1, the most used types of analysis for the evaluation of road transport projects are: CBA, MCA, Quantitative Measures (QM), Qualitative Evaluations (QA) and Not Available (NA) (Odgaard et al., 2005):

Transportation contributes to economic growth that enables a global market, but it also gives rise to externalities, some of which can be expressed in monetary terms. External costs (externalities) are the effects imposed on society, in contrast to benefits, not assumed by the users of the infrastructure and, therefore, not considered in the decision-making process. Internalizing these costs means making such effects part of the decision-making process, using market-based instruments is considered an effective way of limiting the negative side effects of transportation (European Commission, 2019).

(Odgaard et al., 2005) mentions certain effects that are used within the European scope being;

- Infrastructure costs: construction costs, system operation and maintenance costs.
- Benefits for the user: time savings in passenger transport, vehicle-operating costs, benefits for freight traffic.
- Externalities: security, noise, air pollution (local - regional), climate change.
- Also; user charges, revenue and construction disruptions.

According to (Odgaard et al., 2005) in 25 European countries the CBA is used to a greater extent according to the type of element to be evaluated, which is complemented with another type of analysis. Table 2, shows the distribution of analysis used in the countries of the study, it can be seen that the countries mostly use the CBA for purely convertible effects to monetary terms:

Effects	CBA	MCA	QM	QA	NA
Construction Cost	25	4	1	1	0
Disruption from construction	10	1	0	6	11
System operating cost and maintenance	24	4	2	2	0
Passenger transport saving	24	4	3	2	0
User charges and revenues	17	1	1	3	6
Vehicle operating costs	23	4	1	0	2
Benefits to goods traffic	17	2	1	1	8
Safety	24	4	3	1	0
Noise	13	3	7	8	3
Air Pollution - Local/Regional	14	2	5	7	3
Climate change	8	1	3	7	10

Table 1: Type of analysis by effect. Ref: Adapted from (Odgaard et al., 2005)

In 2016, total external costs in EU countries amounted to €726 billion and congestion costs to €271 billion with a total of €987 billion, representing 6.6% of GDP. Road transport is the mode with the highest impact on external costs, accounting for 83%, when including aviation and maritime modes; 97.5%, when excluding them. Considering accidents, congestion, climate change, air pollution, environmental damage and noise (European Commission, 2019).

3. COST-BENEFIT ANALYSIS

CBA is a technique developed in the field of economics, mathematics, statistics, and operations research, which seeks to provide guidance to decision-makers on the formulation of public policies (Nilsson et al., 2008).

The CBA was the first formal economic evaluation method to be applied to potential projects with the impetus of selecting more rational investments that represent better value for money. The CBA through indicators shows a comparative description of the potential costs and benefits of the project, indicating its economic contribution to society, as well as to the project's investors. Currently, during the analysis not only the cash flow is considered but also the economic, environmental and social impacts, both positive (benefit) and negative (costs), quantified in monetary terms adjusted for the present value of money (Dimitriou et al., 2016).

The CBA is the dominant method in the economic evaluation of projects since the 1970s (Macharis & Bernardini, 2015). Despite its wide use, there is still no universal standard CBA model, each organization or country defines its own specific requirements for evaluation, although with similar criteria (Vickerman, 2017).

The methodological advantages of using the CBA are; it carries the improvement of the evaluation since out under the same scenarios and impacts. Decision makers have more complete information to appraise the projects according to its effects, however, it should be taken into consideration that the information might be incomplete or of poor quality, which may cause the decision taken not to be the best one. The CBA can be a good discussion platform for those involved in economic research, design and planning of infrastructure, improving the quality of information for decision-making, helping to support final decisions. Among the negative points, the CBA lacks transparency for the final reports to society, as well as its difficulty to worth environmental impacts without market value. Although it may seem to have few negative points, the area of work is controversial and of great economic impact (Annema et al., 2007).

4. REVIEW OF CBA GUIDELINES

This section provides the costs and benefits that are included in the CBA guidelines by government agencies for the evaluation of transport projects, as a tool to support decision making in road projects, which are: CBA Guide for EC, United States (US) and New Zealand (NZ) investment projects.

4.1 The CBA Guide for transport investment projects of the EC

The CBA Guide of Investment Projects (CBA Guide) for transport projects for the EU aims to provide guidance on the common rules for the European-wide use of the BCA for large projects, referring to works, with a total cost of more than 50 million Euros. Having the intention to ensure; the improvement in the movement of people and goods in order to obtain better accessibility, mobility and safety, improving the quality and safety of infrastructures; better linkage between EU member states, promoting the single market and meeting transport demand, developing transport infrastructures and improving transport services; promote national or regional economic development by investing in newly created, extended or linked infrastructures (European Commission, 2014).

4.2 The U.S Department of Transportation's CBA Guide for Investment Projects.

The application of the CBA in highway projects is to ensure that funding is directed to projects that contribute to the economic growth of the users and the nation as a whole. Through an efficient transportation system, requiring repairs, expansions and modernizing aging facilities but also new projects to ensure that they continue to meet the needs of the population and the marketplace. (USDOT, 2018).

4.3 The N.Z. Transportation Agency's CBA Guide.

The purpose of applying CBA to highway projects is to establish a quality transportation system that promotes the well-being and livability of society through new, upgrade or extension of road projects. The CBA should identify economic effects (including social and environmental) in decision-making, whether or not it can be quantified, establishing consistency, transparency and compatibility between activities to help assess their economic efficiency (NZ Transport Agency, 2020a).

	EC	US	NZ
Transport mode	General	Road	Road
Discount rate (%)	3 - 5	7	4
Economic performance indicators	VAN, B/C, ERR	VAN, B/C	VAN, B/C
Decision indicator	VAN	VAN, B/C	B/C
Time horizon (years)	Up to 30	Upgrade: 20 New project: 30	Up to 40
Risk assessment	Sensitivity (Monte Carlo)	Sensitivity (Monte Carlo)	Sensitivity (Monte Carlo)

Table 2: Guideline's summary. Ref: Own elaboration with data from (European Commission, 2014; NZ Treasury, 2015; USDOT, 2018)

4.4 Review of stages in the application of the CBA

The reviewed guidelines have a similar structure, although they differ in the number of steps in which their application is applied, it can be divided into 3 stages:

- Determination of the project: Describes the context of the project, establish the objectives, introduce the alternatives and define the base case for measure the incremental cost and benefits.
- Identification of costs and benefits: Costs and benefits are identified with/without market prices, usually divided into financial and economic analysis, discounted over the analysis time horizon to obtain the project's performance indicators.
- Analysis of results and report: The results are analyzed and the alternatives ranked. A report is prepared showing the results of the CBA in which the project's performance indicators are shown, as well as the data used to obtain them.

4.5 Financial analysis

4.5.1 Investment Costs

- EC: It is recommended to present both total project cost and unit value, infrastructures should be shown separately to allow comparative assessment and include all works necessary for their operation, land cost (property) and environmental protection costs (European Commission, 2014).
- US: The capital cost of a project is the sum of the monetary resources required to carry out the project, including, direct construction costs, capital costs, planning costs, project design, environmental reviews, land acquisition, utility relocation, or transactions to secure financing (USDOT, 2018).
- NZ: These are the costs required for the planning, analysis and delivery of the transportation infrastructure. Costs include any contingencies in the estimation of infrastructure costs, which may cause a cost overrun (NZ Transport Agency, 2015).

4.5.2 Operation and Maintenance costs

- EC: Operation and maintenance (O&M) cost can be grouped into the following categories; infrastructure operation, service operation, service management, routine maintenance and periodic maintenance. In the financial analysis, they are estimated in on-project and off-project scenarios (European Commission, 2014).
- US and NZ: Transportation facilities require continuous O&M to provide adequate service, maintain assets in operating condition and its costs should be included throughout the analysis period and should be directly related to the proposed project service plan (NZ Transport Agency, 2015; USDOT, 2018).

4.5.3 Revenue projections

- EC: Revenue projection are the product of the charges applied to users for access to the infrastructure, which are estimated based on: traffic volume forecast, projection of changes in the tariff system, pricing policy, traffic forecast for each projection of the tariff system and subsidy projection. In case the operating cost is not fully covered, the gap must be filled with other sources to avoid service closure (European Commission, 2014).
- US: Revenues from user charges (tolls, taxes, etc.) for the right to access transportation infrastructure, are an important source for public agencies to finance the operation of the infrastructure. These revenues cannot be considered "benefits" of the infrastructure, taking them would mean a double counting of the benefits, since the user chooses to pay for greater security, less travel time or operating costs (Lawrence et al., 2014).
- NZ: A comparison of the costs incurred in the transport infrastructure with the revenue is made to determine the financial viability of the project. The existing gap, if any, is determined by testing the funding gap values until the sum of the present value of the net annual cash flows is zero (Wallis et al., 2013).

4.6 Economic analysis

4.6.1 Travel time

- EC: Travel time savings can be derived from the construction of new or improvement of existing transport infrastructure, tell apart between work and non-work travel time estimation (European Commission, 2014).
- US: Estimated travel time savings will depend on engineering calculations and their effects on the operations of the improved infrastructure and the local area transportation network. These improvements can reduce travel time for drivers and passengers, including both in-vehicle time and waiting time (USDOT, 2018).
- NZ: Productivity and utilization of the network are related to the efficient use of the land transport network, seeking to optimize it instead of maximizing its use. The monetization of network productivity is measured through changes in travel time and financial costs of transport use (NZ Transport Agency, 2020a).

4.6.2 Vehicle operating costs

- EC: Vehicle operating costs are defined as costs borne by vehicle owners to operate vehicles, including fuel consumption, lubricant consumption, tire deterioration, repair and maintenance costs (European Commission, 2014).
- US: Operating cost savings commonly result from improved transportation infrastructure projects, resulting in lower fuel consumption and other operating costs (USDOT, 2018).

4.6.3 Accidents

- EC: Transport activities involve a risk to users of suffering an accident, because of mechanical failure or, more commonly, due to the influence of human error (European Commission, 2014).
- US: Transportation infrastructure improvements help to reduce the likelihood of death, injury, and property damage by reducing the number of crashes and / or their severity (USDOT, 2018).
- NZ: There are three variables, the first is the "social cost of death and serious injury" which includes the cost to the user, the cost to the health system and the costs of delay in the network. It considers loss of life, production, incapacitation, legal costs and property damage. In accidents, not only the user is impacted, but also the family and friends who may be affected by the accident. The second is "System safety", which focuses on investment aimed at improving system safety. The third is "Perception of safety and security", physical attributes such as lighting, safety cameras and speed controls that enhance the feeling of safety (NZ Transport Agency, 2020a).

4.6.4 Noise

- EC: Noise pollution can be defined as "unwanted external sound that has negative effects on human health". Noise emissions have a local impact, relating the magnitude of the effect to the location of the infrastructure, vibrations affect the quality of life and the productions of certain goods (European Commission, 2014).
- US: Noise pollution is caused by high levels of ambient sound that cause annoyance, distraction, or harm to people and animals. The US Department of Transportation doesn’t have a reliable means of estimating the public value of noise reductions (USDOT, 2018).
- NZ: Noise and vibration have significant effects on human health, mainly with sleep disruption and stress. Humans are sensitive to vibration and noise, which can come from the construction, operation, maintenance and use of land transport infrastructure (NZ Transport Agency, 2020a).

4.6.5 Air pollution

- EC: Transport investments can significantly affect air quality, reducing or increasing the level of pollutant emissions, having harmful effects on health, causing damage to infrastructure and impacts on nature (European Commission, 2014).
- US: The economic damages caused by exposure to air pollution are borne by society rather than by travelers and transportation operators that generate those emissions. Transportation projects can reduce overall fuel consumption and thus can produce climate and other environmental benefits (USDOT, 2018).
- NZ: The effects of air emissions from road transport that impact human health are monetized by assigning a cost to each tonne of pollutant as a proxy for the harm caused to people exposed to air pollutants (NZ Transport Agency, 2020a).

4.6.6 Climate change

- EC: Economic cost of positive or negative variations in Greenhouse Gas (GHG) emissions, the main emissions are carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4). These emissions contribute to global warming, therefore, it has a global impact and the related cost does not depend on the location of the investment (European Commission, 2014).
- US: GHG emissions have long-lasting even intergenerational impacts, unlike all other benefit categories (USDOT, 2018).
- NZ: Road transport is the largest contributor to emissions, the number of vehicles emitting GHGs emissions should be identified, get their fuel consumption and thus emissions can be monetized (NZ Transport Agency, 2020a).

4.6.7 Benefits to existing and additional users

- US: The main benefits of a project will arise in the "market" that the project would improve, with its users experiencing them directly. Users attracted by the improvement are willing to pay less for use it than the original users (USDOT, 2018).
- NZ: User experience can include comfort, simplicity, convenience, crowding, travel time and network condition (NZ Transport Agency, 2020a).

4.6.8 Loss of emergency services.

- US: Transportation projects can help to reduce the frequency of emergency service delays, generating benefits by reducing damages caused by delay (USDOT, 2018).

4.6.9 Modal diversion

- US: Improvements in transportation infrastructure or services may attract additional users of alternative routes or modes of transportation, it is challenging to capture the impacts of such modal shift within CBA and should be carefully examined to ensure that such benefits are correctly calculated within the analysis (USDOT, 2018).

- NZ: It is critical to know the variables that may encourage or discourage a user from selecting a transport mode. The user assigns a value to options, i.e., the value to individuals or groups of knowing about or having transport mode options available, even if they are not used (NZ Transport Agency, 2020a).

4.6.10 Work zone impacts

- US: A common example of "downsides" associated with transportation projects is impacts during construction or maintenance activities, such as delay due to traffic, increased insecurity, and vehicle operating costs (USDOT, 2018).

4.6.11 Agglomeration economies

- US: Transportation infrastructure improves connections between communities, people and businesses by reshaping the economic space of a region. The economic theory of agglomeration suggests that firms and households enjoy positive benefits from the spatial concentration of economic activity. These benefits can stem from a more efficient exchange of information and ideas, access to larger and more specialized workforce (USDOT, 2018).
- NZ: Changes in productivity result from of agglomeration, where scale and spatial concentration enables an increase of productivity by enabling a better learning, bonding and economic exchange (NZ Transport Agency, 2020a).

4.6.12 State of good repair

- US: These are the project benefits while replacing, repairing, or improving existing transportation assets to bring them to a state of good repair. These are generally captured by cost and benefit factors, such as maintenance, asset repair costs, improved safety, improved reliability, and service or facility quality (USDOT, 2018).

4.6.13 Resilience

- US: Incorporating resilience benefits requires an understanding of the expected frequency of each stressful event and its economic impacts on infrastructure (USDOT, 2018).
- NZ: These are system vulnerabilities and redundancies, are about reducing the risk of exclusion of communities from social and economic opportunities due to system disruptions. These may also relate to the preparation of solutions to ensure that the economic and social needs of communities are met (NZ Transport Agency, 2020a).

4.6.14 Quality of Life

- US: Transportation projects can provide benefits that improve quality of life but are difficult to monetize; these can be as varied as improved pedestrian connectivity, increased accessibility to remote communities, and other localized amenities. Quantifiable data on impacts should be provided, focusing on the changes expected to be generated by the transportation improvement project itself (USDOT, 2018).

- NZ: The impact of transport mode on physical and mental health is related to users' transport mode choice which is associated with the adoption of active modes (NZ Transport Agency, 2020a).

4.6.15 Increased in property values.

- US: Transportation projects improvements can increase the accessibility or improve the attractiveness of land parcels near infrastructure, resulting in increased land values (USDOT, 2018).
- NZ: The role of the transportation system is enabling and maintaining the normal functions of a community, with others or areas of the same community that due to a lack of transportation infrastructure may suffer a disconnection with the rest of the community (NZ Transport Agency, 2020a).

4.6.16 System reliability

- NZ: Comprises the user being able to have on a similar travel experience on the transport system each time with the same travel conditions (NZ Transport Agency, 2020a).

4.6.17 Employment

- NZ: An important impact of transport infrastructure is job creation, not referring to the direct or indirect employment produced by its construction. New or improved infrastructure can make it easier for people to get to work faster and can reduce the discouragement effects on workers by reducing travel times, which increases worker performance (NZ Transport Agency, 2020a).

4.6.18 Imperfect competition

- NZ: As transportation infrastructure improves, output increases in sectors where there may be differences between the price of the product and its marginal cost. Conventional CBA assumes economic sectors operate in perfect competition, where the prices are equal to its marginal costs. However, since there is a margin between price and cost, there is a gap between gross hourly labor costs and the market value of what is produced in that hour (NZ Transport Agency, 2020a).

4.6.19 Regional economic development

- NZ: There is an increase in gross domestic product or gross national income and a change in demand for goods and services (NZ Transport Agency, 2020a).

4.6.20 Water pollution

- EC: Pollution of water bodies occurs by discharging pollutants directly or indirectly without adequate treatment, affecting seriously the water quality, biodiversity and society (European Commission, 2014).

- NZ: Transport infrastructures during their life cycle can have a major impact on water flow and its quality, having short or long term effects, impacting the natural or artificial environment (NZ Transport Agency, 2020a).

4.6.21 Impact on soil and biodiversity

- EC: The presence of chemicals or soil disturbance due to industrial activity or improper waste disposal has long-term social and economic effects on society (European Commission, 2014).
- NZ: Biodiversity is fundamental to the existence of life, as people, animals and other organisms depend on it. Natural resources underpin the economic and social area of our society, during the different stages of the life cycle of transport infrastructures impact biodiversity (NZ Transport Agency, 2020a).

4.6.22 Resource Efficiency

- NZ: Sustainable use of resources, materials and reduction of environmental damage can be achieved by minimizing waste by using green energy and monitoring the carbon footprint generated (NZ Transport Agency, 2020a).

4.6.23 Access to opportunities

- NZ: Transport can function as an enabler and integrator of land use, focusing on the importance of destinations, services and activities that can be equitably accessed to enable economic and community participation (NZ Transport Agency, 2020a).

4.6.24 Heritage and cultural values

- NZ: Cultural values can be closely related to heritage values, the former are physical and can be expressed in monetary terms, the latter are based on perceptions and are not so easily expressed in monetary terms. Cultural values are considered both tangible and intangible benefits. The historic environment is important for health and well-being, playing an important role in urban development and in generating economic activity (NZ Transport Agency, 2020a).

4.6.25 Impact on landscape

- EC: This is the loss of recreational or aesthetic value and not only for rural environments, also there may be urban areas that may be affected (European Commission, 2014).
- NZ: The relationship between people and landscape can be explained as a reflection on their relationship (NZ Transport Agency, 2020b).

4.6.26 Urban landscape

- NZ: It is the constant changes in the urban environment, its form and character that generate an identity (NZ Transport Agency, 2020b).

Variable	EU	Methodology	US	Methodology	NZ	Methodology
Investment costs	✓	✓	✓	✓	✓	✓
Operation & Maintenance costs	✓	✓	✓	✓	✓	✓
Revenue projections	✓	✓	✓	X	✓	✓
Travel time	✓	✓	✓	✓	✓	✓
Vehicle operating costs	✓	✓	✓	✓		
Accidents	✓	✓	✓	✓	✓	✓
Noise	✓	✓	✓	X	✓	✓
Air pollution	✓	✓	✓	✓	✓	✓
Climate change	✓	✓	✓	✓	✓	✓
Benefits to existing and additional users			✓	✓	✓	✓
Loss of emergency services			✓	✓		
Modal diversion			✓	✓	✓	✓
Work zone impacts			✓	X		
Agglomeration economies			✓	X	✓	✓
State of good repair			✓	X		
Resilience			✓	X	✓	X
Quality of life			✓	X	✓	X
Increase in property value			✓	X	✓	✓
System reliability					✓	✓
Employment					✓	✓
Imperfect competition					✓	✓
Regional economic development					✓	X
Water pollution	✓	X			✓	X
Impact on Soil and biodiversity	✓	X			✓	X
Resource efficiency					✓	X
Access to opportunities					✓	X
Heritage and cultural values					✓	✓
Impact on the landscape	✓	X			✓	✓
Urban landscape					✓	✓

Table 3: Cost and Benefits in CBA Guidelines. Ref: Own elaboration with data from (European Commission, 2014; NZ Transport Agency, 2020a; USDOT, 2018)

5. CONCLUSIONS

During the evaluation of projects in the part of the economic analysis may be have difficulties in valuing variables (without market values) that can be easily identified. Despite the difficulties there has been significant progress in integrating them into the economic analysis process of the CBA, there are no methodologies for its analysis but given the importance of these variables to be considered in transportation infrastructure projects, future research still needs to be done in the area. Improvements in the CBA and its evaluation guidelines contribute to better informed decisions and investment, hence the importance to interpret these terms into more useful terms for decision makers.

Table 4 shows the costs and benefits of the guidelines reviewed. The EC, US and NZ columns represent the guidelines by country and the Methodology column represents the existence of guidelines to analyze the cost or benefit by country. In the European case, the costs and benefits have market values, or are easily converted, to avoid the calculation having multiple methodologies that may hinder the evaluation in the possible case of needing EC resources to finance the project. In the U.S. case, some costs and benefits without market value are mentioned, encouraging the evaluator to use their own method with caution and relying on projects carried out previously. The New Zealand case has a greater consideration of non-market value costs and benefits, which they intend to integrate in their CBA, encouraging the evaluator to develop their own method for the time being, but mentioning that a centralized methodology will be provided in future editions of the manuals.

The guidelines reviewed have a similar structure in the application of the CBA, so it can be said that are guidelines with a classic CBA core, differing in the types of costs and benefits taken into account. An important consideration is the update of the guides, NZ (2020) and US (2018), while the last update of the CBA Guide is from 2014 with the experience gained in the previous policies goals, it is expected that there will be a next update that studying at great length the impacts of difficult monetization, given the beginning of the new stage of the EC cohesion policies.

REFERENCES

ANNEMA, J. A., KOOPMANS, C., & VAN WEE, B. (2007). Evaluating transport infrastructure investments: The Dutch experience with a standardized approach. Transport Reviews, 27(2), 125–150.

BANISTER, D. (2011). Cities, mobility and climate change. Journal of Transport Geography, 19(6), 1538–1546.

BERECHMAN, J. (2009). The Evaluation of Transportation Investment Projects. In Advances in Management and Business Studies. Routledge.

BRISTOW, A. ., & NELLTHORP, J. (2000). Transport project appraisal in the European Union. Transport Policy, 7(1), 51–60.

BRONIEWICZ, E., & OGRODNIK, K. (2020). Multi-criteria analysis of transport infrastructure projects. Transportation Research Part D: Transport and Environment, 83(April), 102351.

DIMITRIOU, H. T., WARD, E. J., & DEAN, M. (2016). Presenting the case for the application of multi-criteria analysis to mega transport infrastructure project appraisal. Research in Transportation Economics, 58, 7–20.

ECA. (2018). Towards a successful transport sector in the EU: challenges to be addressed.

EUROPEAN COMMISSION. (2014). Guide to Cost-benefit Analysis of Investment Projects: Economic appraisal tool for Cohesion Policy 2014-2020. In Publications Office of the European Union (Issue December).

EUROPEAN COMMISSION. (2019). Handbook on the External Costs of Transport. In European Commission. https://www.cedelft.eu/en/publications/2311/handbook-on-the-external-costs-of-transport-version-2019

EUROPEAN PARLIAMENT. (2019). Research for TRAN Committee – EU funding of transport projects. July.

FEICK, R., & ROCHE, S. (2013). Understanding the value of Transport Infrastructure. International Transportation Forum Task Force Report 2013, 15–29.

JOHANSSON, E., WINSLOTT HISELIUS, L., KOGLIN, T., & WRETSTRAND, A. (2017). Evaluation of public transport: regional policies and planning practices in Sweden. Urban, Planning and Transport Research, 5(1), 59–77.

JONES, H., MOURA, F., & DOMINGOS, T. (2014). Transport Infrastructure Project Evaluation Using Cost-benefit Analysis. Procedia - Social and Behavioral Sciences, 111, 400–409.

KOGLIN, T., & RYE, T. (2014). The marginalisation of bicycling in Modernist urban transport planning. Journal of Transport and Health, 1(4), 214–222.

LAIRD, J. J., & VENABLES, A. J. (2017). Transport investment and economic performance: A framework for project appraisal. Transport Policy, 56(January), 1–11.

LOWE, C., STANLEY, J., & STANLEY, J. (2018). A broader perspective on social outcomes in transport. Research in Transportation Economics, 69, 482–488.

MACHARIS, C., & BERNARDINI, A. (2015). Reviewing the use of multi-criteria decision analysis for the evaluation of transport projects: Time for a multi-actor approach. Transport Policy, 37, 177–186.

MEUNIER, D., QUINET, A., & QUINET, E. (2014). Project Appraisal and Long Term Strategic Vision. Transportation Research Procedia, 1(1), 67–76.

NILSSON, M., JORDAN, A., TURNPENNY, J., HERTIN, J., NYKVIST, B., & RUSSEL, D. (2008). The use and non-use of policy appraisal tools in public policy making: An analysis of three European countries and the European Union. Policy Sciences, 41(4), 335–355.

NZ TRANSPORT AGENCY. (2015). Cost Estimation Manual.

NZ TRANSPORT AGENCY. (2020a). Land transport benefits framework and management approach guidelines.

NZ TRANSPORT AGENCY. (2020b). Non-monetised benefits manual (Issue July).

NZ TREASURY. (2015). Guide to Social Cost Benefit Analysis (Issue July). http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/guide/

ODGAARD, T., KELLY, C., & LAIRD, J. (2005). Current practice in project appraisal in Europe Analysis of country reports. In Developing Harmonised European Approaches for Transport Costing and Project Assessment (HEATCO) (Issue 2005). http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Developing+Harmonised+European+Approaches+for+Transport+Costing+and+Project+Assessment#0

OECD. (2019). GDP and spending - Investment by asset - OECD Data. https://data.oecd.org/gdp/investment-by-asset.htm#indicator-chart

USDOT. (2018). Benefit-Cost Analysis Guidance for Discretionary Grant Programs. June. https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2018_0.pdf

VICKERMAN, R. (2017). Beyond cost-benefit analysis: the search for a comprehensive evaluation of transport investment. Research in Transportation Economics, 63, 5–12.

VILLA, J. C., BOILE, M., & THEOFANIS, S. (2020). Trade and transportation evolution in the European Union. In International Trade and Transportation Infrastructure Development (pp. 149–180).

YOUNIS, F. (2014). Significance of Infrastructure Investment for Economic Growth. Munich Personal RePEc Archive, 72659, 1–35.