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Appraisal of cycling and pedestrian projects

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Abstract

Cycling and walking have gained a prominent role in the mobility policy agenda as awareness has risen over the growing unsustainability of the current transport system and the multiple co-benefits of active mobility. As interest and investments for cycling and walking increase, how active mobility can be appraised becomes a crucial question, which has been tackled over the years through different methods and tools. The aim of this chapter is to provide a structured review of the methods and the practices of appraisal of walking and cycling policies and projects, focusing on both traditional and emerging assessment techniques. At present, much attention has been paid to the application of four main traditional methods: Balance Sheet Calculations, Cost-Benefit Analysis, Cost-Effectiveness Analysis and Multi-Criteria Analysis. We compare and discuss these methods to identify strengths and weaknesses for each of them, as well as their main limitations and knowledge gaps in their application. We conclude that over the last decades much effort has been undertaken to further expand and

develop these tools thanks to an increased attention to walking and cycling. However, much research is still needed, particularly in the quantification and valuation of specific effects within Cost-Benefit Analysis and in better integrating different appraisal techniques. Finally, the impact of appraisals on decision-making outcomes is still underexplored.

Keywords: Walking, Cycling, Cost-Benefit Analysis, Appraisal, Evaluation, Multi-Criteria Analysis, Cost-effectiveness



1. Introduction

Over the last two decades, interest in the promotion of active mobility, namely walking and cycling, as alternative form of urban transport has grown consistently (Banister, 1990; Buehler and Dill, 2016; Buehler et al., 2017; Pucher and Buehler, 2008). On one hand, concerns have risen about externalities of the current (car-centric) transport system; on the other hand, a better understanding and awareness of the multiple co-benefits of active mobility in terms of health, efficiency and social inclusion is emerging (Banister, 2005; Gärling et al., 2014; Gössling et al., 2019; Mueller et al., 2015). Increased planning and financing activity has followed, targeting larger infrastructure projects such as bicycle and pedestrian networks, cycling highways, mass bicycle parking, diffused traffic calming measures and car-free areas, as well as the experimentation of behavioral interventions such as (non) monetary incentives such as bike-to-work or walk-to-school programs (Banister, 1990; Bertolini and le Clercq, 2003; Braun et al., 2016; Martens, 2007; Pucher and Buehler, 2012; Pucher et al., 2010).

More recently, the COVID-19 pandemic has urged public authorities in many countries to promote walking and cycling even more vigorously as a way to limit the spread of the virus, address physical inactivity and also prevent a mass shift from public transport to private car that would worsen existing traffic conditions (IEA, 2020; World Health Organization, 2020). For example, in 2020 alone the UK government approved a £2 billion package for active mobility and green transportation (UK Government, 2020), the Italian Ministry of Transport allocated over € 137 million for urban cycling infrastructure (Italian Government, 2020), and many other countries have taken similar initiatives.

These developments pose two main challenges:

- (1) A planning challenge: as investments and projects' size increase, questions arise on the feasibility, efficiency, and prioritization of measures (Aldred et al., 2019; Bloyce and White, 2018).

- (2) A political challenge: as changes in the functions of public space (e.g., the removal of car parking to add bicycle lanes) have historically been met with suspicion and sometimes public outcry, a need to build greater stakeholder support and acceptance using rational arguments emerges (see for instance: [Aldred et al., 2019](#); [Bloyce and White, 2018](#); [Oldenziel and Albert de la Bruhèze, 2011](#)).

Transport appraisal attempts to address these challenges by supporting decision-makers in forming a rational opinion about the strengths and weaknesses of alternative options ([Priemus and van Wee, 2013](#)). In many countries in Europe, the US and Australia, standardized frameworks exist to appraise “traditional” transport infrastructure projects, such as highways or railways lines, using methods such as Cost-Benefit Analysis (CBA) ([Geurs et al., 2009](#); [Mackie et al., 2014](#)). However, it is neither a common nor an institutionalized practice to appraise cycling and walking projects, as they usually entail lower costs and risks ([Van Wee and Börjesson, 2015](#)). This is especially the case for countries with low cycling and/or walking rates, but also in The Netherlands and Denmark—where active mobility is widespread—thorough evaluations are not regularly performed (*ibid.*). This can be self-defeating, as either too much or too little resources may be allocated, possibly preventing the realization of greater benefits ([Börjesson and Eliasson, 2012](#)).

Nevertheless, interest on how active mobility projects could be appraised is growing rapidly among governments, practitioners and academics, and multiple approaches are being explored. Recently, governments are starting to include walking and cycling in their own evaluation frameworks (see, for example, [UK Department for Transport, 2014](#)); countries such as Denmark, the Netherlands, Germany and Sweden have commissioned guidelines and studies to identify applicable unit costs for CBA to cycling and walking schemes within their own territories (see for instance [COWI and City of Copenhagen, 2008](#); [Decisio, 2012, 2017](#)). A number of transnational research projects have been funded that among others focus (or have focused) on walking and cycling projects and policies appraisal, such as the EU projects PASTA, FLOW, HANDSHAKE. International agencies have published tools (such as the HEAT tool from the World Health Organization) to support urban planners, professionals, and community leaders in performing economic assessment of the health effects of projects aiming to increase walking and cycling rates ([Deenihan and Caulfield, 2014](#)).

In this chapter, we examine how appraisal methods commonly used in the transport sector are applied to evaluate walking and cycling projects.

The main goal is to observe what strengths, weaknesses, and limitations these appraisal methods entail when applied to walking and cycling. For doing so, we first provide an overview of the main tools used to assess transport policies and projects. Secondly, we examine the literature and provide examples of where such techniques have been applied, together with a critical discussion of such application(s). Finally, we draw some concluding remarks and implications for further research and policies.



2. Transport appraisal methods and assessment criteria

2.1 Overview of appraisal methods for transport policies

Transportation networks provide multiple benefits in terms of accessibility to people, goods and services but they may also be the source of social, environmental and economic impacts. For this reason, decision-makers should, appraise how different policy options trade-off when planning new infrastructure. In a nutshell, project appraisal is the process of evaluating (i.e., attaching a value to) a policy or project outcome with the intent to assess its particular desirability condition (efficiency, effectiveness, etc.) before the implementation, in order to judge the strengths and weaknesses of a particular course of action using a common framework (Rossi et al., 2004). This should enable decision-makers to rank their preferences and deal with multiple stakeholder interests and perspectives over the same issue.

In the field of transport, scholars have proposed several techniques to appraise projects and policies (Bakker et al., 2010; Browne and Ryan, 2011; Grant-Muller et al., 2001; Mackie et al., 2014), with the most widely used being:

1. Balance Sheet Calculations.
2. Cost-Benefit Analysis.
3. Cost-Effectiveness Analysis.
4. Multi-Criteria Analysis.

BSC is typically the first step of any assessment upon which other methods are built, while CBA, CEA and (in most cases) BSC belong to “*Mono-Criterion*” assessment methods, as they consider a single and specific objective, MCA is “*Multi-Criteria*” as it attempts to deal with a plurality of objectives (Dean, 2020). The main characteristics of each method are summarized in Table 1, and a short description is provided, while we refer to the specific chapters for a more in-depth discussion.

Table 1 Appraisal methods and their characteristics.

Method	Observed indicators	When used	Decision criterion
Balance Sheet Calculations (BSC)	Multiple; Mainly financial	Mostly Ex-ante	No integral criterion
Cost-Benefit Analysis (CBA)	Socio-economic	Ex-ante and ex-post	Welfare expressed as sum of all Willingness-to-Pay (WTP)
Cost-Effectiveness Analysis (CEA) or Cost-Utility Analysis (CUA)	Economic	Ex-ante	Ratio of main effects to costs
Multi-Criteria Analysis (MCA)	Multiple	Ex-ante and ex-post	Weighted sum of effects

Inspired by [Bakker et al. \(2010\)](#).

2.1.1 Balance Sheet Calculation

The Balance Sheet Calculation (BSC) is the simplest among transport appraisal methods. It consists of the separate observation of a number of selected criteria and effects upon which decision-makers draw their own conclusions (typically the intervention costs, supplied by extra information about specific effects, such as traffic impacts) ([Bakker et al., 2010](#)). Balance sheets—particularly the cost-analysis, business cases and technical-financial feasibility studies—represent the basic input to other assessment methodologies discussed in this chapter. In general, this approach has the benefit of being quick and cheap, but the assessment of the broader consequences is often limited to the decision-makers' intuition.

2.1.2 Cost-Benefit Analysis

Cost-Benefit Analysis (CBA, or Social Cost-Benefit Analysis for completeness) stands out traditionally as the most common appraisal method for large transport infrastructure projects (see [Boardman and Pearson Education, 2014](#)). CBA is grounded in welfare economic theory and it measures changes in society's welfare (expressed as the aggregation of all individual utilities or willingness-to-pay) resulting from the implementation of a specific project or policy ([Boadway and Bruce, 1984](#)). The analysis' object is said to be “*desirable*” or “*socially efficient*” if it satisfies the Kaldor-Hicks criterion, namely if the sum of gains outweighs the sum of losses and therefore

losers are theoretically compensated by winners (Hicks, 1939; Kaldor, 1939). Hence, in performing a CBA, all the quantifiable effects (direct and indirect) revolving around a policy or a project are listed and monetized (as costs and benefits) during a specific timeframe (usually the project lifespan). These monetized effects, and the associated investment costs, are then discounted to the present value of money (or net present value, NPV) and results are typically expressed as a benefit–cost ratio, which is the means to verify if the Kaldor–Hicks criterion is met (Boadway, 2006). A CBA may be used to compare either an intervention scenario with a do-nothing (or do–minimum) scenario or different courses of action. CBA may also be performed ex–post in order to verify the accuracy of the initial predictions and/or to monitor the effects and promote policy learning (i.e., Eliasson et al., 2015).

In the field of transport, the quantification of the effects often relies on transport models, which provide the necessary inputs for a CBA (such as changes in travel times, emissions, etc.) (Priemus and van Wee, 2013).

2.1.3 Cost-Effectiveness Analysis

Cost-Effectiveness Analysis (CEA), also known as Cost-Utility Analysis (CUA) in health economics (Robinson, 1993), is a form of Cost-Benefit Analysis that focuses on a single, non-monetized effect or outcome which is compared to the costs of different courses of action (Browne and Ryan, 2011). In this way, decision-makers are informed about which measure ensures that a goal will be reached at the minimum cost. CBA and CEA follow similar research techniques and principles; the latter, however, is limited to a narrowly defined goal.

In the field of transport and environmental policy, CEA is used especially for the so called “*optioneering*,” i.e., the comparison of multiple options with a specific set of outputs in order to rank priorities by cost-effectiveness (Bakker et al., 2010). A typical example of CEA application in transport is the ranking of projects by cost per unit of emission reduced (see Kampman et al., 2006, for example).

2.1.4 Multi-Criteria Analysis

Multi-Criteria Analysis (MCA) allows to select alternative projects by considering multiple weighted monetary and non-monetary criteria (Bakker et al., 2010; Beinart, 2001; Browne and Ryan, 2011). The weighing of criteria can be performed in a participatory setting to include expert and stakeholders’ opinions in order to balance trade-offs among different goals

and needs advocated by different actors (Dean, 2020). Several approaches to MCA exist, ranging from formal (continuous and discrete) to simplified methods, the most common being: Analytical Hierarchy Process (AHP), Analytical Network Process (ANP) and REGIME, ELECTRE (etc.) (see Dean, 2018 for a classification of methods). Each method presents unique features as well as advantages and disadvantages (ibid.). The process to draft a MCA follows in general five main steps: (1) The project and its alternative(s) are defined; (2) the judgment criteria, weighing and ranking method are determined; (3) the impacts of the project and its alternatives are analyzed; (4) the impacts are categorized in as list of criteria that are weighted; (5) the judgments may be aggregated into a single criteria depending on the chosen approach (ibid.). In the field of transport appraisal, MCA is the most common alternative to Cost-Benefit Analysis as it allows to consider effects that are typically difficult to quantify and monetize (such as social inclusion, aesthetics, image, equity, etc.) (Browne and Ryan, 2011).

2.2 Literature search and method

A significant body of literature has analyzed appraisal methods for active mobility in the past. As the aim of this paper is to focus on strengths and weaknesses of the different methods, we selected relevant papers to illustrate the application of appraisal tools and focused on the methodology and process of construction of the appraisal technique more than on the results of each application to the context of cycling and walking. In this perspective, the results of the evaluations are of less interest than the applicability of the proposed methods. Therefore, the selection has discarded papers which did not offer new insights on the choice of appraisal method or discussed its applicability and limitations; the initial selection has built upon previous systematic reviews (mainly Brown et al., 2016; Cavill et al., 2008; Mueller et al., 2015) that have addressed appraisal methods and similar research questions in the past. In addition, such sources were integrated and corroborated by:

- (a) Performing a new database search on both Google Scholar and Elsevier in order to fill the 2016–2020 temporal gap.
- (b) Adding missing papers through the snowball method and expert suggestions.
- (c) Integrating academic publications with gray literature and publicly available professional reports for a more comprehensive perspective.

Table 2 Selection criteria used.

Assessment method	Criteria
BS	There is, at least, a financial overview of the costs of a measure
CBA	The expected benefits of an intervention are measured in monetary terms and compared to the costs of the intervention. Results are reported as cost per unit of benefits
CEA/CUA	The expected outcomes (health, traffic reductions, etc.) of an intervention are measured against the costs and expressed in terms of cost per adverted/gained outcome
MCA	Several (weighted) indicators is used to determine the relative importance/priority of measures

- (d) Interviewing active mobility experts from several municipalities within the project CIVITAS Handshake in order to have a more comprehensive understanding of how decisions are formed within municipalities and obtain relevant examples.

The inclusion criteria that were adopted for selecting papers about each method are summarized in [Table 2](#).



3. Applications

3.1 Balance Sheet Calculations

Despite being the most common way in which public authorities perform appraisals on walking and cycling projects, the academic debate on BSC is surprisingly scarce. In part, this might be due to the fact that BSC usually represents only the first phase of a more thorough appraisal. Much of the publicly available knowledge is gray literature in the form of technical-financial feasibility studies (see for instance [Centraal Utrecht 2030, 2012](#); [St. Luis \(City Government\), 2014](#); [Opus Consultants, 2016](#)). Study designs also vary depending on the laws and standards applied in each country, as well as the context-specific needs. In general, the content of such studies can be narrowed down to three main components:

1. A general description of the intervention site.
2. A preliminary technical design and cost estimate of the proposed solution, and its alternative(s).

3. Occasionally, the previous steps are supplemented by qualitative judgments on strengths and weaknesses, sensitivity analyses, traffic impact studies, environmental assessments, etc.

Typical examples of “*Balance Sheet Calculations*” are the financial analyses performed on bicycle sharing projects and large bicycle parking facilities to verify costs and revenues of their operation in order to determine adequate budgeting.

For instance, in 2012 the Municipality of Utrecht, Dutch Railways, and ProRail (the owner of the railway lines) performed a business cases and scenario analyses when redesigning Utrecht’s train station; such redesign included the construction of several large bicycle parking facilities. The BSC was necessary to estimate the financial impacts of different daily/monthly tariffs under several assumptions (daily users, parking duration, quality of service) in order to quantify the costs and revenues and determine a possible management agreement (Centraal Utrecht 2030, 2012). The resulting costs for the different scenarios are summarized in Table 3.

This type of analysis considers mainly financial effects. In the reported example, the construction, maintenance, enforcement, exploitation costs, incidental costs etc., were included, while revenues consisted of tariffs, taxes, sales etc. Sensitivity analyses were included in order to allow decision-makers to understand the order of magnitude of the financial implications.

Bicycle share programs are another example that is typically evaluated using BS studies (St. Luis (City Government), 2014). These studies start by analyzing the potential demand in the area to identify adequate locations of bicycle docking stations; next, the costs of the program for a variable number of years are estimated as well as the revenues of multiple financial plans using scenarios. In most cases, since the demand for such infrastructure projects is complex to determine, significant hypotheses must be introduced and then tested through sensitivity analyses on key parameters (such as duration, trip frequency and modal shift) (ibid.).

Through BSC the broader social, economic, and environmental effects are not systematically captured, thus leaving the judgment about the merits and flaws of the proposal to intuitive assessments.

3.2 Cost-Benefit Analysis

CBA is currently among the assessment techniques that have received the most attention from both practice and academia over the last two decades (Van Wee and Börjesson, 2015). A “*typical*” CBA study applied to walking

Table 3 Balance sheet results example.

Exploitation results (x1.000)	Scenario 1: All free		Scenario 2: All paid		Scenario 3: Different pricing		Scenario 4: Different quality	
	Min	Max	Min	Max	Min	Max	Min	Max
2014	-€ 1.300	-€ 1.600	-€ 900	-€ 1.100	-€ 1.400	-€ 1.700	-€ 900	-€ 1.100
2016	-€ 3.500	-€ 4.300	-€ 1.800	-€ 2.200	-€ 3.700	-€ 4.600	-€ 2.000	-€ 2.500
2021	-€ 5.200	-€ 6.400	-€ 2.200	-€ 2.700	-€ 5.600	-€ 6.800	-€ 2.600	-€ 3.200
2031	-€ 6.400	-€ 7.800	-€ 2.600	-€ 3.200	-€ 6.800	-€ 8.300	-€ 3.100	-€ 3.800

Centraal Utrecht 2030 (2012).

and cycling does not substantially differ from its counterpart applied to other modes, as it consists of:

1. A general description of the intervention site.
2. An analysis of the reference scenario (which usually accounts for a “do-nothing” or “do-minimum” policy intervention) to be used as benchmark.
3. A description of the intervention scenario (including costs and risks), alternatives, and a causal model to quantify the effects.
4. A monetarization of the expected effects that revolve around a project’s lifetime, and a comparison to the costs at the NPV.
5. A (optional) sensitivity analyses to test the effect of some key parameters to the end result.

In contrast to BSC, which is limited to an analysis of financial cash flows only, a CBA provides a more comprehensive picture of all the welfare effects revolving around a measure which would otherwise be underexposed.

An example of CBA that included walking and cycling among other modes is the study performed by the City of Amsterdam in 2016 to appraise different solutions to improve the connection between the City Centre and the expanding neighborhood of Amsterdam-Noord across the river IJ (Hoefsloot et al., 2016). The explored solutions included the improvement of the current ferry system, the construction of a pedestrian and bicycle bridge (including different design variants), the construction of a tunnel under the river IJ, the construction of a metro station and pedestrian tunnel, and several “packages” of different measures. In total, 14 (combinations of) measures were tested in two development scenarios (high and low growth scenario) using Amsterdam’s transport model. Table 4 is an excerpt that illustrates some of the results.

In the scientific literature, Elvik (2000) was among the first scholars to critically discuss the application of CBA on measures designed to improve safety or mobility for pedestrians and cyclists. In doing so, he applied the best available knowledge of the time to a hypothetical case in order to identify a research agenda. What he found is still relevant nowadays and concerns four main aspects:

- (a) how to determine changes in the amount of walking and cycling;
- (b) how to value changes in travel time for pedestrians and cyclists;
- (c) how to measure changes in road user insecurity and feeling of safety;
- (d) how to determine and value changes in the health state.

His analysis indicated that the inclusion of these effects could make a major difference in the results of CBA. Later, Sælensminde (2004) published one of

Table 4 CBA results example.

NPV results (in Mln €)	Alternative 1a: Optimization of the ferry system		Alternative 2a: IJ-plein tunnel		Alternative 3a: Java tunnel		Alternative 3b: Java bridge (9.7 m)		Alternative 6c: Pedestrian tunnel + Optimization of ferry system		Others
	Low	High	Low	High	Low	High	Low	High	Low	High	
Financial effects	-€78.7	-€106.4	-€264.6	-€241.8	-€240	-€216.8	-€290	-267.5€	€270	-266.6€	...
Accessibility effects	+€79.6	+€347.1	+€154.2	+€674.9	+€154.7	+€473.4	+€199.8	+625.3€	+€128.8	+510.8€	...
External effects	+€12.6	-€1.3	+€15.4	+€101.5	+€9.4	+€36.1	+€25.1	+91.5€	-€3.9	+44.1€	...
Indirect effects	+€4.3	+€50.1	+€15.5	+€68	+€17.4	+€58.2	+€18.4	+66.9€	+€18	+58.9€	...
Total	+€17.8	+€289.5	-€79.5	+€603.2	-€58.5	+€350.8	-€47.3	+516.1€	-€127.4	+347.2€	...
Benefit-cost ratio	1.2	3.7	0.7	3.5	0.8	2.6	0.8	2.9	0.5	2.3	...

Hoefloot et al. (2016)—Reworked by authors (simplified to improve readability).

the first “complete” CBA study on walking and cycle tracks in three Norwegian cities. The study included for the first time (a) the health benefits associated with increased active mobility rates, (b) reduced external costs from motorized traffic and (c) reduced parking costs. As hypothesized by Elvik (2000), the inclusion of these social effects meant that the benefits of investment in active travel networks could be as high as 4–5 times the costs. However, the study also acknowledged that improvements in the valuation of some effects as well as more information on the relationship between physical activity and the incidence and costs of different diseases were needed in order to make more accurate estimates. Finally, the traffic accidents effects of a modal shift from car and public transport to cycling were deemed unclear (*ibid.*).

Multiple studies have since been published that have further explored the application of CBA to walking and cycling infrastructure in different contexts and attempted to address various knowledge gaps. Three systematic reviews of the literature have been published between 2008 and 2016 (see Brown et al., 2016; Cavill et al., 2008; Mueller et al., 2015). In general, most studies have found that investing in cycling and walking usually carries a positive effect on society because of lower road externalities, particularly when the shift occurs from car travels (*ibid.*). When losses occur, these are usually due to the missed collection of car and fuel taxes or when a policy fails to generate enough demand for a project (Gössling et al., 2019; Litman, 2020).

The effects with the most significant impact are the reduced health-related costs and travel time gains (especially due to decongestion). Hence, the results of CBAs have been used to harness support among stakeholders by showing that promoting more walking and cycling would create a win-win situation and deconstruct policy frames that marginalize cycling and walking as recreational activities (Aldred, 2015; Bloyce and White, 2018). However, it is unclear from the literature how these results affect the outcomes of decision-making processes.

Over the years, a relevant body of research has attempted to fill the knowledge gaps about the estimation and valuation of specific effects of active mobility and other consequences of changes in travel habits. Notably, Hopkinson and Wardman (1996), Wardman et al. (2007), Ramjerdi et al. (2010) and Börjesson and Eliasson (2012) have focused on estimating the value of travel time reductions and improvements in perceived safety for different types of roadway improvements, finding that cyclists have higher value of times than other mode users due to the physical

effort involved. Studies in the health and epidemiology domain have found positive effects of walking and cycling in reducing all-cause mortality (Kelly et al., 2014), lowering absenteeism (de Hartog et al., 2010), improving fitness and productivity levels (Etemadi et al., 2016; Walker et al., 2017; Wattles et al., 2003), and reducing the cost of several illnesses (Kahlmeier et al., 2017).

A push to the development and use of CBA for walking and cycling projects has indeed come from the health sector. Notably, the WHO made an important contribution by publishing the Health Economic Assessment Tool (HEAT) for walking and cycling (Kahlmeier et al., 2017; World Health Organization, 2014) which is grounded in some of the studies cited before (Kelly et al., 2014 in particular). This planning-support tool, based on CBA principles, aids planners and advocates in estimating the value of reduced mortality and other externalities that results from a shift to regular walking and cycling and compare the monetized effects with the costs of a measure. Despite the limitation arising from its “simplified” dashboard-like functioning, the HEAT tool has contributed to increasing the popularity in both academia and practice of health-economic assessments. For instance, Fishman et al. (2015) used HEAT to quantify the population-level health benefits of cycling in the Netherlands, finding that over 6500 deaths are prevented each year and Dutch people have half-a-year-longer life expectancy thanks to high cycling levels with respect to a non-cycling base. Maizlish et al. (2013), Deenihan and Caulfield (2014), Götschi et al. (2015), Sá et al. (2015), de Sá et al. (2017) and Rodrigues et al. (2019) have all performed similar studies using HEAT or HEAT-like approaches.

CBA has also seen applications to assess non-infrastructure projects such as mandatory helmet laws (Sieg, 2014; Taylor and Scuffham, 2002), programs that encourage active travel habits (Beale et al., 2012), changes to the built environment (Guo and Gandavarapu, 2010), bicycle share programs (Bullock et al., 2017) as well as integrated active travel policies (Chapman et al., 2018). Moreover, CBA has been used to appraise measures at different levels: from site-specific interventions—such as bicycle and pedestrian trails and bridges (Hoefsloot et al., 2016; Li and Faghri, 2014)—to changes at the network level (Beria and Rafaele, 2014; Brey et al., 2017; Gotschi, 2011). CBA is generally applied in ex-ante, while ex-post CBAs of active mobility projects are limited in the literature (one example is Chapman et al., 2018). Moreover, studies that have compared ex-ante with ex-post CBA to validate the results of previous appraisals are not present in the literature.

CBA frameworks have also been used to compare the different societal costs imposed by different transport modes (including walking and cycling) on society in order to advocate in favor of more sustainable transport but also in order to include a wider array of effects in evaluations. For instance, [Gössling and Choi \(2015\)](#) found that in Copenhagen the societal costs borne to society from each km traveled by car is more than six times higher than the same km traveled by bike, if all effects are included (especially health). Similarly, [Gössling et al. \(2019\)](#) estimated that the total passenger-kilometer driven by car in the European Union impose an external cost of more than € 500 billion per year, while cycling and walking kilometers, due to positive health effects, are worth € 24 billion and € 66 billion per year respectively.

A major point when it comes to CBA is the demand forecasting of future infrastructure projects. In the literature, multiple approaches have been proposed, ranging from simple assumptions to more complex approaches depending on the tackled research question, as well as the level of detail and data available. The approach employed by [Sælensminde \(2004\)](#) and [Gotschi \(2011\)](#) is most commonly adopted: present volumes of pedestrian and bicycle traffic are estimated using average statistical figures, sometimes supplemented by traffic counting and surveys, whereas future induced volumes are estimated using assumptions accompanied by sensitivity analyses to account for uncertainty (*ibid.*). More complex approaches involve the use of potential analysis scans to identify short car trips ([Lovell et al., 2017](#)), system dynamic modeling techniques that capture positive and negative feedback loops ([Macmillan et al., 2014](#)) and traditional multi-modal traffic simulation models to better capture changes in consumers' surplus (as in the case of [Beria and Rafele, 2014](#); [Hoefsloot et al., 2016](#)).

3.3 Cost-Effectiveness Analysis

CEA is another common assessment method for appraising walking and cycling measures, more so in the field of health economics than transport economics ([Abu-Omar et al., 2017](#)). That is the case because the promotion of safe walking and cycling is seen by many health authorities—such as the WHO—as a prevention policy to tackle the risks associated to physical inactivity ([World Health Organization, 2020](#)). In fact, multiple studies over the years have tested the effectiveness of different programs (including the promotion of active mobility) aiming at reducing physical inactivity against their cost (some systematic reviews have been conducted by [Campbell et al., 2015](#); [Garret et al., 2011](#); [Mueller-Riemenschneider et al., 2009](#)).

For example, Wang et al. (2004) performed a CEA of bicycle and pedestrian trails to illustrate how cost-effectiveness changed depending on the activity levels of the population. Cobiac et al. (2009) performed a CEA to measure the health outcomes against the costs of six different physical activity interventions compared to identify the most cost-effective option (the comparison included travel smart programs that rewarded travelers for reducing car trips and choosing to walk and cycle).

In the majority of studies produced in the field of health economics, the cost-effectiveness is expressed in terms of a ratio of gained health (usually expressed as Quality-Adjusted Life Years or QALY) or averted DALYs (Disability-Adjusted Life Years) to the costs required to achieve a unit of result. In the field of transport economics, CEA considers also other traffic-related effects, namely road crashes costs, pollution, congested hours as goal criterion.

For example, Hatziandreu et al. (1995) applied CEA to three different approaches (law enforcement, community-based and school education) aiming at promoting the use of bicycle helmets among pupils. Their study used pre-post data and compared the costs of the program with the effect in terms of bicycle-related head injury and deaths. Other studies, such as Peters and Anderson (2012), Wijnen et al. (2013) and Jiao et al. (2019), applied CEA to measure the efficacy of traffic calming aiming at reducing accidents costs. Others such as Gunn et al. (2014) have focused on the effects of sidewalks to increase levels of transport walking and related health effects, while Gu et al. (2016) analyzed the cost-effectiveness of bicycle lanes as means to both improve health of the general population and reduce crashes.

CEA is also often used as an instrument to prioritize program investments. In the field of cycling, a simple example is the study conducted by the City of San Donato Milanese (Italy) (Ruffino and Jarre, 2019) in which the investment priority in cycle routes was sorted by means of a CEA using an accessibility index as effectiveness criterion. The goal of the administration was in fact to provide a transport option alternative to the car to the largest number of residents, commuters, school pupils etc., at the lowest price. The study therefore followed these steps:

1. The investment costs for each bicycle route was determined.
2. An accessibility index of each cycle route was defined that fitted the administration goals.
3. A ratio between the km-costs and the index was performed in order to determine the Cost-Effectiveness.
4. The cycle routes were sorted by least cost in order to determine the intervention with the highest effectiveness at the lower costs.

Table 5 illustrates the results.

Table 5 CEA results example.

Cycleroutes	Investment cost per km	Accessibility index	Cost-effectiveness
Cycle route number 3	€ 196	63	€ 3.1
Cycle route number 5	€ 5.772	59	€ 98.5
Cycle route number 1	€ 21.063	135	€ 156
Cycle route number 4	€ 9.707	57	€ 171.8
Cycle route number 6	€ 19.523	93	€ 209.8
Cycle route number 2	€ 20.560	87	€ 237.5
Cycle route number 8	€ 22.435	28	€ 788.3
Cycle route number 9	€ 50.879	48	€ 1.067.8
Cycle route number 7	€ 95.394	31	€ 3.094.6

Ruffino and Jarre (2019)—Reworked by authors.

This approach clearly shows, once the objective is clear, what measures should be prioritized according to the analysis.

Similar studies have been performed in other contexts using more complex methods. For instance, to determine investment priorities in bicycle highways in the Haaglanden (conurbation surrounding The Hague in the Netherlands), a transportation model was used to calculate the cost-effectiveness of bicycle highways in terms of reduced short car trips and congested hours as effectiveness criterion (Decisio, 2016).

CEA has been applied both in ex-ante and ex-post studies using different methods: ex-post studies have mainly used direct pre-post measurements and/or (interrupted) time series, sometimes complemented by surveys (self-report, etc.); on the other hand, ex-ante studies relied mostly on scenarios, using a variety of statistical techniques (ranging from simple trend analysis to regression analyses and Markov models) and applying sensitivity analysis to assess the robustness of the obtained results. For instance, Moodie et al. (2011) measured the cost-effectiveness of school programs to increase active mobility among pupils aged 10–11 by sharing of a small pilot survey and then extrapolated the results to the entire pupil population of Australia. Dallat et al. (2013) used a quasi-experimental before-and-after household survey and different scenarios to measure the cost-effectiveness of urban greenways in improving physical activity levels. Gu et al. (2016) used regression analysis to calculate the effect of marginal improvements of bicycle lanes in NYC in terms of ridership in order to assess the related health effects.

Yu et al. (2018) used stochastic Markov models to measure in ex-ante the cost-effectiveness of expanding the NYC bicycle share program to other parts of the city.

3.4 Multi-Criteria Analysis

Conventional reductionist approaches have been criticized for leading to sub-optimal decisions due to the inherent complexity of sustainability dilemmas, such as transport policies (Browne and Ryan, 2011; Gasparatos et al., 2008; Omann, 2000). In this perspective, MCA is increasingly being proposed as a viable alternative also in the field of walking and cycling appraisal (Glavic et al., 2019; Gris  and El-Geneidy, 2018) since:

- There is a need to include and deal with effects that are typically difficult to quantify and monetize yet relevant for planning walking and cycling infrastructure (such as comfort, aesthetic quality etc.) as well as addressing equity questions.
- Secondly, there is a need to incorporate opportunities and risks related to the type of infrastructure measure proposed.
- Finally, stakeholders' views and equity issues can be better represented by assigning weights.

In particular, MCA integrated with GIS (also defined as MCDM-GIS) is becoming increasingly popular to appraise walking and cycling projects (Larsen et al., 2013; Rybarczyk and Wu, 2010). For example, Larsen et al. (2013) and Rybarczyk and Wu (2010) were among the first scholars to propose MCA and GIS to identify and prioritize investments by integrating both supply- and demand-analysis criteria for cycling planning. Later, Milakis et al. (2012) and Milakis and Athanasopoulos (2014) expanded on this approach including inputs from cyclists in a participatory setting to plan Athens' metropolitan cycle network. Guerreiro et al. (2018) applied MCA, GIS and data mining techniques to plan and compare the investments in a cycling network. Canu et al. (2018) proposed spatial MCA for the assessment of walkability of intersections and the prioritization of pedestrian-oriented policies. Kent and Karner (2018) explored the application of GIS-MCA to prioritize low-stress and pleasant bicycle routes. Besides traditional infrastructures, spatial MCA has been widely applied to bicycle share systems analyses (Crocchi and Rossi, 2014; Kabak et al., 2018; Milakis and Athanasopoulos, 2014; Moshref Javadi et al., 2013). However, to the best of our knowledge, no study has compared competing investments in walking or cycling with investments in other modes of transport using MCA.

In most cases, MCA has been applied as an ex-ante appraisal method to either assess planned walking and cycling projects (such as Glavic et al., 2019) or to prioritize investments (Guerreiro et al., 2018; Kabak et al., 2018). Although possible, no study has been performed ex-post, hence no reported experiences of the effects and/or the usefulness of the method at a later stage are available.

There is currently no standard framework for MCA, which is tailored to address each specific case. Criteria included in walking and cycling MCA range depending on the planning scale, the method used, the available data and the study design. Usually, at a strategic level (such as in Grisé and El-geneidy, 2018; Milakis et al., 2012) network characteristics, mobility demand patterns, socio-economic features, proximity to destinations, characteristic of the landscape and built environment are observed. At a tactical-operational level (such as in Canu et al., 2018), more detailed criteria related to the specific context as well as technical aspects are included. Some studies have also explicitly included equity criteria in their own analysis (examples are Grisé and El-geneidy, 2018; Kent and Karner, 2018).



4. Strengths and weaknesses of appraisal methods for walking and cycling

In this paragraph we present and compare the main strengths, weaknesses and limitations of the four methods for appraising walking and cycling projects. Table 6 provides a summary.

4.1 Balance Sheet Calculation

The main advantage of this type of analyses is that it provides a clear summary of the direct financial effects from a specific project and the range of variation across different scenarios and assumptions. This is particularly useful for budgeting and ensuring long-term financial sustainability of a project.

However, the social effects are often neglected as they are less relevant for the research objective or too complex to be accounted. Even when positive/negative “social” impacts of the project are considered, these are either qualitative ones (e.g., “bikers will feel safer”) or, when quantitative, they are expressed as non-comparable unit of measurements (e.g., “pollution will go down 10% in the area”). Based on investment costs and impacts (if any), relevant actors decide based on their own judgment, i.e., they introduce their own weights on the importance of impacts for specific stakeholders and value them against the projected costs (Bakker et al., 2010).

Table 6 Comparison of different appraisal methods for walking and cycling.

	BS	CBA	CEA	MCA
	Specific for walking and cycling			
Application	Predominantly on infrastructure projects, bike sharing programs and some behavioral measures	Predominantly on infrastructure projects, bike sharing programs and some behavioral measures	Predominantly on policies aiming at improving physical activity levels	Predominantly infrastructure projects
When used	Ex-ante	Ex-ante	Ex-ante and some ex-post in the field of medicine	Ex-ante
Trend in use	Always performed	Increasingly used but far less than for other transportation projects	Widely used in the field of medicine, less in the field of transport	Increasingly used in combination with GIS as alternative to CBA due to lack of data
Indicator	Financial balance (mainly)	Benefit–cost ratio	Cost–effect ratio	Decision ranking
Positive impacts considered	Cash flow	Predominantly health, travel time savings and reduced car externalities	Predominantly health	Potentially all benefits could be included
Stakeholder participation	Possible but not required and not documented in the literature	Possible but not required and not documented in the literature	Possible but not required and not documented in the literature	Institutionalized in the process and in some cases performed

Impact on decision-making	Unknown	Unknown	Unknown	Increased legitimacy of the planning process
Ease of communication	May be difficult to interpret and explain	Simple	Simple	May be difficult to interpret and explain
Transparency	Transparent calculation but subjective decision criterion	Not clear, many assumptions are made behind results	Not clear, many assumptions are made behind results	Clearer but subjectivity in weights
Ease of use	Easiest as only direct financial aspects are considered	Difficult to monetize impact and forecasting walking and cycling demand presents greater challenges	Relatively easier but challenges in predicting the effectiveness if they entail behavior change	Easier to tailor to a specific need and in the case of absence of data
Others	Welfare effects not accounted	May never be able to quantify properly all impacts correctly	May never be able to quantify properly all impacts correctly	It may lead to lengthy discussions

Many walking and, especially, cycling projects are often evaluated only through a Balance Sheet Calculation; this mainly happens because such method is the quickest and cheapest of all, as it can require, at its minimum, no further analysis besides the financial and technical feasibility studies that are required by the law, and the “*appraisal*” of the project is done through pure judgment by the decision-maker(s). This allows for ample discretion on his/her side, which of course is an advantage or a disadvantage depending on one’s position.

Even when impacts are considered, the weighing phase introduces a high degree of subjectivity, not only on which impacts are considered relevant but also by which stakeholder(s). In fact, these simple and straightforward tools are also the most limited in scope and objectivity: first, as effects are analyzed separately it is not possible to provide a comprehensive comparability of different options. Moreover, the subjectivity of the decision-making might accelerate the process only if interests among stakeholders are aligned, which is seldom the case in public policies and even more so for transport projects: when differences of interests emerge, and no clear power structure that can impose a decision exists, the Balance Sheet Calculation method does not contribute in reaching a shared decision, and the process can be slowed down or altogether stopped.

Hence, in a situation in which budget is limited, the costs are high, the potential number of alternatives increases and/or several stakeholders are involved, the Balance Sheet Calculation approach is usually integrated with other methods such as Cost-Benefit Analysis and/or Multi-Criteria Analysis.

4.2 Cost-Benefit Analysis

CBA applied to walking and cycling present similar methodological strengths and weaknesses already discussed by the literature on general transport CBA. Namely, CBA enables the comparison between costs and benefits of policies and programs targeting different travel modes, which can be a straightforward and convincing way to present arguments of economic efficiency as it has an allure of scientific soundness (Browne and Ryan, 2011). Currently, most of the cases in literature use CBA for this purpose, for example, in Gössling and Choi (2015) and Gössling et al. (2019).

Moreover, CBA may have potential applications to rank program priorities and projects selection for financing, especially when used at the early stages of the decision-making process (Eliasson et al., 2015; Mackie et al., 2014).

Another potential application currently not investigated is the use of CBA in policies aiming at internalizing externalities of walking and cycling (i.e., quantify the value of km reimbursement for bike-to-work schemes).

Finally, CBA may prove to be valuable to structure a debate and improve learning, communication and trust among stakeholders when used in a participatory setting (Beukers et al., 2014), although in this case too the literature lacks concrete examples for walking and cycling.

Despite the growing literature on the social and economic effects of walking and cycling, there are substantive limitations to the quantifications and valuation of these effects. Van Wee and Börjesson (2015) and Decisio (2017) have discussed these in detail.

A major weakness of CBA is that it is extremely “data hungry”; this is particularly evident when it comes to estimating current and future demand for the infrastructure. Demand forecast is a crucial first step also for other assessment methods such as CEA. How many cyclists or pedestrians will use the infrastructure once opened? How will the urban traffic change as a result of the pedestrianization of a specific street? What will be the revenues of a bicycle parking at station? These are questions that are impossible to answer without a model. Hence, the quality of a CBA highly depends on the type of model used as well as the quality of the input data. The integration of walking and cycling into traditional transport simulation models is a “*recent and complicated affair*” (see for a detailed discussion Barnes and Krizek, 2005; Buehler and Dill, 2016; Hollander, 2016; Porter et al., 1999; Turner et al., 1997).

In synthesis, current difficulties with cycling and/or walking modeling include the following.

- There are many gaps in our understanding of what factors play a role in motivating people to choose to walk and cycling instead of driving and building cycle paths alone does not necessarily explain bicycle use on their own. Therefore, a simple correlation between infrastructure quantity and cycling/walking rates is unlikely to be robust.
- Cycling is much more affected by the interaction with other traffic modes, the environment, seasonality, weather conditions and other factors than car traffic. These factors are typically difficult to include in a model.
- Bicycle use and behavioral change according to trip purpose, age groups and the level of some benefits depend on the physical activity levels of the targeted population which is often unknown in an origin–destination matrix.

- For walking in particular it is difficult to determine what counts as a walking trip and distinguish by motive.
- Another issue is related to the zoning of the model which needs to be more refined as walking and cycling trips take place usually at short distances meaning that calculations become more cumbersome and data less reliable.
- Network coding is usually a difficult and lengthy process and the quality of information is not always readily available and requires many more assumptions.
- With walking and cycling infrastructure “the devil is in the detail.” Some slight design choices and infrastructure characteristics (type of pavement, etc.) may have a greater impact on route choice and behavior than on typical road infrastructure.
- Finally, it is also currently difficult to predict the added value of marginal improvements in cycling infrastructure especially in countries in which these type of infrastructure projects might be common such as in the Netherlands and Denmark.

Even though nowadays models have become far better at predicting and estimating the effects of policies and road adjustments to walking and bicycle traffic, in practice these models are not always available, and it is simply impossible to gain a satisfactory level of data coverage. Hence, several academics and practitioners recur to other means to predict induced traffic such as potential analysis tools which observe short car trips to enable the testing of modal shift scenarios (one example is the Propensity to Cycle Tool developed in the UK, see [Lovelace et al., 2017](#)). Although the uncertainty of these methods is high, the use of models is not necessarily a guarantee of improved accuracy considering that interventions happen in a non-closed system ([Næss and Strand, 2012](#)).

Another prominent issue is related to the quantification and valuation of specific effects. In particular:

- Limited research is available about specific travel time valuation (VoT) of pedestrian and cyclists. Related aspects such as the valuation of reliability, waiting time and search time (i.e., when parking a bicycle) have not been investigated either. Moreover, VOT of different target groups and travel motives (utilitarian vs recreational) could be significantly diverging. Moreover, there is limited literature and research on comfort evaluation, travel experience and perception of safety mainly because of the challenge in defining, measuring and attaching a monetary value to this concept ([Van Ginkel, 2014](#)). However, it is likely that comfort, along with

perception of safety, are important factors in motivating people to travel by bicycle or on foot (Handy et al., 2014).

- Although the literature generally suggests that increasing the level of physical activity has positive health consequences (Kelly et al., 2014). Including these effects into CBAs presents several uncertainties. The extent to which people actually become “healthier” is strongly related to the individual herself and his/her lifestyles (Haskell et al., 2007; Pate, 1995): inactive people who start cycling, for example, may have greater health effects than already-active people. Moreover, it is important to assess which means of transport is substituted (car, public transport, e-bike, etc.). The extent to which health effects are internalized is also uncertain. Börjesson and Eliasson (2012) pointed out that most cyclists accounted for health effects when choosing to cycle and argued therefore that there might be a risk of overestimating the size of the external effects. However, it is also unclear to which extent cyclists and walkers are able to quantify the order of magnitude of these effects (ibid.). Another issue is related to new mode of travels such as electric bicycles, steps and pedelecs which are becoming increasingly popular among different target groups and require less effort from the user, limiting the magnitude of the health effects. However, such evidences are difficult to collect everywhere, and it is unlikely to get this specific information for a specific intervention site in which a CBA may be used as appraisal technique. In addition, it is unclear how to trade-off health effects from potentially increasing pollution intake. Finally, there is a lack of understanding on the extent to which increased cycling rates create substitution effects from other sport activities and influences self-selection. Since health benefits are usually very high in slow mode-related CBAs studies (Brown et al., 2016).
- Improving road safety is another important rationale for improving walking and cycling facilities (Pucher and Buehler, 2012). However, including the effects on road safety in CBAs on walking and cycling remains tricky as knowledge on road-type specific disaggregated risk factors is often lacking and the use of aggregated statistics may lead to underestimations of the risks effects for short car trips happening in urban areas which are usually the target of cycling policies (Stipdonk and Reurings, 2012). Moreover, there is some evidence that increasing cycling levels substantially reduce the risk of accidents due to the so called “safety-in-number,” i.e., the fact that vehicle drivers become more accustomed to cycling/walking people and more capable of anticipating their

behaviors and, thus avoid accidents (Jacobsen, 2003; Wegman et al., 2012). However, it is also true that the relationship is inverse, and that when cycling/walking becomes safer (e.g., thanks to infrastructure improvement), more people start to walk/bike.

- There are other intangible effects that are discussed in the literature that can be relevant for the appraisal of cycling and walking project such as increased urban quality and attractiveness (Pucher and Buehler, 2012), increased option value (Geurs et al., 2006; Laird et al., 2009) and reducing transport poverty (Martens, 2013).

4.3 Cost-effectiveness analysis

The main advantage of CEA compared to other methodologies is that it is cheaper and effective as a tool to rank options. This allows decision-makers to easily sort between alternative options that ensure that a goal will be reached at the least possible cost. However, this is also its main limitation as transport policies may not only want to address one objective at a time. Typically, there are in fact a number of competing objectives to be balanced such as: improving health, reducing accidents, alleviate congestion and improve environmental quality (Litman, 2012). Hence, CEA may not be the most suitable method if the objective is to fully consider a wide range of effects in one decision criterion (Browne and Ryan, 2011). Secondly, the results of CEA have limited transferability due to heterogeneous study designs and the context-specific nature of its application, as well as the limited number of ex-post assessment which hinders the generalizability of results. Thirdly, some long-term benefits of cycling and walking that may not occur immediately and other synergistic effects resulting from an intervention (i.e., installing bike lanes may increase bicycle traffic improving health but also reducing car traffic alleviating congestion and pollution) may be underrepresented due to the static picture that a CEA provides.

Similarly, to CBA, there are important limitations related to forecasting which require the analyst to make strong assumption and predictions (ibid.), and uncertainties on how to quantify and value effects (such as s adverted DALY or gained QALY).

4.4 Multi-Criteria Analysis

In general, the main advantage of MCA is that it can incorporate quantitative and qualitative analysis of economic, environmental and social impacts and, therefore, the results can be more informative than quantitative analysis

alone, as is the case in CEA or CBA (Browne and Ryan, 2011). Secondly, MCA can account for multiple stakeholders' opinions, leading in principle to more legitimate approaches as it allows for the inclusion of qualitative and process-related aspects which, for example, the CBA typically does not (Dean, 2020). Finally, it can be used as a policy learning tool, where the objective is process-oriented rather than result-oriented and can be modified to weight criteria with stakeholder input and explicit opinions or values (ibid.).

On the other hand, MCA may be subject to ambiguity and subjectivity in applying weights, it holds risks of double counting and it can present lack of consistency (see Beria et al., 2012; Dean, 2020). In addition, the specificity of the context makes the transferability of the results impossible to generalize and highly subjective. Despite this, most studies underlined some important lessons such as the importance of considering the perspective of multiple actors and to choose the appropriate study design. For example, MCA has been used by Moshref Javadi et al. (2013) to identify the most suitable locations for bicycle share stations. They reported that the most important criteria in determining the final location were proximity to bicycle paths, transportation and networks, demand, and use type. Milakis and Athanasopoulos (2014) included the opinions of cyclists in their study, proposing a four-step methodology for bike-share network planning using multi-criteria and GIS methodology. The methodology was considered to be suitable for cities attempting to introduce and prioritize cycling infrastructures, since it focuses on determining where cyclists would prefer to cycle. Another positive aspect of MCA is the flexibility to tailor the instrument based on the data availability which is typically low for walking and cycling. In addition, the ad hoc definition of criteria may also induce (intended or unintended) manipulations that steer the results to a specific (desired) outcome. Furthermore, certain increasingly popular concepts such as "walkability" and "bikeability" and more broader concepts of fairness find hardly a common definition.

4.5 Impact of appraisal methods on decision-making

Some scholars (Annema et al., 2015; Eliasson et al., 2015; Mouter, 2017a,b) have already investigated the use and view of appraisal methods by politicians. It is argued in this chapter, that appraisals conducted on walking and cycling might be used similarly. In particular, CBA may be one of the instruments used by policy entrepreneurs to promote different framings

of walking and cycling as transport and instrumentally use CBA while harnessing political support as suggested by [Weber \(2014\)](#) and [Aldred \(2015\)](#). However, concrete evidence of the views and uses of CBA applied to walking and cycling by policymakers and other stakeholders remains underexplored. This constitutes an interesting avenue for further research, considering that most of the use of this appraisal technique on walking and cycling is to promote political debate and enhance a positive public dialog (see for instance [ECF, 2016](#)). The purpose of the development of methodological guidelines and tools such as HEAT stems from this very need to provide an instrument to justify investments into active modes from a health-economic standpoint. [Weber \(2014\)](#) has pointed out that there may be value in pointing the research into this direction and has proposed the use of the Multiple Streams Framework (MSF) and other policy process framework as a possible lens to study the use of CBA and other appraisal methods for walking and cycling within decision-making processes. However, multiple other theories and lenses of policy processes could be used as well (see a review by [Sabatier, 2019](#)). From the comparison of multiple lenses, a better understanding of the impact of appraisal methods on decision-making outcome on walking and cycling projects may be identified. Filling this knowledge gap may promote a better integration of CBA within the decision-making processes, promote communicative rationality in transport planning and support the creation of stronger stakeholder coalitions.



5. Conclusion

The appraisal methods that have been discussed were initially developed for traditional transport projects, by which we mean somewhat large-sized projects, mainly concerning infrastructure for motorized private vehicles and/or public transport systems. Such established methods have been adapted to active mobility projects out of reconsiderations about the traditional transport system, which has led to increased interests in active mobility forms and in the methods to evaluate their costs and benefits. At the same time, the last two decades of research are increasingly suggesting that active mobility has a positive impact on society, however, this might be framed, in most contexts. In this sense, appraisal methods have both shaped and are shaped by the increasing interest in active mobility. However, research is unsettled in most, if not all, aspects of evaluation of cycling and walking projects and programs, as the existing methods have been

adapted to the new(er) active mobility field with mixed results in terms of analysis capability, applicability, reliability and communicability.

The evaluation of projects based exclusively on the costs (and revenues) of the proposal (such as the Balance Sheet), technical aspects and intuitive assessments of the merits and flaws remains the only practice that is adopted by most decision-makers across the world. On the one hand, its simplicity promises quicker and clearer decisions, as fewer input data are required, and the decision-maker oversees establishing relevant criteria. However, the BS—and in some way even CEA—considers only the feasibility of the project, which is hardly a justification for the necessity of implementing it, without touching upon the benefits of active mobility projects and thus reducing the room for discussion about the desirability of a project. Although simpler methods promise speed of adoption thanks to the few parameters to be considered and evaluated, this very feature can easily backlash and lead to ill-informed and often inconclusive debate. On the contrary, methods such as CBA or MCA, though more complex to both develop and explain, explore the full spectrum of possible impacts, thus fostering a more comprehensive and informed discussion about the role of active mobility within society.

However, the choice for simpler appraisal methods is mostly driven by considerations of costs, time and increasingly so data unavailability. In particular, cycling and walking demand modeling is probably the largest source of uncertainty and variability to the usability of economic appraisal methods, especially when plans, and not single infrastructures, are concerned. Not being able to quickly, cheaply and reliably assess the effects on cycling or walking level of a certain intervention creates a “garbage in, garbage out” type of problem, especially if forecasts are made through the introduction of a significant number of hypotheses. In that sense, the practitioner has fundamentally two opposite possibilities: (a) increase the modeling effort (combined with data collection in most cases) and provide an improved forecast or correlation linking intervention and results; (b) shift the focus from “*modeling and forecasting*” to “*what if*” scenarios, which would remain more general but would assess scenario impacts without claims of prediction.

However, improved modeling and increased data collection and availability about active mobility would anyway be necessary in most cases in which a certain degree of correlation between the proposed intervention (and relative costs) and expected benefits must be made. This is true for cycling and even more so for walking, for which very little modeling effort has been carried out in the past.

One of the most fundamental issues for economic appraisal methods stems from the necessity to monetize the relevant impacts: in particular, many effects have been identified and quantified to a (somewhat) high degree of certainty, such as the value of time, several types of environmental impacts, value of congestion etc. However, even when impacts can be determined and precisely quantified, it is the phase of their monetization that introduces the largest variabilities and uncertainties. These uncertainties stem from three main factors: (1) the consequences of the impact cannot be determined to the same level of certainty (e.g., the consequences of local air pollution on health); (2) the consequences of the impact, though determined, cannot be reflected into a direct economic measure (e.g., the loss of biodiversity from a specific eco-system); (3) the economic measure attached to the impact, though determinable in principle, is highly context-dependent and subjective (e.g., the value of time). For these reasons, the uncertainty that surrounds economic appraisal methods is significant, thus increasing the variability of the results and potentially hindering the model reliability.

Moreover, the high variability introduces an important drawback for CBA in particular: the possibility to quantify and monetize the impacts, although complicated, appears to support the case for a purported objectivity/ neutrality of the method, which seemingly suggests that the decision can be demanded to the results of the CBA. On the other hand, room for discretion always exists and lies in the hands of the practitioner performing the analysis, who must ultimately choose, even if within ranges, which values to consider and which ones to discard; this is particularly relevant when considered parameters are highly variable (i.e., the value of CO₂ emissions, the value of statistical Life, etc.).

In this sense, the main difference between the CBA and the MCA is that for the latter the subjectivity is clearly visible and transparent, in that the weights are openly discussed and assigned according to personal criteria. On the other hand, the subjectivity of CBA is somewhat hidden, as the practitioner is forced to choose among possible values or evaluation methods for the considered impacts. The best practice for CBA reporting, in fact, is to fully state the introduced hypothesis and communicate median values and variability ranges of the results, as well as providing a sensibility analysis if possible. Nevertheless, CBA results are often not accepted by the audience because choices about parameters range have been made solely by the practitioner and not by a group of stakeholders. This is particularly relevant in fields of application where choices are often “emotionally loaded,” such as

the case for cycling infrastructure that diminishes space dedicated to motorized vehicles or policies that disincentive their use.

Officials from the City of Amsterdam and Munich within the Handshake project, for example, have argued that they prefer to adopt MCA rather than CBA because of the “perceived subjectivity” of the latter, which induces confusion and hinders the discussion. Our own experience suggests that debate about an emotionally loaded project will not be easily solved by the results of a CBA, as these would be interpreted differently by different actors in policy controversies (more on this is discussed by [Rein and Schön, 1996](#)). Quite paradoxically, a higher acceptability could characterize the results from the “highly subjective” MCA, because the weights can be made explicit and part of a transparent participatory process. In that sense, the evaluation of effects within CBA could also be part of a participatory process, as it has been underlined by [Beukers et al. \(2014\)](#).

One aspect that hinders, or at least slows down, the improvement of economic appraisals is that any attempt to reduce the uncertainty and variability of impact monetization in CBA must include a high degree of cross-sectorial expertise, as the process from impact identification to its quantification and then to its monetization requires a very different set of skills. For example, the quantification of air pollution emissions from vehicles is an engineering problem, the diffusion of pollutants depending on the specific context is an environmental scientist-type of problem, whereas the health effects of pollution concentration requires epidemiological studies, whose results must then be assessed in terms of monetized impact through sociological and economic studies about the consequences of increased illness and premature deaths. This type of knowledge-chain is often specific to each identified impact and, in many cases, to each case-study when local context can significantly change conditions.

Finally, the presented methods have been considered as “alternatives,” but they really should not. In fact, these methods can embrace the full spectrum of socio-economically-relevant consequences of increased cycling/walking conditions only when combined, i.e., only when more than one method is applied to the same case-study. A plurality of methods is seldom applied to a single case-study for obvious resource-scarcity reasons, which force the practitioner or the decision-maker toward the single method that can deliver the best results given the constraints (usually, time and money). [Bakker et al. \(2010\)](#) had already suggested to combine, for the evaluation of integrated transport policies, the strengths of MCA and CBA, specifically for projects where impacts might be harder to monetize. On the other

hand, no case-study of such (or other) combinations of methods has been published so far to the best of our knowledge.

However, academics and private researchers might aim at constructing new tools that could develop the potential and overcome the weaknesses of the existing methods, which have been historically developed for quite different contexts and might therefore not be the best possible solution. In this regard, the combination of two or more of the presented tools, and even the transposition of a different appraisal method altogether, might benefit the field and increase the possibility for fast, reliable and high-quality appraisals.

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