15
Appraisal methods for transport policy

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15.1 INTRODUCTION

Transportation networks provide an array of benefits in the forms of goods delivery, access to services and personal mobility. However, transport can also result in several adverse effects such as damage to the environment (nature reserves, CO_2 emissions and noise pollution (see Chapter 10) and crashes (see Chapter 11)). Governments are in many ways involved in transport policy and planning (see Chapter 13). For instance, they determine regulations such as speed limits and they can decide to invest public budget in the extension and/or maintenance of transport infrastructure. In many cases, policy makers want to make decisions informed by the expected positive and negative impacts of a transport policy option. Various ex-ante evaluation methods are available which can be used to provide such information.

This chapter surveys five evaluation methods that are used to inform policy makers about transport impacts: Social Cost–Benefit Analysis (SCBA), Participatory Value Evaluation (PVE), Multi-Criteria Analysis (MCA), Environmental Impact Assessment (EIA) and the Social Impact Assessment (SIA). The five methods will be introduced, and differences will be described. Knowledge about the differences, virtues and limitations of each of the methods can be used by policy makers to select the most appropriate ex-ante evaluation method for the assessment of a specific transport policy decision. Section 15.2 will discuss SCBA which is the most frequently used and hotly debated appraisal method in transport decision-making. Subsequently, Sections 15.3–15.6 will discuss the other four methods. Section 15.7 compares the methods. Finally, Section 15.8 summarizes the main conclusions of this chapter.

15.2 SOCIAL COST–BENEFIT ANALYSIS

In virtually all western countries Social Cost–Benefit Analysis (SCBA) is mandatory when national funding is asked for large transport projects (Mackie et al., 2014). Basically, a SCBA is an overview of all the positive effects (benefits) and negative effects (costs) of a project or

policy option (e.g. van Wee, 2012). These costs and benefits are quantified as far as possible and expressed in monetary terms. Finally, government projects are typically intertemporal in nature, so the benefits and costs occur over a number of periods. To deal with this, they are presented as so-called present values, implying that – even after a correction for inflation – it is better to have one euro or dollar now than in ten years' time, for example (van Wee, 2012). The discount rate is used to express this valuation (Mouter, 2018). Often, present values are aggregated to yield an indicator of the project's net impact on social welfare.

Hence, the aim of SCBA is to derive a summary indicator of the costs and benefits for *all* the actors affected. The term 'social' is used to indicate that the interests of *all* groups are incorporated. This is one of the main differences from the notion of a 'business case', which exclusively focuses on the interests of one particular actor. A SCBA measures the social desirability of a transport policy option in a systematic way based on economic theory. SCBA quantifies the project's positive and negative effects and translates these quantified effects in monetary terms.

15.2.1 General Description

Welfare economics provides the theoretical underpinnings of SCBA (Boadway and Bruce, 1984). One of the key concepts in welfare economics is the Pareto criterion which states that the social welfare effect of a project is positive if it makes someone better off without making anyone worse off (Nyborg, 2014). The problem here is that government policies will hardly ever be able to pass this criterion. For instance, when considering new transport infrastructure, taxpayers will pay the costs, and quite probably there will be negative external effects, e.g. noise or CO_2 emissions. A more practical concept is the Kaldor–Hicks efficiency criterion (Hicks, 1939; Kaldor, 1939), which relaxes the Pareto conditions by adding the possibility of (potential) compensation. The Kaldor–Hicks efficiency criterion asserts that a policy (or other change) can be considered as welfare-increasing if those who benefit can compensate those who suffer from it, creating a Pareto improvement after compensation. According to the Kaldor–Hicks efficiency criterion, the compensation does not actually have to take place: it is enough that it is theoretically possible. This implies that there is only a potential Pareto improvement, and not necessarily an actual Pareto improvement. Standard SCBAs are generally based on the Kaldor–Hicks efficiency criterion. SCBA assesses whether a transport project passes the Kaldor–Hicks efficiency test by expressing all the positive and negative effects of a policy in monetary terms and adding them up. If the sum is positive the project is considered to be welfare enhancing as those who benefit can theoretically compensate those who suffer.

Welfare economics provides strict procedures for the objects that have standing in the SCBA analysis, for the impacts that are considered in the analysis and for the way different impacts are valued. In principle, welfare economics prescribes two principles when conducting a SCBA being individualism and non-paternalism. Individualism implies that the preferences of individual citizens form the basis of a SCBA (Sen, 1979) and non-paternalism assumes that individuals are the best judges of their own welfare. In combination these postulates imply that the citizens and firms that are affected by the policy are the sole objects who have standing in a SCBA study, and their preferences are respected. In principle, preferences of experts, stakeholders and policy makers related to the impacts of the transport project do not

play any role in the analysis as these actors are only consulted to provide methodologies for deriving the preferences of citizens. Welfare economics also provides SCBA researchers with a clear frame of reference when selecting the impacts of transport policy options that should (not) be included in a SCBA because only impacts that affect the welfare of individuals should be included. For instance, citizens' preferences for the way that the benefits and burdens of a transport policy option are distributed across society are not part of the total net benefits in a SCBA (Mouter et al., 2017b). Another consequence that is excluded from a SCBA is public support for a transport policy option (Mouter, 2017).

Welfare economics also provides clear guidance for the weighting procedure that is used in SCBA to evaluate the impacts of a transport policy option. SCBA measures a project's societal value by quantifying the project's societal impacts in monetary terms using the notion of the amount of money individuals are willing to pay (WTP) from their private income. For a positive effect, the WTP is the maximum amount which a person is willing to pay for it. For negative effects, the WTP is negative (then often called willingness-to-accept).

One example of an approach to derive the amount of money that individuals are willing to pay for reductions in travel time and accident risk concerns using (hypothetical) route choice experiments. Participants in these choice experiments are asked to make a series of private choices between routes which differ in terms of travel time, accident risk and travel costs (e.g. Batley et al., 2019; Bahamonde-Birke et al., 2015; Börjesson and Eliasson, 2014; Hensher et al., 2009).

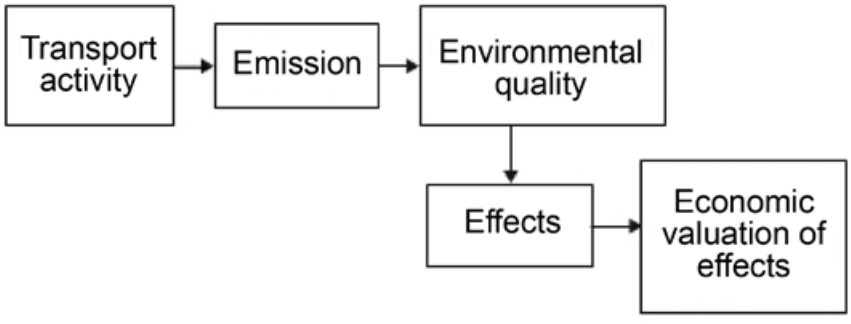

Figure 15.1 Illustration of the consumer surplus (CS) concept

With the choice of consumer preferences as the starting point for SCBA, the consumers' willingness to pay is an important element of the valuation of costs and benefits (Small and Verhoef, 2007). The consumers' preferences can be described by means of a demand function (see Figure 15.1). A demand function describes how much a group of consumers is prepared to pay for a certain product or service. For example, in Figure 15.1, when P0 is the price, N0 consumers will use the service provided. When the price decreases to p1 the number of consumers increases to N1. In the context of transport, the 'transport service' may mean: making a bus trip from A to B, or making use of the road to drive from C to D. Consider now the group of N0 consumers who make use of a certain transport service who are prepared to pay the price P0 for this service. Note that their willingness to pay is at least P0: most of these consumers are

prepared to pay more than just P0. The difference between what a consumer actually pays and what he would be prepared to pay is called the 'consumer surplus'. In Figure 15.2 the consumer surplus of all users of the service when the price P0 is represented by the triangle CS.

The term consumer surplus can be useful in discussions on 'the economic importance of transport'. The total amount of money actually paid by consumers (N0×P0) provides an underestimate of what these consumers are willing to pay for this service. Note that in Figure 15.2 when the price is P0 the consumer surplus is considerably smaller than the actual expenditure for this transport service, but for lower prices, this no longer applies.

Consider now an improvement of a certain connection so that the costs of using it decrease from P0 to P1. For the present users of the transport service the consumer surplus changes from N0×P0 to N0×P1, which implies an increase of N0×(P0−P1). Another consequence of the price decrease is that it generates new users N1−N0. The change in consumer surplus of this group is represented by the triangle DCS1 in Figure 15.2. This change is equal to the increase in the number of users N1−N0 multiplied by half of the price decrease P0−P1: DCS1=0.5×(N1−N0)×(P0−P1). This is the so-called 'rule of half'. It means that the benefits of a price decrease for new consumers are 50% of the benefits of incumbent consumers. That the result is 50% can be made intuitively clear by first considering a new consumer with a willingness to pay very close to P0. This consumer benefits almost fully from the price decrease. But a consumer with a willingness to pay close to P1 hardly benefits from the price decrease. Then the average new consumer's benefit will be 50% of the benefit of incumbent consumers. The rule of half is exact when the demand function is linear, but in real world cases the demand function might not be linear.[1] In such a case, the rule of half is only an approximation.

The notion of consumer surplus can of course also be used in the case of price increases. The analysis is entirely symmetric. Note that in this case the disadvantage of a price decrease is largest for the consumers who continue to use the service and smaller for the consumers who stop using the service because they apparently have another alternative (another transport mode, another destination, staying at home) which is sufficiently attractive for them to decide to change their behaviour. Thus, the economic approach implies that people who do not change their behaviour as a consequence of a price increase are hit harder than people who do change their behaviour. It is worth noting that this result may be rather different from a political economy perspective, where consumers who do change their behaviour are considered to be the ones hurt most by a price increase. These consumers cannot afford to pay the high price and hence should be considered as the greatest victims. This may well lead to a gap between cost–benefit analysis where consumers who change their behaviour get a low weighting and political debates where these consumers get a high weighting.[2] This is an illustration of the difficulties that may emerge when SCBA is applied in situations where equity concerns are high. We will address this subject later in this chapter.

To be able to assess the benefits of a change in transport services leading to a decrease in the price, information is needed on the price in the reference situation and the new situation (see Chapter 14) and the number of consumers in both cases. The reference situation may be the current situation, but in many practical applications of SCBA the alternatives refer to infrastructure projects that may take a long time before they are completed. Hence, predictions are needed of prices and numbers of users in the future, with and without the policy alternative.

Table 15.1 Example of an SCBA table for a road upgrade involving separation of motorized and non-motorized transport

	Valuation
Benefits:	
Decrease of travel time for present road users	200
Welfare improvement of new road users	60
Improvement in traffic safety	20
Costs:	
Environmental costs (higher emissions because of higher speeds and greater traffic volumes)	15
Extra noise nuisance	20
Construction costs	160
Additional maintenance costs	10
Deterioration of landscape PM (pro memory) Benefits – costs	75 – PM

Note: Figures in net present values in million euros.

For this purpose, one needs projections on how the economy and the transport system will look in the future and how transport demand will be affected by a price change. These changes in demand can be estimated using transport models (see Chapter 16) or price elasticities, as mentioned in Chapters 3 and 6.

The final step of SCBA is that an overall assessment of alternatives is carried out by comparing the alternatives with a reference alternative as mentioned above. The changes in costs and benefits for all actors are determined for each alternative (compared with the reference alternative) and then the net balance in the change in costs and benefits can be computed. The alternative with the highest positive net balance is the best candidate to be implemented according to SCBA. Since the results of SCBA depend on many uncertain inputs, sensitivity analysis is recommended. For an example of the results of SCBA, see Table 15.1.[3] Government projects are typically intertemporal in nature, so the benefits and costs occur over a number of periods (e.g. Boadway, 2006). To deal with this, they are presented as so-called present values, implying that – even after a correction for inflation – it is better to have one euro or dollar now than in ten years' time, for example (van Wee, 2012). The discount rate is used to express this valuation. A discount rate is expressed as a percentage per year. If the discount rate is d, then the present value someone puts on a benefit gained from a euro in a year's time is equal to $1/(1+d)$; a euro in two years' time is now worth $1/(1+d)2$ etc. This is called discounting. The resulting value today of a future euro is called the present value. Finally, in a SCBA, present values are aggregated into a final indicator such as the net present value (NPV) - which implies subtracting the present values of all costs from the present values of all benefits – or the Benefit–Cost Ratio (BCR) – benefits divided by the costs.

15.2.2 Valuation Methods

As said, one crucial step in a SCBA is to obtain monetary values for all non-priced impacts. For instance, a Value of Travel Time Savings is obtained to value travel time savings (see Chapter 6) and various valuation metrics are obtained to monetize safety impacts (see Chapter 11). The valuation of environmental impacts of a transport project is relatively challenging as it addresses the final results of a whole chain of effects from transport via emissions to impacts on environmental quality (see Figure 15.2). This chain will vary according to type of environmental effect (see also Chapter 10). In the case of noise, the effect on environmental quality will be restricted to the local environment. The effects concerned are, among others, annoyance, disturbance of sleep, stress and heart diseases for those living or working close by. In the case of CO_2 emissions the spread is much broader, and the effects will be in terms of damage to health and ecosystems, among other things.

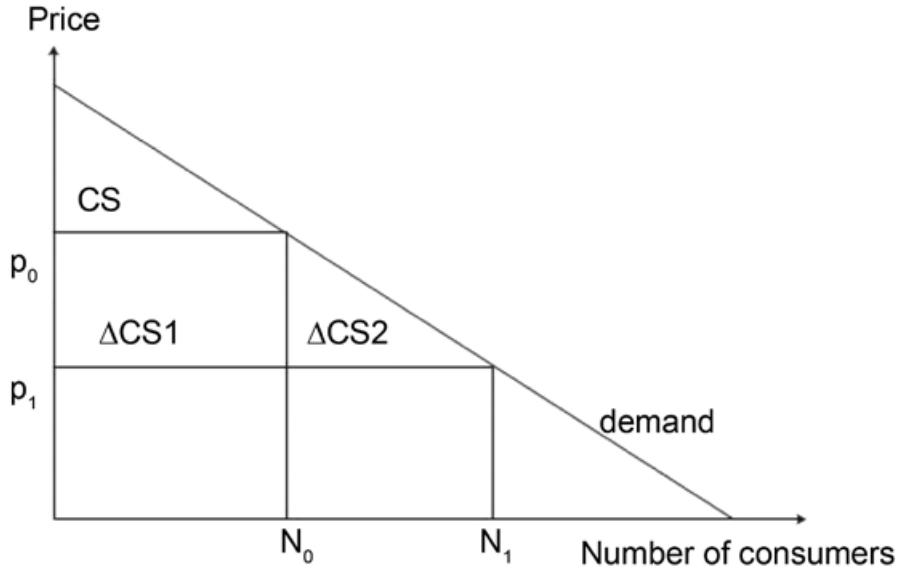

Figure 15.2 Chain from transport to economic valuation of emissions

There are various methods for arriving at monetary values for the environmental effects of transport. For a discussion of various methods, we refer to Johansson (1991) and Perman et al. (2003). Two different classes of valuation approaches can be distinguished. The first class focuses on the valuation of environmental effects via observed behaviour in markets. The second approach focuses on the valuation of environmental effects via stated preferences techniques such as a discrete choice experiment (Train, 2009). Below, we will discuss examples of both approaches in some detail.

An example of the valuation of environmental effects via observed behaviour in markets is that houses in noisy areas will most probably have a lower value. Via a so-called hedonic price

approach one can isolate the effect of noise from the effects of many other factors that have an impact on the value of dwellings. The outcome of a hedonic price analysis is the percentage change in the value of a house due to exposure to a certain noise level when all other features of a house are kept constant. This econometric approach is often applied to the valuation of noise near airports (see, for example, Schipper, 2001; Dekkers and van der Straaten, 2009). Impacts of transport policy options on landscape, nature and the proximity of highways and light rail transit are evaluated through analysing the private decisions of individuals in the real estate market (e.g. Allen et al., 2015; Seo et al., 2014; Tijm et al., 2019). Note that consumers will be heterogeneous with respect to the noise annoyance: people who strongly prefer a quiet environment will usually not live in very noisy places, since people who give less priority to a quiet place will bid higher prices. Thus, the phenomenon of self-selection will reduce the burden of noise (Nijland et al., 2003). A sudden increase in noise levels due to the opening of a new runway, for example, will then affect people with a strong dislike of noise. In the long run a new equilibrium will emerge via spatial sorting of households. A basic assumption behind hedonic price analyses is that the housing market is in equilibrium. Thus, this may lead to an underestimate of the effects in the short run when a sudden unanticipated increase in noise levels occurs.

A related method that is close to actual market-oriented behaviour concerns the costs that people incur to visit nature areas. These costs appear from the travel costs they incur and the entrance fee, if there is one, among others. This so-called travel cost method (see Perman et al., 2003) can be used to determine the use value of nature areas. This method also has its limitations, since it is not so clear how to value the travel time of these leisure trips. In addition, the travel cost method does not address so-called non-use values of a nature area. An implication is that, when there are two identical nature areas, one in a region with high population density and the other one in a sparsely populated area, the former one will attract more visitors who express their willingness to pay via their travel cost than the latter. So, the use value of the former will be larger than that of the latter.

The second approach in the field of valuations is to base them on the subjective valuations of consumers elicited via surveys. These stated preference methods come in different shapes. The Contingent Valuation Method (CVM) uses surveys to ask people directly, in open-ended questions, what money value they attach to effects they (may) experience. For instance, participants are asked how much they are willing to pay to reduce the numbers of animals killed by transport in a certain area. Another stated preference method uses stated choice experiments (Carson and Czajkowski, 2014). Using this method, the respondents in a survey choose between different options, including financial changes. From their choices, the average value they attach to an effect can be derived.

A third method to determine prices when there is no market is the so-called 'prevention cost method'. This method indicates how much it would cost to prevent a certain target being exceeded. For example, how much would it cost to reduce CO_2 emissions such that they comply with international agreements? This method is rather different from the methods discussed above because it is formulated in terms of prevention costs, so that the damage cost is not estimated. The prevention cost method can be used in cases where no damage cost estimates are available, in particular when a clear target has been formulated in the policy

Table 15.2 Assessment of evaluation methods for environmental damage

Method	Scientific basis	Information needed	Reliability	Applicable to
Travel cost method	Good	Observed choice behaviour	Good	Use value of nature and landscape
Hedonic price method	Good	Outcomes of market processes	Good	Noise nuisance, local emissions, safety
Stated preference	Reasonable	Hypothetical choices	Reasonable	Broad range of applications; also for global effects
Contingent valuation	Reasonable	Hypothetical choices	Difficult to verify	Broad range of applications; also for global effects
Shadow price method	Dubious	Prevention costs	Good	Broad range of applications; also for global effects

domain.[4] It is worth noting that the principle of individualism is breached here because it is not the preferences of individuals who form the bases of valuing reduction of CO_2 emissions, but the preferences of politicians who set the targets of reduction of CO_2 emissions. A concise comparison of the methods discussed here can be found in Table 15.2.

15.2.3 Issues in SCBA

The use of SCBA as a decision support tool for the public sector is not without problems. One of the first issues is that the distribution of costs and benefits may be very uneven so a dichotomy of winners and losers may emerge (see also Chapter 12). For example, users of the road presented in Table 15.1 experience safer and faster traffic, but residents around the road may not like the noise. The final outcome of SCBA is the net result of winners and losers so that the distribution is not directly visible. As said, the main idea behind SCBA is that the gains should be high enough so that the winners can compensate the losers (this is the so-called Hicks–Kaldor principle) and still be better off in the end. In that case everybody would be better off (this is known as the Pareto principle). However, the above only involves a hypothetical possibility to compensate, and there is no guarantee at all that an actual compensation will take place. Hence, almost every policy alternative will lead to the situation that there is a group of losers who may see a reason to protest against the proposed plan.

Thus, the strict use of the hypothetical compensation notion in SCBA may lead to the situation that alternatives are selected with a very unequal distribution of costs and benefits. Suppose now that there is another alternative with a somewhat lower net outcome but with a more balanced distribution of costs and benefits. Taking distributional considerations into account, policy makers might prefer the second alternative above the one with the higher benefit–cost result. The issue of transport equity is much discussed in the literature (Aparicio, 2018; Bills and Walker, 2017; Lucas and Jones, 2012; Nahmias-Biran et al., 2017; Pereira et al., 2017). A fair distribution of impacts (benefits and costs) is by far the most discussed type of equity. Van Wee (2012) observes that equity not only refers to a fair distribution of burdens

and benefits, but that it can also refer to other ethical principles such as procedural justice. Equity concerns are cited as the most neglected (and difficult to measure) in transport policy (Berechman, 2018). For instance, SCBA has been criticised for placing too much value on increasing mobility overall, rather than ensuring equitable access to transport services for different age groups, genders or ethnic groups at risk of social exclusion (Ferreira et al., 2012). Transport-related inequalities that tend to be neglected in the literature relate to affordability, proximity to services, inclusivity (e.g. for the disabled), agency, freedom of choice and transport accessibility levels (Pereira et al., 2017).

A second critique on SCBA concerns how SCBA does not distinguish between private and public preferences. SCBA's monetization of the impacts of government projects is based on how much affected individuals are willing to pay from their private income (Persky, 2001), but SCBA fails to consider that private choices may not fully reflect citizens' preferences about public goods and means (Mouter et al., 2021a). As said, transport SCBA use monetary metrics that are either directly derived from individuals' market behaviour or from hypothetical consumer choices. This 'private willingness-to-pay approach' has been criticized by scholars who assert that the way that individuals balance their own after-tax incomes against the attributes of government projects when making private choices may be a poor proxy for showing what individuals believe how their government should trade-off public budgets and impacts of public projects (Mouter et al., 2018). Many of these limitations of SCBA arise due to individuals' perception that the government should allocate public resources in a different way than they allocate their own private income.

The literature discusses various problems with using individual private willingness-to-pay to infer the welfare of a government policy in the context of public choices. A first reason is that private choices may be distorted through collective action problems (e.g. Lusk and Norwood, 2011; Sen, 1995). For instance, people may not be willing to contribute individually to a public good (e.g. air pollution) because the impact of their individual contribution is negligible, but people may be willing to contribute when the whole community is forced to contribute through a new law or a tax increase because the impact of this coordinated contribution can be substantial (Lusk and Norwood, 2011; Sen, 1995). A second reason for a distinction between private preferences and public preferences concerns how individuals value the same impact differently in a private sphere (the real estate market) and the public sphere (ballot box), as distributional considerations might be more relevant in the latter context (e.g. Mouter et al., 2019; Sagoff, 1988). A third reason why scholars criticize the private willingness to pay paradigm in SCBA is that they think that this is an inappropriate way to value impacts of government projects that are not possible to measure with private income (Aldred, 2006). For instance, Sunstein (1993) asserts that values which are not traded in a real-life market setting, such as biodiversity and landscape, might be valued incorrectly when they are expressed in private income.

As well as many theoretical arguments about why individuals entertain different preferences in a private and public setting, the literature also includes empirical insights showing that individuals value impacts of transport projects such as travel time savings and accident risk differently when they trade these impacts against their own budget or the public budget (Mouter et al., 2017a, 2018).

15.3 PARTICIPATORY VALUE EVALUATION

Scholars developed the Participatory Value Evaluation (PVE) to alleviate some of the issues addressed above (e.g. Mouter et al., 2021a). In a PVE, participants are offered several possible public projects, information about the impacts of these projects and a constrained public budget in an (online) experiment (Mouter et al., 2021a). Participants are asked to choose the public projects they like to see implemented while respecting the public budget constraint. The trade-offs made in selecting their preferred portfolio can be used to establish individuals' preferences for (the impacts of) the public projects and to rank these projects in terms of their desirability (Dekker et al., 2020; Mouter et al., 2021b). The PVE approach thus aspires to infer welfare effects of (impacts of) government projects from individuals' preferences regarding the expenditure of public budget. The innovations of the PVE appraisal method are described in various papers (Dekker et al., 2020; Mouter et al., 2021a and b). Mouter et al. (2021b) explain that PVE cannot only be considered as a valuation method which provides input for a SCBA, but that the outcomes of a PVE can also be directly used for establishing the social welfare effects of government policy options. In that case, PVE can be considered as a full-fledged alternative to SCBA. Dekker et al. (2020) present the technical details of such a welfare analysis.

The most important benefit of the PVE approach is that individuals who believe that government budgets should be spent on different purposes than their own money can express these preferences (Mouter et al., 2021a). A second advantage of PVE is that it bypasses the concern that WTP-based valuation might be an inappropriate way to value impacts of government projects that are relatively difficult to translate into private income. As said, examples here include landscape and nature. PVE does not require translation of government project impacts into private income. Instead, an impact of a government project is valued through the extent to which individuals are willing to sacrifice other impacts of government projects (Mouter et al., 2021a). For instance, in a PVE experiment, individuals are asked to trade-off noise pollution against other impacts of governmental policy (e.g. reduction of mortality risk) which contrasts the WTP valuation approach in which individuals are asked to trade-off environmental impacts against private income. Moreover, the other issues with the private WTP paradigm addressed in the previous paragraph ('people may be willing to contribute collectively, but may not be willing to contribute individually' and 'people may place a value on the way collective decisions are made') are addressed in a PVE setting because impacts of transport projects are valued in a collective setting in which overall burdens and benefits of proposed transport projects are considered together in the context of a government decision (Mouter et al., 2019).

At the time of writing this chapter (mid 2022), four large scale PVEs have been conducted for the evaluation of transport projects. In one PVE, 2,498 inhabitants from the Transport Authority Amsterdam were presented with 16 transport projects and related societal impacts (Mouter et al., 2021a). The total cost of the 16 projects was 386.5 million euros but with only 100 million euros to spend. Hence, it was not possible for the respondents to include all projects in their portfolio. The portfolio selections of the respondents were used to establish individuals' preferences for (the impacts of) the public projects and to rank these projects in terms of their desirability (Mouter et al., 2021a). In the study SCBAs made about the 16 pro-

jects under scrutiny. It turned out that projects which focus on improving traffic safety and cycling facilities perform relatively good in the PVE, whereas car projects perform relatively good in the SCBA analysis. Finally, this study revealed that participants in the PVE considered the spatial distribution of projects across the region of the Transport Authority Amsterdam in their portfolio selection.

15.4 MULTI-CRITERIA ANALYSIS

The multi-criteria analysis (MCA), also known as multiple-criteria decision-making (MCDM) or multiple-criteria decision analysis (MCDA), typically encompass the following stages:

1. identification of criteria against which to test transport policy options;
2. weighting and/or scoring the different criteria to arrive at a ranking of options.

Many different MCA methods have been developed (Dean, 2018). A certain class of MCA approaches can be defined by the set of rules establishing the nature of options, objectives, criteria, scores and weights as well as the way in which objectives/criteria, scores and weights are used to assess, compare, screen in/out or rank options.

A distinction can be made between 'sophisticated MCA methods' and 'simple MCA methods'. Sophisticated methods use advanced mathematical principles and procedures to weigh criteria and rank options. One example of such a method is the analytic hierarchical process (AHP) (Saaty, 1990). AHP begins by arranging the elements of the analysis in three main hierarchical levels: the overall goal of the decision-making problem at the top (e.g. satisfaction with a transport policy option); a set of decision criteria in the middle layers (e.g. factors that influence the satisfaction of transport policy options); and a group of competing options at the bottom (e.g. transport policy options). Next, the relative importance of each criterion with respect to the goal of the analysis is determined through a series of pairwise comparisons of criteria. The subjective judgements of experts or policy makers regarding the relevance of the different criteria are translated into a quantitative score and subsequently the most desirable option can be determined. Another example of a sophisticated MCA technique is the best-worst method (BWM) developed by Rezaei (2015). Similar to AHP, the BWM method starts with determining a set of decision criteria. A key difference with AHP is that in the second stage decision-makers participating in a BWM are asked to select the best and the worst criteria after which they should determine the preference of the best criterion over all the other criteria and the preference of all the other criteria over the worst criterion. Based on these choices both the direction and the strength of the preferences of one criterion over the other are computed which provides the basis of selecting the best alternative.

Simple MCA methods use relatively rough procedures to score options or even abstain from scoring and ranking the options. One example is the UK Appraisal Summary Table which does not aim to provide a final ranking of the options. Simplified MCA techniques are very popular, mainly because they are easy to use and understand (Dean, 2018). MCA studies can be undertaken either in non-participatory (i.e. expert-led) or participatory manner. In non-participatory assessments, the analysis is carried out autonomously by one or more experts, according

to a typical technocratic approach. A key argument in favour of this approach is that a group of scientists and trained experts is better suited to make complex decisions than the average citizen. By contrast, participatory techniques adopt a more collaborative decision-making style, with the direct involvement of the different interested and affected parties (i.e. problem stakeholders) in the analysis (Macharis and Bernardini, 2015). Although participatory MCA techniques have been championed by transport scholars in the literature it is not totally clear whether techniques have enjoyed real-world applications or constitute mere academic proposals (Dean, 2018).

15.5 ENVIRONMENTAL IMPACT ASSESSMENT

An Environmental Impact Assessment (EIA) is a comprehensive evaluation of the likely effects of a transport project that significantly affects the environment. An EAI aims to contribute to environmental awareness and environmental protection by providing decision-makers with ex-ante information of environmental impacts of public and private initiatives (Jay et al., 2007). Since the 1970s EIA has become increasingly more important in planning practice and has been introduced in national legislation worldwide (Cornero, 2010). The National Environmental Policy Act of 1969 (NEPA) implemented EIA for federal agency actions in the United States. In the European Union (EU), the EIA Directive 85/337/EEC, which called 'on the assessment of the effects of certain public and private projects on the environment', has been in force since 1985. The goal of the Directive is to ensure that environmental values are fully considered in decision-making. Since 1985, EIA has been incorporated into the legislation of European member states; see Soria-Lara et al. (2020).

The usual information contained in an EIA report is:

1. a description of project alternatives and a baseline description of the environment where the project is located;
2. a prediction of significant effects of the project on the environment;
3. measures envisaged to avoid, prevent or reduce the effects on the environment;
4. description of alternatives and the main reasons for the alternative chosen;
5. a non-technical summary.

One crucial step in EIA is how to measure the environmental impacts originated by transport projects, an issue that has been frequently addressed in the academic literature (Soria-Lara et al., 2020). This is done using the concept of significance (Briggs and Hudson, 2013), which depends on both the magnitude (degree of environmental change caused) and the scale of the environmental impact. The magnitude is measured in terms of the corresponding indicator of altered environmental quality (Joumard and Gundmunson, 2010). These indicators may be quantitative (e.g. soil surface affected, number of people affected by a specific noise level) or qualitative (e.g. alteration of landscape quality).

Initiators of transport projects, which are either governmental agencies or private companies, are responsible for conducting an EIA. The competent authority decides on how to use

the EIA outcomes and has to justify its decision, giving consent to the activity. Proponents may adjust their initiatives voluntarily (Arts et al., 2012).

Due to the legal requirements for EIA implementation, there are now strict guidelines for the EIA process for different countries and regions (Cornero 2010). However, because there was much freedom to adapt EIA to the specific needs of the different member states, there are considerable differences between EIA systems throughout the EU regarding various elements (Arts et al., 2012). For instance, when comparing the Dutch and UK EIA practice, Arts et al. (2012) establish that in the UK, there is no formal requirement to assess alternatives, in contrast to the Netherlands. Moreover, quality reviews of EIAs are better institutionalized in the Netherlands than in the UK. The Netherlands is one of the few countries that have established an independent expert commission charged with quality review. Notwithstanding the differences between the Dutch and the UK practice, Arts et al. (2012) identify that overall the EIA is about equally effective in both countries with regard to the incorporation of environmental concerns in decision-making.

Next to EIA in many countries Strategic Environmental Assessment (SEA) is applied also. In EIA concrete and specific projects are assessed (e.g. building a new highway between two specific cities). SEA is aimed at assessing policies, plans and programmes at a strategic level. The idea behind SEA can be explained with the highway building example just given. Before deciding on such a specific project, in many countries in the world a strategic planning phase takes place in which many more options to improve the accessibility in the region where the highway might be built are considered, compared and discussed. Examples of other options could be building or expanding railways, implementing road pricing, not building a new highway but improving the existing highway network, and so forth. So, assessing such a strategic plan on its environmental impacts gives decision-makers a broad insight in environmental effects of a range of options to improve accessibility discussed on the strategic level. Another key characteristic of SEA compared to EIA is that on a strategic level often combinations of specific plans become clear, e.g. next to building the new highway between the two cities potential plans are also presented to expand the cities with new residential and/or industrial areas. In SEA the cumulative environmental effects of the projects combined can be assessed. If only EIAs were carried out for specific projects, consequently only insights would be given to policy makers on environmental impacts of those specific projects and on mitigations options to make those specific projects more environmentally friendly. This would 'narrow' policy makers' decision-making information. Faith-Ell and Fischer (2021) provide an overview of SEA usage in transport planning.

15.6 SOCIAL IMPACT ASSESSMENT

Social Impact Assessment (SIA) was introduced in the late 1970s in the United States due to the perception of EIA being an assessment method with a strong biophysical bias (Morgan, 2012). The primary purpose of a SIA is to bring about a more sustainable and equitable biophysical and human environment (Vanclay, 2003). SIAs utilize participatory processes to analyze the concerns of interested and affected parties. It heavily involves stakeholders in the

assessment of social impacts, the analysis of alternatives and monitoring of the planned intervention. A typical SIA consists of various steps, such as the identification of interested/affected people, selecting alternatives, assessing the social impacts, developing mitigation measures, developing strategies for dealing with residual or non-mitigatable impacts and proactively developing better outcomes (e.g. Mottee and Howitt, 2018; Vanclay, 2003). Hence, the focus of concern of SIA is a proactive stance to development and developing better outcomes, not just the identification or amelioration of negative or unintended outcomes.

Vanclay (2003) describes the core values of the SIA community and a set of principles to guide SIA practice. The role of SIA goes far beyond the ex-ante (in advance) prediction of adverse impacts and the determination of who wins and who loses (Vanclay, 2003). Esteves and Vanclay (2012) argue that SIA practitioners also believe that there should be an emphasis on enhancing the lives of vulnerable and disadvantaged people, and in particular, that there should be a specific focus on improving the lives of the worst-off members of society. Hence, the normative postulations of SIA are more in line with Rawlsian ethics which differs from the utilitarian philosophy which undergirds SCBA.

Mottee (2022) observes that despite the availability of authoritative international guidelines such as Vanclay et al. (2015), SIA is neither consistently mandated in legislation nor applied in the processes and procedures for infrastructure planning, even across established democracies. SIA in this context, if required at all, is often limited to an EIA 'add-on' technical study as part of a statutory planning process, which diminishes its potential to improve social outcomes (Mottee, 2022). Mottee (2022) observes in focus groups that a key limitation is that current SIA practice in many jurisdictions falls short of the good practice methodologies and theory as proposed in the academic and professional literature. Moreover, she claims that SIA should be deployed more in the strategic stages of integrated urban and transport planning to increase the potential to achieve more sustainable and equitable outcomes from urban planning processes.

15.7 COMPARING THE FIVE APPRAISAL METHODS

SCBA, PVE and MCA are quite similar in several respects. The three appraisal methods all aim to provide policy makers with information to assess the desirability of a transport policy option and the methods all rely on transportation model results. The most important difference between SCBA and PVE on the one hand and MCA on the other hand is that welfare economics provides the theoretical framework underlying SCBA and PVE, whereas MCA methods are not built on welfare economics. Welfare economics provides strict procedures for the objects which have standing in the SCBA/PVE analysis, for the criteria/impacts that are considered in the analysis and for the way different impacts are valued. MCA analysts, on the other hand, have a larger degree of freedom when selecting criteria and developing procedures to determine the weights (e.g. Macharis and Bernardini, 2015). For instance, a MCA analyst can decide to include distributional aspects and public support for a transport policy option as separate criteria which affect the final outcome of a MCA. Both impacts cannot affect the final indicators of a SCBA that is grounded in the Kaldor–Hicks efficiency criterion. PVE assumes

that individuals define the attractiveness of a transport policy option based on standard impacts of a transport project such as reductions in travel time and accident risk (which are reflected in taste parameters) as well as other criteria that might not be on the radar of policy makers and experts (which are reflected in project specific parameters). Hence, PVE includes distributional impacts such as spatial equity (Mouter et al., 2021a) and there is no fundamental difference between PVE and MCA when it comes to the inclusion of transport impacts in the evaluation.

Moreover, the weighting procedure that is used in SCBA to evaluate the impacts of a transport policy option is very clear in the sense that the only criterion that defines the weight that should be assigned to an impact concerns the amount of money individuals are willing to pay from their private income. The same holds for PVE in the sense that transport policy options are valued based on the willingness of individuals to allocate public budget to (the impacts of) the transport policy option. The weighting of impacts/criteria in MCA can be partly based on translating impacts/criteria into monetary units, but the aggregation is also based on at least one other weighting method (e.g. scoring, ranking or weighting of a wide range of qualitative impact categories and criteria).

In sum, the three methods differ in terms of degrees of freedom for the analyst to select impacts and criteria that are relevant for the evaluation as well as weighting procedures. An SCBA analyst has to follow strict procedures of welfare economics when selecting impacts, and weighting procedures and as a result the degrees of freedom are limited; a PVE analyst has more liberty when selecting impacts although participants in the PVE (and not the analysts) eventually determine the relevance of a criterion for the evaluation. As stated above, a PVE analyst has no degrees of freedom when selecting a weighting procedure. Finally, an MCA analyst has large degrees of freedom in terms of selecting impacts and weighting procedures. The relatively large degree of freedom can be seen as a strength of MCA when benchmarked against SCBA and PVE. For instance, Gühnemann et al. (2012) asserts that MCA seems to be better in measuring intangibles and soft impacts than SCBA as these effects do not have to be converted into private income. For this reason, MCA has been used in many countries as complementary to SCBA to capture impacts not properly accounted for by the latter method (e.g. Mackie et al., 2014).

Although the flexibility of MCA can be seen as a strength, this characteristic of the evaluation method has been criticized for the arbitrariness in the selection of the weights applicable to different criteria and risks of double counting impacts (Annema et al., 2015). Qualitative assessment and the imputation of value-laden weightings to different criteria may lead to subjective biasing.

The most important differences between EIA and the three methods that were previously discussed (SCBA, PVE and MCA) is that the EIA puts emphasis on a specific set of (environmental) effects. A second difference is that an EIA also includes recommendations regarding the mitigation and management of negative environmental impacts. The purpose of the other methods that were discussed is not to provide such recommendations.

SIA is an anthropomorphic methodology in the sense that analysts consider all issues that affect people. The main difference with SCBA (and PVE) is that all social impacts are considered in an SIA and not only to the extent that humans are willing to pay (or willing to allocate

public budget) for the impacts of the transport project. As a result, the degrees of freedom for the analyst to include impacts is relatively large likewise the MCA.

15.8 CONCLUSIONS

This chapter surveyed five evaluation methods that are used to inform policy makers about transport impacts: Social Cost–Benefit Analysis (SCBA), Participatory Value Evaluation (PVE), Multi-Criteria Analysis (MCA), Environmental Impact Assessment (EIA) and the Social Impact Assessment (SIA). These are the most important conclusions of this chapter:

1. SCBA is the most frequently used method for the ex-ante evaluation of transport projects. A SCBA measures the social desirability of a transport policy option in a systematic way based on economic theory. SCBA measures a project's societal value by quantifying the project's societal impacts in monetary terms using the notion of the amount of money individuals are willing to pay (WTP) from their private income.
2. In the literature, SCBA is criticized for various reasons. Firstly, citizens' preferences for the way that the benefits and burdens of a transport policy option are distributed across society are not part of the total net benefits in a SCBA. A second critique is that SCBA fails to consider that private choices may not fully reflect citizens' preferences about public goods and means.
3. PVE establishes the desirability of government projects based on an experiment in which individuals select their preferred portfolio of government projects given a constrained public budget. The main difference between the SCBA and PVE is that PVE establishes the desirability of government projects based on people's advice regarding the allocation of the public budget toward (impacts of) government projects, whereas SCBA establishes the desirability of government projects through analysing people's trade-offs between their private income and impacts of government projects.
4. MCA comprises various classes of methods, techniques and tools (with different degrees of complexity) which explicitly consider multiple objectives and criteria (or attributes) in decision-making problems.
5. The most important difference between SCBA and PVE on the one hand and MCA on the other hand is that SCBA and PVE are both based on welfare economics which provides strict procedures for the criteria/impacts that are considered in the analysis and for the way different impacts are weighted, whereas MCA analysts have a larger degree of freedom when selecting criteria and developing procedures to determine the weights. The relatively large degree of freedom can be seen as a strength of MCA as the methods seem to be better in measuring intangibles. Although the flexibility of MCA can be seen as a strength, this characteristic of the evaluation method has been criticized for the arbitrariness in the selection of the weights applicable to different criteria.
6. EIA is a comprehensive evaluation of the likely effects of a transport project that significantly affects the environment. Due to the legal requirements for EIA implementation, there are now strict guidelines for the EIA process for different countries and regions.
7. SIA aims to bring about a more sustainable and equitable biophysical and human environment. A SIA includes the processes of analysing, monitoring and managing the intended and unintended social consequences of planned transport interventions.

8. The most important difference between EIA and SIA and the other three methods is that EIA and SIA put emphasis on a specific set of effects (environmental or improving the lives of the worst-off members of society). A second difference is that an EIA and SIA also include recommendations regarding the mitigation and management of environmental and/or social impacts.
9. The five methods surveyed in this chapter all have their merits and limitations. It is important for practitioners to first define their appraisal need(s) and then select the appraisal method that best fits these needs. Practitioners should also realize that the five methods are not substitutable and therefore a smart combination of methods might be desirable in many cases.

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NOTES

1. Note that in our discussion of the demand curve we did not go into the issues of asymmetric responses with respect to changes in prices.
2. Of course, the range of effects will usually be broader, since price policies may also lead to changes in congestion and hence to travel times, but the essence of the gap between cost–benefit analysis and policy weights remains.
3. The meaning of the PM outcome will be discussed in more detail in Section 15.3.
4. The shadow price method and the conjoint analysis method clearly share the property that a price is obtained that cannot directly be observed in a market. The distinguishing feature of the shadow price method is that it follows from the costs to be made to satisfy a policy constraint, and as a consequence the price is based on prevention costs instead of damage costs.

REFERENCES

Aldred, J. (2006), 'Incommensurability and monetary valuation', *Land Economics*, 82(2), 141–61.

Allen, M.T., G.W. Austin and M. Swaleheen (2015), 'Measuring highway impacts on house prices using spatial regression', *Journal of Sustainable Real Estate*, 7(1), 83–98.

Annema, J.A., N. Mouter and J. Rezaei (2015), 'Cost-Benefit Analysis (CBA), or Multi-Criteria Decision-Making (MCDM) or Both: Politicians Perspective in Transport Policy Appraisal', *Transportation Research Procedia*, 10, 788–97.

Aparicio, Á. (2018), 'Equity Challenges in Major Transport Plans', *Transportation Research Procedia*, 31, 121–35. https://doi.org/10.1016/j.trpro.2018.09.054

Arts, J., H.A.C. Runhaar., T.B. Fischer, U. Jhathakur, F. van Laerhoven, P.P.J. Driessen and V. Onyango (2012), 'The effectiveness of EIA as an instrument for environmental governance: reflecting on 25 years of EIA practice in the Netherlands and the UK', *Journal of Environmental Assessment Policy and Management*, 14(4), 1250025.

Bahamonde-Birke, F.J., U. Kunert and H. Link (2015), 'The Value of a Statistical Life in a Road Safety Context – A Review of the Current Literature', *Transport Reviews*, 35(4), 488–511.
Batley, R., J. Bates, M. Bliemer, M. Börjesson, J. Bourdon, M.O. Cabral, P.K. Chintakayala, C. Choudhury, A. Daly, T. Dekker, E. Drivyla, T. Fowker, S. Hess, C. Heywood, D. Johnson, J. Laird, P. Mackie, J. Parkin, S. Sanders, R. Sheldon, M. Wardman and T. Worsley (2019), 'New appraisal values of travel time savings and reliability in Great Britain', *Transportation*, 46(3), 583–621.
Berechman, J. (2018), *The Infrastructure We Ride On: Decision Making in Transportation Investment*, Basingstoke: Palgrave Macmillan. https://doi.org/https://doi-org.tudelft.idm.oclc.org/10.1007/978–3-319–74606–7
Bills, T.S. and J.L. Walker (2017), 'Looking beyond the mean for equity analysis: Examining distributional impacts of transportation improvements', *Transport Policy*, 54, 61–69. https://doi.org/10.1016/j.tranpol.2016.08.003
Boadway, R. (2006), 'Principles of Cost-Benefit Analysis', *Public Policy Review*, 2(1), 1–44.
Boadway, R.W. and N. Bruce (1984), *Welfare Economics*, New York: B. Blackwell.
Börjesson, M. and J. Eliasson (2014), 'Experiences from the Swedish value of time study', *Transportation Research Part A: Policy and Practice*, 59, 144–58.
Briggs, S. and M.D. Hudson (2013), 'Determination of significance in ecological impact assessment: past change, current practice and future improvements', *Environmental Impact Assessment Review*, 38, 16–25.
Carson, R.T. and M. Czajkowski (2014), 'The discrete choice experiment approach to environmental contingent valuation', in S. Hess and A. Daly (eds), *Handbook of Choice Modelling*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Cornero, A. (2010), *Improving the Implementation of Environmental Impact Assessment. Report*, European Environmental Agency.
Dean, M. (2018), 'Assessing the Applicability of Participatory Multi-Criteria Analysis Methodologies to the Appraisal of Mega Transport Infrastructure', Ph.D. dissertation, The Bartlett School of Planning, University College London, UK.
Dekker, T., P.R. Koster and N. Mouter (2020), 'The economics of participatory value evaluation experiments', Working Paper, Tinbergen Institute.
Dekkers, J. and J.W. van der Straaten (2009), 'Monetary valuation of aircraft noise: a hedonic analysis around Schiphol airport', *Ecological Economics*, 68(11), 2850–58.
Esteves, A. Maria, Franks, D. and Vanclay, F. (2012), 'Social impact assessment: the state of the art', *Impact Assessment and Project Appraisal* 30(1), 34–42.
Faith-Ell, C. and T.B. Fischer (2021), 'Strategic environmental assessment in transport planning', in T.B. Fischer and A. González (eds), *Handbook on Strategic Environmental Assessment*, Cheltenham: Elgaronline, https://doi.org/10.4337/9781789909937, 164–81.
Ferreira, A., E. Beukers and M. Te Brömmelstroet (2012), 'Accessibility is gold, mobility is not: a proposal for the improvement of Dutch transport-related cost–benefit analysis', *Environment and Planning B*, 39, 683–97.
Gühnemann, A., J.J. Laird and A.D. Pearman (2012), 'Combining cost-benefit and multi-criteria analysis to prioritise a national road infrastructure programme', *Transport Policy*, 23, 15–24.
Hensher, D. A., J.M. Rose, J. de D. Ortúzar and L.L. Rizzi (2009), 'Estimating the willingness to pay and value of risk reduction for car occupants in the road environment', *Transportation Research Part A*, 43(7), 692–707.
Hicks, J. (1939), 'The Foundations of Welfare Economics', *Economic Journal*, 49(196), 696–712.
Jay, S., C. Jones, P. Slinn and C. Wood (2007), 'Environmental impact assessment: Retrospect and prospect', *Environmental impact assessment review*, 27(4), 287–300.
Johansson, P.O. (1991), *The Economic Theory and Measurement of Environmental Benefits*, Cambridge: Cambridge University Press.
Joumard, R. and H. Gudmundsson (2010), 'Indicators of environmental sustainability in transport: An interdisciplinary approach to methods', Lyngby: European Commission, Recherches.
Kaldor, N. (1939), 'Welfare propositions of economics and interpersonal comparisons of utility', *Economic Journal*, 49(195), 549–52.
Lucas, K. and P. Jones (2012) 'Social impacts and equity issues in transport: An introduction', *Journal of Transport Geography*, 21, 1–3. https://doi.org/10.1016/j.jtrangeo.2012.01.032

Lusk, J.L. and F.B. Norwood (2011), 'Animal Welfare Economics', *Applied Economic Perspectives and Policy*, 33(4), 463–83.
Macharis, C. and A. Bernardini (2015), 'Reviewing the use of Multi-Criteria Decision Analysis for the evaluation of transport projects: Time for a multi-actor approach', *Transport Policy*, 37, 177–86. https://doi.org/10.1016/J.TRANPOL.2014.11.002
Mackie, P., T. Worsley and J. Eliasson (2014), 'Transport appraisal revisited', *Research in Transportation Economics*, 47, 3–18.
Morgan, R.K. (2012), 'Environmental impact assessment: the state of the art', *Impact Assess Project Appraisal*, 30(1), 5–15.
Mottee, L.K. (2022), 'Advancing beyond project-scale Social Impact Assessment of transport infrastructure: insights into contextual constraints on practice', *Impact Assessment and Project Appraisal*, 40(1), 60–74.
Mottee, L.K. and R. Howitt (2018), 'Follow-up and social impact assessment (SIA) in urban transport-infrastructure projects: insights from the parramatta rail link', *Australian Planner*, 55(1), 46–56. https://doi.org/10.1080/07293682.2018.1506496
Mouter, N. (2017), 'Dutch politicians use of cost–benefit analysis', *Transportation*, 44(5), 1127–45.
Mouter, N. (2018), 'A critical assessment of discounting policies for transport Cost-Benefit Analysis in five European practices', *European Journal of Transport and Infrastructure Research*, 18(4), 389–412.
Mouter, N., S. van Cranenburgh and G.P. van Wee (2017a), 'Do individuals have different preferences as consumer and citizen? The trade-off between travel time and safety', *Transportation Research Part A*, 106, 333–49.
Mouter, N., S. van Cranenburgh and G.P. van Wee (2017b), 'An empirical assessment of Dutch citizens' preferences for spatial equality in the context of a national transport investment plan', *Journal of Transport Geography*, 60, 217–30.
Mouter, N., S. van Cranenburgh and G.P. van Wee (2018), 'The consumer-citizen duality: ten reasons why citizens prefer safety and drivers desire speed', *Accident Analysis and Prevention*, 121, 53–63.
Mouter, N., P. Koster and T. Dekker (2021a), 'Contrasting the recommendations of participatory value evaluation and cost-benefit analysis in the context of urban mobility in-vestments', *Transportation Research Part A: Policy and Practice*, 144, 54–73.
Mouter N., P.R. Koster and T. Dekker (2021b), 'Participatory Value Evaluation for the evaluation of flood protection schemes', *Water Resources and Economics*, 36, 100188.
Mouter, N., M. Ojeda Cabral, T. Dekker and S. van Cranenburgh (2019), 'The value of travel time, noise pollution, recreation and biodiversity: a social choice valuation perspective', *Research in Transportation Economics*, 76, 100733.
Nahmias-Biran, B.H., K. Martens and Y. Shiftan (2017), 'Integrating equity in transportation project assessment: a philosophical exploration and its practical implications', *Transport Reviews*, 37(2), 192–210. https://doi.org/10.1080/01441647.2017.1276604
Nijland, H.A., E.E.M.M. van Kempen, G.P. van Wee and J. Jabben (2003), 'Costs and benefits of noise abatement measures', *Transport Policy*, 10, 131–40.
Nyborg, K. (2014), 'Project evaluation with democratic decision-making: what does cost–benefit analysis really measure?', *Ecological Economics*, 105, 124–31.
Pereira, R.H.M., T. Schwanen and D. Banister (2017), 'Distributive justice and equity in transportation', *Transport Reviews*, 37(2), 170–91. https://doi.org/10.1080/01441647.2016.1257660
Perman, R., Y. Ma, J. McGilvray and M. Common (2003), *Natural Resource and Environmental Economics*, Harlow: Pearson Education.
Persky, J. (2001), 'Cost-benefit analysis and the classical creed', *Journal of Economic Perspectives*, 15(4), 199–208.
Rezaei, J. (2015), 'Best-Worst Multi-Criteria Decision-Making Method', *Omega*, 53, 49–57.
Saaty, T.L. (1990), 'How to make a decision: The Analytic Hierarchy Process', *European Journal of Operational Research*, 48, 9–26.
Sagoff, M. (1988), *The Economy of the Earth: Philosophy, Law, and the Environment*, Cambridge: Cambridge University Press.
Schipper, Y. (2001), *Environmental Costs and Liberalization in European Air Transport: A Welfare Economic Analysis*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
Sen, A. (1979), 'Utilitarianism and Welfarism', *Journal of Philosophy*, 76, 463–89.

Sen, A. (1995), 'Environment Evaluation and Social Choice: Contingent Valuation and the Market Analogy', *The Japanese Economic Review*, 46 (1), 23–37.
Seo, K., A. Golub and M. Kuby (2014), 'Combined Impacts of Highways and Light Rail Transit on Residential Property Values: A Spatial Hedonic Price Model for Phoenix, Arizona', *Journal of Transport Geography*, 41, 53–62.
Small, K.A. and E.T. Verhoef (2007), *The Economics of Urban Transportation*, London: Routledge.
Soria-Lara, J.A., R.M. Arce-Ruiz, A. Arranz-López and A. Ariza-Álvarez (2020), 'Environmental impact assessment for transport projects: a review of technical and process-related issues', in N. Mouter (ed.), *Standard Appraisal Methods, Advances in Transport Policy and Planning,* vol. 6, Amsterdam: Elsevier.
Sunstein, C.R. (1993), 'Incommensurability and Valuation in Law', *Michigan Law Review*, 92, 779.
Tijm, J., T.O. Michielsen, R. van Maarseveen and P. Zwaneveld (2019), 'How large are the non-travel time effects of urban highway tunneling? Evidence from Maastricht, the Netherlands', *Transportation Research Part A: Policy and Practice*, 130, 570–92.
Train, K. (2009), *Discrete Choice Methods with Simulation*, 2nd edition, New York: Cambridge University Press.
Vanclay, F. (2003), 'International principles for social impact assessment', *Impact Assessment and Project Appraisal*, 21(1), 5–12. https://doi.org/10.3152/147154603781766491
Vanclay, F., A.M. Esteves, C.I. Group, I. Aucamp, C. Services and D.M. Franks (2015), *Social Impact Assessment: Guidance for Assessing and Managing the Social Impacts of Projects*, Groningen: International Association for Impact Assessment.
Van Wee, B. (2012), 'How suitable is CBA for the ex-ante evaluation of transport projects and policies? A discussion from the perspective of ethics', *Transport Policy*, 19(1), 1–7.