CEDR

Conférence Européenne
des Directeurs des Routes

Conference of European
Directors of Roads

SPADE

Theory and Practice for Transport Appraisal and Planning: A Literature Review with Focus on Potential Improvements in Practices

Deliverable Number 3.3

02 2019

Panteia
Research to Progress

toi Institute of Transport Economics
Norwegian Centre for Transport Research

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

CEDR Call 2017: Collaborative Planning

Project Nr. 1

Project acronym: SPADE

Project title:

Assessing the added value from **SPA**tial **DE**velopment as a factor in infrastructure planning

Deliverable Nr. 3.3 – Theory and Practice for Transport Planning: A Literature Review with Focus on Potential Improvements in Practices

Due date of deliverable: 28.02.2019

Actual submission date: 01.03.2019

Start date of project: 01.09.2018 End date of project: 31.08.2020

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Version: Final version

Executive summary

The SPADE (Assessing the added value from SPAtial DEvelopment as a factor in infrastructure planning) – project addresses the central question raised by CEDR; *How to achieve integrated project development of infrastructure and its spatial surroundings?* To answer this, CEDR has asked for holistic methods for assessing costs and benefits of combined infrastructure and spatial development in way that adheres to the principles of collaborative planning. This will lead to the development of an assessment tool that (i) assesses the predicted impacts of integrated infrastructure development and (ii) includes relevant stakeholders directly in the assessment process. In doing so, CEDR offers planners a tool to make integrated infrastructure more inclusive and collaborative.

This draft report is the second deliverable in Work Package (WP) 3 of the SPADE project. The objective of WP 3 is to provide an up to date literature review of best practices on the appraisal of integrated infrastructure projects. WP 3 lays the foundation for the development of the SPADE assessment tool conducted in WP 4.

We start in **part 1** by **reviewing the theoretical and empirical foundation of the valuation and types of impacts** resulting from the implementation of transport and spatial development measures. The focus is on impacts not yet included in cost-benefit analysis (CBA; i.e. unconventional impacts, covering economic, environmental, social and public account impacts), since the room for methodology improvement are larger for these impacts. We find an extensive development in the literature on unconventional impacts in recent years, indicating their relatively large magnitude, in particular for the wider economic effects (i.e. agglomeration-, productivity and labour market effects). Yet, large parts of the literature are inconclusive about the valuation methods of the impacts. This suggest that new research is needed to obtain more precise and more reliable valuation estimates that might be used in CBAs or other types of assessments of spatial appraisal and planning.

Next in **part 2** we review literature on **how these impacts are utilized in a collaborative planning process**. Collaborative planning is a planning paradigm that puts the involvement of all stakeholders central in the planning process. In doing so, collaborative planning better accounts for the uncertainty and intersubjectivity of impacts, and their roles in the decision making process. Our review points to computer-based support systems as themost efficient in assessing impacts with stakeholders. This is due to its speed to assess the wide range of impacts that were identified in part 1. In addition, we find that planners need to develop skills to facilitate discussions, as such assessment sessions require many instances of stakeholder interaction.

Then, in **part 3,** we review **impact assessment methods** that deal with the requirements set out in part 1 and 2. CBA is a strong tool for assessing impacts of spatial measures due to its dependence on measurable cost and its ability to illuminate trade-offs, therefore constituting the preferred appraisal tools in national appraisal guidelines. Yet the CBA is limited especially in the assessment of uncertain impacts. This could be handled by supplementary quantitative analyses, multi-criteria analysis (MCA) and various extensions and combinations. There is also a potential to improve the appraisal methods by better integrating stakeholder perspectives, although investigators must be aware of the risk of lobbying and the distinction between impacts on total social welfare and impacts on conclusions.

Part 4 reviews the **practices and recommendations provided in spatial appraisal and planning practices and guidelines** with particular focus on transportation. We start by reviewing earlier studies on guidelines and practices. While inclusion of environmental impacts in general and air pollution in particular was an important focus in the development of the

guidelines up to the turn of the millennium, wider economic impact has become a strong focus over the last fifteen years. Our own mapping shows that the overall coverage in the reviewed guidelines of economic, social and environmental impacts in cost-benefit analyses are rather similar. Supplementary quantitative analyses are most common for economic impacts, while MCA are most common for environmental impacts. The magnitude of wider economic impacts suggest that further research should aim to improve the precision of estimation methods, such that these impact could be included in CBA. Another result of our mapping is the presence of political objective impacts, imply that spatial measures are integrated and help to fulfil other policy objectives. We conclude that guidelines have potential to be more comprehensive, as long as impacts on social welfare are not traded-off with other policy concerns.

In highlighting various impacts and assessment methods, the contingent nature of transport planning deserves extra attention. Above all, the impact to be evaluated and the assessment method to be used depends on the planning project and the knowledge that is available at certain stages in the planning process. In this report we provide both an overview of the current status of the transport appraisal field and discuss the potential for further development.

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1 Introduction

1.1 CEDR Research Programme

This study is a part of the Conference of European Directors of Road's (CEDR) research program, The CEDR Transnational Research Programme. CEDR is the Road Directors' platform for cooperation and promotion of improvements to the road system and its infrastructure, as an integral part of a sustainable transport system in Europe. Its members represent their respective National Road Authorities (NRA) or equivalents and provide support and advice on decisions concerning the road transport system that are taken at national or international level.

The participating NRAs in the **CEDR Call 2017: Collaborative Planning of Infrastructure and Spatial Development** are **Austria, Finland, Netherlands, Norway, Sweden** and the **United Kingdom**. As in previous collaborative research programmes, the participating members have established a Programme Executive Board (PEB) made up of experts in the topics to be covered. The research budget is jointly provided by the NRAs as listed above.

1.2 The SPADE Project

The SPADE (Assessing the added value from **SPA**tial **DE**velopment as a factor in infrastructure planning) – project refers to the central question raised by CEDR on *How to achieve integrated project development of infrastructure and its spatial surroundings?* The project relates to the assessment of an integrated spatial and infrastructure development (issue C in the DoRN). This issue focusses upon the assessment of the added value of the integrated plans and designs, in order to get an insight in the societal relevance of collaborative planning. In order to meet the main objective, a consortium of Panteia (lead), TØI, HaCon and AIT has taken the challenge to develop an assessment method, based upon a literature review and existing knowledge.

The proposed assessment method in the SPADE project is based on a process and a tool:

- The process comprises a description of collaborative planning in which stakeholders from different backgrounds, with different 'wish lists' and different planning procedures need to work together.
- The tool is a combination of a digital workshop and an assessment tool. The assessment tool has been developed for Rijkswaterstaat (NL) and combines a multi-criteria analysis (MCA) with a cost-benefit analysis (CBA).

CEDR seeks inclusive methods for assessing costs and benefits of combined infrastructure and spatial development, building on existing knowledge and including specific contexts such as nation-wide, urban or rural regions. The development of an assessment method puts us for some challenges:

1. There is a need for improved understanding of the relation between spatial and multimodal infrastructure development
2. The question is how to assess the societal value of combined multi-modal infrastructure and spatial development for decision-making on investments. This requires answers to specific questions such as:
    a. How to make an assessment beyond the value-of-time and monetary terms?
    b. How to address topics such as social cohesion or health in the assessment?
    c. How to carefully weigh the different aspects?
    d. How to take the specific contexts (nation, urban and rural) into account?

3. How to capture the added value from combined infrastructure and spatial development and how to translate the added value as a driving factor for infrastructure planning?
4. Mapping of consequences from such an inclusive assessment and capturing added value for the NRAs responsibility for road infrastructure development.

The SPADE assessment method already partially exists and is used by *Rijkswaterstaat*, the Dutch infrastructure manager (see Kiel, Muizer, & Taale, 2015). However, for using it in a process based on collaborative planning it needs to be adapted and extended to meet the requirements listed in the previous subchapter.

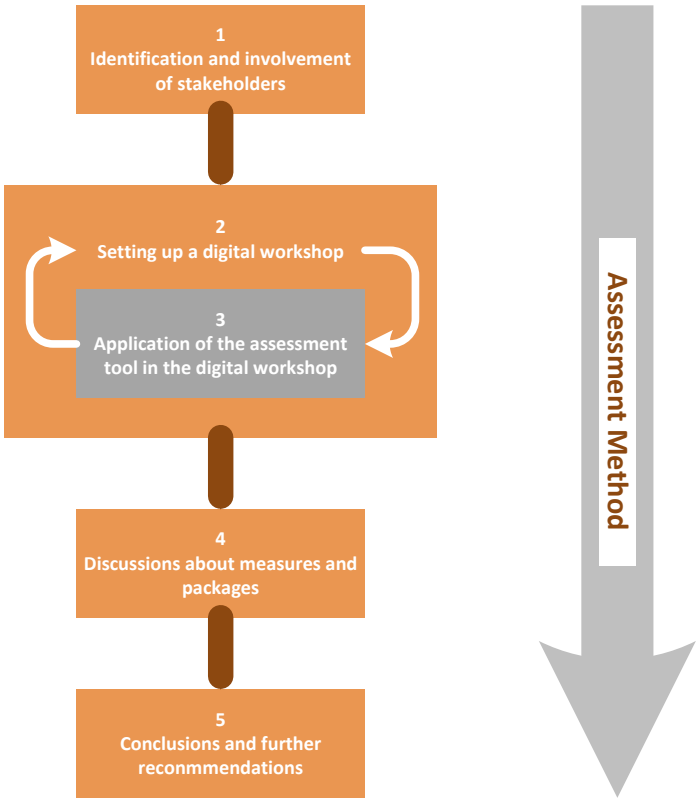


Figure 1-1: The basis of the SPADE assessment method, developed by (Kiel et al., 2014)

The method, shown in Figure 1-1 is based on coordinated steps that include both the process- and tool–side of the planning process. The five steps are

1. Stakeholder identification and involvement;

For the planning of infrastructure and spatial development in a certain area, the stakeholders need to be first identified. After the identification, the stakeholders need to be approached to participate in the collaborative planning process. The stakeholders need to be informed about the policy measures and the stakeholder provides information to the planner as well.

2. Setting up digital workshops for the assessment of policy measures;

The analysis in the previous step forms the basis for the organisation of one or more digital workshop(s), in which the stakeholders will make an assessment of the different policy measures and or packages. The digital workshop involves a discussion about the policy measures that is supported by an electronic discussion tool.

3. Assessment tool for policy measures itself;

The electronic discussion tool assesses policy measures or policy packages on different aspects such as the costs of the measures and the direct impact of the measure on accessibility, environment, safety, quality and the indirect impacts on economy or social value. The results comprise a ranking of policy measures or packages that can be taken a step further in the planning process

4. Discussions about measures and packages between the stakeholders;

The outcome of the digital workshop is base for further discussions and/or more detailed assessments with other instruments. The result of the discussion preferably is a list of policy measures or packages which can be taken into the further steps of collaborative planning.

5. Drawing conclusions and recommendations for the next steps in the planning process

The results of the digital workshop, assessment tool and the discussion should be wrapped up in a brief document with a vision on the infrastructure planning and the spatial development of a region or city. The SPADE assessment method stops here or is used in further round, when more detailed data or insights become available.

While the basis of the method is there, it needs to be expanded to include the current literature on planning impacts, impact assessment methods and collaborative planning methods

1.3 The Objective of the Literature Review

This report is a deliverable from work package 3 in the SPADE project. The task is conducted by TØI (lead), Panteia and AIT. The objective of Work Package 3 is to provide an up-to-date literature review and validation of best practices on the appraisal of infrastructure investments and projects, and their relation with both urban and rural spatial development.

When it comes to the development of the transport system, investment strategies are often based upon a cost-benefit analysis (CBA). However, the broader benefits (or cost) of infrastructure development are not always seen or taken into account and thus not sufficiently considered in planning and evaluation processes. Examples of such ignored effects relate to productivity, agglomeration, economic growth, social value and emissions.

Hence, in the recent years, a bottom-up oriented perspective is emerging with the purpose of reducing the bias stemming from the traditionally used CBA. The former goal is motivated by the ongoing shift toward a more **integrated and strategy-driven approach** (Arts, Hanekamp, Linssen, & Snippe, 2016). Indeed, most of the planners are more aware nowadays that the benefits of one single intervention can be widespread in the whole community and even spill out of its boundaries, so that an inclusive decision-making process is essential for regions, countries and their partners to succeed. Such a broader approach can provide a better basis for agreement on transport investments and contribute to an efficient allocation of investments.

To achieve this, it is required to reorient the position of the traditionally used CBA in the planning process of transport infrastructure. This is done by a state-of-the-art review of best practices on infrastructure appraisal. We base the review on the following four questions:

1. What are the different impacts from spatial development projects and how are these impacts covered by conventional CBA, if at all?
2. What is collaborative planning and how does collaborative planning help to improve the usage of assessment methods in planning processes?
3. What appraisal methods exist alongside and beyond the CBA?
4. How is transport appraisal currently performed in National Guidelines?

1.4 Structure

After this introduction in chapter 1, we first elaborate on the research methodology in chapter 2. We continue with a review on the theoretical and empirical foundation of impact assessment of transport measures in chapter 3. This chapter focusses on impacts that are usually ignored in CBA but however, substantial in size to justify their inclusion. Next, in chapter 4, we discuss the role and potential that lies within the notion of collaborative planning to help to improve the usage of CBA and other assessment methods in planning processes. Then, we discuss alternative assessment methods that better capture the impacts of transport measures in chapter 5. Here, we pay particular attention to the multi-criteria analysis (MCA) and consider the option to combine CBA with MCA. In chapter 6, we discuss how transport appraisal is followed up in practice by reviewing current transport appraisal practices in public guidelines. We draw our conclusions and give recommendations for future assessment frameworks in chapter 7.

2 Research methodology

2.1 Literature Review

The literature review distinguishes between different classes of effects, theoretical and empirical research, methods for calculating or assessing different impacts, and how different these impacts are treated in official guidelines for transport appraisal and their relation with spatial development.

The literature review provides an overview and synthesis of previous research and current best-practice. The review is an objective review of published research literature, official guidelines, technical reports and other written sources relevant to our topic. The DoRN (Direction of Research Needs) outlines the expected output as: A review of the state-of-the-art literature and good practice cases of valuation and capturing of combined spatial and (multi-modal) infrastructure development – taking into account different contexts (urban and rural regional contexts). As outlined in the description of *Topic C* in the DoRN, “an integrated planning approach calls for assessment of infrastructure investments beyond value-of-time, which addresses actual issues and future trends as: climate change, economic development potential, health, social cohesion and the spatial structure for future development of counties, as well as cities and rural regions.”

The literature review should:

1. Identify the key theories, concepts and ideas
2. Distinguish what has been done from what needs to be done
3. Identify how the knowledge on the topic is structured and organized
4. Identify major issues and debates
5. Place the research project in a historical context

We have divided the literature review research task into the following sub tasks, according to the chapters:

1. General literature review on current practice in transport appraisal and/or spatial planning, with a focus on wider economic, social and environmental effects of planning measures.
2. A review of literature on collaborative planning and collaborative planning methods in transport appraisal and spatial development
3. A review of complementary and/or alternative assessment methods, with a focus on MCA and combinations of MCA and CBA.
4. Review of official guidelines for transport appraisal with the aim of identifying broader effects of transport policy measures that are considered important, classifying these effects and their accompanied suggested assessment methods

A systematic review is an explicit systematic method for reviewing literature based on certain predefined criteria by attempting to identify, appraise and synthesize all relevant studies in order to answer a particular question (Gough et al. 2013). In a systematic review, a set of inclusion criteria have to be established in the literature search process. Normally, these inclusion criteria are key words used in the active literature search in the literature databases. Examples of such databases for scientific literature are Google Scholar, Web of Science, TRID and Science Direct. The complete list of the collected literature is found in the reference list.

2.2 Literature Search

The literature search process in a literature review is an iterative process conducted across a series of sources and databases, it is a process that (Avni et al. 2015):

- Collects relevant material
- Merges and refines overall results, and
- Structures the results to add value.

To add to the list of literature contained through the systematic search process, the most common option is to apply snowballing techniques. Forward snowballing implies finding citations to a particular paper, while backward snowballing is to follow the citations in a particular paper. These techniques help adding relevant literature that is omitted by the predefined inclusion criteria. A common "problem" when working with literature reviews is that a search in the literature databases often results in too many papers being found for inclusion in the review. If this is the case, then we impose selection or exclusion criteria. However, there should be a clear rationale behind the selection criteria such as publication year, number of citations, geographical area, etc. If this was the case, we used literature published in the last 10 years, literature that specifically relates to transport infrastructure, or literature covering European cases as selection criteria.

Often there is a need to trim the initial literature search in order to identify what is relevant from the literature and what is not relevant. The retrieved sources can then be organized into three categories according to the relevance for our topic: (1) definitely relevant, (2) possibly relevant, and (3) not relevant. Snowballing techniques are then be applied on the sources categorized as definitely relevant.

As this review covers varies topics which demand different depth of the review, the specific literature search strategy differs per topic. The strategy per topic is summarized in the table below.

Chapter	Topic	Review strategy
1	**Mapping of impacts**	In our assessment of impacts, we have mapped the empirical and theoretical literature on all impacts with focus on valuation, as well as comprehensive reviews. Pioneer, newer, much cited references and impacts mappings are prioritized. Impacts that are large or hard to put a value on are given relatively much attention contra other impacts.
2	**Collaborative planning**	The departure point for this chapter are the authors that brought collaborative planning into the mainstream, most notably (Healey, 2003; Innes, 1998). This is reinforced by a literature review on collaborative governance by (Ansell & Gash, 2007) and other sources familiar to us. For collaborative planning methods, a database search on *(collaborative OR participatory OR communicative OR interactive) AND planning AND (method* OR methodolog* OR tool*)* reveal that the review of 43 collaborative planning methods by (Vacik et al., 2014) was the most recent and comprehensive literature review on this topic. Their work is used as a starting point to discuss these methods.

3	**Assessment methods**	The three main topics of this chapter is CBA, MCA, and combinations of CBA and MCA. For the basics of CBA and MCA recent guidelines and handbooks, e.g., (Transport, 2018), (Dodgson, Spackman, Pearman, & & Phillips, 2009), have been consulted. For finding extensions and variants of MCA methods, one starting point was the review by (Velasquez & Hester, 2013), from which backward snowballing was applied. Additionally, results from searches for *multi-criteria decision making AND transport* were searched for not yet included methods. For finding combinations of CBA and MCA, database searches on (*cost-benefit analysis OR CBA) AND (multi-criteria analysis OR MCA) AND transport* have been performed. The results were filtered by excluding older papers and papers with a low citation count.
4	**Spatial appraisal and planning guidelines and practices**	For this topic, we have mapped much cited references that regards spatial appraisal and planning with focus on transport, as well as earlier mappings of national guidelines. National guidelines are easily found online via the websites of the relevant governmental agencies or through earlier reviews (e.g. Odgaard et al. 2006, Geurs et al. 2009, Mackie and Worsley 2013, Mackie, Worsley and Eliasson 2014, Couture, Saxe and Miller 2016 and Wangsness, Rødseth and Hansen 2017). In order to obtain updated information about impact coverage in the national guidelines for transport appraisal, we have conducted a mapping of 20 spatial appraisal guidelines with focus on transport from 14 independent developed countries. We have review 20 sets of guidelines from 14 independent developed countries. All countries have more than five million inhabitants and belong to the Great Germanic language group (e.g. English, German, Dutch and Scandinavian), where the latter delimitation follow from researchers' primary language skills. Our mapping also emphasizes guidelines four dependent regions (i.e. British Colombia in Canada, New South Wales in Australia and Scotland in United Kingdom), a spatial guideline for the European Union, as well as two distinctive sets of guidelines in the same nations based on different areas of usage (i.e. road and rail for Norway and spatial and transportation for the Netherlands).

Table 2.1: Literature search strategy per chapter employed in this report

2.3 Limitations

In our study, we cover a broad range of empirics, methods, practices and assessment tools in context of transport planning and appraisal processes. This implies that we have not been able to cover everything in detail, but still we provide relevant literature references to readers interesting in a specific topic might pursuit. Specifically, we have focused on impacts, collaborative planning, and assessment methods in the transport sector. Also, we do not go into much detail how the impacts are evaluated but focus more on which impacts can or should be considered. For the assessment methods that use both CBA and MCA we limit ourselves to include CBA and MCA combinations within an integrated approach.

3 Impacts Caused by Spatial Measures

In this chapter, we categorize and provide the theoretical and empirical foundation of impacts from spatial measures, focusing on transport measures. It is important to understand the function and content of the impacts, not only to have a full overview of spatial appraisal, but also to identify potential improvements in planning and assessment methods.

We will focus on efficiency impacts, which concern changes in total social welfare. This opposes distribution impacts, which concern how values are distributed. One might say that efficiency impacts regard the size of the social welfare pie, while distribution impacts regard how the pie pieces are distributed. In some studies, the word 'impact' is applied on a higher and more abstract aggregation level than the word 'effect'. In our study however, we do not ascribe different meaning to these words, but instead use them interchangeably.

Our review captures both conventional and unconventional impacts of spatial measures (i.e. impacts covered and not covered by CBA respectively). Note that wider impacts are sometimes used to describe impacts not covered by CBA (e.g. Australian Transport 2018), but we use it to describe impacts in secondary markets (e.g. DfT 2018). In practice, the contents of these definitions resemblance each other, but they are not coinciding. Most attention will be drawn to unconventional impacts, since potentials for method improvements in transport appraisal and planning is largest for impacts that are not monetized. Economic impacts in secondary markets are given particular attention, because these effects tend to be much larger in theoretical and empirical investigations than other impacts excluded from CBA. Put differently, the most valuable social and environmental effects are already included in CBA.

We begin by classifying the impacts of spatial measures in subchapter 3.1. Thereafter, we review classifications, estimation methods and literature for peculiar effects for economic impacts in 3.2, environmental impacts in subchapter 3.3, social impacts in 3.4 and budget impacts in 3.5. While the distinction between conventional and unconventional impacts among environmental and social impacts are somewhat blurry, most public guidelines for transport planning and appraisal distinguish between conventional economic impacts and unconventional economic impacts both due to the magnitude of and the clear distinction between these effects, and the extensive theoretical framework involved in unconventional economic impacts. Accordingly, we include separate subchapters on the theoretical foundation and empirical evidences on unconventional economic impacts in the subchapter on economic impacts. We end the chapter with some summary remarks in subchapter 3.6, which are taken into consideration in the subsequent chapters and followed up in our conclusions and recommendations in chapter 7.

3.1 Classification of Impacts Caused by Spatial Measures

Spatial measures involve a wide range of impact, and there are many ways to classify them. Oosterhaven and Knaap (2003) suggest a comprehensive division of impacts from investments in transport infrastructure that captures three key dimensions used for impact classification. These are direct and indirect effects, temporary and permanent effects, and market (i.e. supply or demand effects) and non-market effects (e.g. externalities).

Whereas direct effects occur in primary markets (i.e. markets for construction and transport), indirect effects occur in secondary markets (i.e. markets affected indirectly through impulses from the primary markets). Temporary effects are only prevalent in the short run (typically during the construction period), while permanent effects are persistent in a longer time horizon (typically linked to the use of the infrastructure). Market effects might involve supply effects, demand effects or both, while non-market effects involve externalities (i.e. external effects from a market, which the actors in the market does not take into account).

A summarization of Oosterhaven and Knaap's impact classification with examples of effects is given in Table 3.1 below:

Table 3.1: Type of effects of transport infrastructure investments (Oosterhaven and Knaap, 2003)

Type	Recipient	Examples, temporary	Examples, permanent
Direct	**Market**	Construction effects	Exploitation and time savings effects
	Non-market	Environmental effects	Environmental and safety effects
Indirect	**Demand**	Backward expenditure effects	Backward expenditure effects
	Supply	Crowding out effects	Productivity and location effects
	Non-market	Indirect emissions	Indirect emissions

The permanent direct economic effects are linked to the use of the infrastructure and are often the primary reason for making the investment in the first place. The permanent direct effects include the exploitation of time and costs savings from the transport users. The use of the infrastructure will also have permanent effects on inter alia environment and safety. In addition, there will be permanent indirect economic effects related to the backward expenditure effects of the exploration and use of the infrastructure, and related to the production and location decisions of firms and people. Crowding out effects are important temporary indirect effects. Allocating scarce physical and financial capital to a project, may come at the expense of more cost-efficient projects being postponed, which in case would be a welfare loss to society. In addition, there are permanent indirect external effects such as indirect emissions.

In our mapping of effects in this study, we have compiled a practical classification suited for assessment that divide impacts along two dimensions. The first dimension is whether impacts are included in CBA (i.e. conventional impacts) or not (i.e. unconventional impacts). The second dimension is a topical division between economic, environmental, social and public accounts impacts. This classification is chosen, since it is common in the guidelines (e.g. DfT 2018). Economic impacts must here be interpreted in a narrow sense, primarily capturing the production economy. Economic impacts on household are instead recognized as social effects. Socio environmental impacts are recognized as environmental effects rather than social effects, as in most guidelines. Public account impacts involve efficiency cost for public funds related to tax collection and public income generations. The division into four types of impacts is grounded by the recipient of each impact.

- **Economic impacts** are impacts on the **production sector**
- **Social impacts** are impacts on the **household sector**
- **Environmental impacts** are impacts on the **environment**
- **Public budget impacts** are impacts on **public funds**

Our classification resembles the classification in the British guideline for transport appraisal (DfT 2018), which is generally considered best practice among the public guidelines, due to its detail level on effects handled, the methods applied, and the range of transportation means covered (e.g. Gühnemann et al. 2013 and Mackie and Worsley 2013). We do however also include additional effects mapped in our study. Except for separation of wider economic impacts as a separate sort of impact, the British guideline does not distinguish explicitly between conventional and unconventional impacts. Yet, this dimension is implicitly in line with how the guidelines quantify impacts in CBAs (i.e. conventional impacts) or not (i.e.

unconventional impacts).

Table 3.2: Classification of impacts from transport investments and measures based on our mapping

Impacts	Conventional impacts	Unconventional impacts
Economic	Construction, maintenance, time saving for business trips, net income for transport providers and driving costs	Production agglomeration, reduced misuse of market power, increased labour market participation,
Environmental	Local air pollution, global air pollution and noise	Landscape, townscape, biodiversity, heritage and water environment, land contamination and solid waste
Social	Accidents, journey quality, physical activities and time savings for commuting and leisure trips	Security, severance, option and non-option values, service accessibility, affordability, risk of accidents and stress of congestion
Public budget	Tax financing, public income	Tax income related to change in economic activity

3.2 Economic Impacts

While most economists would consider all impacts on efficiency and distribution as economic impacts, public guidelines utilize a narrower definition which limits economic impacts to impacts on the production sector (e.g. DfT 2018). In our review, we make use of the definition applied in the guidelines, since we are interested in how the division is used in practice rather than what the term encompasses from a theoretical point of view.

Classification of Economic Impacts

In the British guideline three type of economic impacts are classified; scheme costs, user and provider impacts and wider economic impacts, which is further broken down to subgroups (DfT 2018). By wider economic impacts we mean impacts in secondary markets caused by market imperfections (as DfT 2018) and not impacts not covered by CBA in general, which constitute an alternative definition used by some authors (e.g. Australian Transport 2018). Yet, whereas impacts covered by CBA mostly concerns impacts in primary markets, impacts not covered by CBA mostly concern impacts in secondary markets, so the two alternative definitions of wider economic impacts are in practice almost similar. Reliability impacts constitute an exception, as they are not monetized in CBA and yet are found in primary markets. Other exceptions are possibly value added or employment impacts in connection to the construction process or in connection with the operation of the infrastructure (e.g. ferries and railways), which might be relevant in rural areas.

- Scheme costs are divided into two categories; investment costs and operational costs:
  - **Infrastructural investment costs** involve costs related to construction, land and property, preparation and administration, and traffic-related maintenance costs.
  - **Infrastructural operational costs** involve costs at roads such as routine and non-traffic related maintenance costs (e.g. drainage, street lighting, fencing, gardening and repainting lines) and train and railway station operating costs (e.g. payroll, fuel and traction and charges for access to railway infrastructure).
- User and provider impacts are divided into impacts on users and impacts on providers:
  - **User impacts** include travel time costs for workers, charges in user charges (e.g. fares, tariffs and tolls) and changes in private transportation costs (e.g. users' vehicle operating costs and reliability).

  - **Provider impacts** include impacts on transport providers' revenues and costs, as well as possible impacts on employment and value added directly related to the infrastructure.
- Economic impacts in secondary markets include employment impacts, induced investment impacts, productivity impacts and more.
  - **Induced investment effects** include dependent development and output change in imperfectly competitive markets.
  - **Productivity impacts** include agglomeration impacts (e.g. improved matching of outputs and inputs, sharing of resources and markets) and competition impacts (e.g. competitive firm selection, disciplinary competition and reduction in market power exploitation).
  - **Other wider economic impacts** not mentioned by DfT (2018) include impacts on capital and land.

Studies on Conventional Economic Impacts

Construction costs often constitute the major cost component in spatial investment appraisal. Although direct costs generally are easier to quantify, there are still challenges related to estimation of construction costs including uncertainty related to price development, process costs, project complexity and timing. Elfaki, Alatawi and Abushandi (2014) survey studies estimating construction costs ex ante, while Peurifoy and Oberlender (2002) and Wilmot and Cheng (2003) address ex ante estimation of various constructions and buildings, and highways respectively. Operational costs for infrastructure are typically easier to estimate, so the recent literature focus more on optimization of operations. Sultana, Rahman and Chowdhury (2010) address optimal maintenance contracting, surveying 62 published reports and journal articles. Reviewing cost-effectiveness of railway infrastructure renewal maintenance, Grimes and Barkan (2006) find indications that maintenance strategies that put more weight on renewal involve lower unit maintenance costs. More concretely, their results imply that higher maintenance expenses will more than offset temporary reductions in capital spendings, when railroads constrain renewal maintenance to reduce overall capital expenditures. Islam and Buttlar (2012) address the impact of sidewalks roughness on user costs.

On the user side, travel time savings constitute an important component, which also require value estimation to quantify properly. The unit values of time savings vary over transportation modes, trip purpose (e.g. work trip or not work trip) and trip length, as well as trip components such as walking, waiting queue, and transfer time and in vehicle time in public transport. Value of travel time is also dependent on heterogeneity in a population caused by observed (e.g. income, age, gender) and often unobserved variables. Becker (1965) provided an early theoretical contribution followed by scholars such as DeSerpa (1971) who provided theoretical framework for valuation of travel time saving. Empirical studies of value of travel time savings (VTTS) relies mostly of discrete choice theory (Train 2009) While VTTS studies before the 1980s typically relied on revealed preferences data on route choice, recent studies have primarily adopted a stated preference approach (see for example Hensher 1994 or Small 2012 for overviews). More recent reviews on empirical issues related to travel time savings are provided by Li, Hensher and Rose (2010), Carrion and Levinson (2012), Wardman (2012) and Zamparini and Reggiani (2016). Zamparini and Reggiani (2007 and 2016) review empirical evidence on the value of travel time savings in freight transport, while Shams, Asgari and Jin (2017) review empirical evidence on travel time reliability for freight transport.

Steg and Gifford (2005) assess trade-offs between individual short-term gains by car users at the cost of long-term losses to society, arguing that negative externalities outweigh values of transport. Börjesson (2012) conduct a state choice experiment, drawing four different types of environment to investigate how various factors in a built physical environment influence valuation of walking time to public transport. These estimates are used to identify policies that could improve perceived reliability among the population. She identifies systematic variation in the value of walking time, depending on physical environment, especially for women. She

shows how the welfare loss associated with uncertainty in public transport supply might be quantified. Other user studies on economic user impacts focus on optimal toll (e.g. Odeck and Kjerkreit 2010, Lindsey 2012 and Meng, Liu and Wang 2012) and change in user costs that follows from new vehicle technologies (e.g. Delucchi and Lipman 2001 and Propfe et al. 2012).

Impact on transport providers by spatial measures are relatively straight-forward to estimate (see for instance Fridstrøm et al. 2000 or Small 2004 for overviews). One part of the literature on transport providers focuses on demand for public transport (e.g. Paulley et al. 2006 and Balcombe 2006; see Holmgren 2007 for an overview), while another part address designing optimal transport routes (e.g. Silman, Barzily and Passy 1974, De Cea and Fernández 1993, Pattnaik, Mohan and Tom 1998 and Fan and Machemehl 2006). Yet another part of this literature, focuses on the cost side of public transport provision and the related subsidies (e.g. Buehler and Pucher, 2011, Pucher, Markstedt and Hirschman 1983, Jakob, Craig and Fisher 2006, Tirachini, Hensher and Jara-Díaz 2010 and Lindsey 2012).

Duranton and Turner (2012) investigate the connection between the size of the road systems and travelled distances in American cities. They find that vehicle kilometres travelled increases proportionately to roadway lane kilometres for interstate highways due to increases in driving by current residents, commercial traffic and migration. They find little degree of substitution between types of road and little evidence that provision of public transportation affects vehicle kilometres travelled. Other notable contributions that address direct transport cost savings caused by infrastructure investments include Shirley and Winston (2004) and Venables (2007).

Theoretical Foundation of Unconventional Economic Impacts

In recent years, wider economic impacts have obtained particular attention in the research literature on effects from transport investments and other transport measures. The reason is that the impact of these effects are much larger than other impacts that have been omitted from cost-benefit analyses. Many economists have stressed the importance of developing reliable estimation methods and including them in cost-benefit analyses (e.g. Venables 2007, Vickerman 2007, and Banister and Thurstain-Goodwin 2011). In the following, we will give the wider economic impacts a special focus due to their magnitude and development potential and the need for a more comprehensive appraisal framework for these impacts.

CBAs are usually conducted as partial market analyses in which the effect in the primary market (the transport market) is assessed partially, while all prices in the secondary (adjacent) markets are assumed to remain constant. Assuming perfect markets, all relevant benefits in the CBA are captured in the calculated transport user benefits (Dodgson, 1973 and Jara-Diaz, 1986). These permanent direct effects from the use of the infrastructure on the production economy are related to user and provider costs (see for instance Oosterhaven and Knaap 2003). In a perfect competitive environment, indirect effects in the secondary markets will equal direct user benefits in the primary market. However, this is not equivalent to infrastructure investments not producing net ripple effects in the economy. Infrastructure investments will produce effects in secondary markets, even in a perfect competitive environment, but these will by default perfectly equate the direct user benefits measured in the primary market. Adding spill-over effects in a perfect competitive environment will therefore only result in double counting (Mohring, 1993). It might also be that the actors in the economy do not internalize potential benefits of economic congestion, when adapting to the product and factor markets.

In case of distorted secondary markets, the direct user benefits no longer equal the total benefits of a project. In situations characterized by deviations from the first-best solution, with prices exceeding marginal cost in secondary markets, market imperfections will produce benefits in secondary markets not cancelling out. There are many reasons for market imperfections, the most common being taxes and subsidies and market power, where, for example, economies of scale may lead to unregulated market power in product markets. Thus, in taking only the direct effects of a project into account, project appraisal may be an over- or underestimation of the total project specific benefits (Harberger, 1964 and SACTRA, 1999),

which in turn could lead to suboptimal public investment strategies.

In the event of prices in secondary markets not equalling marginal cost, the most important welfare effects not captured in a traditional and well-specified CBA are, according to SACTRA (1999) agglomeration externalities (i.e. external synergies of economic congestion over time), labour market effects, and impacts in markets with imperfect competition. Department for Transport (2018) have the same list except for mentioning productivity impulses instead of agglomeration economics. This modification has some appeal, since productivity impulses are the most substantial agglomeration impact (both reflected by theory and empirics), and since productivity impulses might also occur for other reasons (e.g. increased competition). In addition, capital market for financial capital and mobile fixed capital (e.g. equipment, machines, means of transportation and immobile capital) might have similar impacts as labour market, although somewhat less prevalent. Another group of substantial wider economic impact also treated by some guidelines are impacts on land use and prices of land and immobile fixed capital (e.g. buildings and construction). Impacts on the markets for labour, capital and land can together be referred to as factor input impacts.

Productivity Impulses, Agglomeration Externalities and Competition Impulses

Economic performance is statistically correlated with geographic concentrations of economic activities. While the traditional studies offer localization selection as an explanation (e.g. Krugman 1991, Fujita and Thisse 1996 and Martin and Rogers 1995), most economists today recognize that economic congestion might enhance higher economic performance by itself (e.g. Graham et al. 2010 and Behrens, Duranton and Robert-Nicoud 2014).

Theorists offer possible explanations for a potential causal linkage from agglomeration to productivity by agglomeration arguments (e.g. sharing, matching and learning), competition arguments (e.g. firm selection, disciplinary effects and less misuse of market power) and other arguments about traveling cost reductions. The different rationales are not mutually exclusive, but may coexist and explain different portions of the aggregate productivity impact. Different mechanisms might also come in to play at different level of aggregation, considering that productivity impulses from increased economic congestion might both be a result of improved productivity within firms and reallocation of factor inputs between firms. In general, the rationales of productivity impacts from transport investments are not mutually exclusive but might coexist and each explain portions of aggregate productivity impulses. In addition, reallocation of input factors in production might contribute to higher productivity, although firm performance remains the same.

The argument about firm selection can be found in Melitz and Ottaviano 2008, building on Krugman's (1980) monopolistic competition model. They argue that higher average productivity of firms and workers in dense populated areas can be a result of stronger Darwinian selection of firms. Similar arguments could for instance be found in Fujita (1988) and Behrens, Duranton and Robert-Nicoud (2014). Other types of potential productivity impulses from increased competition include disciplinary competition effects and reduction in misuse of market power. Regional integration caused by infrastructure investments may also induce transportation cost reductions directly related to the actual transportation processes (e.g. Shirley and Winston 2004 and Venables 2007).

Agglomeration is the process of congestion of economic activities, while externalities are impacts not take in to account by the source (e.g. persons or firms). Improving transport networks may increase regional effective density by bringing firms and people closer together. Arguments about agglomeration synergies can be traced all the way back to Marshall (1890), who study labour market pooling, input sharing and knowledge spill-overs. Still, there are several types of agglomeration effects that Marshall does not discuss, including natural advantages, home market effects, urban consumption opportunities and rent seeking (Rosenthal and Strange 2004).

A refined version of the agglomeration argument can be found in Duranton and Puga (2004). They distinguish between three agglomeration effects; sharing, matching and learning. Shorter distances and traveling time lead to sharing of larger product markets, factor markets and common goods. Consequently, more firms obtain scale and scope advantages, which in turn will stimulate firm-level productivity (e.g. Aschauer 1989 and Eberts and McMillen 1999 for common goods; and Rivera-Batiz 1988, Berliant, Reed and Wang 2006, Bernard, Moxnes and Saito 2014, Davis, Fisher and Whited 2014 and Holmes 1999 and Eeckhout, Pinheiro and Schmidheiny 2014 for buyer-purchases relations).

In areas with a low economic density, the matching of employers and employees is predicted to be less efficient than in areas of high density. This means that, as density increases, firms can have better access to workers with certain specialized skills and workers have a better chance of finding a job that suits their set of skills (e.g. Rivera-Batiz 1988, Helsley and Strange 1990, Wasmer and Zenou 2002, Combes, Duranton and Gobillon 2008 for labour; and Coval and Moskowitz 1999 and 2001 and Petersen and Rajan 2002 for capital). Note that increased economic congestion could increase the consumer surplus related to traveling beyond what is reflected in wages, for instance in terms of better access to public goods (e.g. Aschauer 1989 and Eberts and McMillen 1999) and consumer product diversity (e.g. Dixit and Stiglitz 1977 and Rivera-Batiz 1988).

Furthermore, high density of firms helps provide a faster and more extensive exchange of knowledge (i.e. learning), than what arises from ordinary market transactions. Thus, the cost of transfer and adaptation of skills and technology become lower (see also Glaeser et al. 1992, Glaeser and Maré 2001, Moretti 2004 and Berliant, Reed and Wang 2006 for technological spill-overs; and Diamond and Simon 1990, Helsey and Strange 2002, Carlino and Kerr 2015 and Davis and Dingel 2015 for knowledge specialization).

Implementation of major infrastructure projects for transportation may involve increase in economic congestion in terms of decreased traveling distances between economic actors. Moreover, regional integration will tend to decrease each economic actors' costs of interactions and increase the amount of possible beneficiary interactions with other firms and individuals in the surrounding areas. Such an increase in agglomeration may contribute to higher national wealth if it stimulates factor inputs to move to areas with higher factor return or result in higher regional income. Higher regional income could be a result of commuting to neighbouring regions with higher factor return or higher factor return locally.

Eaton and Kortum (2003) and Donaldson and Hornebeck (2016) have established general equilibrium models that capture the economic benefits from increased market access. Conversely, there might be sorting mechanisms where some regions loose high-end factor inputs and scale effects to other regions, and thereby experience a negative impulse from agglomeration impulses nearby (see for instance Kanemoto 2013a and 2013b and Behrens, Duranton and Robert-Nicoud 2014). Thinking in terms of a general equilibrium framework, positive impulses for an industry at one location might also lead to displacement of activities in other regions further away, as well being beneficiary for customers in other regions.

Impulses from economic activities nearby also decrease over traveling time, a phenomena known as 'agglomeration decay'. Sevtsuk and Mekonnen (2012) explore various measures for network centrality that might be utilized in further investigations of such nonlinearities. Different aspects related to agglomeration decay are reviewed by Graham, Gibbons and Martin (2010), Sevtsuk and Mekonnen (2012) and Redding and Rossi-Hansberg (2017).

Transportation network and economics of scale is also important for industry structure over space (e.g. Krugman 1991). Burmeister and Colletis-Wahl (1997) point out that non-material flows become more important when transportation costs are at a low level. They argue that transportation infrastructure in a network economy can be considered as resource for circulation. Banister and Berechman (2001) argues that a combination of agglomeration externalities, complementary political environment and investment design that supports

network effects is needed to obtain growth impulses from investment in infrastructure projects. New road constructions different impacts on national welfare through agglomeration are most often analysed separately, but some authors have built model frameworks that compile some of the effects (confer Krugman 1991, Venables 2007, Lakshmanan 2011, Behrens, Duranton and Robert-Nicoud 2014 and Davis, Fisher and Whited 2014 for example of models; confer Duranton and Puga 2013 for a review).

Factor Input Market Effects

The scientific literature highlights several labour markets effects from investments in transport infrastructure that might lead to higher social welfare (e.g. Manning, 2003, DfT 2018, Elhorst and Oosterhaven 2008, Laird and Mackie 2014, and Venables, 2007). These include:

- **Commuting and labour market participation:** Changes in the number of workers choosing to work as a result of lower commuting costs or changes in the number of hours worked as a result of changes in commuting costs
- **Productive re-localization of labour:** Reallocation of labour to more productive sectors or more productive areas
- **Labour market competition and participation:** Reduction in employers' market power in 'thin' labour market and potential impact on excess supply in the labour market
- **Capital market impacts:** Reallocation of financial capital and mobile fixed capital to more productive sector and regions
- **Land impacts:** Land use and prices of land and immobile fixed capital

The labour market is typically subject to several market imperfections, among them distortionary taxation, imperfect information and imperfect competition with asymmetric relations in wage negotiations. In context of the labour market, distortionary implies that workers make their choices based on net wages, the productivity gains for society equal their gross wages, which imply an efficiency loss. Accordingly, Venables (2007) points out that the benefits of increased wages do not fully accrue to the workers, they will not be fully captured by the consumer surplus. If workers do not fully take into account that productivity and wages might raise, when relocating, the wedge between the workers' realized and social optimal adaptions to the labour market will be even higher. We refer to subchapter 3.5 for a discussion on the efficiency implications of tax collection.

Involuntary unemployment implies that the wage level is above and the unemployment rate is below the equilibrium in the labour market. In this case, some unemployed are willing to work at the prevailing wage without getting a job. If employment increases due to infrastructure investments, the gain in social welfare will be larger than the user benefit associated change in commuting costs. Such gains challenges CBA's presumptions that involuntary structural unemployment is not relevant for mature transport networks (Laird and Mackie 2014).

In rural areas, labour markets are often thin, possibly giving the local firms market power over workers (Manning 2003). The rate of market power exploitation will then drive the wedge between the workers' marginal productivity and marginal costs. From the employers' point of view, increased wage levels will provide less incentives to hire new workers, despite the fact that the productivity raises. Laird and Mackie (2014) provide an overview over wider economic impacts in rural areas and possible inclusion of such impacts in spatial appraisals. Since infrastructure improvements may lead to lower searching costs for unemployed and employers, as well as employees and employers, improved matching in the labour market will decrease the information distortion in the labour market. This impact will involve additionality in the commuter benefits beyond the CBA (Pilegaard and Fosgerau 2008). Matouschek and Robert-Nicoud (2005) argue that larger labour markets increase the incentive for workers to improve their productivity by acquiring skills without the danger of being exploited by employers with market power.

By the same token, road construction may lead to more capital investments in the areas subject to the investments. Improvements in the labour market might also affect the optimal allocation of fixed capital and increase the capital return at the margin. Since capital investments are more mobile, and the capital share of value added are lower than the labour share. More knowledge on capital markets might also lead to a home-market bias (e.g. Coval and Moskowitz 1999 and 2001, Petersen and Rajan 2002 and Herpfer, Schmidt and Mjøs 2016)

Whereas financial capital and mobile fixed capital (e.g. equipment, machines, means of transportation and immobile capital) might easily be reallocated over regions, land and immobile capital (e.g. buildings and constructions) remains put. Land, buildings and constructions are not only consumed as factor inputs, but largely consumed by the household sector. Investment in transport infrastructure can affect real estate prices, typically by increasing prices in more connected areas. Such asymmetric price changes over areas within a region will stimulate to new optimal land use and affect the spatial organization of an area, enabling workers to live further away from a concentration of work places. Nevertheless, laissez faire development in land use might break with other concerns and objective in land policies, so land regulations might mitigate such development paths. Increased real estate prices does not by itself constitute an efficiency impact caused by spatial measures and might indirectly be captures by measurement of other impacts (e.g. accessibility and personal affordability in MCA and productivity impulses in assessment of wider economic impacts). However, increased real state price might capture higher return on land locally, and costs of agglomeration for the household sector related to congestion in the housing market might not be fully captured. See for instance DiPasquale and Wheaton (1996) and McDonald and McMillen (2011) for an overview over the literature on agglomeration, land use and land prices.

Impacts in Markets with Imperfect Competition

In rural areas, absence of a functioning and well-developed infrastructure might act as an entry barrier to goods and services. Laird and Mackie (2014) argue that investments in transport infrastructure that increases accessibility and lower transport costs might lead to more firms entering the markets for goods and services, which will increase social welfare beyond what CBA captures.

Jara-Diaz (1986) designs a model with two regional monopolists producing a homogeneous good and facing travel costs when exporting to the other region. He shows that reduced transport costs will enable monopolists to sell their good in the other region by lowering their product price. Consequently, the production and the deadweight loss associated with limited competition increases. An infrastructure improvement may reduce the marginal cost of production for a profit maximizing monopolist. The monopoly equilibrium is characterized by marginal cost equalling marginal income, and when the marginal cost of production falls as a result of improved infrastructure, the quantity produced will rise. This will result in welfare gains not fully accounted for in the CBA. Enhanced regional productivity and market efficiency may also lead to regional specialization in line with comparative advantages (e.g. differences in technology and input factor composition). This might increase intra-industry trade and reduce unit freight costs (Lakshmanan and Anderson, 2002).

Rouwendal (2002) study a regional monopolistic competition model, which involves product differentiation over heterogeneous products and consumers' love of variety. Under such conditions, producers will hold market power over consumers. A reduction in transport costs enables producers explore their economies of scale by expanding their geographic market, which in turn increases the consumer surplus due to consumers' appreciation of product variety.

Empirical Evidence of Wider Economic Impacts

After many years with scientific debate and increasingly more overwhelming empirical

evidence, the economic geography literature has reached a consensus on the causal linkages from economic congestion to productivity and labour market participation (see for instance Graham et al. 2010 and Behrens, Duranton and Robert-Nicoud 2014). Whereas older studies of the topic often are macro oriented, new studies focus increasingly on firm-level evidences and causal identification, often also being more convincing than previous work. There is still some empirical scepticism (e.g. Deng 2013 and Kiel et al. 2015), but this is largely linked to the magnitude of the effects and in which circumstances they prevail. Due to new empirical evidences, most developed countries have either included wider economic impact in their transport appraisal guidelines or at least acknowledge their existence (confer 6.2). In this subchapter, we will review some of the empirical evidences on wider economic impact.

The standard approach to estimating the impact of agglomeration externalities on economic output has been to use a production function framework, see Melo et al. (2009) for a review of 729 elasticity estimates from 34 studies covering the period 1965 to 2002. Melo et al. (2009) show that the findings in the literature on the relationship between agglomeration and productivity differ substantially, depending on sector, geography and method of measurement. They find that average elasticity of productivity with respect to the magnitude of the functional city area is 0.058. Presence of controls for both unobserved cross-sectional heterogeneity and differences in time-variant labour quality may give rise to large differences in the results. Correction for reverse causality of agglomeration does not appear to change the urban agglomeration estimates noticeably. The authors' review also indicates that the impact that the agglomeration impact is stronger in service industries than manufacturing industries, a finding supported by other studies (e.g. Graham 2007, Glaeser and Gottlieb 2009, Graham, Gibbons and Martin 2009, Combes et al. 2012, Deng 2013 and Holl 2016).

Rosenthal and Strange (2004) find similar results in a survey of cross-sectional evidences on productivity effects, with average elasticity of productivity with respect to city size of between 0.04 and 0.11. Similar findings with elasticities around five percent are found in newer studies (Behrens, Duranton and Robert-Nicoud 2014 and Davis, Fisher and Whited 2014). In a cross-sectional study, Ciccone (2002) finds that the elasticity of labour productivity with respect to employment density is 4.5 percent at average in Europe, compared to 5.0 percent in the US. Rice, Venables and Patacchini (2006) find that doubling the working age population in a given area is associated with a 3.5 percent direct increase in productivity, while the occupational composition effect is not robust to different model specifications.

In case of increased economic congestion, the strength of different underlying agglomeration and competition effects will depend on industry and geographical configuration. Investigating agglomeration impacts on sharing of ideas, goods and labour in industries collocated in the US, Ellison, Glaeser and Kerr (2010) evidence for all three Marshallian agglomeration impulses with input-output linkages being the most important. Data for UK industries and from US areas where the two industries are not collocated are used as a control to reduce possible reverse causality. In line with Ellison and Glaeser (1999), they also assess the expected co-agglomeration of each industry pair caused by the uneven spatial distribution of natural advantages.

Applying an empirical spatial general equilibrium model with heterogeneous firms, Gaubert (2018) finds that nearly two thirds of the observed higher productivity in cities than rural areas is due to firm sorting. She finds that political actions that decrease local congestion increase aggregate total factor productivity and welfare, while regional policies for rural areas have negative aggregate effects. Behrens, Duranton and Robert-Nicoud (2014) applies a calibrated regional economy model to study regional productivity differences. By the same token as Gaubert, they find support for geographic reallocation of economic activity caused by agglomeration and vice versa, where firm and individual sorting and agglomeration effects complements each other. Their results are based on calibrated model. Studying trade between cities in the context of US interstate highways, Duranton, Morrow and Turner (2014) find that cities with a more highways specialize in sectors producing heavy goods.

A growing literature has documented productivity effects from agglomeration by decreasing travel times through road constructions. Until recently, studies of wider economic impact of infrastructure of transportation were typically macro studies (confer Melo, Graham and Brage-Ardao 2013 for a review). For instance, Aschauer (1989) finds in an early study that infrastructure for transportation and water systems are the types of public capital yielding the highest productivity impact. Since the turn of the millennium, research on wider impacts from infrastructure projects has become more micro-oriented. Several researchers find that highways attract economic activities, thereby increasing local economic activities (see for instance Chandra and Thompson 2000, Holl 2004 and 2016, Duranton and Turner 2012, Gibbons et al. 2016; confer Redding and Turner 2014 and Combes and Gobillon 2015 for reviews).

Graham et al. (2010) explore the causal linkage between productivity and road investments in United Kingdom, using a panel vector autoregressive model. Their results indicate that both localization and urbanization Granger cause productivity, and vice versa. Combes et al. (2012) apply a nested model of selection and agglomeration synergies, which utilizes productivity distributions over area densities, on a French panel data set from 1994 and 2002. The authors find that firm selection is not enough to explain spatial productivity differences alone. Aggregate productivity is not only determined by firm-level productivity, but also the development in employment in firms and regions. Faber (2014) studies the economic impact of the Chinese national highway system on the economy in rural counties. In his instrumentation strategy for causal identification, he exploits non-random route placements on the way between targeted city nodes based on the construction of least cost path spanning tree networks. His results suggest that network connection have led to reduced value-added growth among non-targeted peripheral counties due to reduction in industrial output growth in these areas and reduced trade costs between peripheral and metropolitan regions.

Utilizing planned portions of the interstate highway system as a source of exogenous variation, Baum-Snow (2007) find that new highway passing through a central city in United States reduces its population by about 18 percent. Duranton and Turner (2012) find that a ten percent in a city's initial stock of highways causes about a 1.5 percent increase in its employment over a twenty years' period. Studying four Dutch maglev line projects Elhorst and Oosterhaven (2008) estimate involuntary unemployment's additionality compared to user benefits in CBA to be in the range minus one percent to plus 38 percent.

Holl (2016) finds support for productivity effects from Spanish highways, investing firms traveling distance to the highway network, particularly in urban areas and for manufacturing firms. As sources for exogenous variation, she exploits ancient Roman routes, assessments of geodesic market potential from 1900 and geological conditions. Gibbons et al. (2016) find that new road infrastructure in United Kingdom provide positive employment effect for small-scale geographical areas, while productivity increases in other areas with negative employment effects. The authors interpret their results that new transport infrastructure attracts transport intensive firms to the local area from other areas. They address the possible reverse causality challenge related to road constructions by fixing travel times within buffer zones over time. Combes et al. (2010) find that reverse causality from productivity to agglomeration is a minor problem in practice.

Some studies substantiate that the agglomeration effects decline with travel time. Rice, Venables and Patacchini (2006) find that the effect of proximity on productivity decline steeply with travel time, ceasing to be important beyond approximately 80 minutes. By the same token, Duranton and Overman (2005) find positive effects from collocation within 50 kilometres. A similar result is found by Graham, Gibbons and Martin (2010) and Rosenthal and Strange (2003). Graham, Gibbons and Martin (2010) also establish that the effects of agglomeration on productivity diminish less rapidly with travel time for manufacturing firms than for service firms, while Rosenthal and Strange (2003) find that industrial structure and corporate organization affect the clustering benefits within a given industry, in line with the finding of

Saxenian (1994). In an early contribution, Hansen (1959) demonstrate how economic gravity could be assessed in a logistic market potential framework.

Bernard, Moxnes and Saito (2015) find that Japanese high-speed train line improves firm performance through decreased travel time, inter alia by contributing to new wholesaler-retailer links and lowering cost of passenger traveling without increased shipping costs. Shirley and Winston (2004) find that highways reduce firms' logistics costs by reducing the inventory stocks. Similar results are found by Datta (2012) and Li and Li (2013). Investigating Canadian manufacturing establishments operating over the period from 1989 to 1999, Brown (2013) find that young, small, domestic and single-plant firms in general obtain more agglomeration gains than older, larger, foreign-controlled and multi-plant firms do. His empirical results suggest that the former group obtain stronger productivity gains from the matching of workers and knowledge spill-overs, whereas the latter group obtain stronger productivity gains from the presence of upstream input suppliers.

Studying area development in United States, Carlino and Saiz (2008) finds that areas with improved access to cultural facilities and recreation have better real estate price deployment than other areas. They also find that these areas tend to attract highly educated individuals and economic activities, as opposed to generally declining trends in the central areas of American cities. Addressing housing production in France by a nonparametric approach, Combes, Duranton and Gobillon (2017) estimate an elasticity of housing production with respect to nonland inputs of about 0.80. Again, applying a nonparametric approach and considering house and land prices as costs of agglomeration, Combes, Duranton and Gobillon (2016) estimate the elasticity of urban costs increases with city the elasticity of urban costs with respect to city population. They find elasticities around 0.03 for urban areas with 100,000 inhabitants and around 0.08 for urban areas of the size of Paris. Mohammad, Graham, Melo and Anderson (2013) provide a meta-analysis on rail projects' impact on land and property prices. Cheshire and Sheppard (2002) address the welfare implications of land use planning.

3.3 Environmental Impacts

Environmental impacts from spatial measure include pollution from the construction phase and from the use of the finalized infrastructure, as well as indirect effects related to change in activities with environmental impact.

Classification of environmental impacts

Environmental user goods involve production, consumption or resource extraction, while non-environmental non-user goods involve concerns about other livings and species. In addition, environmental awareness and commitment might be grounded in concerns for future generation's well-being (e.g. Perman et al. 2003).

The UK guideline for transport appraisal distinguishes between two main categories of environmental impacts from transport investments, which we will refer to as environmental traffic impacts and environmental area impacts. Traffic impacts are impacts that arise from change in traffic such as noise, local air pollution and global air pollution. Environmental area impacts are impacts that arise in surrounding areas as a result of new improved infrastructure and associated spatial development including impacts on landscape, townscape, biodiversity, heritage and water environment (DfT 2018). Albeit, landscape impacts might be estimated in supplementary analyses. Generally, environmental traffic impacts are more captured and quantified in the current CBA frameworks than environmental area impacts. Defining unconventional environmental impacts of transport investment and other spatial measures as recognized environmental impacts not captured by CBA therefore largely coincides with environmental area impacts. Land contamination and solid waste are not recognized as separate impacts in the British guideline, and could also be classified as unconventional impacts.

Impacts related to social environment, such as heritage and townscape, are classified as environmental impacts in most national guidelines for transport appraisal. We recognize that these impacts alternatively could be classified as social impacts, however in our review we have chosen to follow the convention of the guidelines. Environmental impacts from spatial impacts are also interconnected with other sorts of effects. For instance, more economic activities might involve more pollution, while more pollution might have health impacts.

Approaches to valuations of environmental impacts

The literature on environmental impacts from spatial measures is relatively fragmented, but lessons from more general guidelines for environmental impacts are largely transmissible (see for instance Glasson and Therivel 2013 for the British guideline and Wood 2003, Morgan 2012 or Wathern 2013 reviews).

How environmental effects are valued depend on the valuation perspective that is taken. The two wing perspectives are anthropocentrism, where nature is valued in accordance with material or physical benefits for humans, and ecocentrism, where nature is valued for its own sake (see for instance Singer 1977 or Thompson and Barton 1994). Environmental valuation in CBA are built on how human societies value nature, which will be something in between these perspectives. Typically, environmental values will be based on aggregated willingness to pay (i.e. the amount you are willing to pay for an improvement in environmental quality) or willingness to accept (i.e. the compensation you need to accept a reduction in environmental quality). This is often done under assumption that all individuals have the same ability to pay as the average inhabitant. Thus, inclusion of ecocentric will depend on the population's environmental attitudes and concerns. Environmental user goods are often estimated by revealed preference methods, while stated-based preference methods often are used for environmental non-user goods. Important valuation methods include contingent valuation (e.g. Loomis 2005 and Arrow 2001), choice experiments (Hanley, Wright and Adamowicz 1998), travel cost method (e.g. Loomis 2005), hedonic pricing (e.g. Garrod and Willis 1992), production and cost function-based techniques (e.g. Hueting 1970 and Hueting et al. 1998). General overviews over environmental valuation methods are given by inter alia Garrod and Willis (1999), and Perman et al (2003).

Studies on particular environmental impacts

Brown and Raymond (2007) examines the relationships between place attachment and landscape values Otways region in Australia, both in terms of psychometric attributes (following Williams and Vaske 2003) and in terms of spatial attributes (following Brown 2005). They introduce a map-based place attachment index and suggest that survey-based measures of landscape values and special places can be utilized in assessments of risk associated with landscape modification. Kaltenborn and Bjerke (2002) assess the environmental value of landscape and environmental value orientation in case of the Norwegian town of Røros. They find that the highest preferences were expressed for wildland scenes containing water, followed by cultural landscapes and traditional farm environments, and landscapes with elements of modern agricultural practices as the least preferred. They found that people with an ecocentric value orientation tended to ascribe relative larger value on wildlands with water, and for cultural landscapes, while people with anthropocentric value orientation tended to ascribe larger weights on farm environments. Overall, the local population tend to agree with the ecocentric statement and to be neutral towards anthropocentric statements, which Kaltenborn and Bjerke interpret as an indication for acceptance of inclusion of ecocentric arguments in local development and conservation plans. De Vries et al (2013) show highly valued areas could by identified exploiting Google Maps at Dutch landscapes. They find that highly valued areas typically are related to water or vegetation based with small proximity to settlements with relative much tourism and population.

Hubbard (1993) points out that despite of support of the psychological and aesthetic value of the conserved environment, there is limited certain knowledge on people's conscious or

unconscious commitment to buildings from the past or those being constructed today. In his literature review on conservation value, he highlights the dangers associated by neglecting the role of townscape for cultural identities and solely focusing architectural and historical criteria in conservation processes. Choi et al (2010) show how choice modelling techniques often applied within environmental economics could be utilized to value cultural heritage, valuing different attributes of Old Parliament House in Australia. Navrud and Ready review how environmental valuation techniques are transferable to valuation of cultural heritage.

The anthropocentric and ecocentric perspectives are also relevant for measuring the impacts on biodiversity from spatial measures. In his environmental orientation 'deep ecology', Næss (1973 and 1990) extents the ecocentrism to ascribes value to living species beyond own-value not only to creatures and individual livings. Another influential critic of the anthropocentric approach to environmental ethics is Singer (1977), who argue in favour of utilitarian ethics with comprises utility perceived by other self-conscious and feeling spices than humans. Randall (1988) argue that a CBA framework could enlighten the scientific understanding of the value of biodiversity, inter alia by built-in tendency to express issues in terms of trade-offs. A non-technical overview over how CBA can be applied to species and species loss including measurement of efficiency of conservation methods are provided by Pearce and Moran (2013). Overviews over valuation techniques for and approaches to biodiversity are provided by inter alia Humphries, Williams, and Vane-Wright (1995) and Nunes, Van Den Bergh and Nijkamp (2003).

Some of the largest environmental impacts regards local air pollution (e.g. sulphur dioxide, nitrogen dioxide, tropospheric ozone and dust) and global air pollution (e.g. carbon dioxide and methane). Whereas local air pollution is closely related to local health concerns, nature and social environmental concerns, global air pollution is linked to global warming and to some extent dilution of the ozone layer. Thus, in contrary to local air pollution the costs of global air emissions are to a large extent inflicted on individuals outside the location where the spatial measure in question takes place. Although the value coefficients of different sorts of air pollution might be disputed or challenged, their corresponding valuation methods are built on extensive amount of research.

Notable contributions on valuation of air pollution include valuation studies based on life satisfaction (e.g. Welsch 2002 and 2006), contingent valuation studies of health effects (e.g. Hammitt and Zhou 2006 and Desaigues et al. 2011) and studies that aim to put value on global warming (e.g. Nordhaus 2000 and 2004, Berrens et al. 2004, Borgerson 2008, Rezai, Foley, and Taylor 2012, Wheeler and Von Braun 2013 and preceding references). An important scientific debate related to climate change is the debate on discount rates (i.e. how much weight are put on present contra future utility) following the Stern Review on the Economics of Climate Change (Stern et al. 2006). Economists substantiates a more weight on the present than future utility for various reasons, among them people's tendency to put more weight at present than the future, economic progress that makes future generations better off, improvement in future technologies and uncertainty regarding future consumption levels. Although the debate concerns climate change, it is generalizable to other trade-offs between present and future generations with Dasgupta (2007), Nordhaus (2007 and 2010) and Weitzman (2007) and Stern (2008) as notable contributions.

The literature on valuation of other sorts of pollution is thinner, but some relevant references are Barton (2002) and Reddy and Behera (2006) for water pollution, Bartke (2011) and Söderqvist et al. (2015) for land contamination and Jenkins (1993) and Jin, Wang and Ran (2006) for solid waste. Navrud (2002) provide an overview over noise impacts from transport measures. Hamersma et al. (2017) map negative externalities related to live near highways (i.e. noise, local air pollution and barrier effects) in Groningen in the Netherlands through interviews. They find that individuals that have not explicitly chosen to live next to a highway had a more negative perception of negative externalities. Perceived environmental changes, expectations about the future and available information about the negative externalities also

contributed to the attitude the respondents had towards the highway they lived next to.

3.4 Social Impacts

Social impacts of spatial measures concern social development challenges and are often closely related to economic and environmental effects, as well as distributional aspects.

Classification of social impacts

The UK guideline distinguishes between ten types of social impacts, namely accidents, time savings for commuters and other personal users, physical activities, security, severance, journey quality, option and non-option values, accessibility and personal affordability. Accident impacts and time savings for commuters and other personal users are recommended monetized, while journey quality and physical activity impacts may be monetized if they are considered substantial, and the magnitude may be determined with reasonable certainty. Option and non-option values and reliability impact on for commuters and other personal user are not recommended included in the basic cost-benefit analysis, but might be estimated in supplementary analysis. The guidance leaves impacts related to security, severance, accessibility and personal affordability for qualitative assessment (DfT 2015), so these impacts might be considered as unconventional social impacts. Some general practices for social impact assessment are provided by Vanclay (2003) and Esteves, Franks and Vanclay (2012).

Jones and Lucas (2012) distinguish between five direct social outcomes of transportation measures; accessibility, severance, activity location, health, finance and community organization. Furthermore, they distinguish between spatial, temporal and socio-demographics dimension of the distributional impacts. The authors point out that comprehensive data collection and forecasting tools on social impacts are needed to improve forecasts of social consequences of different spatial policy measures. A challenging with the existing appraisal and evaluation literature is that economic, environmental and social impacts partly are overlapping (e.g. local air omission and traffic congestion; see also Geurs et al. 2009 and Parkhurst and Shergold 2009). Jones and Lucas (2012) aim to clarify concepts and definition related to social impacts, how these differs from economic and environmental impacts, as well as notions of distributional challenges. They propose to start by defining impacts and then assess whether the impact have economic, environmental and social efficiency effects, or potential distributional effects.

Most developed public guides do however not leave any uncertainty regarding overlapping effects (e.g. DfT 2018). The American guideline for community impact assessment (US Department of Transportation 2018) among others operate with a broader definition of social impacts, in the American case exemplified by environmental effects (e.g. visual environment), economic effects (e.g. business and employment impacts) and budget effects (e.g. tax base). We stick to the British classification in our review here and refer to the previous subchapters for description of these border line impacts.

Approaches to valuation of social impacts

Valuation methodology used to value social impacts are largely the same as for environmental impacts (i.e. various methods for revealed stated-based preferences), so we refer to previous subchapter for a description of these.

Social impacts of transport projects may receive large public and political attention, but are less focused upon in transport policy appraisals. This is partly because these impacts are considered smaller than other impacts and partly because their magnitudes are subject to uncertainty. Including social impact in transport appraisal is often challenging, the impacts are often hard to quantify or in many cases regarded as distributional impacts (i.e. 'the distribution of the value cake') rather than effectiveness impacts (i.e. 'the size of the value cake'). In addition, it might be hard to draw the distinction between efficiency impacts and distributional

impacts in practice.

Geurs et al. (2009) focus on determining categories of impacts and identifying gaps in the treatment of social impacts in public guidelines. They define social impact of transport as changes in transport sources that might positively or negatively affect preferences, well-being or perception of individuals, social groups or society in general. They further argue that social impacts mainly are influenced through three channels; people, transport and land-use. These factors are mutually dependent and might also reinforce each other. By the same token, direct impacts (e.g. road investments and choice of transport mode), economic impacts (e.g. higher income and choice of transport mode) or environment impacts (e.g. local air pollution and perception of a neighbourhood) may affect individuals' preferences. For instance, higher individual income might result in increased use of cars, while better roads might affect preferred mode of traveling. Geurs et al. (2009) also propose to identify social target groups of impact assessments and policy intervention, in order to make targeting of policy measures more manageable. Social injustice in terms of unacceptable social differences according to values of the society is regarded as a subjective and often political decision.

Lucas et al. (2016) develops a mixed method approach to assessment of social impacts, involving both desk-based quantitative analysis and qualitative methodologies to engage with local communities. Lucas et al.'s (2016) assessment method of social impacts entail four stages. First, potential impacts of projects including their spatial and social prevalence are identified. Second, the scoop of geographic areas, population groups and social challenges that are likely to be object to social and distributional impacts are delimited. Third, a detailed assessment of each issue of interest is conducting, involving desk-based qualitative analyses of publicity available information. Fourth, a qualitative community level fieldwork exercise is conducted, particularly targeting groups that might be difficult to reach in order to complement and validate analyses on the desk-based study.

Studies on particular social impacts

Social impacts related to accidents and physical activities relates to lost in health quality. These impacts are closely related to valuation of life quality (e.g. Briggs, Sculpher and Claxton 2006), although physical activities also contain consumer value, while accidents involve a risk aspect. Elvik (2000) approximate the economic valuation of road accidents in OECD to 2.5 percent of gross domestic product at average, where loss of life quality accounted for nearly half of the costs. Vassanadumrongdee and Matsuoka (2005) find that people's willingness to pay for reduced traffic accident risk is influenced by perceived immediate occurrence. Other studies estimate accident costs both related to loss of health and material damage (Lindberg 2001 and Bastida, Aguilar and González 2001).

Cavill (2008) reviews studies on health effects related to cycling and walking in context of transport measures. In a later study, Kahlmeier et al. (2011) designs a guidance for valuing health benefits from cycling and walking, and find substantial gains from both activities. Litman (2009) lists up several impacts of spatial measures commonly ignored by public guidelines, there among costs of accident risks and of stress in case of congestion. We refer to subchapter 3.2 on economic impacts for a discussion on time savings and reliability impacts for commuters and other personal users, which are discussed together with similar costs for the business sector.

Journey quality is typically related to means of transportation and travel time with comfortable, safety and possibility to perform other activities along the way as important features. Studying public transport in six European cities, Friman and Fellesson (2009) find low correlation between subjective consumer satisfaction and objective measure for travel quality. They also call for research on what determines quality perception. Dell'Olio, Ibeas and Cecin (2011) investigate how actual and potential passengers are satisfied and put weight on different quality features for public transport. They identify some patterns of heterogeneity. For instance, women tend put relatively much weight on cleaning, elderly tend to put relative much at comfort

and potential users tend to put much weight on occupancy. This implies that aberrant quality preferences for small groups tend to be neglected in studies that do not take heterogeneity into account. Cascetta and Cartenis (2012) studies the users' perception of the metro in versus trains after an upgrade in Naples in Italy. They carry out a travel survey based on aesthetic and accessibility measures, where one paired origin-destination both served by metro and train are coupled. Based on these, the authors find that the qualitative factors that the metro offered meant that people preferred the metro, given similar price and travel time. Wardman (2014) utilizes a roundtable to identify features of convenience related to public transport. To estimate value of public transport convenience, they make us of implicit elasticities, assuming that a change in marginal generalized costs will give the same change in demand regardless of what causes the change. Based on psychological research, Delbosc (2012) propose a model for how transport influence life satisfaction through facilitating access to important life domains, physical mobility and externalities.

Community severance involves physical or psychological separation of neighbourhoods caused by transport infrastructure or motorized traffic. Assessing how engineering solutions might contribute to access challenges for local residents, Raje (2004) calls for more social awareness in the planning and design of engineering schemes. Based on three workshops with researchers, Anciaes et al. (2016a) develop a framework for interdisciplinary research on community severance, taking the chains of impacts and complexity in established methods in to consideration. They conclude that severance is better understood by interdisciplinary studies that balance complexity and applicability. Anciaes at al. (2016b) argue that severance is a substantial impact from transport measure that are seldom valued and asks for consideration of this aspect in transport planning. Grisolía, López and de Dios Ortúzar (2015) apply discrete choice models on residents affected by a ring road. They estimate the willingness to pay for undergrounding or burying the highway and incorporating amenities.

Accessibility involves the ease, or extent, in which a service, destination, person or good can be reached by use of the transport system. Accessibility is closely related to option values, travel time and agglomeration effects (i.e. urban consumer opportunities, sharing of resources and knowledge exchange). An extensive treatment of aspects of accessibility is provided by Rietveld and Bruinsma (2012). The guidelines focus on the population’s access to goods and services, which make the impact less overlapping with other specified impacts. Social Exclusion Unit (2003) identify five barriers to accessibility; direct cost of transport, services and activities located in inaccessible places, safety and security, and travel horizons. Preston and Rajé (2007) argue that challenges with immobile socially excluded should be studied together with mobile included to find reliable patterns suited for policy responses. Investigating accessibility and affordability related to transport Bogota in Colombia, Bocarejo and Oviedo (2012) shows that the impact of redistributive fares with respect to accessibility to the labour market can be larger than the expansion and improvement of the public transport network, depending on population characteristics, its location and its purchasing power.

Changes in land use and land prices will also have social consequences, inter alia in the sense that new attractive features of an area (e.g. better access to cultural facilities and recreation) area might attract richer inhabitants at the expense of poorer inhabitants (e.g. Carlino and Saiz 2008). We refer to 3.2 a more detailed discussion on land prices. Other studies focusing on consumer agglomeration address urban consumer possibilities (e.g. Handbury 2013 and Handbury and Weinstein 2014) and crime (e.g. Gaigné and Zenou 2015)

More expensive means of transportation affects poor people that travels more than rich people that travels, since use a larger share of their income on transport. Reviewing affordability of public transport in 27 cities in developing countries, Carruthers, Dick and Saurkar (2005) find that high cost of urban transport has negative impacts on the lives of urban poor through limiting job access, taking a substantial portion of their income or dramatically decrease the number of travels undertaken. Venter (2011) reviews evidence on transport expenditure and affordability low-income and immobile populations in South Africa. They find that the degree

of urbanization for location of an individual affects both their transport expenditures and the perceived severity of their transport affordability challenges. The ones facing the highest transport expenditure patterns and affordability challenges are public transport users in rural locations and displaced locations, and medium-income car commuters in suburbs and urban townships. Nearly similar expenditure patterns and perceptions as travellers were found among disabled and elderly.

Transport networks are vulnerable for attacks from terrorists and criminals. Since the 11th of September 2001 terrorist attack, security improvements have received more focus worldwide. Prentice (2008) establish an economic framework used as a guide to develop a taxonomy of security benefits in terms of sovereignty protection, terrorism prevention, interdiction of illegal activities and personal security. They further distinguish between direct and indirect effects, and tangible and intangible effects. They conclude that the benefits of transportation security measures often constitute a more expedient security measure for a society than community security measures. Oum and Fu (2007) study the social welfare implications of aviation security in a duopoly model for American aviation market, addressing a regime where passengers are charged a flat rate (i.e. the current regime) and a regime where passengers are charged Ad Valorem user fee (i.e. a tax whose amount is based on the value of a transaction). To improve the realism in their estimates, they conduct a numerical experiment with more than 5,000 simulations, exploiting values of firms' conduct parameters, extent of product differentiation and market distribution between full service carriers and low-cost carriers. They find that Ad Valuorem user fees generally provide most social welfare. This finding is generalizable to all other passenger-related fees within aviation.

An option value is the willingness to pay to preserve the option of using a transport services. Option and non-use values are often associated with closure of transportation nodes. Investigating commuting to work, Friesz, Mookherjee and Yao (2008) formulate the value as a European call option (i.e. price is the highest of a fluctuating price and a predetermined price) for congestion. They use a Cournot–Nash non-cooperative Nash game, where commuters choose to drive or use telecommunication, departure time, if driving, and path to work, if driving. They show that flow patterns based on congestion call options contrasts the traditional user optimized flow patterns, inter alia by potentially lower the network-wide social costs of congestion. Denant-Boemont and Hammiche (2010) conducts an experimental study on road haulers' choice between roads and railways. They assume that deliveries to trains are only available at end-line stations, while the delivery choice is flexible with regard to choice of route and reloading for highways. Furthermore, traffic volumes are assumed uncertain for both types of infrastructure. Their theoretical model indicates that the transport choice of road haulers favour roads in case of high railway prices and extensive information on how traffic volumes fluctuate over time, where the information on traffic volume fluctuations are improved by spending more time on the road. Calibrating their model on French data, Denant-Boemont and Hammiche find that haulers overact to infrastructural price changes and that haulers willing to take risk are more inclined to travel by road with exception of cases with the lowest price levels. Geurs, Haaijer and Van Wee (2008) addresses the option value of public transport in the Netherlands. They conduct stated choice experiments to separate the willingness to pay for use, option use and non-use, based on an internet-based survey examining the value of regional rail services to residents.

3.5 Public Accounts Impacts

In addition to economic, environmental and social impacts from spatial measures, impacts on public budgets are recognized as a fourth type of impact by the guidelines (e.g. DfT 2018). These impacts relate to the efficiency costs related to financing of public goods and tax relives in terms of distortions.

Classification of public accounts impacts

The impact on government revenues is not an efficiency impact that affect social welfare itself, but a distribution impact that involves redistribution of wealth. The efficiency impacts follow from efficiency costs related to public funds. In general, an increase in public expenses or decrease in public income must be compensated by increased taxes or decreased public spendings in the short run or the long run. In the end of the day, weakening of public finances have to be compensated for one way or another, which implies that the input factors in production move away from the population's preferred factor allocation. In an efficient tax system, tax levels for different tax instruments will be lower for elastic goods than for inelastic goods to prevent distortions, although other concerns such as distribution, normative attitudes towards different taxes and vested interest might also come into play.

Relocation of factor inputs away from the population's preferences implies a loss of social welfare, which is known as the efficiency costs for public finances. Under such circumstances, demanders and suppliers will face different prices in both product markets and factor markets. In the production sector, such distortions imply that firms do not produce goods that would have been profitable without taxes, but that have become unprofitable to produce with taxes. These inefficiencies do not mean that the funding of "good" purposes over the public budget necessarily is a bad thing. They do however imply that such funding comes at a distortion cost. In case of a positive impact on public finance, the impact is analogous, but opposite, which implies an efficiency gain in public finances.

Details on distortions related to tax collections is complex material that go beyond the purpose of this literature review. Moreover, both tax increases and production of public goods might involve income effects on the behaviour of firms and individuals that counteracts distortive substitution effects. We refer to Atkinson and Stern (1974), Hagen (1979), Usher (1986), Ballard and Fullerton (1992), Snow and Warren (1996), Arrow and Kruz (2013) and Saez, Slemrod and Giertz (2012) for overviews over the theoretical arguments.

Spatial measures might influence public budgets in two ways; by affecting revenues in government bodies and by affecting tax collection. Both might be either positive or negative. The British guideline for transport planning and appraisal distinguishes between efficiency cost related to costs to broad transport budget and indirect tax revenues (DfT 2018). Both impacts might have positive signs. In addition, presence of wider economic impacts will generally also involve impacts on public accounts and thus also an efficiency impact on public accounts. Such wider public account impacts obviously constitute unconventional impacts not taken into account in CBAs, but could easily be calculated after the corresponding wider economic impacts are estimated.

Approaches to valuation of public accounts impacts

The marginal costs of public funds are estimated by general equilibrium models, which models a nation's economy including the nation's public sector (see for instance Snow and Warren 1996 or Saez, Slemrod and Giertz 2012 for overviews). Model specification and choice of parameters affect the models' estimates, implying that the estimates are associated with some uncertainty.

Based on these estimates, public accounts impacts are estimated as a percentage of the impact of public finances, making public-financed spatial projects generally more expensive. Consequently, inclusion of public accounts impact in cost-benefit analysis will generally lead to fewer economically profitable projects for the society. We refer to Fridstrøm et al. (2000) and Levinson (2010) for discussions on costs of public funds in relation to investments in transport infrastructure.

Studies on particular social impacts

In an efficient tax system, the marginal costs of public funds are equal across tax forms.

Differences in marginal costs across tax forms would imply an unnecessary social welfare loss, since social welfare could be increased by moving the tax burdens towards the tax forms with lowest marginal efficiency costs. Generally, marginal costs of public funds tend to be higher in countries with higher general tax burden. Browning (1976) show that the marginal costs of public funds increase with the progressivity of the tax system. Sandmo (1998) study the trade-off between labour market distortions and the redistribution from high-wage to low-wage workers in a model with heterogeneous consumers and a linear income tax. Aaberge, Dagsvik and Strøm (1995) show that gradual Norwegian tax reforms with inter alia more proportional taxation have removed some of the distortions on worker behaviour.

The levels for different tax instruments in developed countries tend to take marginal efficiency costs into account, but there are still some differences. For instance, Jorgenson and Yun (1991) finds that real estate taxes are less distortive than other taxes in the United States, primarily due to a lower general tax burden for real estate taxes. Kleven and Kreiner (2006) shows the marginal costs of public funds increase, when labour force participation responses and the corresponding revenue effects are taken into account. Bråten and Odeck (2009) find that traffic suppression and collection costs of tolls compare favourably with the costs of public funds. Hansson (1985) is an example of a study that assess differences in marginal costs in public funds between different tax instruments. Assessing both types of tax instruments and types of public expenses, he shows that the net efficiency costs of public funds might even be negative if the funds are used to finance infrastructure investments. Another extensive comparison of marginal excess tax burdens in the United States are provided by Ballard, Shoven and Whalley (1985).

Welfare is greater when any revenues from environmental policies is raised via environmental taxes than via lump sum tax, confer the confirmed weak double dividend hypothesis (as originally raised by Tullock 1967). When it is taken into account that some taxes constitute Pigovian taxes that correct for negative externalities (e.g. environmental externalities), the marginal costs of public fund are reduced (e.g. Brendemoen and Vennemo 1996). A stronger version of the double dividend hypothesis proposes a revenue-neutral substitution of environmental taxes for revenue-raising taxes, where the environmental taxes should be set above the Pigovian equilibrium level. The motivation is that such policy both could relieve the tax burden provided by other tax instruments and counteract the negative externality. This version of the hypothesis is controversial and assumes that leisure and the good in question are complements (on average they are substitutes) or at least too little complementary to outweigh a negative income effect. For more details on the debate about double dividends from taxation of externalities, we refer to Goulder (1995), Bovenberg (1999), Perman, Ma and McGilvray (2003), Patuelli et al. 2005 and Phaneuf and Requate (2016).

When it comes to wider public accounts impacts, the literature relates to literature on wider economic impacts. Studying the positive relationship between city size and productivity, Venables (2007) design a theoretical model suited for cost-benefit analysis, which also depict the importance of distortionary taxes. Moreover, the tax base increases as economic performance improves, making it possible to reduce other distortive taxes. In equilibrium, Venable's model involves a wedge between change in wages from relocation and the marginal commuting costs, meaning that the increase in output exceeds the increase in commuting costs. We refer to subchapter 3.2 for a discussion on implications for the labour market. In CBA, efficiency impacts related to public funds of moving to more productive jobs could be calculated by multiplying the tax rate and the cost rate for public funds with the relative productivity adjusted wages. Such transport appraisals should take into account impacts on the labour supply (e.g. total supply and reallocation impacts) to obtain the net effects. Other parts of the literature on market integration and tax collection focus on tax competition and location selection (e.g. Baldwin and Krugman 2004 and Charlot and Paty 2010).

3.6 Discussion

Spatial measures in general and transport measures in particular involve a wide range of economic, environmental, social and public accounts impacts. In this chapter, we have reviewed both theoretical and empirical literature on these impacts with focus on content and valuation. We have also focused on impacts not yet included in CBAs (i.e. unconventional impacts), since the room for methodology improvement are lager for these impacts. Overall, there have been an extensive development in the literature in recent years, especially when it comes to empirical studies suited for valuing unconventional impacts. This is particularly the case for wider economic impacts, among where some effects stand out from other unconventional impacts in terms of their relatively large magnitude.

Yet, large parts of the literature are inconclusive about the precise magnitude of impacts and which context factors that facilitate the differences. This suggest that new research is needed to obtain more precise and more reliable valuation estimates that might be used in CBAs or supplementary assessments of spatial appraisal and planning. New research is also needed to improve and update impacts already established in CBAs, improve other alternative methods to CBA such as MCA and to identify impacts not yet considered in CBA. In addition, the current knowledge on ripple effects and cross effects are incomplete, implying that new research should be conducted to identify and value such linkages.

The impacts and their valuation surveyed in this chapter constitute a knowledge foundation for the proceeding chapters. Thorough knowledge about impacts might help to make the right prioritizing in the planning process and facilitate discussions to improve the planning process (confer chapters 4 and 5). How to implement new knowledge about impacts in assessments methods in practice is discussed further in chapter 6, where quantification of impacts is treated in a section on extensions to CBAs in subchapter 6.2. In chapter 7, we show how these impacts are take into account in the CBA and MCA frameworks recommended in public guidelines for transport appraisal over countries and time.

4 Collaborative Planning and collaborative planning tools

Knowledge on the expected impacts of planning projects are crucial for choosing the right policy measures. But before continuing choosing the right assessment method for determining these impacts, we need to consider how these impacts are utilized in the planning process.

In particular, we consider the usage of these impacts in a collaborative planning process. According to this planning method, planning is a more complex endeavour than simply choosing the policy measure(s) with the most benefits compared to the lowest cost. Reality has shown that deciding on a policy measure is vastly more ambiguous (De Roo & Voogd, 2007; Healey, 2003; Innes, 1998). A typical planning exercise results in a wide range of impacts that are felt and perceived differently by each individual. What constitute a cost and benefit, and the magnitude thereof, is always contested. This changes the way how the expected impacts are to be determined. Therefore, in order to find the right way of assessing the impacts, we need to consider how impacts are used in a collaborative planning process.

In this chapter, we first explain the theory of collaborative planning and its relevance for contemporary planning practices. This is done in subchapter **Error! Reference source not found.**. This view on planning is particularly relevant for transport planning, a field in which collaborative planning is still underrepresented (Tornberg & Odhage, 2018; Vigar, 2017). Second, we elaborate on how collaborative planning is used in practice. Having established collaborative planning in theory is one thing, applying it in practice is another challenge. This is done by elaborate on two main features of collaborative planning practices: collaborative planning tools and the role of the planner in facilitating the communicative process. Specific tools that can be used to make planning more collaborative are discussed in subchapter **Error! Reference source not found.**. Subchapter **Error! Reference source not found.** expands on the role of the planner. The subchapter ends with a discussion in subchapter **Error! Reference source not found.** on what collaborative planning means for the assessment of impacts.

4.1 Relevance of Collaborative Planning

Collaborative planning is a planning paradigm that puts the involvement of all stakeholders central in the planning process. This mode of planning sees planning as a consensus-finding process, where decision-making is determined by dialogue and discussion between communities. Collaborative planning has been named interchangeably participatory planning, interactive planning or communicative planning. We use the notion of collaborative planning, following the terminology used by (Innes, 1998) and (Healey, 2003) the authors that contributed to bringing collaborative planning mainstream. To understand the importance of collaborative planning, we start by describing its emergence as an alternative planning approach.

Emergence of Collaborative Planning

Collaborative planning (CP) gained popularity among planners around the 1980's and 1990's. Since then, it occupies a prominent position in planning practices (Innes, 2016). The emergence of CP can be explained by failures of the at the time dominant planning methods. Until then, planning was mostly considered to be a top-down oriented exercise. Information from expert analysis was used by planners in a hierarchical, centralized and opaque process. It was believed that with sufficient research and rational reasoning, it is possible to determine 'what is best' for society. (Ansell & Gash, 2007) call this form of decision-making as managerialism. As in a managerial process, decisions are made unilaterally, based on expert analysis, with little transparency about the process.

This top-down oriented planning process has been subject to various criticisms. Two of the main flaws are discussed by (Innes, 1998). First, evidence is found that planners frequently

disregard information from expert analysis into their decision making (Vigar, 2017). Planners are often unable to explain how or why certain information is deemed as important. Thus, although a rational decision-making process appears promising in theory, in practice, it is often not applied.

Secondly, even if decision processes would be more rational, theoretical advancement have overthrown the idea that any information is free of value judgement. By now it is well established that information presented by experts, in particular information about social phenomena such as planning, is often contested and subject to own biases. Information is based on certain value-presumptions, which are different from stakeholder to stakeholder. Managerial planners may argue to take into consideration the opinion of different groups in decision-making. But the dangers is that the perspective of others are influenced by the planner's biases, or that the opinion of others are reflected wrongly. One stakeholder may value highly the additional employment generated by the construction of a new highway, whereas another stakeholder is more concerned about the loss in aesthetics value and biodiversity of nature resulting from said project. Currently, there is no objective method to unambiguously compare both perspectives. Different value premises are held by stakeholders, which are both valid at the same time.

In managerial planning processes, stakeholders may not agree with the analysis made by experts. The little transparency of the process itself further reinforces the dissatisfaction with the planning process. For example, if the safety risk of nuclear power plants are stated by experts to be relatively low, the public may have different perceptions about this and disagree with the assessment made by experts. The result is that the public does not agree with the planning decisions that are made. If the concerns of the public are not dealt with, public unrest and other unwanted consequences may follow.

Foundation of Collaborative Planning

To overcome the failures of top-down oriented planning methods, planners have advanced the notion of collaborative planning. Among the earliest contributors of this field are (Innes, 1998) and (Healey, 2003). The authors advance the idea that planning should be considered a *communicative process*. Incorporating communication deals with the flaws related to the non-transparent and biased decision-making. In CP, decision-making is not based on expert analysis but based on the consensus between the stakeholders. This consensus is reached by communication between stakeholders with different backgrounds and interests. In sessions of interaction, the stakeholders share opinions about the information that is provided. The role of the planner in this process is more facilitative. The planner brings stakeholders together to discuss about a planning measure and facilitates the discussion between them. The fundamental idea is that the community determines the planning outcome.

(Pettersson & Hrelja, 2018) favour the term of 'co-action' instead of 'collaboration', because it better captures the essence of the process. In co-action, the participants work together for joint benefits. The underlying idea is that the participants can achieve more collectively than independently. This is opposite to the idea of 'negotiation', where the participants strive to maximize own value.

It is important to stress that collaborative planning does not exclude expert analysis and fact-based decision making. Instead, a thorough analysis of the scope of the issue at hand or the impact of a planning measure are helpful in informing the stakeholders about their decisions. In this regard, we need to consider the place of a CBA in collaborative planning. A CBA can be extremely helpful in showing and ordering information. At the same time, a CBA can be a misleading tool for those (both planners and stakeholder alike) who are less-informed about the weaknesses of a CBA. In chapter 5.1, the limitations of a CBA are discussed in more detail.

Moreover, (De Roo & Voogd, 2007) remind us that CP should not be seen as the only valid planning method. Rather, CP offers valuable tools for planner's toolbox. They consider

planning to exist on a spectrum, with the top-down oriented managerial form of planning occupying one side, and the bottom-up oriented collaborative planning on the other side. The main features of both planning approaches are shown in **Error! Reference source not found.**. The extent to which tools from each perspective should be used depends on the requirements of the issue at hand. However, rarely, using only one of these perspectives is appropriate, and the proper method is usually a mix of both. Importantly (De Roo & Voogd, 2007) stress that traditionally, planning has suffered from a too heavy focus on top-down planning.

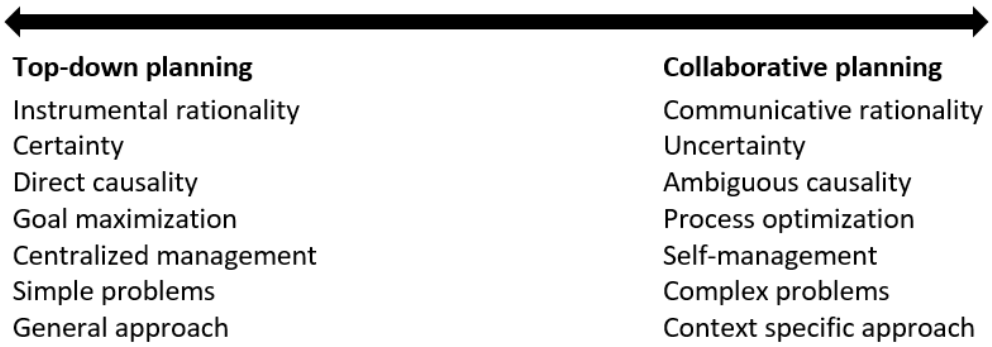


Figure 4-1: Two different approaches on the planning spectrum (De Roo & Voogd, 2007)

Collaborative planning process

Having elaborated on the relevance and theoretical foundations of CP, the question is how collaborative planning should be carried out. Expanding on a subject is one challenge, implementing it in practice is a second. A good description of collaborative planning is given by (Ansell & Gash, 2007). Their work covers collaborative governance in general and is one of the most cited theoretical accounts on this notion. The authors review 137 empirical cases in which collaborative governance is applied and distil from that four main features of collaborative governance. They find that the *starting conditions* (1), the *institutional design* (2) and the *facilitative leadership* (3) significantly shape the *collaborative process* (4). These four main features and their relationship are shown in Figure 4-2.

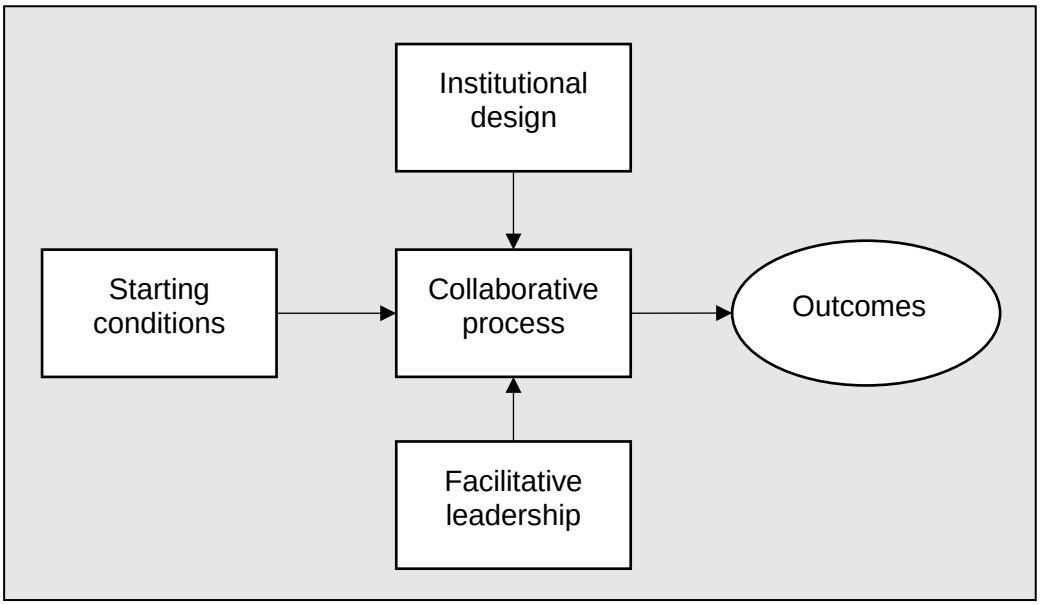


Figure 4-2: The main components of collaborative planning (Ansell & Gash, 2007)

The **starting conditions** refer to the initial situation with which the collaborative process starts. Factors such as the background of the actors, their relationship and their attitude towards the

planning issue significantly impacts the collaborative process. First, for a proper collaborative process, all groups need to be equally represented. This is particularly relevant for the disadvantaged. Second, the participants must be willing to participate, i.e. they need to see added value in participating. Thirdly, the relationship between the participants brings different challenges to the collaborative process. For example, high levels of distrust and antagonism between the participants hinders the possibility of reaching a consensus. In sum, before starting the collaborative process, the initial conditions need to be mapped to determine the rest of the collaborative process.

The **institutional design** consists of the main rules and protocols that shape the collaborative process. Firstly, perhaps the most crucial design issue is selecting the participants. Collaborative planning must be open and inclusive. Not including all relevant participants is one of the main reasons for failure. Secondly, clear rules about the process needs to be established in order to ensure effective and productive discussions. Various tools and techniques can help in structuring collaborative planning (Vacik et al., 2014), such as GIS-tools (Ortega, Otero, & Mancebo, 2014). Lastly, a transparent process is crucial. Participants need to have the feeling of ‚being heard', which gives legitimacy to the process.

Facilitative leadership is widely considered to be crucial for facilitating the collaborative process. The main tasks for the mediator is setting out clear rules, guide the dialogue, build trust and explore mutual interest. It is known that planning processes entail many discussions, namely long sequences of interactions that are not always constructive or well-instructed. One of the reasons is that the participants do not always have a precise idea about 'what to think' even when they are experts. Indeed, the realization of complex infrastructure and spatial development projects can emanate effects in a multitude of fields. Involving experts from different domains should bring, in theory, the discussion to a higher level, and yet it does not always work out. Good leadership therefore occupies a central position in the process.

Regarding the collaborative process itself, (Ansell & Gash, 2007) identify four components which to a large degree determine successful collaboration: trust-building, face-to-face dialogue, developing shared understanding and reaching intermediate outcomes. When designing the rules for or giving leadership to the process, these components needs to be strived for.

4.2 Tools for Collaborative Planning

In this subchapter, we present a framework for exploring the best tools suggested in the literature to embed in our assessment method. Some of these tools are selected from (Vacik et al., 2014) and their main features are then illustrated to find a collocation in the collaboration process. Taking inspiration from their study, we consider three macro-stages of a generic decision-making process regardless of the application context: problem identification, problem modelling, and problem solving. Such distinction is justified because each stage of the planning process demands different requirements for a tool. (Vacik et al., 2014) implemented a cluster analysis to group the tools according to their usefulness in each of the three stages. To do so, a set of criteria is drawn from the literature. A discussion among experts is employed to identify similarities and assign each tool to the most suitable phase. Table 4.1 shows the weights given to each criterion in the different planning phases, with a special focus on the case of Natural Resources Planning.

Among the highest ratings, *increases transparency* and *considers experiences* display a certain relevance in all the planning phases. Whether one agrees with Table 4.1 or not, most researchers and professionals have admitted that the preliminary stages still reveal a deficiency in the meaningful integration of stakeholders (Brömmelstroet & Bertolini, 2008; Hull, 2005). On the case of Land Use and Transport planning (LUTI), (Brömmelstroet & Bertolini, 2008) have realized a remarkable effort to spread new notions about Planning Supporting

Systems (PSS) with the aim to fill the existing implementation gap, especially in the preliminary stage. They stress the role of sharing information in boosting a fruitful collaboration, and that both tacit and explicit experiences need to be considered throughout the process.

Table 4.1: requirements of a collaborative planning tool for each stage in the planning process. The numbers refer to the relative importance of the criterion in the respective planning phase. A zero indicates that the experts don't consider the criterion to be important, whereas a 3 means that the criterion is very important (Vacik et al., 2014).

Criteria	Problem identification	Problem modelling	Problem solving
Supports creativity and innovation	0	3	2
Increases transparency	3	2	2
Considers experiences	2	3	3
Supports gathering interests	1	3	2
Allows for creating a collaborative atmosphere	0	2	1
Supports the process of negotiation	1	2	1
Allows for involving a high number of stakeholders	0	1	2
Requires less time in preparing and applying	2	2	1
High level of expertise is not needed	2	2	1
Can be adapted to different needs	1	3	2
No need for computer-based support	2	3	1
Produces understandable documents/results	2	2	3
Helps to explore/handle uncertainty	0	2	3
Helps to explore/reduce complexity	1	3	1
Allows for including quantitative information/values	0	1	2
Allows for including qualitative information/values	3	3	1

Hereafter we deal with the capacity of some interesting tools to produce understandable insights for a broad range of stakeholders participating to the discussion. Whether they are more prone to report quantitative or (perceived) qualitative information, the intent is to examine perks and shortcomings of each tool in different planning stages and scales. To do so, the reader has to keep in mind that not only one collocation in the assessment process is possible and that the process itself is not linear but circular. Some tools can be helpful in more than one situation and it is up to the mediator and the participants to adopt the most efficient evaluation path in the specific context. However, we leave the considerations about the 'administrative issues' of the assessment process to the next subchapter and focus on its structure suggesting the use of intuitive tools for collaboration.

Tools for problem identification

Monitoring the performance of urban and inter-regional transportation infrastructures has the clear purpose of capturing inefficiencies, but it is much less clear what these inefficiencies actually are. First, dealing with information asymmetry is a delicate matter in spatial planning and, second, diverse actors can disagree on what is problematic. However, the need for intervention on the infrastructure setup does not arise without the support of evidence. From a top-down perspective, the availability of data is a cornerstone for carrying on the quantitative analysis in the ex-post evaluations, and from the study of the possible scenarios derives the concern that some adjustments might be needed. Conversely, a bottom-up perspective prevalently outlines the urge for a qualitative adjustment of the services as well as the restriction of undesired external effects neglected by providers. It is in the latter circumstance

that users demand tools validating the problems they perceive in order to compel the authorities to an ex-ante evaluation of the possible remedies.

To this end, we report some experiences from the literature about public participation, in which the citizens have been gradually entitled to express their opinion about the community's development. Among the numerous examples, we choose a variety which defines problems at different scales and thus handle different complexities. In principle, we shortly discuss the techniques employed in 'real-life' workshops and compare them to the more recent online solutions, as the **Participatory GIS** and, more in general, the **e-Participation**.

Whereas the technological advances increase the pressure on authorities and public to adopt digital approaches, the face-to-face meeting does not lose completely its appeal. Both in small and large scale projects we can find examples of structured discussions and the use of collaboration techniques to identify problems and make action plans. One of the most ambitious and perhaps successful methods is Future Search. (Weisbord & Janoff, 2010) have elaborated a *principle-based meeting design* to enable many parties, from different organizations and communities, to quickly transform their capability for action. After 'getting the whole system in one room', the individuals are called to look together at their (1) past, (2) present, (3) possible future, then (4) discover common ground, and (5) make action plans. They are invited to think globally in the first place, and then gradually develop local action plans.

It is claimed that more diversity and less hierarchy are important requirements to learn other ways of looking at the task at hand and to give each person the chance to be heard. Thanks to its flexibility, the discussion method has been used in a large variety of fields; business, education, art and culture, social services and more. We found particularly interesting the structure of this participatory process as it helps to redefine the interactions and foster the cooperation between parties. The scepticism arises when we think about the time. In Future Search's experience, it is stated that would take about two days and a half to identify the main problems, understand most of the interactions and finally produce desirable collaboration.

Despite the effectiveness of the method supported by (Weisbord & Janoff, 2010), we assume that complex spatial planning processes would require much more time to go through all the phases, not only for a matter of efficiency but also for the organization itself of the workshop. Thus, the mediated 'real-life' discussions work fine for informative purposes, simple problems definition, and relationship building, but one would need to arrange several follow-up meetings to deal with big infrastructure projects as all the information cannot be provided at once. Nevertheless, the choice of participants represents a puzzling moment for the organization of such events. A truly self-validating bottom-up process can only begin through self-invitation, which is made possible by the open access to the World Wide Web.

An initiative that witnesses the development of spontaneous public participation is Planning for Real, a visual method originally applied in Slaithwaite (a village in Northern England) on a miniature model of the area. (Kingston, Carver, Evans, & Turton, 2000) document the activity started in the 1970s, when the citizens were all invited to write their opinions anonymously on little flags placed on the physical model, up to the introduction of the web-based solutions with comments on virtual maps. The spread of interactive maps is nowadays seamless and the participation is extended 24/7 to all the citizens provided with an internet connection. Another case of Participatory GIS application was realized in Finland (Tyrvainen & Makinen, 2014), where the residents were asked to identify areas that had specific positive qualities, such as beautiful scenery and forest feeling, as well as to locate areas with negative features. We have included Figure 4.3 as an example of how the qualitative values, explained below the figure, were attached to the green areas.

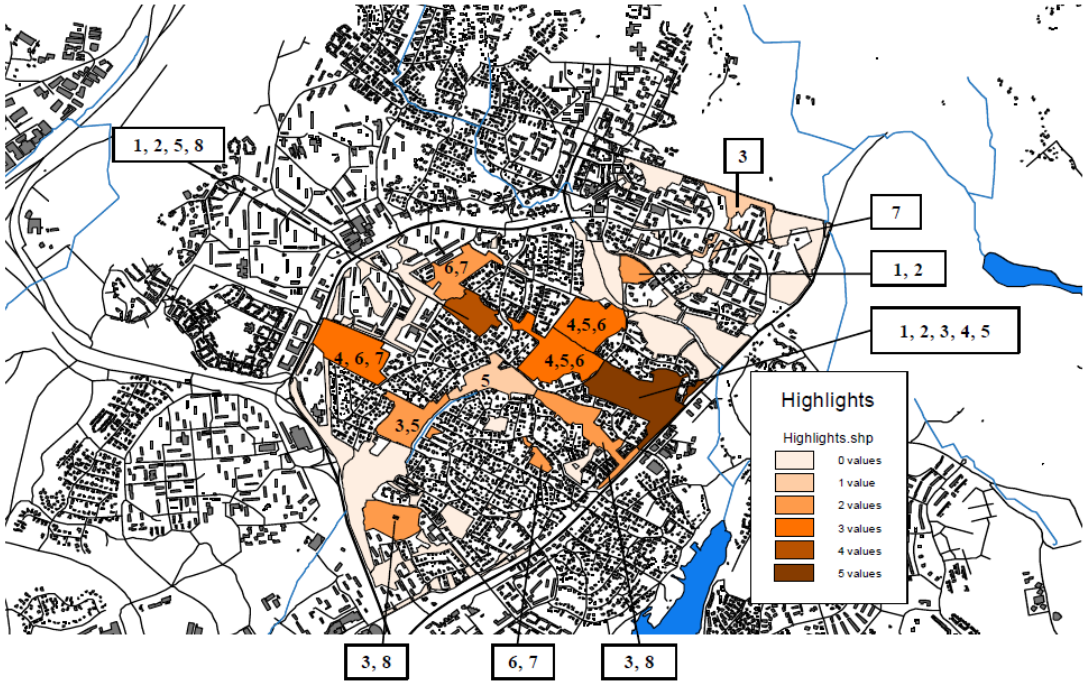


Figure 2. A synthesis map of the areas with highest scores in different social value classes. Explanation of numbers: 1 = beautiful landscape, 2 = valuable nature site, 3 = forest feeling, 4 = space and freedom, 5 = peace and quiet, 6 = attractive park, 7 = possibilities for activities, 8 = history and culture.

Figure 4-3: An example of Planning for Real from (Tyrvainen & Makinen, 2014).

These studies highlight the great potential of maps and online participation to attach qualitative values (quality, beauty, environmental, social, and so forth) to the areas under study. At the same time, it can offset the information asymmetry between different domains, as in (Brömmelstroet & Bertolini, 2008), making quantitative as well as qualitative data available for all the stakeholders to consult. The speed and the neat visualization granted by online platforms and Geographic Information Systems makes them simply indispensable and the drawbacks we can find are really few. Our main concern is that large scale maps (i.e. national) can hardly be read if too many items are included in the same picture, but this can happen also on a small scale if the structure is not well-organized.

The same issue regarding the neat sharing of information can be generalized to the e-Participation, where all topics must be properly separated and clearly exposed. According to the definition given by the OECD (OECD, 2003), the e-Participation consists of the use of ICTs for supporting the provision of information to the citizens concerning government activities and public policies, the consultation with them and also their active participation. (Loukis, Xenakis, & Charalabidis, 2010) have elaborated an evaluation framework for e-Participation stressing on the need for a more symmetric 'two-way relation' between government and citizens, in which citizens have a wider role in proposing policy options and shaping the policy dialogue. This approach is compatible with government-led initiatives (top-down) as well as with the bottom-up support to the elected representatives. Indeed, regardless of the information's direction, the main objectives of such initiatives are stated as to strengthening public trust in authorities and responding to the calls for greater transparency and accountability.

The framework developed by (Loukis et al., 2010)) considers the legislation formation process in the evaluation of (1) the information systems, (2) the level of public participation, and (3) the general e-Participation, adopting many criteria regarding the degree of acceptance, the process, and the quality of contributions (or outcomes). Another interesting framework of online

participatory projects is proposed by (Macintosh & Whyte, 2008), in which the evaluation of e-Participation is layered in democratic criteria, project criteria, and socio-technical criteria, in order from the widest to the most specific one. However, these suggested frameworks from the literature can serve as an inspiration for the assessment of the process itself, but this theme will be addressed in the following chapter while presenting the Delphi Method techniques.

To conclude our discussion about problem identification's tools, we focus on the different shapes that e-Participation can take. (Macintosh & Whyte, 2008) discuss various eDemocracy projects, pointing out e-Panels and e-Petitioning as emerging tools to empower new forms of democracy and enlarge the public involvement. The first is an example of structured platforms integrating various tools such as discussion forums, survey, and live chats, whereas the second is a more handy petitioning process compared to the traditional paper. It is still needed time to fully discover the shortcomings of these methodologies, but we suspect that privacy issues and hackers' threat, or other kinds of intrusion, are the main risks incurred when employing online tools, even though these dangers exist in every possible context when dishonesty comes in action.

Tools for problem modelling

Once the objectives of the decision-making process have been clearly exposed and accepted with a certain degree of consensus, it is the turn of building a model to represent both the relations between management options and (1) outcomes of interest of stakeholder groups and (2) the policy scenarios (Vacik et al., 2014). Stated differently, the subjects involved need to find the best criteria (variables) in order to assess the impacts of each option on stakeholders' matter and measure the contribution the option can deliver in the attempt of reaching the established goals. The set-up of a Multi Actor Multi-Criteria Analysis, which is discussed in more detail in subchapter 5.2, is rather conform to cope with these needs, but the sources of bias are not few. We discuss in this paragraph some tools for collaborative model building which might help to address a correct specification of the variables and the model's interactions.

At this stage of the decision-making process, the participation of citizens and businesses is narrowed so that only the main representatives are called to speak on behalf of their class of interest. This should be a natural step resulting from the previous discussion about the problems definition, as the chosen participants are supposed to have a clear picture of the interests to support and the drawbacks to avoid. In the MCA, the weight and the impact of each option on the collective goals only reveal the subjective importance assigned to certain criteria and this subjectivity must be controlled to avoid bias. For this purpose, a **Bayesian causal map** can find a significant role in modelling objective impacts, whereas the use of **Soft System Methodologies** will consent stakeholders to calibrate the subjective weights, that is, stated rudely, how much they care about certain impacts (D'Este, 2009).

Based on Bayesian probability network, many researchers have employed the Bayesian causal map to model the cause-effect relationship between variables (Nadkarni & Shenoy, 2004). An interesting analysis of the scenarios in the Turkish transportation demand by (Ülengin, Önsel, Topcu, Aktas, & Kabak, 2007) employs this technique to identify the variables, the links, and the strength of the relationships. The relevant variables of the system are initially chosen through a literature survey and their causal relations determined by means of econometric techniques and Artificial Neural Networks. Afterwards, a revision of experts validated the relationships' network. Combining these powerful statistical instruments, the procedure promises a reliable identification of the objective impacts of infrastructure projects on a wide variety of fields.

Less effective is the rationale behind the causal relationship's measurement, when it comes to personal interests and human response to certain effects, especially in the long term. Surely, these 'random' and very personal reactions accrue and then influence the aggregate effects overlooked by Bayesian maps. Forecast errors occur time and time again but this does not

mean that it is not worth to investigate the systematic response of different actors. What we need, instead, is a complementary approach for model building to observe how the collective behaviour adjusts with experience.

As of the introduction of the Soft System Methodology (Checkland, 2000), the strict and technical cause-effect models (*hard systems*) have been challenged and deemed inadequate for dealing with political issues involving human beings and cultural considerations. The *soft system thinking* is an inquiring process with the aim of modelling the most insightful *purposeful activities* that various actors, each with a different world-view, put in place to reach contrasting goals. Figure 4.4 describes synthetically the generic structure of the process.

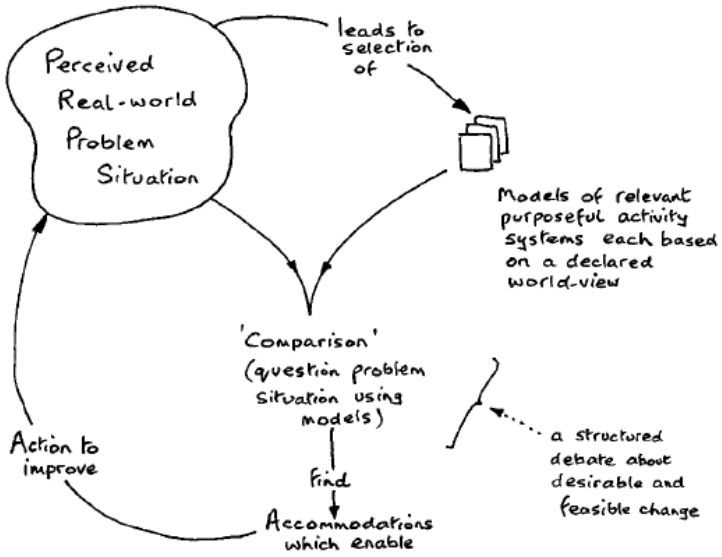


Figure 4-4: The generic structure of the Soft Systems Methodology (Checkland, 2000)

Given the complex and somehow mysterious nature of human interactions, the methodology is organized as a *learning system*, which does not differ much from the Delphi Method presented afterwards, allowing for many models to coexist and be compared. Since there are many models, the best way to proceed is to make an initial handful of models and use them as a source of questions to ask about the real situation. In principle, the process of inquiry can be never-ending and continue until new knowledge and insights concerning the problem situation can be considered useful to someone. However, a certain course of action can be taken when they are both desirable and feasible for all the participants with their particular history, relationships, culture and aspirations.

The cyclic structure is typical of the learning processes where new experiences are recorded and re-evaluated. Another interesting characteristic of this procedure, and very relevant for this paragraph, is the way the models of purposeful actions are built. These are much different from the models we are used to imagine, as they are extremely simple and meant to just stimulate and structure the debate. (Burge, 2015) describes accurately how to formulate the *root definition* of the *systems of purposeful behaviour*, by using the CATWOE:

- Customers, who might be beneficiaries or victims of the activity;
- Actors, usually the businesses or whoever takes action;
- Transformation, the purposeful activity to transform the input into output;
- Weltanschauung (World-view), the belief that makes sense of the action;
- Owner, the wider system decision-maker concerned with the performance of the system;
- Environmental constraints.

From the root definition, each participant can easily draw a model containing these elements which enter the discussion of the different scale levels. Indeed, every system's model can be improved acting on the sub-systems (i.e. answering the question 'How?') and contributing to the improvement of a wider system according to a shared world-view (i.e. answering the question 'Why?').

The Soft System Methodology is an experimental and very promising approach, though it is not too intuitive and requires a certain preparation for the mediator. In short, the newness lies in the way the models are discussed and merged together, bringing the collaboration between stakeholders to a higher level. Eliciting the purposeful actions together with the world-view is a good attempt to enhance the transparency and trust between various actors, leaving the numerical impact of variables in the hands of a few experts implementing econometric and ANN models. These models' outcomes are useful for the scenario analyses but say very little of the actual concern of citizens and businesses involved in the area of intervention. Nevertheless, the exposition of *hard system' forecasts* can create confusion to experts of other fields that are not familiar with all the cause-effect relationships. A fuzzy logic approach to the linguistic summarization (Kacprzyk & Wilbik, 2014) can ease the common grasp of future risks and opportunities hinted by trends in time series.

Tools for problem Solving

For many years, transportation companies and constructors have exerted a strong influence of national and regional authorities sponsoring their projects with little concern about environmental and social impacts. Alternative options are often suggested following partisan interests (Ackerman, 2008), with the responsibility for authorities to choose among them the most convenient in economic terms and, at the same time, interpret the possible wider economic effects. Needless to say, some short-sighted perspectives have precluded countless healthy opportunities for development to occur and ignored the risk of the aforementioned effects. In this paragraph, we want to point out other two inefficiencies of the classical decision-making processes, this time about the shaping of final decisions; (1) the *a priori* specification of solutions, due to both the biased judgment of authorities and the interference of non-governmental actors, and (2) the prefabricated format of the options which need therefore to be adjusted in order to conform with the users' preferences.

Surely, the first inefficiency is more dangerous as the implications of a path-dependency, with negative externalities for decades, are never negligible. As the knowledge accrues about the sustainability of infrastructure projects and the social impact of policy measures, the variety of solutions experienced to tackle deficiencies in transport supply is becoming quite notorious to researchers together with the underlying externalities. Hence, digital platforms have been created in order to classify studies about geographic development and rank the likely success of each measure in a particular context. For example, (Jones, Kelly, May, & Cinderby, 2009) describe an innovative approach to option generation called KonSULT, which delivers a comprehensive list of alternatives with scores relative to the context of application. KonSULT's Library tool included, up to 2009, information on 42 policy instruments divided in six categories: land use, infrastructure, management and service, information, awareness, and pricing. The instruments list has been updated through the years.

We dwell on the functioning of this tool as the approach enables every user to easily display a set of policy instruments and to have a clear overview of the available alternatives. They can specify their requirements in one of these ways: (1) in terms of their policy objectives, (2) the kinds of problem that they face or (3) the indicators that they wish to improve. Deciding whether to base the search on one of the three ways reduce the risk of double counting (Kelly, May, & Jopson, 2008). It is also possible to visualize the scores of a combination of two policy instruments and the expected cost (i.e. low, medium or high) of their implementation. To attain an accurate ranking, the scores were subjected to a careful review by the experts who took part in the development of this 'Library tool'. There is a version available online, and open-

source[1], which can be used by any kind of actor bearing curiosity about the best measures in particular circumstances. We point out this innovative approach as it can generate awareness about the wide range of alternatives, most of them often not considered by stakeholders, authorities and completely unknown by citizens.

KonSULT, however, is just one of the tools of DISTILLATE project (Jones et al., 2009) and represents a systematic approach for ranking options only from 'inside the box'. Other tools have been developed to generate solutions 'outside the box' which do not make use of systematic processes, sometimes even encouraging a 'discontinuous leap in thought'. These tools are particularly helpful to creative industries involved in community space design and include visioning exercises such as the map-based RAP-GIS (Cinderby & Forrester, 2008) another variant of Participatory GIS.. Since transportation projects, regardless of the scale, always 'invade' someone's land or community space, it is fair to engage the people affected in a proactive way (e.g. on design issues and environmental policies).

Nowadays, the literature is dedicating greater attention to public engagement processes, from the identification of goals and needs to the shaping of the final solutions, giving birth to a relatively new sub-field devoted to Community Impact Assessment (US Department of Transportation, 2018). In the quoted guideline, the iterative process is due to the fact that subjects involved are ever-changing, but an iterative process can also be employed to help actors negotiating according to different interests. (Ehtamo, Kettunen, & Raimo, 2001) have developed a model for multi-party negotiation in order to reach a Pareto-optimal agreement (Joint Gains) but the practical use of this method is yet absent. Although, the further evolution of structured online discussions, as we will argue in the next chapter, allows a better categorization of interactions and can help to find patterns in negotiation processes.

In conclusion, online digital tools are deemed to favour, essentially in every case, broader participation and integrate Multi-Actor MCA with interesting information support. There is little doubt that the engagement of public and local stakeholders can benefit the integrated appraisal as far as the discussion structure, embedded in a bigger decision-making process, remains neat and refers clearly to the purposes. In this chapter, we have focused on the advantages of collaborative methods, which can be employed in different planning stages to improve the information systems from the bottom-up as well as the top-down perspective. However, it is still required a framework for the evaluation of the process itself in order to overcome the hurdles of a heated discussion as it usually happens when conflicting and, to some extent, tacit interests come to a confrontation.

4.3 Discussion Strategies for Collaborative Planning

Leadership is widely considered to be crucial for facilitating the collaborative process. The main tasks for the mediator is setting out clear rules, facilitate the dialogue, build trust, explore mutual interest and principles of collaborative planning are adhered to (Ansell & Gash, 2007). In addition to collaborative planning tools, we pay specific attention to the discussions component that is part of any good collaborative planning tool. In this subchapter, we review the role of the mediator and consider a specific tool to reach consensus between stakeholders, The Delphi method.

Mediator's role and practical advice for guidance

The primary challenge we face is understanding and generalizing the patterns of collaboration between agents. It is known that planning processes entail many discussions, namely long sequences of interactions that are not always constructive or well-instructed. First reason, the participants do not always have a precise idea about 'what to think' even when they are experts

[1] See http://www.konsult.leeds.ac.uk/mog/, accessed on 26-02-2019

because the realization of complex infrastructures and spatial development projects can emanate effects in a multitude of fields. Involving experts from different domains should bring, in theory, the discussion to a higher level, and yet it does not always work out.

How to contain the backward steps in discussions is not a simple matter as two different kinds of 'stream' need to be organized and assisted: the *own thinking* and the *opinion sharing*. These streams continuously intertwine, leading the discussion to infinite possible directions. Obviously, the optimal solution would be the one in which every individual maximizes the own utility (Ehtamo et al., 2001) with the minimum number of interactions (as time is costly). Given the limited, or unknown, scientific nature of collaboration patterns, the reflection on how to achieve a neat and efficient discussion must be conducted thoughtfully touching upon psychological and sociological studies. We assume that one mediator must be present and this chapter aims to provide practical advice for guidance.

In the first place, the enhancement of individual thinking is necessary to reduce the egocentric guts and attain a proactive behaviour. (Dhanapal & Ling, 2013) elaborated an 'action research' choosing a sample of scholars to investigate their learning skills about environmental issues. The *Six Thinking Hats* method, developed by Dr. Edward De Bono, is employed jointly with *Bloom's Revised Taxonomy* to give a structure to their thinking. By giving some tips, the mediator can improve the individual and collective learning following a ladder of six steps (the *Six Thinking Hats*), initially filling the gaps in knowledge, then contextualizing the case study and making a list of pros and cons of the possible solutions. The higher-order thinking skills, such as *analysing*, *evaluating*, and *creating*, are thought to be grounded in the lower-order skills merely related to the stock of knowledge and the understanding of theorized concepts. Following this ladder should enable critical thinking to arise from personal hunches and a deeper moral judgment, with openness about searching for a shareable compromise.

Mediator's task 1: *Investigate the expertise of the potential participants and prepare them to a critical discussion.*

In the proposed structure, the first role of facilitators in chronological order is investigating the expertise of the participants, which usually occurs before the discussion starts. As stated before, it is rarely the case that the discussion includes experts with an in-depth knowledge of every field. The purpose of the dispute indeed is to elicit the different viewpoints while learning from the others' experience, although there are some hurdles to overcome when it comes to opinion sharing. On one hand, diverse actors can introduce new concepts to the other participants and stimulate their creative process. On the other hand, the discussion can be overloaded if no critical thinker does filter out any marginal contribution. The mediator has the duty to keep the discussion neat and democratic. Indeed, it happens sometimes, especially in spoken debates, that some voices will prevail wielding influence on other participants limiting their thinking process. Nevertheless, the presumption of some experts and the scarce propensity to pacific debates constantly undermines the quality of the debate.

Many researchers have dedicated attention to the use of mediation techniques to improve the quality of argumentations. The common belief is that arguments concerning the validity of knowledge, the interpretation of evidence, and the appropriateness of experimental designs are at the heart of science. Thus, the presence of many and high-quality *backings* and *rebuttals* are signs of a productive discussion (Erduran, College, & Osborne, 2003). They respectively mean 'the generalizations in favour of the argument' and 'the exceptional circumstances that might undermine the force of the supporting arguments'.

Other studies, albeit disregarding Toulmin's Argument Pattern, also seek to gain fluency in discussion trying to distinguish its elements, that is, the type of interaction. An interesting one from (Hou, Chang, & Sung, 2008) regards the *online asynchronous discussion pattern*. Similarly to (Erduran et al., 2003), they resort to a coding strategy for carrying on the analysis and evaluate the quality of the discussion. Every contribution is classified according to two dimensions of the problem-solving process: the *behaviour sequential pattern* and the

knowledge construction level. For example, *making a comparison* (Code 'P3' in the behaviour sequential pattern) can occur while *negotiating the meaning of terms* (Code 'C3' in the knowledge construction dimension).

Mediator's task 2: *Recognize the key points, collect and illustrate the main insights of the discussion, with the aim of preserving a constructive development in the dialogue.*

The online workshops have one big advantage. All the interactions are recorded as sheet of text and the influence due to the charisma and the 'voice's volume' is limited. All the text contents were assigned in the aforementioned studies by external judges to the phase of the discussion they belong and to the level of contribution in the knowledge-building process. A good mediator should recognize all those elements that characterize a dialogue and intervene when the progress tends to jam or, conversely, when the participants get hastily to the conclusion.

However, guides for mediators are many and pertaining to all fields (see for example (Macmillan, 2012). We need to refer now to our context: the stakeholders' collaboration in economic, in particular spatial, development projects. These projects are usually long and the collaboration between parties consists of several rounds of discussion. It is paramount that each round adds up meaningful information, possibly by making use of the methods and tools described in the previous chapter. In the application of SPADE's assessment method, the mediator has the task to propose, explain, and regulate the use of specific instruments for specific purposes in the different planning phases.

Mediator's task 3: *Propose, explain, and regulate the use of specific instruments for specific informative purposes, according to the phase of the discussion.*

In these complex decision-making processes, it is crucial to reach a satisfactory level of compliance, as it is becoming, even though not without opposition, the main 'function to maximize' (Cascetta, Cartenì, Pagliara, & Montanino, 2015). It might be established a minimum level of compliance below which the discussion can be suspended to delve deeper in the tacit experience of the participants. Therefore, besides filling the knowledge gaps and clear up the status of the discussion, another advice that we retain important to refine the assessment method is recognizing the conditions that hinder the progress and prepare a new round to better discuss the same topics, eventually with other approaches.

The Delphi Method

The formulation of surveys, elaborated throughout the process in accordance with how the discussion is developing, is a very powerful tool to uncover personal perplexities. As of the introduction of the *Delphi Method* by Dalkey and Helmer in 1963, several strategies have been adopted for building consensus among the experts. All of them are based on an iterative process (feedback), in which every round should reduce the range of opinions and cluster the underlying reasons. (Linstone & Turoff, 2010) explain that actually the real scope of the Delphi Method is not to produce unanimous agreement, but giving a structure to the group communication process through repeated feedbacks. Indeed, achieving stability in the responses matters more than having all stakeholders aligned on one side. As they claim, a bipolar distribution of opinions is actually a very significant one and not a rare result.

Mediator's task 4: *arrange questionnaires in various stages of the collaboration process to elicit the different viewpoint of stakeholders and refine the assessment method.*

(Hsu & Sandford, 2007) propose an overview of the features and shortcomings of the methodology, touching upon points of criticism such as data analysis, subject selection, and their involvement. Building the questionnaire with fixed scales for answering makes easier to identify the sub-areas in which the standard deviation of the scores is particularly high and how clusters of opinions take place. It is often interesting also to allow and look at the personal comments (with respect of privacy), as they provide additional input for the formulation of the

next round of questions. Focusing on those areas of major disagreement, the inquiry of the reasons underlying different viewpoints must be conducted bearing in mind the possibility of getting biased results.

In order to reduce the bias in the outcome, the preferred precaution is a careful choice of participants. Usually, the common sense promotes the selection of a heterogeneous sample of experts who have a genuine interest in the topic at issue. If the involvement is not as expected, it will be revealed by a low rate of response, with the possibility for the holder of reducing or enlarging the number of participants. A rather detailed framework about the subjects' selection is described by (Okoli & Pawlowski, 2004). Following a stepwise methodology, the identification of the disciplines related to the topic is the very first step to take and helps with the choice of experts. Regardless of the application's context, it is observed that a heterogeneous group of experts should generally consists of academics, practitioners, governmental, and NGO representatives.

From the first questionnaire, they are called to specify a broad list of influencing factors relative to their preferences. This might already reveal the different viewpoints between or within the groups. Afterward, narrowing down factors brings to the identification and prioritization of the main variables of interest, or criteria for the continuation of the analysis. A simple but appealing technique to study subjectivity and viewpoint is the Q-Methodology). Respondents (P-set) are asked to rank a set of statements (Q-set) and, by means of a factor analysis, the similar viewpoints are grouped in more segments (Exel & Graaf, 2005). This method can easily be incorporated in a Delphi process using the models of purposeful action, previously described in the Soft System Methodology, as statements to rank.

Since many studies and applications of the Delphi Method have proved to be successful in enhancing various aspects of collaboration, its use has increased markedly through the years and yet promises to evolve through online feedback and learning systems. Once more, (Linstone & Turoff, 2010) underline the importance of building group models from the observation of the individual ones (as in the Soft System Methodology) and the way they perform. They point out that one of the main areas of disagreement can be the direction of the influence between two variables in a relationship within the model, also known as causal relationship. However, for this purpose, the Bayesian Causal Map can assist the dispute providing probabilistic information. Finally, the Delphi Method can be a key to unlock any kind of barrier if used thoughtfully, improving the future appraisal and easily incorporating new tools whenever they are discovered to be helpful in transportation and spatial development debates.

4.4 Discussion

We have underlined in this chapter on collaborative planning (1) the importance of collaboration in the planning process and (2) the methods used for collaborative planning. This is done to examine how knowledge on the wide range of impacts should be utilized in the planning process. By now the theory of collaborative planning has gained a strong foothold in mainstream planning practices. In a collaborative planning process it is acknowledged that impacts, their magnitude and their importance are perceived differently by stakeholders. Therefore, for planners to come to a decision, agreement with the stakeholder on the impacts is required. This is particularly important in cases where stakeholders may provide valuable new information for the planning process, accessible information is likely to be biased or the risk for stakeholder disagreement are substantial. Whereas CBA is clearly unable to consider these aspects in the appraisal (Ackerman, 2008; Cascetta et al., 2015), collaborative planning has the potential to include integrative support systems to reduce information bias and make subjectivity a valuable factor.

But involving stakeholders is no small feat. It is often a time-consuming process (Ansell & Gash, 2007). For this reason, we have described a series of tools which promise to enhance

sensibly **transparency** and **agreement**, which, in other words, are means to reduce ignorance, disinformation, and egocentric guts of experts and stakeholders. In **Error! Reference source not found.**, we summarize the tools and the methods presented previously with their advantages and shortcomings.

Tool	**Description**	**Advantages**	**Shortcomings**
Future Search	Principle-based meeting to discover common ground and foster cooperation between stakeholders	Structured	Slow
Participatory GIS	Map-based interaction to attach qualitative or quantitative values to an area	Visualization	Confusing on large scale evaluations
e-Participation	Online forums for discussing relevant topics, petitioning, making surveys, exchanging information and more.	Multi-purpose	Crowded participation
Bayesian Causal Map	Statistical method to identify causal relationships based on econometric tools and Artificial Neural Networks	Statistically consistent	Complex
Soft System Method	Simple models of purposeful actions are built by each actor to discover their world-view and create a unique model.	Accounts for different viewpoints	Subject to interpretation
Fuzzy MA	Method to facilitate the understanding of trends and scenarios	Simplification	Fuzzy definition
KonSULT	Innovative tool for generating alternative solutions and scores in transport planning based on experience	Awareness of options	Determination of scores
Joint Gains	Method for negotiating contrasting items and pursue a Pareto-efficient solution between stakeholders	Pareto-efficiency	Hard to apply
Delphi Method	Usually considered as a method for generating consensus, the questionnaires' technique allows feedback and deeper understanding of tacit viewpoints.	Structures discussion	Possible bias

Table 4.2: Advantages and disadvantages of the tools presented in this chapter

A limitation of the discussed tools is that most are complex (Joint Gains, Bayesian Casual Map) or slow (Soft Systems Method, Fuzzy MA, Future Search). For consulting a wide-range of actors and evaluating a wide range of impacts, in particular the tools are attractive that speed-up the process. The use of online workshops and digital platforms (such as KonSULT, Participatory GIS and e-Participation) contributes to this. This is another aspect that we deem necessary to be improved. As the opportunity costs and the delay costs are large, online surveys and discussions will allow a rapid sharing of information without the need to arrange a meeting for every consultation. Moreover, the **flexibility** of the assessment method, expressed in various occasions, should be intended in the broadest sense. Digital workshops may replace real meetings, tools may perform differently in similar contexts or scale of evaluation, and stakeholders can be interested only in some aspects of the planning process.

Our review of collaborative planning methods confirms the methods that we will expand on in the remainder of the SPADE project developed by (Kiel, Muizer, & Taale, 2015); a method that is based on the usage of a digital workshop. From this chapter, we add to this tool by

highlighting the role of the planner in setting up, before, during and after the workshop. The facilitator plays an important role in various ways, such as involving the relevant stakeholders, making sure that all perspectives are heard, and that the discussions between stakeholders develops fruitfully. Moreover, the use of Delphi Method in addressing adhoc disagreement between stakeholders is a useful tool to integrate within the digital workshop. SPADE's mediator are called to use questionnaires after each tool and apply the Delphi Method to reconsider missing elements and inefficiencies. All of this can have remarkable impacts on infrastructures and policy evaluation and the future of spatial planning.

Now knowing the role of the assessment methods in a collaborative planning process, the next chapter continues with discus singing various impact assessment methods to be used within the planning process. In particular, attention is payed to the use of multi-criteria analysis (MCA) as a powerful method to gather and weigh opinions from various stakeholders.

5 Assessment methods for transport infrastructure projects and policy measures

In many transport projects, decision makers are faced with the difficult problem of choosing the best measure or set of measures among a large list of possibilities to achieve their goal. A thorough assessment methodology for evaluating the different options is not only useful for aiding the decision-makers in their process but, at least when public funding is involved, also necessary to ensure an objective and fair selection. This chapter is devoted to such assessment methods for transport projects and, more generally, measures in the transport sector.

In the previous chapter **Error! Reference source not found.** we have established which individual impacts should be considered in the evaluation of a measure which is the basis for a sound assessment method. Chapter **Error! Reference source not found.** discussed the possibilities of integrating collaborative planning strategies and methods within transport appraisal. Especially, when going from a cost-benefit analysis to a more collaborative multi-criteria analysis, these methods are important to consider and integrate.

First, in subchapters **Error! Reference source not found.** and 5.1 the basics of the most widely used assessment methods, cost-benefit analysis (CBA) and multi-criteria analysis (MCA) are presented with a special focus on how these methods are applied in the transport sector. In these subchapters not only the basic method is sketched but also prominent extensions and limitations of these methods are shown. After describing these methods separately, a special focus on methods that go beyond CBA and combine it with a MCA is given in subchapter 5.2. We conclude the chapter by a brief discussion in subchapter 5.3.

5.1 Cost-Benefit Analysis

Cost-benefit analysis (CBA) is the most widespread methodology for the appraisal of policy measures and assessment of transport and spatial planning projects. The principle that an investment decision should meet the criterion of benefits exceeding costs was established by Dupuit (1844) who applied the method on the calculation of an optimal toll for a bridge. A CBA is, simply put, a support tool in the decision-making that sum up all the benefits and costs of a project alternative, with the aim of allocating societies resources efficiently and by that maximizing the welfare of society as a whole. An efficient allocation of resources implies using them where the net present value of its use is highest. CBA is a decision support tool that enables decision makers to choose the intervention alternative that has superior efficiency relative to a series of alternatives, including the status quo. There is an almost unlimited demand for financing of public projects. However, the public funds are limited. CBA aids the government in the efficient allocation of scarce resources. One of the reasons for that is that the quantification and monetization of project values results in an easily understandable comparison of different measures. Another reason is that a CBA can overcome cognitive, structural, and process-related limitations and biases in decision-making (e.g., (Mackie, et al., 2014)). Thereby, it supports the decision-making on policy measures or alternatives by quantifying the effects, risks, uncertainties, and the resulting costs and benefits as a whole. CBA is referred to as ‘the single most important problem-solving tool in policy work’ (Munger 2000) and is used for ex ante assessment 0of policy options.

There are two main types of CBA, ex ante CBA and ex post CBA. When we commonly use the term CBA, we usually think of ex ante CBA which is the standard project assessment conducted while the policy intervention or project is under consideration and as a part of the planning process. Ex ante CBA is performed after the completion of the project and are often used for project evaluation and contribute to the learning process for project managers, politicians and academics about whether particular classes of projects are worthwhile

(Boardman et al. 2006). Comparisons of ex post analysis to ex ante analysis of the same intervention, is relatively seldom performed but when executed it is a valuable way to evaluate the efficiency of CBA as a decision support tool. In general, ex post studies are more accurate than ex ante studies as more of the project specific benefits have been realized and can more accurately be assessed in the analysis.

The purpose of CBA is to help attaining effective social decision making through efficient allocation of society's resources when markets fail (Boardman et al. 2006). When markets work well economic theory says that self-interest leads to an efficient allocation of resources. When a market failure is present complications arise in determining the correct social surplus change. The presence of market failure is the reason for most of the government interventions that are assessed through CBA. It is up to CBA as an impact assessment tool to demonstrate the need for the intervention, and to demonstrate that the particular intervention is the one that allocates the resources most efficient.

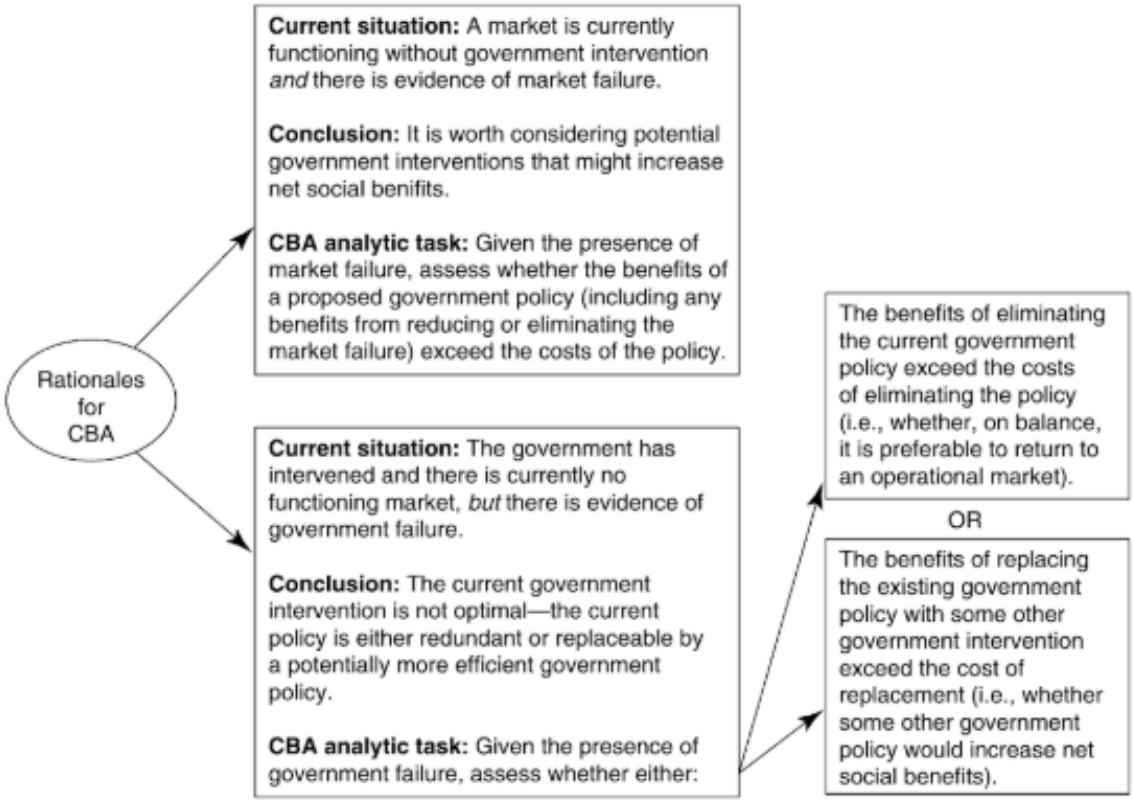


Figure 5-1: How to consider market and government failure in CBA (Boardman et al. 2006)

Common market failures in primary markets include externalities, monopoly, public goods, additive goods and information asymmetries. For a detailed examination of government failure, see Weiner and Vining (20).

The Standard Cost-Benefit Analysis Method

Based on one of many studies and guidelines (e.g., (Romijn & Renes, 2013), (Transport for NSW, 2018)), the general CBA method can be divided in the following eight steps:

1. **Problem Analysis** – Identification of the problem that should be solved, and the finding or defining of the corresponding policy objective.
2. **Establish the baseline alternative** – Identifying the base line, i.e., the most likely scenario when no measures are taken.

3. **Define policy alternatives** – Description of all measures that can be taken and identification of individual elements. Definition of alternatives and variants.
4. **Determine effects and benefits** – Identification, quantification, and monetization of effects.
5. **Determine costs** – Identification of all project-related consumed resources and costs, including one-time and recurring, fixed and variable costs. Only the additional costs to the baseline are determined.
6. **Analyse variants and risks** – Uncertainties, risks, and possible consequences are analysed.
7. **Overview of costs and benefits** – Calculation of the balance of each alternative after discounting the costs and benefits to the same base year.
8. **Interpretation of the results** – The results of the CBA should be presented in an understandable, clear, and transparent form along with an interpretation of the results.

Steps 4-6 are the most important steps in a CBA. A general guidance how to perform such a standard CBA is given in, e.g., (Romijn & Renes, 2013). General overviews over CBA in relation of transport are provided by Layard (1994) Quah and Haldane (2007), Litman (2009), Nas (2016) and Johansson and Kriström (2018), among others.

Extensions to CBA

Technical limitations to CBA, such as limitations in data or analytical resources, may render it difficult for the analyst to measure all costs and benefits in comparable monetized units. In such cases, it could be desirable to perform a cost-efficiency analysis (CEA) or a qualitative CBA. CEA is not an extension to CBA, but rather an analytical tool that may be applied when technical limitations (or unwillingness due to ethical reasons) hinder the use of CBA. A CEA can be performed when it is possible to quantify but not monetize all the impacts. In a CEA it is not possible to calculate net benefits, however the analyst can construct a ratio involving the quantified non-monetized benefits and the total cost of the intervention. A comparison of alternatives enables the analyst to rank the alternatives according to the cost-effectiveness criteria. Examples of CEA could be an intervention to save wildlife, where the cost of the intervention would be monetized, whereas the effectiveness could be units of wildlife saved. In this example the cost effectiveness ratio will be the amount of wildlife saved per unit of cost.

Non-monetized impacts might also be analysed in relation to CBA, by considering how much value must be assigned to these omitted impacts in order to change the conclusion of the analysis, and thereafter discuss whether such valuation seems realistic or not. This type of supplementary analysis is known as a break-even analysis (see for instance Spackman 2013).

The largest extensions to CBA concerns inclusion of wider economic impacts in the benefit-cost ratio. Wider economic impacts are additive impacts to the benefits calculated in a conventional CBA and arise due to market failures in secondary markets. There is no scientific consensus on how to quantify these impacts, but at least two main branches of theory singles out as promising:

1. Calculations based on estimated agglomeration elasticity values and the expected change in effective density, as recommended in the UK guidelines for transport appraisal
2. Spatial detailed models such as LUTI or SCGE models.

The UK guidelines, outlined in detail and extended in Graham and Gibbons (2018), recommends a three-step calculation method for quantifying the wider economic impacts of agglomeration for transport appraisal:

a) Calculate access to economic mass via effective densities
b) Estimate agglomeration elasticities
c) Quantify how the proposed transport scheme is expected to change productivity.

This three-step procedure is appealing in its simplicity, although the estimation of agglomeration elasticities could be a challenging task. In case of missing country specific agglomeration elasticities, it could be debated whether elasticity values from other regions are transferable and these estimated values must at least be handled with caution when applied in the calculation of wider economic impacts from agglomeration.

The second promising way to estimate wider economic impacts is by use of spatially detailed models, such as Land-Use Transport Interaction models (LUTI) and Spatial Computable General Equilibrium models (SCGE). LUTI models link transport models with land-use models, with the aim of modelling system dynamics (i.e. the feedback cycle between transport and land-use). In this modelling class, the term “land-use” mainly refers to activities which use space – in particular, where people live and where they work (Simmonds and Feldman, 2011). Overviews of operational LUTI models are given in Kii, Nakanishi, Nakamura and Doi (2016) and Wegener (2004, 2014). Johansen and Hansen (2015) identifies LUTI models as suitable to predict the changes in urban systems over time, both because the feedback cycle between land-use and transport is taken explicitly into account in the models and because it will be possible to calculate user benefits for cost-benefit analyses based on forecasts and scenario evaluation. An example of applying LUTI models to assess wider economic impacts of transport infrastructure investments, are provided in Wang et al. (2019). In Oosterhaven and Knaap (2003), an overview of different approaches to estimating wider economic effects of investments in transport infrastructure is given. The authors argue that the focus of interest should be on spatial detailed models, such as LUTI and SCGE models, a claim that is backed by Simmond and Feldman (2011). Further, Oosterhaven and Knaap (2003) claim that LUTI models are most suited for infrastructure projects at the level of urban conglomerations and that SCGE models are more theoretically satisfying and suited to model interregional impacts at a larger spatial scale.

Traditionally, multiregional SCGE models have been used for quantifying regional effects of transport infrastructure investments or changes in transport policy. An investment in infrastructure, or a change in transport policy, lead to changes in the generalized transportation costs, which in turn produce repercussions throughout the economy. SCGE models embrace the entire economy, making these models especially suited for analysing the wider economic impacts of infrastructure investments through the link between the transport sector and the transport using sectors (SACTRA 1999; Tavasszy, Thissen et al. 2002; Vickerman 2007; Lakshmanan 2010). Most SCGE models incorporate regional and inter-regional trade and transport. More recently, new SCGE models have included properties from the New Economic Geography literature that account for regional and industrial agglomeration. In a SCGE model the economy is typically viewed as a regionally disaggregated representation of the national economy. The regions consist of economic agents (households, firms, institutions, etc.) that interact through trade, both intra-regionally and inter-regionally. Trade requires transport, which is derived from the regional agents’ demand for commodities. An overview of pitfalls of and fine-tuning tips for SCGE models is presented in (Tavasszy, et al., 2002). The authors showed that by using this SCGE inaccuracies in transport project appraisal can be mitigated. Hansen and Johansen (2017) demonstrate how SCGE models can be applied in transport appraisal. They develop a SCGE model of the Norwegian economy and calculate the total project benefits (direct user benefits + wider economic impacts) for a large set of infrastructure projects for the Norwegian national transport plan.

While inclusion of wider economic impacts in CBA often calls for complex models (i.e. equilibrium models or gravity functions that captures increase in regional value added caused by increase in market access, inclusion of unconventional environmental impacts and unconventional social impacts in CBA will in many cases involves utilization of simple mark-up coefficients (for instance in case of water environment; traffic volume times a valuation coefficient for water pollution per traffic volume collected from the empirical literature) or transparent extensions to such an approach (could for instance involve different coefficients

depending on means of transportation and type of land area, as well as nonlinearities). Inclusion of more social and environmental impacts in CBA to a much larger extent follow the established methods. Still there might be exceptions of course, for instance modelling of climate gas emissions, and potential ripple effects and cross effects between different kinds of impacts. Comparing cost and benefits of a given intervention in a common unit, is at the core of CBA. The use of CBA thus hinges upon the ability to monetize impacts, reflecting how much those that are affected by a policy intervention value the changes. The environmental impacts have proven to be one of the hardest class of impacts to monetize, where continuous research in valuation methodologies have greatly improved the accuracy and reliability of environmental impact valuation. For an updated guide to the recent development in the valuation of environmental impacts, we refer to OECD (2018). Guers et al. (2009) and Venables (2007) provide some comments on social impact extensions and how to handle wider public account impact respectively.

Limitations to CBA

Although a cost-benefit analysis is a strong and widespread tool for assessing measures, it has several limitations and shortcomings which have been discussed in the literature. Among these, the most commonly mentioned ones are difficulties in quantifying and monetizing effects and the resulting need for supplementary methods. The quality of input data is also a large concern when using quantitative methodologies like a CBA. Especially, the accuracy (or inaccuracy) of traffic forecasts can have a large influence on the outcome of a CBA since effects like travel time savings, accident costs, congestions, and reliability play a large role in the assessment of the benefits (Vickerman, 2017), (Jones, et al., 2014). This is a problem in general but has more severe implications in a CBA. More generally, uncertainty in the input data could lead to different outcomes but could also be explicitly considered in the CBA. The topic of how discounting in a CBA should be done and how it handles the residual value is also widely discussed in the literature (Jones, et al., 2014), (Mouter, et al., 2013). We refer to subchapter 3.3 for a discussion on CBA's vulnerability related to the choice discount rate.

In general, the main reservations against the use of CBA as a decision-making tool for transport appraisal, can be summarized in the following four bullet points (OECD, 2002):

- Understates the economic development benefits of certain investments, e.g. the industrial reorganization benefits which could arise from modern logistical practices (Mohring and Williamson, 1969)
- Favours some user groups at the expense of others. This bias result in the reliance of willingness to pay as a measurement of opportunity cost.
- Fails to incorporate all of the external effects of projects, such as environmental impacts, social effects and wider economic benefits.
- Fails to deal with distributional effects.

The standard CBA approach in transport appraisal is well justified and perfectly suitable as long as two conditions are met (Bröcker, Korzhenevych et al. 2010): 1) the distribution of benefits between household groups or regions is not a concern and, 2) as long as all benefits can be measured within the transport system itself. In the following section we will discuss the limitations linked to the first condition, for the latter we refer to chapter 3.2 and chapter 3.3 for a discussion on the failure of CBA to capture indirect external effects of projects.

Implicitly in the CBA framework is an assumption of utilitarian welfare functions, meaning that individuals are assigned equal weights in the summing up of monetized welfare effects. The aim of CBA is to maximize the total welfare of a project – ignoring distributional effects. This is an often raised objection towards CBA, as the preferred ex ante decision making tool for transport appraisal, where the ethical considerations of the utilitarian approach are criticized (e.g. Harberger 1978, Kelman 1981, MacIntyre and Syre 1992, Hanson 2007, Lowry and Peterson 2012 and van Wee 2012). However, in most cases the criticism towards the utilitarian

approach are of limited relevance. For most transport related projects, e.g.. the choice between a rail or a road extension, these moral questions does not really play a significant role. On the other hand, for some social inclusion projects it might be relevant (van Wee 2012).

In addition, several authors (Flyvbjerg, 2009, Button et al, 2010) have found that there is a tendency that planners and economists overestimate the benefits and underestimate the costs when performing CBAs for large transport infrastructure projects. However, this bias is linked to the application of CBA and not to the intrinsic methodology (Button and Eklund, 2016). Further limitations like the difficulties in considering equity and distributional effects are mentioned (e.g., in (Jones, et al., 2014) (Thomopoulos & Grant-Muller, 2012) (Wee, 2012) (Ackerman, 2008)). This is, however, mainly a critique in the practical application of the CBA and not the method itself. CBA does not exclude the reporting of distributional effects, for instance benefits distributed over income groups. Following the utilitarian principle, the value of each individual benefit counts equally. However, CBA is a decision support tool and reporting the benefits (and costs) distributed over different user groups will enable the decision-makers to accrue larger weights on benefits (or costs) to user-groups with targeted policies (e.g. disadvantaged groups or regions). On the other hand, the marginal utility of one monetary unit decrease with wealth, which could make the summing up of individuals willingness to pay in CBA, problematic from a distributional standpoint.

In the next subchapter we will discuss the multi-criteria analysis as a complementary method to overcome some of the limitations above.

5.2 Multi-Criteria Analysis

Based on the weaknesses of the CBA which we identified in the previous chapter, a multi-criteria analysis (MCA) is able to mitigate some of these. Most public guidelines for transport appraisal and planning include a framework of partial multi-criteria analysis (MCA) as a supplement to CBA. MCAs are generally recommended for impacts that are hard to value precisely or are considered to be limited or hard to measure precisely. Also, it allows including multiple stakeholder perspectives. In light of the first point, (Dodgson, et al., 2009) present a comprehensive framework for MCA manual, which stress that MCA should not be regarded as a substitute, but a complement of CBA. The main purpose of MCA is to address criteria that are beyond monetary terms, thus taking into account qualitative and quantitative aspects in decision making.

(Boggia, et al., 2018) propose a new Model GeoUmbriaSUIT for evaluating areas at local, regional or national level with environmental, economic and social aspects with GIS. Their framework MCA-GIS is used as policy decision support tool in sustainability assessment and applied on a Malta as use case. In their study the region was divided into 6 regions and 3 indicator groups were evaluated.

The Standard Multi-Criteria Analysis Method

Contrary to CBA, which does not have such a large variety of approaches, there are numerous different multi-criteria analysis techniques. All these methods, however, have in common that they make explicit use of the assessment by individuals for each different option and criteria. The difference of the methods mainly lies in the combination and aggregation of these assessments (Dodgson, et al., 2009). The following eight steps are the main steps in a MCA method (see, e.g., (Transport for NSW, 2018)). Note that the first two steps are similar to the initial steps of a CBA.

1. **Problem analysis** – Identification of the problem that should be solved, and the finding or defining of the corresponding policy objective.
2. **Definite alternatives** – Description of all measures that can be taken and identification of individual elements. Definition of alternatives and variants.

3. **Define criteria** - The set of relevant assessment criteria must be defined. The selection should be made project-specific.
4. **Scoring** – A numerical (quantitative) or ordinal (qualitative, e.g., plus / minus) score is assigned to each criteria of each alternative.
5. **Weighting** – A numerical value is assigned to each criterion to determine their relative importance.
6. **Aggregate results** – The scores and the weighting are combined into a unified assessment of the alternatives. In the simplest case a weighted average can be used.
7. **Examine the results** – The aggregated results are examined to be able to make interpretations and conclusions.
8. **Sensitivity analysis** – Examine if and how small changes to the weights and scoring alter the overall evaluation.

In the standard MCA as described above, high scores on one criterion would compensate low scores on another criterion. Therefore, if a very low score on one criterion would make the alternative infeasible it must be explicitly considered. Additionally, there must exist a discrete and finite set of alternatives and independence of the criteria must be established to avoid double counting effects.

Applications of MCA methods in the transport sector can be found in (Pérez, et al., 2014), who reviewed 86 published papers on applying MCA in urban passenger transport systems. Another review of MCA applications is given in (Deluka-Tibljaš, et al., 2013) who considered the topic of investments in urban transport infrastructure.

Extensions to and Variants of Multi-Criteria Analysis

Beside the standard approach of a MCA as presented in the previous section, there are numerous extensions proposed in the literature. Although presenting an extensive list of all MCA variants is out of scope of this literature review we focus on some prominent examples of the literature. First, a multi-actor extension is presented which focuses on the inclusion of the different points of view of different stakeholders. Then, goal-oriented MCA variants are considered, which evaluate the different options with respect to a predetermined goal, which is usually set by the government, e.g., national transport policies. Finally, multi-criteria decision-making tools and methods are listed which are possibly quite different to the general structure of a MCA but have all the same purpose of assessing a range of limited options based on multiple criteria.

Multi-Actor Multi-Criteria Analysis (MAMCA)

Macharis et al. (Macharis, et al., 2008), (Macharis, et al., 2012) introduced the Multi-Actor Multi-Criteria Analysis (MAMCA) framework as an extension of the MCA. This variant allows for adding different stakeholder views in the MCA. This is achieved by defining the criteria not based on the effects of the measures but on the stakeholder's objectives. The weighting is determined by the stakeholders as well to determine the relative importance from the stakeholders' point of view. Doing this reduces the risk of double-counting effects and the needed independence of the criteria can be reached. As a second step, it is also possible to assign a weight to the stakeholders to express the importance of each stakeholder. The MAMCA changes the general structure of an MCA by introducing an additional step for the stakeholder identification and an additional step to construct indicators to evaluate the alternatives based on the stakeholder's criteria. In (Macharis, et al., 2008), (Macharis, et al., 2012) the authors demonstrate the MAMCA approach on transport projects. Case studies include transport policy measures, alternatives for a possible modal shift of waste transport in the Brussels region, and the location of a new high-speed train terminal in Brussels.

An extension to the MAMCA method is proposed in (Cornet, et al., 2018) who focus on the sustainability viewpoints in transport projects. They conclude that there is no standard practice

for appraising transport projects against sustainable development objectives. Nevertheless, a dual approach is proposed that compares expert-based versus principle-based approaches. The use case is the appraisal of a high-speed rail connection from London to Birmingham with 3 options, and 3 stakeholder groups (sustainability experts, government transport experts, and other transport experts).

Goal-oriented assessment methods

There exist several alternatives to the standard structure of a MCA which focus on predetermined goals, which are, e.g., deduced by objectives set by the government. The official guideline of New South Wales for economic appraisal of transport investment and initiatives describes several such methods (Transport for NSW, 2018). In a Goal Achievement Matrix (GAM) each option is ranked based on how and if it can achieve the goals. It follows the same base structure as the MCA but for scoring its goals typically +1, 0, or -1 is used showing whether the option contributes, leaves unchanged, or detracts from goal achievement. Advantages of the GAM tool are that it is simple and a wide range of goals including equity effects can be considered. On the other hand, beside the general disadvantages of MCAs, objective measurements of the degree of goal achievement can be hard and interdependencies between objectives are not taken into account. A purely qualitative tool is the Strategic Merit Test (SMT) which can be used in the strategic planning phase of a project. It is based on a set of questions for examining the strategic fitness of an option including the alignment to the predefined goals of the government. A more detailed analysis of the different options is done in the Objective Impact Assessment (OIA) which extends the SMT method by a more detailed analysis of the options in form of an impact table.

Another variant of a goal-oriented MCA is proposed in (Ward, et al., 2016), where a generic 'Policy-led MCA' (PLMCA) is presented. This method has a strong emphasis on better incorporating social and environmental aspects with regards to existing policies. The results are then visualized in a decision matrix like the one in **Error! Reference source not found.**. Since PLMCA is a participatory assessment method it is a variant of a MAMCA, in which the participating stakeholders put values into this matrix of the agreed appraisal criteria against their policy goals.

Table 5.1 - Example of a decision matrix in the PLMCA (Ward, et al., 2016)

Policy Led Appraisal Dimensions	Objectives	Criteria	Evidence	Risks & Opportunities	Weights	Scores
Economic	Objective 1	Criterion 1.1				
		Criterion 1.2				
Financial	Objective 1	Criterion 1.1				
…	…	…				

On a side note it should be mentioned that all the above methodologies should be applied with caution so that the neutrality of the analysis is not at stake.

Multi-Criteria Decision-Making (MCDM)

There exist numerous methods which can be used for multi-criteria decision-making. Some but not all of them fit the general structure of the MCA described above. Based on the general overview given by (Velasquez & Hester, 2013) and the classification of (Penadés-Plà, et al., 2016), in **Error! Reference source not found.** we list several of these methods with their classification, properties, advantages, and disadvantages.

Table 5.2 - Overview of different MCDM methods. (based on (Velasquez & Hester, 2013)

Method	Type	Main Properties	Advantages	Disadvantages
Analytical hierarchy process (AHP)	Pairwise comparison	Based on pairwise comparison of alternatives, popular method	Easy to use, scalable	Problems with interdependencies
Multi-attribute utility theory (MAUT)	Utility / Valuation	Assignment of utility value to each consequence	Considers uncertainties and preferences	A lot of input data is needed
Case-based reasoning (CBR)	Other	Decision is made based on similar cases documented in history	Not much additional data needed, adaptable to new information	Sensitive to inconsistent data, many cases needed
Data envelopment analysis (DEA)	Distance-based	Assigns efficiency rating using linear programming techniques	Capable of handling multiple inputs / outputs, quantifiable efficiency	Assumes that all data is exactly known
Fuzzy set theory	Other	Mathematical modelling technique using fuzzy sets	Considers imprecise and insufficient data	Difficult to develop
Simple multi-attribute rating technique (SMART)	Utility / Valuation	Simple variant of MAUT	Simple, any weight assessment method can be used	Same as MAUT
Goal programming (GP)	Distance-based	Variant of multi-objective optimization using target values (goals)	Handling of large-sale problems and infinite alternatives	No weighting of coefficients possible
Elimination and Choice Expressing Reality (ELECTRE)	Outranking	Outranking method	Considers uncertainty	Difficult interpretation and explanation
Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE)	Outranking	Similar to ELECTRE, outranking method	Easy to use, no assumption about proportionate criteria	No clear weight assignment method
Simple additive weighting (SAW)	Scoring	Weighted scoring method through linear combinations	Intuitive to decision makers, simple calculations	Results may be illogical, revealed results may not reflect reality
Technique for order preferences by similarity to ideal solutions (TOPSIS)	Distance-based	Based on distance of each alternative to the ideal and worst alternative, i.e., best score in each criterion	Simple process, easy to use, scalable	Difficult to weight and keep consistency in the assessment
Multi-criteria optimization and compromise solution (VIKOR)	Distance-based	Similar to TOPSIS, comparison to ideal alternative	Useful if preferences are not known from the beginning	Added alternatives influence the scorings
Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH)	Pairwise comparison	Based on qualitative judgement of differences between options	Easy to use for the decision makers	Results can be unreliable

Numerous applications of AHP can be found, e.g., in (García-Melón, et al., 2012) for evaluating sustainable tourism, (Shang, et al., 2004) for transportation projects in Ningbo, China, (Nedevska, et al., 2017) for choosing rail routes in parts of Macedonia, and (PIANTANAKULCHAI & SAENGKHAO, 2003) for aligning alternative motorways. Another application of AHP is the 'Sustainable Mobility Inequality Indicator' (SUMINI) approach (Thomopoulos & Grant-Muller, 2012). There, the focus lies in incorporating equity in transport project evaluation, where equity is seen to be the distribution over society, over time, and over place. A combination of scenario analysis and MCA is shown in (Hickman, et al., 2012) and used for assessing the progress of policy making against a range of objectives. How the value of ecosystem goods and services can be assessed is presented by (Curtis, 2004) in a method combining elements of economic theory, MCA, and a Delphi panel to assign the weights for the MCA. A meta-decision support for choosing the appropriate methodology is presented in (Guarini, et al., 2018) in the domain of real estate and land management. Finally, theoretical and methodological contribution for analysing a discrete set of alternatives using MCA is given in (Granat, et al., 2009) and the integration of uncertainty is handled in (Hyde, 2006).

Limitations to Multi-Criteria Analysis

Although a MCA can overcome major drawbacks of a CBA by being able to include qualitative and non-monetized effects, it is inferior in other aspects. By monetizing all effects, the result of a CBA is, in principle, neutral (because the common unit *money* is used for all effects compared to qualitative assessments), easy to interpret, and comparable. The result of a MCA depends on the individual and subjective scores and weights set by the decision makers and involved individuals. The more and more diverse perspectives are included, the less biased towards the interests of one stakeholder the MCA gets. Furthermore, it is not guaranteed that even the best result determined by a MCA leads to an actual improvement over the base case, i.e., when nothing is done. Furthermore, (Treasury, 2015) claim that a MCA, as a CBA, could be unprecise. Common problems of MCA include using qualitative analysis instead of quantitative analysis or the 'do nothing' option is producing a bias towards action. The more these issues are solved, the more the MCA might look like a conventional CBA. Other limitations of MCA are the lack of an agreed upon theoretical framework (which is reflected in the large number of MCA variants) and impacts that occur at different times are harder to evaluate (Transport for NSW, 2018). In the case of the MAMCA approach, (Macharis, et al., 2012) conclude that it is sensitive to the selection of criteria and the choice of weights. If not properly chosen, it can lead to a strategic bias. MAMCA also avoids giving definitive statements or rankings of options as final results but is more intended to raise awareness as basis for discussions. We conclude that both MCA and CBA have limitations when using individually, but some of these can be overcome by a reasonable combination. As already mentioned in (Munda, 2017) and (Thomopoulos & Grant-Muller, 2012), MCA and CBA are complementary to each other. A review of such combinations will be presented in the next subchapter.

5.3 Combinations of CBA and MCA

It is mentioned by several authors that CBA and MCA are complementary methods in nature, see, e.g., (Munda, 2017) and (Dodgson, et al., 2009). Therefore, the goal of this subchapter is to give an overview of the combination possibilities of these methods.

Application of Cost-Benefit Analysis and Multi-Criteria Analysis in Spatial Appraisal

A structured comparison of the differences in the methodology, applicability, and results is given in (Munda, 2017), whereas (Gamper, et al., 2006) propose decision criteria when and how to use CBA or MCA within implementation guidelines. Furthermore, a comparison of the outcome of CBA and MCA (AHP specifically) is performed in (Khaki & Shafiyi, 2011), where the authors showed that these methods can lead to significantly different periodization. It was

shown in (Annema, et al., 2015) that asking decision makers on their opinion about the usage of CBA and MCDM for transport policy appraisal can lead to interesting outcomes. In their interview-based study the authors asked 21 Dutch politicians on their perspective on transport appraisal methods. In general, they all make use of the outcome of a CBA, but do not base their final decision on it and find its outcome to be 'pretentious'. The interviewees further stated that they are more interested in the politically interesting trade-offs than in the aggregated result. This also forms the basis of the proposed supportive tool based on CBA and MCDM with the help of a trade-off sheets. In (Vickerman, 2017) an overview of methods that go beyond a classical CBA and focus on user benefits is given. The inclusion of wider economic impacts is not easy in a CBA and often omitted because of the fear of double-counting benefits. Also, the authors state that a CBA focusing on welfare impacts must allow for distribution of costs benefits between groups in society and time periods. The relevance and influence of MCA in public decision making is analysed in (Gamper & Turcanu, 2007) where the authors showed that even without any appearances in national laws or guidelines, MCAs are still performed and have an influence on the decision-making.

Methods for combing Cost-Benefit Analysis and Multi-Criteria Analysis

In several national guidelines (e.g., British) and the scientific literature a qualitative assessment along a CBA of transport projects is performed. In many cases, however, this assessment is an additional task and does not influence the CBA results or vice versa. This would result in a qualitative statement next to, e.g., the benefit-cost ratio, how beneficial a project is, measured on the defined qualitative criteria. Then the decision makers see on the one hand an assessment of the quantitative impacts and on the other hand an assessment on the qualitative measures, both in a unified value. In this subchapter we do not consider such forms of combinations but identify assessment methods that combine CBA and MCA in a more integrated sense within a unified framework.

In (Barfod & Salling, 2015) the EcoMobility (EM) framework is introduced which is based on an excel-based software model (EM-DSS) with CBA, feasibility risk assessment (FRA), and a multi-criteria decision analysis with a customized examination process. Since classical CBA and their sensitivity analysis does not include probability of occurrence of the considered scenarios, in the FRA tool a Monte-Carlo simulation is applied. Together with the CBA module, the results from the input to the MCA module as a new criterion. Contrary to the other approaches, not the resulting values like the benefit-cost ratios are used but the certainty graphs from the FRA. These graphs are presented to the decision makers which set the weights of the criteria so that they are able to take uncertainty and risks into account. As MCA method variants of SMART and AHP is used (see above). The proposed method is applied to the Oresund fixed link between Copenhagen and Malmö. Results show that in this framework it is possible to include wider range of effects. Furthermore, the authors stated that documentation of the stakeholder involvement conference should be seen as integrated part of the decision-making approach. Limitations of this EM-Framework are, however, like most other MCA-based methods that there is no 'value-for-money' rating in the end.

Another variant of combining CBA and MCA is proposed by (Gühnemann, et al., 2012). The authors' assumption is that new assessment methods should ensure compatibility and comparability to already existing procedures in place. In the proposed method the monetized values of the sub-criteria of the CBA (in this case air, noise, accident reduction, transport efficiency, and wider economic impacts) are scored and scaled between 1.0 and 7.0. The same scale is also used for the non-monetized elements of the MCA. Then, the decision makers define the weights of each criteria and a linear additive model is used to combine the scores to a single value. To be able to make statements about whether or not the project offers value, an investment worthiness threshold is introduced based on the benefit-cost ratio computed by the scores. The proposed method is applied to a data set of 182 projects concerning the secondary road network in Ireland.

An approach named Strategic Option Assessment (SOA) is presented in (Prosser, et al., 2015) which is also a combination of MCA and CBA. The main idea of the SOA is to monetize all impacts like in a CBA and then apply a weighting (e.g., temporal, spatial, or cost) of the costs and benefits. The focus of SOA lies in the comparison of different option, so the costs and benefits are not reduced to the same level, but the weighted cost benefit performance is compared. The evaluation of this method was done in three case studies: Dutch *Ecologische Hoofdstructuur*, German Emssperrwerk, and the Sustainable Corporate Performance policy by a Dutch company. Similar to other combined methods, here, the assessment is performed against policy objectives as well. Additionally, spatial and temporal distributional effects are considered. A hypothetical example based on Liverpool, Australia is presented, and the results show that SOA lies in between MCA and CBA and has the advantage of an objective comparison of alternatives based on monetized costs and benefits over MCA.

With the goal of developing a method for sustainable project evaluation, the tool named 'multi criteria cost benefit analysis' (MCCBA) is presented in (Sijtsma, 2006). As the name suggests it is a combination of elements taken from CBA and MCA. An important aspect of the MCCBA is the stakeholder involvement as the aggregation of monetary and non-monetary scores is based on consensus among the identified stakeholders. Another additional step in the MCCBA is the trade-off analysis. In this step which is the last but one step before the sensitivity analysis, the aggregation is interpreted, and trade-offs are analysed by a ratio-analysis and a stakeholder perspectives analysis. In the former, e.g., net-CBA outcomes per outcome of another criterion are considered which might give further insights. Similar to a sensitivity analysis, the latter changes the weights of the different criteria to the stakeholders and analyses the outcome.

A simpler and direct approach of combining CBA and MCA is followed by (Schutte & Brits, 2012). In their proposed method they focus on four decision criteria; optimal allocation of scarce resources, equity, sustainability, and compatibility to the stated objectives. The first criterion is evaluated using a CBA from which the results are taken as one decision criteria in a MCA. This methodology was developed for the City of Tshwane.

Two more straightforward combinations of CBA and MCA are proposed by (Diakoulaki & Grafakos, 2004) and (Beria et al. 2016). In the first paper, an indirect monetization strategy for environmental impacts using a MCA is presented which can then by integrated into a CBA. Monetization is done by using a relative value scale which is then related to the weight of the cost criterion. The second paper, which considers ex-ante evaluation of sustainable mobility assessments at a neighbourhood scale, suggests two general ways to combine CBA and MCA. Without going further into detail, one way is to develop a CBA and evaluate soft effects with MCA. The other way is to develop a MCA for a broad screening of options and evaluate public costs and consumer benefits with CBA.

A new, unified, integrated, comprehensive, and transparent transport measure appraisal method is proposed by (Kiel, et al., 2015). The authors named it 'Assessment method for demand and traffic management' (AMDTM) and it is based on nine steps. This method includes monetized effects based on the measures' costs and benefits but also other quantifiable impacts as well as unquantifiable measures in a weighted manner. Notable features of AMDTM are that it is an integrated and comprehensive method to determine cost-efficiency of measures and that different policy objectives can be taken into account.

Limitations of Cost-Benefit Analysis and Multi-Criteria Analysis combinations

In general, combining CBA and MCA could strengthen the advantages while also mitigating the disadvantages and limitations of each individual method. However, the combination has to be designed cautiously as to not inherit the disadvantages of both methods. As stated in (Sijtsma, 2006), such a combination is able to reduce the *strictness-in-reasoning* of a CBA while also reducing the *over-flexibility* and richness of a MCA. Furthermore, the (revealed) preferences (MCA) can be considered along with the budget constraints and externalities

(CBA) at the same time. Most of the methods presented in the reviewed articles do not result in a value-for-money rating which is a limitation of a MCA which has not been solved by the combined methods so far. Some methods try to overcome this limitation, e.g., by introducing indicators and a worthiness threshold value. By using such values, however, more subjectivity is introduced. Also, to some extent, limitations of both CBA and MCA still remain in the combination even if possibly mitigated, e.g., subjectivity and difficulty in understanding of MCA criteria. The largest potential of combining CBA and MCA lies, however, first, in the inclusion of a wider range of effects than in a CBA or MCA alone within a unified framework. Second, a stronger participation by stakeholder involvement is possible while still taking objectively evaluated monetized effects into account

5.4 Discussion

This chapter presented the most commonly used assessment methods for transport measures with focus on CBA and MCA. While a CBA is still the most widely used assessment method, the difficulty of monetizing wider economic and non-economic, environmental, and social effects resulted in the development of more inclusive assessment methods. Therefore, these methods evolved from a classical CBA, which has already been used several decades ago towards more qualitative and other quantitative methods. In the literature, several approaches how a combination of CBA with MCA could improve the meaningfulness of the assessment results are described. Many authors noted that both methods are complimentary in nature. A main advantage of integrating a MCA is that different stakeholder views can be integrated in the assessment method. Most of these combinations use a CBA to evaluate the public costs and monetized consumer benefits and use these results as an additional criterion within a MCA. Alternatively, in some methods, results from a MCA are used within a CBA using a monetizing method. Many decision-makers (e.g., politicians) in practice, however, often ignore the outcome of traditional assessments methods like CBA, e.g., because not all relevant effects are included, they are not convinced by its outcome, or they are more interested in the politically favourable trade-offs than in the aggregated result. Therefore, new assessment methods must be transparent, robust, and inclusive, as well as able to include wider impacts, environmental issues, and social effects which are now more important than ever.

After presenting different variants of assessment methods proposed in the literature, in the next chapter we take a deeper look how these methods are applied in a practical context. In chapter 6, which is the final chapter before we draw overall conclusions, we discuss the current practices and how the national guidelines propose to perform transport policy and project appraisal.

6 National Guidelines and Practices

Decent overview over impacts and methodology for spatial appraisal and planning have limited real-life impact if they are not followed up in practice. In this chapter, we review the current standing with regard to national practices and guidelines. We start by giving some insights to practices in transport appraisal and transport planning in subchapter 6.1. Thereafter, we account for current-state-of-the-art practices in national guidelines in subchapter 6.2, both by reviewing earlier studies on the topic and by providing our own updated mapping of guidelines. We discuss our findings and relate them to the previous chapters in subchapter **Error! Reference source not found.**.

6.1 Transport Appraisal and Transport Planning in Practices

For starting the discussion about current transport planning in practice, first, the historic development of transport planning in two exemplary countries (Austria and Germany) is shown based on the results of contributions to the 14th World Conference on Transport Research 2016 from members of a Special Interest Group on National and Regional Transport Planning and Policy, see (Emberger & May, 2017) for the editorial. The aim is to show the development of the transport policies in these countries which lead to current examples and best practices as of today. The second part of this subchapter reviews currently used assessment methods for transportation projects and their role in the overall project planning process.

Transport Policy Planning in Practice

Developments of methods for transport planning and appraisal have followed public transport reforms and spatial policies. A famous example is former U.S. President Franklin D. Roosevelt two packages of countercyclical and reform programs, the ‘New Deals’, during the American Great Depression from 1933 to 1936 (e.g. Schlesinger 2003). In 1998, the British government led by Tony Blair launched a ‘New Deal for transportation’ to stimulate the economy, although not for countercyclical reasons (e.g. Shaw and Docherty 2008). In the following, we will provide two examples on developments within past and present transport planning, before we render insights from some more general studies.

Our first example regards development within Austrian transport planning. Emberger (2017) finds that environmental challenges became more important in Austrian transport policies from the 1990s, but economic arguments such as business connectivity still dominate. Focus of the planning process has shifted between passenger and freight transport, which also have influenced policies. Policies nowadays are to a lager extent based on more scientific-based approaches. Furthermore, different future scenarios and policy instruments to handle negative impacts of transport have emerged. From assessing one mean of transportation at the time in the 1980s, Austrian assessments has become gradually more comprehensive, assessing multiple transportation means at once. Yet, the lack of measurable policies often constitutes a challenge. Emberger also point out that need for updated information implies that adequate monitoring systems should be made at a regular basis. For instance, regular household surveys could help update information on the household sector, including modal split, number of trips per day per person, travel time budget and energy consumption for mobility.

Our second example regards the new German master plan for transport investments. Fichert (2017) review the German developments in transportation policy plans and policies. He finds that the focus in policy programs for transportation policies have shifted from sustainable developments and calls for modal shifts in 2000 to competition in the provision of transportation services in recent years. The federal government enacted a new masterplan for transportation investments in 2016, where overall investment and shares of different nodes are analysed in more detail. To assess transport policy developments, both data on modal splits and user costs are applied. The master plan is analysed based on the investment allocation over modes of

transportations and types of investment. Nevertheless, Fichert finds that despite the change in priorities in policy programs, the effect in overall traffic development remains rather limited. The plan has received criticism due to overestimation of completed projects within given timeframes. Since the introduction of the master plan, countercyclical financial policies during downturns have contributed to financing unfunded parts of the project portfolio. According to Fichert, deficits and more positive economic development might press forward harder prioritization in the future.

More general recommendations and best practices are presented in a publication by NETLIPSE (Staal-Ong, et al., 2008), which is a network of experts working in the field of large transport infrastructure projects in Europe. The authors describe best practices regarding the management of such projects and review the past 10 years. Beside topics like financial, risk, and knowledge management, important best practices regarding stakeholder management are proposed. Initially such an involvement was planned mainly for legal purposes but it evolved into a more integrated approach throughout the project lifecycle which is beneficial for the project and increases its credibility. Also, an open and proactive approach towards stakeholders is most promising.

Regarding the development of transport policies, (Emberger & May, 2017) identify several challenges for national plans; the need to specify clear objectives, distinguish between objectives, strategy, and selection of policy measures, adopt a multi-modal approach, avoid optimism bias, ensure the monitoring of the national transport plan against its objectives. Best practices of multi-modal transport planning are shown by (Litman 2017), inter alia by listing non-quantifiable impacts, considering a variety of measures or combinations of measures and using an integrated planning approach.

Transport Policy Appraisal in Practice

The question of the role of transport appraisal (with a focus on CBA) within the overall decision-making process is considered in (Mackie et al. 2014), which includes a survey of several countries having included CBA in their decision-making process. The role of CBA within this process is shown in **Error! Reference source not found.Error! Reference source not found.**. It shows that the project appraisal depends and is embedded in a larger process on top of which there are the strategic objectives of the decision makers. This suggests a policy-oriented project assessment method. It was shown that the benefit-cost ratio (BCR) is strongly correlated to project selection in many countries, including United Kingdom. Again, important impacts for the assessment are identified to be travel time savings, safety, travel time variability, crowding relief, fitness and health, carbon emissions, and more wider economic impacts.

However, there are strong evidences that the CBA appraisal results have not significantly influenced the final policy decisions in other countries such as in Scandinavia, partly because the influencing factors were not covered by the CBA (e.g. Odeck 1996, Nyborg 1998, Boge 2006, Eliasson and Lundberg 2012, Mackie et al. 2014, Eliasson et al 2015 and Sager 2016). Similar results for the Netherlands are shown in Annema et al. (2016). In Norway and Sweden, cost-benefit analyses have limited impact on the prioritized projects due to vested overrepresentation of rural areas in parliament, political interests and solid state-finances in case of Norway (Nyborg 1998 and Sager 2016, Johansson et al. 2017 and Vigren and Ljungberg 2018). In line with these evidences, distribution of transportation investments over Norwegian counties have been rather stable over time (Nyborg 1998 and Strand et al. 2015). Elvik (1995) do however find evidence that road standards have been decisive for the distribution of road investments in Norway. Some studies find that high raking based on cost-benefit analyses might increase selection probability slightly in rural Scandinavian counties (Odeck 1996, Fridstrøm and Elvik 1997 and Eliasson et al. 2014). Other studies show that non-monetized impacts and MCA play a minor role in Norwegian transport appraisal (e.g. Bull-Berg, Volden and Grindvoll 2014).

Investigating 67 CBAs in the Netherlands for transport and spatial development projects made in the period from 2000 to 2011, Annema and Koopmans (2015) find that many analyses omit or do not monetize environmental impacts. In addition, uncertainties from CBA and implicit assumptions on discount rate are most often not communicated to decision makers. Mouter, Annema and van Wee (2013) find that that Dutch decision makers consider the neglect of non-monetized effects in CBA as substantial with transport appraisals.

In Mackie et al. (2014), three types of appraisal challenges are mentioned; technical, planning, and policy, see Figure 6-2. In the first category there is uncertainty in the methods and data (e.g., for forecasts), which can lead to fragile results. Furthermore, there are problems in valuation of the business travel time savings, time savings for freight transport, congestion and crowding, and supply / demand interaction. Second, the integration in the planning process can be difficult due to a lack of alternative solutions to a given problem. Furthermore, some desirable effects like reliability, regeneration, and resilience are hard to quantify. Also, the overall planning concept in the strategy of the region is not covered within the formal appraisal framework. Third, spatial distribution is often not covered in the CBA. For instance, local and regional impacts are dismissed. They state that SCGE and LUTI methods could help solve the lastly mentioned problems.

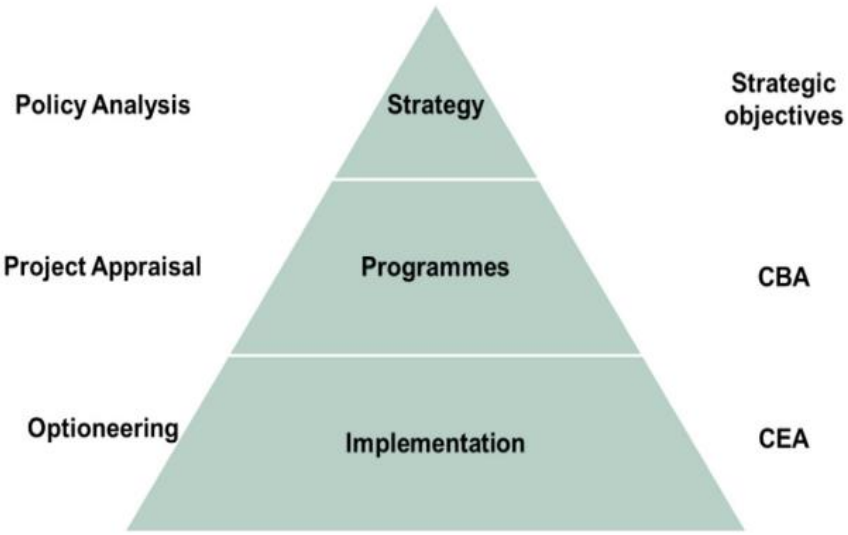


Figure 6-1 - The planning / decision making hierarchy. (Mackie, et al., 2014)

Similar practical challenges of appraisal methods, especially CBA, within the context of sustainable urban mobility plans are presented in (Rudolph et al. 2014), namely limited comparability, dominance of travel time, neglecting full range of externalities, decision independent of CBA result, and data need. Still, the role of project appraisal in the policy making process is investigated in five European case studies. Results show that in these cases a CBA is only rarely undertaken to objectively assess the options but to support an already existing policy path.

6.2 Current State-of-the-Art Based on National Guidelines

In the following, we will review earlier mappings on national guidelines and present the results for our own mapping.

Insights from earlier mapping of national guidelines

As discussed throughout chapter 5, CBA is the preferred appraisal tool in national guidelines. CBA measures all impacts by the same neutral measure (i.e. money) and aid planners and

decision-makers in the trade-off they face in project prioritization. When the value of an impact is considered too small or uncertain to include in the CBA, the impact is instead estimated in supplementary quantitative analysis or instead treated by a comprehensive assessment framework for non-monetized impacts such as MCA. By the same token, the strength of CBA largely depends on how much of the substantial impacts that are included and how uncertain the estimates are. Accordingly, earlier mapping of national guidelines for transport appraisal focuses on CBA and extensions of the CBA framework rather than MCA.

Several studies point out the British guidelines as state-of-the-art guideline (e.g. Gühnemann et al. 2013 and Mackie and Worsley 2013). Investigating United Kingdom, Vickerman (2000) reviews the methodologies of transport project evaluation and identifies key elements. Although this publication is already several years old a transition from a CBA which was compulsory and described in the official 'Design Manual for Roads and Bridges' to a more inclusive appraisal method could be observed. The basis for this transition is the 'New Approach to Appraisal' (NATA). Although a CBA still was the key element, qualitative measures are also included using a seven-point scale (similar to Ireland confer Gühnemann et al. 2012). Key elements of road project appraisal procedures (still within a CBA) are identified to be demand forecasts, value of time, traffic safety, environmental impacts, regional economic effects, and equity considerations. In the NATA, at the turn of the millennium, wider economic effects are still only considered using a simple indicator.

Advices given in guidelines and practices in transport appraisal might not always be coinciding. A good overview of practices in project appraisal (state 2006) in European countries is given in Odgaard et al. (2006). Results show that all countries use CBA, but it is not always required. Nine countries also use MCA in combination with CBA, but the level of detail is not specified. Odgaard et al. also find that Nothern and Western European guidelines in general include more impacts in their guidelines for transport appraisal than Eastern European countries, which in turn include more impacts than Southern European countries. Gühnemann et al. (2013) assess how impact coverage develops over time across type of impact and transport sector. Apart from CBA and MCA, other quantitative and qualitative methods are used as well. As in Vickerman (2000), key effects of appraisal methods are identified to be time savings for passengers and goods, safety issues, environmental impacts and indirect socio-economic effects.

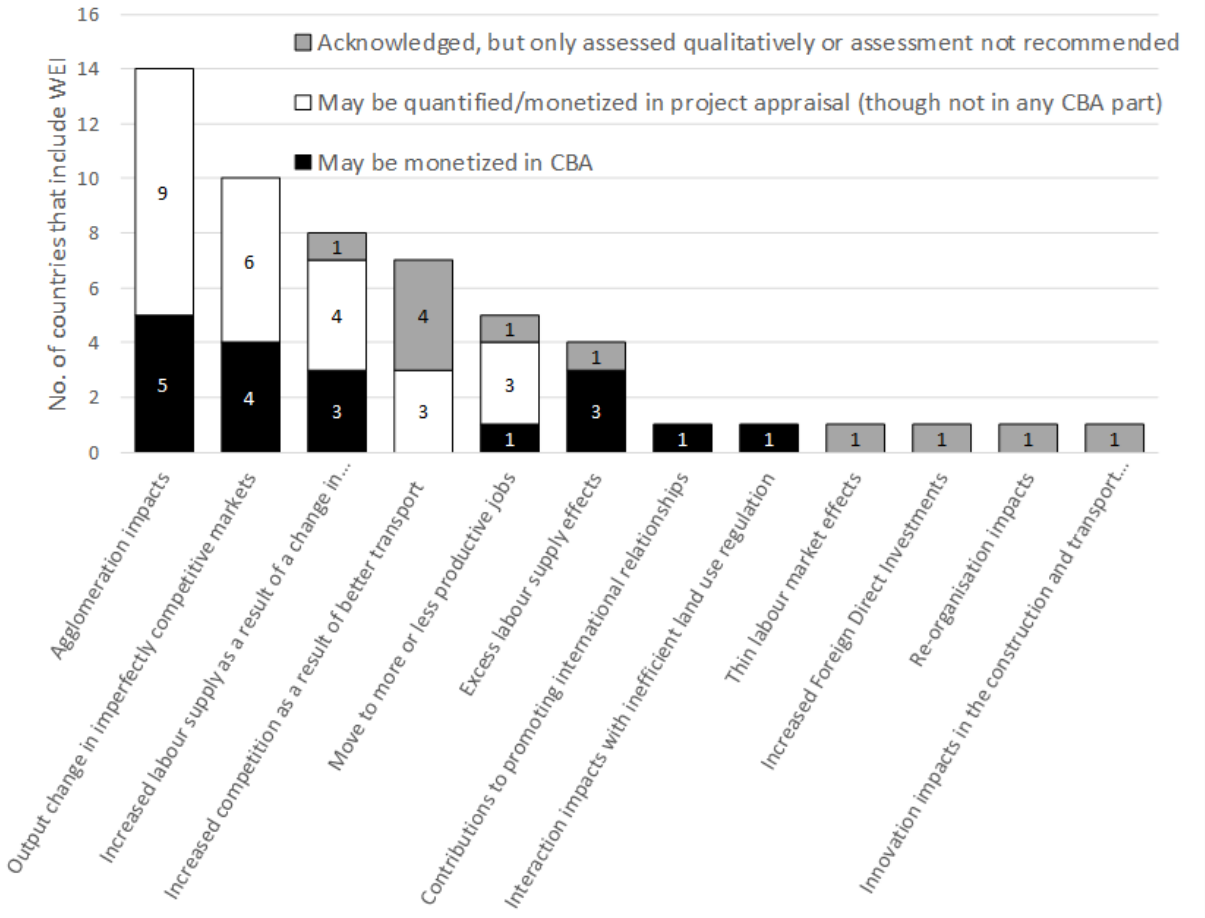
Mackie and Worsley (2013) find important improvements in English guidelines since 2003 with regards to how wider economic impacts, crowding, reliability and air population are considered. They point out that although there is an overall tendency to move in the direction of monetization as, for example, in the case of climate change, local pollution and noise, neither the UK guideline nor other international guidelines have very explicit appraisal procedures for summing up monetized and non-monetised effects. As possible improvement points for future guidelines, Mackie, Worsley and Eliasson (2014) point out time savings, congestion, crowding relief and reliability benefits in the business sector. Mackie and Worsley (2013) also find that the regional dimension is relatively more challenging to handle in countries with a federal structure.

Geurs et al. (2009) focus on determining categories of impacts and identifying gaps in the treatment of social impacts in public guidelines. On the practical side, the authors also study inclusion of social impacts in the Dutch appraisal guidance (OEI) and the UK transport appraisal guidance (WebTAG). In general, the British guideline covers social impact to a larger extent than the Dutch guideline quantitative and especially qualitative assessments, although not all impacts are dealt with. This is partly because the British guideline follows a relatively objective-led approach, while Dutch guideline follows a relatively strict welfare economic perspective. The UK appraisal guidance includes a much broader spectrum of social impacts than the Dutch appraisal guidance through quantitative and qualitative assessments. Yet it does not cover the full range as identified in the literature. Geurs et al. argue that the guidelines lack clear operational definitions of social cohesion and related concepts. Social injustice and

alternative welfare weights is not focused upon in neither guideline. They also argue that the evidence on how transport investment or policy may affect people's level of participation in activities or the number of neighbourhood contacts are missing (see also Forckenbrock et al. 2001 and Centre for Transport Studies 2006).

Some authors find substantial improvement on inclusion of environmental impacts in CBA and transport appraisal in general (Pearce 1998 and Pearce, Atkinson and Mourato 2006). Yet, climate changes and discounting of future utility impacts constitute a substantial challenge addressed by some authors (e.g. Tol 2003 and Masur and Posner 2011). Recent developments in climate change prognosis will also improve CBA estimates. We refer to subchapter 3.3 for a review of the discussion on the discount rate applied in CBA in context of modelling of climate changes.

Until the turn of the millennium, many economists remained sceptically to include so-called 'wider economic impact' in the cost-benefit analyses for transportation (see for instance Krugman 1995). Reviewing European appraisal practice, Grant-Muller et al. (2001) identify substantial progress on estimating environmental impacts, but still see large potential for inclusion of unconventional impacts. In Oddgard, Kelly and Laird's (2005) review over cost-benefit analyses across developed countries, agglomeration impacts were not even mentioned. During the last twenty years, many economists have argued in favour of such



inclusion due the impacts magnitude and more precise estimation (see for instance Venables 2007, Vickerman 2007, and Banister and Thurstain-Goodwin 2011).

Figure 6-2: The types of wider economic impacts that are acknowledged in official guidelines for transport appraisal in the 23 reviewed countries in Wangsness, Rødseth and Hansen (2017).

In a review of how 23 industrialized countries treat wider economic impacts in their official

guidelines for transport appraisal, Wangsness, Rødseth and Hansen (2017) identify 12 different types of wider economic impacts that are considered in the reviewed guidelines. Based on their review, they identify *agglomeration impacts* and *production changes in imperfect markets* as the most accepted wider economic impacts, being recognized by 14 and 10 countries respectively.

Figure 6.2 also shows an overview of how the various wider economic impacts are treated in transport appraisal. In 5 out of the 12 countries that recognize agglomeration effects as a wider economic impact in their transport appraisal, this effect is included and monetized in the CBA, the 9 remaining countries quantify this effect but keep it as a separate additive measure outside of the CBA. It may be worth noticing that 7 countries recognize *increased competition in imperfect markets* as a possible impact from transport investments, but that 4 out of these 7 countries do not recommend qualitative assessment of this effect – which may be due to the difficulties in quantifying and separating this effect from the other wider economic impacts.

The main output from the review in Wangsness, Rødseth and Hansen (2017) is summarized in table 6.1. In the table, the wider economic impacts identified in the review are classified into three classes:

A. WEIs may be monetized and included in the CBA as part of the net present value (NPV) and/or in the benefit-cost ratio (BCR)
B. WEIs may be monetized/quantified but presented separately from and CBA-part in the project appraisal, e.g. as an account of its own in a multi-criteria analysis, impact assessment or other form of appraisal
C. WEIs may be presented, but only as a qualitative assessment, or not recommended to be assessed at al.

Secondly, the observations are classified according to whether the guidelines have specific recommendations with respect to type of assessment method recommended for each identified impact.

M: The corresponding type of WEI is included in the country guideline, with method recommendations.

NM: The corresponding type of WEI is included in the country guideline, but with no method recommendations.

Table 6.1: Overview of country guidelines for including wider economic impacts in transport appraisal (Wangsness, Rødseth and Hansen, 2017)

	WEI1: Agglomeration impacts			WEI2a: Output change in imperfectly competitive markets			WEI2b: Increased competition as a result of better transport			WEI3a: Increased labour supply as a result of a change in commuting costs			WEI3b: Move to more or less productive jobs			WEI3c: Excess labour supply effects			WEI3d: Thin labour market effects			WEI4a: Increased Foreign Direct Investments			WEI4ab: Contributions to promoting international relationships			WEI5a: Interaction impacts with inefficient land use regulation			WEI5b: Re-organisation impacts			WEI5c: Innovation impacts in the construction and transport sector			**SUM**
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	
Australia		M			NM				NM		NM			NM																							5
Belgium	M			M					NM							M																					4
Canada		NM																																			1
Denmark		NM			NM					M																												3
Finland		NM						NM			NM																											3
France	M			M																																		2
Greece	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0
Ireland		NM			M				NM			NM			NM			M			NM			NM								NM						9
Iceland	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0
Italy																																						0
Japan																																						0
Luxembourg																																						0
The Netherlands	M			M						M			M			M														M							6
New Zealand	M			M						M																												3
Norway																																						0
Portugal	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	0
Spain		NM			NM			NM																														3
UK		M			M				NM		M			M																								5
Switzerland		M																																		NM		2
Sweden		NM			NM			NM			NM			NM																								5
Germany																M									M													2
USA	M																																					1
Austria																																						0
SUM	5	9	0	4	6	0	0	3	4	3	4	1	1	3	1	3	0	1	0	0	1	0	0	1	1	0	0	1	0	0	0	0	1	0	0	1	54

A = «May be monetized in CBA», B = «May be quantified/ monetized in project appraisal (though not in any CBA part)», C = «Acknowledged, but only assessed qualitatively or assessment not recommended», M = The corresponding type of WEI is included in the country guideline, with method recommendations, NM = The corresponding type of WEI is included in the country guideline, but with no method recommendations. Grey = WEI are not included in country guidelines, Black = There are no country guidelines.

Wangsness, Rødseth and Hansen (2017) point to the degree of uncertainty and lack of standardized estimation methods, as a reason behind countries not including the wider economic impacts in the benefit-cost ratio. As an example, they refer to the UK guidelines that state that wider economic impacts should not be included in the initial BCR, as the evidence for estimation of these impacts is less robust than for the other impacts that *are* included in the initial BCR.

Insights form our mapping of national guidelines

In order to obtain updated information about impact coverage in the national guidelines for transport appraisal, we have conducted a mapping of transport appraisal guidelines from 15 developed countries. Our mapping can be seen in connection with several earlier mappings of appraisal guidelines (e.g. Odgaard et al. 2006, Geurs et al. 2009, Mackie and Worsley 2013, Mackie, Worsley and Eliasson 2014, Couture, Saxe and Miller 2016 and Wangsness, Rødseth and Hansen 2017). An overview over reviewed guidelines are provided in Table 6.2 below.

Table 6.2: Reviewed guidelines

Country	Guideline
Australia	Australian Transport (2017): *Australian Transport Assessment and Planning*
	Bureau of Infrastructure, Transport and Regional Economics, Department of Infrastructure and regional development (2014): *Overview of project appraisal for land transport*
Australia (New South Wales)	Transport for NSW (2018): *Principle and Guidelines for Economic Appraisal of Transport Investments and Initiatives*
Austria	Bundesministerium für Verkehr, Innovation und Technologie (2010): *Nutzen-Kosten-Untersuchungen im Verkehrswesen (RVS 02.01.22)*
Belgium	Rebel Advisory Group 2014: *Maatschappelijke kosten-batenanalyse van een derde Scheldekruising te Antwerpen*
	Rebel Advisory Group (2013): *Standaardmethodiek voor MKBA van transportinfrastructuurprojecten. Aanvulling: Infrastructuurprojecten voor vrachtvervoer over land (weg, spoor en binnenvaart)*
	De Lijn (2015): *MKBA van de vertramming busbundel 7 tussen sint-denijs-westrem en gent dampoort*
Canada	Treasury Board of Canada Secretariat (2007): 'Canadian Cost-Benefit Analysis Guide: Regulatory Proposals'.
	Transport Canada (1994), 'Guide To Benefit-Cost Analysis In Transport Canada'.
Canada (British Colombia)	Ministry of Transportation and Infrastructure (2014): *Benefit Cost Analysis Guidebook*
Denmark	Danish Ministry of Transport (2015): *Manual for samfundsøkonomisk analyse på transportområdet*
European Union, spatial	European Comission (2014): *Guide to Cost-Benefit Analysis of investment projects*
Germany	Federal Ministry of Transport and Digital Infrastructure (2016): *The 2030 Federal Transport Infrastructure Plan*
Ireland	Department for Transport, Tourism and Sport (2016): *Common appraisal framework for transport projects and programmes*
Netherlands, spatial	Centraal Planbureau (2018): *Ruimtelijke- én mobiliteitsprojecten in de stad: wat en hoe groot zijn de effecten?*
	Centraal Planbureau (2013): Plannen voor de stad - Een multidisciplinaire

	verkenning van de effecten van verstedelijkingsprojecten op het functioneren van een stad
	Romijn and Renes (2013): Plannen voor de stad - Een multidisciplinaire verkenning van de effecten van verstedelijkingsprojecten op het functioneren van een stad, Centraal Planbureau.
	Rijkswaterstaat (2018): *Werkwijzer MKBA bij MIRT-verkenningen*
	Centraal Planbureau (2018): MKBA-methoden en bereikbaarheid: Hoe omgaan met niet-infrastructurele maatregelen, zoals wegbenuttingsmaatregelen?
	Romijn and Renes (2013): Plannen voor de stad - Een multidisciplinaire verkenning van de effecten van verstedelijkingsprojecten op het functioneren van een stad, Centraal Planbureau.
New Zealand	NZ Transport Agency (2018): *Economic Evaluation Manual*
Norway, road	Norwegian Public Roads Administration (2018): *Konsekvensanalyser, veiledning, Håndbok V712, Vegdirektoratet 2018.*
Norway, rail	*Norwegian Railway Directorate (2018): Veileder i samfunnsøkonomiske analyser*
Sweden	Trafikverket (2018): *Analysmetod och samhällsekonomiska kalkylvärden för transportsektorn: ASEK 6.1*
Switzerland	Bundesamt für Strassen, ASTRA (2010): *Handbuch eNISTRA – ein Tool für zwei sich ergänzende Methoden zur Bewertung von Strasseninfrastrukturprojekten:* *NISTRA – Nachhaltigkeitsindikatoren für Strasseninfrastrukturprojekte*
UK	Department for Transport (2018): *Distributional Impacts Appraisal*
	Department for Transport (2018): *Social Impacts Appraisal*
	Environment Agency (2007): *Addressing environmental inequalities: cumulative environmental impacts*
UK (Scotland)	Transport Scotland (2018): Scottish Transport Appraisal Guidance (STAG)
USA	U.S. Department of Transportation 2018: *Benefit-Cost Analysis Guidance for Discretionary Grant programs*

Our mapping suggests that the reviewed guidelines loosely apply three different three different impact categorizations; monetized and non-monetized effects (e.g. the Norwegian guideline), direct, indirect and external effects (e.g. the Belgian guideline) and thematically (e.g. the British guideline). Some of the guidelines apply hybrid classifications of impacts, such as the Australian guideline which classify the impacts into monetized, non-monetized and secondary or flow-on impacts. Most of the countries that apply a thematical classification of impacts, classify these according to type of impact (i.e. the Irish guideline classify the impacts into economic, environmental, accessibility and social inclusion, physical activity and integration), while a few countries/agiencies classify the impacts according to which stakeholders that are affected by the impact (i.e. Norwegian Railway Directorate: transport consumers, operators, public sector, rest of society, residual value, non-monetized effects) Our categorization is loosely based on the categorization in the British guideline. The English guideline is mostly considered as a best practice guideline, both due to its detail level on effects handled and due to the range of transportation means covered (e.g. Mackie and Worsley 2013).

We have review 20 sets of guidelines from 14 independent developed countries. All countries have more than five million inhabitants and belong to the Great Germanic language group (e.g. English, German, Dutch and Scandinavian), where the latter delimitation follow from researchers' primary language skills. Our mapping also emphasizes guidelines four dependent regions (i.e. British Colombia in Canada, New South Wales in Australia and Scotland in United

Kingdom), a spatial guideline for the European Union, as well as two distinctive sets of guidelines in the same nations based on different areas of usage (i.e. road and rail for Norway and spatial and transportation for the Netherlands).

Our mapping involves 34 impacts, distributed over 13 economic impacts (i.e. impacts on the production sector). 12 social impacts (i.e. impacts on the household sector), 11 environmental impacts (i.e. impacts on the environment) and 2 public account impacts (i.e. impacts on public funds). Among these, four impacts on travels are counted twice, as they could be regarded both as economic and social impacts, depending on the institutional sector belonging of the impact's recipient.

Some of these impacts are very specific, among them 'noise and vibration' and 'water quality'. Other impacts are more defined more broadly. For instance, labour market impacts capture both potential impacts from the production sector and wider impacts from labour market integration. Political objectives capture a wide range of topics, among them policy coordination, spatial planning, international relations and contributions to reach other policy objectives. This impact is recognized as social impact to stick to the classification in chapter 3 and the British guideline (DfT 2018) but could alternatively have been regarded as a political impact along with the public account impacts. We refer to chapter 3 for an overview over the different impacts.

We have reviewed three type assessment tools; cost-benefit analysis (CBA), multi-criteria analysis (MCA) and supplementary quantitative analysis (SQ), as well as qualitative noting of impacts that are not discussed directly in context of these analyses. In addition, our mapping involves some cases where guidelines recommend both CBA and MCA or SQ and MCA for analyses of an impact, depending on how well the quantitative method are considered to capture the impacts in question. We refer to chapter 5 for an overview over assessment tools.

In Figure 6-3 below provide an overview over how well different the four impact groups are captures by the guidelines in all countries. This result is of course dependent on how impacts are defined, and the magnitude of the impacts defined (e.g. measured by money) are not taken into account. The figure should therefore not be taken literally, but it still gives an impression on how different impacts are captured. The overall coverage of economic, social and environmental impacts in cost-benefit analyses are rather similar. Yet, we know from chapter 3 that the magnitude of the omitted economic impacts generally is larger in monetary value than the omitted social and environmental impacts, particularly in case of the wider economic impacts. Our mapping suggests that supplementary quantitative estimations are most common for economic impacts. Many guidelines recognize wider economic impact in terms of magnitude and therefore recommend quantitative assessment, but only supplementary due to the value estimates uncertainty and possible overlap with impacts covered by the CBA. MCA is most common for assessment of environmental impacts, which often are challenging to put a value on. Social impacts appear to have a little notch poorer coverage than the other groups of impacts. Some of the social impacts are blurry defined and might be hard to distinguish from distributional aspects and other policy aims (e.g. affordability and political objectives). Most guidelines, but not all, include both public budget impacts.

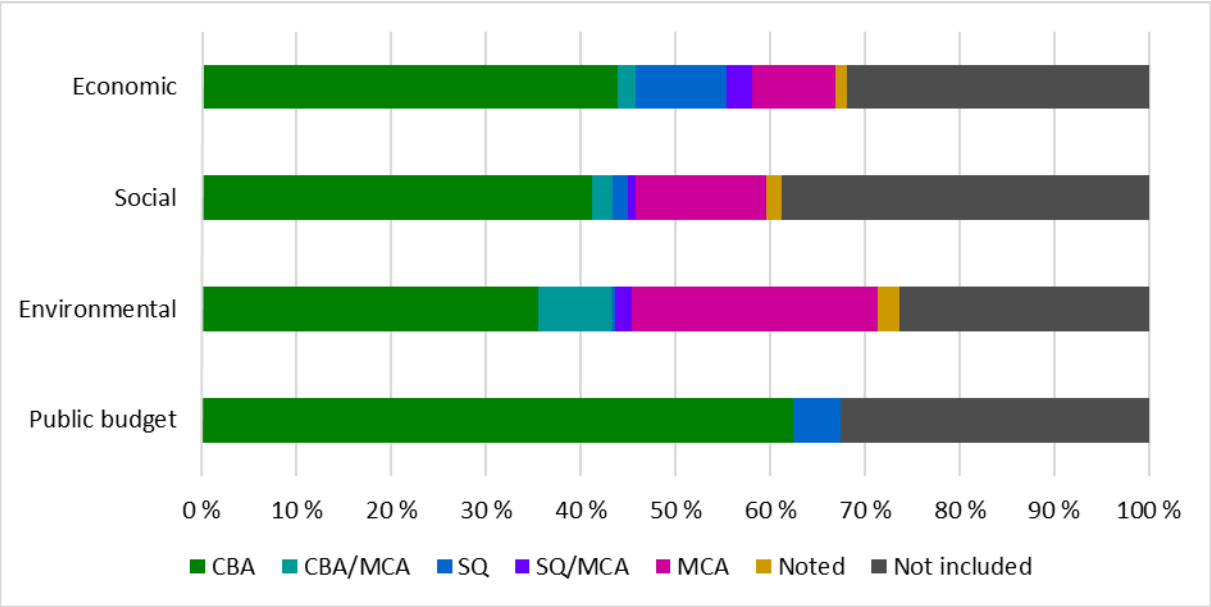


Figure 6-3: Coverage of impact groups in all reviewed national guidelines accross appraisal methods. Explanation of abbreviations applied in the table: CBA – Cost-Benefit Analysis, MCA – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis

In Figure 6-3, we review have the different impacts are covered by the guidelines. The coverage varies from full CBA assessment for maintenance and construction costs to poor for urban consumer variety and affordability. This is not surprising. Construction and maintenance regards the infrastructure directly. Impacts on urban consumer variety requires large investments and is hard to measure, whereas the impacts on affordability that are connected to efficiency (i.e. the size of social welfare pie) and not distribution (i.e. the distribution of social welfare cake pieces) are not always easy to identify. Generally, direct effects have better coverage than indirect effects. We see that production agglomeration are assessed through supplementary quantitative analysis by most guidelines, whereas impacts on environmental capital such as landscape and townscape typically are addressed by MCA.

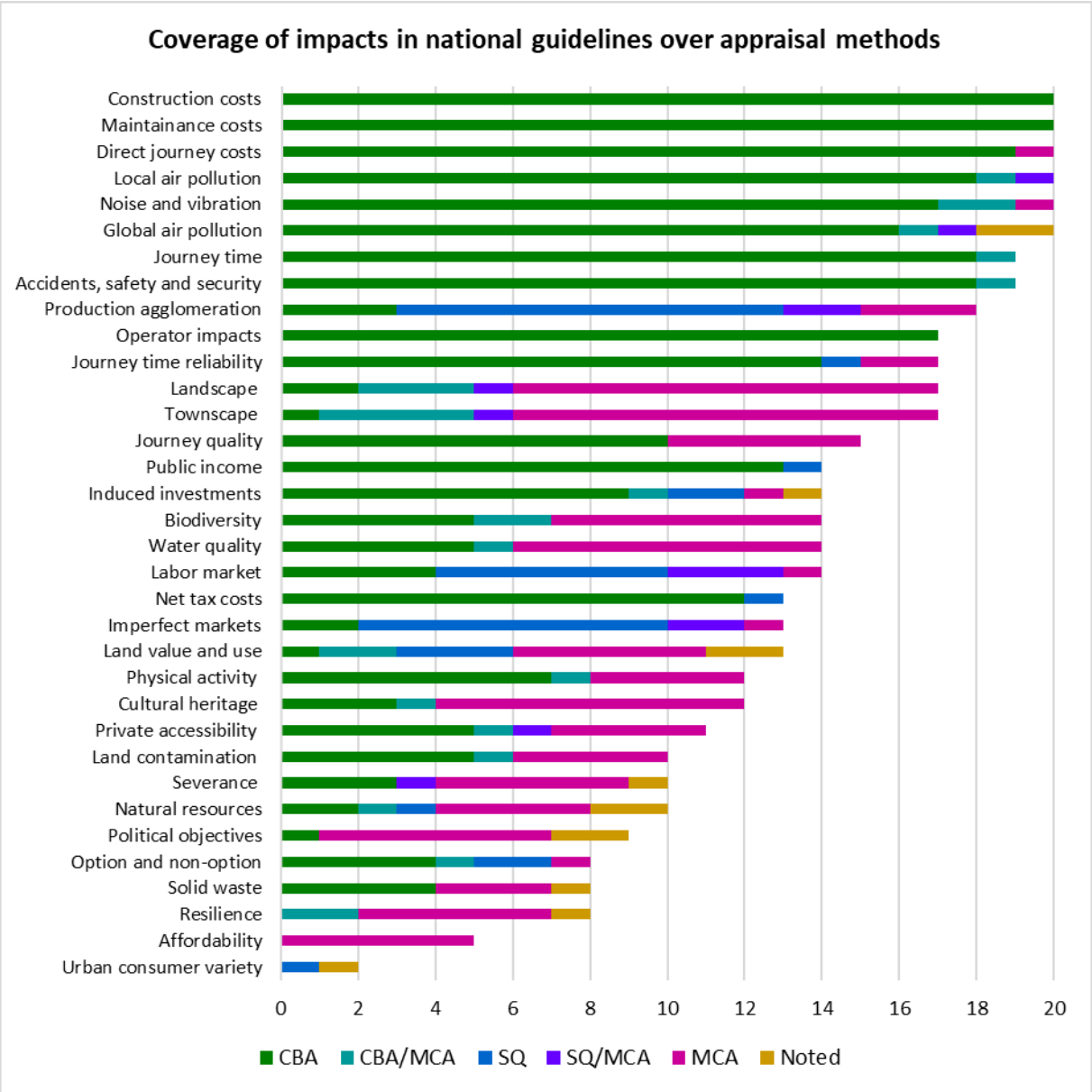


Figure 6-4: Detailed coverage of impacts in all reviewed national guidelines for transport appraisal across appraisal methods. Explanation of abbreviations applied in the table: CBA – Cost-Benefit Analysis, MCA – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis

Previous mapping from 5 to 15 years back have indicated that the British guideline have had best practice coverage along with the Netherland, Sweden and Norway (e.g. Odgaard et al. 2006 and Mackie and Worsley 2013). The detail level of the guidelines varies quite a lot, but this does not show in the figure. The British guideline is the most comprehensive guideline. Many of the other guidelines refer to the British, particularly guidelines in other Anglo-Saxon countries, but also in others including the Dutch, the Swedish and the Norwegian.

Our mapping suggest that the British guideline still is among the guidelines with best coverage in CBA and overall together with the guidelines from New Zeeland and Norway (road). The Dutch guidelines are still among the leading with regard to CBA coverage, but have fallen behind in total impact coverage due to limited assessment of social impacts. The Swedish guideline quantify most impacts (21), while the New Zealand guide at European Commission's spatial guideline quantify most impacts in CBA (20 and 18 to 20 respectively. Of course it is not all about quantifying all impacts in CBA, considering the reasons for MCA and

supplementary quantitative analyses typically regard the uncertainty in the quantitative estimates. Scotland (United Kingdom) and New South Wales (Australia) have the best overall impact coverage, covering 30 impacts each. The poorest overall impact coverage is found in European countries with both relatively small population and land area (i.e. Denmark, Switzerland, Belgium and Austria), as well as Canada and the United States. Admittedly, much of the impact coverage in many American and Canadian states and territories are better than their national guidelines suggest, considering that there exist many guidelines at state level (exemplified with British Colombia in Canada in our mapping). In addition, the Canadian and American guidelines are older than the other guidelines, and infrastructure investments are more privatized.

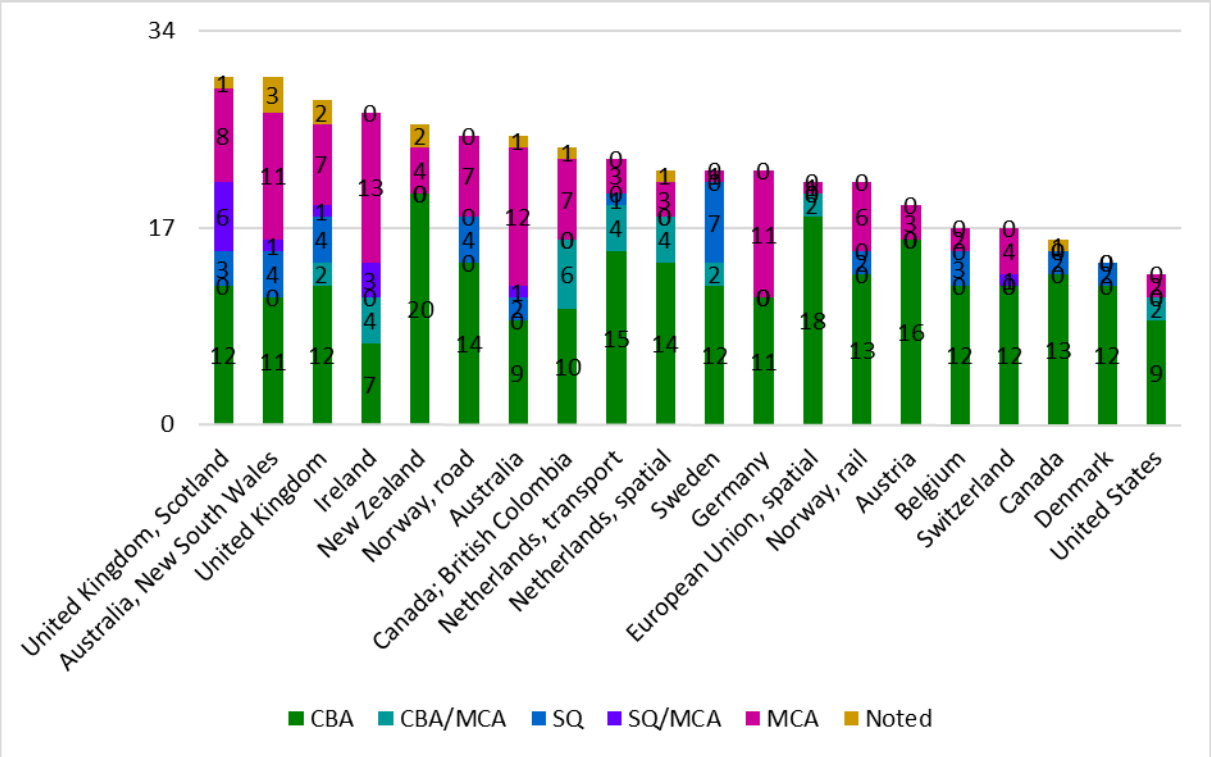


Figure 6-5: Total coverage of impacts in national guidelines across appraisal methods and countries. Explanation of abbreviations applied in the table: CBA – Cost-Benefit Analysis, MCA – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis

A detailed summarization of the results from our mapping of guidelines are provided in Table 6.3. The table reveals that the countries with the poorest impact coverage (e.g. United States, Denmark, Canada and Switzerland) particularly have fallen behind when it comes to inclusion of social and environmental impacts. For the countries with best overall coverage (e.g. Scotland in United Kingdom, New South Wales, United Kingdom and Ireland), the omitted impacts from the guidelines are more evenly distributed over impact groups, except for public account impacts, which are covered by most guideline with high impact coverage.

Group	Country Impact \ Latest update	AT 2010	AU 2017	AU-NSW 2018	BE 2013	CA 2007	CA-BC 2014	CH 2010	DE 2016	DK 2015	EU spat. 2014	IE 2016	NL spat. 2018	NL trsp. 2018	NO road 2018	NO rail 2018	NZ 2018	SE 2018	UK 2018	UK-SC 2018	US 2018
Economic	Construction costs	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Maintainance costs	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Resilience	MCA	MCA	MCA					MCA					CBA/MCA				CBA/MCA		Noted	MCA
	Induced investments	CBA	CBA		CBA		CBA	MCA		CBA	SQ			CBA/MCA	CBA	CBA	CBA	CBA	SQ	Noted	
	Operator impacts	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA		CBA	CBA	CBA	CBA		CBA	CBA	
	Production agglomeration		SQ	SQ	SQ	SQ	MCA	SQ/MCA	MCA	SQ	MCA	SQ/MCA		CBA	SQ	SQ	CBA	SQ	SQ	SQ	CBA
	Labor market		SQ/MCA	SQ/MCA	SQ				MCA	CBA		SQ/MCA	CBA	CBA	SQ	SQ	CBA	SQ	SQ	SQ	
	Imperfect markets		SQ	SQ	SQ				CBA	SQ		SQ/MCA		SQ	SQ	MCA	CBA	SQ	SQ/MCA	SQ	
	Land value and use		MCA	Noted		SQ	MCA		MCA		CBA	MCA	CBA/MCA				Noted	SQ	SQ	MCA	CBA/MCA
Social and economic (depending on receipent)	Direct journey costs	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	MCA	CBA	CBA	CBA	CBA
	Journey time	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA/MCA		CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA
	Journey quality		MCA	CBA	CBA			MCA	MCA		CBA	MCA	CBA	CBA	CBA	CBA	MCA	CBA	CBA	CBA	
	Journey time reliability		CBA	CBA	CBA	CBA	MCA	CBA	CBA		CBA	MCA	CBA	CBA	CBA	CBA		CBA	SQ	CBA	CBA
Social	Accidents, safety and security	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA/MCA	CBA		CBA	CBA	CBA	CBA	CBA
	Option and non-option			CBA		CBA	MCA								SQ		CBA	SQ	CBA/MCA	CBA	
	Affordability		MCA	MCA									MCA						MCA	MCA	
	Private accessibility		MCA	CBA		CBA	MCA		MCA			CBA/MCA			CBA	CBA	CBA		MCA	SQ/MCA	
	Severance	CBA	MCA	MCA			MCA		CBA			MCA	Noted				CBA		MCA	SQ/MCA	
	Physical activity	MCA	MCA	MCA						CBA		CBA		CBA/MCA	CBA	CBA	MCA	CBA	CBA	CBA	
	Urban consumer variety																	SQ	Noted		
	Political objectives	MCA	Noted				Noted		MCA			MCA	MCA				CBA			MCA	MCA
Environmental	Local air pollution	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA/MCA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	SQ/MCA	CBA
	Global air pollution	CBA	CBA	Noted	CBA	Noted	CBA	CBA	CBA	CBA	CBA	CBA/MCA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	SQ/MCA	CBA
	Biodiversity	CBA	MCA	MCA		CBA	CBA/MCA				CBA	MCA	CBA	CBA/MCA	MCA	MCA	CBA		MCA	MCA	
	Land contamination	CBA		MCA		CBA	CBA/MCA				CBA	MCA	CBA	CBA	MCA					MCA	
	Water quality	CBA	MCA	MCA		CBA	CBA/MCA	MCA			CBA	MCA	CBA		MCA	MCA	CBA		MCA	MCA	
	Solid waste			MCA			CBA				CBA	MCA	CBA	CBA					Noted	MCA	
	Natural resources	CBA		Noted			MCA	CBA	MCA				CBA/MCA		MCA	MCA	Noted	SQ			
	Landscape	CBA	MCA	MCA	MCA		CBA/MCA	MCA	MCA		CBA/MCA	MCA	MCA	MCA	MCA	MCA	CBA	MCA	CBA/MCA	SQ/MCA	
	Townscape	CBA	MCA	MCA	MCA		CBA/MCA	MCA	MCA		CBA/MCA	MCA	CBA/MCA	MCA	MCA	MCA	MCA	CBA/MCA	MCA	SQ/MCA	
	Cultural heritage	CBA	MCA	MCA					MCA		CBA	MCA	CBA/MCA	MCA	MCA		CBA		MCA	MCA	
	Noise and vibration	CBA	CBA	CBA	CBA	CBA	CBA/MCA	CBA	CBA	CBA	CBA	MCA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA	CBA/MCA

Table 6.3: Overview over coverage of impacts across national guidelines for transport appraisal. Explanation of abbreviations applied in the table: CBA – Cost-Benefit Analysis, MCA – Multi-Criteria Analysis, SQ – Supplementary quantitative analysis, spat – spatial appraisal, trsp. – transport appraisal, AT – Austria, AU – Australia, NSW – New South Wales, BE – Belgium, CA – Canada, BC – British Colombia, CH – Switzerland, DE – Germany, DK – Denmark, EU – European Commission, IE – Ireland, NL – Netherlands, NO – Norway, NZ – New Zealand, SE – Sweden, UK – United Kingdom, SC – Scotland, US – United States

6.3 Discussion

In this chapter we presented an overview of current practices in transport policy)\ planning and project appraisal with consideration of national guidelines. First, we put the transport planning methodology in a historical context and outlined why and how transport policies have developed from a purely economic point of view to a more inclusive general view of the multi-modal transport system and the affected other sectors. This development also influenced the assessment methods for the evaluation of the policies and measures. The literature shows that in some cases the outcome of a traditional CBA does not significantly influence the final decision (e.g. the Netherlands, Norway and Sweden), whereas traditional CBA in other cases play a larger role. Therefore, a trend towards assessment methods that allow a stronger inclusion of impacts by other methods can be observed (e.g. supplementary quantitative analyses and MCA). Hopefully, development and implementation of new and improved planning and appraisal tools will contribute to better improved spatial investment process in the future with references to chapters 4 on collaborative planning and 5 on appraisal methods.

We have studied earlier studies of national appraisal guidelines and contributed with our own mapping, based on our mapping of impacts in chapter 3. While inclusion of environmental impacts in general and air pollution in particular was an important focus in the development of the guidelines up to the turn of the millennium, wider economic impact has become a strong focus the last fifteen years. Both our own and earlier mapping show that support references to the British guidelines as the state of the art guideline with the Netherlands, Sweden, Norway and Anglo-Saxon countries outside of North American also having a wide impact coverage. The countries with the poorest impact coverage (e.g. United States, Canada and European countries with relatively small population and land area) have fallen behind when it comes to inclusion of social and environmental impacts. The overall coverage in the reviewed guidelines of economic, social and environmental impacts in cost-benefit analyses are rather similar. Supplementary quantitative analyses are most common for economic impacts, while MCA are most common for environmental impacts. Not surprisingly, the impact coverage is generally better for direct effects and effects that are easy to monetize than indirect effects and effects that are challenging to monetize.

The magnitude of wider economic impacts in empirical studies (confer subchapter 3.2) suggest that inclusion of wider economic impacts in CBA should continue to be a focus in development of national guidelines in the years to come. This requires higher estimation precision, and thereby methodology development and more empirical research (confer subchapter 5.1). Even higher precision in estimation of climate change impacts probably also constitutes an improvement potential in the guidelines that requires more research, but this does not follow directly from our mapping. Another feature from our mapping is the presence of political objective impacts, imply that spatial measures are integrated and help to fulfil other policy objectives. We believe that guidelines have a potential for more comprehensive inclusion of political objective impacts in their guidelines for spatial planning and appraisal. Political objective impacts already play an important in collaborative planning, so there should also be a potential here for synergies in method development. Yet, policy impacts might not concern efficiency (i.e. social welfare), but distributional and other policy concerns, so they should be dealt with carefully.

7 Conclusions and Recommendations

In this final chapter we end the report by summarizing the conclusions of the literature review and by giving recommendations for future research directions and development possibilities. Generally, we considered the theory and practice for transport appraisal and planning and performed an extensive literature review including scientific articles and best-practices and guidelines from practical applications. In the following, we will draw our conclusions in subchapter 7.1, before we give our recommendations in subchapter 7.2

7.1 Conclusions

We started in chapter 3 with an in-depth analysis of the theoretical and empirical foundation of impact assessment of transport measure. We review direct and indirect economic, environmental, social and public account impacts. Valuation aspects and unconventional impacts that are usually not covered by conventional CBA constituted particular focuses. In the review we identified an extensive development regarding these impacts over the last years, but also improvement possibilities, in obtaining more reliable valuation estimates.

Especially when methods that go beyond CBA are considered for transport appraisal, stakeholder involvement is becoming possible and relevant. Therefore, in the next step we looked at collaborative planning methods in chapter 4. When multiple stakeholders are involved, the perception on the importance and magnitude of the impacts is different and an agreement on this is sought. We argue that broadening and structuring the participation in decision-making processes may provide a better basis for including information from various stakeholders in the decision process in a neutral way and contribute to a more stable decision climate over stakeholder. We reviewed numerous collaborative planning methods from the literature and listed their strengths and weaknesses. We observed that most of the existing tools are either complex or slow, therefore quicker tools like online workshops and digital platforms should be preferred. The most important properties of collaborative planning tools are their flexibility, transparency, and feasibility to reach an agreement.

Since CBA is the most widely used assessment method for transport appraisal but has several limitations, especially when unconventional impacts should be assessed, we proceeded in chapter 5 to review assessment methods that go beyond CBA. Furthermore, CBA might not be listened to by decision-makers and only relying on cost-benefit analysis and easily accessible information might not provide a precise representative picture of stakeholders' perspective and valuation of impacts. Therefore, we laid a focus on reviewing MCA methods and especially combinations of CBA and MCA. The existing methods show that both methods are complimentary, and a combination can be beneficial overall. However, the exact setup of the overall method should be chosen with care as to not inherit the limitations of both individual methods. We conclude that there is still a need for new assessment methods that are transparent, robust, inclusive, and able to take unconventional economic, environmental, social and public account impacts into account.

In chapter 6, we review the practices and recommendation provided in spatial appraisal and planning with particular focus on transportation. We put the transport planning methodology in historical and methodical contexts and outlined why and how transport policies have developed from a purely economic point of view to a more inclusive general view of the multi-modal transport system and the affected other sectors. While inclusion of environmental impacts in general and air pollution in particular was an important focus in the development of the guidelines up to the turn of the millennium, wider economic impact has become a strong focus the last fifteen years. Both our own and earlier mapping show that support references to the British guidelines as the state of the art guideline with the Netherlands, Sweden, Norway and Anglo-Saxon countries outside of North American also having a wide impact coverage. Our

own mapping shows that the overall coverage in the reviewed guidelines of economic, social and environmental impacts in cost-benefit analyses are rather similar. Supplementary quantitative analyses are most common for economic impacts, while MCA are most common for environmental impacts. Not surprisingly, the impact coverage is generally better for direct effects and effects that are easy to monetize than indirect effects and effects that are challenging to monetize.

7.2 Recommendations

In this literature review we showed the potential and need of new assessment methods for transport appraisal based on existing methods. We identified a set of requirements for new methodologies such as:

- Possibility to include wider economic, environmental, social and political impacts
- Support for stakeholder involvement in a flexible, transparent, and time-efficient way
- Further focus on empirical research and method improvement for wider economic impacts, such that these impacts can be taken into account in CBA in the future.
- Ability to take political objectives and interactions of different measures into account in transport appraisal
- Transparent, robust, and inclusive assessment method that extents CBA by including qualitative aspects from MCA

Inclusion of impacts

The magnitude of wider economic impacts in empirical studies suggest that inclusion of wider economic impacts in CBA should continue to be a focus in development of national guidelines in the years to come. This requires higher estimation precision, and thereby methodology development and more empirical research.

Another feature from our mapping is the presence of political objective impacts, imply that spatial measures are integrated and help to fulfil other policy objectives. We believe that guidelines have a potential for more comprehensive inclusion of political objective impacts in their guidelines for spatial planning and appraisal. Political objective impacts already play an important in collaborative planning, so there should also be a potential here for synergies in method development. Yet, policy impacts might not concern efficiency (i.e. social welfare), but distributional and other policy concerns, so they should be dealt with carefully.

Leaning outcomes for development of a spatial planning tool

With the requirements above in mind, we return to the overarching goal of the SPADE project: the development of a collaborative planning tool which realizes an efficient and effective all-embracing assessment method for policy measures in different scales and contexts. We do this by building forth on an existing collaborative planning tool for infrastructure planning developed by (Kiel et al., 2015), introduced in the introduction in subchapter 1.2. The tool is both content-related and process-related, and we provide recommendations for both aspects.

1. Stakeholder identification

A crucial component of the collaborative planning process is involving the relevant stakeholders; i.e. all those that may be impacted by the policy measure. The planner needs to pay particular attention to those that are less vocal or have less resources to participate. Making a first inventory of the potential impacts aids in selecting the right stakeholders.

2. Digital workshop

In the workshop, policy measures are assessed with stakeholders based its policy impact. Chapter 3 gives an overview of all the impacts of which the planner needs to be aware. Particular attention needs to be paid to the unconventional effects. It is confirmed in chapter 6

that some of them are still not common practice in national CBA guidelines. But above all, flexibility from the planner is required, since the impacts differ greatly from project to project, depending on the context and the knowledge that is available.

3. Assessment tool

The assessment tool should include some form of MCA. In contrast to a CBA, a MCA allows for transparency and intersubjectivity, i.e. the fundaments of collaborative planning. At the same time, we cannot ignore the power of a CBA to convey information and to compare impacts. The planners need to find the right balance between both tools to properly assess the impacts.

4. Discussion

Discussion emerge in the periphery of the digital workshop and the assessment tool. Here the planners play an important role as the facilitator. The main tasks for the mediator is setting out clear rules, facilitate the dialogue, build trust and explore mutual interest. This involves investigating the expertise of the potential participants and prepare them to the discussion. Furthermore, mediators should recognize the key points and collect the main insights of the discussion, with the aim of preserving a constructive development in the dialogue.

5. Conclusion and recommendation

Conclusions of the digital workshop are compiled by the planner and shared and discussed with the stakeholders. Another round workshop may be carried out by if deemed necessary by the stakeholders.

The next step of the SPADE project is to make these recommendations more concrete into a step-by-step guideline for the SPADE assessment tool.

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