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SPADE – Assessment method for the collaborative planning of infrastructure and spatial development

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Abstract

The development of infrastructure takes place at different spatial levels, spatial functions, time horizons and involves many stakeholders. The consequence is that planning may become complex. The SPADE project – funded by CEDR – developed a method to keep the planning process efficient. The method addresses different planning challenges, thereby going beyond the traditional assessment package of cost-benefit analysis and multi-criteria assessment methods. First, it exploits the information of the different stakeholders to achieve a better outcome from a social point of view. Second, it supports the decision-making process. The method comprises a process and an instrument. The process is embedded in collaborative planning. The instrument consists of a digital workshop or e-participation with a Delphi method and a tool to assess policy measures or packages based upon their impacts. The method allows a cost-efficient and fast exchange of information and a better understanding amongst stakeholders on the different impacts, which include qualitative aspects.

Keywords: collaborative planning; infrastructure planning; spatial development; assessment method; impact assessment; stakeholder involvement.

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1. Introduction

The continuous development of the transport system takes place at different spatial levels and involves many stakeholders. The achievement of a sustainable and integrated transport system is essential for a good functioning of society, economy and environment. When planning the future of the transport system, different stakeholders face an ongoing pressure to collaborate on the planning of their part of the system. The National Road Administrations (NRAs) in Europe expressed the need for innovative approaches that address the multi-dimensional challenges of infrastructure planning and spatial development, such as multimodal mobility, spatial development, timing, valuation, quality of life as well as institutional and governance dimensions. The central question raised by the Conference of European Directors of Road (CEDR) is '*How to achieve integrated project development of infrastructure and its spatial surroundings?*'

This paper addresses the assessment of integrated spatial and infrastructure development. CEDR seeks a method for assessing costs and benefits of combined infrastructure and spatial development, building upon existing knowledge and including specific spatial contexts such as nation-wide, urban or rural regions. SPADE (*Assessing the added value from SPAtial DEvelopment as a factor in infrastructure planning*) is providing this method.

The development of an inclusive assessment method for infrastructure planning and spatial development comprises different challenges:

- How to gain a better understanding of the relation between spatial and multimodal infrastructure development?
- How to assess the societal value of combined multimodal infrastructure and spatial development for decision making on investments?
- How to capture the added value from combined infrastructure and spatial development?
- How to map the consequences of an inclusive assessment?
- How to utilize stakeholder information without suffering from information skewness?
- How to identify and distinguish between vested interests and the interests of society?

Different instruments and methods already exist to carry out assessments. Some are tailor made, while other instruments and methods have a wider range of application. Often these are part of guidelines for infrastructure development and comprise appraisal methods, such as cost-benefit analysis (CBA), multi-criteria analysis (MCA), supplementary quantitative estimation, or qualitative discussions. Yet, these guidelines not always capture or focus on all impacts that stakeholders are worried about, particularly when it comes to the social impacts and distributional concerns. Given the challenges as described before, the SPADE assessment method comprises the following topics:

- Stakeholder identification and involvement;
- Inclusion of both passenger and freight transport;
- Applicable on different spatial levels (international, national, regional and local);
- Assessment of indirect benefits on economy, society, environment and public accounts;
- Applicable at different time horizons (short, medium and long);
- Inclusion of different types of data or information;
- Different paces of spatial planning at the different stakeholders;
- Systematization of stakeholders interests and strategies:
- Classification of impacts with distinction between efficiency and distributional impacts;
- Inclusion of weights of different aspects.

The SPADE method has been developed based upon existing knowledge and tools. For this, an extensive literature review has been carried out which is presented in section 2. This comprises findings on impacts, assessment tools and methods (such as CBA and MCA), and different national and regional guidelines. The SPADE assessment method is described in section 3, together with an outlook on the results from the method. Finally, conclusions and further recommendations are described in section 4.

2. Literature Review

To develop and inclusive assessment method for spatial planning and infrastructure development, an extensive literature review has been performed, see Holmen et al. (2019). The review considers different topics. First, the theoretical and empirical foundation of the valuation and types of impacts are made, with a focus on impacts which are not yet broadly included in CBAs. Then, the collaborative planning paradigm is investigated and how an impact assessment can be done in a collaborative planning process. Thirdly, different methodologies for assessing impacts were examined with a focus on CBA, MCA, and possible extensions and combinations. Lastly, an overview of practices in planning guidelines is given. The entire review is used to develop an integrated assessment method.

2.1. Impacts of spatial measures

The review on impacts comprises both empirical and theoretical research, with focus on transport-related measures (see Holmen & Hansen (2019). Table 1 provides an overview of the classification of impacts from transport investments and measures based on the mapping of the impacts found in appraisal guidelines. This section summarizes the key points of the review, with a focus on efficiency impacts (i.e. impacts on total social welfare), valuation and the largest impacts excluded from conventional CBA. Earlier mappings have classified impacts from spatial measures (e.g. Oosterhaven and Knaap 2003 and Department for Transport 2019).

Table 1: Classification of impacts from transport investments

Impacts	Conventional impacts	Unconventional impacts
Economic	Construction; maintenance; driving costs; time savings and journey quality for business trips; net income for transport providers; time reliability for business users; resilience; security for operators and business users	Production agglomeration, reduced misuse of market power, increased labor market participation, induced investments; land value and use, capital market impacts, reallocation impacts
Environmental	Local air pollution, global air pollution; noise; vibration	Landscape; townscape; biodiversity; cultural heritage; water environment; land contamination; solid waste
Social	Death, injuries and material damage in accidents; journey quality, time savings for commuting and leisure trips, driving costs for business users; physical activities; risk of accident; time reliability for inhabitants; stress of congestion; security for households	Severance; option and non-option values; private service accessibility; affordability; urban consumer variety
Public	Tax financing; public income	Public accounts impacts related to change in economic activity; impacts on public measures

Source: Holmen et al (2019)

Economic impacts are defined in a narrow sense, only to include impacts on the production sector. Direct economic impacts include scheme costs and user and provider benefits, which are well understood and measured. The wider economic impacts include topics such as productivity and labor market effects related to increased competition and agglomeration synergies. Key contributions related to spatial economic development include Duranton and Puga (2003) and Venables (2007). Recent progress in the literature has been made on causal measurement of impacts under various circumstances, such as Combes et al (2016) on addressing housing production or Bernard et al (2019) on the improvement of firms' performance due to the introduction of high speed rail services.

Environmental impacts involve externalities of the transport system. Pollution is included in the standard CBA, but valuation remains under constant development, especially emission of climate gases. Geographical environmental impacts are more challenging to estimate. Important valuation methods include contingent valuation, choice experiments, travel cost method, hedonic prices and production and cost-function techniques. For environmental user goods, revealed preference methods are most common, while stated preference methods are most common for environmental non-user goods (Garrod and Willis 1999 and Perman et al. 2003).

Social impacts are impacts concerning households except socio-environmental impacts. These impacts are generally well understood, but this scientific literature does not draw much attention towards their valuation. Some additional impacts are proposed by Geurs, Boon and Van Wee (2009). In principle, valuation methodology for

indirect environmental impacts would often be suitable for social impacts. For impacts such as affordability and social cohesion, the borderline between social efficiency impacts and distributional impacts are somewhat blurry.

Public impacts are impacts related to distortions related to tax collection and public provision of goods. Costs of public funds are relatively well understood and straight forward to include in CBA, although value estimates vary (e.g. Fridstrøm et al. 2000 and Levinson 2010). In contrast, the literature on spatial impacts on provision of other public measures are limited, although policy integration plays an increasingly important role in transport planning.

Concluding, the impacts in transport appraisal guidelines are well founded in a large, but fragmented, scientific literature. Still, the magnitude of several impacts in secondary markets remain uncertain and depend on many contextual factors, making the inclusion in CBA problematic.

2.2. Collaborative planning and collaborative planning tools

In collaborative planning, there is more to decision making than choosing the policy measures with the highest net benefit. Practice shows that deciding on a policy measure or package of measures can be 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 various individuals. What constitutes a cost and benefit, and its magnitude, is often contested by stakeholders. This changes the way how the impacts are determined. The development of an integrated assessment method needs to take into account the multi-interpretable nature of impacts.

Literature on collaborative planning methods is not conclusive on the methods that work best to capture the multi-interpretable nature of impacts. The literature mainly consist of authors describing single use cases of a particular method and conclude on highlighting various components that seem to be advantageous of that particular method. An empirical analysis of collaborative methods with large sample sizes is absent, making it difficult to conclude on the requirements for collaborative planning methods on a high level of detail. However, a meta-comparison of various collaborative planning methods reveals the general features of these methods. Vacik et al. (2014) analyse 43 collaborative planning methods used in natural resources planning and find that most of them share similar features with no single method being universally the ‘best’.

In addition, several collaborative planning tools have been reviewed. These tools promise to enhance transparency and stakeholder agreement. These are means to reduce ignorance, disinformation, and biases of stakeholders. The findings of the main tools and methods with their advantages and shortcomings are summarized in table 2.

Based on the conclusions from by Vacik et al. (2014) and our review, we conclude that a successful collaborative planning tool consists of the following features:

- A form of stakeholder interaction (physical such as focus group or online such as e-participation) that facilitates trust-building, face-to-face dialogue, and developing a shared understanding;
- Is relatively simple to understand and to apply;
- Includes technological support systems (such as computer-based systems such as GIS-technology or web-applications or physical tools such as maps or models);
- Involves decision support systems (such as soft-systems methodology, SWOT-analysis the Vroom-Yetton method or the Four Rs framework); and/or
- Uses basic statistical analysis methods (such as MCA and its variants or Q methodology).

2.3. Assessment methods for projects and policy measures

CBA is the most widespread methodology for the appraisal of policy measures or assessment projects. 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 resources efficiently, thus maximizing the welfare of society. CBA is a tool that enables decision makers to choose the alternative that has the best efficiency compared to alternatives, including the status quo. Because public funds are limited, CBA helps governments in the efficient allocation of scarce resources.

CBA gives an easily understandable comparison of different measures. It overcomes cognitive, structural, and process-related limitations and biases in decision-making (Mackie, et al., 2014). 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 of policy options.

Table 2: Assessment of selected collaborative planning tools

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 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 trans-port 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

Source: Holmen et al (2019)

Despite its popularity, some well-known reservations exist against the use of CBA methods. Reservations such as understating the economic development benefits of certain investments, favouring some user groups at the expense of others, failing to incorporate all external effects into account (such as environmental or social impacts), and failing to deal with distributional effects (OECD, 2002). MCA as is sometimes used as a complimentary method to overcome some of these limitations.

MCA methods are generally recommended for measuring impacts that are hard to value or measure precisely, e.g., environmental impacts on landscape and other qualitative effects. Therefore, most public guidelines for transport appraisal and planning include a framework of (partial) MCA as supplement for CBA. General reviews of MCA methods applied to transport appraisal can be found in Pérez, et al. (2014) and Deluka-Tibljaš et al (2013). A prominent example for a variant of the MCA method is the Multi-Actor Multi-Criteria Analysis (MAMCA) introduced in Macharis et al. (2008) and Macharis et al. (2012). In a MAMCA, stakeholders are grouped in homogenous groups. Each group performs an MCA with criteria relevant for that specific group. This approach enables the planners to identify differences in wishes between the groups and also allows for adding weights to the groups in the final results. Results can be presented as a set of different scoring matrices for each group.

The Multi-Criteria Decision-Making (MCDM) methods can be further classified, based on Velasquez & Hester (2013) and Penadés-Plà et al. (2016) into:

- *Goal-orientation methods* based on predetermined goals, e.g., by deducing preset objectives. See Transport for NSW (2018) for methods like a Goal Achievement Matrix and a Strategic Merit Test.
- *Utility and valuation methods* based on assigning a utility value to each consequence which could consider uncertainties and preferences. Examples are methods based on Multi-Attribute Utility/Value Theory and Analytical Hierarchy Process.
- *Mathematical programming methods* based on maximizing or minimizing a set of objectives respecting a set of constraints. Examples are Goal Programming or methods based on fuzzy set theory.

- *Distance-based comparisons methods* based on comparing each alternative to the best and worst alternative in each criterion. Examples are Technique for Order Preferences by SImilarity to ideal Solutions (TOPSIS) and multi-criteria optimization and compromise solution (VIKOR).
- *Outranking methods* based on pairwise comparisons of each criterion between each pair of measures to identify a ranking for all measures from best to worse. Examples are methods based on Elimination and Choice Expressing Reality and Preference Ranking Organization Method for Enrichment of Evaluations.

Using an MCA based method is particularly useful in including qualitative and non-monetized effects and in including different stakeholder views in the appraisal. The method, however, is prone to an intersubjective bias towards the views of the participants of the scoring process. MCA is also sensitive to the choice of criteria and weights. The different MCA methods mentioned above show a lack of an agreed upon theoretical framework.

To overcome the challenges using a CBA or MCA separately, the benefits of combining CBA and MCA have been reviewed as well. The literature on integrated assessment methods combining CBA and MCA is rather sparse because the results of both methods are usually considered separately. In general, there are two types of integrated CBA/MCA combinations. *First*, the results of a CBA are used as an additional criterion in a MCA. An application is presented by Sijtsma (2006) in the form of a tool for sustainable project evaluation called Multi-Criteria Cost Benefit Analysis (MCCBA). It is based on stakeholder involvement since the aggregation of monetary and non-monetary scores is based on consensus among the stakeholders. *Second*, the results of a MCA are used within a CBA using a monetization method. This is used for example in Strategic Option Assessment (SOA) presented in Prosser, et al. (2015). The main idea 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. Then, the weighted cost benefit performance is compared between the options. Another integrated method is the AMDTM (Kiel et al, 2015). In this method, monetized and other quantifiable and unquantifiable values are considered in a weighted manner to determine cost-efficiency.

Overall, there is a large volume of literature on assessment methods based on either CBA or MCA. Concerning the combination of CBA and MCA, we observe potential for further research. Especially when the inclusion of non-monetizable and non-quantifiable impacts as well as stakeholder involvement is needed while at the same time keeping the objectivity of the method is a requirement, the development of assessment methods are getting challenging. Especially for reducing the subjective bias of the involved parties of the assessment process, tools and techniques from collaborative planning approaches should be used.

2.4. National appraisal guidelines and practices

National appraisal guidelines are important for the prioritization of spatial measures. Nevertheless, impact coverage and appraisal tools vary substantially over countries. A set of 20 spatial appraisal guidelines from 14 independent developed countries have been reviewed. We refer to Holmen et al. (2019) for the full survey. Here, we will account for the main points.

In a mapping of 25 European national appraisal guidelines, Odgaard et al. (2006) find that all countries use CBA and that nine of them also used MCA. The results suggest better impact coverage in Northern and Western Europe than in Eastern Europe, which in turn had better impact coverage than Southern European countries. Mackie and Worsley (2013) summarize a mapping of guidelines in Northern and Western Europe, North America and Oceania. All countries assessed transport project using CBA in combination with various non-monetized assessments. They point out wider economic impacts and reliability as the most important topics for progress at the time. Wangsness, Rødseth and Hansen (2017) find substantial progress in the coverage of wider economic impacts in the appraisal guidelines.

The national appraisal guidelines apply many dimensions to classify impacts. In the section on impacts' scientific foundation, we accentuated impact recipients, persistency, operative usage and market attachment as important dimension for impact classification. Other dimensions used for classification in the guidelines include geography, infrastructure, size and sign. In our review, we found 38 impacts, including 11 environmental, 9 pure economic, 6 pure social, 4 economic and social (depending on impact recipient) and 7 public (defined as impacts on public funds and measures). The level of detail varies, so results should be interpreted only as indications.

The impact coverage in public appraisal guidelines is higher for economic and environmental impacts, than for social, but the differences are not large. Yet, environmental impacts have the poorest CBA coverage. Moreover,

MCA is commonly recommended as an assessment tool for geographic environmental impacts. Supplementary quantitative estimations are mostly used on wider economic impacts. Public impacts have the poorest coverage, but this is largely because we have included several impacts on policy objectives in the mapping (i.e. impacts on education, emergency services, general policy integration and spatial policy integration). Although the potential magnitude of these impacts suggest that they should be included in CBA, uncertainty about the magnitude and possible overlap between impacts makes it difficult in practice. In addition, estimation of impacts from spatial measures often assume no market failures in secondary markets, whereas wider economic impacts are caused by such market failures. Maintenance and construction costs, air pollution, noise and direct journey costs are included in all guidelines, while affordability and urban consumer variety are seldom included.

The widest impact coverages overall are found in Anglo-Saxon countries, while the poorest coverage are found in North America and small Continental European countries. The widest CBA coverage are found in the guidelines of European Union and New Zealand, while Australia and United States have the poorest coverage. Of course, it is not all about quantifying all impacts in CBA, considering the reasons for MCA and supplementary quantitative analyses often are applied due to uncertainty in the quantitative estimates. Moreover, the countries with poor impact coverage are generally less focused on environmental and social impacts.

3. Integrated assessment method for collaborative planning

Based on the literature review and existing tools an integrated assessment method has been developed. It comprises a method for assessing measures and packages of measures for infrastructure and spatial development in the setting of collaborative planning. The assessment method consists of a *process* and a *tool*, see figure 1.

- The *process* describes the place of the method in the collaborative planning of policy measures, in which stakeholders from different backgrounds, with different wish lists and different planning procedures, need to work together. It is important to ensure that resourceful and resource poor groups are heard on equal basis, reveal vested interested and ensure as broad stakeholder participation as possible.
- The foundation of the *tool* –and partly the process– is laid in (Taale et al, 2016), but is improved based on the outcome and findings of the literature research. The tool supports the process and consists of a combination of a digital workshop and an assessment tool, which combines a multi-criteria analysis with a CBA. The digital workshop or e-participation offers room for the stakeholders to enter into a discussion with each other about the assessment tool and is led by a moderator.

The *process* starts with finding the right moment to apply the method in the planning process. The identification and involvement of stakeholders is an important first step in the assessment method. Involving many stakeholders involves several challenges. Planners should therefore aim to create a broad and representative stakeholder arena, and map and analyze the interests of groups not fully included by other means. The challenges comprise:

- Stakeholders are often poor on resources, unorganized or small;
- Stakeholders consider it to be a better strategy to oppose the CP process from the outside;
- Stakeholders are not interested or don't have time to participate, stakeholders might possess different information relevant for their position on topics related to spatial measures;
- Some stakeholders might have interests in building relations between each beyond the workshop.
- Identified stakeholder groups are sometimes heterogeneous and gathering stakeholders can be costly and time-consuming in practice.

The *tool* comprises a workshop and an assessment tool based upon the combination of a CBA and a MCA. The workshop is supported by electronical means such as e-participation or a digital discussion tool, in combination with a Delphi method. This supports the discussions among the stakeholders (Taale et al, 2016). Both the digital discussion tool and e-participation are electronic tools that support a structured discussion. Based upon focused questions such as 'What is the impact of a policy measure on accessibility?', each attendant provides input. This way every attendant is 'heard' and contributes actively to the discussion. To reveal and handle potential vested interests with corresponding exaggerating or downplaying of impacts, the respondent's results are benchmarked with each other and with other mappings. The workshop is led by an independent moderator to avoid biased and unproductive discussions. The moderator pays attention to that every stakeholder is heard and no one is dominant.

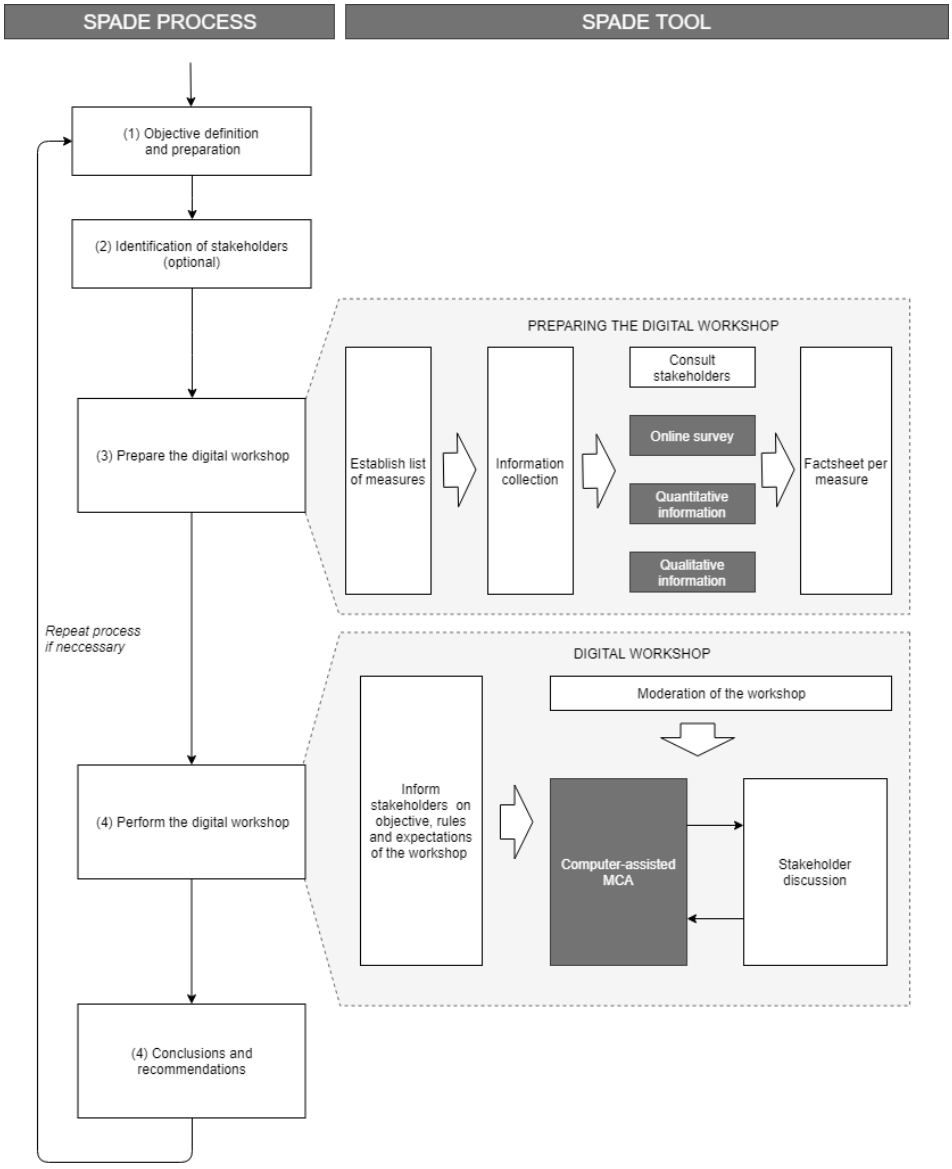

Fig. 1 SPADE assessment Method

The workshop is accompanied by an instrument to assess different policy packages and measures by means of an MCA and – if information is available – a CBA. This technique is not new, but the real innovation lies in the combination with the support of electronic means, and the fact that fairly accurate results can be made in a relatively short time frame without a lot of modelling work. In small projects where more comprehensive appraisals are unlikely to give another project, this could potentially speed up the planning and decision making process. Even at the very beginning of a planning process, the tool is helpful in selecting options. In larger projects where potential disinvestments might be very costly, the method contributes to an increased information basis for further analyses. The method could contribute to anchoring of the decision process among stakeholders.

The reasoning behind this is that at the beginning of a planning process there are a lot of questions and hardly any answers. The SPADE method allows early answers by using the MCA-part of the method in the beginning of the process. The results from the assessment tool will be taken along in further discussions among the different stakeholders. The results support the discussion about which measures should be included in policy packages and which could be left out. Based upon the outcomes of the discussion, the results, conclusions and recommendations can be taken further in the planning process, when more CBA information becomes available. The assessment method therefore allows for multiple uses in the planning process. As soon as more information becomes available, or when alternatives are available with more detail, the method can be repeated.

4. Conclusions

This paper addresses the shortcomings of collaborative planning methods and proposes an integrated assessment method.

Scientific literature on impacts from spatial measures is large, but fragmented. Valuation of impacts in secondary markets are often complex and uncertain, and therefore not included in the CBA. Judged by the size of their value estimates, wider economic impacts are considered important. Impacts on other public measures constitute the impact group that have received least attention in the literature, although it remains central in spatial planning.

Although both CBA and MCA constitute mature appraisal tools, both tools are under continuously development. In CBA, estimation and integration of wider economic impacts constitutes a recent focus, while stakeholder involvement has become an important in MCA. Since the turn of the millennium, there have been a trend towards more integration of the spatial appraisal tools and to interpret their results in relation with each other.

Mappings of national appraisal guidelines suggest that the widest impact coverage are found in Northern and Western European and Oceania. We find that current widest coverage overall is found in the guidelines of Anglo Saxon countries, while New Zealand and European Union have the widest CBA coverage. Impact coverage are relatively even over types of impacts. Likely future progress in the guidelines include more frequent inclusion of wider economic impacts in CBA and improved assessment tools for policy integration.

Based upon the literature review a method has been developed that can be applied for different policy measures at various stages in the planning process. It provides an efficient way of weighing up measures, getting input from stakeholders and gaining stakeholder support. Through this method, the planner gains a better understanding of the impacts of the proposed measures (in particular the less-tangible and more subjective measures) and the different views held by the different stakeholders. The interactive component allows stakeholders to learn from each other and exchange views. This way the planner may gain more support for a project or policy measures.

The combination of CBA and MCA include the best of both worlds. In combination with a digital discussion tool or e-participation, and the Delphi method, it makes a powerful and complete assessment method for use in a collaborative planning. The method improves the planning process by reducing the number of policy measures, to get a deeper insight in the impacts of policy measures, and to create support and understanding amongst the stakeholders. It can be applied in different spatial and infrastructural projects of different size and different planning stages. The method is flexible and provides more degrees of freedom to the planner to adapt to the needs of the planning process.

The method in its preliminary form has been tested in the Netherlands. It has shown its practical use in the selection of alternatives and policy measures between stakeholders. The assessment method meets with all the requirements as set out in the introduction of this paper.

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