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## Need for a holistic assessment of urban mobility measures – Review of existing methods and design of a simplified approach

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### Abstract

The lack of suitable tools to assess sustainable mobility measures' costs, benefits and overall impacts is a significant factor impeding their implementation. Cost-benefit analysis (CBA) is often applied to large-scale infrastructure projects, but does not capture all relevant socio-economic impacts. Small-scale but potentially highly cost-effective measures often do not have the critical mass to warrant a thorough cost-benefit analysis. This paper reviews existing assessment methodologies, including their advantages, limitations and application to different urban mobility measures, and current assessment practice in cities based on survey results. Based on these analyses, a holistic approach for project appraisal is proposed, consisting of aspects of a multi-criteria analysis (MCA) and CBA and applicable to a variety of urban mobility measures.

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### 1. Introduction

Planning and managing urban transport is often a difficult task for local administrations. A reliable urban transport system is crucial to a functioning local economy, as it provides access to services and enables personal mobility (Browne and Ryan, 2011). At the same time, high levels of traffic impose negative externalities on society, including congestion, accidents, noise pollution or environmental damage (Santos et al., 2010). Decision-makers must consider a variety of different impacts (economic, social and environmental) resulting from urban transport projects or measures, along with their objectives. Investments in urban transport should deliver the maximum economic, social

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and environmental benefits; while in times of constrained budgets, projects' economic viability is often the deciding factor. Decision-makers need information on the potential costs, benefits and overall impacts of urban transport measures or projects.

The concept of evidence-based decision-making is intended to help policy-makers to maximise the benefits from their investments, and to prevent investments in measures or projects that fail to address critical problems. Ideally, decisions should be based on ex-ante assessment of measures' potential effects, preferably from all relevant fields. However, there is a tendency in transport decision-making to assess measures more narrowly, focusing on direct economic effects, which favours traditional measures. Including a wider range of factors when assessing urban transport measures promote the implementation of soft measures or innovative projects, whose costs and benefits lie predominantly beyond direct economic effects. Road expansion, for instance, might promise short-term congestion relief and economic benefits, but wider sustainability concerns are typically not addressed well, if at all.

This paper examines how cities can assess the costs, benefits and overall impacts of urban transport projects and measures on an ex-ante basis to facilitate sound decision-making. To do so, firstly, the advantages and limitations of the methods most commonly used to appraise transport projects are analysed, especially cost-benefit analysis (CBA) - frequently applied to large-scale infrastructure projects - and multi-criteria analysis (MCA), often seen as an alternative to CBA (Beria et al., 2012). Secondly, examples of these methods' application are presented - for both the ex-ante and ex-post assessment of various urban transport measures - from an extensive review of scientific literature and complementary examples from grey literature. Thirdly, current practice for ex-ante impact-assessment in European cities is examined, based on a written survey of 14 cities, conducted as part of an EC FP7 project (i.e. TIDE – Transport Innovation Deployment for Europe). Insights from the survey are complemented by literature analysis. Based on the overall analysis, a new approach for a holistic impact-assessment method was designed, reflecting cities' needs and also the need for applicability to a diverse range of urban mobility measures.

## **2. Analysis of existing assessment approaches and their application**

This section contains an introduction to the two widely used assessment methods, and their advantages and limitations. Subsequently, examples of various measures' assessments are presented, followed by an overview of assessment practice throughout Europe.

### *2.1. Common assessment approaches*

Cost-benefit analysis (CBA) and multi-criteria analysis (MCA), common methods for ex-ante and/or ex-post evaluation of transport projects or measures (Beria et al., 2012), have been subject of a detailed analysis, below. Other approaches, such as cost-effectiveness analysis - designed to identify the lowest-cost option to achieve a specific objective - or environmental impact assessment, have not been included as they focus on a selected set of impact factors rather than all of a project's or measure's impacts (Browne and Ryan, 2011).

#### *Cost-benefit analysis*

The idea of a CBA is to express a project's or measure's impacts, direct and indirect, in monetary terms, allowing the economic viability of a project to be assessed and expressed by viability indicators such as benefit to cost ratio (BCR), internal rate of return (IRR) or net present value (NPV). Impacts already expressed in monetary terms, such as investment or operative costs can be included easily in a CBA, whereas those impacts expressed in non-monetary terms must first be monetized. Some of these impacts have a direct market value, such as travel times or material damage caused by accidents. Otherwise, non-monetary impacts may be monetized by determining a monetization factor for them, for which many techniques are available (Tudela et al., 2006).

One of the main advantages of the CBA method is the ease in communicating its results through one or more indicators (Browne and Ryan, 2011). A project can be easily accepted or rejected based on the NPV (which indicates whether the benefits exceed the costs). By comparing the BCR of two alternative projects, the project that yields the higher benefits for each Euro spent can be identified easily. Especially in times of constrained local-government budgets, a project's economic efficiency is important to local decision-makers. The limitations of the method arise

mainly from the monetization of non-monetary effects. It is questionable if all impacts can be appropriately expressed in monetary terms, and there is uncertainty about the robustness of the results of non-market valuation techniques (Bickel et al., 2006). Especially less-tangible impacts, such as comfort or quality of life, are difficult to monetize and thus often neglected or ignored in CBAs. Furthermore, ethical questions are raised by assigning monetary values to factors such as road fatalities (Beria et al., 2012). Another criticism of the method is that travel time savings are usually among the dominating factors, although these can be too small to be noticed by individual users. Additionally, the fact that these savings can lead to side effects, such as longer or more frequent trips, is neglected. Finally, CBAs also have the disadvantage of extensive data requirements, resulting from the need to quantify and monetize all effects (Browne and Ryan, 2011).

### *Multi-criteria analysis*

The MCA method involves assessing measures in a two-step process. Firstly, a set of criteria is developed by which the measures should be assessed, with each of them assigned a weighting value, reflecting the relative importance of each of the criteria (Browne and Ryan, 2011). Secondly, the performance of the measure and its alternatives is analyzed in either qualitative or quantitative terms. There are various approaches to assign the criteria weights and combine the scores (Beria et al., 2012), a common approach being the Analytic Hierarchy Process (AHP), developed by Saaty (1977). Regardless of the method chosen, all result in a final score for each alternative which reflects its appropriateness.

The main advantage of the MCA method is that it can accommodate a variety of factors, even if they are difficult to quantify or monetize, allowing for more holistic evaluations (Beria et al., 2012; Browne and Ryan, 2011). The processes by which scores and weights are assigned are seen, however, as both an advantage and disadvantage of the method. On the positive side, the scores can be based on experts' estimates (limiting the amount of work required for the assessment), while the criteria weights can be assigned through participatory processes (Tudela et al. (2006)). Browne and Ryan (2011) argue that stakeholder involvement in a MCA can contribute to the resolution of conflicts. On the negative side, these processes are subjective, negatively affecting the results (Beria et al., 2012). Furthermore, participatory processes can be very resource intensive (Browne and Ryan, 2011). Also, weighting processes are criticised for aggregating various stakeholders' priorities into an average weight or for forcing consensus in group-weighting procedures (Garmendia and Gamboa, 2012). Moreover, participants might be hesitant to reveal their preferences (Rogers and Seager, 2009): individual preferences may differ depending on whether the weighting is conducted in a group setting or in isolation. For an extensive review of the various weighting approaches, including their advantages and disadvantages, see Wang et al. (2009).

### *2.2. Application to urban mobility policies and measures*

A huge variety of measures or projects regarding the planning and management of urban transport systems have been completed, ranging from major infrastructure projects to small information campaigns. Accordingly, there is a diverse range of costs and benefits, both in type and magnitude. A selection of examples of CBAs and MCAs, both ex-ante and ex-post, of various urban transport policies or measures has been investigated here, based on a literature review. This investigation can only reflect a small proportion of measures, and is subject to the limitations imposed by the non-publication of many analyses. A detailed critique of the various case studies, such as of their evidence base, indicators considered and methodological consistency is beyond the scope of this paper. However, this paper does provide some insight into the application of the assessment methods for the various kinds of measures.

A measure commonly assessed by CBA is urban congestion charging, with manifold examples. CBAs for the London congestion charge were conducted by Prud'homme and Bocarejo (2005), and by Transport for London (2007). The Stockholm congestion charging scheme was analysed in a CBA by Transek (2006) and Eliasson (2009). Milan's Ecopass scheme was evaluated by Rotaris et al. (2010). Finally, in their review of CBAs themselves, Raux et al. (2012) reviewed the CBAs conducted for Stockholm and London, highlighting some methodological problems, such as the way travel time savings and their sensitivity were calculated, and how indirect effects were assessed. Even though the studies investigated quite similar measures, the impact criteria used in their assessments vary. In general, however,

indirect effects on pedestrians, cyclists or public transport passengers are not included in the CBAs, while the dominant benefits are often time savings for individual motorised transport (Raux et al., 2012).

For measures addressing walking and cycling, mainly infrastructural measures have been assessed with a CBA. Sælensminde (2004) investigate the cost and benefits of the expansion of walking and cycling paths in three Norwegian cities. The resulting BCRs varied between 2.94 and 14.34, but uncertainties were revealed in a sensitivity analysis. Examples from the USA include an ex-ante CBA for footpath construction in Dane County, Wisconsin by Guo and Gandavarapu (2010), and a CBA for cycling infrastructure in Portland, Oregon (Gotschi, 2011). Based on a review of 16 economic analyses of cycling and walking infrastructure, Cavill et al. (2008) found that the underlying assumptions differed significantly between the 16 studies, as did the criteria assessed. Most the 16 CBAs under investigation resulted in a BCR larger than one – indicating economic viability. Several assessments in the field of walking and cycling focus on, or limit their investigations to, health benefits (e.g. Gotschi, 2011). In several countries, HEAT (Health Economic Assessment Tool), developed by the World Health Organisation, is used to assess the economic benefits of walking and cycling (Kahlmeier et al., 2010). In the ex-ante assessment conducted by Sælensminde (2004), the projected effect on cyclist numbers of a package of measures supporting cycling – such as bicycle parking facilities and safer crossings – is quantified. The assessment of a package of measures, rather the individual component measures might be beneficial for cycling assessment, as single, stand-alone projects might not result in measureable effects.

For some measures, impact studies are available, but no CBA or MCA. Bus priority systems using intelligent traffic lights, for instance, were evaluated in several cities for their impact on travel time and reliability (Gardner et al., 2009), however, no overall appraisal was conducted. Soft measures like improving traveller information are usually not covered by impact assessments at all: no MCAs or CBAs in this field could be identified in the literature.

More examples of CBAs can be obtained from the EC-funded CIVITAS project, for which many of its measures were evaluated with the method. The measures include alternative fuels for public transport and car sharing or pooling initiatives, however, for some measures no CBA could be conducted due lack of a clear reference case, or limited or inconsistent data (Piao et al., 2010).

Overall, the examples of appraisals available in the literature indicate that CBA is mainly applied to infrastructure projects – including infrastructure for non-motorised modes – and to projects intended to generate revenue, such as city tolls. However, the exact design and the impact criteria included in the assessment vary between measures as well as between studies of the same measure, greatly limiting the comparability of the results. Communicating only overall results, summarized for instance into a BCR, carries the risk of non-assessed impacts being neglected in the decision-making process, and that of BCRs of different studies being compared despite them resulting from assessments with different assumptions and criteria.

### *2.3. Current application in research and by transport practitioners*

After reviewing the available assessments of specific urban mobility measures, now the way in which the assessment approaches are embedded and applied in the local decision-making process is examined. CBA is frequently used in decision-making for road and rail infrastructure: Odgaard (2006) found that 9 of 26 European countries use MCAs in road project appraisal, while all countries surveyed used CBA. However, a CBA is sometimes complemented with an MCA to allow appraisal of non-monetary criteria (Bristow and Nellthorp, 2000; Odgaard et al., 2006), although the exact approaches used vary between the countries (ibid.). In many EU countries, the national appraisal framework for transport infrastructure projects mandates a CBA and/or MCA, while in some countries the appraisals are mandatory only for major infrastructural investments in order to receive public funding. Examples of the latter are provided by the WebTAG tool in the UK and the OEI in the Netherlands, both of which are reviewed by Annema et al. (2007) and Geurs et al. (2009). Geurs et al. (2009), criticises both, noting that, even though the UK WebTAG performs slightly better than the Dutch guidelines, neither cover the full range of potential social impacts stemming from a transport measure. In addition to being a requirement for funding, the UK WebTAG guidelines are also intended to serve as best-practice for the assessment of other transport projects. As they were primarily developed for nationally-relevant projects, the appraisal guidelines pay little attention to local effects (Geurs et al., 2009), and thus may not properly reflect cities' objectives. Similar to the national frameworks, the EC Directorate-General Regional Policy has developed a common guideline for cost-benefit analyses (required to be eligible for funding), including a

specific section on transport projects. However, this primarily focuses on larger transport projects: depending on the fund, a CBA is required only for projects with a volume of €10m or more. MCA is recommended as a complementary tool where monetization is difficult or impossible (EC DG Regional Policy, 2008).

Besides large infrastructure projects, there are a variety of urban transport measures implemented by cities which are not directly affected by national guidelines or funding guidelines. Insights into the actual assessment practice in cities across Europe have been obtained from a survey of 14 European cities. Although the survey is not representative, it nevertheless contains results from cities of various sizes (ranging from  $\approx 50,000$  to  $\approx 2.7$ m inhabitants) and from 10 different countries across Europe. The results may be influenced by the respondents' various roles and positions within the local administration. The qualitative analysis revealed that the cities usually do not have a standard appraisal method for all transport projects, while some cities stated that they select or adopt a method depending on the measure being assessed. In line with the results from the literature, CBAs are often applied for larger infrastructure projects in the cities; several respondents referred to national regulations requiring them to do so. For instance, in Italy a CBA is *"the ordinary tool for projects above €10m and mandatory for projects above €50m"*. Several other cities referred to national guidelines on the CBA method and cases to which it must be applied.

Additionally, some cities also use MCAs in their project appraisal. The survey's British participant city highlighted the importance of the WebTAG tool, and mentioned that although smaller schemes can be assessed in a simpler way, *"there would need to be a very good justification for not following the guidelines"*.

Many projects are not subject to a cost-benefit analysis as such. Nevertheless, financial viability checks are of major importance. According to the survey, economic viability is not necessarily the decisive factor in transport decision-making. City representatives mentioned that *"local issues"*, *"the service offered to the citizens"* and *"impacts which cannot be quantified"* can balance or dominate the CBA results. Additionally, the cities were asked about the challenges presented in carrying out a CBA. Issues like *"the monetization of qualitative externalities and not-clear impacts"*, *"putting value on all the externalities"*, *"lack of statistical and traffic data"*, *"[lack of] evidence base for ... small schemes and soft measures"* and *"lack of standard guidelines"* were mentioned. It can be concluded that especially the quantitative and monetary basis of a CBA is challenging for a city and that this limits the method's applicability to local projects.

The analysis of existing assessment practices reveals that, especially for non-infrastructure measures, there is a lack of a standardised assessment approach in most cities. Additionally, the assessment of infrastructural measures – often with CBA – varies significantly in terms of the criteria assessed, including those that are difficult or impossible to monetize and thus often neglected.

### 3. A holistic but simplified assessment approach for local mobility measures

Based on the analysis presented in Section 2, the authors concluded that there is a demand for a simple (i.e. the effort required is not excessive compared to the magnitude of the measure itself), but holistic (i.e. including all factors) assessment approach that can be applied to a variety of urban transport measures. The approach suggested here is primarily based on the MCA method, but also allows the integration of CBA aspects if required and if sufficient data is available. A step-by-step guide addressing local practitioners is currently under publication (Hüging et al. 2014). Table 1 provides an overview of the assessment method. However, note only the key characteristics of the approach can be outlined here.

The approach is designed to compare a measure or project to a reference case or/and to a set of alternative measures, primarily ex-ante. A CBA can be conducted in parallel within the process, on all criteria for which monetization is feasible. The performance of the remaining criteria can be assessed either quantitatively (non-monetary, e.g. tonnes of NO<sub>x</sub>) or qualitatively (i.e. expert-based and literature-based scoring). In the overall assessment all criteria are included after undergoing normalisation.

Table 1. Steps of the suggested assessment approach for cities (Hüging et al. 2014)

| Step                                 | Description  |
|--------------------------------------|--|
| 1. Describe project and alternatives | The planned project and alternatives, including the reference (BAU) case are described. The assessment details (e.g. appraisal period) are determined. |
| 2. Identify effects and indicators.  | The effects by which measures should be assessed, along with the indicators by which the performance should be measured, are identified.               |
| 3. Impact assessment.                | For BAU and the proposed project (and any alternatives), the magnitude of each of the effects selected in step 2 is determined.                        |
| 4. Normalisation                     | The performance figures are converted to unitless, relative numbers.   |
| 5. Criterion weighting               | The criteria are assigned a weight value reflecting their relative importance.   |
| 6. Visualisation and interpretation  | Final scores for each measure are calculated from the normalised performance and weighting value, which are displayed in graphs.                       |
| 7. Sensitivity analysis.             | The significance of individual effects is assessed to test the effect of less-reliable assumptions/values.   |
| 8. Communicate results.              | The results and key information about the assessment procedure are communicated to the decision makers.  |

A key aspect of the method is the combination of different kinds of performance values (monetary, non-monetary but quantitative, qualitative), which is facilitated by normalisation (step 4). All performance figures, including the monetary values, are normalised using a maximum score approach, i.e. Measure A's score for Criteria 1 (C1) is based on its original performance value ( $x_{C1(A)}$ ) divided by the largest (absolute, i.e. positive or negative) performance value for Criteria 1 ( $x_{C1(max)}$ ) for any of the measures being assessed. To ease communication of results it is recommended to use a scaling factor ( $F_{scale}$ ) of 10:

$$Score\ C1(A) = \frac{x_{C1(A)}}{|x_{C1(max)}|} \times F_{scale}$$

This internal normalisation approach (i.e. relating data from the different alternatives to each other) was chosen by the authors over a transformation based on a linear function drawn from the minimum and maximum performance for a specific criterion (e.g. van Herwijnen (undated) and Steierwald et al. (2005)). Developing a linear function would require additional efforts - either to determine threshold values or the inclusion of a larger number of measures from which the threshold values could be obtained. The selected maximum score approach is assumed to better reflect the cities' needs and capacities.

For the criteria weighting process (step 5), the authors suggest a process based on AHP (Saaty, 1977), with considerable simplifications: the criteria are clustered on a hierarchical basis and a limited, predetermined number of weighting points are allocated to the categories in the first hierarchy level. Those points are then further allocated to the subcategories until the lowest hierarchy level is reached. This relatively simple weighting procedure allows for stakeholder participation without needing to expend significant extra effort. Also, the authors suggest the weighting be carried out in a group setting, wherein the various stakeholders agree upon the weights in a deliberative process. This allows the participants to change their preferences based on exchange of information, rational reflection and social learning (Garmendia and Gamboa, 2012). It should be noted, however, that such open weighting procedures are susceptible to bias (e.g. by the dominance of very powerful stakeholders), although extensive processes and mathematical algorithms have been developed to reduce the bias in eliciting weights (e.g. Rogers and Seager, 2009, Garmendia and Gamboa, 2012). Such sophisticated methods might be suitable to apply for larger scale measures, but for small, low-cost measures, a low effort approach, as suggested, here is needed. Based on the normalized performance scores and the weights, an overall score can be obtained for each alternative measure or the reference case. If a CBA is included in the process, the economic viability indicators can be obtained and communicated to decision-makers together with the overall score.

In the following, a case study is presented to illustrate key aspects of the proposed method. The case study is meant to illustrate the method – not to present a final analysis of the alternatives assessed. It is fictional, although some of the data is based on a CBA conducted for Toulouse by Piao et al. (2010). The example compares two options for urban bus fleet renewal: new diesel buses or new CNG buses (along with the necessary additional infrastructure), over a period of 14 years (the assumed lifetime of the new buses). Of the various criteria included in the assessment, some are quantified, while others were addressed qualitatively (Table 2). In a real assessment, additional or other criteria might be of importance, depending on local conditions.

Table 2. Overview of the impacts assessed in the example (ql. = qualitatively assessed) (adapted from Hüging et al. 2014)

| Effects                    | Impact (assessment duration 14 years) |           |
|----------------------------|---------------------------------------|-----------|
|                            | Diesel buses                          | CNG buses |
| Bus purchase               | €6.22m                                | €7.71m    |
| Refilling station          | 0                                     | €2.01m    |
| Fuel costs                 | €4.39m                                | €2.39m    |
| Maintenance costs          | €2.43m                                | €3.56m    |
| NOx emissions              | 706t                                  | 712t      |
| CO emission                | 296t                                  | 74t       |
| HC emissions               | 93t                                   | 36t       |
| PM <sub>10</sub> emissions | 7t                                    | 0.6 t     |
| CO <sub>2</sub> emissions  | 60.2kt                                | 57.6kt    |
| CH <sub>4</sub> emissions  | 2.33t                                 | 12t       |
| N <sub>2</sub> O emissions | 0.04t                                 | 1.35t     |
| Noise (ql.)                | -6                                    | -2        |
| External city image (ql.)  | 1                                     | +3        |
| PT user comfort (ql.)      | -4                                    | -1        |
| PT non-user comfort (ql.)  | -5                                    | -1        |

A total number of one hundred weighting points were allocated, working down the criteria hierarchy shown in Fig. 1. Basic assumptions for this were that investment costs and local air pollution should be heavily weighted (i.e. important), which is reflected in these being allocated a high number of points.

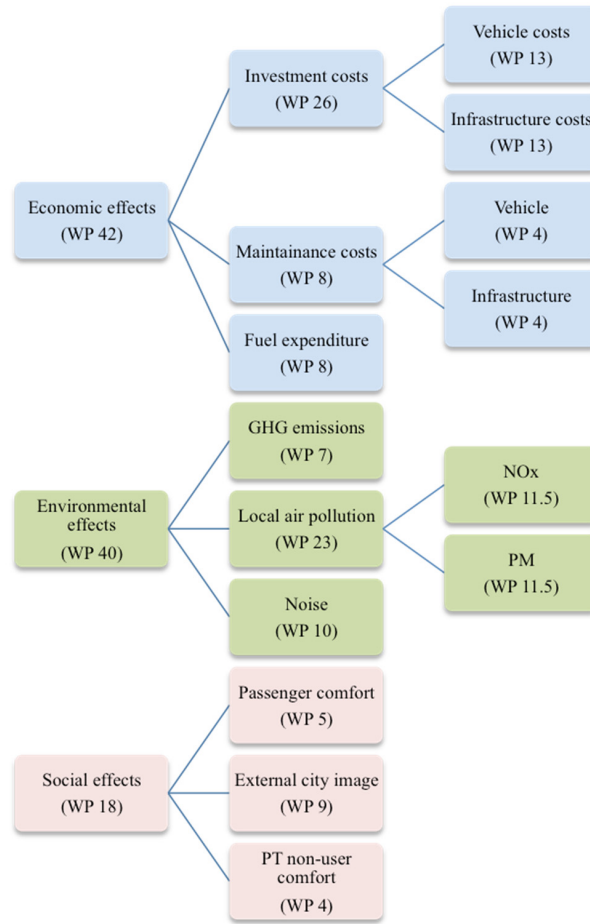


Fig. 1. Simplified illustration of the weighting results (adapted from Hüging et al. 2014)

Fig. 2 summarizes the individual criteria scores and the overall results of the assessment for the example assessment. The blue box summarizes the results of the integrated CBA assessment, which take only those impacts into account which can be monetized (without weighting or normalization). The diesel bus alternative constitutes the business as usual (BAU) case, against which the economic performance of CNG buses is compared. With a BCR of 0.63, the CNG buses are not economically viable.

The turquoise section of Fig. 2 shows the weighted, normalised performance scores for the criteria included in the CBA only. The overall scores are to compare the measures against each other. They can be positive or negative, but this does not indicate whether a measures is viable in general. If the assessment were limited to these monetary criteria, after normalization and weighting, the diesel buses still yield favourable scores (-600.8) compared to the CNG buses (-643.6). Accordingly, these results would suggest to decision-makers that the diesel buses were the optimum choice. However, if the assessment is widened to include criteria which are not reflected in the CBA due to the difficulties in quantification and monetization, the results are quite different: If the non-monetary factors in the yellow sections are included, the CNG-bus option yields an overall score of -607.4, better than the diesel-bus option, which scores -761.1. By including all impacts considered to be relevant, as well as local priorities (reflected in the weights), the results swing from one option to the other, and can be defended as a more holistic indicator than the BCR alone. This example illustrates that impacts not included in a conventional CBA can make a substantial difference, in this case making CNG busses the preferable option to renew the city’s bus fleet.

|                         | Impacts          |                  | CBA              | Normalised score |      | Weights | Weighted normalised scores |               |
|-------------------------|------------------|------------------|------------------|------------------|------|---------|----------------------------|---------------|
|                         | Diesel (BAU)     | CNG              |                  | Diesel           | CNG  |         | Diesel                     | CNG           |
| <b>Monetary</b>         |                  |                  |                  |                  |      |         |                            |               |
| Investment              | -€6.22m          | -€9.72m          | -€3.5m           | -6,4             | -10  | 26      | -166.4                     | -260          |
| Maintenance             | -€2.4m           | -€3.6m           | -€1.1m           | -6.8             | -10  | 8       | -54.4                      | -80           |
| Fuel                    | -€4.4m           | -€2.4m           | +€1.9m           | -10              | -5.4 | 8       | -80                        | -43.2         |
| GHG emission            | -€1.22m          | -€1.16m          | +€0.06m          | -10              | -9.6 | 7       | -70                        | -67.2         |
| Local air pollution     | -€5.4m           | -€4.6m           | +€0.8m           | -10              | -8.4 | 23      | -230                       | -193.2        |
| <i>Economic results</i> | $\Sigma$ -€19,6m | $\Sigma$ -€21,4m | <b>BCR: 0.63</b> |                  |      |         | -600.8                     | -643.6        |
| <b>Non monetary</b>     |                  |                  |                  |                  |      |         |                            |               |
| Noise                   | -6               | -2               |                  | -10              | -3.3 | 10      | -100                       | -33.3         |
| External city image     | 1                | 3                |                  | 3.3              | 10   | 9       | 29.7                       | 90            |
| Passenger comfort       | -4               | -1               |                  | -10              | -2.5 | 5       | -50                        | -12.5         |
| PT non-user comfort     | -5               | -1               |                  | -10              | -2   | 4       | -40                        | -8            |
| <b>Overall results</b>  |                  |                  |                  |                  |      |         | <b>-761.1</b>              | <b>-607.4</b> |

Fig. 2. Simplified example of potential result of a CBA and the combined approach (authors)

As has been shown, the assessment approach detailed here allows all of a measure's effects to be assessed, thus making the assessment more holistic. It can be assumed that the possibility of including impacts in a relatively simple, qualitative manner will encourage cities to include effects in their assessments which are often neglected due to difficult quantification or monetization. Such a holistic assessment's results may be different to those of a traditional CBA, and thus might positively influence the increased selection of more sustainable urban transport measures. In contrast to parallel assessment using both CBA and MCA methodologies, i.e. performing a CBA and evaluating soft effects with an MCA, as suggested by Beria et al. (2012), the approach presented here does not produce conflicting results, as it includes all effects (hard and soft) in the overall score. With this method it can be clearly communicated to decision-makers that the 'classic' economic viability indicators are a valuable result, but these probably reflect neither all of a measure's impacts nor the city's overall priorities (as reflected in the weights). Additionally, the method is designed to easily accommodate stakeholder consultation and public participation. Moreover, the results are not limited to a single value, but accompanied by a comprehensive impact summary table (see Fig. 2), with various options for visualising the results, which may improve the understanding of the method and its relevance in the decision-making process.

An important advantage of this approach is its applicability to a variety of urban mobility measures, opening up the possibility of establishing it as the standard assessment method, while maintaining CBA as an optional addition. Furthermore, the approach is flexible concerning the amount of work required to perform it: minimal for less costly and small-scale measures, probably focussing on qualitative assessment with a greater role for experts' estimates. For larger-scale or cost-intensive measures, a more intensive assessment, including extensive data gathering and modelling, can be performed, allowing more criteria to be quantified. Although the simplification of the weighing process or qualitative performance assessment can increase the approach's susceptibility to bias, these simplifications are seen as prerequisites to allowing cities to conduct the assessment within their own capacities.

#### 4. Conclusion and outlook

Currently, no standardized method for assessing all relevant costs, benefits and overall impacts of urban transport projects exists in Europe, which affects the reliability of existing assessments, the comparability of results and the transferability of measures. Large-scale infrastructure projects are often assessed using the CBA method, which is mandated by some national funding regulations. However, no such regulation exists for smaller, but potentially highly cost-effective projects. This leaves these measures with a competitive disadvantage in the decision-making process compared to large-scale projects. In addition, CBA methodologies are only as good as the available data and the factors assessed. As Cost-Benefit Analysis is a very resource-intensive methodology, it is not always suitable for small-scale innovative measures, where Multi Criteria Analysis (in which qualitative and quantitative data is equally important) is sometimes applied instead.

The lack of a more standardized and holistic approach to assessing the costs, benefits and overall impacts urban transport measures may affect the adoption of small and innovative measures, with considerable sustainability effects. It is apparent that MCA is more adept at capturing the variety of local impacts of urban mobility measures. A simplified assessment approach based on MCA was developed, combining qualitative and quantitative performance evaluation. The suggested approach was designed to be applicable to a variety of urban transport measures – including small scale or low cost measures. It is more holistic than CBA, but can still be complemented by economic viability indicators if necessary. It was shown that such a holistic assessment can produce different results compared to a traditional CBA, and thus might have a positive effect on the selection of more sustainable urban transport measures.

The next step is to test the applicability of the approach, possibly including case studies on specific measures, as well as the method's general integration into the assessment and decision-making practice of a sample city. A special focus will be on the applicability of the simple weighting procedure and the risk of bias. In addition, a systematic review of existing evidence for the impacts of different urban transport measures will be conducted. This could considerably improve experts' estimates, who can then provide more robust advice to decision-makers on the potential impacts of similar measures.

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