Capturing Different Viewpoints in Multi-Criteria Analysis

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Abstract

Multi-Criteria Analysis (MCA) is a popular technique for bringing together a wide range of quantitative and qualitative assessments into the decision making process. While its ability to handle diverse criteria is often seen as an asset of MCA, in other ways, MCA can stifle diversity. In particular, it is generally required that consensus can be obtained (or forced) at some point in the process regarding the relative importance of the criteria. This can lead to dissatisfaction with the process and loss of richness and alternative viewpoints. This paper reviews available methods and recent research results for group decision making in MCA and assesses the implications of these methods in terms of simplicity, transparency and practicality. Often these methods are complex and lack transparency. Then the paper describes a simplified approach that has been successfully used on several transport projects as a way of capturing the richness of alternative viewpoints into the options comparison and decision making process. Finally the paper includes observations about links between this approach and the adjusted BCA method described in the Australian Transport Council "National Guidelines for Transport System Management in Australia".

1 Introduction

Multi-Criteria Analysis (MCA) is a popular technique for bringing together a wide range of quantitative and qualitative assessments into the transport decision making process. While this ability to handle diverse criteria is often seen as an asset, MCA has also been the subject of criticism from a number of perspectives. For example, D'Este (1988), BTE (1999), Steele (2009) and others have highlighted a range of shortcomings including:

- lack of an established analytical framework or uniform approach;
- subjectivity in its key elements of scoring and setting weights, and the potential for these inputs to interact;
- compensatory effects can mean that exceptional performance against one criterion can make up for very poor performance against another and lead to an option achieving a high overall ranking when in practice, it is not a viable option;
- MCA does not adequately account for costs and benefits that are spread over an extended time period. It is generally a collection of snapshots often with no common or clearly defined base period; and
- MCA is well-suited to comparing alternatives for implementing a single project, such as different routes for a road, but not for comparing different projects.

In the last two decades there has been considerable research activity and many advances in the machinery of MCA, but most of these technical criticisms are still valid and point to the need for considerable care when implementing an MCA process. In addition, there are a number of practical and procedural issues that often arise:

- MCA methods can be complex and lack transparency, in particular, some methods devised to address the technical shortcomings listed above are based on complex mathematical procedures that are difficult to explain to a non-technical stakeholder and may be locked within proprietary software;

- the standard MCA process requires that all key stakeholders are brought together in the same room to participate at one or more points in the process. This requirement for a lot of face-to-face time can be expensive and is becoming increasingly difficult to achieve, especially when it involves busy people with many urgent priorities. Just finding a time to meet and getting everyone to turn up has become a major challenge. Software packages are available to help manage the process and do the number crunching but generally they are still based around face-to-face time; and
- generally the aim is to finish up with a single "answer" – the preferred option. This requires that consensus is obtained (or forced) at some point in the process, often at a very early stage. This can lead to dissatisfaction and suspicion with the process for some members of the decision making group; and also to a loss of richness and alternative viewpoints. The mechanism of MCA has been refined to work well for an individual decision maker or a group with a common objective engaged in co-operative group decision-making, but genuinely different viewpoints tend to be lost along the way. This means that in addition to its technical problems, MCA can stifle diversity.

Despite these issues, MCA is surviving and perhaps growing in popularity. The reasons for its ongoing popularity are diverse but appear to include:

- the ability of MCA to incorporate factors that are seen by some stakeholders as being critical to the decision process but are difficult to reliably express in quantitative terms;
- suspicion about "cold-blooded" approaches that demand that all factors, such as the value of human life and environmental factors, are reduced to a dollar equivalent, for instance as required by Benefit-Cost Analysis (BCA). This issue also includes differences of opinion about conversion factors, such as the dollar value of a tonne of greenhouse emissions; and
- a perception that the concept of MCA is easier to understand and closer to the way that people think and actually make decisions.

As a result, many stakeholders feel more comfortable with MCA than other approaches.

The aim of this paper is not to debate the technical merits of MCA versus other appraisal methods. Instead, it describes a mechanism for group decision making within an MCA framework that successfully addresses some of the practical and procedural issues listed above. In particular, the suggested approach reduces the need for face-to-face meeting by using a mixed mode architecture (face-to-face, online and off-line); and it provides a way of capturing and retaining the richness of alternative viewpoints in the process of comparing options and making decisions. Alternative viewpoints and the way that they can be managed in an MCA framework is the main focus of this paper.

In a standard group MCA process, the only outcome is the "average" weights and the joint decision about ranking of options. However this is a compromise and may not correspond to the decision that any individual would have made on their own. The main reason for seeking to also retain alternative viewpoints is that it provides insights into the range of views likely to be seen in the community, including their relative priorities and the decision that they would have made. Viewpoint analysis can help pinpoint options that are generally favoured (disfavoured or neutral) across a range of viewpoints; and those for which there are strong views for and against, and why. This can help the project proponent to understand and anticipate where support and opposition may come from, and their main areas of concern. In turn, this can be very valuable for targeting further work on addressing potentially problematic aspects of the project, and for framing communications strategies.

Finally the paper makes some observations about links between this approach and the adjusted BCA method described in the Australian Transport Council "National Guidelines for Transport System Management in Australia".

2 There is no single MCA method

First, it is worthwhile revisiting some aspects of the MCA process, especially in relation to how they manage group decision making. MCA has been around for a long time, but in recent decades two distinct schools have emerged both of which has its devotees:

- the *American* school which is based on the notion of a single utility function that combines option performance and the preferences of the decision-maker. This is the familiar rating and weighting approach which directly calculates a weighted sum of scores as a measure of the overall utility of each option. This weighted score is then used to rank the options. This approach includes the widely used Analytic Hierarchy Process (AHP) (Saaty 1980).
- the *European* (or French) school which is based on the notion of outranking, where alternative decisions are compared in a pair-wise way. Sophisticated methods and software has been developed to facilitate the process, such as the PROMETHEE and ELECTRE methods (for example see Figueira et al, 2004).

Within both schools there are a number of variants. The features of these variants that are of most interest in this paper are how they are applied to group decision making; the way that they handle consensus; and where it is in the process that alternative viewpoints are lost. Table 1 shows a classification of MCA methods based on the nomenclature and analysis in de Keyder and Springael (2002), Dias and Clìmaco (2005) and Lamboray (2007). The Table shows the degree of group consensus required by each type of MCA method; whether or not the method can generate individual ranking corresponding to alternative viewpoints; and the extent to which it is necessary to bring together all participants at the same time and place.

Table 1 – Spectrum of MCA methods

	Type 1	Type 2	Type 3	Type 4
Consensus				
Alternatives	✪	✪	✪	✪
MCA Method	✪	✪	✪	
Criteria	✪	✪	✪	
Evaluation/Scores	✪	✪		
Weights	✪			
Outputs				
Individual Ranking		✪	✪	✪
Group Ranking	✪	✪	✪	✪
Same Time and Place				
Throughout	✪			
Partial		✪	✪	
Minimal				✪

The key features of the MCA variants are:

- Type 1 – in this architecture, the decision making group is brought together and agrees on all aspects of the process (alternatives, MCA method, criteria, evaluations, weights). This is the traditional and most widely used approach. The MCA problem is solved by consensus as if the group is a single entity. A major drawback of this approach is that some group members may feel that their opinion has been lost or is badly represented by the outcomes.
- Type 2 – in the second architecture, the group agrees on the alternatives, MCA method, criteria and evaluations; but each group member can separately define a set of criterion weights and these can be used to derive an individual ranking of alternatives. The individual rankings are then combined into a collective group model. This can be done in a meaningful way because all rankings are derived from the same MCA method. This architecture preserves the individual viewpoints longer in the process, but the way that the individual rankings are combined to produce a group decision can sometimes be opaque.
- Type 3 is a variation on Type 2 which relaxes the need for consensus on evaluation and scoring. Each group member can do their own evaluation against each of the agreed criteria and report back the resulting ranking of alternatives.
- Type 4 is a more radical architecture in which there is agreement on the alternatives, but no assumptions are made with respect to a particular MCA method, criteria or evaluations. The only thing that matters is the ranking of the alternatives that each group member derives by whatever method they choose. The individual rankings are then aggregated into a common group ranking by finding the ranking that fits best these different rankings. A method for implementing this architecture is described in de Keyser and Springael (2002) and Springael and de Keyser (2004).

This highlights the flexibility of MCA and the opportunities available for retaining alternative viewpoints in an MCA framework. However for use in actual transport project comparison and decision making there are some practical constraints.

3 A practical approach to capturing different viewpoints

For a start, it is preferable that "everyone is on the same page". In practice this means that the MCA method is specified at the start of the process, and at an early stage there is group agreement on the alternatives to be considered and the decision criteria to be used. Without at least this level of consensus it is unlikely that the results will be given much credibility. There are also practical constraints on the extent of group participation in the evaluation of the performance of options against the agreed criteria. For transport projects, this can typically involve modelling and detailed quantitative analysis which is best done off-line and then reported back to the group for review. In addition, the process should be transparent and understood by group members; and not make undue demands on their time.

These constraints define an approach to the MCA that is consistent with Type 2 in Table 1. That is, an architecture in which the group agrees on the alternatives, MCA method, criteria and evaluations; but each group member can separately define a set of criterion weights and these can be used to derive individual rankings of alternatives from different viewpoints. This approach has been successfully implemented in several recent transport projects using the steps shown in Figure 1.

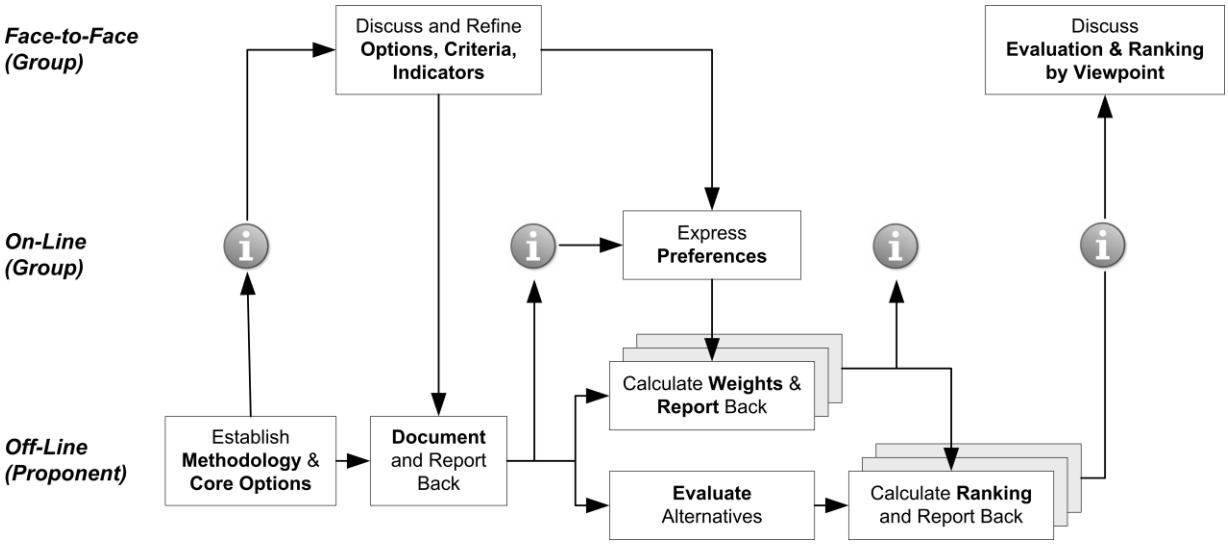

Figure 1 – Overview of proposed method

The steps in the process are described below focusing on the mode of interaction (face-to-face, online, off-line); the way that different viewpoints are handled; and role of the following main players in the process:

- Project Proponent: the organisation (private or public sector) intending to implement a development proposal (and their advisors);
- Group: the group of stakeholder representatives to be included in the MCA process;
- Individuals: each of the members of the Group; and
- Viewpoint: a cluster of Individuals with similar preferences.

Within this framework, the key features of the suggested MCA process are;

- prior to getting the Group together, the Proponent first formulates an initial set of core options and selects the MCA process, typically, an approach based on the *American* school. A briefing on the MCA process along with background information about the project and set of core options is then prepared and sent electronically to Group members prior to the first face-to-face meeting.
- the Group meet face-to-face to discuss and refine the options and identify a small set of headline criteria; and at the same time receive a more detailed briefing on the subsequent steps in the MCA process. In particular, the Group is briefed on the method by which they (as Individuals) express their preferences for the criteria. With access to information before the meeting and a short agenda, the length of the initial face-to-face meetings can be kept to a minimum (perhaps 1-2 short meetings). The results of the meeting are then documented and sent back to the Group members by email.
- to collect information about their preferences, each Individual is then emailed an electronic survey which involves pairwise comparison and rating of the relative importance of the headline criteria. The electronic survey form is designed to guide the Individual through the process and record the results which are then emailed back to the Proponent for processing.
- the raw data from each survey is converted to a pairwise comparison table and analysed using the method developed for AHP. The result is the set of underlying criterion weights most likely to have produced the pairwise comparisons for that Individual. Other methods for eliciting criterion weights from each Individual could be used, but in practice, pairwise comparison is a robust method that is easy to explain;

quick and easy for the Individual to complete; and easy to implement in an user-friendly electronic format. The individual results are pooled and analysed to calculate a set of Group weights corresponding to the overall group preferences and also a set of criterion weights for each viewpoint cluster.

- the results of the analysis of preferences including the Group and Viewpoint weights are then documented and emailed back to all Individuals for information. In this way, stakeholders were kept informed of progress and outputs at each stage in the process.
- in parallel, each of the options is evaluated using the agreed criteria and indicators.
- the weights are then applied to the criterion evaluations to derive an overall score for each option and a ranking of alternatives. This is done for Group and Viewpoint weights to continue to preserve the alternative viewpoints through the process. The results, including the ranking of options for each Viewpoint and for the Group as a whole, are then documented and emailed back to Individuals for information.
- the final step is to reconvene the Group for a face-to-face meeting to run through the results of the evaluation and MCA and to respond to questions and discuss any refinements to options or evaluations; or follow-up analysis.

Throughout the process, the aim is to keep it as user-friendly, efficient and transparent as possible, and at the same time, to retain alternative viewpoints. This involves:

- keeping face-to-face meeting time to a minimum, while keeping Group members informed each key step in the process to retain the sense of participation and ownership of the results;
- using mixed face-to-face, online and off-line modes. Group members are kept informed of progress and results throughout the process by email; and the preference survey is conducted electronically. This allows Group members to complete the survey at a time of their own convenience and to take as long as they required without the pressure of a group situation. There appears to be little published literature on the use of mixed mode and web/email-based methods to replace some (or all) of the face-to-face time in transport MCA group decision making.
- not requiring consensus on criterion weights to be reached at face-to-face meetings, again avoiding Group pressure;
- encouraging Group members to complete the preference survey as quickly and intuitively as possible and not worry unduly about the internal consistency of their responses. A certain amount of inconsistency in pairwise comparisons is only to be expected and is tolerated by the AHP eigenvector method used to extract the underlying set of criterion weights.
- keeping the number of headline criteria to a manageable number. It is generally recommended that the number of headline criteria should be kept to 7 or less; otherwise the required number or pairwise comparisons quickly becomes too large and the process of expressing preferences becomes overly arduous resulting in survey fatigue; and
- using simple methods to define viewpoint clusters and aggregate responses both within clusters and across the Group as a whole. Complex statistical and geometric techniques exist for extracting clusters and aggregating results (such as Zahir 1999a, 1999b) but at the possible expense of some technical purity, simpler methods are used as described below.

Viewpoint clusters are defined to correspond to each of the headline criteria. For example, consider a hypothetical urban transport projects, with four headline criteria:

- Project Cost
- Transport User Benefits
- Environmental Impacts
- Land Use Integration

These are typical criteria that cover much of the spectrum of decision factors that generally arise as part of a transport MCA. So in this example, there would be a viewpoint cluster corresponding to a high level of concern about Cost; another corresponding to a strong Environmental viewpoint; and so on. Defining the clusters in this way provides a simple and intuitive method of defining clusters with a direct interpretation in terms of decision criteria. It also ensures that the clusters correspond to factors (criteria) that have already been identified by the Group as their main concerns.

Each viewpoint cluster contains the survey results (calculated vectors of criterion weights) of all those Individuals that expressed a priority for the corresponding criterion by giving it an above-average weight. Having allocated Individuals into clusters, the next step is to calculate the overall set of criterion weights for the viewpoint cluster by simply taking the vector mean of the sets of weights in the cluster. For instance, the set of weights for the Cost Viewpoint cluster is the mean of the weights for all Individuals that gave the Project Cost criterion a higher than average weight. Although the averaging process represents a degree of compromise, it is only amongst individuals who already have expressed a similar viewpoint. The process is repeated to derive a set of criterion weights for each Viewpoint and for the Group as a whole.

The process is shown schematically in Figure 2. Each stack of boxes in the upper rectangle represents the vector of criterion weights for each Individual in the Group, with criteria given an above-average weight highlighted with shading. All those individuals that gave the Project Cost criterion an above-average weighting then become members of the Cost viewpoint cluster, noting that a particular individual could belong to several clusters. The individual results are then combined to produce an overall Group mean and mean set of weightings for the Cost viewpoint cluster and other viewpoints.

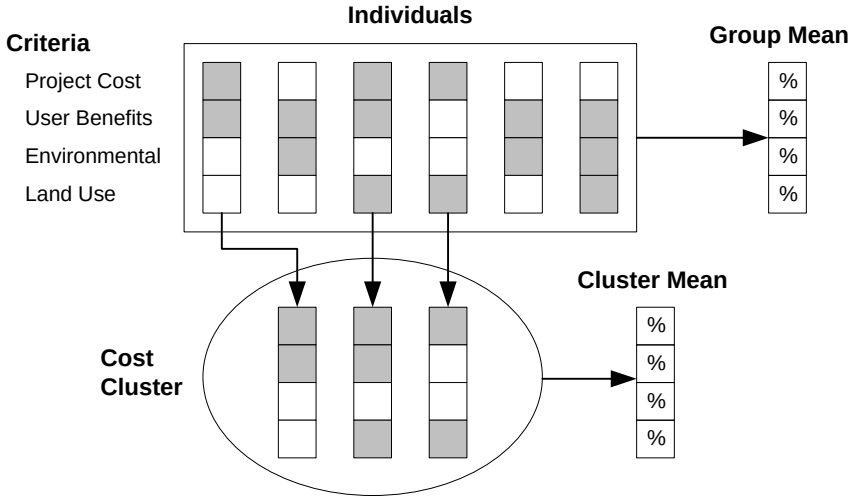

Figure 2 – Overview of clustering process

4 Example of alternative viewpoints

With a spread of perspectives within government and across the community it can be expected that preferences and priorities will vary significantly, for example depending on whether the Individual is representing a funding agency; a transport planning agency; an environmental protection agency; or a land use planning agency. In addition, the way that these priorities translate into criterion weights will depend on the details of the specific

transport project (what, where) and the prevailing policy environment. For example the relative weight given to an environmental impact criterion by all viewpoints is likely to be different for a transport project in an environmentally sensitive area versus a "brown fields" site. This means that the pattern of weights for various viewpoints (and for the Group as a whole) is likely to vary significantly from project to project. Perhaps in the future it will be possible to extract typical patterns of viewpoint preferences from an analysis of a large number of project MCA, but at this stage, it is recommended that a new preference survey and viewpoint analysis should be undertaken as part of each MCA process.

However to illustrate the spread of viewpoints likely to be observed when setting weights for comparing options for a particular project, Figure 3 continues the example of a transport MCA with four criteria (Project Cost, Transport User Benefits, Environmental Impacts, Land Use Integration). It shows criterion weights for a hypothetical transport project for each of these viewpoints. The weights are loosely based on MCA of actual transport projects; and are indicative of viewpoints likely to be encountered in a transport project.

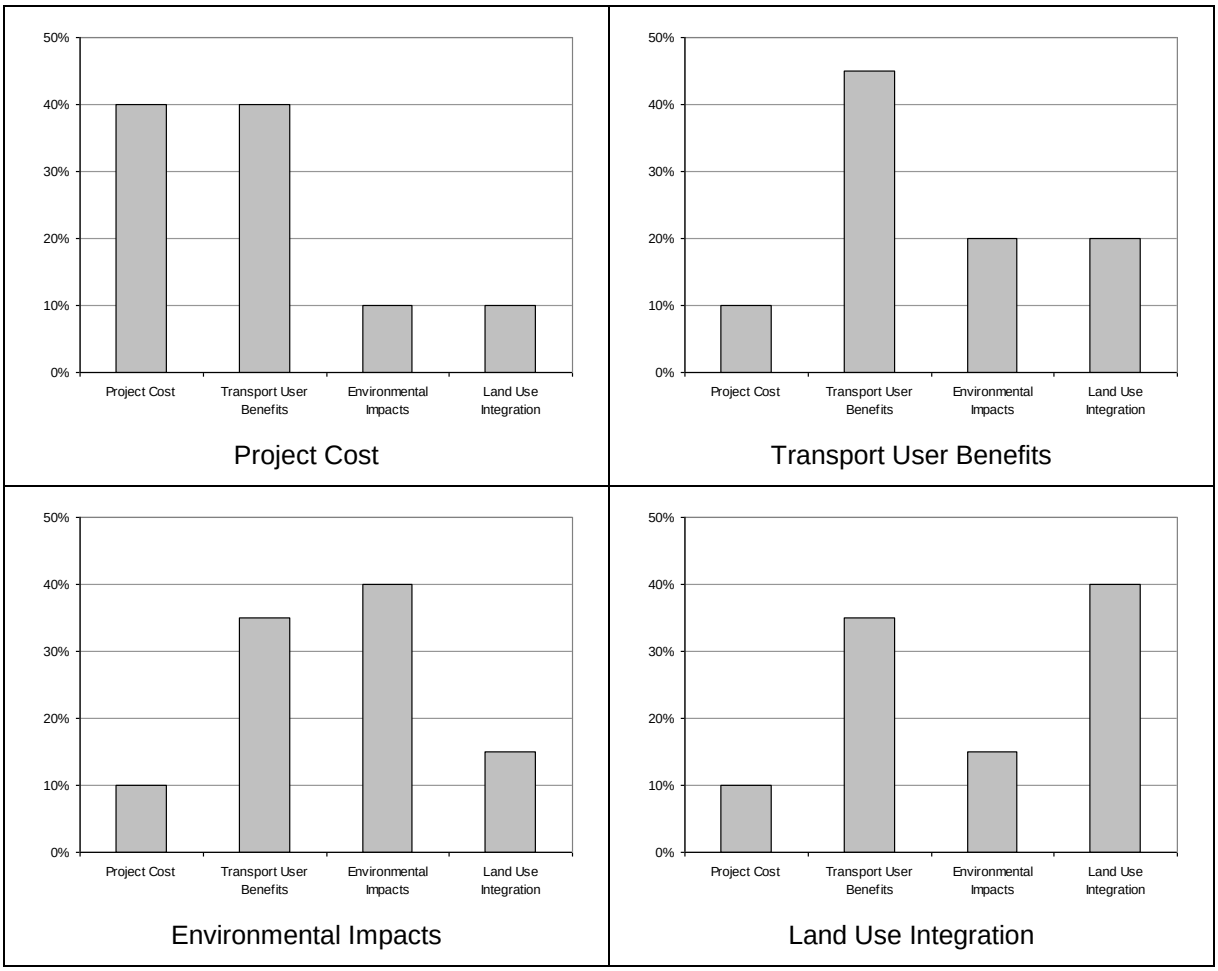

Figure 3 – Criterion Weights from Alternative Viewpoints

The pattern of weights in Figure 3 reflects some broad features that have been observed in many transport MCA processes:

- each viewpoint gives its corresponding criterion a high weighting (by definition), but not necessarily the single highest weighting;
- all viewpoints tend to recognise the importance of transport user benefits, since achieving these benefits is the essential objective of a transport project; and

- viewpoints other than the financial viewpoint tend to give project cost a somewhat low-to-middling weight. A possible interpretation is that some Individuals may see MCA as a mechanism for balancing outcomes versus impacts with consideration of project cost taking a back seat.

5 MCA and Adjusted BCA

The Australian Transport Council (ATC) Guidelines (ATC 2006) describe a recommended approach to transport project appraisal. In general, the ATC Guidelines are not supportive of MCA methods, but offer a similar method called adjusted BCA which is described in the Guidelines as a hybrid of BCA and MCA and a formal way to re-weight or incorporate non-efficiency objectives. One way of adjusting the BCA is to multiply some benefits and costs by weights, in a similar way to weighting MCA criteria, for instance to reinforce a safety objective. However the ATC Guidelines provide little guidance as to how to determine these weights other than that they are to be supplied by the government agency undertaking the adjusted BCA.

The results of preference surveys undertaken to set MCA weights can provide an insight into the relative priorities given to the various decision factors and inputs, and hence weights that could be used in Adjusted BCA. Table 2 continues the example of a transport MCA with four criteria (Project Cost, Transport User Benefits, Environmental Impacts, Land Use Integration). The Table compares implicit values from MCA viewpoint analysis against equivalent ATC BCA parameter values. The values are derived from actual transport projects where both viewpoint MCA and BCA were undertaken in parallel. It is possible to estimate these implicit values because there are two performance indicators that generally have parallel quantitative analysis in both BCA and MCA streams:

- transport user benefits – linked to Value of Time (VOT) measured in $/hour
- environmental impacts – linked to vehicle activity and measured in $/VKT (vehicle-km of travel)

The implicit MCA parameter values are calculated as the ratio of the financial cost ($) and level of transport activity (hours of travel time saving; or reduced VKT) that would produce the same contribution to the MCA score; with adjustments for the relative weight assigned to each criterion. As a result, it is possible to estimate an implicit MCA value for each viewpoint.

Table 2 – Implicit parameter values by viewpoint

			Relative to BCA Parameter Value		
Parameter	Value of Time (VOT)	Environmental (EVKT)	Project Cost	VOT	EVKT
	($/hr)	($/VKT)			
BCA Value (ATC 2006)	$11.39	$0.05	1	1	1
Implicit MCA Value by Viewpoint					
Project Cost			1	1	20
Transport User Benefits			1	5	100
Environmental Impact			1	5	200
Land Use Integration			1	5	100

Note that the values in Table 2 are based on actual projects but are illustrative only and not suggested for general use in Adjusted BCA. As noted above, it is recommended that a new preference survey and viewpoint analysis should be undertaken for each appraisal process.

The purpose of Table 2 is to highlight and stimulate debate over the different values given to benefit/impact parameters in BCA versus MCA and by different viewpoints. In particular, the implicit MCA parameter values for VOT and value of environmental impacts per vehicle-km (EVKT) tend to be much higher than the BCA parameters, especially for the environmental parameter. In other words, the experience of MCA is that it tends to place a much higher value on benefits-side inputs than does BCA. For some viewpoints, the values can be very high, perhaps as much as 100 times as high as the standard BCA parameters. This disparity is somewhat reminiscent of the apparent inconsistency between parameter values used in transport project appraisal for VOT versus value of life, as highlighted in a classic paper by Hauer (1994).

In terms of its implication for Adjusted BCA, the figures in Table 2 suggest that for Adjusted BCA to simulate viewpoint analysis, some very high adjustment factors may be necessary.

6 Conclusions

In any multi-stakeholder decision process, it is important to understand the range of different viewpoints and anticipate where support and opposition may come from and why. The MCA process has the capacity to incorporate alternative viewpoints into the analysis, but in most cases, the only output is a single compromise decision about ranking of options. This need to obtain (or force) consensus at some point in the process can stifle diversity and create dissatisfaction and suspicion with the process for stakeholders who may feel that their viewpoint has been lost.

This paper describes a practical and relatively simple and transparent method for running a group MCA process in a busy multi-stakeholder environment while preserving the richness of alternative viewpoints. In addition to providing a joint ranking of options for the group as a whole, the suggested process generates a separate ranking of options for each viewpoint cluster. This provides deeper insights into the decision-making dynamics and widens the value of the MCA process from project appraisal to stakeholder analysis. The end result is somewhat similar to sensitivity testing, but instead of simply testing ranges of numbers, the analysis reflects alternative viewpoints that are likely to actually exist in the community.

The suggested mechanism also addresses some of the practical and procedural issues that sometimes arise with MCA, in particular by keeping the need for face-to-face meeting time to a minimum. In summary, the key features of this approach are:

- mixed face-to-face, online and offline modes;
- the sense of participation and ownership in the results is retained by keeping group members informed by email or other means at each step of the process;
- at an early stage of the process there is group agreement on the MCA method, the alternatives to be considered and the decision criteria to be used, but consensus on criterion weights is not required;
- the information (pairwise comparisons) needed to estimate criterion weights is collected by means of an electronic survey form that group members can complete at their own convenience without the pressure of a group situation;
- a viewpoint is defined to coincide with each decision criterion and a set of criterion weights is calculated for each viewpoint, thereby preserving a diversity of views into the process of ranking options; and
- a separate ranking of options is produced for each viewpoint cluster and for the group as a whole.

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