Paper 2
Theory and Background of Multi-Criteria Analysis (MCA): Toward a Policy-led MCA for megaproject transport infrastructure appraisal

E. John Ward, Harry T. Dimitriou and Marco Dean*

OMEGA Centre, Bartlett School of Planning, University College London, 14 Upper Woburn Place, London, WC1H 0NN, United Kingdom.

E-mail addresses: h.dimitrou@ucl.ac.uk (H.T. Dimitriou), eric.ward@ucl.ac.uk (E.J. Ward), marco.dean.11@ucl.ac.uk (M. Dean).

* Corresponding author

Abstract
The aims of this paper are twofold. Firstly, to present a review and critical analysis of the varying forms and functions of Multi-Criteria Analysis (MCA) presented in the literature, and secondly, drawing from this, to introduce methods and processes by which policy leadership can be introduced into MCA processes for the appraisal of large-scale infrastructure projects (such as Mega Transport Projects, or MTPs) to form a policy-led multi-criteria analysis (PLMCA).

Following the discussion in Paper 1, this contribution commences by outlining further the generic features and challenges of MCA approaches to project appraisal whilst emphasizing the difference among various MCA frameworks and attendant processes. It also highlights the important role/value of the MCA mapping stakeholder policies and agendas affecting project decision-making as a means of defining and scoping the boundaries of the project exercise under study and the trade-off decision-spaces for stakeholder dialogues and negotiations in their search to arrive at mutually agreed actions and outcomes. The paper discusses how MCA frameworks can be tailor-designed for particular agencies and stakeholders developed around particular problems, challenges and issues. This is done in the acknowledgement that such exercises, especially when applied to mega infrastructure project appraisal, typically attract a multiple-institutional response and where ultimately an institutional leader (or partnership of stakeholders) exists/emerges that impose its/their priorities on others. Alternatively, the approach can be tailor-made for specific institutions with its imbedded hierarchy of policies and priorities that frame the MCA stakeholder decision space within which other parties can participate and trade off interests. The first part of the paper highlights the important role of scenarios of policy-making contexts and policy leadership indicating the new risks, uncertainties and opportunities these may offer in MCA exercises, indicating that some/many past MCA processes have been conducted outside of any real reference to such matters. In so doing, such MCA applications have them silently and implicitly adopt scenarios and policy assumptions that are not transparent frequently reflecting, it is alleged, 'business as usual' circumstances in contexts when the signs are very much that these trends will not/cannot prevail. The authors content that without explicit policy leadership there is a danger that certain institutional stakeholder

priorities will be imposed over others by the most powerful without adequate dialogue. Understanding that this matters a great deal in contexts when/where project stakeholder powers shifts occur is very significant. Examples of such circumstances are when national governments become, less or more powerful and economically affluent, when relative legislative and regulation powers become less or more binding and powerful, and when a major private sector investor upon which a project depends goes bankrupt.

The second half of the paper builds on these observations to offer a generic MCA framework and attendant processes that imbed policy leadership firmly within multi-stakeholder decision-making (termed PLMCA). The framework developed is to be applied to MTPs *via* the use of suitable appraisal criteria in the pursuit of sustainable development goals, which seek to address both quantitative and qualitative dimensions and concerns of multiple stakeholders, with particular emphasis on the processes required to identify and incorporate suitable policy leadership, including feedback between MCA and policy.

Keywords: multi criteria analysis, policy-led multi-criteria analysis, project appraisal, multiple stakeholders, mega projects, sustainable development
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2.1 Introduction

Multi-Criteria Analysis (MCA)[1] concerns the making of choices using multiple, and often conflicting, criteria, in efforts to arrive at pre-considered desired outcomes. MCA in particular, looks to deciding on preferences by choosing among options that refer to an explicit set of objectives assigned to the decision-making body or those identified by it. Such criteria (and related indices and targets) represent measures and assessments of the extent to which the objectives of the decision-making exercise have been/can be achieved.

In the case of the appraisal of mega MTPs, MCA permits a wide set of objectives, often across different sectors, to be included *within* the decision-making appraisal process. Such objectives relate to a spectrum of economic, environmental, social, cultural, technical, technological and institutional aspects of the project assessed. Criteria may be monetised, non-monetised (but nonetheless quantified *wherever possible*) or qualified (with supporting text and/or proxy indicators). MCA frameworks and their related processes conveniently allow both these quantified and non-quantified criteria of project outputs[2], outcomes[3] and impacts[4] to be set out together in a common framework – typically a matrix - with the aim of providing decision-makers with a holistic picture of the potential implications across a host of selected possible fields. In this way, MCA provides a structured decision space that assists its users (project stakeholders) to systematically and transparently make trade-offs between costs and benefits when selecting among alternative courses of action that best satisfy the project's objectives.

[1] For the purposes of this paper, MCA is considered synonymous with Multi-Criteria Decision-making (MCDM) and Multi Criteria Decision Analysis (MCDA)

[2] The tangible and intangible products that result from project activities

[3] The benefits that a project or intervention is designed to deliver

[4] Higher level strategic goals, such as increased social cohesion or improvements in public safety

The early development of MCA is widely attributed to the US Military which used it as a decision-making tool for application to logistical problems during the Second World War. Its subsequent development, mainly in the fields of Operations Research, Computer Science and Mathematics led to the proliferation of a wide variety of related methods and tools (Morgan, 2004). The last 20 years, in particular, have seen a marked acceleration in interest in MCA (Bragge, 2010) with the result that it is now widely used for both appraising policy *and* project options as a basis for decisions on their adoption or implementation. Particular applications of MCA using a variety if procedures, including Multi-criteria Mapping (MCM) (discussed below), are to be found in the fields of: GM crops (Stirling and Mayer, 2001, 2004); hydrogen energy futures (McDowall and Eames, 2007); agricultural innovation (Thompson, et al., 2010); stem cell research policy (Morgan, 2010); transport infrastructure appraisal (Macharis 2010); nuclear emergency management (Papamichail and French, 2012) and waste management (Chung and Poon, 1996). MCA has also been adopted by lending international development institutions such as the Asian Development Bank (ADB) for road project appraisal and transport project appraisal more generally (Véron-Okamoto and Sakamoto, 2014); it is also being currently used by the European Investment Bank (EIB) in urban project appraisal (OMEGA Centre, 2014).

Building on the opening introduction to MCA in the previous paper, Section 2.3 of this paper reviews the various generic features of MCA, its frameworks and attendant processes. Many of the MCA methods reviewed contain common elements which, expanding on the work of Triantaphyllou *et al.,* (1998), are presented here as a list of generic characteristics. In Section 2.4, the paper reviews a number of MCA frameworks and attendant processes identified as particularly applicable to megaproject development in the infrastructure field. These have been derived primarily from recent research undertaken by the OMEGA Centre (2011). The pros and cons of MCA are reviewed here and on this basis, a number of developments suggested to enhance their application to MTP appraisal. As well as the role of policy leadership in the decision-making process earlier referred to, a particular focus of the paper is on the ability of MCA to identify and manage risks and uncertainties (commonplace in the context of megaprojects decision-making)

Section 2.5 examines the applicability of MCA to megaproject infrastructure appraisal in particular in light of the OMEGA 2 Project findings concerning what constitutes 'successful' MTPs (OMEGA, 2012). As earlier alluded in Paper 1, this was undertaken with a view to seeking how to operationalise these lessons within the MCA framework by building on the MCA practices reviewed, whilst simultaneously advocating the use of a policy-led (rather than market-led) multi-criteria analysis framework. Moving toward the Conclusions (in Section 2.6), this section contends that whilst MCA aims (*inter alia*) to provide a sound basis for determining project performance and impact (by reference to an explicit set of objectives), it is highly desirable that the formation of these objectives be informed by international, national and local policy guidelines, alongside secondary information sources, as well as stakeholder participation and consultative processes.

2.2 A review of MCA frameworks and processes

Because, as earlier indicated, MCA is concerned with supporting decision makers when confronted with particular problems that involve multiple (often-conflicting) criteria and considerable uncertainty there is frequently no unique 'optimal' solution. The process instead needs to be considered an outcome of decision makers' preferences to rank a series of possible solutions.
A review of MCA frameworks reveals a large variety of processes, tools and techniques, leading the authors to conclude that currently there is no single universally adopted MCA method, but a range of methods which have been developed for application to particular decision problems and stakeholder use. For a useful overview of different types of MCAs see: Vincke, (1992); DTLR (2001); Belton and Steward (2002) and Figueira *et al* (2005). Despite this diversity, as earlier indicated, many methods have a number of common features as described immediately below.

2.3 Generic features of MCA

2.3.1 High level generic structure

MCA methods tend to consist of a firmly developed framework accompanied by a set of attendant processes. Whist the processes adopted to operationalise each of these may vary greatly in sophistication, depending upon the context in which the model is to be applied, three principal phases are generally common to the majority of such methodologies (Holtzman, 1988; Belton and Steward, 2002). They are:

- **The problem-structuring phase:** This involves the scoping (definition) of the decision context(s) (political, legislative, spatial, temporal, cultural etc.), the identification of the decision-makers and other key stakeholders involved, and the specification of the aim(s) of the use of the analysis (and decision space identified). It also entails the collection of information regarding the possible options appraised, as well as criteria and related targets and indices employed.
- **The model-building phase:** This involves defining the criteria and deciding on their relative importance attributed to them by stakeholders, typically, of a numerical scale (providing 'weighting').
- **The model-use phase:** This is where the performance of each alternative is determined by using some a form of 'scoring' which can be expressed either quantitatively (where possible) or qualitatively (possibly involving the use of proxy measures). The model output is here once again employed to inform the decision-making process.

2.3.2 Decision-maker(s)

MCA exercises may entail the direct involvement of all the key stakeholder groups within the decision-making process (Macharis, 2012), the participation of a limited number of actors (DCLG, 2009a) or exclusively by analysts alone (DfT, 2009). The choice of decision-makers represented in the selected MCA method is critical to the outcome of the process (Stirling, 2008). Methodologies by which stakeholders are selected for inclusion within the MCA frameworks tend to vary in line with the purpose of the exercise. Processes which could be adopted to help identify stakeholders,

such as those defined by the UK's statutory consultation process (DCLG, 2009b), tend to rely on generic lists of consultees defined according to institutional decision-making frameworks and geographical proximity of project under scrutiny to identify interested parties. Those stakeholders related to more subtle and causal relationships are typically not easily identified without a detailed issue analysis (of the kind, for example, advocated by Hogwood and Gunn, 1984).

2.3.3 Alternatives or options

MCA is often used to derive a ranking between a set of options or courses of action. Alternatives (options) represent the different choices of action available to the decision maker. Usually, the set of alternatives is assumed finite, ranging from several to hundreds. At a minimum, there will usually be two options: a particular course of action (with the project) set against the counterfactual (without the project) option (Boardman et al., 2016). The development of options to be appraised may be either internal or external to the framework. For example, MCA frameworks can be applied in their 'pure' form as an appraisal tool for application to a set of pre-defined options or as a design and development tool where a set of potential options is defined *within* the MCA framework that may be subsequently revised during an iterative MCA process (Macharis, 2000, 2005 and 2013).

2.3.4 An open or closed process?

MCA approaches have been classified in a number of ways (see Malczewski, 1999; Belton and Stewart, 2002; Figueira et al., 2005) with the different levels of 'openness' in moving toward a solution offering a useful taxonomy. According to Belton and Stewart (2002), MCA provides a framework that represents benefit to both:

- **the decision process**, by helping the decision-maker know more about the decision problem and explore the alternatives available (opening up the analysis); and
- **the decision outcome**, by helping elicit value judgements about trade-offs between conflicting objectives (closing down the analysis).

By involving different numbers and types of participants, and by adopting different scoring and weighting procedures within the framework (Pellizzoni 2001, 2003; Stirling, 2006, 2008b) MCA can allow a greater or less 'open' analysis favouring either the decision process or decision outcome.

Morgan (2010) expands on the above classification by suggesting an MCA analysis may be couched in the terms of three rationales for public engagement in decision-making: the instrumental, normative or substantive. These rationales not only can be used to explain stakeholder motivations for participating in the engagement exercises, but can also be applied to both examine the intentionality behind different appraisal processes and to inform the strategic choice of appraisal exercises in the first place. An instrumental MCA process is typically focused on outcome without specific reference to the means and could involve an appraisal which seeks to produce a unique overall judgment about a decision, say through a ranking of preferred options. A normative outcome, by comparison, is concerned more with the process than outcome, along with the values of independence, openness and legitimacy. With this in mind, it may choose to leave the preferences of each stakeholder group disaggregated, clearly presenting the position of the different actors, perhaps to be taken into account by a particular decision-maker or body in the final stage. Finally, the substantive outcome would be to focus both on the means and the ends. It would, by

example, focus on explicit, socially deliberated and publicly reasoned criteria for outcomes, whereby stakeholders present their positions through a structured process but nonetheless involve some form of closing down of decisions on the basis of establishing trade-offs between stakeholders.

2.3.5 Multiple criteria

MCA criteria are critical dimensions by which a project's goals, objectives and targets (and related indices) may be measured and assessed. They also represent the different dimensions from which alternatives can be viewed. Reinforcing the above definition of criteria in a MCA exercise, DCLG guidelines (2009) explain that project objectives typically spawn the appraisal criteria (e.g. measures of performance) by which project options are assessed during appraisal. However, guidance in the literature concerning the processes by which to define multiple criteria is limited. DCLG guidance suggests that care should be taken to ensure decision criteria are capable of being made operational. It advocates assessing criteria against a range of qualities, including:

- **Completeness:** cross-checking if all important criteria are included.
- **Redundancy:** assessing whether the criteria are necessary or not.
- **Operationality:** judging whether each option can be assessed against each criterion.
- **Mutual independence**: establishing whether preferences associated with the consequences of options are independent of each other, and from one criterion to the next.
- **Double Counting:** ensuring that impacts and outcomes are not recorded more than once in an appraisal or evaluation exercise.
- **Size:** avoiding the use of an excessive number of criteria.
- **Impacts occurring over time:** making sure attention is drawn to time differential impacts.

A practical process to ensure criteria are consistent with the above qualities in a MCA exercise is to group derived criteria into a series of sets which relate to separate and distinguishable components of the overall aims of the exercise. Goodwin and Wright (2004) suggest that in cases where the number of attributes is large, these can be arranged in a hierarchical manner as a value tree. For example, certain key stakeholders may consider some attributes related to international policy on climate change primary. Each of these primary attributes may be associated with several sub-attributes related to national interpretations or applications of the policy. Similarly, each sub-attribute may be associated with several sub-sub-attributes related to regional policy interpretations and so on. Although some MCA methods explicitly consider a hierarchical structure in the attributes of a problem, most assume a single level of attributes without a hierarchical structure. Grouping criteria in a hierarchical form, however, helps to check the relevance of the criteria, simplifies the process of calculating criteria weights and facilitates the emergence of higher-level views of the issues, especially regarding trade-offs between key objectives.

2.3.6 Conflict among criteria

Since different MCA criteria represent different dimensions of alternative choices or options, they may (and frequently do) conflict with each other. For example, there are inherent conflicts between megaproject objectives related to economic growth challenges and concerns related to of environmental and social sustainability. To jointly address economic, environmental, social and institutional factors of project development and appraisal in a sustainable way, it is essential to

understand and manage the tensions, contradictions and potential trade-offs that need to be made between the different goals. A major infrastructure project by illustration, may involve finding 'solutions' to problems in several different fields/sectors simultaneously. Understanding this and bringing the relevant parties on board, and then appraising the multiple effects of doing this are very complex. MCA, nonetheless, allows a framework to be developed by which such conflicts (and commonalities) can be identified and trade-offs sought (Stirling, 2006; Macharis, 2010). Whilst varying by MCA methodology, guidance on how these trade-offs are managed tends to define the establishment of trade-offs as a 'mechanical process'. Papamichail and French (2012), for example, explain that 'value function approaches' such as those employed by MCA encourage the explicit articulation of trade-offs between criteria. The 'outranking methods', on the other hand, appraise alternatives in pairs by identifying incompatibilities, indifferences and vetoes. Unlike other approaches, these methods assume that preferences and values are *not* pre-existing but need to be constructed during the MCA process. Goal programming is especially applied when it is difficult to articulate trade-offs and assign importance weights but possible to express goals and aspirations for all criteria. Analytic Hierarchy Process (AHP) assesses alternatives in pairs using semantic scales such as 'highly important' rather than numerical scores (see Goodwin and Wright, 2004).

2.3.7 Decision scores and weights

MCA often requires some form of scoring to be undertaken of the options under consideration. Usually the performance of an option (expressed in terms of outputs, outcomes and impacts) is scored against a set of criteria derived from the aims of the exercise within a 'performance matrix'[5]. Such matrices contain a variety of indicators to represent the different criteria (quantifiable and non-quantifiable) which often use different units that are incommensurable and thus cannot be combined directly to achieve an overall evaluation. For example, in the case of choosing between routes for a high-speed rail line using two criteria 'costs' and 'visual impacts', costs will be measured using ultimately a monetary variable, whilst visual impacts would be measured by some kind of qualitative index.

The process by which scores are derived depends largely upon the phenomena under appraisal. Where empirical or technically derived data exists, these can be used to derive performance functions directly. Elsewhere, where data is not readily available, or are of a more qualitative nature, such data can be used by decision makers or analysts to derive comparative performance scores. On this basis, scales are constructed to represent and measure preferences for the consequences of a project against both qualitative and qualitative criteria. A typical performance scale may be a likert scale, adopting a fixed choice response format. For example, where a decision maker is asked to score the consequences of a project against a particular criteria using a scale ranging from 1 – 3, 1 would represent poor performance, 2 average performance, and 3 good performance. However, the preference scales derived in this manner still cannot be combined because a unit of preference for one criterion does not necessarily equate to a unit of preference for another. Equating the units of preference is equivalent to judging the relative importance of the scales, so with the right weighting procedure, the process becomes meaningful to those making the judgements. Again a Likert Scale can be employed, for example, with a range from 1-3 with 1 representing an unimportant criteria, 2 a moderately important criteria, and 3 a very important

[5] This matrix sets out how each of the options being appraised performs on each of the criteria that form part of the analysis.

criteria. A variation on this is the use of 'swing weighting' which is a common approach applied to MCA (OMEGA, 2011) and requires the decision maker to rank the relative importance of the 'swing' or change from the least-preferred to most preferred value for each criteria.

Once scores and weights have been derived, these need to be combined through the use of mathematical functions. These may range from 'simple linear additive evaluation models' which involve the multiplication of the value score on each criterion by the weight of that criterion, and then adding all those weighted scores together, through to more complex functions, based upon Multi- Attribute Utility Theory (MAUT), Linear Programming and Analytical Hierarchy Processes (DCLG, 2009).

2.3.8 Decision/performance matrix and accompanying processes

A standard feature of most MCAs is the performance matrix - sometimes referred to as the consequence table (DCLG, 2009). The matrix is typically presented as a table laid out in such a way that each row describes an option for decision-making, and each column describes the performance, according to the outputs, outcomes and impacts, of each option against a set of criteria. In a basic MCA framework the performance matrix may be the end product of the analysis, where decision-makers are left with the task of assessing the extent to which their objectives are met by the entries in the matrix. More advanced applications of MCA include scoring and weighting to arrive at a ranking of options using the methods alluded to above. Formally, a decision matrix (see Figure 1) can be defined as an (M × N) matrix in which element 'aij' indicates the performance of alternative 'Ai' when it is evaluated in terms of decision criterion 'Cj,' (for i =1,2,3,..., M, and j = 1,2,3,..., N). A decision maker determines the weights of relative performance of the decision criteria (denoted as Wj, for j = 1,2,3,..., N) and these are recorded in the decision matrix.

	Criteria				
	C_1	C_2	C_3	...	C_N
Alt.	W_1	W_2	W_3	...	W_N
A_1	a_{11}	a_{12}	a_{13}	...	a_{1N}
A_2	a_{21}	a_{22}	a_{23}	...	a_{2N}
A_3	a_{31}	a_{32}	a_{33}	...	a_{3N}
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
A_M	a_{M1}	a_{M2}	a_{M3}	...	a_{MN}

Figure 1: An MCA decision matrix (source: Triantaphyllou *et al.*, 1998)

2.3.9 Temporal dimensions of MCA frameworks

Although few of the MCA frameworks reviewed for this publication made explicit mention of the temporal dimension of decision-making, it appeared that the majority of models examined that were conducted for *ex-ante* (project appraisal) decision-making. It is unclear from the literature reviewed, however, how the temporal nature of project appraisal is considered in the examples reviewed with the result that it is here assumed that the criteria employed represented measures of aggregated performance over the entire project lifecycle, rather than any particular part of a project life cycle. This is an important distinction, which may need to be made explicit in the MCA exercise as the

performance of a particular option during different phases of the project lifecycle may require a significantly different set of objectives and criteria. Clarity in assessing temporal impacts of a project are particularly important if they are to help decision-makers prescribe weightings to differentiate between short term high impact events, and long term high impact events for example. However, such distinctions will be stakeholder dependent, for example, measures of aggregate performance over the entire project lifecycle might be the key criterion for a public policy analysts but less so in investment appraisal for some other key stakeholders who employ more immediate horizon dates as a basis for examining project viability.

OMEGA Centre work in the field of MCA applications to the appraisal of major infrastructure investments (see Dimitriou et al., 2010; OMEGA Centre, 2014) advocate that such frameworks be more flexible and applicable to multiple phases of the project life cycle. This is advocated so they can act as design, appraisal *and* monitoring platforms for action when undertaken at particular stages in the project life cycle. As earlier explained, this monograph focuses particularly on the use of MCA at the appraisal stage of the project lifecycle, albeit that the outcome of this phase has fundamental implications for all subsequent stages.

2.4 Review of selected frameworks for megaproject developments

Reflecting the findings of Paper 1, a review of the MCA literature here reveals that there is no 'best' MCA framework and attendant processes for application to the appraisal of projects. This is because each framework builds upon the generic MCA characteristics as outlined above *but* with a particular decision-making context in mind. In this sense, each framework plus attendant processes presents its own set of unique advantages and drawbacks within its own particular contextual setting. To further elaborate MCA methods may be used to:

- **identify a single most preferred option** to distinguish between 'acceptable' from 'unacceptable' possibilities or
- **produce a list of options for subsequent detailed appraisal** and possibly, in addition, to be employed as a risk analysis register/tool, as in the case of the OMEGA-RAMP Study outlined in Section 2.4.2 (Dimitriou *et al.,* 2010) MCA also has a role as a risk analysis tool.

2.4.1 Multi-actor methods

Because of its above-described generic features it is evident that MCA is particularly relevant and valuable within 'open' and transparent decision-making processes. To be further strengthened, however, MCA can (and should) be tailored towards a specific context, facilitating the engagement of project sponsors and investors with other stakeholders, including community groups, so as to provide valuable inputs into project design and appraisal (see Paper 3). This is especially advocated since it allows decisions to be formed (and made) based on consensus and compromise among a plurality of actors, ideas, interests, and priorities (Banville et al., 1998; Munda, 2004; Stagl, 2007, Stirling, 2006; De Brucker et al., 2011). Research has shown that meaningful engagement with project stakeholders can have a number of important beneficial outcomes including enhanced risk management (Stirling, 1999; OMEGA, 2011), especially if embarked upon in the earliest phases of project development (OMEGA Centre, 2012).

Several MCA methods capable of implementation in more participatory contexts have been developed. These include: the Novel Approach to Imprecise Assessment and Decision Environments (NAIADE) method (Munda, 1995); the Integrated Assessment of Decisions Under Uncertainty for Sustainable Development (IANUS) method (Klauer et al., 2002); the Analytical Hierarchy Process (AHP) method (Saaty, 1980); the Three-stage MCA (TSMCA) method (Renn at al., 1993); the ELimination Et Choix Traduisant la REalité (ELECTRE) method (Norese, 2002); the Multi-Criteria Mapping (MCM) Technique (Stirling and Mayer, 1999); the Multi-Criteria Model Analysis (MCMA) method (Macharis, 2000 and 2005) and hybrid techniques integrating MCA and other participatory methods (see Antunes et al., 2006 2006; Antunes et al., 2012).

As earlier argued, when MCA methods are employed to identify a ranking or 'single most preferred' solution from a choice of possible options, generally, the main outputs from the decision-making process are plotted onto a single performance matrix. A number of other techniques - such as the Multi Criteria Mapping (MCM) and Multi Criteria Multi Actor (MCMA) methods - are more oriented toward the provision of plural and conditional advice, rather than the determination of the 'best' solution. In this sense, they are more akin to the substantive rational model for public engagement highlighted by Morgan (2004). Both the MCM and MCMA methodologies make explicit the viewpoints taken by the different stakeholders and (most importantly) allow them to freely develop their own appraisal criteria, define their own additional options, and perform their own assessment. The goals of such appraisal projects are seen in this sense to be more inclined towards the normative and substantive schools of public participation and most suited to MTPs.

The MCMA method comprises seven iterative steps (see Figure 2). The first four, that of problem definition (step 1), stakeholder identification (step 2), determination of objectives and related appraisal criteria of each stakeholder, as well as the ascription of the relative importance (weights) to each criterion (step 3), and the construction of opportune indicators for each criterion (step 4) are mainly 'analytical'. They precede the 'overall analysis' consisting in the elaboration of plausible alternative options (step 5), the ranking of them (step 6) and finally in the analysis of the outcome of the process (step 7) which may entail an effective implementation of these results (Macharis, 2000 and 2005, 2013).

In comparison, MCM is based on a long interview (2-3 hours) with each stakeholder (represented as either an individual or a group) participating in four stages: choosing options (stage 1), developing a set of project appraisal criteria (stage 2), scoring the option against each criterion (stage 3) and ascribing weights to the criteria (stage 4). Similar to MCMA, the process of MCM is iterative and allows the actors involved to return to a previous step *at any time* to make changes or additions until they are completely satisfied with their input to the process (see Figure 3). However, unlike other MCA processes, MCM is driven by the stakeholders themselves. So criteria definition, scoring, and weighting are all decided on/agreed by the stakeholders. This makes it a reflexive, as well as iterative process.

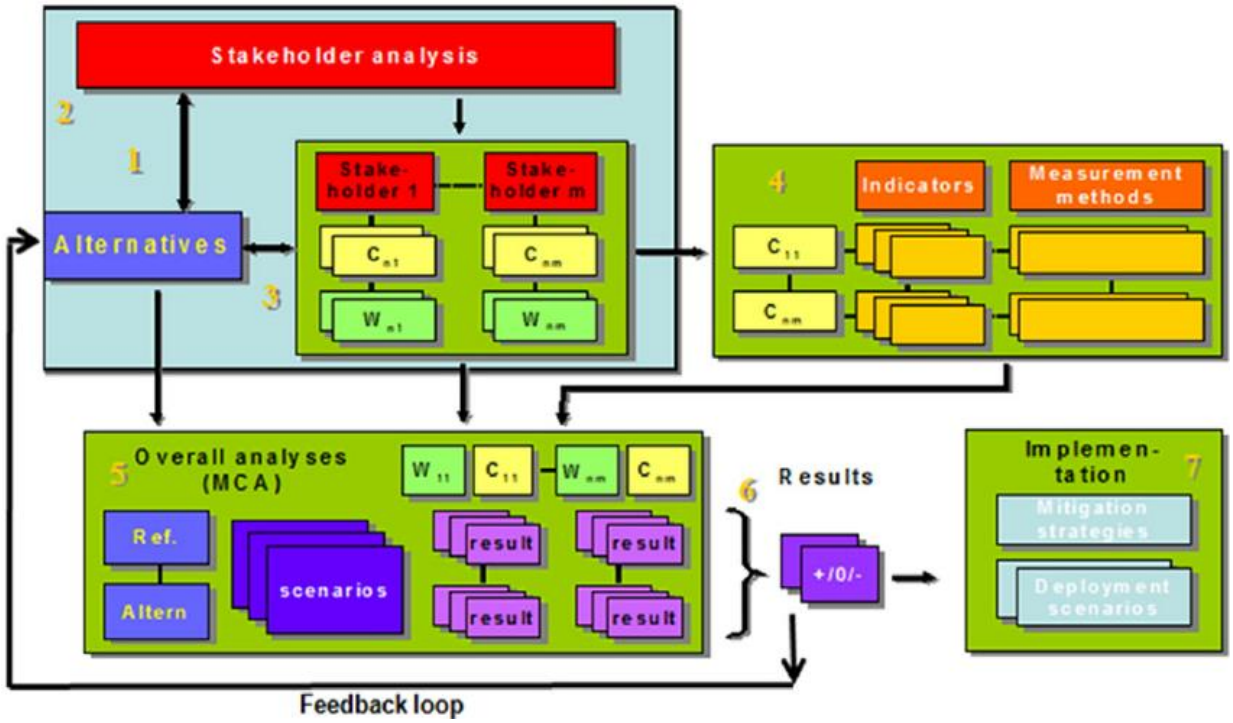

Figure 2: MAMCA methodology (Source: Macharis, 2007)

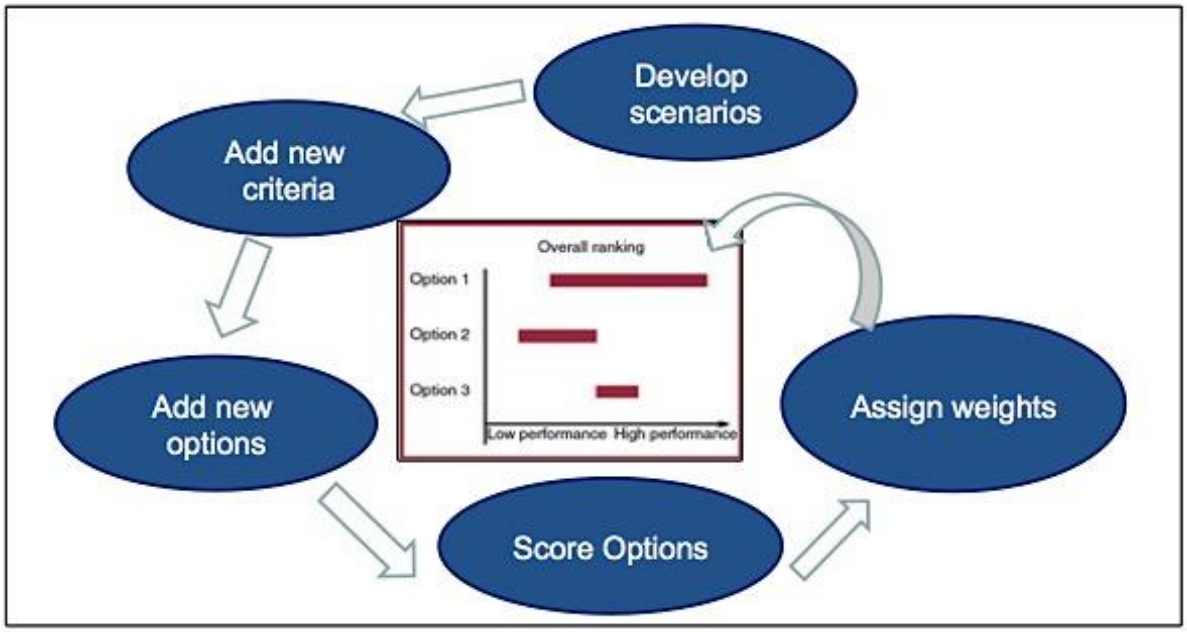

Figure 3: The MCM process (Source: http://www.multicriteria-mapping.org)

MCA frameworks (and attendant processes) for multi-actor participation are deemed particularly useful for the appraisal of mega infrastructure projects. This was noted in light of the findings of the OMEGA 2 Project (OMEGA Centre, 2012) discussed earlier both in Paper 1 and in Section 2.1 which highlight the importance of engaging with key megaproject stakeholders, particularly within

the early stages of the development process. An approach of this kind offers important opportunities to better manage/mitigate risk, uncertainty and complexity in project developments, and more specifically, to assist in the adjustment of project objectives to address manifold contextual influences impacting on the project such as those spawned by policy changes.

2.4.2 Importance of risk, uncertainty, complexity and context

As earlier alluded to, a number of infrastructure researchers and practitioners have highlighted the importance of risk, uncertainty and complexity within the megaproject decision-making. Apart from the work of the OMEGA Centre earlier cited in this paper and Paper 1, these include Flyvbjerg *et al.*, 2003; and Priemus *et al.*, 2013). It should be noted that although certain frameworks have been developed to deal with risk and uncertainty in decision-making more generally - such as those promoted by Montibeller *et al*.,(2007) and Stewart *et al.*, (2012). Of the MCA approaches reviewed, only the MCM method developed by Stirling (1999) and the OMEGA-RAMP MCA (OMEGA 3 Project) developed by the OMEGA Centre (Dimitriou *et al.*, 2010) attempted to present a typology of risks and uncertainties explicitly within the decision-making process to make the appraisal process more robust.

The MCM framework advocated by Stirling (1999) both captures and maps the risks and uncertainties related to appraisal judgments made for each option. Here stakeholders are asked to assign different scores (optimistic [high] pessimistic [low]) to *every* alternative under each criterion. Figure 4 refers to the application of MCM to the appraisal of seven competing hydrogen technologies. It illustrates the results of the appraisal exercise undertaken by two stakeholder groups, namely a nuclear industry expert and a carbon trust analyst. The length of each bar represents the uncertainty attached to each score and in this case indicates that the scores ascribed by the carbon trust analyst to each option have a higher degree of uncertainty than those assigned by the nuclear industry expert. From this illustration, it may be appreciated that MCM captures the level of uncertainty a particular stakeholder would ascribe to the performance of each option against his set of defined criteria. However, the underlying sources of risk and related uncertainty plus the contribution of each source to the overall range of scores for each criterion, whilst explicitly captured within the framework as qualitative data, are not presented as top tier information within the data tables.

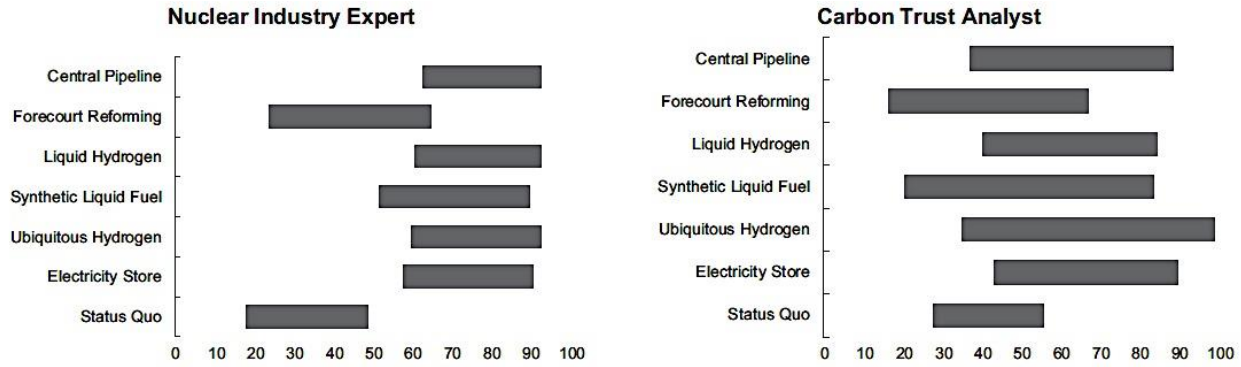

Figure 4: Example of outputs from the MCM process (source: McDowall and Eames, 2007)

The OMEGA-RAMP MCA developed by the OMEGA Centre between 2008 and 2010 (referred to elsewhere as the OMEGA 3 Project) (Dimitriou *et al*., 2010) - sought to overcome some of the more serious limitations identified by the adoption of monetary values for such dimensions as required by CBA. As part of efforts to better incorporate environmental, social and institutional dimensions of sustainable development (alongside economic and financial) within the RAMP[6] handbook, the main features of this approach was a framework and attendant processes providing a performance matrix (see Figure 5) that it includes the potential for it to also act as a risk register. This register can report on quantifiable and non-quantifiable risks associated with the performance of a given project option against each appraisal criterion, along with information on the qualitative and quantitative impacts of that option.

Building on the strategic framework for managing project risk and its financial implications outlined in the RAMP Handbook (ibid, 2005), the OMEGA-RAMP MCA method introduced scoring procedures based on the project's ability to achieve desired ends, measured against carefully selected appraisal criteria. It introduced scoring procedures based on the proposed level of mitigation required to reduce the identified risks, on the other. The overall appraisal score of any alternative option against each project criterion is derived from a combination of the assessment of project evidence (considering outputs, outcomes and impacts) and risk assessment scores.

Option 1						
Criteria		**Impacts**			**Scoring**	
Criteria	Sub- criteria	Qualitative Impacts	Quantitative Impacts	Risks	Impact Assessment	RISK Assessment
Criteria 1	Criteria 1.1	Qualitative Description	Quant Description	Risk Description	Score	Score
	Criteria 1.2	Qualitative Description	Quant Description	Risk Description	Score	Score
Criteria 2	Criteria 2.1	Qualitative Description	Quant Description	Risk Description	Score	Score
	Criteria 2.2	Qualitative Description	Quant Description	Risk Description	Score	Score

Figure 5: Example of the OMEGA-RAMP MCA matrix

Concerning the importance of context, although generic MCA methods acknowledge in their narrative the power of context on decision-making early within the analysis, few explicitly and fully explore the full (temporal, geographic, cultural, economic etc.) dimensions of context and their implications on decision-making. This issue is of particular pertinence when considering whether one employs more 'open' or 'closed' systems thinking (of the kind alluded to in the Editorial and cited in Paper 1) when entertaining major investment responses to complex and dynamic infrastructure challenges. Drawing from the findings of both the OMEGA 1 Project and the OMEGA 2 Project (Dimitriou *et al*., 2008; OMEGA Centre, 2012, respectively), the authors consider that The *Cynefin* Framework developed by Kurtz and Snowden (2003) offers much promise in such circumstances as a framework for framing the MCA project appraisal exercise. The framework (see Figure 6) identifies four domains, each corresponding to different forms of relationships between cause and effect (of identified problems); namely: the known; the knowable, the complex, and the chaotic.

[6] 'Risk Analysis and Management for Projects procedures' handbook advocated by UK Institution of Civil Engineers (ICE) and Actuary Profession (AP) (ICE and AP, 2005)

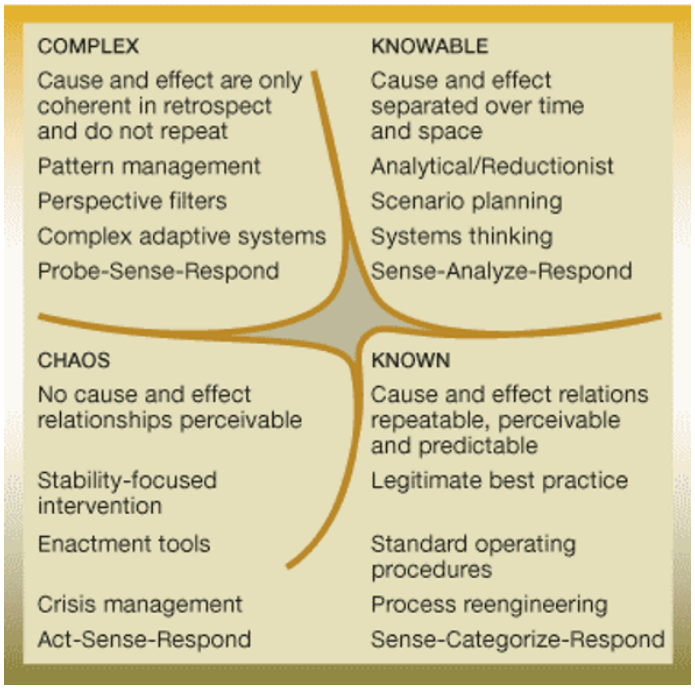

Figure 6: The *Cynefin* Framework (Source: Kurtz and Snowden, 2003)

The first two domains represent the 'order' in a system, while the latter two domains represent the 'un-order' (dis-order'). Each has its own distinct characteristics, analytical methods, diagnostic methods, intervention approaches, and set of supporting tools and technologies. In the 'known' space, the relationships between cause and effect are fairly well established and consequently a traditional method of analysis based on a 'predict-and-control' approach may be used. In the 'knowable' space, however, more analyses are required *before* the consequences of any action may be predicted with any certainty. Conversely, in the 'complex' space, there is no real possibility to rely on quantitative methods to model the relations between cause and effects. In this space, informal qualitative models (such as scenario planning) prove most relevant. It should be finally noted that events embedded in the 'chaotic' space cannot be analysed by any method. Stewart (2013) suggests that such decision-making can be characterized as 'act-sense-respond' or more prosaically as 'trial and error.'

2.4.3 Scenario planning, resilience testing and strategic thinking

Addressing uncertainties and risks in megaproject delivery has been a challenge long recognised in the project management field with authors such as Chapman and Ward (2011) articulating and responding to many of the issues involved. These perspectives, however, as earlier explained in Paper 1 very much focus on uncertainties and risks that arise *within* the project and/or toward the delivery end of megaprojects. Much less attention has been paid to risks and uncertainties that arise *outside* of the project within decision-making environments that impact such projects.

This is despite the seminal work of Hall in his book entitled *Great Planning Disasters* (1980) and the much earlier work of Friend and Jessop (1969) from which Hall drew extensively in his 1980 publication. Both publications highlighted the risks and uncertainties concerning strategic decision-making with their origins *outside* projects (from within policies and broader development contexts)

affecting the decision-making. Friend and Jessop argued that it is critical that these 'external' dimensions also be incorporated in the planning of major projects *if* their decision-making is to be made more robust to changing decision-making environments and thus strategic. They identified three types of such uncertainties; namely (ibid, 1969:5):

- **uncertainties about the relevant planning environment (UE)**, i.e., everything outside the immediate decision-making system (of the project);
- **uncertainties about decisions in related decision areas (UR)**, including decisions that are within the decision-making system but related to areas of discretion beyond the immediate problematic addressed by the project; and
- **uncertainties about value junctions (UV)**, which includes all the problems where information has been assembled, but where the final decision turns upon questions of value.

Building on the above, Dimitriou and Thompson (2007) and the OMEGA Centre (2011), in the context of regional planning and megaproject infrastructure planning respectively, present the case that for strategic decision-making to incorporate effective risk analysis it needs to also draw on the expertise of scenario planning (see later discussion), particularly when employing MCA for megaproject appraisal. This is argued on grounds that project appraisers are inevitably required (to some degree at least) to consider the different risks, uncertainties and opportunities spawned by different scenarios.[7] If so designed, MCA can highlight the various resource constraints and opportunities that each scenario might offer to mitigate the identified risks and uncertainties (see later discussion). In this way, MCA (linked to scenario planning) can yield numerous attendant processes by which MCA and scenario planning can be combined to cope with the many uncertainties and risk that arise in both short-term and long term strategic decision-making contexts (Priemus *et al*., 2008).

It can be argued that by asking stakeholders in a MCA exercise to ascribe positive, neutral or negative scores for each criteria, in effect requires respondents to assess the performances of the alternatives under a scenario, most likely the 'business usual' scenario, although in this context the concept of 'scenario(s)' remain implicit within the process rather than explicit. There are, however, other examples of MCA methods that make greater explicit use of the notion of scenario as in the case of Montibeller *et al*., 2007 and Stewart *et al*., 2012. In either case, this growing interest in the link between MCA and scenario planning, as well as scenario building, has an acknowledged complementary role of encouraging not only more robust decision-making but also more holistic decision-making for both planning and appraisal exercises.

Scenario planning is a proven method which helps decision makers to take a long view on the future and to test and understand the robustness of decisions that need to be taken now according to alternative futures. Scenario planning does not include option appraisal phases (Stewart, 1997; Goodwin and Wright, 2001; Stewart et al., 2013) whilst MCA allows the appraisal of options to take into account decision-makers' multiple (and often conflicting) objectives, although usually for a single scenario. Thus, the integrated use of scenario-building and MCA can create potentially a powerful combination for supporting strategic decisions for projects (especially MTPs) that allow

[7] Here a scenario is defined as a *"plausible description of the exogenous (economic, social, environmental, political and technological) conditions in a possible and probable future with attention to timing"* (Rehfeldx, 1998: 3).

the appraisal of options not only against different criteria but also under different possible future states of the world.

Methods aiming to integrate MCA and scenario-building entail modification of scores, weights and criteria under each scenario identified. Hence, for example, given a defined set of scenarios, the framework proposed by Goodwin and Wright (2001) implies only a change in the scoring of each alternative under the different scenarios, while the relative importance (weights) of each criterion remains the same in every scenario. This would produce results similar to the multi-criteria mapping (MCM) method adopted by Sterling (1996). By comparison, Belton and Stewart (2002) and Lambert *et al.*, (2012) propose a shift in the weights of the criteria. Both sets of authors assume that the performances of each alternative will remain constant under different scenarios but that the relative importance of each criterion will change. Montibeller *et al.*, (2007) go further and hypothesize the adoption of various criteria under each scenario. Thus, under this method, given a number of options to assess, this framework entails the creation of a completely different model under each scenario. In each scenario, a different set of criteria may be listed. Scores and weights used in one model are thus independent from those adopted in the others.

The key difference between the three MCA approaches outlined above with scenario building is summarised in Figure 7 below. Whereas the suggested approaches of Goodwin and Wright (2011) and Lambert *et al* (2012) leave the objectives and criteria intact, and enable the methodology to be used to test for 'option robustness' against a range of scenarios, Montibeller *et al.,'s* (2007) recommendation to tailor the objectives and criteria to a particular scenario reduces the frameworks utility for direct comparison of options across a range of scenarios.

FRAMEWORK	**CHANGES**			**PRACTICAL APPLICATION**		
	Objective/ criteria (Ob)	Weights (W)	Scores (S)	Scenario *i*	Scenario *j*	Scenario *k*
Goodwin and Wright (2001)	-	-	X	Ob W S_i	Ob W S_j	Ob W S_k
Lambert *et al.* (2012)	-	X	-	Ob W_i S	Ob W_j S	Ob W_k S
Montibeller *et al.* (2007)	X	X	X	Ob_i W_i S_i	Ob_j W_j S_j	Ob_k W_k S_k

Figure 7: Comparison between the different frameworks aiming at integrating MCA and Scenario-Building

2.4.4 Sustainability criteria, policy leadership and the HalSTAR wheel

While the complexity of MCA undoubtedly increases with the number of stakeholders involved in project appraisal, this complexity is further compounded when such exercises are also required to adhere to policies, aims and targets of the multiple dimensions plus inter-generational issues of sustainable development. Here, MCA has been deemed by a number of parties (see Munda *1995, 1998*; Omann, 2004) to be particularly useful in its potential capability to simultaneously not only address challenges posed by multiple stakeholder interests but also by the various social, environmental, economic and institutional aspects of sustainability.

In the efforts of the OMEGA 3 Project alluded to earlier (Dimitriou *et al*., 2010) to ensure that the selected criteria for megaproject appraisal capture adequately multiple sustainable development concerns, an adapted use of the HalSTAR Wheel was advocated (See paper 1). This model, originally developed by Halcrows (a UK international consultancy firm engaged extensively in infrastructure projects) sought to provide a common framework to assess and manage sustainability, integrated with a generic decision support method (Pearce, 2008). The revisions incorporated for the OMEGA 3 project were undertaken to better reflect the OMEGA Centre's framing of its then on-going research in decision-making in the planning, appraisal and delivery of MTPs.

Of particular note in this framing is the treatment of the attribution of weights to different appraisal criteria. This was done by advocating that the role (and choice) of policy directives and associated visions employed to prioritise criteria (both explicitly and implicitly) should be critical to policy makers and project appraisers alike in determining which criteria matter more (when, where and why); and in deciding to what degree market forces should influence such prioritisation. This position was accompanied by an equally important normative stance that such prioritisation should also be transparent. Acknowledging the fluidity of policy positions and societal values over time that impact on decision-making about and perceptions of project 'success' attested by Friend and Jessop (1969) and Hall (1980), such transparency offers a better platform for stakeholder accountability and providing a clear trail of changes in policy stances and related prioritisation of project appraisal criteria. Although this methodological stance on policy leadership was not part of the finally recommended OMEGA-RAMP MCA development work, the inspiration for it and its later use firmly had its roots in this work. The link between policy directives and MCA will be more firmly established in Section 2.6.3 of this paper.

2.5 Reflections on MCA applications to megaproject appraisal

2.5.1 The relationship of MCA to CBA

As earlier indicated in Paper 2, a number of institutions of late, including global lending institutions such as the World Bank, the Asia Development Bank and the European Investment Bank, have undertaken partial revisions of their project appraisal methodologies and in so doing have moved closer towards the application of multi-criteria approaches (see Véron-Okamoto and Sakamoto, 2014; OMEGA Centre, 2014). However, having achieved this modest level of recognition as a potential suitable method for addressing complex decision-making of the kind confronted by major infrastructure projects, it should be emphasised that MCA is not a *panacea* for addressing all the appraisal challenges confronted by such projects. It is furthermore, not a guarantee that a more holistic appraisal outcome will be arrived at. An explanation of why this is so ensues.

When MCA is employed in a manner similar to many CBA exercises (i.e., as an attempt by a group of analysts cum 'experts' to *in effect* appraise a single potential 'right' answer to a complex problem), this has inevitably raised questions regarding the lack of transparency and objectivity employed. A number of authors, in particular D'Este (1988), Stirling (1999) and BTE (1999) have, furthermore, highlighted the fact that MCA can often be biased towards the viewpoint of the agency co-ordinating/overseeing the appraisal. Subsequently, when such bodies commission appraisal exercises, it should be appreciated that this request can frequently be confined (by design and/or intent) to a narrow scoping of one option or a cluster of similar options around the same 'solution'. Another critical observation to bear in mind regarding MCA is that whereas those undertaking CBA

exercises are obliged (at least in the narrative) to include or represent the costs and benefits of a particular project to *all* stakeholders 'with standing', no such stipulation appears to be required of MCA.

By illustration, the UK Government's New Approach to Transport Appraisal (NATA)(DfT, 2007), underpinning the DfT's WebTAG methodology for appraising transport plans and projects, adopts a form of MCA where all 'project impacts' are *ostensibly* set (and judged) against five key objectives derived from a UK Department of Transport policy document entitled *Delivering a Sustainable Transport System* (DfT, 2008). These objectives are defined in a manner whereby, it is claimed, they take into account a project's impacts in terms of both monetary values, and non-monetary assessments. The former (the monetary values) include travel time savings, the latter (the non-monetary assessments) include social and environmental impacts such as noise and blight, which may be quantified but not adequately valued or assessed in monetary terms.

A more critical examination of the NATA approach and its DfT derivatives reveals that whilst it introduces a level of compatibility between all MCAs undertaken for transport projects within the UK employing this method, it most significantly avoids advising on the weightings that should be assigned to different criteria in the spirit of any normative decision-making. Instead, for the sake of ease of operationalization of the MCA model, the default policy embedded within the NATA approach encourages a prioritisation of appraisal criteria that ultimately gives priority to traditional criteria employed by transport specialists, in particular, monetized travel-time savings. The approach, in other words, addresses social and environmental concerns (and institutional matters) very much as secondary to those criteria that matter most to the Department for Transport which has as its mandate the optimisation of the operational efficiency and capacity of its transport infrastructure investments under its watch. As a consequence, under closer scrutiny, the much applauded NATA approach inevitably raises questions of ambiguity and value assessments as well as accusations of stakeholder bias toward the concerns and interests of today's transport economic priorities. Left unchecked and unchallenged, these weaknesses of the NATA process (and others like it) can greatly erode the credibility of MCA by not being transparent about the policy guidance and related priorities it employs.

In a different way, but also somewhat disappointingly, the claimed extensive use of MCA during the 1980s and 1990s (and beyond) in France by its government for MTPs, including TGV projects, was progressively abandoned on account of the fact that the appraisal weightings employed allegedly were not formally allocated in either a satisfying or transparent way (Jessop et al., 2003). In the case of the TGV projects, the rational for their support and justification drew heavily on urban regeneration and regional development policies and budgets for the areas they served and traversed, plus national transportation objectives and related budgets made available by the French Ministry of Transport nationally. In these terms, such fast train projects were in fact justified on a multi-criteria basis with transport economic criteria representing *only* one (albeit very important) dimension of the appraisal exercise. The failure, however, to make this appraisal process more transparent and (some would say) systematic, together with subsequent pressures exerted by the European Commission (EC) and private sector investors to provide more clear monetised assessments of the costs and rates of return involved (see Boiteux, 1996) ultimately led to the French Government abandoning its earlier broader approach to major transport infrastructure appraisal. Instead, it was obliged (at least formally) to comply with market-led appraisal approaches supported by more stringent CBA guidance of the kind most recently published by the

European Commission in its CBA Handbook (EC, 2014). What the above account highlights, as do other contributions to this monograph, is the significance of understanding the role of policy leadership of MCA exercises that ultimately sets the prioritisation of competing policies and the appraisal criteria adopted. It also emphasises the importance of clarifying the relationship between CBA and MCA as appraisal methods; in particular, deciding from the outset whether MCA is to be employed to *inform* CBA or whether CBA is to be a tool to be used *within* a MCA exercise. OMEGA Centre research findings have concluded on several occasions (see Dimitriou *et al*., 2010; OMEGA Centre, 2012; 2014) that MCA is better suited to the role of providing an overarching appraisal method for MTPs, informed by CBA in tandem with other appraisal tools as appropriate. Either way, it is evident from the literature reviews and research undertaken that there is an important requirement to ensure a two-way flow of information between developments in the two methodologies. The same sources reveal that for certain project stakeholders MCA has potentially two important roles to play in MTP appraisal. Firstly, in terms of informing investors of appraisal risks (and opportunities) *not* typically shown on the radar screens of CBA (i.e., acting as a form of 'risk/opportunity register') and secondly, as an aid to identify project interdependencies of both a monetised and non-monetised nature that would otherwise *not* be identified by CBA.

2.5.2 Public consultation, participation, governance and MCA

The frequently awkward relationship between public consultation and participation and the project appraisal process observed for megaprojects (particularly MTPs) has already been alluded to in Paper 1. Findings of the OMEGA Centre (2011) reveal that early engagement with key stakeholders is critical in dealing effectively with risk, uncertainty and complexity in megaproject developments. The 'opening up' of the appraisal process to a plurality of voices and corresponding lines of arguments (requiring the building of relationships with key project stakeholders beyond the investors), however, is not comfortably accommodated by CBA. This is despite the fact that consultation and participation has been found to facilitate a deeper and more accurate problem analysis for projects, as well as help the establishment of trust, credibility and transparency; all critical to creating consensus in MTP decision-making. It is evident, furthermore, that when MCA is conducted in a participatory manner, it has the potential to become a powerful and flexible decision-aiding tool which can in the long run reduce project delays and thus costs (Fischer, 1993; Fineberg et. al, 1996; Fiorino, 1990; Kliger and Rempling, 2015).

Despite the above arguments, it needs to be understood that public participation and/or consultation are not in themselves sufficient to deliver transparency and accountability (Munda, 2004). In this regard, for example, allowing stakeholders to freely ascribe scores and weights to options and criteria does not solve completely the problem of bias and subjectivity in the scoring and weighting procedures alluded to earlier (BTE, 1999; Dobes and Bennett, 2009; Macharis and Nijkamp, 2011). Consequently, compensatory effects can occur whereby exceptional performance of an option against one criterion can hide very poor performance against another, leading to an acceptably high overall ranking whereas in practice the option is non-viable. In extreme cases, certain 'no-go' thresholds can be introduced to criteria which negate the option, regardless of its positive performance against other criteria. Several authors have tried to establish mathematical functions for combining scores and weights together limiting compensatory effects but with limited success.

These procedures for aggregations have become increasingly complex and excessively difficult to explain to a non-technical stakeholder and have sometimes even been locked within proprietary

software. This has drastically reduced the transparency of analysis conducted in this way. It is clear from these experiences, particularly during the allocation of weights assigned in accordance with guidance/intervention provided by an overarching body capable of assuring the clarity and regularity of the whole procedure, that such arrangements are more likely to keep in check the prioritisation of criteria in line with pre-agreed policies and regulations.

Building on these conclusions, the authors contend that any ambiguity and consequent possible conflicts between stakeholders are more likely to be successively overcome, if, a MCA exercise is policy-led as opposed to being principally concerned with economic efficiency concerns. This is argued on account of broader priorities in such instances being better integrated within the overall government strategy and related decision-making process being in place, reinforced by international policy guidance and targets where appropriate (Dimitriou *et al.,* 2010).

This position is consistent with other OMEGA Centre research findings that suggest only when major infrastructure projects are accompanied by a suitable and sustainable institutional, policy and legislative framework throughout their project lifecycle can they deliver the full range of 'agent of change' benefits envisaged (*ibid*, 2010). It subsequently seems reasonable to argue that where politicians are democratically elected and the policies they introduce have already been decided upon and disseminated, they should take some form of priority within the appraisal process. Notwithstanding this, the praxis of mega infrastructure planning encounters many situations when it is not always possible to identify a strong policy framework or policy leadership to address the main priorities of a megaproject, particularly over a sustained period. This is especially the case if the viability of the project is acknowledged sensitive to market force fluctuations and contain high levels of innovation, as is the case of many MTPs.

Despite the rhetoric of many governments and international development agencies, furthermore, sometimes policy statements and strategies inadequately identify important aspects of environmental or social impacts (preferring to be judged instead against market imperatives). The result is that any project deriving its objectives against such policy statements and strategies may well also inadequately cover these aspects. In such instances, it is the authors' opinion that MCA exercises can also be used as a method for generating policy recommendations (and/or precedents) and subsequently have them adhered to on the basis of an obligation of adherence, such as those set by the UK common law legal system. Building on many of the points earlier raised, the following section presents the case for the application of policy-led MCA (PLMCA) as an appraisal approach to mega infrastructure project appraisal more particularly for MTPs.

2.6 The OMEGA PLMCA method

2.6.1 Some key OMEGA 2 study's observations

The basics of the PLMCA framework and its attendant processes were developed during the OMEGA 3 Project (Dimitriou *et al.,* 2010). As earlier explained, this was designed to 'assist decision-makers to better understand holistically the nature and balance of factors involved in mega infrastructure project management' as part of ICE and AP's effort to update the latest edition of their RAMP Handbook (ICE and AP, 2014). Its particular emphasis was on better incorporating social and environmental aspects of sustainability and their attendant risks into the project appraisal process for major infrastructure projects. Since the initial conception of the PLMCA approach, it

was informed by the research findings of the OMEGA 2 Project which provided some intriguing insights believed to offer additional significant potential implications for the development of the approach. These are outlined in the discussion that follows and presented in the OMEGA 2 Project's Final Report (OMEGA Centre, 2012).

To recap, the OMEGA 2 Project entailed an extensive analysis of decision-making for 30 selected MTPs in 10 countries in the developed world, presenting amongst its many findings, nine sets of key lessons. These lessons are seen to greatly facilitate the achievement of more 'successful' project outcomes judged against broader and longer-term. As identified earlier in this and the preceding paper, in line with these arguments and those presented in other literature, these OMEGA 2 lessons assert that planning, appraisal and delivery of megaprojects should be framed in a more holistic manner in a way that extends its coverage of concern far beyond those of project management. This stance further argues that judgements about the 'success' of MTPs should abandon its essentially 'closed systems' analyses approach to project development which typically measures project 'success' in accordance with (iron-triangle) targets set for finishing projects on time, on cost and to specification. The broader policy-led framing of the planning and appraisal processes advocated by PLMCA, together with its acceptance that MTPs are far more than mere engineering artefacts (as impressive as they may be) are premised on the findings of another OMEGA 2 Project conclusion, namely that such projects are essentially 'organic phenomena.' They are structures that interact (and adapt) dynamically with the context(s) into which they are planned and ultimately constructed, spawning impacts that go far beyond the physical asset being delivered (OMEGA Centre, 2012).

To assure an adequate framing of such projects is adopted PLMCA advocates from the outset an examination of the dynamic interactions between the megaproject under study and the ever-changing context(s) in which it has been conceived and then developed. The approach further advocates the employment of a wide gamut of different appraisal criteria that are not biased by default to economic and financial outcomes, even though these are frequently fundamental to the economic viability of a project. As earlier explained, MCA, and PLMCA in particular, offer invaluable approaches to megaproject planning and appraisal to assist stakeholder decision-makers in handling complex information concerning a wide range of qualitative and quantitative criteria when making trade-offs between key objectives. PLMCA also permits, as earlier emphasised, a testing of the robustness of decisions taken against selected multiple scenarios. It, furthermore, acknowledges another OMEGA 2 Project finding, namely, that effective institutions play a pivotal role in setting and supervising the entire decision-making process throughout *all* stages of the project lifecycle. This, the authors contend, can only be achieved by the provision of adequate policy guidance and the positive implementation of a PLMCA approach employed in a manner that has its policies linked to a high level of commitment by government and key agencies involved in megaproject developments.

The nine main lessons extracted from the OMEGA 2 Study, alongside an explanation of how each of these have informed the development of the PLMCA framework and its attendant processes, are summarised in the Appendix to this paper. What ensues is an explanation of how these lessons can enrich the PLMCA approach, building on the OMEGA-RAMP Study findings referred to earlier.

2.6.2 PLMCA as an eclectic approach to megaproject appraisal

PLMCA for megaproject infrastructure appraisal as outlined here has been conceived as an eclectic method, incorporating different appraisal processes and tools that seek to assist project stakeholders to manage and shape (as best as they can) the dynamics of the interactions between the project and it's context. The discussion that follows outlines what are considered the generic features of a PLMCA approach suitable for the appraisal of MTPs, drawing extensively from the lessons derived from the OMEGA 2 Project. Given a key lesson from this source alludes to the importance of context awareness, rather than abiding by a ridged template of defined steps irrespective of context, the approach looks to rely on a flexible framework with a broad range of attendant processes that can be configured in a variety of ways depending on the challenges and problems encountered and contextual forces at play. In this sense, while the PLMCA approach is generic, the support processes and tools employed are much more tailor-made. Notwithstanding this, two key themes underlie a PLMCA approach. These are (as above): the importance and role of the policies guiding the planning and appraisal exercises and the need to acknowledge when the analysis should be in an 'opening-up mode' and when (and how) it is to be 'closed down' as in nears the commencement of implementation. These two important areas of concern are elaborated in the ensuing discussion immediately below.

2.6.3 Importance of policy leadership and strategy

The significance of policy-leadership to the project appraisal process within PLMCA has been alluded to on several occasions earlier in this paper. Numerous readings from a variety of sectors and disciplines highlight the fact that the effective management of risk, uncertainty and complexity in decision-making requires strategic thinking and that this in turn requires some form of adherence to policy guidance - often linked to a vision rather than economic and market forces alone (as important as these may be). Impressive infrastructure achievements (especially MTP developments) in Hong Kong, France and Japan attest to the success of such strategies. OMEGA 2 Project findings point to the conclusion that a failure to comply with a strategy in mega infrastructure investments is more likely to lead to incomplete, disconnected and ineffective projects - in the long run, at least. The key to drawing up such strategies as a means to manage adverse short-term pressures on megaproject developments with long-term aims is to identify which forces of change are in play that can/do detract from the long view. Following this, to then try to influence and/or harness these in a manner whereby some level of strategic consistency is maintained (Dimitriou and Thompson, 2007).

Evidence suggests the relationships between megaprojects, visions of development and broader spatial/sectoral planning frameworks are, however, frequently neither fully understood nor properly exploited (OMEGA Centre, 2012). As a result, some/many such projects (particularly MTPs) become serious victims of fluctuations of economic downturns and economic boom periods that can undermine the most meaningful of policies and programmes affecting the project, especially in relation to the pursuit of goals of 'sustainable development'. Failure to employ an overall strategy for major infrastructure developments can, furthermore, lead to missed opportunities for megaprojects to effect beneficial change and act as desired 'agents of change'. They can also contribute to a serious under-estimation of the negative impacts (both in the short-term and long run) where/when a broader and longer strategic view is not taken.

The second high-speed rail project in UK (HS2) is a case in point. By initially confining the project's planning and appraisal to a narrowly framed economic and engineering exercise that essentially considers 'iron-triangle' criteria, construction cost concerns plus projected benefit outcomes assessed largely in travel time savings, the initial presentation of the project failed to address multiple other strategic concerns of a spatial, institutional, environmental and social nature. These, added later in a rather *ad hoc* manner, include agglomeration impacts and 'agent of change' implications for national and regional development.

The above arguments reinforce earlier calls for the role of strategic decision-making within the megaproject development process, and the need to forge stronger links between policies, plans and project appraisal frameworks. By illustration, sustainable development frameworks generated and enforced internationally, nationally and locally provide an opportunity to act as guidelines for these efforts, accompanied and reinforced by appraisal and performance indicators plus enforcement legislation. Of those infrastructure specialists interviewed for the OMEGA 3 Project (Dimitriou *et al*, 2010), 69 per cent concurred with this position, supporting the view that public authorities need to set clear and firm policy priorities for the appraisal of environmental and social enhancements of major infrastructure projects. While PLMCA is (by definition) led by policy and offers the opportunity for such policy leadership, it should be understood that it is not enough to simply use appraisal to check compliance with policies and plans, much in the spirit of which EIA assessments are currently undertaken (ibid, 2010). Instead, there needs to be a symbiotic link established between policy-making, planning and the project appraisal processes, with adequate feedback loops provided as earlier advocated.

As a starting point to any PLMCA exercise, the various decision-making parties involved need to be aware that no decision takes place in a vacuum. There are always multiple contextual forces in play, potentially affecting decisions that need to be considered and responded to during the megaproject development process. There is, furthermore, an intricate set of limits, including those demarked by government policies, plans and guidelines, which decision-makers should take into account alongside their own project delivery priorities when choosing a specific course of action. These (alluded to above as policy guidance) effectively define 'the decision-making space' for the PLMCA exercise in which stakeholder trade-offs can occur (see Figure 8). In other words, policies promulgated in the course of time by governments (often in response to specific perceived problems), establish the boundaries of the mediation exercise undertaken during any multi-stakeholder appraisal process (Considine, 2005).

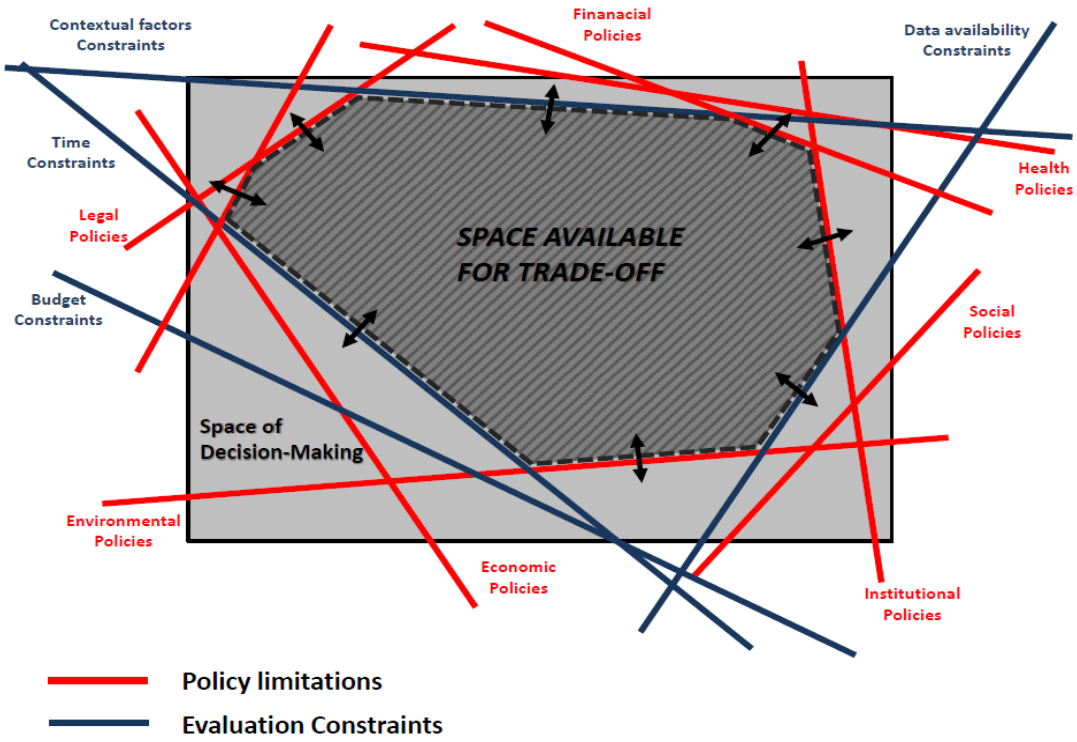

Figure 8: Policy constraints define the decision-making space for PLMCA (Source: Dimitriou, 2013)

At the beginning of the PLMCA process (see later discussion), along with stakeholder identification and analysis, as earlier alluded to on several occasions, the problem identification phase requires a deep scan of the policy context(s) of the decisions to be made and the (thematic and geographical) areas impacted by the project. This initially needs to be regarded as fundamental to fixing the 'non-negotiable areas' which the priorities of the different stakeholders groups have to confront. In this context, it needs to be appreciated by all parties concerned that some groups are asked to follow specific policy guidance in consideration of the role they have within society. This is particularly true for public sector entities which, differently from private sector interests, in the past (prior to the introduction of austerity measures) often possessed greater flexibility in pursuing their objectives given that the private sector's actions are ultimately oriented toward making a profit – preferably in the short run. These circumstances pose a number of constraints limiting what private sector parties can and cannot do when making strategic choices, especially in the long run. The identification of any prevailing hierarchy of public policies can also prove fundamental, especially in cases where such policies are in conflict with each other, and particularly in the weightings allocated to different appraisal criteria. Other considerations have to do with resource issues such as data availability and budget, as well as time and spatial constraints. These combine to further bound the decision-making space for PLMCA within which stakeholder trade-offs ultimately take place for appraising project options.

2.6.4 Opening up and closing down the analysis

Given that the findings of the OMEGA 2 Project concluded the best way to deal with emergent threats (and opportunities) to the success of MTPs during their planning and appraisal is to adopt an 'open systems' approach that focuses not only on the issues, problems and influences that occur

within the project but also those *external* to them. With this in mind, it is prudent to advocate a commensurate 'opening-up' of the decision-making process to a plurality of stakeholder agendas in these same phases. In so doing, a broader swath of potential challenges and issues can be identified (and ultimately addressed) and in consequence, the underlying potential common and conflicting values will be better understood. This in turn facilitates the consideration of different types of costs and benefits produced by alternatives and helps avoid the premature discarding of options (Stough and Rietveld, 1997; Bickerstaff et al., 2002; Miller and Lessard, 2008; Allport, 2011; Premius, 2012).

If at some stages of the decision-making process an 'opening-up' of the analysis of the problems and challenges the project is to address is deemed necessary to generate a more inclusive decision space that reflects a broader range of alternative options, then at some point, these options must correspondingly be 'closed down' or limited for the decision-making to proceed (Priemus, 2012; Salet, 2012; Salet *et al*., 2012). In this respect, these 'opening-up' and 'closing-down' processes should be considered as two fundamental and contrasting modes of analysis which are complementary rather than mutually exclusive (Stirling, 2006 and 2008). As earlier argued, by opening-up the analysis this facilitates strategic thinking and sense-making of the context of the appraisal exercise. This in turn helps the multiple project investors (and planners) become more aware of the various levels of risk, uncertainty and complexity presented in the decision-making space they have been left, allowing them then to select and deploy the tools and techniques appropriate for the particular circumstances.

This processes of 'opening-up' and 'closing-down' forms the backbone of the PLMCA framework. It is supported by an iterative and dynamic set of attendant procedures that have various grades of 'openness' (reflected in the different types and numbers of participants, different types of procedures to elicit scoring and weightings, and different treatments of uncertainty). These are provided according to the needs of each stage of the project lifecycle and level of importance of the issue/challenge under consideration. It should be stressed here that the proposed framework does not attempt to draw a rigid/fixed line of demarcation between the 'open' and the 'closed' phases of decision-making. Conversely, the framework accommodates the opportunity for re-opening the analysis as a monitoring and/or evaluation tool (after project implementation) in response to new contextual changes.

The above approach is consistent with the OMEGA Centre's perspective of viewing MTPS as 'organic phenomena' that frequently produce unintended and unexpected outcomes as part of a more general 'emergent order' (Kurtz and Snowden, 2003; OMEGA, 2011). It also complies with the notion that the continuous monitoring of the context of decision-making plus the subsequent adaptation of decisions to reflect new levels and types of uncertainty (and opportunity) enhances the robustness of project outcomes. This adaptation may be viewed as a product of the trade-offs made by project stakeholders in overcoming disagreements and/or compromising on different project priorities at the end of the PLMCA analysis before deciding on action. It is, as earlier emphasised, an iterative process embedded within the framework's attendant processes, permitting at one stage for the analysis to be 'closed-down' but allowing (following further iterations using the same or even different methodological responses) the 'opening-up' of the analysis for a subsequent decision-making stage. This process draws on multi-criteria assessments as a basis for the generation of feedback loops to inform further steps.

2.6.5 Conflicts, trade-offs and stakeholder perspectives

As already indicated, PLMCA highlights both areas of agreement between individual stakeholder policies and agendas as well as areas of conflict. Notwithstanding the advantages of employing an 'open-systems' approach of the kind advocated, stakeholder conflicts are too often erroneously viewed as threatening and potentially even destructive to an appraisal exercise. Contrary to this position, OMEGA 2 Project findings reveal that a certain level of divergence of priorities among different stakeholder groups can actually trigger a deeper and more thorough scrutiny of the initial concept of the project. This in turn, can lead to a possible redesign of some aspect(s) of the project, even a total re-positioning of the project if need be. In these terms, the friction generated by the multiplicity of perspectives may be seen to enhance outcomes rather than constrain them (De Brucker and Verbeke, 2007).

The above finding, to some degree, is reflective of the position forwarded by Surowiecki (2004) in his seminal book entitled *The Wisdom of Crowds*. Here Surowiecki convincingly argues (with the help of a number of examples) that in circumstances of high ambiguity and complexity a diverse group of stakeholders employing multiple perspectives is frequently capable of arriving at more appropriate 'solutions' than those provided by a few experts/specialists. Accordingly, in the case of MTPs, it is attested here that while it is possible to consider the more technical and engineering aspects of their construction as an almost exclusive domain for experts, other broader aspects and issues (including socio-political, environmental and institutional concerns) benefit greatly from a much higher degree of stakeholder participation that goes well beyond tokenistic consultation.

2.7 PLMCA: The framework and processes

The proposed generic PLMCA framework follows Belton and Stewarts' (2002) classification of MCA as a highly iterative three step (Steps A-C) process as illustrated by column 3 of Figure 9 below.

PLMCA FRAMEWORK STEPs	ACTORS INVOLVED IN PLMCA	THE PLMCA PROCESSES
STEP A: • Primary project analysis and problem structuring to establish the decision-making context	• Project team and project promoter (closed approach) • Project team and steering group (open approach)	• **STEP A1:** Problem definition (including issue analysis) • **STEP A2:** Design of PLMCA • **STEP A3:** Context analysis and Boundary definition • **STEP A4:** Option Identification • **STEP A5:** Policy analysis • **STEP A6:** Stakeholder identification • **STEP A7:** Scenario building
STEP B: • Model Building	• Project team and steering group (closed approach) • Project team and wider stakeholders (open approach)	• **STEP B1** - Formulation of objective/appraisal criteria (adopting an open or closed process) • **STEP B2** - Derivation of Weighting (adopting an open or closed process)
STEP C: • Module Use	• Project team and steering group (closed approach)	• **STEP C1** – Scoring (adopting an Open or closed process) • **STEP C2** - Further development of

	• Project team and wider stakeholders (open approach)	issues, objective/criteria, options, scenario (adopting an Open or closed process)

Figure 9: The three step PLMCA framework and attendant processes (Source: Adapted from Belton and Stewart, 2002)

As stated above, rather than being a ridged framework of defined steps, PLMCA comprises a framework of three steps supported by a broad range of processes configured according to the particular problem definition(s) employed and resulting attendant contextual forces.

2.7.1 STEP A: Problem structuring

The problem-structuring step is critical to the success of subsequent steps of PLMCA as a number of key decisions need to be taken at this stage. In broad terms, it comprises the following sub-steps (see below). The order in which these are performed and the level of iteration between them may vary according to the particular context in which the framework is being applied:

- **Step A1 – Problem Definition:** This entails clarification/specification of the appraisal problem in sufficient detail to enable its reasonable assessment. It includes definitions and elaborations of: the overall 'vision' of/for the appraisal, the appraisal's principal aims and objectives and its current status (e.g. whether it is already well-advanced/well-defined in design terms or at a preliminary stage).
- **Step A2 - Design of PLMCA:** This involves the development of the generic PLMCA structure into a tailor-made framework according to the decision-making context.
- **Step A3 - Context analysis and Boundary definition**: This entails the identification of the context of the decision-making space (political, legislative, spatial, temporal, cultural, etc.), including its overall 'boundaries' in time and space to assist its better understanding.
- **Step A4 - Option Identification:** This entails the identification of any possible options/alternatives to the project that may spawn different outcomes.
- **Step A5 - Policy Analysis:** This involves the identification of key policy drivers and their impacts on the project.
- **Step A6 – Stakeholder Identification:** This entails the identification of principal decision-makers and other key players – for both open and closed appraisals – as a basis for comprehending stakeholder trade-offs.
- **Step A7 - Scenario building:** This involves identification of the scenarios to be examined/applied and their different outcomes.

2.7.1.1 STEP A1: Problem definition

The starting point for any PLMCA exercise clearly has to be the decision by some decision-making entity (be it a person, organization or group) to make use of PLMCA for the appraisal of a complex, potentially risky major investment decision; in the context of the discussion here a MTP. For the purposes of this paper, this 'lead entity' is assumed the principal driver for undertaking a PLMCA appraisal process. It may later also be responsible for the implementation of the project, although not necessarily. The project's front-end decisions taken by the lead entity are critically important, as these will generally determine how the MTP's appraisal is to be conducted and subsequently what is built and delivered in terms of services.

The precise aims of PLMCA appraisal need to be made clear to all involved key stakeholders at the outset, as these will materially affect the nature of the down-stream decision-making processes. Some key questions that should be posed in this phase include:

- **Is the PLMCA exercise to be tailor-designed around particular problems or issues** (attracting a multiple-institutional response where ultimately an institutional leader or partnership emerges that impose its/their priorities) or should it be tailor-made for specific institutions with its imbedded hierarchy of policies and priorities that frame the MCA space within which outsiders are invited to trade of interests?
- **Does the PLMCA appraisal outcome represent a single solution to a known issue** or are there multiple options/alternatives that need to be examined that involve numerous issues? Is it, furthermore, an exercise that is merely used to inform other methods, for example as a form of 'risk register' for another appraisal method such as CBA, or does it instead provide a framework within which a multiplicity of other appraisal methods may be incorporated?
- **Is the PLMCA exercise to be employed primarily as a means to identify stakeholder positions and agendas** or to arrive at a particular decision, for example, concerning the ranking of project options or the overall level of risk a particular project presents to certain stakeholders?

2.7.1.2 STEP A2: Design of PLMCA

Of prime importance is the decision as to whether the PLMCA appraisal process is to be fully 'open' (i.e. involving all relevant external key stakeholders within the appraisal) or 'closed' to the extent that it is expected to involve only parties that represent those stakeholders with a common interest in pursuing a particular project or policy. It may well be the case that PLMCA is an iterative process, which starts out 'closed' but subsequently, becomes 'open' as more is understood about the decision-making context. Once reached, this decision will fundamentally affect the processes by which the appraisal is carried out, as explained further below.

In regard to a 'closed' PLMCA appraisal exercise, this may be undertaken/led by a particular interest group in a process akin to an analyst-led MCA. It, however, should be recognised that appraisals undertaken on an intra-agency/organisation basis are often impacted by the different standpoints and agendas that are held/taken by internal units. These may well reflect competing aims and objectives to the extent that the agency/organisation does not necessarily 'speak with one voice'. This suggests the need for very careful consideration by the lead stakeholder of whether and how an open or closed appraisal process is to be adopted. It also calls for the risks (and opportunities) associated with each type of approach to be fully explored. Moreover, as noted elsewhere, OMEGA 2 Project lessons suggest that the planning and appraisal of complex large-scale infrastructure projects should always employ 'open systems' in light of the multiple interrelationships with the territories such projects traverse and the sectors they serve. This is so, up to project implementation when by necessity the decision-making needs to be 'closed' for construction, only to be opened once again for monitoring and evaluation, post implementation.

In the case of a fully 'open' appraisal process, steps B and C (see Figure 11) may need to be undertaken using a series of workshops held to discuss the outcomes during each step in an iterative process (Burgess *et al.*, 2007). These stakeholder workshops can facilitate highly participatory discussions about issues and challenges of mutual concern and allow participants to achieve a shared awareness of the decision-making context, encouraging the parties concerned to weigh the pros and cons of a variety of perspectives, opening-up new lines of thought and building common

ground. In the specific case of PLMCA exercises, the workshops may be used to highlight the commonalities and differences between each of the stakeholder responses revealed during the first phase initial iterations of Steps B and C. This helps to reach an understanding of the agendas and policies driving the viewpoints of different stakeholder groups, and moves towards convergence through trade-offs of costs and benefits to the different parties where applicable.

The management of such workshops needs to be undertaken by an experienced facilitator whose selection is particularly critical for the positive outcome of the workshop. Phillips and Phillips (1993) advocate that such parties should guide workshop participants in a manner that enables them to: actively take part in debates, properly include the different perspectives which are presented, and record the main workshop findings/outcomes *without* attempting to interpret the perceptions.

2.7.1.3 STEP A3: Boundary definition

As highlighted above, the lead entity, perhaps in consultation with other decision-makers, will need to decide the extent to which key stakeholders can/should assist in helping to identify/clarify the nature of the decision context at an early stage of the PLMCA exercise. It may do this, for example, by identifying: physical boundary considerations, key issues, challenges and problems, other project alternatives, and potential 'winners and losers' to be considered.

It is increasingly being acknowledged that major infrastructure projects such as MTPs are not conceived as single and indivisible packages/projects. They are instead frequently presented as a part of a wider economic and technological system as 'agents of change' (Dimitriou, 2009; Allport, 2011; OMEGA, 2012). Defining project/policy boundaries in these terms, however, is notoriously difficult, particularly if mapped out over time and space. The challenges of boundary selection are inextricably linked to considerations of stakeholder policies and priorities at multiple levels. Indeed, certain policies (and plans) may impose considerably more limits to the project decision-making space than others may. It is, nevertheless, important to delineate boundaries at an early stage of the PLMCA exercise as this will not only have a very significant impact on the appraisal process and its outcomes, but also on the identification of stakeholder interests.

Once identified, the defined 'boundary' may well need to be the subject of further stakeholder discussion and adaptation subject to consequent iterations on account of the fact that different stakeholder perspectives will see the appraisal outcomes as having different attributes/characteristics and potential impacts. Additionally, it needs to be recognised that reaching consensus among multiple stakeholders (whether in an open or closed systems approach) regarding the scale/nature of the appraisal process and its potential impacts is typically not a straightforward matter and thus may call for a number of iterations following consultation.

2.7.1.4 STEP A4 – Identification / formulation of a primary list of options

In the case where PLMCA is used for the appraisal of pre-defined options, the lead entity should agree on a common set of policy guidance and project options to be appraised. While Beesley (1973) did not employ a MCA approach for the appraisal of the Victoria Line in London, he argued that option identification is perhaps the most critical stage in helping ensure one arrives at the 'best' result. Notwithstanding this, few MCA methodologies reviewed deal adequately with the interface between project design and project appraisal, and the nature of feedback loops by which the process of appraisal feeds back to influence the re-design of project options. The iterative nature of MCA

methodologies allows this to happen, although specific guidance on the relevant processes for undertaking such tasks are under-developed.

It is, unfortunately, all too common in the presentation of MTP developments for 'solutions' to precede the problem analysis. Where this happens (and it happens all too frequently), there are also tendencies to close prematurely the decision-making system to some external players and thereby make important project information inaccessible (Priemus *et al.,* 2012). Snell (1997) argues that this kind of behaviour is not simply about the distinction between rational and irrational decision-making but more subtly about the application of the rational model in an irrational way. Such practices are an illustration of the lack of sufficient consideration of robust alternative options for which PLMCA is well suited to help identify and test by the framework and its attendant processes within any given scenario. A starting point in this respect may be guidance on the identification of project options such as that featured in the UK Government Treasury's Green Book (HMT, 2003).

2.7.1.5 STEP A5: Policy analysis

Compiling a comprehensive framework for the project (comprising policy and planning objectives and any related criteria) extracted from the relevant policy and planning contexts at local, regional, national or international scale is vitally important as the fundamental plank of a PLMCA approach to MTP planning and appraisal. While building this framework may be undertaken collaboratively with identified key project stakeholders, it is essential that this be 'kicked-off' by the lead project entity in the first instance. Against this background, careful thought then needs to be given (*inter alia*) to considering the adequacy of available policy and planning parameters through identifying:

- **policies and related plans likely to critically inform the appraisal process**: these originate from a wide variety of agencies representing different interests and hierarchical levels;
- **policy and planning gaps:** where these are seen to be significant, accompanied by some indication of how these are to be plugged;
- **policy and planning conflicts:** where these exist, accompanied by some idea of how these are to be resolved;
- **whether certain policies and plans represent absolute requirements (i.e., are 'showstoppers'):** any project under consideration which does not meet the requirements of such policies and/or plans cannot readily be taken forward for appraisal;
- **whether the hierarchical nature of the existing policy and planning framework:** informs the relative importance/weight of such policies (and their related criteria) in the appraisal process; and
- **whether the existing policy and planning framework is adequately broad:** when set against the background of any postulated scenario conditions.

Once completed, the policy and planning framework needs to be agreed with all involved stakeholders – be they external to the lead entity (in an 'open systems' approach) or internal (in a 'closed systems' approach). Allowances also needs to be made for additions to the policy and planning framework to be made once involved stakeholders have scrutinised them and contributed subsequently to their enhancement/modification.

2.7.1.6 STEP A6: Stakeholder identification

The early identification of a balanced composition and comprehensive range of stakeholders to be involved in a PLMCA exercise is critical to the effective identification of project risks and opportunities. It is also important for the avoidance of bias during the development of project objectives toward any particular party. Context scanning - in order to identify which stakeholders and stakeholder interests are to be included - represents a very significant activity at this stage. This is the case either in terms of inviting participation in an 'open' appraisal or in terms of identifying which stakeholder interests to role-play in a more 'closed system'. Clearly, unrepresentative stakeholder involvement in the appraisal exercise will skew appraisal outcomes, contributing to among other things potentially unidentified risks (and opportunities). In this regard, elements from OMEGA 2 Project (see Lesson 7 in Appendix) concerning effective and early engagement with key stakeholders is seen as very important in megaproject planning, appraisal and delivery. It is also strongly advocated in the work of other authors (see Axelsson, 1992; Pouloudi and Whitley, 1997; Koppenjan, 2004, Macharis and Nijkamp, 2011) and should be born in mind during this step because :

- **Decision-making on mega-projects** are carried out in a very complex network of interaction between far more numerous actors than in the case of smaller and less complex projects.
- **Consensus building at the preliminary stages** of the planning and appraisal of MTPs is critical as it can contribute to significant cost savings through, for example, the reduction of delays caused by public opposition and challenges that could otherwise occur in the post-planning stages. **Stakeholder engagement** is much less effective if undertaken *after* project objectives have been firmed-up by project promoters, partly because such consultation can actually increase confrontation.
- **Changes in project context during the project lifecycle** can lead to shifts in the position and changes in membership of key project stakeholders as well as to changes in the inter-relationship between different actors. This is particularly true for MTPs having a lengthy gestation period between their conception and implementation.
- **Building relations with key project stakeholders** is critically dependent upon the establishment of trust, credibility and transparency among the parties involved. Only in the presence of such trust and transparency can sustainable consensus building be achieved, especially in turbulent and uncertain times.
- **Stakeholders not directly involved in the core of MTP decision-making** (especially local community groups) who have a critical interest in project outcomes but have not been involved rarely trust the outcomes of any project appraisal process (PLMCA or otherwise) on account of their perceived opaqueness of the processes(es) employed.
- **Access by key stakeholders to all relevant project information** is very important. Despite increasing demands for access to such information, there are usually limits to full disclosure because of legitimate (and some non-legitimate) commercial sensitivities.

The PLMCA stakeholder identification process needs to be seen as a dynamic and iterative process capable of recognizing new stakeholders entering the decision-making domain and previous stakeholders leaving it. The process is initiated through interviews and brainstorming sessions with the project client or key informants supported by the analyses of secondary data, terms of reference

or other project documents, including policy documents which may infer a requirement to involve certain stakeholder groups. Industry-specific stakeholder typologies can aid the identification of key stakeholders. It should be possible from the employment of such typologies to derive, at least, a first list of relevant project actors upon which to build the PLMCA exercise.

Once a potential list of project key stakeholders has been identified stakeholder mapping techniques can then be employed to aid the design and planning of the subsequent stakeholder engagement. The most common of these mapping techniques plot the stakeholders on a matrix, which has two key stakeholder attributes as its axes, as in the case illustrated in Figure 10 (Bryson, 2004). Thus, for example, stakeholders may be mapped on a power/interest matrix (after Eden and Ackermann, 1998), on a power/attitude matrix (after Anderson *et al*., 1999), on impact/priority matrix (after DFID, 2002), and so on - depending on the overall objectives of the PLMCA exercise. A power/interest matrix considers the ability of stakeholders to influence a given project (power) against the extent to which they will be active or passive concerning this initiative (interest). This configuration thus, allows the identification of potential power stakeholder imbalances and possible strategies for addressing them. It also provides an opportunity to verify that all the stakeholders that have been identified are validated by their relevance to the project as illustrated by Figure 10 below.

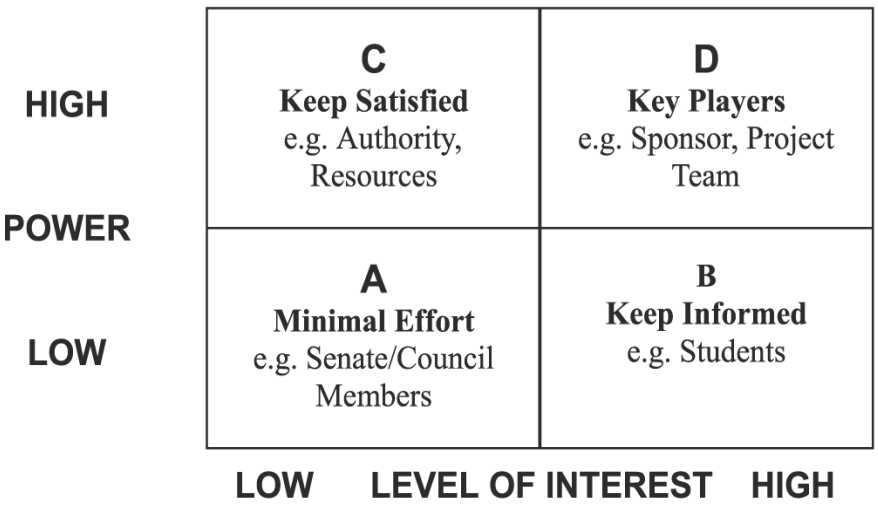

Figure 10: A power/interest matrix (Source: www.emeraldinsight.com)

More complex techniques for mapping stakeholders include: the three-dimensional power/legitimacy/urgency diagram (see Mitchell *et al*., 1997), the stakeholder circle power/proximity/ urgency matrix (see Stakeholder Management Pty. Ltd, 2006) and the three-dimensional grid power/interest/attitude diagram (Murray-Webster and Simon, 2006) depicted in Figure 11 below. Despite the increased complexity of the third dimension, these latter set of methodologies offer a more robust basis on which to understand the engagement with stakeholders. For example, the power/interest/attitude grid, when compared with the power/interest matrix, offers the opportunity to also map the extent to which different stakeholders support or oppose a project, or in the case of the PLMCA, provides a record of their agendas and policies (where they exist).

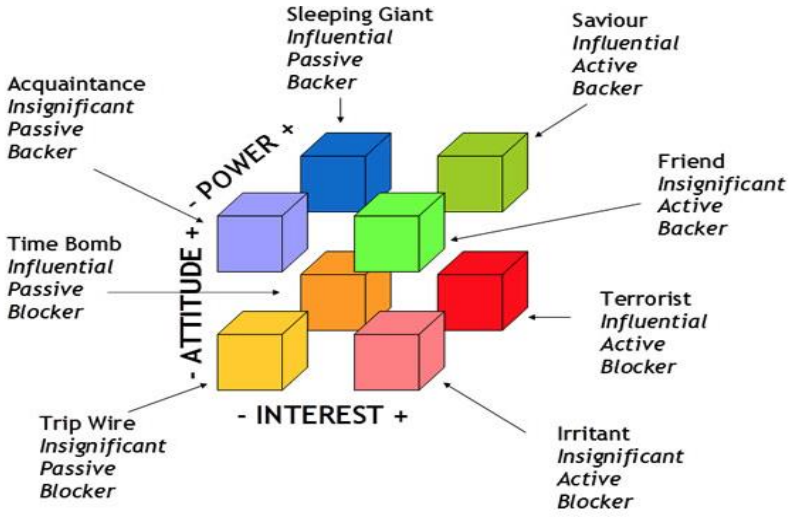

Figure 11: The three-dimensional grid power/interest/attitude diagram (Source: Murray-Webster and Simon, 2006)

2.7.1.7 STEP A7: Scenario building

OMEGA 2 Project findings (Dimitriou *et al.*, 2011) suggest that scenario building and testing, of the type advocated since the 1970s by the petroleum company Shell International (Wilkinson and Kupers, 2014), should be undertaken for all but the most straightforward MTP appraisal. In so doing, his enables multiple future contextual circumstances to be examined and (where possible) addressed. This is especially important for large-scale, complex and/or vulnerable infrastructure projects that possess multiple interrelationships with the territories and sectors they traverse, impact and serve. This is advocated because that some scenarios may ultimately call into question the very wisdom of pursuing a particular option due to previously unidentified risks, or may highlight deficiencies/gaps in the overriding policy and planning frameworks. Thus, it is important at this stage to confirm whether (and what type) of scenario testing is to be undertaken. The stakeholder lead entity may here wish to seek advice/agreement from other interested parties as to the nature and content of the scenarios to be used and tested.

2.7.2 STEP B: The model building phase

The principal activities in this phase of the PLMCA exercise concern the formulation and/or clarification of project objectives, the derivation of associated project appraisal criteria and the establishment of a scheme of weights to reflect the actual or perceived importance attributed to each appraisal criteria.

2.7.2.1 STEP B1 - Formulation of objective and appraisal criteria

As a first step of the PLMCA exercise it is necessary to clarify and clearly articulate the objectives emanating from the various policies that comprise the overall policy and planning frameworks for the project being planned and appraised. Processes similar to those reviewed in Section 2.3.5 above will facilitate the identification of operational objectives. It is, however, of utmost importance for PLMCA in particular that:

- **Each policy objective is readily comprehensible to all** involved stakeholders and that there is consistent understanding of them in terms of the opportunities or constraints they impose on the appraisal subject.
- **Each policy objective is to be constructed in such a manner as to provide a positive statement to enable their further translation into appraisal criteria** that can (where at all possible) be assessed in some way – either quantitatively or in a qualitative fashion. This is important, as it is often the case that policy objectives are cited in an all-embracing or rather vague manner, which tends to make their interpretation very difficult.
- **Any potential policy 'gaps'** (i.e., gaps in the coverage of related plans and objectives) should be addressed in conjunction with involved stakeholders, whether internal (closed) or external (open).
- **Thought be given as to whether policy objectives are capable of dealing with planning scenarios** that are to be built and tested.
- **Due regard is given to the hierarchy of objectives that emanate from the broader policy and planning hierarchy.** This is important as it can inform subsequent weighting. It should include re-confirmation and clarification of those policies and any objectives deemed non-negotiable (i.e., 'showstoppers).
- **Any perceived risks associated with policies and related plans and objectives** are clearly identified and articulated.

Subsequent to the above, there will be a need for stakeholders (as individuals or in a group) to identify and articulate project appraisal criteria for each key policy objective. It should be noted here that, like the above policy objectives, related appraisal criteria must be readily understandable and assessable (quantitatively or qualitatively) in some rational way and that due regard should be given to the overall policy and planning hierarchy. Moreover, as earlier indicated, each project appraisal criteria should be capable of identifying project 'winners and losers' over time and space, as well potential risk (and opportunity) sources plus impacts (including the costs and benefits of any mitigation measures).

2.7.2.2 STEP B2 - Derivation of Weighting

Also in this step is the need to ascribe weights to the project appraisal criteria that identify their relative importance in the appraisal exercise. Depending upon the nature of the appraisal and the standpoint of the lead entity (especially concerning whether the appraisal approach is to be 'open' or 'closed'), this may be variously undertaken by:

- an 'open' appraisal exercise, allowing individual external stakeholders to set weights according to their particular agendas and needs
- a 'closed' appraisal exercise, individuals within the interest group ascribe weights to perceived stakeholder agendas and needs.

In both open and closed appraisal approaches, it is only sensible that due regard is given to the overall policy-objective-criteria and planning hierarchy which is likely to suggest that some criteria should be accorded greater weight than others should. This may be especially pertinent to those policies, objectives and criteria that are legitimately considered to be non-negotiable (i.e., 'showstoppers'). There then arises the question of whether the above is undertaken involving all key stakeholders or in a more closed manner whereby both objectives and appraisal criteria are selected primarily by the lead entity. Whichever, and this will vary according to the overall aims of

the project appraisal exercise and its context, it is probable that several iterations will be required for a consensus to be reached, as earlier discussed.

Only when a common set of policy objectives, sub-objectives, criteria and indicators has been rigorously established can PLMCA offer a suitable 'platform' for consensus-building around selected issues. Hence, for instance, MTP promoters, who typically tend to focus on financial and economic concerns, are required to understand that in many/most cases objectives (and related criteria) pertaining to other important realms of concern should/must be considered in the appraisal. Local community groups that are only interested in matters that affect them locally and refuse to take a broader view (often referred to as NIMBY groups) concurrently need to recognize that the possible decision *not* to go ahead with a project should be supported by sound criteria that allude to legitimate concerns of a wider policy breadth. Even when different project stakeholder parties appear to share the same overall objectives, the process of disaggregation of these objectives through the formation of sub-objectives, appraisal criteria and performance indicators may bring to light unexpected (sometimes major) conflicts. The UK Department for Transport (DfT), for example as earlier alluded, tends to measure safety in monetary terms (i.e., in terms of the statistical value of lives saved) which is not the indicator that other stakeholder groups, above all environmental groups representing public transport users and non-motorised travelers would necessarily agree to adopt.

2.7.3 STEP C: The model use

The model use is the step where the relative 'performance' of the appraisal options are assessed against each appraisal objective.

2.7.3.1 STEP C1 – Scoring

Each participant stakeholder will assign a series of performance scores to each project option in the PLMCA exercise and enter these into the relevant section of the appraisal matrix (see Figure 14) using a pre-determined numerical scale (for example -2 to +2) against the appraisal criteria identified in the model building phase. As part of this process, for each dimension, participant stakeholders are required to identify and describe (wherever possible) the quantitative and qualitative outputs, outcomes and impacts of the appraisal object against each policy objective using *agreed* appraisal criteria. This holds true for:

- single option appraisal;
- multiple option appraisal; and
- single and multiple option appraisal that are subject to multiple scenario analyses.

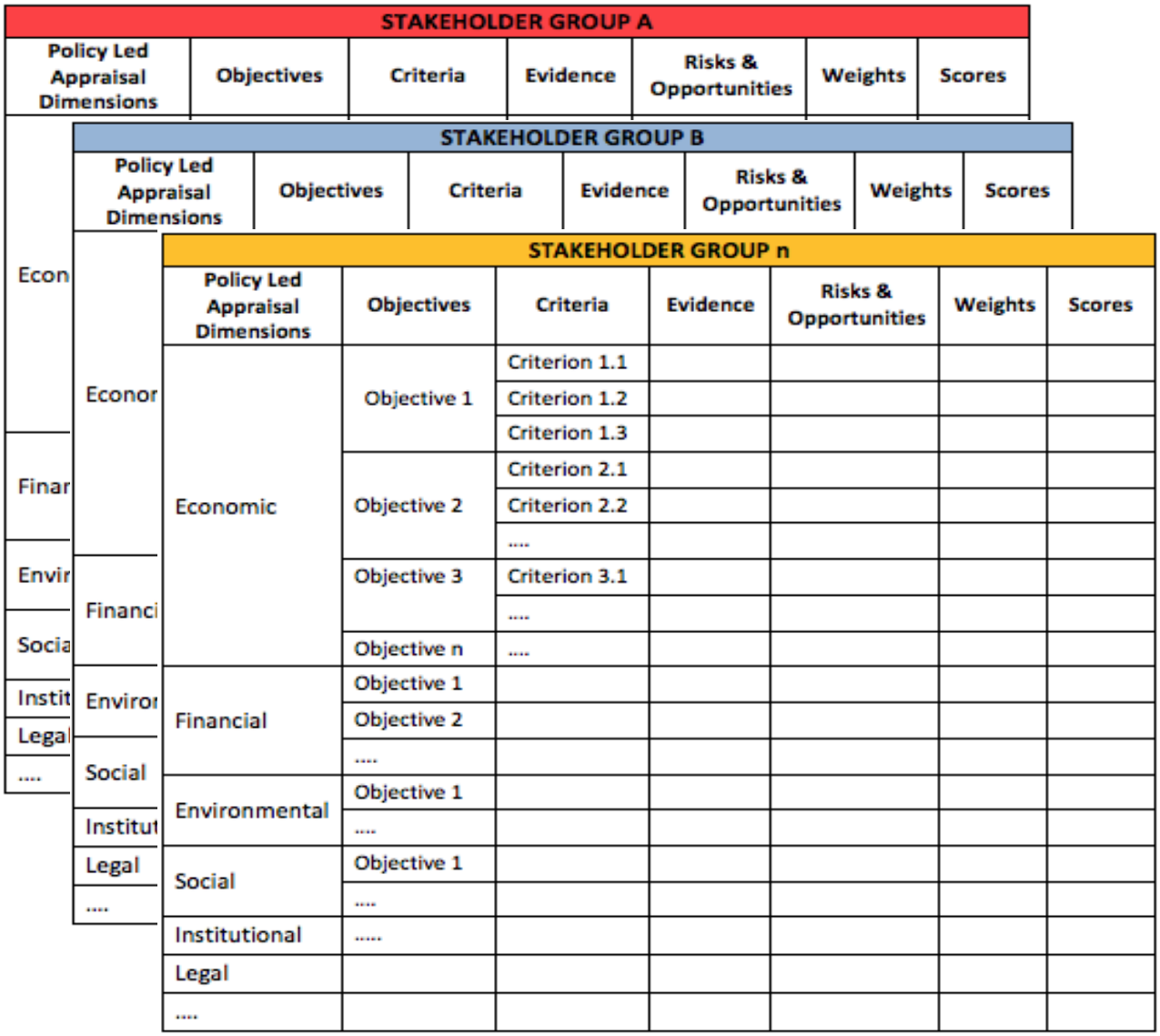

Figure 12: The PLMCA Decision Matrix (Dimitriou et al., 2013)

Concurrently, each stakeholder participant will need to identify and describe all potential risk (and opportunity) sources under each dimension, translating these where possible into qualitative and/or quantitative performance measures. Once this has been completed, all the numeric scores are aggregated for each appraisal option to help provide a 'baseline' performance indicator. Following this, the overall 'scores' for both performance and risk are adjusted using the previously identified weighting scheme to provide a new 'weighted score' and risk analysis for the appraisal object. This enables cross-comparison of the impacts of the weighting scheme on the baseline indicator.

2.7.4. STEP C2 – Further development of issues, objectives, criteria, scenarios and options

Following the above, it is important for participant stakeholders to both thoroughly examine and discuss among themselves the outcomes of the preceding analyses derived from the appraisal (including under different scenarios), highlighting the impact of any weighting scheme employed so as to help determine 'winners and losers' over time and space of the completed project (Dimitriou,

2015). At this juncture the lead entity may close the PLMCA appraisal process *if* it is decided that a sufficiently clear 'steer' has been obtained concerning the overarching objectives of the appraisal. It is, however, more probable that negotiation/trade-off discussions will need to take place between the various key participant stakeholders with a view to reaching consensus on:

- the final appraisal of outcomes;
- the need for adjustments to the project options under appraisal so as to enable improved performance to be achieved (including under different scenario conditions); and
- whether a full review of the appraisal object(s) is required in light of potentially any unacceptable performance levels or unacceptable risk levels are flagged up.

It is unlikely, especially in the case of MTPs that successive iterations of the PLMCA appraisal process will ultimately lead to total agreement among all key stakeholders. Instead, it is more likely that a compromise will be agreed on (involving numerous trade-offs among stakeholders) and a few residual unresolvable conflicts will be parked for later resolution and monitoring – depending on their severity.

2.8 Conclusions

This paper commenced with a review of the generic features of MCA following the preceding paper's presentation of the case for the application of MCA to megaproject infrastructure appraisal. In addition, relating the appraisal needs of MTPs identified by the OMEGA Centre in its OMEGA 2 Project, this paper sought to offer a policy-led MCA approach that explicitly recognises the plurality and complexity of project stakeholder involvement. In particular, it looked to present a framework and attendant processes designed to aid decision-makers make trade-offs and compromises that need to be made in arriving at agreed actions in a transparent and accountable manner. As presented, this framework and related supporting processes permit the 'holistic' incorporation of monetary and non-monetary costs and benefits side-by-side over time and space (and in different selected scenarios).

The PLMCA's advocacy of transparent multiple project stakeholder involvement is in contrast to many/most traditional infrastructure appraisal approaches, usually carried out exclusively by analysts on behalf of project promoters in a manner that is typically more market-led and economically focused. Being policy-led, PLMCA has the potential to dramatically reduce the earlier frequent reliance of MTP appraisal exercises based essentially on iron-triangle concerns of project delivery. Through attempts to systematically link broader agent of change policies to project delivery aims and targets, it also reduces the consequent risk of the manipulation of project appraisal outcomes as part of 'green wash' practices. One of its major advantages is that it offers much greater opportunity to reduce the widespread lack of transparency common to much MTP stakeholder decision-making. The approach finally provides the additional advantage of offering a greater degree of stakeholder accountability thereby helping to reduce the numerous unresolved/fudged conflicts among project stakeholders commonly associated with past infrastructure appraisal practices. The example of the UK DfT NATA appraisal methodology - where non-monetary factors have tended to be assigned lower weightings compared to economic and financial criteria - point clearly to the fact that even within a MCA approach such as NATA, there is the risk that priorities can be biased by individual government departmental and/or sectoral interests to the detriment of broader policy concerns such as sustainable development.

The underlying premise of PLMCA is that *only* when project appraisal is conducted in a participatory manner (preferably as early as possible), with full regard for all relevant key stakeholder policies and agendas, can the appraisal process insure that broader priorities are reflected in trade-offs between different project objectives and related appraisal criteria in line with various stakeholders' priorities. The preceding discussion has sought to show that such engagement allows the identification of conflicting objectives and potential issues, including risks (and opportunities) emanating from factors external to the project that should nonetheless be addressed but which are frequently undervalued by CBA. It is contended, furthermore, that the inclusion of policy directives into PLMCA allows for mediation of areas of disagreement between stakeholders, at the same time assuring the validity and impartiality of the analysis itself. These conclusions are in line not only with the findings of OMEGA 2 Project case study research but are also reinforced by other megaproject decision-making specialists (see Hall, 1980; Altshuler and Luberoff, 2003; Flyvbjerg *et al.;* 2003) who all confirm that *ultimately* the outcome of MTP project appraisal is mainly a political process and *not* a simplified technical computational exercise.

While it is readily acknowledged by the authors that PLMCA is in its early stages of development and in its application can take on various forms, depending upon the stage of the project lifecycle it is applied to and the client(s) and context(s) for which it is prepared, the approach is seen as a more holistic structured and transparent 'decision-making approach to megaproject infrastructure appraisal. PLMCA looks to promote a more robust way of dealing with MTP decision-making risks, uncertainties and complexities (plus opportunities) found not only within the physical boundaries of the project but also within the external decision-making environments and spaces that impact on the outcomes of such projects. The need to be sensitive to the changing contexts and societal values of such external factors over time and space, and the possession of a skill of knowing when to 'open-up' and 'close-down' project appraisal analyses in line with different needs of each stage of the project development cycle is fundamental to the advocated approach. The former, as earlier explained, implies an inclusion into the decision-making process of a plurality of voices and the employment of a line of argument that reflects a shared awareness of the decision problem together with a shared ownership of its 'solution'. The 'closing down' of the decision-making process is necessary when it is time (or opportune) to take a final decision to move forward with the execution of approved project and the manner pre-planned and designed. Because uncertainties need to be reduced to a minimum or manageable levels, and a convergence of opinions of key stakeholder reached in order to positively move ahead, a very careful balance needs to be struck between dangers of procrastination (and related unproductive delays) and the premature closure of decision-making thereby sacrificing opportunities that would otherwise be available.

Although aspects of the above discussion confirm the literature on megaproject decision-making is continuously increasing, the search for 'the perfect' decision-making method remains an elusive goal (Triantaphyllou, 2000). The authors contend that this search for 'the perfect' single 'solution', particularly of the kind driven by iron-triangle concerns, is not only highly misleading but also potentially unproductive and even destructive. What is instead advocated here is the employment (and continuous development) of a set of evidence-based generic principles and practices drawn from an evaluation of past international practice and research that can inform a more robust, structured and inclusive infrastructure planning and appraisal exercise more suited to the challenges posed by 21st Century, especially concerns about sustainable development. This is advocated here within the confines of a generic PLMCA decision-making framework and attendant processes that can be subsequently tailor-made to the needs of specific interested parties to facilitate multiple

stakeholder decision-making for complex decisions regarding mega infrastructure projects, particularly MTPs, in contexts of high uncertainty and risks - and potentially high opportunities.

References

Adams, J., (1995) *Risk*, UCL Press, London

Alexander, E.R., (2006a) Evolution and Status: Where is Planning Evaluation Today and How did It get Here? In: Alexander, E.R. (Ed.) *Evaluation in Planning*, Ashgate, Aldershot

Alexander, E.R., (2006b) Problems and Prospects: Dilemmas in Evaluation and Directions for the Future. In: Alexander, E.R. (Ed.) *Evaluation in Planning*, Ashgate, Aldershot

Allport, R.J. (2011) *Planning Major Projects*, Thomas Telford, London

Altshuller, A., and Luberoff, D., 2003. Mega-Projects: The Changing Politics of Urban Public Investment. Brookings Institution Press

Antunes, P., Santos, R. and Videra, N. (2006) Participatory decision-making for sustainable development—the use of mediated modelling techniques. Land Use Policy 23, 44–52

Antunes, P, Karadzic, V., Santos, R., Beça, P. and Osann, A. (2011): Participatory multi-criteria analysis of irrigation management alternatives: the case of the Caia irrigation district, Portugal, International Journal of Agricultural Sustainability, 9:2, 334-349

Axelsson B (1992) Corporate strategy models and networks - diverging perspectives. In *Industrial Networks: A New View of Reality* (AXELSSON B AND EASTON G, Eds), pp 184-204, Routledge, London.

Banister, D. & Berechman, J., (2000) *Transport Investment and Economic Development*, UCL Press, London

Banville, C., Landry, M., Martel, J.M., and Boulaire, C., 1998. A Stakeholder Approach to MCDA. Systems Research and Behavioral Science, Vol. 15, No. 1, pp. 15–32.

Baumol, W., (1968) On the Social Rate of Discount, *American Economics Review* 58(4), 788-802

Beesley, M.E., (1962) Some Aspects of the Economics of the M1, *Journal of Industrial Economics* 10(3), 204-208

Beesley, M. E. (1973): "Urban Transport Studies", ECMT Economic Research Centre, 24th Round Table, Paris.

Belton, V., and Steward, T., 2002. Multiple Criteria Decision Analysis: An Integrated Approach. Kluwer Academic Publisher

Dobes, L. and Bennett, J. (2009). Multi-Criteria Analysis: good enough‖ for government work? Agenda, 16(3), 7-29.

Boiteux, M (1996) Transports: pour un meilleur choix des investissement, Paris: la Documentation Francais.

Boardman, A.E., Greenberg, D.H., Vining, A.R. and Weimer, D.L., 2006. Cost-Benefit Analysis: Concept and Practice, Third Edition, Prentice Hall.

Bragge, J., Korhonen, P., Wallenius, H., & Wallenius, J. (2010). Bibliometric analysis of multiple criteria decision-making/multiattribute utility theory. In*Multiple criteria decision-making for sustainable energy and transportation systems* (pp. 259-268). Springer Berlin Heidelberg.

Brent, R.S., (2006) *Applied Cost-Benefit*, Edward Elgar, Cheltenham.

Bristow, A. & J. Nellthorp, (2000), Transport project appraisal in the European Union, *Transport Policy* 7(1), 51-60

Bryson, G.M. (2004). What to do when Stakeholder matter? Stakeholder Identification and Analysis Techniques. *Public Management Review*, 6(1), 21-53.

BTE (1999) *Facts and Furphies in Benefit–Cost Analysis: Transport*. Bureau of Transport Economics Report 100, Canberra.

Burgess, J., Stirling, A., Clark, J., Davies, G., Eames, M., Staley, K. and Williamson, S., 2007. Deliberative Mapping: A Novel Analytic-Deliberative Methodology to Support Contested Science-Policy Decisions. *Public Understanding of Science*, Vol. 16, pp. 299–322.

UN - United Nations (1987) *Our Common Future, Brundtland Report,* Report of the 1987 World Commission on Environment and Development, Oxford, Oxford University Press

Cameron, J., (2011) Social Cost−Benefit Analysis – Principles. In Cameron, J., Hunter, P., Jagals, P., Pond, K. (Eds.) *Valuing Water, Valuing Livelihoods - Guidance on Social Cost-benefit Analysis of Drinking-Water Interventions, with Special Reference to Small Community Water Supplies*, World Health Organization, IWA Publishing, London

Chapman, C. & S. Ward, (2011) *How to Manage Project Opportunity and Risk,* John Wiley, Chichester

Considine, M (2005). Making Public Policy: Institutions, Actors, Strategies. Polity.

D'Este, G.M. (2009). *Capturing Different Viewpoints in Multi-Criteria Analysis*. Proceedings of the 32nd Australasian Transport Research Forum.

Dodgson, JS, Spackman, M, Pearman, A and Phillips, LD (2009) Multi-criteria analysis: a manual. Department for Communities and Local Government: London.

Department for Transport, (2007), *Towards a Sustainable Transport System,* London

Department for Transport, (2008), *Delivering a Sustainable Transport System,* London

Department for Transport, (2009), *NATA Refresh: Appraisal for a Sustainable Transport System*

Dimitriou, H.T., and Thompson, R., 2001. The Planning of Sustainable Urban Development: The Institutional Dimension. In Layard, A., Davoudi, S., and Batty, S., (Eds.), *Planning for a Sustainable Future*, Spon Press, pp. 61-80.

Dimitriou, H.T., Oades, R.S., Ward, E.J. (2008), *Generic Lessons for Improving the Treatment of Risk, Uncertainty and Complexity of Mega Transport Projects*, Working Paper #4, OMEGA Project 1, OMEGA Project 1, OMEGA Centre, Bartlett School of Planning, University College, London, June

Dimitriou, H.T., Harman, R., Ward, E.J. (2010) *Incorporating Principles of Sustainable Development within the Design and Delivery of Major Projects: An International study with particular reference to major infrastructure projects,* Report prepared for the Institution of Civil Engineering and the Actuarial Profession as part of the OMEGA-RAMP Study, OMEGA Centre, University College London, London

Dimitriou, H.T. (2013) Multi-Criteria Analysis: Policy Inputs and Targets, Lecture Notes for Lecture 5, MIPAD Module entitled *21st Century Infrastructure Planning, Appraisal and Delivery Toolbox,* Bartlett School of Planning, University College London, February

Dimitriou, H.T. & Wright, P.G. (2013a) Final Report, *Scoping Study on Applicability of Multi-criteria Analysis in Appraisal of Urban Projects,* prepared for Projects Directorate's Regional and Urban Division of the European Investment Bank by OMEGA Centre, Bartlett School of Planning, University College London, London, March

Dimitriou, H.T., Wright, P.G., Ward, E.J, Dean, M. (2013b) *Policy Led Multi-Criteria Analysis (PLMCA) in the Planning, Appraisal and Delivery of Mega Infrastructure Projects:*

Dissemination to key stakeholders, Bartlett School of Planning, University College London, December

Dimitriou, H.T., Wright, P.G., Ward, E.J, (2014) *Multi Criteria Analysis Methodology for Project Appraisal in the Regional & Urban Development Division*, OMEGA Centre, Bartlett School of Planning, University College London.

Dimitriou, H.T (2015) BENVGMP1 – Mega Infrastructures as Agents of Change Lecture Notes, MSc Mega Infrastructure Planning, Appraisal and Delivery, Bartlett School of Planning University College London.

De Brucker, K., Verbeke, A., Winkelmans, W., (1998) *Sociaal-Economische Evaluatie van Overheids Investeringen in Transportinfrastructuur*, Garant, Leuven

DTLR. (2001) DTLR Multi-Criteria Analysis Manual. London, Department for Transport, Land and the Regions.

Dobb, M., (1970) *Welfare Economics and the Economics of Socialism,* Cambridge University Press, Cambridge

DOT, (2010) *Guidelines for Cost Benefit Analysis,* Department for Transport, HMSO, London

EC, (2014) Guide to Cost-Benefit Analysis of Investment Projects, [online] Avaiable at: http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf, [accessed:6th July 2016].

Eckstein, O., (1958) *Water Resource Development: The Economics of Project Evaluation*, Harvard University Press, Cambridge, Massachusetts

Eden, C. and Ackermann, F. (1998) Making Strategy: The Journey of Strategic Management, London: Sage

European Commission (2014) *Guide to Cost Benefit Analysis of Investment Projects*, Brussels, December.

Figueira, J., Greco, S., and Ehrgott, M. 2005. Introduction. In Figueira, J., Greco, S., and Ehrgott, M. (Eds.), *Multiple Criteria Decision Analysis: State of the Art Surveys*. Springer, pp. xxi-xxxiv.

Fischer, F. (1993) Citizen Participation and the Democratization of Policy Expertise: From Theoretical Inquiry to Practical Cases. *Policy Sciences,* 26**,** 165-187.

Fineberg, H., Stern, P. C. & Committee on Risk Characterization, N. R. C. (1996) *Understanding Risk: Informing Decisions in a Democratic Society.* Washington, DC: National Academy Press.

Fiorino, D. J. (1990) Citizen Participation and Environmental Risk: A Survey of Institutional Mechanisms. *Science, Technology and Human Values,* 15**,** 226-243.

Flyvbjerg B., Bruzelius N., Rothengatter W., (2003) *Megaprojects and Risk – An Anatomy of Ambition*, Cambridge University Press, Cambridge

Foster, C. D. & Beesley, M.E., (1963) Estimating the Social Benefit of Constructing an Underground Railway in London, *Journal of the Royal Statistical Society Series A* 126(1), London

Friend, J., and Jessop, N., 1969. *Local Government and Strategic Choice: An Operational Research Approach to the Processes of Public Planning*. Tavistock.

Funtowicz, S., Martinez-Alier, J., Munda, G., Ravetz, J., (1999) Information Tools for Environmental Policy under Conditions of Complexity, European Environmental Agency, Experts' Corner, *Environmental Issues Series*, n. 9

Goodwin P. and Wright, G. (2004) *Decision Analysis for Management Judgment*, Third Edition, Chichester: Wiley

Goodwin P. and Wright G. (2001), *Enhancing Strategy Evaluation in Scenario Planning: A Role for Decision Analysis*, Journal of Management Studies, vol. 38, n.1, pp. 1-16.

Gowdy, J.M., (2004) The Revolution in Welfare Economics and Its Implications for Environmental Valuation and Policy, *Land Economy* 80(2), 239-257.

Grant-Muller, S.M., MacKie, P., Nellthorp, J., Pearman, A., (2001) Economic Appraisal of European Transport Projects: The state-of-the-art revisited, *Transport Reviews* 21(2), 237-261

Greiman, V.A. (2013) *Megaproject Management: Lessons on Risk and Project Management from The Big Dig*, John Wiley Press, New Jersey

Guba, E.G., &Lincoln, Y.S. (1989) *Fourth Generation Evaluation*, Sage, London

Hall, P., 1980. *Great Planning Disasters*. University of California Press.

Hammond, R.J. (1966) Convention and Limitation in Benefit-Cost Analysis, *National Resources Journal* 6(2), 195-222

Hansson, S.O. (2007) Philosophical Problems in Cost–Benefit Analysis, *Economics and Philosophy* 23(2), 163–183

Hausman, D.M. & McPherson, M.S. (2006) *Economic Analysis, Moral Philosophy, and Public Policy*, Cambridge University Press, Cambridge

Hayashi, Y. and Morisugi, H., (2000) International Comparison of Background Concept and Methodology of Transportation Project Appraisal, *Transport Policy* 7(1), 73-88

Heydenreich, A-K., (2008) *Organising a Multi-Stakeholder Process: Creating a paradoxical collaborative identity*, PhD dissertation, Graduate School of Business Administration, Economics, Law and Social Sciences, University of St. Gallen, St. Gallen

Heinzerling, L., & Ackerman, F. (2002) *Cost-Benefit Analysis of Environmental Protection*, Georgetown University, Washington D.C.

Hicks, J. (1939) The Foundations of Welfare Economics, *The Economic Journal* 49(196), 696–712

Hill, M. (1966) A Method for Evaluating Alternative Plans: The Goals-Achievement Matrix Applied to Transportation Plans, PhD dissertation, University of Pennsylvania, Philadelphia

Hill, M. (1968) A Goals-Achievement Matrix for Evaluating Alternative Plans, *Journal of the American Institute of Planners* 34(1), 19-29

Hill, M. & Schechter, M. (1971) Optimal Goal Achievement in the Development of Outdoor Recreational Facilities. In: Wilson, A.G. (Ed.), *Urban and Regional Planning*, Pion, London

Hitch, C.J. & McKean, R.N. (1960) *The Economics of Defence in the Nuclear Age*, Harvard University Press, Cambridge, Massachusetts

HM Treasury (2003) *The Green Book - Appraisal and Evaluation in Central Government*, Treasury Guidance, HMSO, London

Hogwood, B.W., and Gunn, L.A., 1984. Policy Analysis for the Real World, Oxford University Press.

Holtzman, (1989) Intelligent Decision Systems, Addison-Wesley.

Hook, W. (2011) Use and Abuse of Economic Appraisal in Urban Transport Projects. In Dimitriou, H.T. & Gakenheimer, R. (Eds.) *Urban Transport in the Developing World: A Handbook of Policy and Practice*, Edward Elgar, Cheltenham

Institute of Civil Engineers, Institute and Faculty of Actuarys (2014), Risk Analysis and Management for Projects (RAMP), 3rd edition, ICE Publishing.

Irvin, G. (1978) *Modern Cost-Benefit Methods – An Introduction to Financial, Economics and Social Appraisal of Development Projects*, The Macmillan Press Ltd.

Jacobs, M. (1991) The Green Economy, London, Pluto Press.

Jessop, A., Sayers, T. & Hills, P. (2003). Multi-criteria evaluation of transport options - flexible, transparent and user-friendly? Transport Policy 10(2): 95-105.

Kay, J. (2003) *The Truth About Markets: Their Genius, Their Limits, Their Politics,* Allen Lane, London

Kaldor, N., (1939) Welfare Propositions in Economics and Interpersonal Comparisons of Utility, The Economic Journal 49(195), 549–552.

Klauer, B., Drechsler, M., Messner, F., (2002): Multicriteria analysis under uncertainty with IANUS - method and empirical results, UFZ Leipzig-Halle GmbH, Leipzig, 29 pp

Klinger, R. and R. Rempling (2015), PANTURA Report Summary, available at: http://cordis.europa.eu/result/rcn/149821_en.html; Accessed: 26/4/2015.

Koppenjan, J.F.M., and Klijn, E-H., 2004. Managing Uncertainties in Networks: A Network Approach to Problem Solving and Decision-making. Routledge.

Koopmans, C. & Rietveld, P. (2013) Long Term Impacts of Mega-Projects: The Discount Rate. In Priemus, H. & van Wee B. (Eds.) *International Handbook on Mega-Projects,* Edward Elgar, Cheltenham

Kurtz, C.F., and Snowden, D.J., 2003. The New Dynamics of Strategy: Sense-Making in a Complex-Complicated World. *IBM Systems Journal,* Vol. 42, No. 3, pp 462-483.

Layard, R. (1972) *Cost-Benefit Analysis,* Penguin Books, Harmondsworth

Lambert, J.H, Karvetski C.W., Spencer, D.K, Sotirin B.J., Liberi D.M., Zaghloul H.H., P.E., Koogler J.B., Hunter S.L., Goran ,W.D., Ditmer, R.D, and Linkov, I., 2012. Prioritizing Infrastructure Investments in Afghanistan with Multiagency Stakeholders and Deep Uncertainty of Emergent Conditions. *Journal of Infrastructure Systems,* Vol. 17, No. 2, pp. 155-166.

Leonard, H.B., & Zeckhauser, J.R. (1983) Cost-Benefit Analysis Defended, *Institute for Philosophy and Public Policy* 3(3)

Levin, H.M., (1995) Cost-effectiveness Analysis in Carnoy, M. (ED.) *International Encyclopaedia of Economics of Education,* Pergamon Press, Oxford

Lichfield, N. (1956) Economics of Planned Development., *The Estates Gazette Ltd.,* London

Lichfield, N. (1960) Cost Benefit Analysis in City Planning, *Journal of the American Institute of Planners* 26(4), 89-91

Lichfield, N. (1966) Cost Benefit Analysis in Town Planning - A Case Study: Swanley, *Urban Studies* 3, pp. 215-249.

Lichfield, N. (1970) Evaluation Methodology of Urban and Regional Plans: A Review, *Regional Studies* 4(2), 151-165

Lichfield, N. (1985) From Impact Assessment to Impact Evaluation. In Faludi, A. and Voogd, H. (Eds.) *Evaluation of Complex Policy Problems,* Delftsche Uitgewersmaatschappij, Delft.

Lichfield, N. (1994) Community impact evaluation, *Planning Theory* 12, 55-79

Lichfield, N. (1996) *Community Impact Evaluation*, UCL Press, London

Litmam, T. (2008) *A Good Example of Bad Transportation Performance Evaluation*, Victoria Transport Policy Institute, Victoria, British Columbia

Litman, T. (2013) *Critical Analysis of Conventional Transport Economic Evaluation*, Victoria Transport Policy Institute, Victoria, British Columbia

Litte, I.M.D. (1950) *A Critique of welfare Economics,* Clarendon Press, Oxford

Macharis, C. & Ampe, J. (2007) The Use of Multi-Criteria Decision Analysis (MCDA) for the Evaluation of Transport Project: A review, Paper prepared for *EURO XXII Conference*, University of Economics, Prague

Macharis, C. and Nijkamp, P. (2011). *Possible bias in multi-actor multi-criteria transportation evaluation: Issues and solutions*. Research Memorandum 2011-31. Faculty of Economics and Business Administration, VU University Amsterdam.

Macharis, C. (2000), *Strategische modellering voor intermodale terminals: Socio-economische evaluatie van de locatie van binnenvaart/weg terminals in Vlaanderen*, [Strategic modeling for intermodal terminals: Socio-economic evaluation of the location of barge / road terminals in Flanders], Brussels: Vrije Universiteit Brussel.

Macharis, C. (2005), The importance of stakeholder analysis in freight transport, *Quarterly Journal of Transport Law, Economics and Engineering,* **8** (25-26): 114-126.

Macharis, C. (2007), Multi-criteria analysis as a tool to include stakeholders in project evaluation: the MAMCA method. In: E. Haezendonck (ed.) *Transport project evaluation: extending the social cost-benefit approach,* Cheltenham UK/Northampton MA USA:Edward Elgar Publishing: 115-132.

Macharis, C., De Witte, A. and Turcksin, L. (2010). The Multi-Actor Multi Criteria Analysis (MAMCA) application in the Flemish long-term decision-making process on mobility and logistics. *Transport Policy*, 17,303–311

Macharis, C., De Witte, A., and Ampe, J., 2008. *The Multi-Actor, Multi-Criteria Analysis Methodology (MAMCA) for the Evaluation of Transport Project: Theory and Practice*. Journal of Advanced Transportation, Vol. 43, No. 2, pp. 183-202

Macharis and Nijkamp (2013), *Multi-Actor and Multi-Criteria Analysis in Evaluating Mega-Projects. in In Priemus, H., and van Wee, B., (Eds.), International Handbook on Mega-Projects. Edward Elgar, ch. 11.*

Makie, P. & Preston, J. (1998) Twenty-One Sources of Error and Bias in Transport Project Appraisal, *Transport Policy* 5, 1-7

Malczewski, J., 1999, GIS and Multicriteria Decision Analysis (New York: Wiley). Massam, B. (1980) *Spatial Search*, Pergamon Press, Oxford

McAllister, D.M. (1982) *Evaluation in Environmental Planning: Assessing Environmental, Social, Economic and Political Trade-Offs*, MIT Press, Cambridge, Massachusetts

McDowall, W., Eames, M. (2007) Towards a sustainable hydrogen economy: A multi-criteria sustainability appraisal of competing hydrogen futures. International Journal of Hydrogen Energy 32, 4611 – 4626

Meadows, D.H., Meadows, D.L., Randers, J., Behrens III, W.W. (1972) *The Limits to Growth: a Report for the Club of Rome's Project on the Predicament of Mankind*, New York: Universe Books.

Mishan, E.J. (1967) *The Costs of Economic Growth*, Pelican Books, Harmondsworth, London.

Mishan, E.J., (1988) *Cost-Benefit Analysis*. Allen and Unwin, London.

Mitchell, R. K., Agle, B. R. and Wood, D. J. (1997) 'Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts'. Academy of Management review, 2:4 pp853-86.

Montibeller G., Gummer H. and Tumidei D. (2007), Combining Scenario Planning and Multi-Criteria Decision Analysis in Practice, Working Paper LSEOR 07.92, The London School of Economics and Political Science.

Morgan, M. (2004) Regulating Stem Cell Research: Stakeholder analysis of values and policy option performance using Multi-Criteria Mapping. SPRU - Science and Technology Policy Research. Falmer, Brighton: University of Sussex.

Morgan, M. (2010) Governing the constructs of life: What constitutes 'good' governance? Submitted in partial fulfilment of the degree of Doctor of Philosophy in Science and Technology Policy, University of Sussex.

Munda, G. (1996) Cost-Benefit Analysis in Integrated Environmental Assessment: Some Methodological Issues, *Ecological Economics* 19(2), 157-168

Munda, G. (1995). Multicriteria Evaluation in a Fuzzy Environment - Theory and Applications in Ecological Economics. Springer.

Munda, G. (2004) Social Multi-Criteria Evaluation (SMCE): Methodological Foundations and Operational Consequences, *European Journal of Operational Research,* 158(3), 662–677

Munda, G. (2008). *Social Multi-Criteria Evaluation for a Sustainable Economy*. Springer

Munda, G., Nijkamp, P., Rietveld, P., (1994) Qualitative Multicriteria Evaluation for Environmental Management, *Ecological Economics,* 10(2), 97-112.

Murray-Webster and Simon, 2006

Musgrove, R.A., (1969) Cost Benefit Analysis and the Theory of Public Finance. In Layard, R. (Ed.) *Cost-Benefit Analysis*, Penguin Books, Harmondsworth (1972)

Næss, P. (2006) Cost-Benefit Analyses of Transportation Investments: Neither Critical nor Realistic, *Journal of Critical Realism* 5(1), 32-60.

Nijkamp, P. & Van Delft, A. (1977*) Multi-criteria Analysis and Regional Decision-making,* Studies in Applied Regional Science, Springer Press, Berlin

O'Connor M., Faucheux, S., Froger, G., Funtowicz, S.O., Munda, G. (1996) Emergent Complexity and Procedural Rationality: Post-Normal Science for Sustainability. In Costanza, R., Segura, O., Martinez-Alier, J. (Eds.) *Getting down to Earth: Practical Applications of Ecological Economics,* Island Press/ISEE, Washington D.C.

Oka, T., (2003) Effectiveness and Limitations of Cost-benefit Analysis in Policy Appraisal, *Government Auditing Review* 10, 71-83

Olivera, V., Pinho, P., (2010) Evaluation in Urban Planning: Advances and Prospects, *Journal of Planning Literature* 20(10), 1–19.

Omann, I. (2004). Multi-Criteria Decision Aid as an Approach for Sustainable Development Analysis and Implementation. Ph.D. Dissertation. Faculty of Business, Economics and Social Sciences, University of Graz.

Omega Centre (2010) *Incorporating Principles of Sustainable Development within the Design and Delivery of Major Projects: An International Study with Particular Reference to Major Infrastructure Projects*, Final Report prepared for the Institution of Civil Engineering and the Actuarial Profession, Bartlett School of Planning, University College London, London

Omega Centre, 2011. *Lessons for Decision-makers: A Comparative Analysis of Selected Large-scale Transport Infrastructure Projects in Europe, USA and Asia-Pacific*. University College London.

OMEGA Centre (2012) *Mega Projects: Executive Summary – Lessons for Decision-makers: An Analysis of Selected International Large-Scale Transport Infrastructure Projects,* Bartlett School of Planning, University College London, London

OMEGA Centre (2014) "Multi Criteria Analysis Methodology For Project Appraisal In Regional And Urban Development Division", Undertaken for Projects Directorate's Regional and Urban Division (REGU) of the European Investment Bank (EIB)

Page, M., Forester, J., Jones, P., (2007) *Enhanced Appraisal Tools: Deliverable G of the DISTILLATE* (Design and Implementation Support Tools for Integrated Local LAnd use, Transport and the Environment) Research Programme. [online] Available: http://www.distillate.ac.uk [accessed 15th June 2013]

Papamichail and French (2012), 25 years of MCDA in nuclear emergency management. IMA Journal of Management Mathematics, Vol. 24, no. 4 pp. 481-503

Patel, M.B., Morris and P.G.W., (1999), *Guide to the Project Management Body of Knowledge*, Centre for Research in the Management of Projects, University of Manchester, Manchester

Pearce, D., (1998) Cost-Benfit Analysis and Environmental Policy, *Oxford Review of Economic Policy,* 14(4), 84-100.

Pearce, D., Atkinson, G. and Mourato, S. (2006) *Cost-Benefit Analysis and the Environment*, Organisation for Economic Co-operation and Development (OECD), Paris

Pearce, O (2008) Holistic assessment of sustainability and its application at Halcrow, *The Journal of Corporate Citizenship* 30, 37-65

Pellizzoni, L. (2001) The myth of the best argument: power, deliberation, and reason. *British Journal of Sociology,* 52**,** 59-86.

Pellizzoni, L. (2003) Uncertainty and Participatory Democracy. *Environmental Values,* 12**,** 195-224.

Peters, G.H. (1968) *Cost-Benefit Analysis and Public Expenditure,* Institute of Economic Affairs, London

Phillips, L., and Phillips, M. (1993). Facilitated work groups: Theory and practice. *Journal of the Operational Research Society*, 44, 6, pp. 533-549.

Porter, T.M. (1995) *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*, Priceton University Press, New Jersey

Pouloudi and Whitley (1997) Stakeholder identification in inter-organizational systems: gaining insights for drug use management systems. European Journal of Information Systems (1997) 6, 1–14

Prest A.R. & Turvey R. (1965), The Main Questions. In: Layard, R. (Ed.) *Cost-Benefit Analysis* Penguin Books, Harmondsworth

Priemus, H., (2008) How to Improve the Early Stage of Decision-Making on Mega-Projects. In Priemus, H., Flyvbjerg, B. and van Wee, B. (Eds.) *Decision-Making on Mega-Projects: Cost-Benefit Analysis, Planning and Innovation*, Edward Elgar, Cheltenham

Priemus, H., Bosch-Rekveldt, M., and Giezen, M., (2013), Dealing with Complexity, Uncertainties and Risk of Mega-Projects: Redundancy, Resilience and Adaptivity. In Priemus, H., and van Wee, B., (Eds.), *International Handbook on Mega-Projects*. Edward Elgar, ch. 5.

Rehfeld, C., 1998, *Transport infrastructure investment and decision support systems*, Ph.D.-dissertation, Institute of Planning, Transport Studies, Technical University of Denmark

Renn O., Webler, T., Rakel, H., Dienel, P. and Johnson, B., 1993. Public Participation in Decision-making: A Three-Step Procedure. *Policy Science*, Vol. 26, No. 3, pp. 189-214.

Rietveld, P. (2013) Appraisal Methods for Transport Policy. In van Wee, B., Annema, J.A., Banister, D. (Eds.) *The Transport System and Transport Policy, An Introduction*, Cheltenham, UK and Northhampton, MA, USA: Edward Elgar, pp 329-52.

Rogers, M. & Duffy, A. (2012) *Engineering Project Appraisal*, Blackwell Science, Oxford

Rosen, R. (1977) Complexity as a System Property, *International Journal of General Systems* 4(3), 227-232

Rothengatter, W. (2008) Innovation in the Planning of Mega-Projects. In Priemus, H., Flyvbjerg, B. and van Wee, B. (Eds.) *Decision-Making on Mega-Projects: Cost Benefit Analysis*, Edward Elgar, Cheltenham

Saaty, T.L., 1980. The Analytic Hierarchy Process. McGraw-Hill.

Sager, T. (2003) Rationality Types in Evaluation Techniques - The Planning Balance Sheet and the Goals Achievement Matrix, *European Journal of Spatial Development* 2(1), pp.1-30.

Sen, A.K. (1980) Personal Utilities and Public Judgments: Or What's Wrong with Welfare Economics, *Economic Journal* 89, 537-558

Simon, H.A. (1976) *Administrative Behaviour*, New York Free Press, New York

Snell, M. (1997), *Cost Benefit Analysis for Engineers and Planners*, Thomas Telford Ltd., London

Söderbaum, P. (1998) Economic and Sustainability: An Actor-Network to Evaluation. In: Lichfield, N., Barbanente, A., Borri, D., Khakee, A., Prat, A. (Eds.), *Evaluation in Planning: Facing the Challenge of Complexity*, Kluwer Academic Publishers, Netherlands.

Sinnott-Armstrong, W. (2014), "Consequentialism", *The Stanford Encyclopedia of Philosophy* (Spring Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2014/entries/consequentialism/>.

Snell, M. (1997), *Cost Benefit Analysis for Engineers and Planners*, Thomas Telford Ltd., London

Stagl, S. (2007). *SDRN Rapid Research and Evidence Review on Emerging Methods for Sustainable Valuation and Appraisal*. A report to the Sustainable Development Research Nertwork, Final Report, Policy Studies Institute, London.

Stakeholder Management Pty. Ltd, 2006, The Stakeholder Circle, [online] Available at: http://www.stakeholder-management.com/shopcontent.asp?type=methodology-description [accessed:6th July 2016].

Stewart, T.J., French, S. and Rios, J., 2013. Integrating Multicriteria Decision Analysis and Scenario Planning - Review and Extension. *Omega*, Vol. 41, pp. 679–688

Stirling, A. & Mayer, S. (1999) *Rethinking Risk: A Pilot Multi-Criteria Mapping of a Genetically Modified Crop in Agricultural Systems in The UK*, (SPRU Report No 21), Science Policy Research Unit, University of Sussex.

Stirling, A., 2006. *Analysis, Participation and Power: Justification and Closure in Participatory Multi-Criteria Analysis*, Land Use Policy, vol. 23, pp. 95–107.

Stirling, A., (2008a) Precaution, and the Politics of Technological Risk: Converging Implications in Evolutionary and Social Scientific Perspectives, *Annals of the New York Academy of Science* 1128, 95–110

Stirling, A. (2008b) 'Opening up' or 'Closing down': Participation, pluralism and diversity in the social appraisal of technology. Science, Technology & Human Values, 33, 262-294.

Surowiecki (2004) The Wisdom of Crowds. Anchor Books.

The Systems Centre, University of Bristol and The Bartlett, University College London (2013) *A Proposed Interdependency Planning and Management Framework: Development and Application for UK Infrastructure*, Final Report prepared for HM Treasury and Infrastructure UK, Contract HMT 1055, University of Bristol, Bristol, September

Tisdell, C.A. (2005) *The Economics of Environmental Conservation*, Edward Elgar, Cheltenham

Thompson, P.B., 2010. What Sustainability is (and What It isn't). In Moore, S.A. (Ed.), *Pragmatic Sustainability – Theoretical and Practical Tools*. Routledge, pp. 16-29.

Triantphyllou, E. and Mann, H. (1989). An Examination of the Effectiveness of Multi-Dimensional Decision-Making Methods: A Decision-Making Paradox. Decision Support Systems, 5, 303-312.

US Congress, (1969) The Planning-Programming-Budgeting System: Progress and Potentials. In Hinrichs, H.H. & Taylor, G.M. (Eds.) *Program Budgeting and Benefit-Cost Analysis: Cases, Texts and Readings,* Goodyear Publishing Co., Pacific Palisades, California

Van Wee, B. (2011) How Suitable is CBA for Ex-Ante Evaluation of Transport Projects and Policies? A Discussion from the Perspective of Ethics, *Transport Policy* 19(1), 1-7.

van Wee, B. & Rietveld, P. (2013) CBA: Ex-Ante Evalutation of Mega-Project. In Priemus, H. & van Wee, B. (Eds.) *International Handbook on Mega-Projects,* Edward Elgar, Cheltenham

van Wee, B., and Tavasszy L.A. (2008) Ex-Ante Evalutation of Mega-Project: Methodological Issues and Cost-Benefit Analysis. In: Priemus, H., Flyvbjerg, B. and van Wee, B. (Eds.) *Decision-Making on Mega-Projects: Cost-Benefit Analysis, Planning and Innovation*, Edward Elgar, Cheltenham

Vasconcellos, E. (2003) Inclusion of Social Benefits in Road Transport Planning, unpublished paper sent by author to H.T. Dimitriou

Véron-Okamoto, A. and K. Sakamoto (2014) 'Toward a Sustainability Appraisal Framework for Transport', ADB Sustainable Development Working Paper Series, No. 31, Asian Development Bank, Manila, January

Vincke, P. (1992) *Multicriteria Decision-Aid*, John Wiley&Sons, New York.

Vining, A.R. & Weimer, D.L. (1992) Welfare Economics as the Foundation for Public Policy Analysis: Incomplete and Flawed but nevertheless Desirable, *Journal of Socio-Economics* 21(1), 25-37

Vickerman, R. (2008) Cost-Benefit Analysis and the Wider Economic Benefits from Mega-Projects. In Priemus, H., Flyvbjerg, B. and van Wee, B. (Eds.) *Decision-Making on Mega-Projects: Cost-Benefit Analysis, Planning and Innovation*, Edward Elgar, Cheltenham

Wilkinson, A., & Kupers, R.. (2014). *The Essence of Scenarios: Learning from the Shell Experience*. Amsterdam University Press. Retrieved from http://www.jstor.org/stable/j.ctt6wp7mz

Wideman, R.M. (2004) *The Role of the Project Life Cycle (Life Span) in Project Management - A review of literature Over Three Decades*, [online] Available: http://maxwideman.com/papers/ [accessed 5th July 2013]

Appendix: OMEGA 2 Project Lessons

LESSON 1: Megaprojects as 'Agents of Change'
There is a need for a change of mind-set concerning the way in which* megaprojects *are positioned, framed and planned.

Key Recommendations

Many MTPs are not megaprojects but programmes of a combination of mega projects ('metaprojects') that evolve over time and in different contexts. Such projects frequently become critical 'agents of change' that have multiple spatial, economic, environmental impacts. The potential for such projects to change the contexts into which they are placed however is often under-appreciated by decision-makers. Therefore, for any new mega/metaprojects it is opportune to investigate from the outset and during its strategy formulation, the project's interdependencies with other projects, as well as its transformational potential - regarding the types of change spawned, the timeframe needed and resources and policies required.

Implications for PLMCA

An in-depth problem analysis needs to be carried during the initial phase of the MCA exercise to better understand the projects 'agent of change' potential. This should be undertaken by the project's lead entity (including as a minimum the project promoter and appraisal facilitator) and should guide and inform the successive steps of the MCA process.

LESSON 2: Megaprojects as 'Open Systems'
Planning, appraisal and delivery agents need to recognise that megaprojects are phenomena that require treatment as 'open systems' in light of their complex and fluid relationships with the areas, sectors and communities they serve, traverse and impact upon.

Key Recommendations

The best way to deal with emergent opportunities and threats posed by MTP development cycles appear to be *via* an 'open system' approach, aiming to address not only issues, problems and influences that occur *within* the megaprojects themselves but also consider the complex interrelationship between such projects and their external environment(s) in which they have been placed. Adopting this position implies the need to acknowledge that many outcomes of megaproject planning, appraisal and delivery processes are difficult to identify precisely; and to accept unanticipated events as part of an 'emergent order'.

Implications for PLMCA

The MCA process adopted must enhance stakeholder awareness of the significant levels of risk (and opportunity), uncertainty and complexity that megaprojects usually entail - both internal and external to the project. In so doing, the MCA process advocated needs to offer frameworks and attendant processes for the identification and management of such risks by also acting as a risk (and opportunity) register and by underlying the uncertainty in the outcomes of the analysis. Furthermore, as the application of MCA is advocated throughout the project lifecycle, its framework and attendant processes is more likely to capture (to some degree) a level of 'emergent order' as a result of identifying/monitoring emergent objectives and changes in stakeholder interests and/or priorities over time.

LESSON 3: Megaprojects as 'Organic' Phenomena
Megaprojects are 'organic' phenomena - rather than static engineering artefacts - that often need 'time to breathe' in their preparation which can present special opportunities that should be seized and exploited by key decision-makers.

Key Recommendations

Often, particularly in the case of the larger and more complex MTPs, a period of reflection ('time to breathe') in the preparation of such projects is necessary. This is required to both ensure a genuine re-examination of past decisions and to incorporate newly 'emerging objectives' that may reshape the original project's vision (and outcomes) in light of the changing contextual influences impacting the function of the project and its interdependencies.

Implications for PLMCA

Any MCA process employed should capture a series of 'snapshots' at different stages of the project lifecycle, recording the projects objectives, policy leadership and stakeholder agendas so as help to develop a suitable project decision-making platform for subsequent planning and appraisal exercises. Contextual changes and emerging needs, it should be reminded, can trigger further such exercises to reappraise the project by undertaking additional different iterations.

LESSON 4: The Framing of megaprojects:
The changing demands placed on megaprojects can make it excruciatingly difficult to judge their successes and failures. This makes it imperative to ensure proper project framing so as to enable their appraisal to be based upon a fair and transparent foundation.

Key Recommendations

A clear early statement of the envisaged roles, goals, objectives of MTPs, together with clarification regarding the project's underlying assumptions, appraisal criteria and anticipated impacts need to be provided and thoroughly discussed with all key project stakeholders. Sound judgements about the 'success' (or failure) of a MTP is more likely to be achieved/understood when such projects are presented to key decision-makers in a manner that lays out *all* key financial and economic costs and benefits alongside non-financial and economic costs and benefits. This needs to be done in a transparent way against different time lines and within a policy-led multi-criteria framework to enable a multi-faceted assessment of progress to be gauged. This assists the setting of priorities and helps make trade-offs among different project objectives and stakeholder interests much clearer and more transparent.

Implications for PLMCA

The appropriate framing of problems and challenges that an MTP is to address is central to any MCA approach employed. Moreover, the particular structure of the MCA framework and its attendant processes facilitates the breakdown of the priorities of different stakeholders into objectives and sub-objectives pertaining to the four pillars of sustainable development and the decomposition of them, in turn, into appraisal criteria and specific indicators of performance. The identification of objectives and the formation of relevant related criteria is a critical task of any MCA approach. This can present particular challenges due to the multi stakeholder nature of the advocated approach but nonetheless is seen to generate more enduring outcomes.

LESSON 5: The Power of Context
Context awareness and sensitivity to context on the part of megaproject decision-makers is vital for both the successful planning, appraisal and delivery of such projects and suitable treatment of contextual risks (opportunities), uncertainties and complexities.

Key Recommendations

For the 'successful' planning, appraisal and delivery of MTPs the recognition and analysis of the impacts and implications of the risks, uncertainties and opportunities associated with changing (temporal, geographical, cultural, environmental, political, societal and economic) contexts throughout their lifecycles - from project conception through to completion and project operations - is fundamental.

Implications for PLMCA

The advocated approach does not attempt to propose a particular MCA as the 'best approach" for any phase of project lifecycle but, conversely, it adopts different multi-criteria appraisal methods and approaches according to the level of risks, uncertainties and complexities that characterizes a particular issue for which an analysis is required. For example, it is equally applicable to the appraisal of issues or problems attracting a multiple-institutional response where ultimately an institutional leader or partnership emerges that impose its/their priorities (such as the development of a particular city zone) *or* tailor-made for specific institutions (such as the appraisal of specific urban regeneration projects) with its imbedded hierarchy of policies and priorities that frame the MCA space within which outsiders are invited to trade interests.

LESSON 6: Role of Sustainable Development Visions

The lack of a clear and shared vision of the meaning of 'sustainable development' threatens to seriously undermine the potential for, and use of, megaprojects to make a positive contribution to its achievement. Simultaneously, it is readily apparent that there is a widespread lack of clarity about the capability of such projects to support sustainable development visions -despite the rhetoric that exists in this respect.

Key Recommendations

Megaproject development processes should address sustainability concerns through the consideration of the environmental, economic, social and institutional dimensions of sustainable development challenges. However, the lack of a clear and shared vision of the meaning and the consequent operationalization of the concept of 'sustainable development', and inbuilt conflict between concerns for environmental sustainability and the manner in many MUTPs are designed and funded undermine the potential for, and use of, MUTPs to make a positive contribution to this objective.

Implications for PLMCA

The introduction of the adapted HalSTAR model as basic method to cross-check possible omissions from the list of appraisal criteria may be considered a starting point towards the addressing of sustainability concerns. These should, however, be supplemented by relevant policy directives before incorporation into the PLMCA.

LESSON 7: Engaging with megaproject Stakeholders

***Effective and early engagement with key stakeholders is seen as critical in megaproject planning, appraisal and delivery. This presents important opportunities to manage/mitigate risk, uncertainty and complexity in project developments and more specifically to assist in the adjustment of project objectives to address manifold contextual influences* (and changes thereto), manage expectations and help progress the project delivery process.**

Key Recommendations

Effective and early engagement with key stakeholders is seen as critical for dealing with risk, uncertainty and complexity in project developments, although the identification of key stakeholders and the analysis of their mutual relationships may be very challenging.

Implications for PLMCA

The OMEGA Centre recognizes the critical importance of conducting the PLMCA exercise through a participatory approach with multiple stakeholder groups. It also recognises the need to carry out further PLMCA analyses in response to changing contexts throughout the project lifecycle.

LESSON 8: Institutional, Policy and Legislative Support

Megaprojects are unlikely to be able to deliver the full range of agent of change benefits unless accompanied by a suitable institutional, policy and legislative framework that is in place

throughout the project lifecycle.

Key Recommendations

MTPs are unlikely to be able to deliver the full range of agent of change benefits *unless* accompanied by a suitable and permanent institutional, policy and legislative frameworks throughout the project lifecycle, which may make easier for MTPs to respond to contextual change.

Implications for PLMCA

The revised OMEGA MCA Framework is driven by policies and related plans. One of the main analyses required at the beginning of the process is depicted by the definition of the policy (and planning) context which, then, helps decision makers in:

- defining the boundaries within which the trade-off will take place as well as the areas which instead are not negotiable;
- Identifying objective, sub-objective, appraisal criteria and indicators of each stakeholder group, as well as highlighting conflicts between stated aims and hidden agenda of some parties;
- Selecting viable alternative options to be appraised which are compatible with government guidance;
- ultimately establishing priority between appraisal criteria during weighting procedure.

Without explicit policy leadership, it is contended that certain multi-institutional and stakeholder priorities will be imposed by the most powerful. This matters a great deal in contexts when the powers shift - when national governments become, for example, less powerful and economically less affluent, when a major private sector investor upon which the megaproject depends goes bankrupt or when relative powers become less or more binding/powerful.

LESSON 9: Lesson Learning and Sharing

It is apparent that systematic, widespread lesson-learning and sharing is not currently a significant feature of megaproject planning, appraisal and delivery, and that there are few examples in the public domain of post-project evaluation that go beyond time/cost/specification assessments of project performance. Furthermore, there is evidence to suggest that knowledge acquired by the private sector in the field of megaprojects developments is frequently jealously guarded for commercially competitive gain, often ultimately at the expense of the public purse.

Key Recommendations

It is fundamental to ensure the systematic spread and sharing of 'good practices' and key lessons learned from past megaprojects experiences by the establishment of 'knowledge platforms' capable of breaking through the tendency for silo thinking which characterizes different organizations, departments and professions, especially in the public sector.

Implications for PLMCA

PLMCA may also depict a knowledge platform by means of having lesson learning integrated within its core processes. In effect, the OMEGA Centre Lessons which have been obtained from the analysis of 30 selected megaprojects in 10 countries and on which the revised OMEGA MCA Framework is grounded, constitute already themselves important advices for decision-makers which can be integrated within the PLMCA in the form of criteria.

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