PROBLEM STRUCTURING FOR MULTICRITERIA DECISION ANALYSIS INTERVENTIONS

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INTRODUCTION

Multicriteria decision analysis (MCDA), a methodology for supporting decision making when multiple objectives have to be pursued [1–3], has been extensively used to support a wide variety of complex decision problems [4,5]. While the literature on axiomatic aspects of multicriteria decision analysis models is extensive, much less attention has been devoted to the process of structuring these models, with few exceptions [6–8].

The task of structuring MCDA models in real-world interventions is far from trivial. This is mainly due to the intrinsic complexity of the models, where several objectives have to be articulated, defined, and measured by attributes. Furthermore, the definition of a set of alternatives to be evaluated is not always straightforward, as decision makers may struggle to think creatively about the problem and consider innovative alternatives.

At a broader level, much of the MCDA literature neglects the role of problem structuring as a prelude to the structuring of an MCDA model, a phase of the intervention whose proper management is absolutely crucial if both the decision analysts and the decision analysis are to have some effect on the organization.

In this article, we discuss problem structuring for MCDA interventions. There is a limited literature on how to structure MCDA models, and this will be reviewed here. Furthermore, while there is a large body of literature on problem structuring and on problem-structuring methods, most of it is disconnected from the mainstream MCDA literature. We will build on this body of work to give a coherent perspective on problem structuring for MCDA, which we hope will be useful for both MCDA researchers and practitioners.

The chapter is structured as follows: we start by discussing two key problem-structuring tasks concerning the earlier stages of an MCDA intervention. The subsequent section reviews general guidelines for structuring MCDA evaluation models. In the final section, we build on the preceding sections to propose a general framework for conducting MCDA interventions, in which problem structuring plays a significant role. The chapter ends with concluding remarks and some directions for further research in the field.

STRUCTURING THE PROBLEM SITUATION

There are two main problem-structuring tasks faced by decision analysts when conducting MCDA interventions: *defining the problem*, and *scoping participation*. Below we discuss each of these tasks and comment on the challenges the decision analyst may encounter when carrying them out, together with a set of tools/techniques that could be used to facilitate their achievement. Although, in the discussion that follows, we present each problem-structuring task separately, it is worth noting that in practice these tasks are not necessarily undertaken in a linear fashion. Rather, there are two "modes" of problem structuring between which the decision analyst is continually "cycling" during the early stages of an MCDA intervention.

Defining the Problem

Given the significance ofproblem formulation

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in organizational decision making [9–12], it is surprising that the literature on MCDA has devoted relatively minor attention to the processes of articulating and defining a multicriteria problem. It seems that the underlying assumption is that arriving at a well-structured multicriteria decision problem is somehow a relatively trivial task. There is also a widespread belief among many practitioners that structuring a decision problem is more "art than science" and that it can best be learned through experience. This view suggests that experienced analysts are able to recognize familiar patterns or structures of problems, and use them as templates to build their decision models [13]. Our experience as researchers and consultants, however, suggests that the use of decision analytic structures are well suited to problem situations that are clearly defined, but less so when they are ill-structured or 'messy' [14]. In such situations, attempts to impose a structure too early in the intervention can lead to focusing on and solving the 'wrong problem' and thus incurring in what is known as the *Type III* error [15].

Indeed empirical research has shown that the definition of problems, particularly those of the ill-structured type, is not given but continually negotiated among members of the organization before and during an intervention [16]. This process of negotiation can be conceptualized as follows. First, managers are constantly striving to make sense of their internal and external environments in order to manage and control their organizations [17]. This sense-making process is aided with the help of a unique mental framework that is developed through experience, and which includes systems of beliefs and values. A 'problem' emerges when the use of such a mental framework, to make sense of a particular situation, leaves the manager uneasy or dissatisfied because she/he does not know how to deal with that situation. Because different managers will experience different problems by applying their own unique mental frameworks to what might be thought of as the same situation, the decision analyst will not be able to think and talk about the 'problem' without ascribing an owner or owners to it.

Second, the problem which will eventually be presented to the analyst is the result of a process of 'problem framing' within the organization, most typically within a team of managers. As Eden and Sims aptly illustrate, a manager who wishes to get others in the team to take on a problem she/he has identified as being the team's, "...will present the problem in such a way as to make it apparent that there are gains to be had or losses to be averted for other members of the team by solving this problem. He (sic) may seek to show some member of the team that a solution to his (the initial problem's definer) problem would also solve some different problem, which he believes this member to be experiencing....he may define his problem to be in line with other problems which seem to be being experienced at that time....(or) express concern and commitment about some problem being stated by another member in the hope of getting some concern and commitment about his problem in return" (16, p. 121).

Thus, we might expect that when the analyst starts an MCDA intervention with a given problem situation presented by the client, the reality is that other versions of the same situation are likely to exist. These other versions will become apparent as the analyst listens to others in the organization. One challenge for the analyst at this stage is then not so much to model what will become the actual multicriteria decision problem to be solved, but to identify and model the different perceptions of the *problem situation* held by different managers. Several problem-structuring tools are available to support this task. These include, for example, cognitive mapping [18,19]; soft systems methodology [20,21]; dialog mapping [22]; strategic choice approach [23], and group model building [24,25]. (For an overview of these tools see Ref. 10.)

Most of these tools have been developed to capture multiple aspects of a problem situation, including objective and subjective ones. This is important because when managers define a problem situation, it will be defined in their own language and based on their own interpretations of the situation, their own experience or expertise and their own value

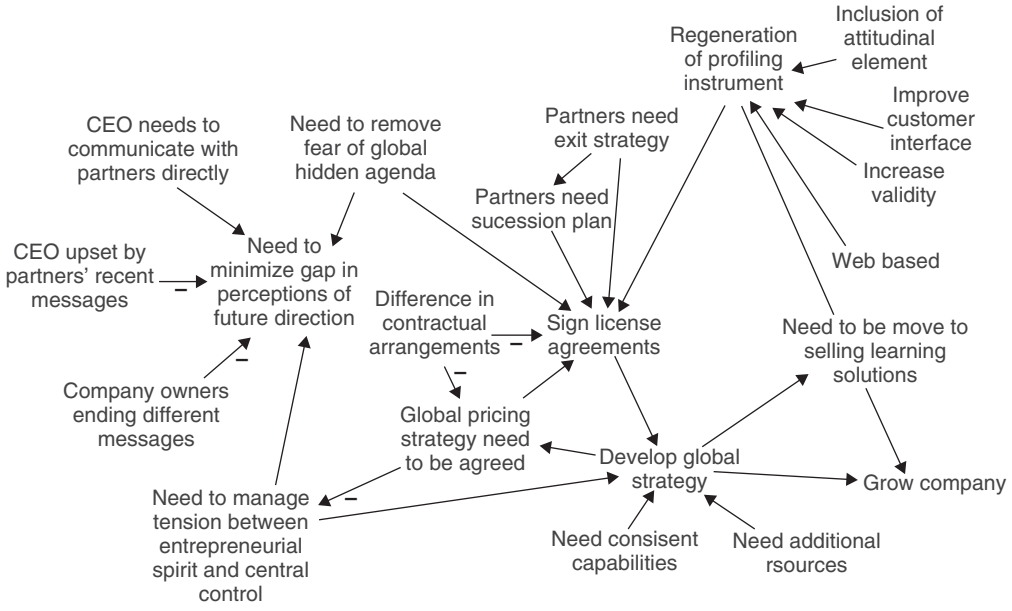

Figure 1. An example of a cognitive map, representing strategies for growth of an organization.

systems. A problem situation defined in this way will thus include factors that may not be typically regarded as legitimate variables in a standard MCDA modeling project, but that are nevertheless important if the analyst wishes to understand the needs and concerns of any particular client or client group. The challenge for the decision analyst is, therefore to be able to formally map aspects of the problem situation in terms of the concepts used by the client. For if there is a doubt in the client's mind about whether correct concepts have been taken into account, she/he is unlikely to believe in the solution to the problem, let alone act upon it [16].

For example, Fig. 1 illustrates a way to capture a client's understanding of a problem using the client's own concepts. The figure shows the beginning of a cognitive map that contains different aspects of a problem faced by an organization operating in the learning and professional development sector. Here the client is concerned about the growth of the organization, which eventually led to a multicriteria evaluation of strategic priorities at a later stage in the intervention. Nodes in the map contain statements describing different aspects of the problem. The links between the statements denote means–end chains of arguments. For example, the "regeneration of profiling instrument" (top right in the map) is seen by this client as a way to get partners to "sign license agreements" (center right in the map).

The recognition that problem definition in organizations involves negotiation between managers with multiple world-views [20] about the problem has some practical implications for the analyst. First, if the MCDA intervention is intended to have some effect on the organization, the decision analyst may need to discuss a redefinition of the problem with the client before trying to help. The structuring tools cited above can all assist in this process [10]. Secondly, when working with members of a client group that have different views or interpretations of the problem situation of interest, the analyst must choose whose interpretation to pay attention to. The choice does not necessarily imply favoring one particular interpretation over another. Rather, it is about focusing on some combination of interpretations which for reasons that are explained later in the chapter, will often be a reflection of the analyst's understanding of the key stakeholders of the organization.

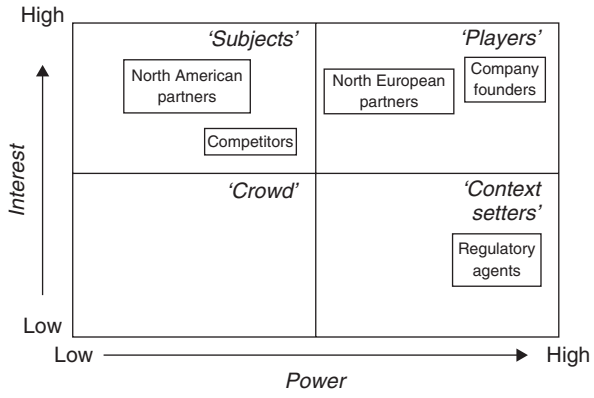

Figure 2. An example of a power–interest grid of stakeholders when considering strategies for growth of an organization.

Once the problem situation has been defined and agreed with the client or client group, the decision analyst should be in a good position to identify a particular decisional element of the situation upon which a relevant a multicriteria evaluation model can be built. A quite useful tool at this stage is Keeney's concept of decision framing [6], which connects the strategic objectives of the organization with the fundamental objectives for the particular decision and the alternatives to be considered [as illustrated by Barcus and Montibeller [26]]. However, before proceeding, the decision analyst must scope the required levels of participation needed for the subsequent stages of the intervention. This aspect is discussed next.

Scoping Participation

Nutt conducted a careful analysis of 400 decisions in a variety of organizations and found that almost half of them 'failed' in terms of implementation (e.g., not implemented or only partially implemented) or the achieved results (e.g., poor results rather than good results) [27]. He discovered that the overriding reason for these failures was due, in large part, to the failure of decision makers to attend to the interests and information held by the *key stakeholders* of the organization. Although several definitions of stakeholders are possible [28], we conceptualize them here as those individuals, or groups, who have the power to affect the decision under consideration; or those groups that are affected, or perceived to be affected, by the decision. This broad definition thus considers the internal as well as the external stakeholders of the organization.

Within the context of an MCDA intervention, attention to stakeholders is needed to assess and enhance political feasibility of decision implementation. Attention to stakeholders is also important to satisfy those involved in, or affected by, the decision that the intervention has followed rational, fair, and legitimate procedures. This does not imply that all possible stakeholders should be satisfied by or involved in the intervention; only that the key stakeholders must be. As in the case of defining the problem, the choice of which stakeholders are "key" should be the result of a discussion between the client and the analyst.

In the literature, there are several tools available for stakeholder analysis [28,29]. The most widely used techniques include the power–interest grid, star diagram, and stakeholder influence map [17]; and stakeholder–issue interrelation diagram and problem-frame stakeholder maps [28]. For example, Fig. 2 shows a power–interest grid for the problem situation discussed earlier. The grid arrays stakeholders on a two-by-two matrix, where the dimensions are the stakeholder's interest or stake in the decision at hand (i.e., they care about the decision or are affected by it), and the stakeholder's power to affect its implementation or impact. Four broad categories of stakeholders are shown in Fig. 2: 'players' who have both, an interest and significant power (e.g., Northern

European partners); 'subjects,' who have an interest but little power (e.g., North American partners); 'context setters,' who have power but little direct interest (e.g., regulatory agencies); and the 'crowd,' which consists of stakeholders with little interest or power. The grid allows the decision analyst to determine which players' interests and power bases must be taken into account in order to address the decision at hand.

Whichever stakeholder identification technique is used, the actual process of choosing which stakeholders to involve in the intervention is often the result of several iterations along the following generic stages [28]:

- The analyst and client initiate the process by doing a preliminary stakeholder analysis, using any of the analysis techniques cited above. This step is useful in helping the client to think strategically about how to create the conditions needed for the intervention to reach a successful outcome.
- After reviewing the results of this analysis, a larger group of stakeholders can be assembled if judged appropriate. The assembled group should be asked to brainstorm the list of stakeholders, who might need to be involved in the intervention. Again, many of the techniques cited above might be used as a starting point. After this analysis has been completed, the analyst should encourage the group to think carefully about who is not at the meeting but that should be at subsequent meetings during the intervention. The analyst should ask the group to carefully think through the positive and negative consequences of involving—or not—other stakeholders or their representatives, and in what ways to do so.
- Last, both analyst and client finalize the various groups, who will have some role to play in the intervention. These will typically include the sponsors and champions, a coordinating group, a core decision analysis team, and various advisory or support groups [23].

The above process should be designed by the decision analyst to gain needed information, build political acceptance, and address some important questions about legitimacy, representation, and credibility [28]. However, the analyst should encourage the client to include stakeholders only when there are good and prudent reasons to do so. They should not be included when their involvement is not needed, impractical, or inappropriate.

Once the required participation is scoped, the next stage in the intervention process is to structure the MCDA evaluation model, which we present next.

STRUCTURING MCDA EVALUATION MODELS

There are three main tasks in structuring MCDA evaluation models: the *representation of objectives* in a value tree, *the definition of attributes* to measure the achievement of objectives, and *the identification of decision alternatives*. Below, we discuss each of these tasks and discuss the challenges that an analyst may encounter when undertaking them, as well as the tools/techniques that may be used to support their accomplishment.

Structuring Value Trees

The first step in building an MCDA evaluation model is always to represent the objectives that decision makers want to achieve (e.g., increase profitability, increase flexibility, reduce damage to the environment, and so on). In many multicriteria models, but particularly so in multi-attribute utility/value models [2], these objectives are organized as a value tree [1,30]. A value tree decomposes the overall objective of an evaluation into operational objectives, which can be more easily employed to assess the performances of decision alternatives. For example, Fig. 3 presents a value tree for evaluating different sites for building an industrial plant in Brazil. The client was concerned with the logistic costs associated with each site but also wanted to take into consideration the potential benefits from each site, such as accessibility to logistic

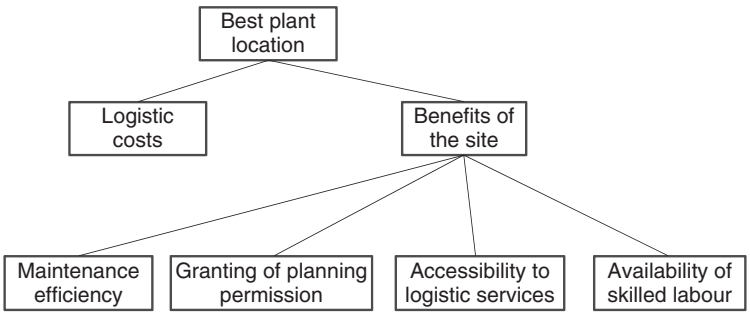

Figure 3. A value tree for selecting an industrial plant location.

systems (e.g., warehouses) and availability of skilled labor required for operating the plant.

Two approaches have classically been suggested for structuring a value tree [31,32]: top-down and bottom-up. The top-down approach is driven by the overall objective, which is then decomposed into objectives and the latter ones into sub-objectives, and so on. For example, if an analyst is structuring a value tree for the plant location problem described above, using a top-down approach, he/she would start with the overall objective (best location for the plant) and decompose it into logistic costs and benefits of the site. Each of these objectives could be decomposed even further, if required. The bottom-up approach is driven by the alternatives. In this case, the analyst would try to identify which attributes distinguish the alternatives and they would be included in the value tree. These attributes would then be grouped by their nature (e.g., in the plant location problem, all the attributes related to the potential benefits from a given site) and these groups could be further grouped upwards, composing the value tree.

There are compelling arguments that MCDA should employ a value-focused thinking approach for supporting decision making [6], as alternatives should be seen as mere means for organizations to achieve their fundamental and strategic objectives. This calls for a more top-down approach for structuring value trees. On the other hand, behavioral decision research has shown that individuals may struggle to think about their fundamental objectives [33], and may need prompts from the analyst to reflect about the objectives prior to their explicit articulation. Behavioral research has also discovered that these two approaches (top-down and bottom-up) may generate value trees with different shapes [34], as values are "constructed" instead of merely extracted from decision makers' minds [35]. Therefore, the choice of approach is clearly an important modeling decision that the analyst has to make.

Other possible tools for structuring a value tree involve the use of probes and grouping of ideas, such as Belton and Stewart's CAUSE probes [1] and Parnell's affinity diagrams [36]. Another set of tools for such purpose involves qualitative models that represent causality/influence between variables. Along these lines, Keeney [6] suggests the use of networks of means–ends objectives, where arrows represent the influence between a means and an end objective. Cognitive maps (illustrated in Fig. 1), a network of ideas connected by perceived influence and having a means–ends structure, have also being employed for structuring value trees [37–39] as discussed in Montibeller and Belton [40]. In a similar way, Merkhofer [41] suggests the use of qualitative influence diagrams to help the structuring of value trees. The main advantage of using these causality/influence tools is that they permit laddering-up toward the decision makers' values, and laddering-down toward the attributes and decision alternatives, in a systematic and integrated way.

Objectives in a value tree must follow a set of properties that need to be checked when structuring it [1,2,6]. These properties are the following:

- *Essential.* They should consider all the essential organizational objectives involved in the decision.
- *Understandable.* They should have a clear meaning for all the members of the group involved in making the decision.
- *Operational.* It should be possible to measure the performance of decision alternatives against each of the fundamental objectives.
- *Nonredundant.* They should not measure the same concern twice.
- *Concise.* It should be the smallest number of objectives required for the analysis.
- *Preferentially independent.* If it is possible to measure the performance of decision alternatives on one objective disregarding their performance on all other objectives, then a simpler aggregation function can be used to aggregate partial performances.

Checking that these properties are observed in practice will usually, impact on the structure of a value tree. For example, a new objective may be included if the initial set does not cover all the essential issues in the evaluation. An objective may be removed, if it is not operational (e.g., if the information is considered as important but is unobtainable) or if it is redundant. Concerns about conciseness also can reduce the size of a value tree. Finally, if there are objectives that are preferentially dependent, the analyst may choose to restructure them to avoid using a complex aggregation function (for a detailed discussion on how to deal with preferential dependences, see Ref. 6).

Defining Attributes

For each objective placed at the bottom level of the value tree, an associated attribute or criterion should be specified. This attribute is a performance indicator employed to measure the impact of adopting each decision alternative on the organizational objective being pursued. There are two dimensions for classifying attributes in terms of: 1) the way it is measured; and 2) its alignment with the objective being pursued [6,36,42]. We describe these two dimensions below.

The way the objective is measured: Direct or Indirect

- A *direct attribute* measures directly the degree of attaining the objective. For example, in Fig. 3, logistic costs have a direct attribute: the total logistic cost in US dollars.
- A *proxy attribute* measures indirectly the concern expressed by the objective, by assessing the degree of achievement of its associated objective. For instance, in the value tree shown in Fig. 3, the concern about having the planning permission granted is assessed by the number of months required for the processing of such permission.

The type of attribute: Natural or Constructed

- *Natural attributes* measure directly the concern expressed by the objective, are of general use and have a common interpretation. An example, in the value tree shown in Fig. 3, is to measure the logistic costs in US dollars.
- *Constructed attributes* measure directly, using indicators created specifically by the analyst, the concern expressed by the objective. In the plant location example, the availability of skilled labor (Fig. 3) is measured by a set of labels ranging from the best level ("wide availability of skilled labor from similar production plants in the region") to the worst one ("the plant will need to provide training to all its new employees").

Attributes can then be classified using these two dimensions; for example, a direct-natural attribute or a direct-constructed one. In terms of the way the objective is measured, whenever possible, it is usually better to use a direct attribute instead of a proxy one. If a direct attribute is not available, many times it is feasible to decompose an objective into subobjectives—with these subobjectives being assessed via direct

attributes—but avoiding excessive decomposition. In the same way, regarding the type of the attribute, a natural attribute is typically better than a constructed one, if the former is available and provides a clear way for decision makers to assess the alternatives. (See Refs 36, 42, and 43 for a comprehensive discussion on defining attributes and guidelines on how to develop suitable ones.)

Independently of its type, each attribute should possess five properties [42] if it were to be employed in a MCDA evaluation model:

- *Unambiguous.* The attribute should present a clear relationship between the impact of adopting a decision alternative and the description of such impact.
- *Comprehensive.* The attribute should cover the full range of possible consequences, if the decision alternatives were implemented.
- *Direct.* The attribute levels should describe as directly as possible the consequences of implementing a decision alternative.
- *Operational.* The information required by the attribute can be obtained in practice and it is possible to make value trade-offs between objectives [1,2].
- *Understandable.* Consequences and value trade-offs using the attribute can be clearly understood by the decision making group and communicated to other stakeholders.

Quantitative attributes tend to be less ambiguous than qualitative ones. A key point about comprehensiveness is that the upper and lower limits of the attribute are well-specified (maximum feasible and minimum acceptable, respectively) otherwise it would distort value trade-offs. Finally, it is critical that attributes are understandable, particularly if the analysis involves a group of decision makers and the modeling is conducted in a facilitated mode [44], such as in a decision conference [45].

Identifying Decision Alternatives

The other major task in structuring an MCDA evaluation model is the definition of which decision alternatives will be assessed by the model. Traditionally, MCDA has taken an alternative-focused thinking perspective, where the set of options was assumed as given and stable [3]. However, the identification and creation of new alternatives is certainly one of the most important aspects of any MCDA intervention. No matter how careful and sophisticated the evaluation model is; if the decision alternatives under consideration are weak, it will lead to a poor choice [46].

An important aspect in structuring an MCDA model is that the decision alternatives should have the same nature (in the plant location example, for instance, all the alternatives are potential sites). If the analyst is careless about this aspect, it may be difficult to create a coherent value tree. There are several tools that may be employed in the creation/definition of decision alternatives, such as brainstorming techniques [47], cognitive mapping [18], dialog maps [22] among others.

Particularly useful tools are the ones, where decision alternatives are created from considering the decision makers' objectives [6] or stakeholders' values [48]. For example, the analyst can ask the decision makers to imagine options that could perform really well on a single objective. This process can be repeated for each of the fundamental objectives present in the value tree. Once the list of objectives is exhausted, the same procedure can be done for two objectives at once. Another way of creating a new option is by combining the existing alternatives, trying to maintain the best features of each alternative. Recently we have used a value-focused brainstorming using a cognitive map—which allowed eliciting, organizing, and displaying a large set of ideas from a client group—these ideas were then grouped as decision alternatives [39]. [For an extensive review of tools for creating alternatives see Keeney [6], Keller and Ho [49] and Parnell *et al*. [29].]

Although there is a natural tendency by decision makers to discard decision alternatives or options that may appear to generate some negative outcomes, any attempt at option evaluation should be contained at this stage. The assessment of alternatives should

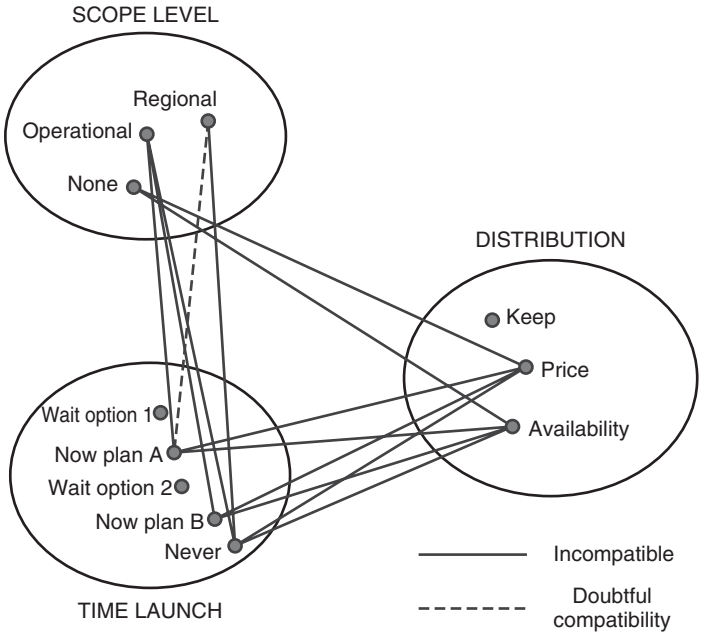

Figure 4. An example of areas of interconnected options.

be left for the evaluation phase of the process and not intermingled with their generation.

Another aspect concerning the identification of decision alternatives is that there are instances where the alternatives are comprised by a large set of sub-options. There are some methods that can be used to structure complex decision alternatives. The strategy generation table proposed by Howard [50] is a simple way of creating decision strategies from the combination of options under several dimensions. Another tool is the analysis of interconnected decision areas (AIDA) technique that is a part of the strategic choice approach [23]. In this technique, the links between several "decision areas" are represented, each one with several options, with their compatibility explored, in order to generate a list of possible option portfolios. For example, in an intervention with a major international hotel company, we used AIDA to initially shape a strategic decision concerning how to tackle "cost of sale," and produced a list of candidate interconnected strategic options, grouped in three areas (*distribution, timing launch,* and *scope level*). This is shown in Fig. 4, where the links between specific options represent incompatible combinations.

AN INTERVENTION FRAMEWORK

The techniques for multicriteria evaluations are already well-established in the literature. However, there has been much less investment in the development of techniques to support the structuring stages of MCDA interventions. We have reviewed both the mainstream problem structuring and MCDA literatures, and identified a number of modeling tools, which can be used to support problem structuring in MCDA interventions. Perhaps, more importantly, our foregoing discussion should have made clear to the reader of the important role that problem structuring plays in MCDA interventions.

In Fig. 5, we suggest a framework for conducting MCDA interventions, in which the role of problem structuring is made explicit. In Phase 1, the analyst structures the problem situation, helping the client to arrive at an agreed problem definition, and designs a decision process with the appropriate level of participation. Once this phase is finished,

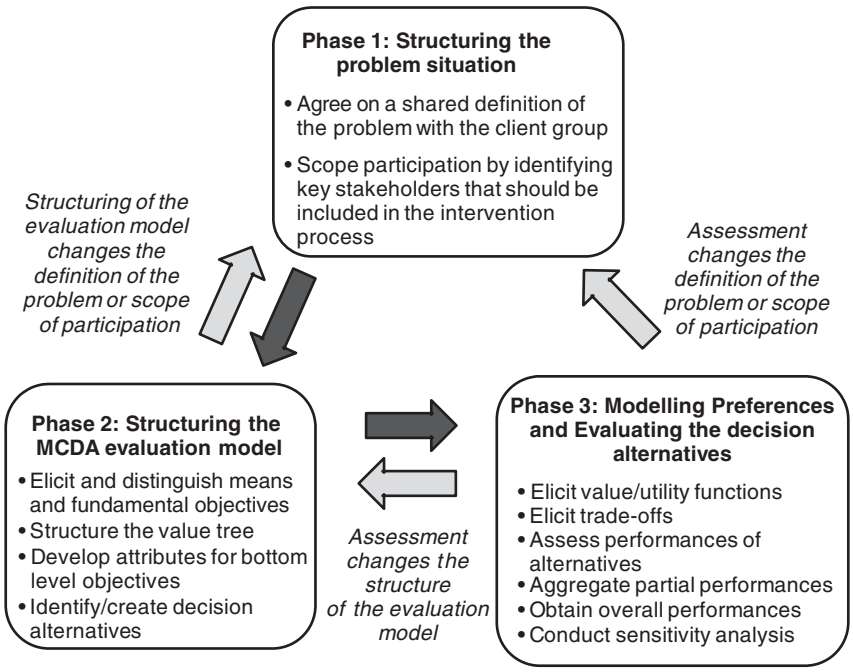

Figure 5. A framework for structuring MCDA models.

the analyst then can start Phase 2, the structuring of an MCDA model, which consists of eliciting and distinguishing means and fundamental objectives, structuring a value tree, developing attributes and identifying decision alternatives. With this second phase completed, the analyst can finally proceed to undertake Phase 3, modelling preferences and the evaluation of decision alternatives. The natural flow of phases is indicated with black arrows in Fig. 5, but notice that the process is not linear and can cycle back to earlier phases (grey arrows): back from Phase 2 to 1, if the structuring of the MCDA model changes the definition of the problem or the scope of stakeholders' participation; back from Phase 3 to 2, if modelling of preferences or the assessment of alternatives changes the structure of the MCDA model; and back from Phase 3 to 1, if modelling of preferences or the assessment of alternatives changes either the definition of the problem or the participation required. Table 1 contains a list of useful tools for supporting the different activities within each of the structuring phases of an MCDA intervention.

CONCLUSIONS AND DIRECTIONS FOR RESEARCH

While decision analysts have recognized for a long time the importance of problem structuring for successful MCDA interventions, most of them have relied on ad hoc practices for structuring the decision problem. The main aim of this chapter has been to provide a review of tools that can help this pre-MCDA evaluation phase of problem structuring. Furthermore, we have also reviewed the main tasks involved in building an MCDA evaluation model per se, while attempting to provide a more integrated view by relating these tasks with the problem-structuring literature.

As discussed in this chapter, there are a number of problem-structuring tools available to help decision analysts deploy effective MCDA interventions. However, our discussion should have also made clear that when the client comprises a group of managers, mastering the tools will not be sufficient. The analyst will also need skills for facilitating the group processes associated with

Table 1. Tasks and Tools for Structuring MCDA Models

Phase 1: Problem Structuring		
Activity	Task	Supporting Tools and Useful References
Defining the Problem	Capture the different understandings about the multicriteria problem and facilitate a definition of the problem that is shared by the client (or client group).	• Cognitive mapping [18,19] • Dialog mapping [22] • Soft systems methodology [20,21] • Strategic choice approach [23] • Group model building [24] • Decision framing [6]
Scoping Participation	Determine the type and level of participation of different stakeholders required for the intervention.	• Power-interest grid; star diagrams and stakeholder influence diagrams [17] • Stakeholder-issue interrelation diagram and problem-frame stakeholder maps [28]
Phase 2: Structuring the MCDA Evaluation Model		
Activity	Task	Supporting Tools and Useful References
Structuring Value Trees	Organize the objectives to be considered in the evaluation as a hierarchy.	• Top-down or bottom-up approaches [31] • Checklist and grouping of ideas [1,36] • Means-ends objective networks [6] • Cognitive maps [37–39] • Qualitative influence diagrams [41] • Checklist of properties for a value tree [1,6]
Defining Attributes	Specify, for each bottom level objective in the value tree, an associated attribute.	• Keeney's and Gregory's [42] decision model for selecting attributes and Parnell's [36] preference ranking for selecting attributes • Kirkwood's [43] classification of attributes and guidelines for their development • Checklist of properties for an attribute [6]
Identifying Decision Alternatives	Define/identify/create decision alternatives to be assessed by the MCDA model.	• Brainstorming [47] • Laddering-down in a cognitive map [18,19] • Dialog maps [22] • Focus on the objectives to be achieved [6,49] • Ideation techniques [29] • Strategy tables [50] • Analysis of interconnected decision areas [23]

defining the problem, which are significantly influenced by the power and interests of the managers in that group [16,44].

It worth noting that the chapter has focused on modeling decision making with multiple objectives. Frequently, however, key uncertainties are present and should also be represented. Useful tools for modeling decision making under uncertainty are influence diagrams [51] and decision trees [52]. A good introduction to this type of modeling is provided by Clemen and Reilly [53] and Kirkwood [54].

We believe that problem structuring for MCDA is a rich field of research, where the focus can be not about developing and testing

suitable problem structuring tools, as well as about the study of facilitated modeling in this intervention context. We thus suggest some directions for further research:

- *Development of Problem-Structuring Methods.* While the field of problem-structuring methods (PSMs) is already well-established in management science, more research could be conducted on tools that could be tailored specifically for MCDA interventions.
- *Integrated Use of PSMs.* The use of standard PSMs with MCDA requires transitions from a problem-structuring model to a multicriteria decision analysis model, which may prove challenging [40]. Consequently, a direction of research is the development of methods that could provide a seamless transition. The reasoning maps method, suggested by Montibeller *et al*. [55], and the use of means objectives to assess the performance of decision alternatives on fundamental objectives, suggested by Butler *et al*. [56] are examples of research in this direction.
- *Tools for Supporting Structuring MCDA Tasks.* The paper reviewed some tools that could be employed for structuring value trees, defining attributes and identifying decision alternatives. The development of new tools is, however, still a potentially area of research—particularly if it were based more on psychological aspects [e.g., how to spark off creativity when creating alternatives; how to identify/display complex options to a group of decision makers, such as the approach proposed by Montibeller *et al*. [39]].

To summarize, this chapter provided an overview of the phases and tasks involved in structuring an MCDA evaluatoin model within an intervention, from defining the problem and identifying key stakeholders to building the MCDA model itself. Problem structuring is a fundamental and challenging task for any MCDA intervention; thus, we hope this chapter may be of help to decision analysts involved in such interventions and may also serve as a useful resource for researchers interested in this field.

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