Decision Analysis and Political Processes

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Abstract

Decision analysis has been with us for at least half a century. Over that time it has developed from a theoretical paradigm for individual rational choice to a practical tool for individuals, small groups and 'unitary' organisations, which helps them towards a sound decision-making mindful of the behavioural characteristics of individuals and group dynamics. Decision analysis has also shown its worth in the context of stakeholder engagement and public participation. The time is right for it to be more widely used in making societal decisions. However, to achieve that we need to realise that in many circumstances it will only be *one* input to the political process that leads to the actual decision. Recognising that suggests that our community of decision analysts needs to deconstruct our paradigm and attend more to communicating the result of the analysis in comparison with other inputs to the societal decision.

Keywords: Bayesian decision analysis; political process; public participation; stakeholder engagement; System 1 and System 2 Societal Deliberation.

1 Introduction

In 2014 Informs' Decision Analysis Society celebrated 50 years of decision analysis. Some might contest that it is somewhat older, beginning perhaps with Ramsey (1926) or even with Benjamin Franklin's oft-quoted 1772 letter to Joseph Priestley. Whatever the case, decision analysis has been with us some time now. In this essay, we want to reflect on its application in societal decision-making. Here by 'society' we mean a locality, region or country that has autonomous authority to make decisions. We use the term 'societal decision-making' rather than 'public policy analysis' because many public debates concern specific decisions, such as granting planning permission for an industrial complex, rather than more general policy, such as whether to use tax structures to encourage lower fat diets. Nonetheless, we intend that our discussion extend over contexts from specific decisions to the more general policy choices.

Our decision analytic paradigm separates beliefs and preferences in its modelling. The former it models with probabilities, the latter with utilities, bringing the two together via expected utility to rank alternatives. We shall refer to this as the Bayesian paradigm and note the connections between Bayesian statistics and decision analysis.

At its heart, the Bayesian paradigm is individualistic, applying to a single decision-maker. Yet it can be and has been developed to articulate small group deliberation, helping them decide. A small group might make decisions entirely on its own behalf; it might be part of a unitary organisation, sharing common perspectives, beliefs and values, allowing the group to make decisions on behalf the organisation; or it may represent a stakeholder group in a diverse society in which true consensus on beliefs and values is unlikely. In this last case, the ultimate decision for society is taken by a political process, be it with a small or large 'p'. It is this last case that forms the focus of this paper. How do Bayesian analyses fit into and support stakeholder engagement and public participation in societal decision-making? In answering this, we will need

recognise that the practice of decision analysis in societal decisions differs in many ways from the idealised, individualistic Bayesian paradigm. Thus the discussion in this paper continues those begun in, *inter alia*, Gregory et al. (2005), French et al. (2007) and Rios Insua and French (2010). In developing our arguments, we inevitably draw on our UK-and-European-centric experiences, but we strongly believe that they would be similar elsewhere.

We shall be making two broad points. Firstly, the citizens in diverse societies hold many different opinions, beliefs and values, that a true consensus on some decisions may be impossible. In such cases, political processes lead to the decision and those processes will have many inputs perhaps including the scientific advice from a number of expert panels, regulators and ministries, alongside several decision analyses representing the specific views of different stakeholder groups. Only seldom will there be an all embracing decision analysis pulling all the factors, concerns and uncertainties into a single expected utility analysis.

It has been long recognised that actual individual decision-making and the prescription of the normative Bayesian model differ in many ways (see, e.g., Edwards 1954, Kahneman and Tversky 1974). Current terminology distinguishes intuitive System 1 Thinking, which drives our unsupported decision behaviour, from the analytic, explicit System 2 Thinking, which decision analysis seeks to promote (Chaiken et al. 1989, Kahneman 2011). We shall make a further, similar distinction between System 1 Societal Deliberation and System 2 Societal Deliberation: the former referring to the *de facto* informal processes by which organisations and society decide, the latter to the *de jure* formal governance processes by which the law and constitutions expect that they should (Argyris and French 2017). This will bring us to our second broad point. To develop sound and acceptable processes of stakeholder and public engagement, we need to recognise the interplay between System 1 and 2 Societal Deliberation in political processes. Despite many applications of decision analysis in

the public arena, we believe too little attention has been paid to this interplay and its implications for the design of consultative engagement.

In the next section, we briefly outline the Bayesian paradigm. We note the need to develop decision analyses so that decision-makers are helped to move from System1 Thinking towards System 2 Thinking. In Section 3 we discuss the implications of Arrow's Impossibility Theorem for group decision support within organisations, noting that generally within organisations there is broad agreement on values and objectives. In the next two sections, we turn to discuss societal decision-making, looking at how the techniques of Bayesian statistics, risk and decision analysis support development of the public understanding of the issues. However, we also note in Section 5 that the full apparatus of subjective expected utility is seldom used. We conclude that our profession need acknowledge the role of political processes not just pragmatically in our work, but explicitly in our methodology.

2 The Bayesian Decision Analysis Paradigm

The Bayesian paradigm is illustrated in Figure 1. A full axiomatic justification of the Bayesian model is provided in, *inter alia*, French and Rios Insua (2000), who also describe its feasibility, robustness and transparency. Although the theory is essentially mathematical, its implementation is much more subtle, articulating discussion as much as quantitatively ranking alternatives. The approach separates the decision-maker's beliefs and understanding of how the world is working and the consequences that her[1] actions may bring, i.e. her Science, from her preferences about those consequences, i.e. her Values. Throughout we shall use the term 'Science' more in its classical meaning of all knowledge. Thus, it will refer not just to the knowledge arising in, e.g.,

[1] Decision-makers will be referred to in the feminine or plural; and statisticians, risk and decision analysts in the masculine.

the physical and biological sciences but also that arising in, e.g., economics, the humanities and social sciences. We choose to use this terminology, contrasting Science with Values, because we have found it more acceptable within the public sector than 'knowledge, beliefs and preferences'.

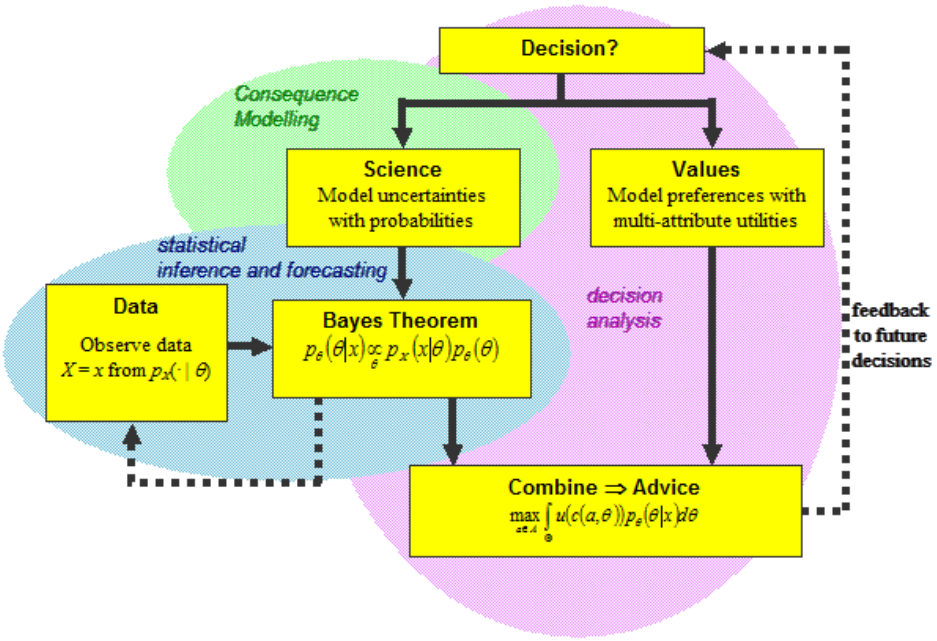

Figure 1: The Bayesian Paradigm (modified from French 2003)
The topmost box represents the issue and problem formulation in which the need for a decision is recognised and the analysis structured to separate the Science of what might happen and what might be done from Value judgements about the potential outcomes. In the obvious notation, p is used for the decision-maker's probabilities, u for her utilities, $c(a, \theta)$ for the consequence of her action a when the state of the world is θ.

It has been long recognised that there is a tension between descriptive studies of how people *do* reach decisions and normative theories of how they *should*. Edwards (1954) asked whether people actually followed the principles of rationality that were being proposed by Savage, von Neumann and Morgenstern, and others. It has become clear empirically that generally they do not (Kahneman and Tversky 1974, Hogarth 1980, Bazerman 2006). Currently one talks of *System 1* and *System 2 Thinking* (Chaiken et al. 1989, Kahneman 2011), the former referring to instinctive thought on the fringes of consciousness, the latter to more conscious, explicit, analytic patterns of

thought. System 1 thinking is subject to behavioural biases; indeed, its literature has been referred to under the label *heuristics and biases* (Kahneman et al. 1982). Whether there is a true dichotomy between System 1 and System 2 Thinking or a gradation between subconscious informal and explicit formal thought is moot in behavioural science, but here the simple distinction will serve. Strictly, System 2 thinking need only be conscious and explicit: it need not be rational. For our purposes, however, we assume that it is and, specifically, Bayesian or a good approximation to that. For important decisions, one strives to use rational System 2 thinking.

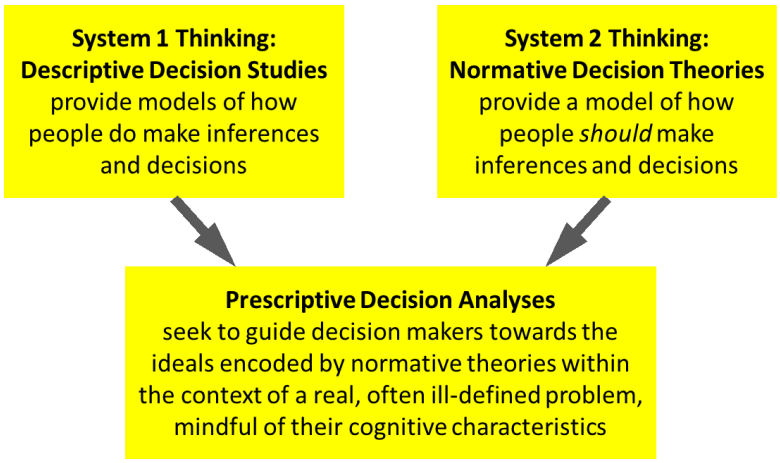

Figure 2: The interplay between System 1 Thinking and System 2 Thinking in prescriptive decision analysis

For individual decision-makers, prescriptive decision analysis (see Figure 2) has become a process akin to psychotherapy, using the formalism of subjective probability and utility to challenge the decision-maker to think deeply about her problem. The ultimate expected utility ranking together with sensitivity analyses guides her towards an action which balances the factors affecting her choice (French 2003).

The Bayesian model is only part of a much more extensive process which passes, often cycles through many steps from initial formulation through knowledge gathering, modelling and analyses, deliberation and evaluation to final implementation (see, e.g., French et al. 2009). The entire process of helps the decision-maker move from System 1 Thinking towards System 2 Thinking. Not all decision analyses pass through

these phases. French et al. (2009) discuss decision analyses in the different contexts of instinctive, operational, tactical and strategic decision-making, arguing that in well-rehearsed cases such as instinctive or operational decisions, issues are well understood and formulation and interpretation need less emphasis. More complex tactical and strategic decisions, perhaps with novel aspects, require more careful exploration, formulation and, subsequently, interpretation during implementation . Here, we focus on strategic decision-making in which decision-makers need to think through their beliefs and preferences as well as many other issues.

3 Supporting Groups

The Bayesian paradigm is individualistic. It provides a model of how a rational person should organise her beliefs and preferences and balance these to form a ranking of the alternatives. Arguably, most important decisions are taken by groups. Here we are talking about a true group of individuals seeking agreement. We are not assuming that there is an arbiter or supra-decision-maker who will use altruistic values or perceptions to form a 'fair' agreement for the group (Keeney and Raiffa 1976, Raiffa et al. 2002). It would be comforting if the Bayesian model extended simply to allow group probabilities and utilities to be constructed and group expected utilities formed democratically. Sadly, a host of impossibility results and paradoxes show that a democratic, Bayesian group decision-making paradigm that is immune from manipulation by one or more members is unlikely to exist (Arrow 1963, Gibbard 1973, Satterthwaite 1975, Kelly 1978, Hodge and Klima 2005). De Finetti (1974, 1975) began his seminal work with: "Probability does not exist!" He argued that probability is an individual's mental construct used to describe and model her (rational) beliefs. Similarly a text on group decision-making might begin: "Group decisions do not exist!" and then argue that group decisions are social constructs describing the outcome of a social process. That is the course that we shall take.

Others, we realise, disagree. Recently Keeney (2013) and Keeney and Nau (2011) argued that one can construct group probabilities and utilities, form group expected utilities and so model rational group decision-making in a consistent, logical way. Earlier work in this vein include Bacharach (1975), Harsanyi (1978) and (Harsanyi 1979). Such approaches implicitly make assumptions about interpersonal comparisons of utility between the group members. Their quantitative model necessarily resolves diametrically opposed preference between individuals. If the model is cardinal using some weighted combination, it effectively places the members' utilities on a common scale. If there were a real supra-decision-maker, then this could be done using her judgement; but we are assuming that there is no such person. So the resolution must assume that the group agree on a common scale of utility. The literatures of social choice and cost benefit analysis abound with discussions and examples showing the impossibly of finding such a common scale that allows true comparisons between individuals (French 1986, Hammond 1991, Bedford et al. 2005). Moreover, group expected utility models also assume that all members honestly reveal their beliefs and preferences and do not game the system. Yet results such those of Gibbard (1973), Satterthwaite (1975) and Taylor (2005) suggest that this assumption is deeply flawed.

None of this is to say that we would differ substantially in the practical processes and techniques that we would use for supporting group deliberation from those who believe that interpersonal comparisons of preference are possible, or perhaps that partial comparabilities are sufficient (see, e.g., work stemming from Sen 1970, Hammond 1991). The style of interventions and challenges, the modelling and its analysis and the broad deliberation would be very similar, only our conception of the underlying theory and foundations of the methodology would differ.

Thus, we take the view that groups cannot make decisions, but are social processes that lead to a course of action by translating the wishes of their members in some way.

Simplistically, the individual members vote – it might be better to say 'behave' – and that leads to a course of action being implemented . Often a chairperson or facilitator recognises agreement and the groups tacitly accept this by not doing anything to contradict this. Indeed, in some cases, the chairperson has the authority and responsibility to impose his or her choice and the group accepts this, the other members' roles are more advisory or perhaps regulatory. Moreover, groups usually have an existence that extends beyond the specific decision under consideration. Members may be playing a much longer game involving explicit or implicit horse-trading across several decisions, looking to support friends, or perhaps block the wishes of others; and there may be issues of career progression at stake. A group is generally a very complex social process and political behaviours may be rife.

Taking a group process view, decision analysis has developed a number of approaches for supporting groups of decision-makers. Typical of these is the decision conferencing approach. In this a facilitator works with the group in a meeting to build a putative decision model and then uses sensitivity techniques to explore differences between individual members (French 2003, Phillips 2007, French et al. 2009, Owen 2015). The putative model *does not* reflect democratically agreed group beliefs and preferences. It is purely a starting point for discussion and that discussion is articulated through sensitivity explorations. Usually the group reaches a shared understanding and agreement on a way forward, though that agreement may be partly influenced by external factors unrelated to the decision. Group dynamics are driven not just by the immediate issues being discussed but also by loyalties, historical and future debts and favours, and many other factors. Originally, decision conferences were conducted face-to-face, but collaborative computing and Web 2.0 has enabled the development of online deliberation systems for participants dispersed across different locations (Nunamaker et al. 1991, Coakes et al. 2002, Tredinnick 2006, Rios Insua and French 2010).

Decision conferences and similar methods were first used to support decision-making groups in organisations. Organisations may be described in many ways, but one is particularly relevant here. Members of organisations share broadly common objectives and values. Whether profit maximising firms, government departments or NGOs, an organisation's members have roughly the same aims, at least in relation to their work in the organisation. Thus, groups within organisations have far more values in common than a randomly selected group from the public at large. This organisational correlation means that decision conferences can generally help groups within organisations reach agreement on what to do. Of course, there will be times when this is not so; one only has to think of boardroom battles over strategy.

4 Societal Decision-making, Public Participation and Stakeholder Engagement

Global, national, regional and local societies are far less likely to share values than members of an organisation are. International crises are often driven by starkly different values and objectives of different countries or groupings. In the worst case, values such as those held by ISIL can lead to civil war and terrorism (Siebert et al. 2015). Thankfully, however, democratic societies almost always solve differences of opinion though peaceful means: namely, political processes.

There are many definitions of democracy and many forms that it might take. We have already referred to the paradoxes and impossibility results that suggest that there can be no rational system of direct democracy in which all citizens have a vote on every decision. The complexity of modern society would mean that there are too many decisions for this to be possible anyway. Thus, modern democracies are procedural and representational. Their citizens elect representatives who take the decisions according to constitutionally agreed procedures. Some decisions are delegated to

agencies and regulators. Constitutional and legal checks and balances ensure that broadly the will of the majority prevails.

Some 50 years ago, most societal decisions were made without much consultation. The instruments of state, its cabinets, parliaments, ministries, regulatory bodies, and regional and local governments made the decisions, perhaps after issuing a discussion paper ('green' or 'white' paper). Concerned citizens might write to their representative or, perhaps, to the editor of an influential newspaper. The last few decades, however, have seen many challenges to full representative democracy. There has been a growing cynicism, disillusionment and perception of a democratic deficit (Steffek and Kissling 2007). Discomfort with regulation – particularly science-based regulation – has grown. Disasters such as Bhopal, Seveso, Chernobyl and BSE (mad-cow disease) led to further public distrust in the authorities. Business and industry have lost public confidence, as they became bigger, more multi-national and dominant.

In response, public participation and stakeholder engagement have increased (Beierle and Cayford 2002, Bayley 2008, Renn 2008). Although there is no general move towards direct, deliberative democracy, in specific areas of concern there is undoubtedly wider use of participatory methods. Governments, their agencies and regulators, as well as some businesses and NGOs regularly engage with stakeholders and the public.

The most obvious way that decision analysis has supported developing participation is through stakeholder workshops, in which discussions are regularly articulated through multi-criteria decision analyses (MCDA). Multi-attribute value (MAV) approaches are commonly used (Belton and Stewart 2002). Gregory et al. (2005) and French et al. (2009), inter alia, describe how MAV analyses can support stakeholder workshops. Papamichail and French (2013) chart the history of such approaches in nuclear safety and post-Chernobyl remediation. Initially, stakeholder workshops were

real meetings run along the lines of decision conferences. However, the interactivity of Web 2.0 have allowed many to be conducted virtually, using some elements of decision analysis to articulate the debate. Decision analysis has thus been at the heart of the movement to stakeholder engagement and public participation (Gregory et al. 2005, Rios Insua and French 2010). However, stakeholder workshops seldom address risk formally through encoding risk attitude and taking expectations against a probability model. Mostly, stakeholder workshops focus on understanding the stakeholders' perceptions on how conflicting objectives should be balanced.

In parallel with developments in stakeholder engagement that address societal values (Figure 1 right hand side), Bayesian statistical methods have been providing greater support for developing the scientific understanding of the uncertainties (Figure 1 left hand side). With the advent of MCMC, emulation methods and the enormous gains in computational power, Bayesian methods, once intractable, now lie at the heart of complex statistical analyses and machine learning algorithms (Conti and O'Hagan 2010, Williamson and Goldstein 2012, Gelman et al. 2013, Rogers and Girolami 2015). Moreover, structured processes have been developed to elicit and summarise the judgements of panels of experts when data are sparse or would take too long to collect (O'Hagan et al. 2006, French 2011, Dias et al. 2017). The Bayesian perspective on statistical inference sees the growth of scientific knowledge as a gradual move towards a consensus (Box and Taio 1973), with sensitivity analysis and robustness studies being used to investigate residual differences between scientists (Rios Insua and Ruggeri 2000, French 2003). Bayesian methods bring further advantages in that it is natural and seamless to move from inference to forecasting and risk analysis (French and Rios Insua 2000, Aven 2003). All these methods may be used to support the work of expert panels convened to advise on the uncertainties in a societal decision.

5 Decision Analyses as an Input to a Political Process

In the early 1970, books such as Raiffa (1968), DeGroot (1970) and, above all, Keeney and Raiffa (1976) suggested that Bayesian decision analyses with full use of subjective expected utility models were capable of supporting complex societal decisions. All the parts of the analysis would fit together coherently to provide a rational balanced perspective on all the issues involved in a problem. The siting of Mexico City Airport (De Neufville and Keeney 1972, Keeney and Raiffa 1976), a nuclear power station (Keeney and Nair 1977) and similar studies (Bell et al. 1977) gave hope that these methods would find regular use in a matter of a few years. But that promise has not been fulfilled. That is not to say that there have not been applications of decision analysis to societal decisions: there have been plenty (e.g., Rios Insua et al. 1997, Bana e Costa et al. 2001, Bana e Costa et al. 2002, Edwards et al. 2007 Part VII).

However, very few applications to major societal decisions have been *the only* input to the eventual decision and even fewer have used the full Bayesian paradigm in basing their recommendations on an expected utility ranking. Indeed, more careful study of current approaches to societal decision-making suggests that Figure 1 is too simplistic in having a single pathway on each side.

Usually several scientific studies are conducted independently, some by different government agencies focusing on 'their' responsibilities, some by pressure groups and other stakeholder groups. Some studies may use non-Bayesian statistics. Unaligned academics, researchers and others may offer further perspectives on the uncertainties. Sometimes consensus emerges, but far from always. Societal risk and decision analyses often concern emerging technologies, environmental risks, business systems or societal behaviours on which scientific consensus has yet to form. Furthermore, some stakeholders may reject the established science perspective and adopt a different worldview. The single coherent, comprehensive analysis of the uncertainties

in Figure 1 is rarely present. Turing to the right hand side, stakeholders may hold very different values and a single comprehensive analysis of their preferences bringing together all stakeholder perspectives is hardly ever conducted, or indeed possible. So there are several competing analyses on each side of the diagram.

Perhaps, we are just being impatient. Democracies evolve slowly. If we accept chronology of the Decision Analysis Society, the practical application of decision analysis is barely 50 years old. It may be too soon to expect its full implementation in societal decision-making with a single comprehensive analysis supporting the entire process. But we do not believe that we are being impatient. We simply do not believe that such an approach is practicable; societies are too diverse. Societies live with disagreements rather than resolve them. In our view, the task of decision analysis is not to resolve these disagreements, but to *clarify* them. It should enable a society's citizens and organs of state understand the different perspectives and values so that political processes can reach and implement a course of action that will enable to society to move forward.

So we believe that for societal decision-making the situation is much more that represented in Figure 3.

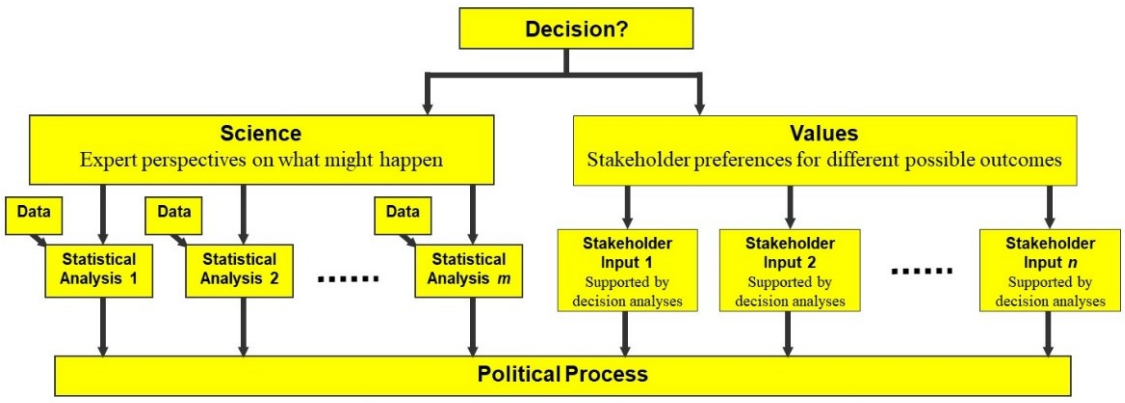

Figure 3: *Multiple analyses within societal decision-making*

Decision analysts, risk analysts and statisticians have roles in supporting the parallel pathways on both the Science and Value sides. Their loyalties will perhaps be more to the expert or stakeholder group they are supporting than to the societal decision as a whole. They will need skills not just to support the deliberations within the group but also to support communication between groups. They may need to understand and critique other groups' analyses for their own group, as well as helping explain their group's analysis to others. If there is a possibility of different groups joining forces, they may need to support negotiations on the Values side (Raiffa et al. 2002) and meta-analyses on the Science side (Hartung et al. 2008, French 2012). These are much more complex tasks than those apparent in the perspective offered by Figure 1, ones which bring many challenges to our community. If we see our role as providing guidance mainly through the maximisation of subjective expected utility, we may miss many opportunities to support and inform debate and the political processes that will take lead to the ultimate decision.

The separation of Science and Values that remains in Figure 3 is itself a questionable assumption. Whether Science, i.e. knowledge, is value-laden is itself a question (Cortner 2000, Chalmers 2013), but it is certainly true that this neat separation is not always found in practice. Presentations of 'objective scientific facts' are often conveyed in value-laden frameworks; while arguments in support of particular values can embody rather specific worldviews. Perhaps one of the more significant benefits of helping individuals move from holistic System 1 ways of thought to explicit decision analytic System 2 thinking is that is encourages this separation, clarifying those aspects of arguments. For instance, debates in the UK on whether to legalise cannabis have arguably confused science and values, and the limitations of scientific advice in the policy process (Nutt et al. 2010, Berridge 2012, Stevens and Ritter 2013). We maintain the conceptual separation of Science and Values in the following, though we do recognise that it will be challenging to do so in practice.

6 System 1 Societal Deliberation and System 2 Societal Deliberation

Taking this line of argument, what are the implications for the practice of decision analysis? Firstly, if its role is to clarify the different perspectives on an issue to inform the political processes, we need to recognise those political processes within our conception of decision analysis. In Figure 2 we recognised that if we are to inform individuals, we should recognise that they seldom act fully in accord with the Bayesian paradigm. We had to acknowledge that System 1 Thinking might lead them to quick, but in retrospect ill-judged responses during elicitation and a poor, superficial understanding of the conclusions of the analysis. Interactions within decision analysis are designed to help the decision-maker move from instinctive System 1 Thinking to more explicit, rational System 2 Thinking. Similarly, to support societal decisions, decision analysts need to recognise potential tensions between informal societal discussion and more formal debate conducted within political structures laid down by the constitution. To emphasise this, we suggest the following terminology (Argyris and French 2017):

- *System 1 Societal Deliberation*: In society many of the ways that individuals receive information, discuss issues and express their opinions are informal, such as a chat in a supermarket aisle or Tweets, blogs and similar social media. Free speech in modern democracies means that these are unstructured and subject to little or no control. They do much to shape opinion and influence voting, but have no formal, defined role in the political system.
- *System 2 Societal Deliberation*: Formal public and stakeholder input to political debate is much more structured and controlled. Its format is laid down by constitution, precedent and accepted ways of working: discussion papers, town

hall meetings, political surgeries, stakeholder workshops, citizens' juries, referendums, etc. In many political systems, an independent judiciary can be asked to review whether consultation processes were fair and inclusive within the bounds set by the constitution and precedent, i.e. within the structures of System 2 Societal Deliberation.

As with System 1 and System 2 Thinking, we do not suggest that this is a strict dichotomy, but rather a gradation from completely informal, uncontrolled conversations through to constitutionally established debate and consultation. For example, where does public broadcasting fit? While it is usually free to choose issues and how they are explored, it may be required by the state to ensure that a full breadth of views are expressed. In using a dichotomous terminology to simplify our overall argument, we recognise that we skim over many subtleties.

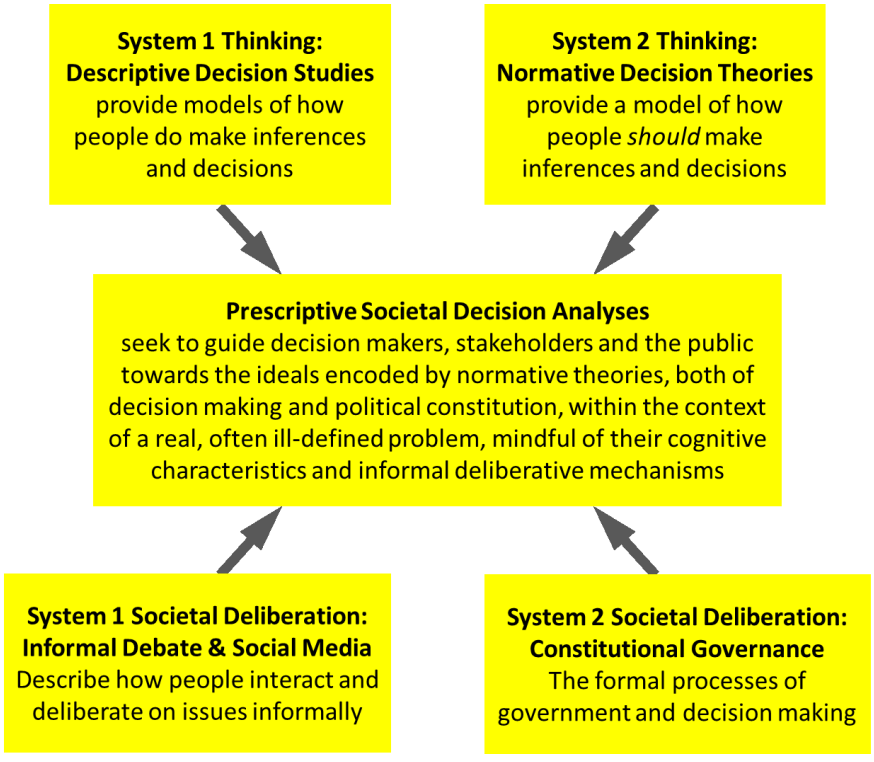

Figure 4: The interplay between System 1 Thinking, System 2 Thinking, System 1 Societal Deliberation and System 2 Societal Deliberation in prescriptive societal decision analysis

With this distinction in mind, we suggest that societal decision analysis should be seen as seeking to guide decision-makers, stakeholders and the public towards the ideals encoded by normative theories, both of decision-making and political constitution, within the context of a real, often ill-defined problem, mindful of their cognitive characteristics and informal deliberative mechanisms: see Figure 4. Note that the analysis, its presentation and the decision process should seek to provide support both at the individual level (top part of figure) and at the level of stakeholder groups and society itself (lower part of figure). The former support seeks to ensure that each individual is informed and expresses his or her opinion in a manner which leans towards System 2 Thinking, guarding against the superficial, instinctive irrationality 'traps' of System 1 Thinking. The latter support seeks to ensure that appropriate formal discussion and debate take place and that the ultimate constitutionally legitimate decision process – the System 2 Societal Deliberation – is well-informed, while providing information and guidance to and learning from informal social debate – the System 1 Societal Deliberation.

We have developed the distinction between the informal social processes of System 1 Societal Deliberation and the formal governance structures of System 2 Societal Deliberation in the context of societal decisions. But the same distinction applies in group and organisational decision-making. It is just less apparent. Common objectives, the involvement of fewer individuals, perhaps shorter timescales and tighter focus mean that less effort is needed in managing informal and formal deliberations. The distinction is not as obvious nor as important in coming to a decision. Nonetheless, analysts facilitating decision conferences generally seek to understand both formal and informal relationships, power structures and accountabilities (Eden and Radford 1990).

A case in which informal System 1 Societal Deliberation had a clear influence on the final decision is provided by the UK's intermittent progress towards dealing with its nuclear waste. After a long history of false starts and indecision, the government

created the Committee on Radioactive Waste Management (CoRWM) to develop a broad long-term strategy for the management of its nuclear waste. This used many decision analytic techniques to structure its discussion and the broader debates, making sure that all stakeholders and the broader public were listened to, while being aware of the broader debates in the public arena: see (Morton et al. 2009). The conclusion accepted and implemented by the government was that the best course lay in a Geological Disposal Facility (GDF) sited by process that would have an emphasis on community volunteerism and public participation, In particular the government decided that no potential site for the GDF would be considered unless the local community volunteered to host it. The next phase was to invite such volunteers. However, that process has faltered because no communities volunteered. In Cumbria in particular, there was a careful formal debate with many points of view being aired, but crucially the community decision making was delayed by several months after the debate finished. However, informal debate, i.e. System 1 Societal Deliberation, continued during the delay and was led by anti-nuclear pressure groups and seemingly swung the final vote from a fairly positive view to decision not to volunteer (Gilbert et al. 2016, Gilbert 2017).

7 Implications and Challenges for Societal Decision Analysis

7.1 Designing societal deliberation processes

Our view of societal decision-making raises many challenges for decision analysis. We should design decision processes that reasonably reflect the concerns, issues and imperatives present in informal System 1 Societal Deliberations while ensuring the actual decision is taken legitimately within the governance structures required by System 2 Societal Deliberation. The means of doing this, however, is far from clear. Bayley and French (2011) note that although there is a lot of evidence that public

participation and stakeholder engagement improve the acceptability of much societal decision-making, relatively little evaluation has been undertaken to identify best or even good practice in these (see also Rowe and Frewer 2000, Abelson et al. 2003, Abelson and Gauvin 2006). To give but one example, suppose there are several distinct stakeholder groups, representing conflicting worldviews and values. Is it better to organise different workshops for each stakeholder group or to mix the stakeholders in multi-perspective workshops? There is little empirically tested evidence to provide guidance. Indeed, it is moot what is meant by 'better' in these circumstances. Moreover, what form should the workshops take: decision conferences, citizens' juries, or what? We might look further afield to the literatures of information systems, computer supported co-operative work and Web 2.0 to see how they design deliberative systems, but again there are few unambiguous, empirically supported guidelines.

Although stakeholder engagement and public participation is routinely adopted by many governments and their agencies, the selection of techniques and their integration into the overall deliberation may be described as pragmatic. In our experience, choices are often based on factors such as:

- "We have experience of stakeholder workshops, but not of citizens juries, …."
- "The cheapest facilitator/consultant based his pricing on …."
- "The guy down the corridor recommended …."

Frustratingly, although experience of using such methods is accumulating, it is not being documented fully and certainly not in ways that enable empirical comparisons of the relative effectiveness of such methods. As a profession, we need to establish reporting standards that ensure that all experiences are recorded in a way that allow comparisons. Many current reports do not include any data on:

- numbers who were invited as opposed to attended;
- cost of the interactions, and timescales of events;
- how participants were selected;
- what methods were used to ensure representativeness in some sense;
- how information was validated and shared before the interaction, etc.

If comprehensive reporting were the norm, it would be possible to develop a knowledge base that could inform good practice.

Bayley and French (2008) and Gilbert et al. (2016) have explored some tools that might help in the overall design of the decision process. The methods of collaboration engineering might be usefully developed to the societal context to provide more detailed planning of individual events (Briggs et al. 2003, De Vreede 2006). The real issue, however, is that we do not have the evidence base on which to identify which technique is better for which circumstance. If stakeholder engagement and public participation is truly to serve the needs of society, we need to understand the relative merits of different methods and use this knowledge appropriately to design public participation methods.

7.2 The importance of facilitating communication

This view of societal decision analysis challenges us to recognise even more the importance of supporting communication between groups. Moreover, if we subscribe to the broad imperatives of democracy, then we surely cannot disenfranchise groups because they adopt different ways of thinking. We must recognise that many of the parallel statistical analyses on the left of Figure 3 will be supported by non-Bayesian analyses. The data used may have a dubious experimental design. Experts with very different views to conventional Science may have input their views. There have been many occasions in which non-established views have held sway. Parental doubts about the MMR vaccine, which led to many children being unprotected, arose because

of a dubious publication on supposed side effects (Bellaby 2003, McMurray et al. 2004). Similarly, on the Values side of the figure, we must recognise that some groups may reject Bayesian multi-attribute value or utility analyses and, indeed, *any* MCDA methodology, arguing that values are holistic, non-decomposable and that intangibles are not subject to any quantitative analysis. As statisticians, risk and decision analysts, we need to plan communication strategies alongside our developing analyses, recognising that we need to help our clients explain their perspectives on the issues and also help them understand other perspectives. Without attention to engagement and communication, the entire political process may be fraught with conflict, fail to build any consensus and lead to very poor overall outcomes (Renn 1998, Beierle and Cayford 2002, McDaniels and Small 2004, Pidgeon and Rogers-Hayden 2007, Renn 2008, Bennett et al. 2010).

7.3 Potential ways forward

Against this background what should decision analysts be doing to develop methodologies to support societal decision-making? We have a few suggestions, but do not believe that our list is more than a beginning.

Problem structuring

Firstly, issue structuring and problem formulation has always been part of decision analysis, but it has not the emphasis that it needs – save for the literature on attribute tree structuring and value-focused thinking (Keeney 1992, Keeney and Gregory 2005). The soft OR literature offers many catalytic tools and techniques that can be used to help build decision models (Belton et al. 1997, Rosenhead and Mingers 2001, Losa and Belton 2006, Shaw et al. 2006, 2007, French et al. 2009, Marttunen et al. 2017). Cognitive maps, rich picture diagrams, even checklists such as PESTLE, all provide succinct perspectives on the uncertainties, constraints, values, assumptions, etc.

These tools can provide a non-quantitative framework for communication (French et al. 2005) that can help share perspectives between different groups.

Scenario-focused decision analysis

Over the past decade, there have has been a growing convergence between quantitative and more qualitative approaches to analysis. We note particularly the growing interest in scenario-focused decision analysis (Wright and Goodwin 1999, Montibeller et al. 2006, Ram et al. 2011, Schroeder and Lambert 2011, Stewart et al. 2013, French 2015). This combines ideas from scenario planning in which qualitative future scenarios are constructed to form backdrops for strategic debates (Schoemaker 1995, van der Heijden 1996) with conventional quantitative decision analysis. The aim is to generate several interesting scenarios and then build a decision analysis within each based on assumptions appropriate to that scenario. How 'interesting' is defined is moot. There are many possibilities. A scenario may:

- assume some particular event happens or does not, which can help address 'deep' uncertainties for which no agreed probabilities are available;
- represent a best or worst case of some form, which can help bound possibilities;
- represent a most likely case in some sense, which is useful for maintaining a balanced perspective;
- develop a future that some of the stakeholders wish to explore, even if its likelihood is infinitesimally small, which can help compare differences in stakeholder values.

While the decision analyses within each scenario should be coherent and rigorous, the analyses are not commensurate and directly comparable across scenarios (Stewart et al. 2010, French 2014). Moreover, the scenarios do not form a spanning partition of the future; indeed, not only may some futures be missed, but also some scenarios may overlap others. What they do is focus discussion and explore issues, assumptions and contingencies. Looking back to Figure 3 the fit of scenario-focused decision analysis

with societal decision-making is clear. The disparate experts and stakeholder groups effectively frame and explore different scenarios in their reports. Thus, the nascent techniques of scenario-focused decision analysis can be drawn upon to inform and support societal deliberation and the general political process.

Further development of sensitivity techniques

Debates between different parties to a decision can be inflamed by disagreements over aspects of a decision model that are turn out to have little or no influence on the ultimate direction of the analysis. Decision analysts have long realised how sensitivity analysis can inform deliberations and steer them towards the issues that matter (Keeney and Raiffa 1976, Rios Insua 1990, French 2003). Thus in societal decision-making, we would expect to see increased emphasis on sensitivity techniques and intuitive graphical presentations. However, we may go further. Eliciting a decision model and its judgemental inputs creates the possibility for disagreement. In many cases, disagreement can stimulate valuable discussion; but some disagreements will be irrelevant. If the modelling and elicitation process can be constructed to reduce the number of judgements required of the participants while focusing those judgements on the more important issues, there will be less chance of being side-tracked into sterile debate. This was the motivation behind the development of interactive decision-making algorithms several decades ago (Zionts and Wallenius 1976, French 1984). These methods concentrated on eliciting weights and parameter values within models, but more recently attention has switched to interactively eliciting the shape and functional behaviour of the model itself (Greco et al. 2012, Argyris et al. 2014). We believe that such approaches will have a role to play in avoiding and defusing some of the tensions between the different, parallel inputs to the political process, focusing attention on where agreements lie.

Communicating the import of analyses

We have noted that one of the implications of the plurality of views in Figure 3 is that decision analysts will need to pay increased attention to communication between groups and the political process. Since the 1990s there has been much research into many aspects of risk communication, particularly to lay stakeholders (see, e.g., Palenchar and Heath 2007, Fischhoff 2008, Maule 2008, Bennett et al. 2010, Campbell 2011, Spiegelhalter and Riesch 2011). Moreover, much of the accumulated knowledge has been encoded into advice on effective means of communication (see, e.g., US DHHS 2002, Risk and Regulation Advisory Council 2009, Cabinet Office 2011, EFSA 2012). However, informative though this literature is, it focuses more in the communication of risk and uncertainty than on decision analyses. Moreover, risk communication tends to deal with issues that are confounded with dread and other emotions driven by the risk context. We need a parallel development of communication tools to convey the implications of decision analyses to lay stakeholders and the public who have not been party to particular deliberations. The tools need convey the reasoning behind the recommendations in a measured way. Decision analysis still has a long way to go in communicating its results within the context of a wider public debate.

8 Concluding Remarks

It is our contention that the Bayesian paradigm of decision analysis, which has worked so well for supporting individuals, groups and organisations, will not extend fully to supporting major societal decisions with a single unitary and comprehensive analysis. It will certainly help government agencies, stakeholder groups and others each develop their views and perspectives, but the overall decision will be the result of a political process, which draws together many inputs. We have argued that to support this process, we may need to deconstruct our paradigm, recognising that many different,

often partial analyses relating to different scientific and stakeholder perspectives will feed into this process. Rather than chasing an impossible goal of bringing these analyses into a coherent whole, we should develop many more means of helping all parties to this political process understand and compare the import of each of these analyses, in relation its assumptions, data, and underpinning beliefs and values. We have suggested a few elements of a broad research agenda, but our main intention has been to stimulate discussion.

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