



Invited Review

Operational research and ethics: A literature review

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ABSTRACT

Any human activity raises ethical questions, questions about 'good' and 'right' ways to act and to live; or to put it differently, questions of values and responsibility. From its inception operational research (OR) has engaged with such questions in terms of professional behavior, the handling of preferences in OR, the societal role of OR, the process of OR intervention and the content of OR analysis. As a result, analytical methods and processes have been developed to help clients explore the ethical dimension of their decisions. The paper reviews the literature published in selected OR journals (*Management Science; Operations Research; Interfaces; the European Journal of Operational Research; the Journal of the Operations Research Society; Omega; International Transactions in Operational Research; the Journal of Multi-Criteria Decision Analysis*), organizing it along the lines of OR's core competences. The review identifies a number of significant research programmes that are well established and are being energetically pursued; the research findings are being applied to a wide range of important issues. Ethical questions lie at the heart of the great governmental and commercial issues of the day: economic growth and instability; inequality and injustice; environmental degradation and sustainability. They also lie at the heart of the more mundane decisions of day-to-day OR. 'Ethics' therefore provides a useful focus for OR both in terms of raising the awareness of all concerned and in providing a theme for research. As a result of the review some research questions are suggested. There is much of interest, much to do.

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1. Overview

Operational research (OR) is an activity done by people for people. As Brans and Gallo (2007) put it, OR is a human activity in which OR workers engage with other humans to improve human-activity systems. The emphasis on the humanity of OR and on improvement as its aim means that engagement with ethical issues is inevitable. 'Efficiency questions—which lie at the heart of the OR/MS problematic—are best understood against a background of ethical questions' (Picavet, 2009, p. 1121).

1.1. The ethics of early military OR

It is true that the assumptions and accounts of OR may not always reflect on and make explicit its ethical basis, but that does not alter the fact that the analysis rests on implicit assumptions. OR emerged in the UK and the US out of the experience of harnessing the investigatory skills of scientists in the context of WW2. Ethical concerns at that time could not have been more prominent nor the stakes higher; the morality of indiscriminant bombing of

civilian populations, of incendiary bombs, and ultimately of nuclear bombs could hardly go unquestioned. OR scientists were engaged in making the war effort more effective, a war effort not necessarily of their choosing; but once entered, winning the war became a necessary, and for many a worthy, perhaps even noble cause.

1.2. Ethical concerns in early civilian OR

After the war the situation changed. While work in the military sphere continued, the aim in the peace was now to harness the same scientific endeavor to make civil government, commerce and industry more efficient and more effective; there was plenty to do. OR scientists engaged in non-military problems that they could get their hands on and which they judged might yield to their particular (research based, scientific, interdisciplinary) approach to management problems. The unspoken assumption was that the scientists themselves were well intentioned and the aims they pursued were supported by society. Whatever the merits of such an assumption, it meant that little attention was paid by practitioners to the fact that the previous unanimity regarding proper ends and means could no longer be taken for granted.

A few exceptions confirmed this rule. In the UK, Blackett, the influential pioneer of military OR, publicly argued against nuclear

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weapons (Hore, 2003), while left-leaning OR scientists advocated the use of OR to develop better economic plans, as documented by Rosenhead (1989). In the US, it was Churchman, one of the founders of OR, who first systematically questioned the fundamental value assumptions of OR and set out to place ethics at the center of the discipline; 'the problem of systems improvement', he admonished us, 'is a problem of the ethics of whole systems' (Churchman, 1968, p. 4; c.f. Ulrich, 1994, 2006a, 2012a; Horner, 2002). He consistently argued that OR should not only be about developing models to improve means but should also consider ethical purposes and consequences (Churchman, 1970, 1973, 1979).

1.3. The 'crisis in OR' debate of the 1970–80s

At the time Churchman hardly convinced his US colleagues; but in the 1970s his work and that of his collaborator Ackoff played into a debate in the UK about a perceived state of crisis in OR. Some were concerned that OR no longer had the ear of the top decision makers in government and industry and instead concentrated on providing a technical service (Eilon, 1980); others pointed out that OR could only be afforded by rich and powerful organizations and it therefore failed to serve the interests of those without the ability to pay (Rosenhead and Thunhurst, 1982; Rosenhead and Mitchell, 1986); or that OR had become a supporter of the managerial *status quo* and lacked radical intent (Dando and Bennett, 1981). Yet others were concerned that, despite its visible success in practice, OR lacked a proper understanding of applied research and professional intervention (ORS Education and Research Committee, 1973; Tomlinson, 1974). In the UK the concerns about process intertwined with a debate about professionalism. Why should OR not, like other professions, set entry qualifications and adopt a code of ethics? In the US similar questions were being explored, for example, in connection with OR's involvement in a debate about the deployment of antiballistic missiles (ABMs) (Gass, 2009).

1.4. New developments in the 1980s and 90s

The debates gave rise in the UK to an academic interest in the process of OR and gave focus to both conventional and soft approaches that were already under development (for instance, articulate intervention, soft systems methodology, cognitive mapping, strategic choice approach). The so-called soft OR approaches, by supporting wider participation in the decision process, opened up discussion about the ends of the clients' organization as well as the means for achieving such ends. Growing awareness that there are always options in defining problems, and that the choice among these options has ethical implications, in turn led to a call for developing specialized problem-structuring methods (PSMs). But for some this did not go far enough and they advocated a more critical and socially responsible approach with ethical concerns brought to the fore of methodological considerations (Ulrich, 1983, 1987, 2003; Munro, 1997; Jackson, 2000).

1.5. The situation today

After 30–40 years even the best known of these new approaches have yet to achieve widespread use by OR practitioners (Munro and Mingers, 2004; O'Brien, 2011). There certainly remains a need on the part of professionals for more support in dealing with normative questions. Our own view is that before this need can be met satisfactorily, more work needs to be done about the ethical foundations of applied research and professional practice; only on such a basis can we expect to develop frameworks and tools that will be convincing and practicable enough to be adopted by a majority of practicing researchers and professionals (see, in addition to the

sources already mentioned, Le Menestrel and Van Wassenhove, 2004, 2009; Maclagan, 1989; Ulrich, 1988, 2006b, 2007, 2012a,b; Wallace, 1994; Wenstøp, 2010).

Meanwhile, non-academic OR practitioners have tended to deal with ethical issues in an *ad hoc* intuitive way in the context of a particular intervention. Where normative issues are considered to be central to a decision, practitioners may turn to more conventional OR models/approaches such as multiple-objective mathematical programming (White, 1990) and multiple criteria decision analysis (MCDA) (Roy, 1996; Roy and Vanderpooten, 1996; Belton and Stewart, 2002) and/or of the tools of impact analysis and assessment as they are known in many disciplines (Becker, 2001). Finally, even in those application domains where it is clear that ethical concerns are crucial (military, health, education, police, energy, and so on) an OR project may simply concentrate on making operations more effective on the assumption that this a desirable end in itself. In doing so OR consultants have tended to rely on their good sense to recognize when ethical issues need special attention and when they do not.

1.6. The aim and organization of this review

A reading of the OR literature reveals that many OR academics have nevertheless continuously drawn attention to the importance of ethical issues, keeping the subject alive through the first 60 years of OR's history. In 1970 Churchman said: 'We need to ask to what extent any one of us ought morally to be concerned about lives beyond our own life spans. Today's concern with the ecology of the environment seems to say that we should' (Churchman, 1970: B50). The environmental issue was brought into focus again in the 1970s by the members of the Club of Rome who were concerned about the headlong rush, through unfettered population growth, consumption increases, developmental activity, into the limits of energy, land use, mineral resources and the environment capacity necessary to sustain human activity (Meadows et al., 1972). The same themes are with us today (Rauschmayer, 2001).

Within OR, sustained advocacy by a number of scholars has been central to the effort to maintain a focus on ethical issues: Churchman (1961, 1968, 1979, 1994) and Ackoff (1974b) placed ethics at the center of the OR *intervention*; Gass (1991a, 1994, 2009) emphasized the adoption of ethical codes for OR *personal* and *professional* practice; Rosenhead (1976, 1987) campaigned for an ethical, *socially* responsible OR profession; and Saaty (1977, 1980, 1994) and Keeney (1982, 1988, 1994) in the US and Roy (1987, 1990, 1991, 1993) and Brans (1982, 2002a,b, 2004); Brans and Gallo (2007) in Europe placed ethics at the center of the development of *analytical* methods to support decision choice.

The aspects of OR that these scholars have worked on together with their colleagues, collaborators and like minded others, can be mapped onto the core competences of OR (Ormerod, 2002) as shown in Fig. 1. It is clear that ethics is relevant to all aspects of OR competence. The following discussion of ethics in OR will use the four headings in Fig. 1 to provide some structure. This structure is similar to that used by Brans and Gallo (2007, p. 167) and the distinction drawn by Le Menestrel and Van Wassenhove (2004) and Brocklesby (2009) between 'ethics within OR models' and 'ethics beyond OR models'. An OR consultant is an individual, engaged in analysis, within an investigation located in the context of an organization embedded in a particular society. Ethical issues can be viewed as nesting in the opposite direction – *societal ethics* forms the context for *intervention ethics*, which in turn provides the context for *ethics in analysis*. Finally, *personal and professional ethics* sit within the ethics of society, intervention and analysis, providing the consultant with the basis for an ethically aware approach to OR. In the following sections the four domains are

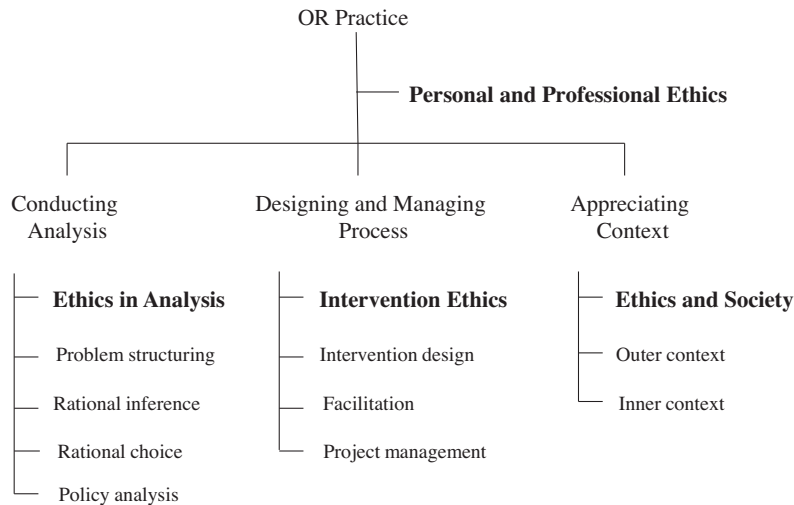


Fig. 1. Ethics in OR practice.

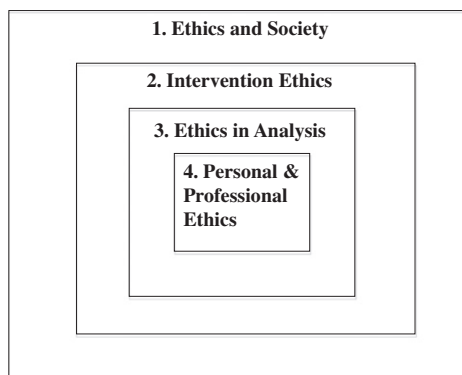


Fig. 2. Structure of the paper.

therefore addressed in turn, proceeding from the general (ethics and society) to the specific (personal and professional ethics) with each section providing the context for the next one. This arrangement, illustrated in Fig. 2, provides the structure for the paper. Of course, in practice the domains overlap, intermingle and vary from project to project in their salience and strength.

The efforts of OR to achieve efficacious, efficient, and effective outcomes (the three Es) have to contend with the fact that its activities and the activities of its clients are embedded in a social context with demands and expectations that go beyond the three Es; actions have to contend with societal norms and mutual expectations. The three E's really need to be expanded to OR's *four E's*, the fourth standing for 'ethical'. Engagement in the subject of ethics is thus both necessary and potentially productive for OR.

One significant omission in this paper is military OR; very obviously military work always has an ethical dimension. However, most of the work does not find its way into the mainstream OR literature surveyed here (we did not include, for instance, the journal *Military Operations Research*).

2. Ethics and society

2.1. Ethics and morality

When we talk about the ethical aspects of OR, we suggest the focus should be on the implications that professional intervention

may have for third parties and for society at large. Thus understood, ethical questions refer not merely to the individual values, worldviews and forms of life that unavoidably condition what people consider as good and rational ways of action; they refer, more specifically, to the handling of *conflicts* between differing individual notions of the good. We here encounter the important distinction between ethics and morality: while *ethics* is a matter of personal worldview, *morality* is a matter of interpersonal fairness, that is, of notions of what is acceptable and right to all the parties concerned by an intervention. Moral reflection means to move from 'my' (or 'our') to 'their' point of view (Ulrich, 2006a, p. 54). In an epoch of value pluralism and of a growing diversity of forms of life, clashing notions of the good have become a constant challenge to the professional quest of operational researchers to help others secure improvement. What does improvement mean in the face of clashing notions of the good? How as professionals are we to deal with differing views and values? That is the central issue of moral reasoning, the one aspect of ethics that lends itself to rigorous argumentation.

To be sure, in an epoch of ethical pluralism it is not the task of professionals to tell others what is good and right for them. But acceptance of ethical pluralism provides no argument against including moral considerations in our notion of competent professional intervention. On the contrary, *because* we live in an epoch of ethical pluralism, moral reflection and argumentation are relevant so as to give everyone a fair chance to articulate and (with due respect for the different views and values of others) to live their own notions of the good. It is precisely where ethical conflicts arise that rigorous moral questioning becomes important.

The distinction matters for the purpose of this literature review, although – or perhaps rather, because – it is not part of the more conventional terminology that most OR authors use. In conventional terms, 'ethics' is a general (if not meta-level) concept referring to the way we think about normative issues, whereas 'morality' is a narrower concept referring to some sets of rules or codes of behavior that certain societies or groups of people adhere to; this latter terminology tends to blur the different methodological questions that ethics and morality as we understand them raise.

In essence, these methodological questions can be summed up as follows: an *ethical* stance as we understand it here implies that we undertake an effort to make ourselves and everyone concerned aware of the values assumed and implied in an action or action proposal. In what sense does it bring improvement, that is? A *moral*

stance, by contrast, will require us to look more specifically at the way we handle the value conflicts involved. How can we justify it, is it right? For example, do we pay sufficient attention to the worldviews of those concerned but not involved, as compared to the importance we give to the worldviews of those involved?

A basic test of morality is the universalizability (or generalizability) of the values assumed or implied in the consequences. We have referred to this test above as the move from 'our' to 'their' point of view: could we also want and justify our ethical judgements from the perspective of all others who may have to live with the consequences? Demanding as such moral reasoning is, in the form of this basic test it provides us with a standard that allows for rigorous questioning and argumentation; it thus provides an important leverage point for methodological developments. We can rationally *argue* about moral questions, whereas we can only *recognize* the diversity of people's ethical assumptions, that is, their individual notions of improvement and forms of life.

To date, the OR literature largely fails to discuss the relevance and methodological implications of thus-understood moral reasoning as distinguished from other ethical considerations in OR intervention, analysis and professional conduct. Most contributions to the 'ethics' of OR, well-taken as they are in drawing our attention to the value content of all OR practice, tell us accordingly little about how to handle ethical conflicts. In fact, they do not usually address the issue at all. We suspect this circumstance is due in part to the conventional terminology that most authors use for writing about the 'ethics' of OR, a terminology that tends to have them focus more on issues of subjectivity, emotion, and personal notions of improvement – issues about which we cannot rationally argue – than on the crucial issue of ethical conflicts, despite the fact that such a focus allows rational argumentation and methodological development.

2.2. Addressing the big issues

This situation may explain why the OR literature, rather than working out practicable forms of moral reflection and discourse in professional intervention, has occasionally attempted to discuss *what kind of society OR might help us achieve* and the role it should consequently play – in the terminology adopted here, an ethical issue that requires adequate handling of value judgements (a matter of value transparency) but which does *not* lend itself to rigorous moral reasoning (a matter of rational argumentation). A pertinent requirement is to be aware of the degree to which a view of what a 'good' society is, and how it can be achieved, pervades not only state institutions and industrial and commercial organizations but also the patterns of behavior (including professional conduct) within these collectivities.

A basic issue that sooner or later comes up in this connection concerns the place (or space) that OR practitioners should give to their subjectivity. There are those who argue that professionals should strive for a strictly objective stance, while others argue that in the interest of transparency they should reveal their personal values and emotions. In 2005 a paper by Wenstøp gave rise to an interesting exchange of views that is helpful in dealing with this sort of question (Wenstøp, 2005a,b; Brugha, 2005; Daellenbach, 2005; Le Menestrel, 2005; Rauschmayer, 2005; Tsoukiás, 2005; see also Wenstøp and Seip, 2001; Wenstøp and Koppang, 2009; Wenstøp, 2010; Diekmann, 2012). Issues discussed included the relationship between subjectivity and objectivity; between the emotional and the rational in decision-making; between ethical consequentialism and other "ethical perspectives. Such exchanges help raise the sophistication of the debate.

Related issues discussed in the OR literature range from whether the economy should be run on planned, egalitarian, perhaps Marxist lines, or as a market-based capitalist enterprise, or

somewhere in between, to concerns about sustainable development, environmental impact, intergenerational transfers, international collaboration and animal welfare. Few papers in the OR literature have directly addressed these issues though. Churchman (1970) examined some of the philosophical arguments; there has been some discussion of Marxism (Rosenhead, 1989; Rosenhead and Thunhurst, 1982; Ormerod, 2008b); Sadler (1978) speculated on the post-industrial society; Ackoff (1994) examined the future of university education in America; and Müller-Merbach (2002) described the genesis and impact of European culture. But, in the main, OR relies on analysis from other disciplines (for instance, economics, politics and sociology) and from the general discourse reported in quality newspapers, non-academic journals (for instance in the UK, the *Economist*, the *New Statesman* and *Prospect*) and other media (for instance books, films, and the internet).

OR sometimes works directly on highly charged issues where the ethical and moral dilemmas involved are apparent to all and central to the investigation (energy policy is one such issue; provision for the elderly would be another). Such issues often give rise to arguments between conflicting groups about how the situation should be viewed and what should be done. The main issue for the OR investigator then is seen to be whether it is possible or desirable to try to maintain a neutral stance or whether it is better to commit to one side of the argument and work with one of the parties to the conflict (a company, the government, a charity, a special interest group such as Friends of the Earth). Recent examples in the literature include health care (Brailsford and Vissers, 2011), sustainable development (White and Lee, 2009; Brans and Kunsch, 2010), and green logistics (Dekker et al., 2012).

More generally a view of society immediately informs the first big ethical question for would-be interveners: which organizations to work for and what problems or issues to work on. Not many of us would be happy to work with an illegal trafficking gang even though it might make good use of our expertise in logistics; and we might have doubts about working on a tax avoidance scheme even though it was for some otherwise respectable organization. Equally, most OR people would be keen, when presented with the opportunity, to work on, the logistics of humanitarian aid relief (Van Wassenhove, 2006). The issue of who to work for or with is rarely addressed directly in OR case studies: the very fact that the reported intervention has taken place is taken to mean that the author, for whatever reason, accepted that working for the particular client was a desirable or acceptable thing to do given the circumstances. However, in more general terms there has from time to time been discussion about the fact that OR tends to serve the managerial interests of business and government at the expense of the affected poor (Ackoff, 1974b; Chesterton et al., 1975; Rosenhead and Thunhurst, 1982; Rosenhead, 1987). In similar vein there has been concern about the lack of OR in less developed countries (LDCs). Such concerns gave rise to initiatives to promote Community OR and OR in LDCs (see the special issue on OR in developing countries in the *Journal of the Operational Research Society*, 1986, Issue 2; Parry and Mingers, 1990; Midgley and Ochoa-Arias, 2004).

2.3. Assumptions about society in OR analysis

Societal ethics shape the development of scenarios for decision choice; the circumstances depicted in the scenarios will mirror the values that inform the decision (O'Brien, 2004). In OR practice though, very often the analysis of decisions recognizes only one scenario, namely business-as-usual (perhaps better described as society-as-usual). When the time horizon of the decision is short and the focus is tight (in operational decision-making, for instance), such a simplification is usually taken to be

uncontroversial. Ethical positions are then merely implicit but sometimes come to the fore as the following examples illustrate.

Example 1. In 1974 Ackoff addressed the UK OR Society's conference on *The Role of the OR Worker*. He described a series of interventions, which examined: the design of a pay scheme to satisfy the desires of both managers and (women) workers; the use of potentially health threatening additives in beverage production; the environmental impact of alternative beverage containers (cans, disposable bottles or re-usable bottles); and, how a programme of collaboration was established between a University and the so-called 'black ghettos' that surrounded it (the Mantua project). Ackoff's presentation was met by a barrage of questions and criticisms. The subsequent publication of his address included responses to some of the criticisms (Ackoff, 1974b). This gave rise to an exchange of views (Chesterton et al., 1975; Ackoff, 1975; Rees, 1976; Rosenhead, 1976). Essentially the criticism was that apart from the Mantua programme, the projects described by Ackoff, by concentrating on resolutions to 'apparent' conflicts narrowly defined, failed to address adequately the wider societal issues of disparities of power.

Example 2. In the 1980's the British Coal Corporation (previously the NCB) decided they wanted to close some of their mines. The case in the first instance was that these mines were losing money. Management accounts, designed to inform managerial decisions provided the data and the Corporation's accountants diligently applied the current standards laid down by various accounting bodies. However, when it came to a closure decision it was clear that adjustments needed to be made; in particular depreciation needed to be taken out as the costs involved had already been incurred. Some assumptions needed to be made about the cost of decommissioning and perhaps continued, limited operation to prevent adverse affects (water ingress) in neighboring mines. More controversially, some assumption had to be made about the overheads that were allocated to the mine. Could it be assumed that the cost of central services would be correspondingly reduced or would they simply be allocated elsewhere. There was then the question of redundancy payment to the miners. Up to this point the assumptions could be reasonably defended. Ethically speaking though, they present the situation from the perspective of the Corporation as a business. There would be, however, immediate knock-on affects beyond the business. Realistically, employment opportunities for miners were limited and the payment of state unemployment benefits could be anticipated. The mines would no longer be paying local taxes and the reduced spending power of miners would depress local economies. On a more personal level many miners would be devastated by their loss and the loss of future job opportunities for their children, jobs on which the local communities had come to depend. The future of whole communities was thus at stake; a case could be made (and was forcibly made by the unions) to keep the pits open. The Government's argument was that if they were to concede the validity of these social-impact arguments in the case of mines, they would then be obliged to support other facilities in difficulty in other industries; the result would be an ossified economy with the declining industries supported at the expense of more productive enterprises. Clearly those for and those against closure were appealing to very different ideas about how society could and should meet the needs and desires of citizens: they represented different ethical positions. Churchman (1970, p. B41f) makes a similar point about the mundane data required for the analysis of an inventory control system. The OR community within the British Coal Corporation was split over whether to close the pits or not, but mainly sympathized with the miners.

Example 3. In the 1990s there were exchanges in *ORMS Today* about the analysis of organ transport:

Differences of scale and perspective were, I believe, at the heart of a debate in this journal over the modeling of distribution of transplantable human livers. I criticized simulation modelers and others who I believed sought to maximize the efficiency of organ supply and distribution without attention to a broad range of social and political factors. I modeled the problem at a courser [sic] scale, focusing upon broad social restrictions and inequities that define the general context. In arguing at this geographical and political scale, however, I was criticized in turn for misunderstanding the technical elements of the problem and the model. (Koch, 2000, p. 16)

Any decision will similarly (though not always so dramatically) reflect ethical positions on what should be considered as relevant fact, on what values should be applied, and what weight or relative emphasis should be placed on one value relative to others. The corollary is that OR can be depicted as a vehicle for addressing ethical problems (Campbell, 2004; Mingers, 2011), as should any applied discipline. Despite the criticisms of Ackoff after his 1974 paper (see Example 1 above), his call in 1979 for a different sort of OR resonated in the UK with general concerns about the role of OR (Ackoff, 1979a,b).

In the OR literature one can often glean something about important societal issues when papers about specific OR applications address or touch upon them. Such papers may then offer an introduction to relevant literature in other disciplines. But very often OR is more concerned with improving the workings of the current system than with exploring the fundamental ethical and moral issues involved. For instance, Koch, in his above-cited account of an OR conference in the US says:

The OR practitioners whose lectures I attended have, by and large, taken a manufacturing model of production and applied it to areas affecting social policy, and more importantly, social life. By doing this they've allowed themselves too often to avoid the consequences of their work upon the greater society, the greater import of their small-scaled work upon the greater field. ... The failure of this general perspective was forcibly brought home to me in a session on health care in Philadelphia where I asked each speaker about these greater links. "What does this mean to you as a citizen?" I would ask. "Gee, I don't know," came the refrain, "it's not in the study's parameters." But whatever our expertise, we are all citizens first and foremost. If the OR mystique blinds practitioners to that, then it blinds them to the world their work may indeed affect. In that event, research contracts in hand, we become what we've been taught to despise: amoral bureaucrats without a care for the world we inhabit. ... the practitioner has a dual obligation in seeking even a limited solution to an assigned problem. He or she must see it first as a citizen involved in the social context and then as a specialist who will insist upon addressing the problem and its context together. We are first and foremost citizens of societies, or we are nothing much at all. Our first obligation is therefore not as practitioners working for wealthy client companies, but as citizens who see those problems in the context of our social world. (Koch, 2000, pp. 16–17)

Or, as one of the present authors concluded from a discussion of our contemporary notion of professional competence:

I cannot think of a more meaningful vision for a truly systemic concept of rational management than that of management as competent citizenship. (Ulrich, 1998, p. 13)

The ethically concerned OR practitioner would want to see the same ‘citizen’ perspective applied to industry and commerce as well as the public sector. All activities are manifestations of our attempt to help citizens meet their needs and to help them achieve their desires and aspirations. As Koch puts it:

A dialog about the sometimes conflicting roles of analyst and the citizen is rarely read in these pages, or heard at INFORMS meetings. There were almost no social policy-based sessions at the Philadelphia meetings, and the few that were scheduled were buried at odd times and in small rooms. Who cares? These aren’t the issues set forth by the client. And yet, issues of citizenry and responsibility undeniably bear upon the success or failure of the health, transit, and other programs modeled by OR practitioners. (Koch, 2000, p. 17)

3. Intervention ethics

The problem of grounding ethical practice remains today essentially unresolved in all applied disciplines, theoretically as well as practically (Ulrich, 2006a, p. 54f). The connections between OR intervention and ethical considerations are always real but not always recognized and not often subjected to reflection and critique (Bell and Morse, 2007; Brocklesby, 2009). Complete theoretical solutions are not available; even if they were available, they would hardly lend themselves to practice. What can be expected is, at best, helpful discussion of partial aspects. We would argue, therefore, that an adequate framework for grounding ethical practice will be of a qualified *pragmatic* nature (‘pragmatic’ in the philosophical as well as in the everyday meaning of the term; compare Ormerod, 2006, 2007; and Ulrich, 2006a). Our shared bias leans towards developing a framework for professional intervention based on what we call ‘critical pragmatism’ (Ulrich, 2007). A review paper such as the present one is not the place to develop such a framework, a task that poses difficult theoretical and methodological challenges; instead, what we aim to offer here is a somewhat representative overview of the diversity of necessarily fragmentary attempts by OR authors to grapple with the topic of intervention ethics from a more or less explicitly pragmatic perspective.

3.1. The process perspective

One pragmatically helpful way to deal with intervention ethics is by adopting a *procedural* or process-oriented perspective. The process adopted for an OR intervention will influence the way that key ethical choices are made: what is the project scope, who is to be involved in what capacity, what are the organizational aims to be met and the societal norms to be complied with, what constraints apply? Accordingly, many OR authors have chosen such an approach. Historically speaking four process-orientated ethical perspectives can be identified: the ‘mainstream’ OR approach, the ‘systems’ approach, the ‘strategy group-support’ approach, and the so called ‘soft OR’ approach which brings together methods from the other traditions.

3.1.1. Mainstream OR perspective

A literature survey of the use of OR and Systems approaches in environmental management and sustainable development conducted by Paucar-Caceras and Espinosa (2011), found that over 90% of the reports they identified took a mainstream (in their terms, classical) approach. The mainstream OR approach can arguably be traced from wartime OR (Blackett, 1950), to the early simple depiction of the OR modeling process (Ackoff, 1956), to *articulate intervention* (Boothroyd, 1978; see also Ormerod, 2010a), to *applied systems analysis* (Miser and Quade, 1985), which

despite its systems label is more appropriately placed in the OR tradition, to the seven step method for OR consultants (Ormerod, 1996).

3.1.2. Systems perspective

The systems approach can be traced from *inquiring systems* (Churchman, 1971) to *soft systems methodology* (Checkland, 1981), *strategic assumptions surfacing and testing* (Mason and Mitroff (1981), and the boundary critique of *critical systems heuristics* (Ulrich, 1983).

3.1.3. Strategy group-support perspective

The strategy group-support approaches come out of research into the way groups of decision-makers make strategic decisions, including: the *strategic choice approach* (Friend and Jessop, 1969), *cognitive mapping* and *strategic options development and analysis* (Eden, 1988) and *drama theory* (Bryant, 1997).

3.1.4. Soft OR perspective

Soft OR is generally taken to include the systems and strategic group support approaches, together with: *interactive planning* (Ackoff, 1974a); *metagames* (Ackoff et al., 1969; Howard, 1971, 1987) and *hypergames* (Bennett, 1980). For a recent overview of soft OR applications in this journal, see Vidal (2004).

3.1.5. Other approaches

In addition a number of approaches have addressed the choice of models to be used within interventions, for example: the initial work in this area of Bennett (1990) and Cropper (1990); *total systems intervention* (Flood and Jackson, 1991), *multimethodology* (Mingers, 1997) and the *transformation competence perspective* (Ormerod, 1997; see also Ormerod, 2008a). Many other approaches have been proposed, for instance the viable systems model of Beer (1985) based on cybernetics, the post-modern approach of Taket and White (1993), and a variety of step-by-step approaches attached to specific techniques such as simulation, systems dynamics, DEA, and decision analysis of one form or another.

3.2. Ethical issues and ranges of intervention

These approaches have been developed to support a range of interventions. Consider a scale constructed between two poles with a single investigator working on a well-defined local problem for a single client at one pole, and a team of investigators working on a complex problem with extended social implications at the other. The ethical issues at the small, simple pole may well be considered uncontroversial while at the large, complex end they may be transparently at the center of the issue at hand. Plotted on this scale, reports of early OR, that is mainstream OR, tended to cluster at one end or the other: problems of queuing, inventory, scheduling and logistics clustered at the simple end; strategic and social issues clustered at the complex end. At the simple end it is likely that the OR intervention will tackle the whole of the limited problem that is of concern for a client who is in a position to take a decision and implement it. At the complex end the OR analysis will usually (along with other competing analyses) be embedded in a political process in which the power to decide is vested in some democratic structure involving many people. In the US such analysis of large scale problems would be referred to as RAND systems analysis or just *systems analysis* (Miser and Quade, 1985); more generally it is referred to as *policy analysis* (within OR literature, for instance, Murphy, 1991) or *impact assessment* (within OR literature, for instance Allett, 1986; Becker, 2001; Chmaco and Craveirinha, 2010). Recently in European OR it has been referred to as the field of complex societal problems (DeTombe, 2001, 2002).

The depiction of the process of mainstream OR as either a model building and implementation exercise (definition of problem, construction of model, solution of the model, validation of the model, implementation of the final results) or an exercise in assisting decision choice (definition of the problem, identification of possible options, define criteria for choosing between options, evaluate the outcomes of each option in terms of the criteria, choose the best option in terms of the criteria, implementation of the final results) has served practitioners well as a general starting point but contains little operational guidance. In the model-building approach to intervention it is assumed that relevant (relevant that is to the issue being addressed) ethical issues will become apparent as choices required in the modeling process; in the assisting-decision-choice approach ethical issues are generally assumed to arise in the choice of criteria, which in turn determine the consequences that need to be included in the modeling.

These depictions had seemed more or less adequate at the simple or complex poles assuming that at the complex pole the OR contribution is embedded in a wider (democratic) process which lays bare the ethical issues. However, much of the debate about the process of OR over the past 40 years or so has been concerned with the conduct of interventions which lie somewhere between the two poles – addressing problems that are somewhat complex, where the issues need clarifying, where values come into conflict, but where the issues addressed are not large scale societal issues receiving attention from wide-scale political analysis and (democratic) discourse. We can refer to these interventions, which lie somewhere between the simple and complex poles, as *mid-range interventions*. In fact much practical OR lies in this mid-range.

3.3. The need for ethical guidance in mid-range interventions

For mid-range interventions the depiction of the process of OR as model building and/or decision choice was seen by many to be not particularly helpful; on the one hand, ethical issues arise that clearly go beyond the ‘givens’ of local/technical problems, while on the other hand, democratic processes as they come into play with complex/societal problems are too far away. This important range of intervention has therefore given rise to a number of specific proposals within the intervention perspectives given above referred to above; examples are articulate intervention (Boothroyd, 1978; see also Ormerod, 2010a) for the mainstream OR perspective; boundary critique (Ulrich, 1983, 1987; see also Midgley and Munlo, 1998) for the systems perspective; and particular types of modeling (for instance, for simulation see Robinson (2004), and for linking soft with hard methods see Lehane and Clarke (1997)) for the other approaches. The main change introduced by these mid-range approaches has been to increase the amount of participation in the investigation process; the result is that ethical considerations in general and more specifically moral choice have been brought into focus.

In the US Churchman, adopting a systems perspective, initiated the debate by questioning what ‘improvement’ should mean and drawing attention to the importance of reflecting on whom the system should be seeking to benefit; he argued that the ‘anatomy’ of decision-making was more complicated than normally assumed and hence the choice of an appropriate systems boundary was crucial. He advocated ‘sweeping in’ as many relevant people (and ideas) as possible (Churchman, 1970, 1971, 1979). *Inter alia* participation serves this end; it results in more opinions and fewer unchallenged assumptions about both ultimate aims (objectives, ends) and the consequences of the means being considered. Increased participation ensures that, even without the guidance of specific methods, greater attention is paid to the variety of ethical issues espoused by different participants, leading to the identification of both common ground and conflicting views. The resulting

dialogue should lead to greater understanding, if not always agreement. Churchman’s colleagues (and Churchman himself) took this theme of participation and emphasis on ethics into management practice: Ackoff (1974a, 1978, 1981a,b) applied his ‘interactive planning’ approach to a wide range of issues; Mason and Mitroff (1981) and Mason (1969) proposed a dialectic approach (strategic assumption surfacing and testing); and Ulrich (1983) developed boundary discourse, a discursive form of boundary critique.

In the UK new participative approaches such as the strategic choice approach (Friend and Hickling, 1987, 2005), soft systems methodology (Checkland, 1981, 1985), cognitive mapping (Eden, 1988), and gaming approaches (Howard, 1987, 1989; Bennett et al., 1989; Bennett et al., 2001), were introduced. The collective term ‘soft’ was used to differentiate these approaches from the mainstream, more mathematically orientated, analytical approaches. The soft methods are generally found to be most effective at the beginning of an intervention and are now often collectively referred to as problem structuring methods.

Compared to mainstream OR, systems approaches and soft OR approaches provided much greater scope for reflection on ethical issues both prior to and during an OR intervention. The various approaches offer the possibility of reducing the participatory/democratic deficit of the more traditional mainstream approaches (White and Bourne, 2007). The boundary critique of Ulrich provides, in the form of critical questions, a method for ensuring that ethical issues are given due prominence at every step in an intervention from determining the scope to deciding who should be involved and what assumptions condition clashing claims and arguments; it can support the use of other methods (Ulrich, 1983, 1987, 2003).

Parallel developments have been taking place within the more traditional OR domain of decision analysis and choice. The scope of traditional mathematical OR models, their sophistication and their ease of use, have steadily progressed throughout the history of OR. The emphasis, for many years at least, was on the models themselves. However, with increasing experience of their use and a greater demand for transparency and validation, attention turned to the process in which the model building work is embedded. This ongoing effort, centered today in Belgium and France (referred to by Roy and Vanderpooten (1996) as the European School of multi-criteria decision-making) is currently producing a number of papers on both theory and practice. A special issue was published under the title ‘Management of the Future MCDA: Dynamic and Ethical Contributions’ in the *European Journal of Operational Research*, (Brans et al., 2004). This stream of research, inspired particularly by Roy (1968, 1978, 1985, 1987, 1990, 1991, 1996) and Brans (1982, 2002a,b, 2004); Brans et al., 1984; Brans and Vincke, 1985; Brans et al., 1986, 1998, 2001), seems to have achieved critical mass, attracting many researchers.

3.4. The search for comprehensive OR approaches to societal problems

For large investigations into societal problems at or near the complex pole, elaborations to conventional OR approaches have generally been favoured. Because of the importance, as well as the scale and impact of large-scale policy and developmental issues, appropriate methodologies have to be comprehensive and documented for democratic scrutiny. At the International Institute for Applied Systems Analysis (IIASA) a three-volume handbook for systems analysis (as previously mentioned this is the term used in the US for OR analysis of large scale societal issues) was written under the joint editorship of Miser and Quade (1985, 1988) and Miser (1995). Examples in the book include water management, energy supply and blood availability. Such a handbook has to be comprehensive by its nature. The choice of objectives, preferences, criteria and constraints (all of which reflect ethical judgements) are

discussed throughout the handbook. Attention is also drawn to implementation (Tomlinson et al., 1985), a subject that is often left as an afterthought in the literature of methods. Implementation initiates social change and can be thought of as an experiment; and implementation is indeed sometimes conducted as an experiment (we will try it out first at location X or organizational unit Y, learn about the consequences and then adopt the change more widely) where this is feasible (Nagel and Neef, 1979). In decisions that involve a conflict of values, protagonists often generate strong emotions (Belton, 2005; Brugha, 2005; Wenstøp, 2005a). Wenstøp and Koppang (2009) suggest that these need to be tempered by strategies such as to focus on consequences (rather than virtues and rules) and to engage in discourse.

A number of approaches that are designed to support the issue of large-scale social choices have been developed with ethical considerations to the fore. For instance, Brans and Mareschal (1994) proposed their PROMETHEE-GAIA decision support system based on multi-criteria decision analysis; DeTombe reviews the issue of complex societal problems (DeTombe, 2002) and proposes the complex program handling method (COMPRAM) making use of systems dynamics (DeTombe, 2001); emphasis is placed on participation and communication by Geurts and Joldersma (2001), on cooperation by Theys and Kunsch (2004), and on responsibility, sharing and cooperation by Gallo (2004); Wiek and Walter (2009) advocate a transdisciplinary approach; Walker et al. (2001) propose an adaptive approach. Another closely related field of activity is (environmental, economic, social and technological) impact assessment (Allett, 1986; Becker, 2001; Clímaco and Craveirinha, 2010).

4. Ethics in analysis

This section first considers the way models depict ethical issues and then turns to the ethical issues involved in the modeling activity itself. Much OR discussion about ethics centers on the embedding of values, preferences, objectives, constraints, weights and so on in models so as to inform decision choice effectively (Walker, 1994; Kunsch et al., 2009). How should values be handled (included, represented) in models, how should the results be interpreted, what are the moral hazards of building models?

4.1. The depiction of ethical issues in OR models

Early in the history of OR the mathematics of games and decisions was developed in the US (Luce and Raiffa, 1957; Ormerod, 2010b). In 1964 the UK Operational Research Society held an international conference on 'Operational Research and the Social Sciences' at Cambridge (Lawrence, 1966) to build links with the social science disciplines and their various approaches to management problems. The way in which decisions and choices were made was at the center of discussion. Much of the analysis at that time was depicted in economic terms supported by mathematical analysis; subjects such as gaming, decision theory, cost-benefit analysis, welfare economics and utility theory were discussed. Many of the concerns raised at the conference are still with us: the appropriateness of cost-benefit analysis; emphasis on economic at the expense of non-economic values; sub-optimization; the inappropriateness of a single measure of utility; the inclusion of non-measurable consequences; the impact on income distribution; the irrationality of actual decision making; the political nature of decision making; the difficulty of exercising social choice; and so on (see for instance, Foster, 1966; Lichfield, 1966). What is striking when reading the proceedings today is that the mathematical formulations generally used calculus rather than mathematical programming. At about this time Raiffa in the US

concluded that, given the difficulties in applying game theory in practice and the availability of the new powerful analytic techniques of mathematical programming, the use of a utility approach was more practical than game theory when advising clients (see Ormerod, 2010b, p. 1767). However, the concepts of utility and optimal decisions remain controversial, as Clímaco (2004) notes among others.

Focusing on the mainstream OR perspective introduced above, we will follow three related long-term modeling research programmes that developed from these beginnings and see how they deal with the modeling of ethical issues: mathematical programming; multi-criteria decision analysis (MCDA); and impact analysis. A further stream of activity, which partly draws on what we have earlier referred to here as the 'systems perspective', will also briefly be considered as represented by a group of researchers including Kunsch et al. (2009), (compare Rauschmayer et al., 2009, also Rauschmayer, 2001, 2005).

If we accept that OR models are basically concerned with advising on or evaluating actions, we must also accept that all models are ethical in intent in that (a) they assume preferences to be satisfied, ends to be pursued, values to be respected and (b) they are based on assumptions about the meaning and significance of the data used (for example, whose problems and concerns do they capture and whose not?). The use of mathematical programming to model such ethical issues is best understood by considering an example.

The example considered here is energy modeling. Consider the simple case of an LP model of an electricity system consisting of an objective function to minimize cost and constraints to represent demand, the technical constraints of the existing power plants, and the possibilities of investing in new capacity. The decision to use cost in the objective function is an implicit statement that cost minimization in this particular circumstance (the circumstances in which the model is being applied) is a good thing to try to do and that the costs used do indeed represent costs relevant to society, or at least it is reasonable to assume the costing conventions are appropriate. If carefully done the model will answer the question: What investments should we choose if we want to minimize our costs based on our usual accounting conventions? There is nothing ethically suspect about such a statement given the premises. However, we may want to ask other questions, based on a different ethical perspective on what is important. So for instance, we may want to introduce a constraint on the total level of CO₂ emissions (relevant today but in the 1970s and 1980s SO_x and NO_x were the main concerns; Watson, 1986). More radically, we may wish to make minimizing CO₂ the subject of the objective function, demoting cost to a constraint or perhaps merely an information row. By varying the assumptions it is possible to explore the relationship between CO₂ reduction and cost for the electricity system as an exercise in multiple-objective optimization. To explore the issue further we can make the LP into a multi-time-period model of the whole energy system adding constraints on finite resources available (such as gas in a particular gas field), perhaps overlaid by some structure to represent intergenerational transfers (the time value of money, for instance). The model could also be extended to see how energy demand and supply interact within the wider economy (Bayraktar et al., 1979; Lev, 1983; Ormerod, 1980; Labys and Weyant, 1990) and to examine risks and uncertainties within different scenarios; for instance, such a model could be used to track dependence on imports in order to inform a debate about geo-political risks; upper limits could be placed on imports or minimization of imports could be made the primary objective. Such questions were being debated in the 1970s and 1980s when international oil supply constraints were causing concern (Häfele, 1981).

As the ambition for these models grew, so did the technical challenges and concerns about their validity (Gass, 1979b,

1991b; Murphy, 1991) and the possibility of communicating the (by now rather complicated) results (Cherniavsky, 1979). The technical, economic, environmental, social and political issues surrounding energy supply and demand continue to be of urgent concern for policy makers today; energy modeling remains relevant (Oliveira and Antunes, 2004). Over the years the theory of mathematical programming (Hwang and Yoon, 1981) has advanced and the computing power needed to run large complex models has become widely available but issues of validity and communicability remain. There is also the question of how to choose a suitable type of model (Mulvey, 1979; Allison et al., 1994); many applications of different mathematical programming multiple-objective optimization methods have been recorded in the literature (White, 1990).

One of the problems, as the energy example demonstrates, is that on any one issue the number of normative considerations (objectives, preferences, constraints and so on) to be taken into account can be very large. Furthermore, deciding how to represent values, how to attach quantitative or qualitative measures to them and how to interpret and compare such measures is problematic and will be understood differently by different people. For complex policy decisions, understanding and eliciting values becomes a major issue (Keeney and Raiffa, 1976; Keeney, 1988; Keeney et al., 1990; Weber and Borcherding, 1993; Keeney, 1994; Gregory and Keeney, 1994). Reflecting on the past, Keeney observed:

Many complex decision problems have significant potential consequences, including, for example, costs of hundreds of millions of dollars, or fatalities, or large-scale environmental degradation. The only reason for taking an interest in such problems is that some consequences may be much better than others, and so some alternatives may be much better than others. Yet the amount of time usually taken to articulate appropriate values for a decision problem is minuscule relative to the time used to address other aspects of the problem. The objective function might be chosen in an hour with very little thought, and yet several person-years of effort and millions of dollars may be used to model the relationships between alternatives and consequences and to gather information about those relationships. (Keeney, 1994, p. 795)

One way to handle the issue is by multi-criteria decision analysis (MCDA), as Roy (1996), Belton and Stewart (2002), and others have described. MCDA represents a change in emphasis from the use of models for the purpose of exploring options in the light of desired outcomes (cost, emissions, sustainability security, etc.) to the use of models for the alternative purpose of exploring more deeply the nature of desires and values that are embedded in the desired outcomes. MCDA evolved from decision analysis (Keeney and Raiffa, 1976; Keeney, 1982; French, 1988). Over the years many different approaches have been suggested, sufficient in number to raise questions of choice (Guitouni and Martel, 1998). The *analytic hierarchy process* (AHP), which emerged in the early 1970s in the USA, was the first approach to be widely applied (Saaty, 1980, 1994). It has been the subject of much debate and research (Vargas, 1990) and has an impressive record of applications (Zahedi, 1986; Omkarprasad and Sushil, 2006). Saaty explains:

From past knowledge, we sometimes can develop standards of excellence and poorness and use them to rate the alternatives one at a time. This is useful in such repetitive situations as student admissions and salary raises that must conform with established norms. Without norms one compares alternatives instead of rating them. Comparisons must fall in an admissible range of consistency. The analytic hierarchy process (AHP) includes both the rating and comparison methods. Rationality

requires developing a reliable hierarchic structure or feedback network that includes criteria of various types of influence, stakeholders, and decision alternatives to determine the best choice. (Saaty, 1994, p. 19)

The analysis is structured such that decision-makers find the results easy to understand (Macharis et al., 2004). On-going research into AHP is aimed at providing evidence of its efficacy (Ishizaka et al., 2011).

Another long running research programme is centered on the ELECTRE approach of Roy (1968, 1978, 1985, 1987, 1990, 1991, 1993); see also (Papadopoulos and Karagiannidis, 2008) based on outranking. It gave rise to PROMETHEE, a decision support system based on multi-criteria decision analysis initiated by Brans and further developed with colleagues (Brans, 1982; Brans et al., 1984, 1986; Brans and Vincke, 1985; Brans and Mareschal, 1994). The latter approach, which is also based on outranking, offers the user considerable flexibility as to whether and how to aggregate assessments made against different criteria. In Macharis et al. (2004) the strengths and weakness of the PROMETHEE and AHP approaches are compared. The ELECTRE/PROMETHEE European research programme has developed a network of collaborating researchers and would seem to be progressive.

If MCDA represents a shift in direction towards focusing on the problems surrounding values and preferences, *impact analysis* (also often called impact assessment) represents a shift in a different direction. In impact analysis no attempt is made to trade one value off against another nor to represent the different weights people may place on the values involved. Instead, and more straightforwardly, the (environmental, economic, social and technical) consequences of various options are explored and laid bare to inform the decision process (Allett, 1986; Becker, 2001; Clmaco and Craveirinha, 2010). However, most papers describing the theory and practice of impact assessment are found in non-OR journals and books (see for instance, Holling, 1978). Often impact analysis is applied to a single proposal, the alternatives being to accept or reject the proposal. From an OR perspective, comparison ought to be made with alternatives, in which case impact assessment needs to be associated with some decision analysis to examine the choices faced. Alternatively, the impact of each of several options can be presented as a 'scorecard' (Walker, 1994, p. 235) such that decision makers can make up their own minds.

Kunsch et al. (2009); (compare Rauschmayer et al., 2009; and Rauschmayer, 2001, 2005) advocate taking a 'systems-based approach', particularly for analyzing sustainability issues. The modeling approaches they suggest include systems dynamics, non-linear dynamic biological systems, agent-based modeling, evolutionary computing algorithms, small world theory, and adaptive policies. These approaches model the behavior of human-activity systems; to support decision-making they need to be linked to a process of decision analysis. Further, the authors suggest forging links between system approaches and MCDA; in particular, the use of systems dynamics with MCDA has been suggested (Brans et al., 1998, 2001).

MCDA can be used to assess the efficiency of multiple units that perform similar tasks (bank branches, retail outlets, schools and so on). This is an issue that has been addressed independently as *data envelopment analysis* (DEA). Both approaches involve assigning weights to criteria (Belton and Vickers, 1993; also see Cooper et al., 2004, 2005; Zhou et al., 2008 for recent accounts). Thus both are concerned with the ethical question of how performance should be judged (Stewart, 1996; Belton and Stewart, 1998). In response, a new approach to weighting in DEA is proposed by Sarrico and Dyson (2004) who acknowledge the connection between the two research programmes (p 26). Similar connections can be made with other research programmes (for instance, Feng et al., 2004;

Linares and Romero, 2000; Sinuany-Stern et al., 2000; Yang and Kuo, 2003). Ethics is ever present in all models designed to support decision-making.

4.2. The ethics of model building

In terms of ethical issues arising during the activity of model building itself, Mason (1994, p. 184) suggests there are three ethical obligations that have to be met through reflection and the assumption of responsibility:

- i. to represent reality to clients adequately;
- ii. to understand and to incorporate the client's values into the model in an effective way; and
- iii. to insure the actions the client takes based on the model have the desired effect.

Mason (1994, p. 187) argues that in effect management scientists qua professionals enter into two major implied covenants: the *covenant of reality*, in which the model builder is entrusted with understanding things as they actually exist in the problem area and representing their most salient features as accurately as possible, and the *covenant of values*, in which the model builder is entrusted with the visions, goals, and objectives of the client and pledges to serve those values as loyally as possible.

Walker (1994, p. 228), considering the requirements of what he refers to as a rational-style model-based policy analysis (which in the last section we described as a mainstream perspective addressing complex problems with extended social implications), suggests seven activities should be examined. Together with an eighth activity added later (Walker, 2009, p. 1054), they are:

1. Formulating (and reformulating) the problem.
2. Specifying objectives and deciding upon criteria.
3. Identifying alternatives.
4. Designing scenarios to deal with uncertainty about the future.
5. Building models.
6. Collecting data.
7. Analyzing alternatives and drawing conclusions.
8. Documenting work and communicating results.

To these we can add two more activities that are subjects in their own right:

9. Validation (Gass, 1983); and
10. Implementation (Churchman and Schainblatt, 1965).

This conventional modeling approach is an extension of Ackoff's original 6 step method for OR (Ackoff, 1956). Walker (1994) proposes that most of the so-called ethical issues in modeling can be considered as matters of best practice, a question of quality control in handling the mentioned activities. With a view to supporting best practice in the different activities, Walker (see also Allen et al., 1992) draws heavily on the 1971 ORSA *Guidelines for the Practice of OR* (Caywood et al., 1971) and the previously referred to IASA *Handbook of Systems Analysis* (Miser and Quade, 1985, 1988). Based on Miser and Quade, Walker proposes a list of evaluative questions for internal peer critique and external assessment as to the validity of the advice given. He found little wrong with the 1971 guidelines, calling for them to be updated and adopted as a code to be used both in practice and for educational purposes.

Gass (1979a,b, 1983, 1984, 1987, 1991a,b, 1994, 2009) has been involved with ethical issues in analysis over an extended period. As a result of his engagement in attempts to improve the quality and usability of models used for policy analysis by the US Government,

he concluded that a model life-cycle consisting of thirteen phases should be considered:

- Embryonic (initiation),
- Feasibility,
- Formulation,
- Data,
- Design,
- Software development,
- Validation,
- Training and education,
- Installation,
- Implementation,
- Maintenance and update,
- Evaluation and review,
- Documentation and dissemination. (Gass, 1987, pp. 4–5).

Gass argues that each phase of model building must be conducted professionally, properly documented and the models must be accessible by and give confidence to the designated user. This amounts to an ethical imperative for model builders. He also concluded that codes of ethics should be adopted.

One of the key activities early in the process of formulating a model is to decide on the basic modeling approach: optimization, simulation, MCDA, DEA and so on. Allison et al. (1994) draw attention to the impact of the choice of model on the outcome, giving examples of public policy disputes in which models from different disciplines gave different answers. In the AT&T anti-trust trial they relate how the use of a goal programming/restrained regression approach exposed data errors in the statistical analysis. In the case of the Texas v. New Mexico Pecos River water dispute a similar approach demonstrated that the analysis based on traditional methods violated basic physical flow relations. They conclude that model builders in policy areas have an obligation to explain the effect of adopting models from different disciplines and also different models from within the same discipline. Cooper et al. (2009) describe how moral hazards were dealt with in an example involving the tracking of mobile phones.

As a last relevant contribution, we wish to consider briefly Rauschmayer et al. (2009), to which we have already referred in relation to the work of Kunsch et al. (2009). The authors first identify the key relationships between various actors, between actors and the model and between the model and the problem in the real world (see Fig. 3).

They then examine the key questions relevant to each relationship and briefly discuss them in respect to rules (by which we take them to mean codes) of good practice, concluding:

We doubt that the rules of good OR practice . . . are sufficient by themselves to solve all problems of ethical relevance in the different relationships. Rules of good practice cannot free the practitioner from facing these responsibilities and from dilemmas arising from these responsibilities. Such rules are a good starting point, though, and should be a necessary part of OR practice. To be better prepared to face the ethical difficulties necessarily implied by OR practice, OR practitioners, we suggest, need a better training in ethics, and also in psychology, even if this might involve less mathematical or business training. Such training should lead OR practitioners to establish their own ethical values, and give them a basis to develop them further in the course of their commitments. (Rauschmayer et al., 2009, p. 1098)

Undoubtedly, when it comes to explaining the nature of ethical practice (in model building, analysis and intervention), rules or codes of professional conduct have their limitations. They gain

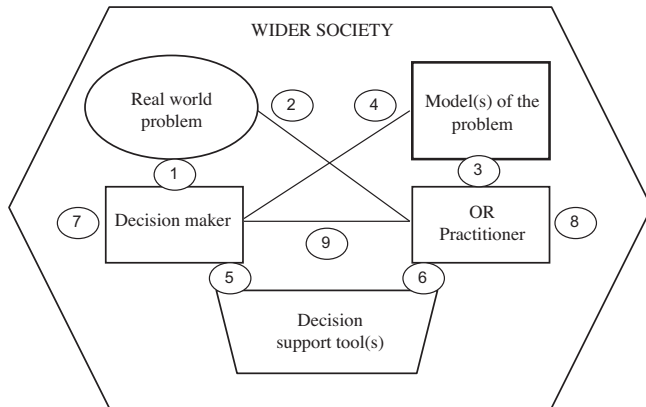


Fig. 3. Basic model of nine ethically relevant relations between different elements of OR practice (Rauschmayer et al., 2009).

their main importance in the development and training of a personal ethical stance of professionals, which is the issue to which we turn in the next section.

5. Personal and professional ethics

From the inception of OR it was implicitly assumed that the OR worker would be personally responsible for ensuring that ethical issues were adequately addressed in any particular project: a high standard of ethical attitudes and behavior was taken for granted. These high standards presumably derived from home, education and work experiences. It was further assumed that ethical dilemmas would be recognized and satisfactorily resolved by individuals, perhaps in consultation with their clients and colleagues. These assumptions have continued to hold sway for most practitioners to this day and they remain the default position. It has not been widely accepted that ethics should be taught on OR courses, nor have codes of professional ethics or other kinds of ethical standards been widely adopted.

5.1. A brief history of the debate about codes of practice in OR

Debate about professional ethics and codes of practice have inevitably been intertwined with discussions about the nature and purpose of OR and the role of professional societies. In the USA in 1953, The Institute of Management Sciences (TIMS) was set up by a group of researchers and practitioners who were concerned that the Operations Research Society of America (ORSA) was institutionalizing a limited and limiting vision of OR, or management science as they preferred to call it. Churchman, whose background was in philosophy, was appointed the first editor of *Management Science*, the new organ of TIMS, which started publication in 1954. As previously noted Churchman determined to put ethics at the center of OR, a counter balance to the predominant mathematical orientation. Having stepped down from the editorship of *Management Science* in 1960, Churchman continued to initiate debates in its pages on the practice of OR/MS; in 1965 he published a paper (with Schainblatt) on the relationship between researcher and manager which provoked a number of responses from other researchers (Churchman and Schainblatt, 1965; Churchman et al., 1965); and in 1970 he elicited contributions from a number of eminent US and UK academics on the question of education for operational researchers including Ackoff (1970), Churchman (1970), Cook (1970), Eilon (1970), and RA Howard (1970).

The question of adopting a code of practice was brought to the fore in the USA in 1971 as described by Gass (1991b, 2009). He explains:

The Operations Research Society of America (ORSA) published in its journal *Operations Research*, the report “Guidelines for the Practice of Operations Research” [Caywood et al., 1971]. This report was prepared by The ORSA Ad Hoc Committee on Professional Standards and was developed as part of a larger report that dealt with the proposed deployment of an antiballistic missile system (ABM) called SAFEGUARD. The Ad Hoc Committee was asked to evaluate “the professional conduct during the ABM debate” ... The ORSA constitution stated one of the purposes of ORSA shall be: ... the establishment and maintenance of professional standards of competence for work known as operations research. Until the publication of the “Guidelines”, ORSA had no such statement of standards. (Gass, 2009, p. 1045)

The ORSA Guidelines were criticized (Botts et al., 1972; Carpio et al., 1972; Churchman, 1972; Mitroff, 1972; Peters et al., 1972; Wagner, 1972), were never formally adopted, and were largely forgotten. However, ten years on Machol (1982) suggested the issue should be revisited and a report from the ORSA Committee on Ethics and Professional Practice was duly published (Kettelle, 1983). Gass relates that:

The “Guidelines” were meant to be an unofficial document directed at the individual analyst and the organization within which the analyst works; they dealt more generally with professional and business practices. The report suggested that its material be combined with the previous 1971 report so as to provide ORSA with an official code of ethics and guidelines for practice. No action on the report was taken. (Gass, 2009, p. 1046)

Meanwhile in the UK in 1973 a Fellowship for Operational Research (FOR) was formed by some members of the (UK) Operational Research Society (ORS) so that practitioners could have a recognisable professional qualification. This initiative was taken in response to a vote by a majority of the society’s then members for the society to remain an open, non-professional body (Kirby, 2006). The FOR produced a guide for professional conduct (*Fellowship of Operational Research*, 1974). The guide avoided ‘rigid instructions and admonishments’ preferring it to be used by a Fellow to provide him or herself with ‘a basis for his own decisions, a basis most likely to be acceptable to his professional colleagues’ (Gass, 2009, 1045).

The issue of ethical codes was revisited in the UK when Gass, giving the opening plenary address to the 1990 UK ORS annual conference, commended the ORSA guidelines. He suggested there were three views of a scientist’s role in the analysis of public issues:

1. The scientist is to present the facts in an unbiased manner and not advocate a particular position in attempting to influence the decision-making process (one works on nuclear plant citing and presents the results objectively).
2. The scientist has a moral responsibility for the effects of his own involvement in the scientific endeavors of society (one does not work on site selection of a nuclear plant if one believes such plants are a menace to society and the environment).
3. The scientist works openly as an advocate for a particular point of view (the best site for the nuclear plant is in location A). (Gass, 1991a, p. 12).

He suggested that when working in the policy analysis area, OR analysts usually are operating in the second or third role. Drawing on Dror (1971) he proposed that a code of ethics for policy analysts should be concerned with the following:

- (a) Goals and values of the client: do they contradict basic values of democracy and human rights?

- (b) Relationship between the analyst's values and the clients: do the client's beliefs contradict the basic values of the analyst?
- (c) Presentation of all viable alternatives: the analyst should not hide an alternative because it contradicts his or her personal values or preferences.
- (d) Increasing the judgement opportunities of the client: the analyst should make a careful delineation of assumptions and present unbiased sensitivity studies.
- (e) 'Rubber stamping' a conclusion: a study should not be undertaken whose sole purpose is to support the client's conclusion that has been reached by other means.
- (f) Access to information: the analyst should not work for a client who does not provide the necessary information and opportunities for presentation of the study and its findings.
- (g) Conflicts of interest: the analyst must avoid all such conflicts, including the use of the study for personal gain and the making of recommendations on matters in which the analyst has a private or personal interest.

An additional ethical consideration to the above is given by Quade (1989)...:

- (h) Analysts should try to keep their work from being misinterpreted or used to imply more than it should.

I would reinforce that statement with the following addition:

- (i) Analysts should do their utmost to ensure that their models are used in an objective manner. When their models are used to bolster an advocacy position, such use should be stated explicitly. (Gass, 1991a, p. 12).

5.2. On the use and limits of ethical guidelines

Despite obvious limitations of what they can achieve, such guidelines would seem potentially relevant and helpful. However, Taket (1994a) took issue with Gass pointing out that in her experience of working on health and community issues, in areas where the ORSA Guidelines would seem to apply, she found she breached them. In other areas they had little to say about the dilemmas she faced: for instance, when working in a dual role, firstly as a member of the organizations concerned and secondly as an OR analyst (p 126). She therefore argues against the adoption of a code of ethics, particularly if it is understood, in Gass' words, as 'a set of principles or a set of rules that sanction or forbid certain kinds of conduct' (Gass, 1991a, p. 11). To be relevant to OR as it had developed in the UK, she argues, practitioners should instead engage in critical ethical reflection without the comfort of a set of guidelines: it is better to struggle with a 'restless conscience' than to be told what to do (Taket, 1994a, p. 130). But of course, to do justice to Gass it should also be noted that guidelines such as he provides can indeed serve to stimulate ethical reflection, as the response of Taket demonstrates.

If guidelines are to be used at all, Taket would require them to recognize and support four critical demands:

1. Undertaking a process of critical self-reflection: At any point where a dilemma arises there is no single 'right' answer/course of action. ... This necessitates forming a view on power relations in particular....;
2. Recognizing subjectivity and responsibility: This process of reflection is necessarily personal and subjective, one for which the analyst must assume responsibility ... we must accept responsibility for our own role as agents;

3. Recognizing non-neutrality: In most situations it is impossible to remain neutral. ... This involves recognizing our own, and others', non-neutrality, and considering, as part of the process of reflection, the likely consequences of this in each situation;
4. Recognizing the pervasiveness of ethical issues: This involves a recognition that there is nothing separate from context. Our actions, including the OR we do, are part of a nexus of interwoven and interconnected relationships, constantly being shaped by the relationships they shape. The process of ethical examination must be part of all stages of the OR process: how I decide whether to get involved, how I present myself to the 'customer'/how I get involved, how I carry out the study, how I write the report, what I include/exclude in the report, how I act following the report. (Taket, 1994a, p. 130)

Taket's paper gave rise to an exchange of viewpoints (Bowen, 1994; Gass, 1994; Taket, 1994b, 1995; see also Wenstøp, 2010). In 1997 a "Prospective Code of Ethics" was approved by the UK OR Society but has not been adopted (Gass, 2009, p. 1046).

In 2002 Brans proposed that all decisions should be 'well-balanced between the influence of three poles'. Two poles, the rational and the subjective, he suggests are well established in OR; the third, the ethical pole should also be taken into account in order to respect the social and the ecological environment of the affected people, and to promote sustainable development for future generations (Brans, 2002b, p. 191). To stimulate an ethical dialogue, and a commitment by the OR community, Brans proposed the adoption of an Oath of Prometheus (Brans, 2002b, p. 195).

Reviewing the situation in 2009, Gass notes that among the members of IFORS so far the only codes of ethics in place were those of the US based *Military Operations Research Society* (2003) and the *Japanese Operations Research Society* (JORS). However, members of JORS were not required to agree to or comply with the code (Gass, 2009, p. 1047).

In summary, all contributors to the debate agree that ethics is, and to the extent that this is not recognized should become, a central concern of OR practice. All agree that this can only be achieved by personal commitment and reflection. However, opinion is divided as to whether a code, whether voluntary or enforced by some mechanism, is helpful in achieving the desired end.

6. Questions for future research

To conclude this literature review, what directions for future research does it suggest? Despite the energetic engagement in ethical issues explored above, we are left with the general impression that there is still a lot to do and indeed, that there is a deep lack of clarity as to how OR practice is to be grounded ethically. Perhaps this is inevitably so: if, as we suggest, OR and ethics are integrally intertwined, there will be an interest in connecting OR and ethics so long as there is an interest in OR. Further, it is arguable that the future of OR rather depends on how well it handles the question of ethics. The current avenues for future research will now be considered under the same headings as the preceding literature review. The research questions selected here for further attention reflect our views and are not meant to exclude alternative avenues considered more relevant by other researchers.

6.1. Ethics and society

Question 1: How can OR become more sophisticated in dealing with the ethical dimension of key social and economic problems it is asked to help solve?

- Observation: A significant part of the ethical discussions found in the OR literature looks at specific problem areas in which OR encounters challenges or opportunities related to ethical issues (e.g. health care, sustainable development, green logistics).
- Intent: To increase the analytic skills of OR in dealing with the ethical content of problem situations, beginning with particular areas of problem solving and decision-making in which it already has demonstrated high analytic sophistication (such as health care, logistics, and others).
- Difficulty: OR today largely lacks some agreed-upon, pragmatic framework (s) for analyzing the ethical dimension of problems.

Question 2: What are the basic ethical positions, principles and criteria that OR could adopt from the philosophical discourse on ethics and which it might help to pragmatize?

- Observation: In the account of ethics-in-OR to be found in the OR literature today resulting from this literature review we can see the influences of the various approaches to ethics, which are generally considered under the headings virtue ethics (reliance on virtuous individuals), ethics of duty (reliance on people meeting their responsibilities as members of society), and consequentialist ethics (reliance on making the right choices based on the consequences for all concerned).
- Intent: To raise the level of understanding of ethical discourse both in OR practice and theory.
- Difficulty: This is a very broad and deep subject area that is continually evolving. Currently the ideas of academics such as John Rawls, Jürgen Habermas and Amartya Sen are particularly influential. However, such ideas are highly theoretical; their implementation in practice needs to be explored.

Question 3: What are the specific contributions that OR can make with respect to the ethical dimension of contemporary social and economic problems?

- Observation: OR is a discipline with specific analytical and other skills, so it should try to bring these skills to bear on the ethical dimension of the problems it deals with.
- Intent: To identify OR tools and methods that could help in modeling and assessing the consequences of alternative policies for dealing with key contemporary economic and social problems.
- Difficulty: There are many other disciplines engaged in these activities, a knowledge of which is needed to identify where OR's distinctive competences might be useful.

6.2. Intervention ethics

Question 4: How can ethical considerations, whether guided by the concerns of those involved in an intervention and its stakeholders or by criteria drawn from ethical theories (such as those of Habermas, Rawls or Sen), be built into the design and management of OR intervention processes?

- Observation: All interventions bring participants into contact with ethical issues. However, although the connections between OR process and ethical considerations are accordingly obvious and real, they are not always recognized and subjected to reflection and critique; to the extent they are recognized and analyzed, they tend to clash.

- Intent: To bring ethical issues to the fore in designing and managing intervention processes and to explore the possibility of pragmatically applying ethical theories.
- Difficulty: There is a lack of suitable case material to provide the necessary understanding of current practice. The implementation of ethical theories is a formidable intellectual challenge facing philosophy, economics, political science and sociology.

Question 5: What can be learnt about handling ethical issues from collaboration with researchers in other disciplines that are concerned with intervention?

- Observation: Ethical issues know no disciplinary boundaries. Experience needs to be gained by engaging with other disciplines in collaborative efforts.
- Intent: To learn from the other professional advisors and service providers such as the medical, legal and accounting professions; social services, the civil service; engineering consultancy; and management consultancy in general.
- Difficulty: Most professions rely heavily on practitioners developing an appropriate ethos through education and experience (see question 8 below). The challenge here is to identify the activities built into the design and operation of interventions to ensure ethical issues are given transparent consideration.

6.3. Ethics in analysis

Question 6: What can be learnt about handling ethical issues from the experience of applying methods such as multiple-objective optimization, multi-criteria decision analysis and data envelopment analysis in practice?

- Observation: Approaches to embedding ethical issues in models and using models to clarify attitudes and preferences are the subject of active research programmes. Many disciplines look to OR as a source of analytical and procedural methods for their research.
- Intent: It is important that this research should continue as long as new insights are thereby stimulated and new questions raised. It is also important that the methods developed are made available to other disciplines. New impetus can be provided by identifying new areas of application and by responding to problems as they arise in practice.
- Difficulty: The difficulty lies both in understanding what is being gained (or made transparent) and what is lost (or hidden) in adopting particular models, and in appreciating how the weaknesses of the model adopted are dealt with in practice.

Question 7: How can combinations of methods be used to address ethical issues within complex analysis?

- Observation: One emergent trend in the literature is the combination of methods to examine significant issues (Feng et al., 2004; Linares and Romero, 2000; Sinuany-Stern et al., 2000; Yang and Kuo, 2003).
- Intent: The weaknesses of one model can sometimes be mitigated by combining it with another. To do so it is necessary to overcome the conceptual and practical incompatibilities of the two (or more) models.
- Difficulty: OR's modeling efforts are very often one-sidedly concentrating on either instrumental rationality or eliciting values. Combining models in practice presents formidable technical problems.

6.4. Personal and professional ethics

Question 8: What personal professional standards do practitioners adhere to in practice, what is the experience within OR of adopting standards, and what is the experience in other applied professions?

- Observation: Considerable effort has been devoted to developing suitable codes but they have not been widely adopted. The issue now is one of take up, agreement and implementation.
- Intent: The ethical behavior of professional practitioners has been the cornerstone of sound practice, largely taken for granted by practitioners and clients.
- Difficulty: There has generally been a reluctance within OR to continually revisit this issue, to adopt codes and an even greater reluctance to agree and means of enforcement.

7. Final observation: ethics matters

All decision-making is informed by ethical considerations. This is a fact of life whether we choose to focus on it or not. In many cases, such as scheduling and stock control, to be continuously reminded that there are ethical considerations may seem overly pedantic. In others, such as health and military applications, the ethical considerations are so prominent that any reminder is superfluous. But there is much OR analysis and advice that comes somewhere between these two extremes and as a consequence OR practitioners must be sensitized to the possibility of latent or non-obvious ethical implications when engaged in an intervention. Further, practitioners have an obligation to alert clients to the ethical content of their everyday taken-for-granted assumptions and habits. As the question of ethics is always of importance for OR practitioners, it must also be important for OR academics.

Partly because the practice of OR has been continuously confronted with ethical issues, and partly because some prominent advocates of OR theory and frameworks have placed ethics at the center of their conception of practice, a number of methods and techniques have been developed to ensure that ethical aspects are given due attention. Relevant research programmes are in progress and are progressive in the sense that they are giving rise to new research questions and new notions of, and frameworks for, good practice. However, it takes time for such new frameworks to be widely applied in practice. There is much to do both in terms of developing and implementing improved professional tools as well as encouraging individual and collective awareness. We have identified some possible research questions. On a personal note we would like to see a greater flow of exchange between OR and other basic and applied disciplines, something we hope to pursue further.

We conclude that ethics matters for our understanding of competent professional practice. But if ethics matters, good conceptual and analytical tools for handling the ethical dimension of problems also matter. OR is strong in developing and applying rigorous tools, and therefore should consider seriously what contribution it can make in this regard.

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