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Engaging with Behavioral Operational Research: On Methods, Actors and Praxis

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1.1 Introduction

In many other disciplines, attention to the study of behavioral issues becomes prominent when their theoretical core has reached maturity. This has happened in economics (Camerer and Lowenstein 2003), finance (Bruce 2010), accounting (Birnberg et al. 2007) and strategic management (Powell et al. 2011), as well as in cognate disciplines such as operations management (Bendoly et al. 2015), decision and Game Theory (Camerer 2003; Von Winterfeldt and Edwards 1986) and environmental modeling (Hämäläinen 2015). The development of the discipline of

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Operational Research (OR) is similar, and thus the current resurgence of interest in the behavioral perspective (Franco and Hämäläinen 2016) is not surprising. We use the term *resurgence* deliberately: attention to the non-mathematical and behavioral aspects of the OR profession can be traced back to past debates in the 1960s and 1970s within mainstream OR (e.g. Ackoff 1977; Churchman 1970; Dutton and Walton 1964; Lawrence 1966) and in the 1980s and 1990s within systems thinking (e.g. Senge and Sterman 1992) and in the specialized domain of soft OR (e.g. Jackson et al. 1989). Behavioral issues received less attention in subsequent years. For example, they are hardly mentioned in the 50th anniversary issues of *Operational Research* (Wein 2002) and the *Journal of the Operational Research Society* (Brailsford et al. 2009). However, as the OR discipline attends to the improvement of *human* problem solving and decision making in practice, a return to behavioral concerns within the discipline was in some ways foreseeable. What motivates this renewed attention to behavioral issues in OR is the recognition that developing technically correct and valid models is not enough; we also need to design model-supported interventions by taking into account behavioral factors that could enhance or hinder their effectiveness.

The latest evidence of the revival of what is now known as *behavioral OR* (Hämäläinen et al. 2013), or BOR for short, can be found in the special issue of the *European Journal of Operational Research* that focused on BOR (Franco and Hämäläinen 2016). In addition, high levels of participation in BOR streams at international conferences, the creation of a BOR national interest group sponsored by the UK OR Society[1] and the launch of a BOR website portal hosted by Aalto University[2] are all clear testimony to the closer attention that the OR community is increasingly showing to the behavioral perspective. Noticeable in this return to BOR is a commitment to *empirically* examine what people actually do within a system or when engaged in OR-supported processes, for not doing so would limit the development of relevant theories that could help advance explanations linking the key behavioral dimensions that shape the conduct of OR in practice. Such behavioral-based explanations would go

[1] https://www.theorsociety.com/Pages/SpecialInterest/Behaviouralor.aspx.
[2] bor.aalto.fi.

beyond pure description and have a prescriptive orientation concerned with improving the use of OR in practice (Franco and Hämäläinen 2016), including the responsible and ethical use of OR-supported processes (Le Menestrel and Van Wassenhove 2004, 2009; Ormerod and Ulrich 2013).

Two main streams of work that have generated attention within BOR can be identified. The first stream has a long history within academic OR and concentrates on the use of the OR approach to model human behavior in complex settings. For example, there is long standing tradition of modeling behavior in decision analysis (e.g. French et al. 2009) and System Dynamics (e.g. Sterman 2000). The second stream investigates how behavior affects or is affected by OR model–supported processes in individual, group and organizational contexts. Although still relatively under researched, this stream is receiving increasing attention from both OR academics and practitioners, particularly in Europe (e.g. Ackermann and Eden 2011; Amini et al. 2012; Brailsford and Schmidt 2003; Franco 2013; Hämäläinen et al. 2013; Morton and Fasolo 2009; Ormerod 2014a; Rouwette et al. 2011; White 2009). While different in focus, the two streams share the common goal of designing and deploying OR-supported interventions to improve organizational systems and operations.

Against the above background, we propose in this introductory chapter an agenda for driving the development of BOR as a legitimate subdiscipline within OR, by means of an integrative framework based on the three interdependent concepts of OR methods, OR actors and OR praxis. The framework is intended as an organizing device for the conduct of empirical BOR studies, highlighting different analytical foci and points of entry into the study of behavioral issues in the practice of OR.

The chapter is structured as follows. In the next section we draw on practice theories within the social and organizational sciences to introduce the three central concepts of OR methods, OR actors and OR praxis. Next, we link these three concepts together within an integrative framework intended to organize and guide the conduct of empirical BOR studies. The framework is illustrated with exemplars from the developing BOR literature that increase or challenge our current understandings of OR practice and its impacts. We end the chapter with a discussion of the implications of the behavioral perspective for advancing the OR discipline.

1.2   OR Methods, OR Actors, OR Praxis

In this section we draw upon the practice traditions within the social and organization sciences (Feldman and Orlikowski 2011; Jarzabkowski et al. 2007; Nicolini 2012; Reckwitz 2002; Schatzki et al. 2001; Turner 1994; Whittington 2006) and in particular the work of Richard Whittington within strategy research (e.g. Whittington 2003; Whittington 2006, 2011), with a view to offering an integrative framework that highlights different analytic foci and entry points for the conduct of empirical BOR studies. Three important questions derived from practice theories are particularly relevant to the BOR perspective, and they underpin the central elements in our framework. Specifically, when examining an OR-supported process using a behavioral lens, we need to address the following questions: (*i*) What guides behavior in the process? (*ii*) Whose behavior counts in the process? and (*iii*) How behavior is enacted in the process? Importantly, answers to these questions can explain the impacts that are achieved (or not) from the application of OR. We turn to each of these questions below.

What guides behavior in an OR-supported process are the *methods* used by those engaged with that process. OR methods provide the resources through which people are able to interact in order to accomplish OR-supported work. At a basic level, then, methods include the range of OR techniques and tools available to support interactions in an OR-supported process. However, our conceptualization of OR methods goes beyond techniques and tools; it also includes standardized routines for building and using models; approaches to communicating with and about models; and norms and procedures for intervention design, data collection, training and teaching and embedding OR-supported processes in organizational routines. These are important but often overlooked aspects of the methods of OR, and they too provide a source of guidance for actual problem solving and decision making interactions.

From a BOR perspective, the role or identity of those participating in an OR-supported process also matters. Here we adopt the general category of *actors* to refer to those individuals who—acting in isolation or as part of a team—design, implement, or engage with OR-supported

processes. Thus, OR actors include not just mainstream OR practitioners (e.g. modellers, analysts, facilitators, consultants) who are at the center of any OR-supported work but also others who participate in OR-related activity as clients, sponsors, experts or simply users. All these can be seen as OR actors whose behavior is critical to the success or failure of OR-supported processes. Indeed, actors' behaviors matter because their effects and those of the OR methods used are intertwined in practice.

How behavior is enacted in an OR-supported process is also important from a BOR perspective, because it has to do with what OR actors actually *do* with OR methods in situ. We adopt the term *praxis* to conceptualize this process, namely, all the various streams of actual OR activity carried out by OR actors. Although actual OR praxis involves dynamic flows of activity taking place at different organizational levels (Mitchell 1993), behavioral aspects of OR praxis are most visible within specific episodes (cf. Luhmann 1995) of OR-related activity, such as modeling sessions, meetings, presentations and workshops of varying duration, frequency and sequence. Examining actual behavior in OR praxis has the benefit of highlighting potential gaps between espoused or *textbook* OR practice and what actually happens on the ground.

Answers to the above questions can provide a more holistic picture of the role and impact of behavior-related issues in OR-supported processes. To find possible answers, we need to investigate a wider range of OR methods in context, attend to who engages in them and closely examine how they are actually used in practice. In the next section we build on our preceding discussion to introduce an integrative framework that links the three central concepts of OR methods, OR actors and OR praxis to the context and outcomes of OR practice.

1.3 An Integrative Framework to Study Behavior in OR

Figure 1.1 shows an integrative framework for the study of behavioral issues in OR-supported processes. The framework highlights three key interrelated concepts of OR methods, OR actors and OR praxis (cf.
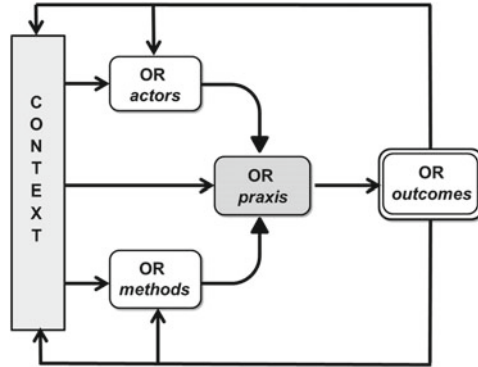
Fig. 1.1   An integrative framework for the study of behavior in OR

Whittington 2006) already introduced above. Our framework also makes clear that OR methods are available for use by OR actors when they engage in OR praxis. Although shown in separate boxes, methods, actors and praxis are not discrete entities operating in a vacuum but highly intertwined within their organizational context. Thus, OR methods cannot be separated from the actors who use them, and OR methods can have material existence only within OR praxis. Furthermore, the framework shows that the impact of OR methods on outcomes cannot be understood without taking into account the behavior of OR actors and that this will be particularly salient within given episodes of OR praxis. Finally, the framework underlines the potential feedback effects of OR outcomes on the actors and how they carry out their praxis, on the OR methods themselves and on the organizational context within which actors, methods and praxis are all embedded.

Our framework contrasts with that proposed recently by White (2016), which is offered as a device for thinking about behavior across a three-dimensional typology of OR interventions. This typology is theoretically derived from alternative configurations of the values taken by the dimensions of *OR user* (individual/group), *issue divergence* (high/low) and *model use* (instrumental/symbolic). Thus, behavioral issues pertaining to individual–low divergence–instrumental interventions will be different to those pertaining to group–high issue divergence–symbolic interventions. While useful as a heuristic device, the dimensions in White's framework

would be difficult to use to guide practical BOR studies. For example, whilst there may be instances where models are indeed used in purely instrumental or symbolic terms, model use can vary considerably across OR interventions and it has been shown that models can in fact show both uses within the same type of intervention (e.g. Franco and Lord 2011). The elements in our proposed framework do not represent binary conceptualizations, as in White's framework but, instead, allow a range of empirical possibilities intended to facilitate the conduct of empirical BOR studies in both the field and the lab.

From a behavioral perspective, any BOR study will inevitably link all three intertwined concepts, methods, actors and praxis, to OR outcomes. Empirically, however, this can be challenging due to the complex nature of the relationship among these elements. One way to get round this issue is to choose one dominant area of empirical focus by foregrounding only one of the three central concepts while backgrounding the others, and then to examine the link between the chosen focus and OR outcomes. It is to a wider consideration of such an empirical approach that we now turn.

1.3.1 Focus on OR Methods

Perhaps unsurprisingly, in most OR studies the focus is on OR methods and the outcomes achieved from using them. Typically, the methods of interest are modeling techniques and models. From a BOR perspective, however, a major concern is to examine the extent to which OR methods produce *behavior-related* outcomes, such as changes in cognition (e.g. learning), attitudes or interactions. Current empirical evidence of the methods–outcomes link is relatively strong only for some OR methods, such as group model building (e.g. Rouwette et al. 2002; Schilling et al. 2007; Scott et al. 2016), and thus more BOR studies with this choice of focus are needed.

It is important to clarify that a focus on OR methods does not necessarily imply that the methods must capture behavior explicitly. Hence, for example, an optimization model that does not take into account any behavioral considerations would still be of interest from a BOR

perspective, as long as the study connects the model to behavior-related outcomes. Likewise, OR methods that capture behavior explicitly by drawing on experience or formal theory (e.g. Brailsford et al. 2012) are not in themselves of interest to BOR unless they are linked to behavior-related outcomes.

Methods other than modeling techniques and models should also be studied in relation to OR outcomes. As discussed in the previous section, OR methods also include norms and standardized procedures for designing interventions, eliciting data, training and teaching and communicating with and about models and even for selling or embedding OR in organizations. For example, scripts for running modeling workshops have been developed (e.g. Ackermann et al. 2011; Hovmand et al. 2012) and their link to behavioral outcomes examined (e.g. Scott et al. 2013; Tavella and Papadopoulos 2015b). With respect to methods for eliciting data, there is a long tradition in decision analysis and risk analysis of using of standard protocols to produce unbiased expert judgments of probabilities and preferences (for a recent review, see Montibeller and Von Winterfeldt 2015). The impact of training methods using structured procedures (e.g. Carlson and Bond 2006; Ellspermann et al. 2007) and games (Graham et al. 1992; Lane 1995; Morecroft 1988) has a long history too (e.g. Hartley et al. 1979) and is typically analyzed via experimentation (Bakken et al. 1992; Capelo and Dias 2009). By contrast, the behavioral impacts of OR teaching methods have not been the focus of empirical research, although shared experiences and reflections about different teaching methods used in the classroom are available (e.g. Kunc 2012; Mingers and Rosenhead 2012; O'Brien 2004; Pierre Brans and Macharis 1997; Wright et al. 2009). Finally, the impact of approaches to communicating with and about models, selling or embedding OR are perhaps the areas that have received the least empirical attention to date, with some exceptions (e.g. Brailsford et al. 2013; Franco et al. 2004; Hämäläinen et al. 2013).

Other under researched areas with a focus on the methods–outcomes dimensions include the multiple interdependencies that OR methods can have in practice. The effect of a particular method (e.g. a model) in practice can vary according to the presence or absence of other methods (e.g. modeling script, communication protocol). In addition, the

introduction of new OR methods and their behavioral effects offers further research possibilities. For example, Internet technologies are generating new methods of expert judgment elicitation (e.g. Hämäläinen et al. 2010). Overall, the adoption of a methods analytic focus prompts us to investigate the wider range of OR methods actually used in practice (e.g. Ahmed and Robinson 2013; O'Brien 2011; Ranyard et al. 2015); how method use changes over time (e.g. Fortuin and Zijlstra 2000); and, crucially for BOR, what the behavioral consequences of different use patterns are (e.g. Chung et al. 2000; O'Keefe 2016).

1.3.2 Focus on OR Actors

Foregrounding OR actors and their impact on outcomes offers a different choice of analytical focus that makes the behavioral dimension particularly salient. Indeed, if we were to adopt a more holistic BOR perspective then we should move beyond just OR methods to include the individuals and teams that engage with them. There is a long but sparse tradition of BOR studies that focus on particular types of OR actors and the outcomes of methods used. For example, there is a stream of research that examines the work of expert modellers (Tako 2014; Tako and Robinson 2010; Waisel et al. 2008; Willemain 1994, 1995), novice modellers (S. G. Powell and Willemain 2007; Tavella and Papadopoulos 2015b; Willemain and Powell 2007) or both (Tavella and Papadopoulos 2015a). Research focusing on other types of actors is also beginning to appear, such as studies of forecasting experts (Petropoulos et al. 2016; Syntetos et al. 2016), decision analysts (Papamichail et al. 2007), and OR consultants providing strategy support (O'Brien 2015).

Consequently, from a BOR perspective, claims about the link between OR methods and OR outcomes should be taken with caution if they do not account for the role and impact that the different OR actors involved can have, for OR actors may be more or less successful in their use of particular OR methods, depending on their level of competence and expertise (Huxham and Cropper 1994; Keys 2006; Ormerod 2008, 2014b; Wright and Bolger 1992), their cognitive style (Fasolo and Bana e Costa 2014; Franco and Meadows 2007; Franco et al. 2016) or their preferred

consulting approach (Cropper 1990; Eden and Ackermann 2004; Franco and Montibeller 2010). Thus, the same OR method may lead to different outcomes when deployed, used or even sponsored by a competent and experienced actor who enjoys analysis carried out in participative fashion than by a novice actor who relies highly on intuition and prefers expert advice.

As in the case of methods, OR actors can also exhibit interdependencies that can affect outcomes. For example, the effectiveness of a modeling workshop facilitator will be contingent on who participates in the workshop: the presence or absence of a powerful and skillful actor can undercut the work of the facilitator and increase or decrease the participation of other actors, hence affecting the quality of the model. A similar argument can be made for the case of larger OR interventions. Therefore, this is an area that is worth exploring empirically, as most published accounts of OR practice tend to be positive about or downplay the impact of OR actors (Connell 2001). An empirical focus on OR actors and their impact on outcomes also can begin to unravel the feedback effects of outcomes on actors. For example, a few BOR studies have shown enduring changes in actors' mental models (Scott et al. 2013). Other long term effects on actors can be subject to empirical examination within this focus, including effects on actors' competences, status and professional relationships.

1.3.3   Focus on OR Praxis

At the core of the BOR perspective lies the assumption that to improve OR methods we must pay attention to *how* they are actually used by those who engage in them. As most OR practitioners will already know, the actual use of OR methods is influenced by the needs of the users and the specific contexts of use. Thus, a focus on OR praxis reminds us of the complex and *situated* dynamics of method use, which must be taken into account to avoid superficial understandings of what OR actors actually do in practice and of the critical role of these doings on generating OR outcomes. This is an area that is still relatively under explored, particularly in the field. Nevertheless, some relevant work is beginning to appear following calls to conduct fine-grained studies of the use of OR methods (e.g. Franco and Rouwette 2011; Horlick-Jones and Rosenhead 2007).

For example, Shaw et al. (2003) show how management teams using the same OR method within a workshop context develop knowledge about issues with different degrees of complexity, which affects their ability to develop in-depth understanding about those issues. Also within a workshop context, White et al. (2016) use activity theory to show how participants use mediating artifacts to wrestle with the object of a *zero carbon zone*, and they demonstrate how a shared activity system is developed to accommodate contradictions between participants' motives. On a larger scale, Ormerod (2014a) reflects on the development of the National Coal Board UK Energy model in the 1970s and 1980s and discusses how the *mangled* (Pickering 1995) intersection of OR actors and methods affected the intervention's design, deployment and outcomes.

Despite their standardization, OR methods can be used in diverse and variable ways and adapted to the uses to which they are put by those engaged with OR-supported processes, and this has particular effects on outcomes . This is a salient feature of the three works mentioned above and is also evident in the recent review of mixed-methods interventions by Howick and Ackermann (2011). However, deviations from expectations of method use do not necessarily imply bad praxis. There might be cases where skillful adaptations and improvizations in the use of OR methods can take place in specific contexts (e.g. Montibeller et al. 2009; Robinson et al. 2013), which may reveal potential OR method innovations. Therefore, the adoption of OR praxis as the analytic focus means attention is paid to the situated nature of OR method use: by examining how OR methods are enacted locally in practice, in ways that perhaps are not recognizable to the methods' originators, BOR studies can develop theories about the role of method adaptations in generating OR outcomes.

Of course, not all method adaptations or even transformations may be positive, and in this case empirical research that examines uses of methods that deviate from their standard forms can highlight areas for improvements in method use. For example, Lahtinen and Hämäläinen (2016) conducted a controlled experiment to show the emergence of path dependence in the use of the Even Swaps method[3], which they explain is

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[3] Even Swaps method helps decision makers to find the most preferred alternative out of a set of multi-attribute alternatives (Lahtinen and Hämäläinen 2016).

the result of the accumulated effect of successive biased even swap tasks. Their findings led them to develop a strategy for carrying out the even swaps process so that the accumulation of the effects of biases is reduced.

1.4   Implications of a Behavioral Perspective for OR

In this section we build on our preceding discussion to develop four broader implications of adopting the behavioral perspective for advancing the OR discipline: foregrounding OR praxis in academic papers, attending to a wide diversity of OR actors, developing OR competences and grounding BOR studies on relevant theories. We briefly discuss these implications next.

1.4.1 Foregrounding OR Praxis in Academic Papers

The first implication is the recognition that the practice of OR will remain a "black box" unless we examine how methods are actually used by OR actors. That is, a focus on OR praxis is central to advancing the BOR agenda. Therefore, it is proposed here that the kind of micro-level examinations of praxis that are common in practice and decision making studies within the behavioral, social and organization sciences and which are beginning to appear in the OR literature (e.g. Horlick-Jones and Rosenhead 2007; Lahtinen and Hämäläinen 2016; Velez-Castiblanco et al. 2016) be used. The goal here is to demonstrate how OR methods are actually used by conducting empirical and close interrogations of their claimed effects in the field or the lab.

1.4.2 Evaluating Impact of Diverse OR Actors

A second implication is the consideration of the wide variety of OR actors that participate in the practice of OR. The research agenda here concerns the study of different types of practitioners and their role and influence in the

use of OR methods. Traditionally, published accounts of OR practice are written from the perspective of the OR practitioner (e.g. modeller, analyst, consultant). This focus is natural, as OR practitioners are central in designing, deploying and adapting OR methods. However, actors such as sponsors, clients and users also play a key role in OR-supported processes and ultimately determine what OR can practically accomplish. Considering a wider range of actors will extend our understanding of OR practice beyond that provided by the OR-practitioner view. Empirical studies in the field and the lab should undertake fine-grained analyses that can illuminate how the characteristics of different types of OR actors (e.g. roles, motivations, cognitive styles, emotional states) and the dynamics in which they engage contribute to shaping outcomes of OR-supported processes.

1.4.3   Developing Different Competences in OR

The third implication is that effective OR praxis relies heavily on OR actors' competence in applying and engaging with OR methods. Lack of adequate skills for the deployment, use or interpretation of OR methods can profoundly affect OR outcomes, and this requires managing effectively the technical as well as the behavioral and social aspects of OR-supported processes. From a BOR perspective, how OR actors become competent in the application, use and interpretation of OR methods in praxis is a crucial research question. Here, empirical research that focuses on the teaching and training of *doers* (practitioners) and *users* of OR is highly relevant. BOR studies might thus track how OR actors learn, master or embrace different methods within the classroom or during actual praxis. Such research can help to produce empirically grounded theories of what it takes to become a competent OR actor in different settings.

1.4.4   Grounding BOR Studies on Relevant Theories?

The final implication is the need to ground empirical BOR studies in relevant theories drawn from outside the OR field. Attention to theory might seem at odds with the applied nature of the OR discipline.

However, as Brocklesby (2016) notes, the practice of OR involves a complex array of dimensions that need to be better understood, and thus the use of a relevant theory can bring into view those dimensions that otherwise would remain hidden in the background, which can help generate new levels of awareness to inform OR practice. This does not imply a preference for a particular theory, nor the adoption of a specific research method to empirically test it. Thus, for example, the adoption of a theory of heuristics and biases to conduct empirical research via experimental methods (e.g. Tversky and Kahneman 1974), a common approach that has produced many useful insights in economics, finance and operations management, would represent in our view just one possible way of studying behavioral issues in OR.

Consequently, the concern here is less with what theories or research methods are adopted than by what behavioral issue related to OR practice is examined. In this respect, our proposed framework should be seen as an organizing device that could help inform empirical BOR studies grounded on a wide range of theories and research methodologies, as illustrated by the collection of works published in the 2016 special issue of the *European Journal of Operational Research* (Franco and Hämäläinen 2016). It is worth noting that besides the use of experiments, research methods that can track behavioral factors in OR-supported processes as they arise are also needed (e.g. Franco and Rouwette 2011). In this respect the use of data generated from process-type research (e.g. Poole 2004), both macro and micro, has the potential to offer additional valuable insights into the practice of OR from a BOR perspective.

1.5   Conclusions

The "science of better", as the OR discipline is commonly referred to, is never just about modeling and models, but also about people. Thus, *empirically grounded* explanations of how actors use OR methods in their praxis can help to develop a theory of effective OR practice. Such a theory can highlight the generative mechanisms that are responsible for the success or failure of OR interventions.

We have argued elsewhere that the current concern with the behavioral aspects of OR practice represents a return to the roots of the OR profession (Franco and Hämäläinen 2016), as evidenced by the growing number of empirical studies being published in this area. These studies represent an eclectic collection of works examining behavioral issues in OR practice from different theoretical perspectives, at different levels of analysis (individual, group, organizational) and with different research methodologies. We embrace this eclectic approach to conducting BOR studies, and in this chapter we have proposed an integrative framework to organize extant studies and also guide future research according to specific analytic lines. Specifically, the framework helps define different emphases for conducting empirical BOR studies. Furthermore, the framework suggests a wider approach to OR outcomes that considers not just improved organizational performance but also the performance of the individuals and groups involved in an actual episode of OR praxis.

The behavioral perspective in OR offers a distinctive lens that highlights the interdependencies among OR methods, OR actors and OR praxis and the ways they affect and are affected by OR outcomes. By adopting this perspective, OR academics would be more likely to produce robust and empirically grounded advice for improving the science of better. Ultimately, the central promise of the behavioral perspective is to enable the production of better OR methods, the conduct of improved OR praxis and the development of increasingly competent OR actors.

References

Ackermann, F., and C. Eden. 2011. Negotiation in strategy making teams: Group support systems and the process of cognitive change. *Group Decision and Negotiation* 20: 293–314.

Ackermann, F., D.F. Andersen, C. Eden, and G.P. Richardson. 2011. ScriptsMap: A tool for designing multi-method policy-making workshops. *Omega* 39: 427–434.

Ackoff, R. 1977. Optimization + objectivity = opt out. *European Journal of Operational Research* 1: 1–7.

Ahmed, R., and S. Robinson. 2013. Modeling and simulation in business and industry: Insights into the processes and practices of expert modellers. *Journal of the Operational Research Society* 65: 660–672.

Amini, M., T. Wakolbinger, M. Racer, and M.G. Nejad. 2012. Alternative supply chain production-sales policies for new product diffusion: An agent-based modeling and simulation approach. *European Journal of Operational Research* 216: 301–311.

Bakken, B., J. Gould, and D. Kim. 1992. Experimentation in learning organizations: A management flight simulator approach. *European Journal of Operational Research* 59: 167–182.

Bendoly, E., W. Van Wezel, and D.G. Bachrach (eds.). 2015. *The handbook of behavioral operations management: Social and psychological dynamics in production and service settings*. New York: Oxford University Press.

Birnberg, J.G., J. Luft, and M.D. Shields. 2007. Psychology theory in management accounting research. In *Handbook of management accounting research*, ed. C.S. Chapman and A.G. Hopwood, 113–135. Oxford: Elsevier.

Brailsford, S.C., and B. Schmidt. 2003. Towards incorporating human behaviour in models of health care systems: An approach using discrete event eimulation. *European Journal of Operational Research* 150: 19–31.

Brailsford, S.C., P. Harper, and D. Shaw. 2009. Milestones in OR. *Journal of the Operational Research Society* 60: S1–S4.

Brailsford, S.C., P.R. Harper, and J. Sykes. 2012. Incorporating human behaviour in simulation models of screening for breast cancer. *European Journal of Operational Research* 219: 491–507.

Brailsford, S.C., T.B. Bolt, G. Bucci, T.M. Chaussalet, N.A. Connell, P.R. Harper, J.H. Klein, M. Pitt, and M. Taylor. 2013. Overcoming the barriers: A qualitative study of simulation adoption in the NHS. *Journal of the Operational Research Society* 64: 157–168.

Brocklesby, J. 2016. The what, the why and the how of behavioural operational research: An invitation to potential sceptics. *European Journal of Operational Research* 249: 796–805.

Bruce, B. (ed.). 2010. *Handbook of behavioral finance*. Northampton: Edward Elgar Publishing.

Camerer, C.F. 2003. *Behavioral game theory: Experiments in strategic interaction*. Princeton: Princeton University Press.

Camerer, C.F., and G. Lowenstein (eds.). 2003. *Advances in behavioral economics*. Princeton: Princeton University Press.

Capelo, C., and J.F. Dias. 2009. A system dynamics-based simulation experiment for testing mental model and performance effects of using the balanced scorecard. *System Dynamics Review* 25: 1–34.

Carlson, K.A., and S.D. Bond. 2006. Improving preference assessment: Limiting the effect of context through pre-exposure to attribute levels. *Management Science* 52: 410–421.

Chung, Q., T. Willemain, and R. O'Keefe. 2000. Influence of model management systems on decision making: Empirical evidence and implications. *Journal of the Operational Research Society* 51: 936–948.

Churchman, C.W. 1970. Operations research as a profession. *Management Science* 17: 37–53.

Connell, N. 2001. Evaluating soft OR: Some reflections on an apparently 'unsuccessful' implementation using a soft systems methodology (SSM) based approach. *Journal of Operational Research Society* 52: 150–160.

Cropper, S. 1990. Variety, formality and style: Choosing amongst decision-support methods. In *Tackling strategic problems: The role of group decision support*, ed. C. Eden and J. Radford, 92–98. London: Sage.

Dutton, J.M., and R.E. Walton. 1964. Operational research and the behavioural sciences. *Operational Research Quarterly* 15: 207–217.

Eden, C., and F. Ackermann. 2004. Use of 'soft OR' methods by clients, what do they want from them? In *Systems modeling: Theory and practice*, ed. M. Pidd, 146–163. Chichester: Wiley.

Ellspermann, S.J., G.W. Evans, and M. Basadur. 2007. The impact of training on the formulation of ill-structured problems. *Omega* 35: 221–236.

Fasolo, B., and C.A. Bana e Costa. 2014. Tailoring value elicitation to decision makers' numeracy and fluency: Expressing value judgments in numbers or words. *Omega* 44: 83–90.

Feldman, M.S., and W.J. Orlikowski. 2011. Theorizing practice and practicing theory. *Organization Science* 22(5): 1240–1253.

Fortuin, L., and M. Zijlstra. 2000. Operational research in practice: Consultancy in industry revisited. *European Journal of Operational Research* 120: 1–13.

Franco, L.A. 2013. Rethinking soft OR interventions: Models as boundary objects. *European Journal of Operational Research* 231: 720–733.

Franco, L.A., and R.P. Hämäläinen. 2016. Behavioural operational research: Returning to the roots of the OR profession. *European Journal of Operational Research* 249: 791–795.

Franco, L.A., and E. Lord. 2011. Understanding multi-methodology: Evaluating the perceived impact of mixing methods for group budgetary decisions. *Omega* 39: 362–372.

Franco, L.A., and M. Meadows. 2007. Exploring new directions in problem structuring methods research: On the role of cognitive style. *Journal of the Operational Research Society* 58: 1621–1629.

Franco, L.A., and G. Montibeller. 2010. Facilitated modeling in operational research. *European Journal of Operational Research* 205: 489–500.

Franco, L.A., and E.A. Rouwette. 2011. Decision development in facilitated modeling workshops. *European Journal of Operational Research* 212: 164–178.

Franco, L.A., M. Cushman, and J. Rosenhead. 2004. Project review and learning in the UK construction industry: Embedding a problem structuring method within a partnership context. *European Journal of Operational Research* 152: 586–601.

Franco, L.A., E.A. Rouwette, and H. Korzilius. 2016. Different paths to consensus? The impact of need for closure on model-supported group conflict management. *European Journal of Operational Research* 249: 878–889.

French, S., J. Maule, and N. Papamichail. 2009. *Decision behaviour, analysis and support.* Cambridge: Cambridge University Press.

Graham, A.K., J.D.W. Morecroft, P.M. Senge, and J.D. Sterman. 1992. Model-supported case studies for management education. *European Journal of Operational Research* 59: 151–166.

Hämäläinen, R.P. 2015. Behavioural issues in environmental modeling: The missing perspective. *Environmental Modeling and Software* 73: 244–253.

Hämäläinen, R.P., J. Mustajoki, and M. Marttunen. 2010. Web-based decision support: Creating a culture of applying multi-criteria decision analysis and web supported participation in environmental decision making. In *e-Democracy: A group decision and negotiation perspective*, ed. D. Rios-Insua and S. French, 201–221. Dordrecht: Springer Science and Business Media B.V.

Hämäläinen, R.P., J. Luoma, and E. Saarinen. 2013. On the importance of behavioral operational research: The case of understanding and communicating about dynamic systems. *European Journal of Operational Research* 228: 623–634.

Hartley, D.A., P.V. Johnson, A. Fitzsimons, J. Lovell, B. Chippendale, and J.K. Clayton. 1979. A case study on the development of the home defence training game HOT SEAT. *Journal of the Operational Research Society* 30: 861–871.

Horlick-Jones, T., and J. Rosenhead. 2007. The uses of observation: Combining problem structuring methods and ethnography. *Journal of the Operational Research Society* 58: 588–601.

Hovmand, P.S., D.F. Andersen, E. Rouwette, G.P. Richardson, K. Rux, and A. Calhoun. 2012. Group model-building 'scripts' as a collaborative planning tool. *Systems Research and Behavioral Science* 29: 179–193.

Howick, S., and F. Ackermann. 2011. Mixing OR methods in practice: Past, present and future directions. *European Journal of Operational Research* 215: 503–511.

Huxham, C., and S. Cropper. 1994. From many to one—And back. An exploration of some components of facilitation. *Omega* 22: 1–11.

Jackson, M.C., P. Keys, and S.A. Cropper (eds.). 1989. *OR and the social sciences*. New York: Plenum Press.

Jarzabkowski, P., J. Balogun, and D. Seidl. 2007. Strategizing: The challenges of a practice perspective. *Human Relations* 60: 5–27.

Keys, P. 2006. On becoming expert in the use of problem structuring methods. *Journal of the Operational Research Society* 57: 822–829.

Kunc, M. 2012. Teaching strategic thinking using system dynamics: Lessons from a strategic development course. *System Dynamics Review* 28: 28–45.

Lahtinen, T.J., and R.P. Hämäläinen. 2016. Path dependence and biases in the even swaps decision analysis method. *European Journal of Operational Research* 249: 890–898.

Lane, D.C. 1995. On a resurgence of management simulations and games. *Journal of the Operational Research Society* 46: 604–625.

Lawrence, J.E. (ed.). 1966. *Operational research and the social sciences*. London: Tavistock Publications.

Le Menestrel, M., and L.N. Van Wassenhove. 2004. Ethics outside, within or beyond OR models? *European Journal of Operational Research* 153: 477–484.

Le Menestrel, M., and L.N. Van Wassenhove. 2009. Ethics in operations research and management sciences: A never-ending effort to combine rigor and passion. *Omega* 37: 1039–1043.

Luhmann, N. 1995. *Social systems*. Stanford: Stanford University Press.

Mingers, J., and J. Rosenhead. 2012. Introduction to the special issue: Teaching soft O.R., problem structuring methods, and multimethodology. *INFORMS Transactions on Education* 12: 1–3.

Mitchell, G. 1993. *The practice of operational research*. Chichester: Wiley.

Montibeller, G., and D. Von Winterfeldt. 2015. Cognitive and motivational biases in decision and risk analysis. *Risk Analysis* 35: 1230–1251.

Montibeller, G., L.A. Franco, E. Lord, and A. Iglesias. 2009. Structuring resource allocation decisions: A framework for building multi-criteria portfolio models with area-grouped projects. *European Journal of Operational Research* 199: 846–856.

Morecroft, J.D. 1988. System dynamics and microworlds for policymakers. *European Journal of Operational Research* 35: 301–320.

Morton, A., and B. Fasolo. 2009. Behavioural decision theory for multi-criteria decision analysis: A guided tour. *Journal of the Operational Research Society* 60: 268–275.

Nicolini, D. 2012. *Practice theory, work and organization: An introduction.* Oxford: Oxford University Press.

O'Brien, F.A. 2004. Scenario planning: Lessons for practice from teaching and learning. *European Journal of Operational Research* 154: 709–722.

O'Brien, F.A. 2011. Supporting the strategy process: A survey of UK OR/MS practitioners. *Journal of the Operational Research Society* 62: 900–920.

O'Brien, F.A. 2015. On the roles of OR/MS practitioners in supporting strategy. *Journal of the Operational Research Society* 66: 202–218.

O'Keefe, R.M. 2016. Experimental behavioural research in operational research: What we know and what we might come to know. *European Journal of Operational Research* 249: 899–907.

Ormerod, R.J. 2008. The transformation competence perspective. *Journal of the Operational Research Society* 59: 1435–1448.

Ormerod, R.J. 2014a. The mangle of OR practice: Towards more informative case studies of 'technical' projects. *Journal of the Operational Research Society* 65: 1245–1260.

Ormerod, R.J. 2014b. OR competences: The demands of problem structuring methods. *EURO Journal on Decision Processes* 2: 313–340.

Ormerod, R.J., and W. Ulrich. 2013. Operational research and ethics: A literature review. *European Journal of Operational Research* 228: 291–307.

Papamichail, K.N., G. Alves, S. French, J.B. Yang, and R. Snowdon. 2007. Facilitation practices in decision workshops. *Journal of the Operational Research Society* 58: 614–632.

Petropoulos, F., R. Fildes, and P. Goodwin. 2016. Do 'big losses' in judgmental adjustments to statistical forecasts affect experts' behaviour? *European Journal of Operational Research* 249: 842–852.

Pickering, A. 1995. *The mangle of practice: Time, agency and science.* Chicago: University of Chicago Press.

Pierre Brans, J., and C. Macharis. 1997. Play theatre a new way to teach O.R. *European Journal of Operational Research* 99: 241–247.

Poole, M.S. 2004. Generalization in process theories of communication. *Communication Methods and Measures* 1: 181–190.

Powell, S.G., and T.R. Willemain. 2007. How novices formulate models. Part I: Qualitative insights and implications for teaching. *Journal of the Operational Research Society* 58: 983–995.

Powell, T.C., D. Lovallo, and C.R. Fox. 2011. Behavioral strategy. *Strategic Management Journal* 32: 1369–1386.

Ranyard, J.C., R. Fildes, and T.-I. Hu. 2015. Reassessing the scope of OR practice: The influences of problem structuring methods and the analytics movement. *European Journal of Operational Research* 245: 1–13.

Reckwitz, A. 2002. Towards a theory of social practices: A development in cultural theorizing. *European Journal of Social Theory* 5: 243–263.

Robinson, S., C. Worthington, N. Burgess, and Z.J. Radnor. 2013. Facilitated modeling with discrete-event simulation: Reality or myth? *European Journal of Operational Research* 234: 231–240.

Rouwette, E.A.J.A., J.A.M. Vennix, and T. Van Mullekom. 2002. Group model building effectiveness. A review of assessment studies. *System Dynamics Review* 18: 5–45.

Rouwette, E.A.J.A., H. Korzilius, J.A.M. Vennix, and E. Jacobs. 2011. Modeling as persuasion: The impact of group model building on attitudes and behavior. *System Dynamics Review* 27: 1–21.

Schatzki, T.R., K. Knorr-Cetina, and E. Von Savigny (eds.). 2001. *The practice turn in contermporary theory*. London: Routledge.

Schilling, M.S., N. Oeser, and C. Schaub. 2007. How effective are decision analyses? Assessing decision process and group alignment effects. *Decision Analysis* 4: 227–242.

Scott, R.J., R.Y. Cavana, and D. Cameron. 2013. Evaluating immediate and long-term impacts of qualitative group model building workshops on participants' mental models. *System Dynamics Review* 29: 216–236.

Scott, R.J., R.Y. Cavana, and D. Cameron. 2016. Recent evidence on the effectiveness of group model building. *European Journal of Operational Research* 249: 908–918.

Senge, P.M., and J.D. Sterman. 1992. Systems thinking and organizational learning: Acting locally and thinking globally in the organization of the future. *European Journal of Operational Research* 59: 137–150.

Shaw, D., F. Ackermann, and C. Eden. 2003. Approaches to sharing knowledge in group problem structuring. *Journal of the Operational Research Society* 54: 936–948.

Sterman, J.D. 2000. *Business dynamics: Systems thinking and modeling for a complex world*. Boston: Irwin McGraw-Hill.

Syntetos, A.A., I. Kholidasari, and M.M. Naim. 2016. The effects of integrating management judgement into OUT levels: In or out of context? *European Journal of Operational Research* 249: 853–863.

Tako, A.A. 2014. Exploring the model development process in discrete-event simulation: Insights from six expert modellers. *Journal of the Operational Research Society* 66: 747–760.

Tako, A.A., and S. Robinson. 2010. Model development in discrete-event simulation and system dynamics: An empirical study of expert modellers. *European Journal of Operational Research* 207: 784–794.

Tavella, E., and T. Papadopoulos. 2015a. Expert and novice facilitated modeling: A case of a viable system model workshop in a local food network. *Journal of the Operational Research Society* 66: 247–264.

Tavella, E., and T. Papadopoulos. 2015b. Novice facilitators and the use of scripts for managing facilitated modeling workshops. *Journal of the Operational Research Society* 66: 1967–1988.

Turner, S. 1994. *The social theory of practices*. Cambridge: Polity Press.

Tversky, A., and D. Kahneman. 1974. Judgment under uncertainty. Heuristics and biases. *Science* 185: 1124–1131.

Velez-Castiblanco, J., J. Brocklesby, and G. Midgley. 2016. Boundary games: How teams of OR practitioners explore the boundaries of intervention. *European Journal of Operational Research* 249: 968–982.

Von Winterfeldt, D., and W. Edwards. 1986. *Decision analysis and behavioral research*. Cambridge: Cambridge University Press.

Waisel, L., W. Wallace, and T. Willemain. 2008. Visualization and model formulation: An analysis of the sketches of expert modellers. *Journal of the Operational Research Society* 59: 353–361.

Wein, L.M. 2002. Introduction to the 50th anniversary issue of operations research. *Operations Research* 50: iii-iii.

White, L. 2009. Understanding problem structuring methods interventions. *European Journal of Operational Research* 99: 823–833.

White, L. 2016. Behavioural operational research: Towards a framework for understanding behaviour in OR interventions. *European Journal of Operational Research* 249: 827–841.

White, L., K. Burger, and M. Yearworth. 2016. Understanding behaviour in problem structuring methods interventions with activity theory. *European Journal of Operational Research* 249: 983–1004.

Whittington, R. 2003. The work of strategizing and organizing: For a practice perspective. *Strategic Organization* 1: 117–125.

Whittington, R. 2006. Completing the practice turn in strategy research. *Organization Studies* 27: 613–634.

Whittington, R. 2011. The practice turn in organization research: Towards a disciplined transdisciplinarity. *Accounting, Organizations and Society* 36: 183–186.

Willemain, T.R. 1994. Insights on modeling from a dozen experts. *Operations Research* 42: 213–222.

Willemain, T.R. 1995. Model formulation: What experts think about and when. *Operations Research* 43: 916–932.

Willemain, T.R., and S.G. Powell. 2007. How novices formulate models. Part II: A quantitative description of behaviour. *Journal of the Operational Research Society* 58: 1271–1283.

Wright, G and Bolger, F. 1992. *Expertise and decision support.* New York: Springer Science and Business Media.

Wright, G., G. Cairns, and P. Goodwin. 2009. Teaching scenario planning: Lessons from practice in academe and business. *European Journal of Operational Research* 194: 323–335.