1

Behavioral Operations and Behavioral Operational Research: Similarities and Differences in Competences and Capabilities

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1.1 Introduction

The research focus in Behavioral Operational Research (BOR) is mainly related to facilitation for model building and communication of model results when Operational Research (OR) practitioners are supporting human problem solving by modeling. Research seems to be limited to and for specialists in OR modeling (mainly Soft OR models) and focused on process design and facilitation without understanding the purpose of the approaches within organizational contexts. On the other hand, Behavioral Operations Management (BOM) seems to mostly focus on the impact of behavioral factors on the solutions to problems within organizational contexts. Is there a possibility that BOM can enhance the practice of BOR? This chapter aims to explore this question.

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1.2 Behavioral Operations Management: A Short Literature Review

This section presents a brief analysis of the field of Behavioral Operations Management with some interesting insights. For more exhaustive analysis, see Bendoly et al. (2006, 2010), Bendoly and Schultz (2006), and Loch and Wu (2007). Firstly, like BOR, there are different definitions of BOM. On the one hand, Gino and Pisano (2008) define "behavioral operations as the study of attributes of human behavior and cognition that impact the design, management, and improvement of operating systems, and the study of the interaction between such attributes and operating systems and processes." They assert that BOM should employ concepts from social, which recognize the impact of groups, social norms, and systems as well as organizations on operations, and cognitive and psychology theories, which reflect how the properties of individuals impact on operations. On the other hand, Croson et al. (2013) suggest "behavioral operations as the study of potentially non hyper-rational actors in operational contexts." They consider the role of bounded rationality within operations, but they do not advocate for specific theories like Gino and Pisano (2008). However, both papers share similar constructs: the importance of the context, operations, and behavioral aspects of decision making.

In more detail, BOM and traditional Operations Management share the same goal: the design, management, and improvement of operating systems and processes. Croson et al. (2013) suggest three criteria characterize the actors in traditional Operations Management: (1) motivated by self-interest expressed in monetary terms; (2) acting consciously and in a deliberate manner; and (3) optimizing a defined objective function. On the other hand, BOM focuses on deviations from any of the three criteria through the application of behavioral theories. However, the application of behavioral theories is not aimed at getting a deeper understanding of leadership, fairness, emotions or motivation (Croson et al. 2013) or modifying cognitive and behavioral theories. The application of behavioral theory originates from the initial consideration of human behavior as a second-order effect, rather than first-order effect,

in operations (Gino and Pisano 2008). For example, normative models in traditional Operations Management, such as inventory or scheduling, assume decision makers and agents in the system are rational but operating issues involve groups of people with various skills and organizational responsibilities so cognitive and behavioral aspects shape how people behave differently than hyper-rational actors.

The value of BOM lies in recognizing that almost all contexts studied within Operations Management contain people that do not behave following normative models (Croson et al. 2013). Therefore, BOM starts at a micro-level to make better recommendations of how to design and improve processes. Given the deviation from a mechanistic and rationalistic view of the organization, BOM mostly has an empirical focus testing Operations Management theory for their robustness in laboratory and real world.

However, there are researchers who suggest BOM's perspective is flawed as they use mainly one view of decision making, where heuristics are liabilities because they lead to deviations from normative models based on economic rationality (Katsikopoulos and Gigerenzer 2013). Katsikopoulos and Gigerenzer (2013) suggest there are situations where heuristics are useful for better decisions. Their program of research called *fast-and-frugal-heuristics* evaluates heuristics not according to logical norms but according to performance in the ecology of real-world decision problems.

1.2.1 The Focus of BOM Research

BOM has been usually associated with experimental research (Katok 2011) but recent research practices involve a wider set of methodologies and the identification of heterogeneity at individual level, e.g. gender and risk preferences (Croson et al. 2013). Additional methodologies are experiments using games (e.g. the Beer Distribution game in a controlled laboratory setting to evaluate impact of advance warning of disruptions; see Engin and Vetschera, Chapter 4) or decision task (e.g. systematic variations of operational tasks and scenarios involving operational decisions), modeling and simulation, surveys, archival (e.g.

service time from supermarkets), biometric research (using information from capturing body movements), psychometric research, and qualitative/conceptual studies.

Finally, there is diversity of behavioral content in terms of theoretical perspectives employed in BOM. Some of them are related to Behavioral Economics (e.g. *prospect theory*, *reference point*, heuristics and biases, and strategic behavior affecting queuing, ordering, pricing) and some perspectives associated with Organizational Behavior (e.g. social preferences, emotions, culture). The adoption of different perspectives is an important evolution in BOM compared with its beginnings where the focus was on identifying gaps between theoretical models of what should happen and what did happen in reality (Croson et al. 2013). Examples of these approaches are observed in Önkal et al., Chapter 2 of this book, as they focus on behavioral effects such as *pull-to-center* and Engin and Vetschera (Chapter 4) who observed the impact of information feedback effects.

1.2.2 The BOM Focus on Operational Contexts

The scope of BOM has been broadening in recent years (Croson et al. 2013). The original papers in BOM mostly focused on inventory, more specifically the ordering policy by relaxing newsvendor models (see Önkal et al., Chapter 2, for an example), or on supply chain settings, by using the Beer Distribution game. However, the operational issues studied in BOM have broadened together with the journals (Bendoly et al. 2006). Nowadays, applications encompass supply chain issues such as contracting or supplier relationships, product development issues such as ideation and design decisions, quality issues such as error detection (Croson et al. 2013). Other areas are forecasting (e.g. issues on how optimistic forecasts affect inventory management), production (e.g. a behavioral study of the implementation of just-in-time), service (e.g. issues such as the impact of *social loafing* on servers when they have pooled queues, the impact of the last place in queues, service selection through the use of anecdotes and other social information when consumers do not have enough information, and the effect of feedback on

workers' effort allocation), risk management (e.g. learning operational risks through benchmarking rather than using probabilistic methods) in financial operations such as portfolio selection (see Momen, Chapter 3), and project management (e.g. abandonment decisions on multi-stage projects) (see Wang et al., Chapter 8).

1.3 Behavioral Operational Research: A Short Literature Review

OR is "the application of analytical methods to help make better decisions." In practice, however, the application of analytical methods is often not sufficient: a theoretically optimal solution obtained from an OR model is often not practical or becomes irrelevant by the behavior of the user of the model or the people who may be influenced by the decisions resulting from the model. The previous book on Behavioral OR compiled by these editors (Kunc et al. 2016) provided a framework, for academics and practitioners alike, to demonstrate the connection between behavior and OR modeling. A more formal definition of Behavioral OR (BOR) proposed in the current book is: "The study of the effects of psychology, cultural, cognitive, and emotional factors on our thinking and action with the use of (advanced) analytical methods and/or models to solve complex problems, support perplexing decisions and improve our ever-changing organizations" with the focus on how behavior is included in models, how people behave with models and how behavior is influenced by the model. At the core of BOR is the concept of *models* that connect the practice of OR modeling with the realm of organizational activities: problem solving and decision support systems.

The context for BOR applications is wider than the context for BOM. However, BOM has a more defined field because operations, as a set of organizational activities, has dimensions that are more discernible than problem solving or decision support systems as in the case of BOR. On the other hand, BOR shares similar appetite with BOM for the use of diverse theories such as psychology and economics to represent

individual behavior. However, BOR uses these theories for uncovering how behavioral factors affect the development and use of OR models.

1.3.1 The Focus of BOR Research Practices

Franco and Hämäläinen (2016) propose a framework for organizing empirical BOR studies. In this framework, BOR research focuses on *OR actors*, such as expert modelers, decision analysts, consultants, users, etc., *OR methods*, e.g. mathematical programming, simulation, etc., and *behavior in the OR actors* during the process. In other words, BOR is closer to the work of consultants and analysts than managers and workers, as in BOM.

BOR comprises three behaviors associated with the outcome of OR processes: behavior in models, behavior with models and behavior beyond models (Kunc et al. 2016). The first area evaluates the representation of human behavior. Human behavior can be included in OR models in many different ways depending on the assumptions of the modelers (Greasly and Owen 2016). Table 1.1 presents different perspectives used to include human behavior in OR models and most common OR technique under each perspective.

The second area relates with the use of models for decision making, what information is used and how it is processed (Katsikopoulos 2016). Decision makers have different psychological capacities, do not necessarily use all available information and employ simple computations (Katsikopoulos 2016). Therefore, users may not use the model as an OR expert but there may be changes in the users' behavior still. For example, one dimension to consider is changes in cognitive functions, such as an increase in the number of options considered, occurring by using an OR model in a real setting (e.g. Kazakov and Kunc 2016) or through laboratory experiments (Arango et al. 2016). Another dimension is the impact of using a model on the behavior of a group such as affective or cognitive conflicts between members (Huh and Kunc 2016). Table 1.2 displays a summary of this position.

The final area of study in BOR is the behavior of the organization using the lens of the socially situated nature of OR practice (White 2016).

Table 1.1 OR modeling perspectives to consider when including human behavior

Approach taken to represent human behavior	Description	Representation of human behavior in the model	World view of the OR modeler	OR technique (examples)
Simplify by not including any behavior	Eliminate human behavior by omission, aggregation, and substitution	No representation or subsumed in one variable, e.g. random	Optimization	Mathematical programming
Externalize from the model	Incorporate human behavior outside the model by allowing decision makers interact with the model	Since behavior is too complex to codify, it is recorded empirically from real decisions	Gaming; Naturalistic decision making	Management flight simulators Experiments using models
Incorporate as a passive current	Model humans following similar rules without any difference	High-level variables represent average human behavior	Continuous process over long term	Continuous simulation System Dynamics Markov models
Incorporate as individual entities	Model human as a discrete entities such as machines	Discrete processes capture b variables inside the model	Discrete particles controlled by rules	Discrete Event Simulation
Incorporate through activities	Model human performance in tasks	Output variables inside the model	Actions are response to pre-defined sequence of tasks	Discrete Event Simulation
Incorporate as free individuals	Model individual human behavior with all its complexity	Micro-level variables inside the model represent states and process of change	Specific attributes of behavior are presented individually and emergent from interactions with other humans	Agent-Based Simulation

Source Adapted from Table 1. Kunc et al. (2018)

Table 1.2 The impact of OR models on decision makers' behavior

Behavioral change in:	Description	Representation of human behavior	OR technique (examples)
Heuristics	Use of heuristics under different interactions with the model	Elicitation of heuristics and their consequences	Decision analysis
Cognition	Change of mental models Better understanding of complexity	Elements of mental models (variables, causal links)	System Dynamics Cognitive mapping
State of mind	Change in the state of mind is associated with two categories of conflict: functional task-related conflict (e.g. cognitive conflict) and dysfunctional emotion-related conflict (e.g. affective conflict)	Level of conflict	Problem structuring methods

Source Adapted from Table 2, Kunc et al. (2018)

Table 1.3 The impact of using OR models on organizational behavior

Organizational behavior change expected	Description	Representation of collective behavior
Interpreting/ integrating	Interpreting is a process of explaining an insight or idea to others	Language
		Dialogue
	Integrating is a process of developing shared understanding and taking coordinated action through mutual adjustment	Storytelling
		Shared
		Observations
Institutionalizing	A process of routinization where tasks and actions are specified together with organizational mechanisms to embed the learning	Systems
		Procedures
		Structures

Source Adapted from Table 3, Kunc et al. (2018)

Since OR models do not prescribe action, differently than BOM, this area of study intends to evaluate the externalization of the inclination to act after using models (White 2016). From an organizational learning perspective, the model can help to institutionalize routines, rules, or procedures (Crossan et al. 1999). Table 1.3 provides a summary of this area.

The next section attempts to compare the competences required for BOM and BOR in terms of similarities and differences.

1.4 A Comparative Summary of BOM and BOR

The aims of the practice from both fields differ substantially as BOM is concerned with operations whereas BOR is concerned with only problem solving or supporting decision making. Therefore, the scope is more contextualized for BOM, as it involves design, implementation, and improvement of operations, compared to BOR. However, BOR focuses on qualitative (soft) and quantitative (hard) models while BOM only on quantitative models. Given the focus on practice, BOR is more

eclectic on the theories employed to address behavioral aspects suitable for addressing the OR modeling process. On the other hand, BOM is limited in their theoretical sources given the strong interconnection between traditional operations management normative theories with the field of economics. In terms of methodologies, there is an overlap on experimental research methods but the experimental design diverges: BOM focuses on variations from normative models while BOR focuses on exploration of practices with behavioral lenses. However, BOM employs more research approaches to evaluate the impact of behavior because the context involves activities, resources, actors, and decision makers. BOR, with its focus on modeling, can only use research methods associated with processes, e.g. action research and case studies. Finally, the stakeholders are completely different due to the type of work evaluated. Table 1.4 presents a summary of the main aspects considered for BOM and BOR.

Table 1.4 Differences and similarities between BOM and BOR competences

Aspect considered	BOM	BOR
Aims of the practice	Detecting deviations from normative theories related to the field of operations management	Understanding and embedding behavioral aspects in the practice of Soft and Hard OR modeling related to problem solving and decision support in any organizational area
Scope	Typical activities in operations: inventory management, production management, service management, product development, quality management, procurement and strategic sourcing, and supply chain management Core area: operations	The practice of developing OR models (both soft and hard) for different organizational contexts and type of problems (strategic, tactical, and operational) with the focus on behavior in models, behavior with models and behavior beyond models Core area: models
Behavioral theories applied	Behavioral economics Organizational behavior	Bounded rationality Group dynamics Organizational behavior
Methodologies	Experimental Surveys Modeling Datasets Biometric and psychometric research	Action research experimental
Stakeholders	Managers/workers	Consultants/analysts

1.5 Comparative Examples of BOM and BOR Research Practices

This section presents two studies published in academic journals to highlights the competences employed by BOM and BOR practitioners through two examples. Table 1.5 presents a summary of the findings from the two studies.

1.5.1 BOM Competences in Practice (Moritz et al. 2013)

Research on how people make inventory decisions has provided with interesting evidence on behavioral decision making related to newsvendor decisions. People tend to follow an average response between average demand and profit-maximizing optimal quantity. Additional research has tested these average responses by influencing subjects' available information or reflecting environmental conditions such as experience, training, partial demand, etc. In this study, the authors intended to evaluate causal factors explaining the individual variations observed

Table 1.5 Similarities and differences between BOM and BOR competences in the studies discussed

Aspect considered	BOM study	BOR study
Aims of the research	Detecting deviations from the optimal decision in a newsvendor model	Understanding behavioral aspects of CEOs engagement in modeling to support their strategic decision
Scope	Only inventory management Core area: operations	The practice of developing OR models (both soft and hard) with the focus on behavior with models and behavior beyond models Core area: strategy
Behavioral theories applied	Cognitive reflection	Cognitive structures (mental models)
Methodologies	Experimental	Action research
Stakeholders	Managers/workers	CEO/consultants

in previous empirical works because they argued that previous research reported average results implying homogeneity in the subjects while subjects are heterogeneous.

The authors employed evidence from research in cognitive psychology and consumer behavior to justify the need for evaluating individual variance in newsvendor-type decisions. More specifically, they used the concept of *cognitive reflection*, as measured by the Cognitive Reflection Test (CRT), to evaluate behavior and task outcome. They employed three experimental studies varying the conditions and subjects, e.g. experienced decision makers and students. Study 1 comprised experienced supply chain managers and analysts. Study 2 with three different conditions employed students from a business school. Study 3 used another set of professionals with a different condition than in study 1.

The basic theory tested is the newsvendor model, which is dated from 1888. This model assumes that a decision maker needs to define an order quantity to satisfy stochastic demand in a single period. The decision maker has costs, price, loss for unsatisfied demand, and a salvage value for unsold inventory. There is an optimal order quantity that depends on the inverse of the cumulative distribution function for demand and a critical ratio between the costs of having too few units relative to demand (price minus costs plus loss of customer goodwill due to unsatisfied demand) and the total costs comprised by the costs of having too few and too many inventory units relative to demand (costs minus salvage value).

Empirical research indicates that people tend to over-order when the critical ratio is low and under-order when the critical ratio is high. In other words, when the cost of having too few units is low, people tend to over-stock; but when the cost of having too few units is high, people tend to under-stock. Some explanations suggest that some people use heuristics such as anchoring and adjustment using the mean demand while other people followed a demand-chasing heuristic.

The authors attempted to understand the decision making process of individuals using cognitive science instead of heuristics. They use *cognitive reflection*, which is a perspective based on dual process theories of decision making, e.g. *System 1* (intuitive, tacit, contextualized, and

quick decision making processes) vs. *System 2* (reflective, analytical, and based on abstract reasoning decision making processes).

They designed experimental conditions varying the availability of information related to the newsvendor model with the expectation the decision maker is able to solve the optimal quantity. If subjects are not able to solve the optimal quantity, they may be influenced by System 1 features. Therefore, they measured the use of System 1 features using CRT. To justify the adoption of this method, they employed a set of psychology literature explaining the drivers of the values observed in CRT tests. Then they proposed a set of hypotheses associating previous observed heuristics in newsvendor's experiments with cognitive reflection conditions. For example, a hypothesis stated "when making repeated newsvendor decisions, individuals with higher cognitive reflection will exhibit less chasing of prior period demand" (p. 75).

Experiments looked at behavior, e.g. exactness versus variance, and backgrounds, e.g. engineers vs. accountants. The experiments were developed using a computer-based newsvendor experiment previously utilized in other studies and a new variation in the demand of the model. More than 300 subjects participated in the studies.

The analysis of the results involved direct (e.g. ANOVA) as well as mediation models considering the different treatments for the experiments.

In addition to the contribution to the literature, the authors offered potential implications for practitioners. For example, analysts with higher cognitive reflection tendencies perform better when demand is stochastic and stable. They are also better to employ demand-chasing heuristics in high and medium critical ratio newsvendor environments.

1.5.2 BOR Competences in Practice (Torres et al. 2017)

A central debate concerning strategy processes is related to how managers can effectively manage their organizations and strategies in dynamic environments. System Dynamics modeling, as a modeling methodology for developing strategies within dynamic environments, is a widely employed OR modeling method for strategic planning. However, most

studies only report the final model and the results of using the model to test strategies under diverse scenarios. There is a gap in terms of how the modeling process affect the behavior of the decision makers and their impact on decisions made.

Moreover, there are important synergies between System Dynamics models and the field of strategy to support the development of strategy because many managerial challenges are associated with a manager's ability to understand and manage reinforcing feedback loops driven by asset stock accumulation through learning by doing, scale economies, network effects, information contagions, and complementary assets. Traditionally, System Dynamics modeling is known as a behavioral modeling method (Kunc 2016). Therefore, there are protocols to include behavior in models as well as understanding the impact of behavior with models and beyond models, as suggested in Kunc et al. (2016). More specifically, there are protocols to measure the improvement in cognition, e.g. *mental models* (Gary et al. 2008).

Their study has two contributions. Firstly, they propose a protocol for supporting strategy development via System Dynamics modeling developed in collaboration with the CEOs of a set of small organizations. Secondly, they illustrate the effectiveness of this protocol one year after the initial study.

Their study involved performing the development of strategies with five different small companies and their CEOs over a period of a month and then measuring the insights generated with the performance of the companies a year later. Similar to previous research in OR modeling, they employed case studies in real rather than experimental settings.

The authors illustrated the process using a swim lane flow chart, as shown in Fig. 1.1. The study describes each step in detail with the reactions from the decision makers through quotes. Additional evidence of the engagement of the decision makers was a selection of relevant variables, initiatives adopted in the face of uncertainties as well as decisions to be made.

The results from the study were related to changes in cognition. For example, they measured the development of cognition through the changes in the structures recognized in each iteration during the modeling process such as strategic resources, adjustment processes, drivers of adjustment processes, causal relationships, feedback structures, and

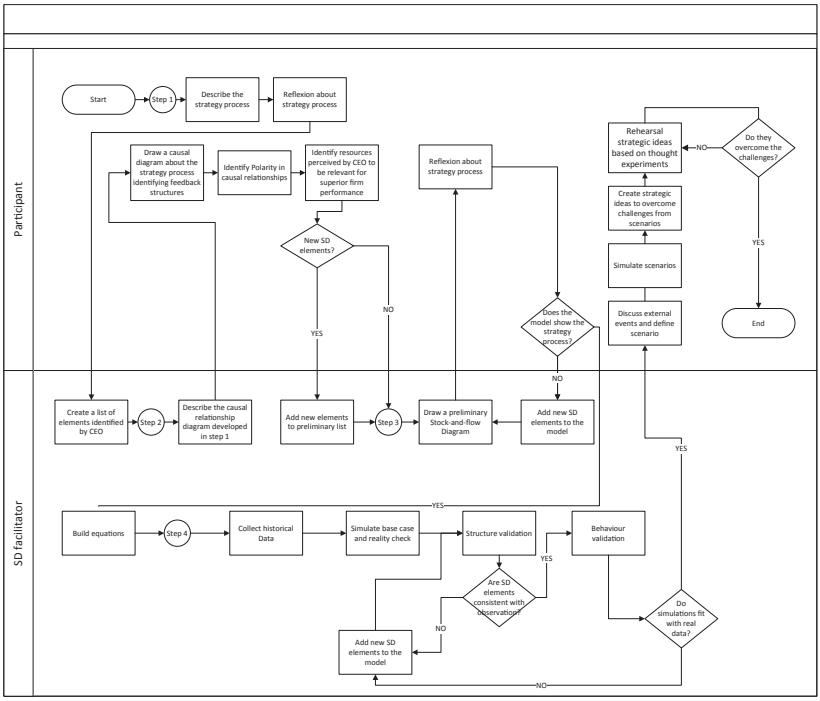

Fig. 1.1 Modeling process followed with the decision maker (*Source* Based on Fig. 1, Torres et al. 2017, p. 1084)

delays in processes (see Fig. 1.2 for an example). Another important aspect observed was the heterogeneity in individual behaviors during and after the modeling process. For example, three of the CEOs did not develop improved strategies as well as showing no changes in their mental models. The performance of their companies was poorer a year later. The rest of the CEOs generated more strategic options that were implemented over time and obtained an improvement in the performance of their businesses.

Some implications from the study were evidence of CEOs from small businesses usually running their companies based on past experiences so most strategic decisions are based on judgments emerging from mental models of their organizations and industries through trial and error. Thus, strategies employed in small organizations emerge from

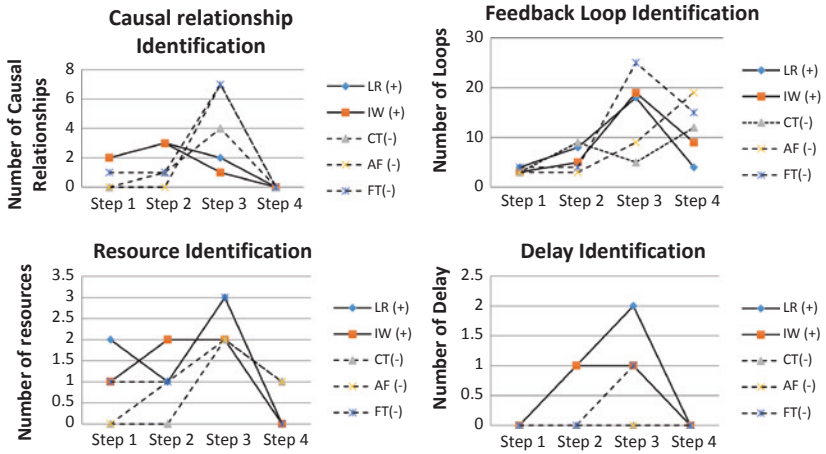

Fig. 1.2 Changes in cognition during the modeling project using a protocol based on CEO's answers in each step of the protocol. Each case study has associated the outcome of the process one year later adding (+) if it was a positive results and (–) if it was a negative outcome (*Source* Based on Fig. 7, Torres et al. 2017, p. 1092)

contingency rather than from a planning process. Consequently, System Dynamics models, in this case for strategic planning, enabled the CEOs to test and refine their strategic decisions through simulation exercises that reflect dynamic environments. Modeling helped the CEOs theorized the potential impacts that emerged from their mental models influencing the business decisions made under uncertain conditions.

1.6 Different Competences for BOR and BOM

Competences are based on how technical skills enable the proficient design and application of deliberate decision processes, taking into account behavioral factors that intervene in deliberate decision structuring. This chapter considers the purposeful and explicit application of technical skills to decision problems, ranging from decision support provided to individual decision makers (BOR example) to decisions made in a specific task environment (BOM example). From an analysis

of the BOM and BOR literature and the two studies, we suggest some questions of relevance for competences pertaining to both fields: What is the subject knowledge (inventory management vs. strategic management)? What is discipline-specific skill (operations vs. strategic planning)? And what type of education/proficiency is required (operations and psychology vs. strategy and modeling)?

There are important differences in the competences between both fields. Firstly, BOM uses mostly normative models with an optimal solution defined (e.g. portfolio selection problem discussed in Momen, Chapter 3) while BOR uses normative modeling methodology for problems that may not have an optimal solution. Secondly, BOM uses experiments to variate the conditions under the normative models runs to test boundary situations and try to approximate real decision making settings (see Engin and Vetschera, Chapter 4). On the other hand, BOR follows case study and action research approaches (see Wang et al., Chapter 8, for examples on project management) to evaluate behavioral aspects affecting real decision making settings. Thirdly, BOM core competences are based on behavioral economics (see Önkal et al., Chapter 2, Momen, Chapter 3, and Engin and Vetschera, Chapter 4, for examples) while BOR is grounded on cognitive science and organizational behavior (see examples in Burger, Chapter 11, and White, Chapter 16, in this book). Fourthly, BOM intends to improve the design and performance of operations considering the impact of human behavior on normative models while BOR intends to improve the modeling process that is inherently driven by human behavior.

1.7 Conclusions: Toward an Enhancement of BOR using BOM

There are some opportunities for enhancing BOR based on the competences observed in BOM. Firstly, the area of operations has been thoroughly modeled using normative models with clear optimal solutions. Scholars have not explored if there are better ways to adapt the normative models to the real settings. This is an area where BOR can

help BOM, especially accounting for the impact of behavioral aspects in the process of structuring the issues faced in operations (focused on modeling rather than testing). Secondly, BOR can adopt some of the BOM competences for the area of *behavior with models* such as experiments, psychology theories and use of normative (or quasi) normative models. Thirdly, BOM core competences in the area of *behavior in models* in terms of the inclusion of the results from experiments to portray realistic behaviors in models can be used in BOR to contextualize the behavioral aspects of the models. For example, Wang et al. (Chapter 8) show how biases and heuristics are improved in project management. Fourthly, BOR and BOM have similar scope when the concern is *behavior beyond models* since they try to improve the performance by influencing behavior of the actors or decision makers (see Wang et al., Chapter 8). However, the scope of BOM also involves design and implementation of solutions, which is an area that BOR can benefit substantially.

BOR practice can definitively enhance its competences and capabilities by adopting some of the principles of BOM such as the use of similar (quasi-normative) models in different context to account for the clear impact of behavioral aspects. Another aspect is to use already well-established literature on biases and heuristics to account for behavioral issues in and with models. However, the use of biases and heuristics should consider perspectives that consider them not only liabilities but also assets in decision making, as discussed previously. Finally, a more realistic and contextualized BOR practice, which takes into account the operations, can be the most useful enhancement to be learned from BOM.

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