Chapter 10
Summary: Executive Decision Synthesis Paradigm

Abstract We have two goals for this chapter. The first is to present a summary of the key ideas of our prescriptive decision paradigm. Second is to state the overarching concepts of our paradigm. These concepts are "like the skeleton, which, invisible to the naked eye, gives form and function to the body" (Morgenthau, *Politics among nations*. Alferd A. Knopf, 1960). These concepts are faintly visible throughout the book, but they form the skeleton of our book. We must be clear that we are making no claims about paradigm as theory. We are grounded on theory, but we are not building theory. Third, we will argue that we a rigorous paradigm. To demonstrate rigor, we submit our paradigm to tests of theory formulated by scholars. These tests of theory are the "eye of the needle" to demonstrate the paradigm's rigor, not to claim to theory. But nevertheless, we will thread the needle. We conclude that we have a rigorous prescriptive paradigm for robust executive decisions. The functionality and efficacy of our systematic process is verified by our simulations and case studies.

10.1 Introduction

This book began with a discussion about who is an executive, what is their span of control and the source of their power. We defined a decision as an artifact in the sciences of the artificial (Simon 1997, 2001), and the decision-enacting sociotechnical system as manufacturing production, a factory whose quality can be rigorously measured. We presented a systematic, step-by-step prescriptive paradigm to design robust executive decisions framed within a life-cycle management process spanning five spaces. We discussed the historical background and extant theories of decision theory and located our work in the prescriptive school. This chapter recapitulates our contributions and salient points about our paradigm. And finally, we argue that we have a rigorous and systematic prescriptive process executives can practice with confidence.

The chapter proceeds as follows. Consistent with the rubric of Summary, we begin by presenting a condensed list of the key concepts of our prescriptive paradigm (Sect. 10.2) These are the most salient and original ideas of our prescriptive paradigm. Foremost in the list of ideas is the *design of robust decisions*. Section 10.3 discusses how we answer the question about whether our methodology *works*. For any prescriptive methodology to be meaningful, it must *work*. We

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argued in Chap. 4 that a prescriptive sociotechnical methodology *works* if and only if its functionality and efficacy can be verified. We summarize the metrology and the measurement instrument we developed for the functionality and efficacy verification processes. This is an original contribution to the field of prescriptive decisions. In Sect. 10.4 we discuss another important question, does our paradigm produce good decisions? We discuss this by evaluating our paradigm using Howard's criteria for good decisions (Howard 2007) and Carroll and Johnson's criteria (1990) for good processes. We show that our methodology exceeds their criteria. Finally in Sect. 10.5 we evaluate our paradigm using tests of theory. We use these tests not to show we have a theory; rather, because these tests are so strict they serve as the "eye of the needle" for paradigm rigor. We conclude that the work in this book gives us confidence that we have a rigorous paradigm that works. Finally we conclude with the fundamental overarching concepts that underpin our work.

10.2 Our Paradigm's Salient Ideas

- Robust executive decisions. Decision processes that are highly immune to uncontrollable conditions are said to be robust. Our prescriptive paradigm presents a systematic process to design decisions whose outputs are highly insensitive to uncontrollable and unpredictable conditions. This is a departure from conventional decision strategies that seek to maximize output without the property of high immunity to unpredictable conditions. Robustness reduces the downside risk of decision-making while still being able to capture upside opportunities.
- Our paradigm is grounded on the sciences of non-physical artefacts that are man-made. These are the Sciences of the Artificial and Bounded Rationality. Executive decisions are nonphysical artefacts. They are intellectual artefacts. Bounded rationality recognizes the limitations of time, data, computing power, and cognitive capacity. Therefore, the goal is to *satisfice* with robustness**,** not necessarily optimize or maximize in the absence of uncontrollable conditions.
- Executive decisions are non-physical man-made objects. Decisions are specifications designed for organizational action. They are blueprints for action that produce intended outcomes. Decisions are prescriptions created from design synthesis processes.
- Decision-making is an event. Executive decision management is a life-cycle process of five sociotechnical spaces. They are the Problem, Solution, Operations, Performance, and Commitment Spaces (Fig. 10.1).

Each space has at its core a fundamental sociotechnical system (Fig. 10.1)—the cognitive, design, production, measurement system, and the decisive executive, respectively. Each is intended to focus on a specific functional domain, i.e. sense making, decision synthesis, *gedanken* experiments, performance evaluation, and commitment to action, respectively.

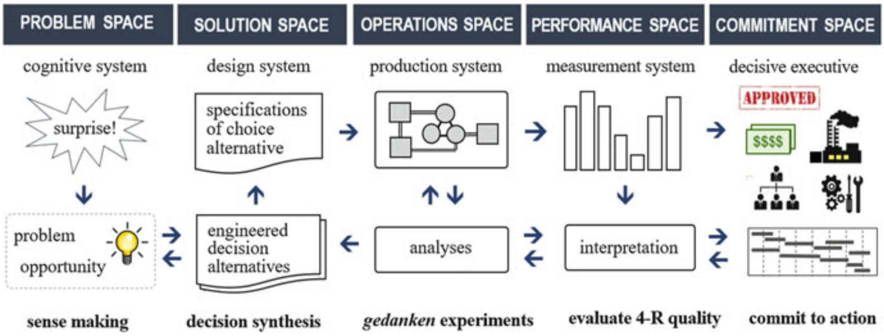

Fig. 10.1 The five spaces of the executive decision life cycle

Table 10.1 Systematic processes for the five spaces of executive decision's life cycle

Process spaces	Our systematic process
Characterize Problem space	• Sense making—uncomplicate cognitive load
	• Frame problem/opportunity and clarify boundary conditions
	• Specify goals and objectives
	• Specify essential variables – Managerially controllable variables – Managerially uncontrollable variables
Engineer Solution space	• Specify subspaces of solution space – Alternatives space and uncertainty space
	• Specify entire solution space
	• Specify base line and uncertainty regimes – Do-nothing case and choice-decision – Estimate base line and dispel bias
Explore Operations space	• Specify – Sample orthogonal array – Do-nothing case and choice decision-alternative
	• Predict outcomes
	• Design and implement robust alternative • Design and implement any what-if alternative
Evaluate Performance space	• Evaluate performance: analyze 4R • Robustness, repeatability, reproducibility • Reflect
Enact Commitment space	• Decisive executive • Approval of plan • Commit funds, equipment, organizations

- The sociotechnical system that enacts decision specifications is a ***production system,*** like a factory that makes parts. In our case, the parts are decision specifications. As in every manufacturing and production system, its performance must be rigorously measured, *viz.* what is its production quality? Our paradigm adopts the Gage R&R manufacturing quality-measurement methodology for this purpose. The R&R stand for Repeatability and Reproducibility quality measures.

- Systematic Actionability is a fundamental goal of our prescriptive paradigm. To that end, we specified actionable prescriptive processes, within each space (Table 10.1).
- Unconstrained capability to explore any region of the solution space is a uniquely useful and practical capability of our prescriptive methodology. Exploration is accomplished using *gedanken* experiments. These experiments are not constrained to restricted local regions of the solution space under limited uncertainty conditions. Nor are the uncertainty conditions limited to small regions of the uncertainty space. The uncertainty space is made tractable by the specification of *uncertainty-regimes* that can span the entire uncertainty space.
- Powerful predictive capabilities are inherent in this paradigm. Unconstrained exploration is not very useful without the capability to predict outcomes of designed decision alternatives. Moreover, predictions without knowledge of their associated standard deviations would also make the prescriptive methodology very insipid. Our paradigm provides the ability to predict outcomes of any designed decision alternative including their associated standard deviations under any uncertainty regime. Our systematic processes make explorability very meaningful and practical. It enables us to design robust decision alternatives.
- In the final analysis the question is always: Does our paradigm work? This question cannot be answered as if we were discussing a light bulb. To address this question, we develop a metrology and a measuring instrument to calibrate the extent to which our paradigm will work. This another first in the field of executive decisions and the subject of the next Sect. 10.3.

10.3 Does Our Paradigm Work? A Metrology with Instruments

Whether complex systems, methodologies, or technologies "work" cannot be understood as a binary attribute. "Does it work?" cannot be framed, and addressed using the light-bulb on/off metaphor and posed as a false dichotomy. "It works" is a composite verdict of two orthogonal judgements about a designed decision and its specifications. One verdict is about *functionality*; the other is about *efficacy* (Fig. 10.2). Functionality and efficacy are necessary conditions. This is like the development of a drug in the pharmaceutical industry. Does a drug work? First it must be verified that it is functional in the laboratory of the pharmaceutical company. Namely, that it is functional. Second, that it must be verified that in the field of its efficacy, *viz*. that usage by customers is effective.

Functionality means that the prescriptive methodology is *ready-**to**-work*. This means that we, as creators of our executive-decision paradigm and its methods, can

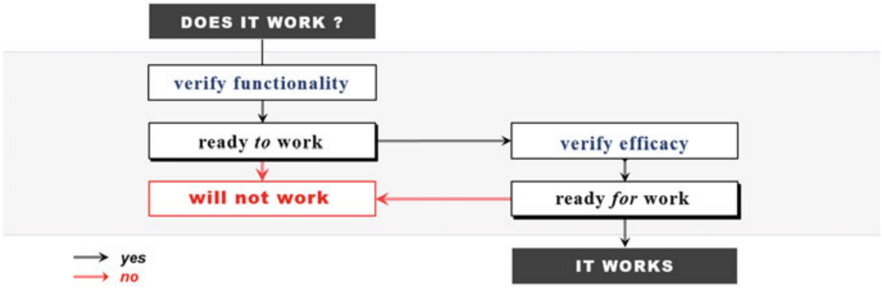

Fig. 10.2 Framing the concept of "It Works"

legitimately claim that our prescriptive methodology will perform as intended. For functionality, we must convince ourselves that our methodology meets our engineering design specifications. The onus is on us, as the original engineers and designers of this methodology. On the other hand, efficacy means that an executive, has made an independent verdict of effectiveness and made a commitment for usage. An executive has systematically acquired a body of information confirming or refuting the functionality and performance claimed by the artefact's creators. An executive is now convinced that our methodology is *ready-**for**-work*. This is a test of efficacy. In summary:

- Readiness is at the center of ready-**to**-work and ready-**for**-work. Our methodology "works" if and only if it is ready-to-work and ready-for-work.
- Functionality is necessary and sufficient to demonstrate our methodology is ready-to-work. The presumption is that it meets all design specifications, i.e. it will function as designed.
- Efficacy is necessary and sufficient demonstration that our methodology is ready-for-work for an executive. The presumption is that it is ready-to-work, and it is effective for an executive.

We now know the "what" of readiness. The "how" remains to be addressed, *viz.* "how" do you demonstrate readiness? What are the tools to measure the extent of readiness?

Measuring readiness is not like using a ruler, handling an ohmmeter, or simply standing on a weight scale in the bathroom. All of which can be accomplished in one undemanding move. In contrast, measuring readiness is a systematic and disciplined socio-technical process. It involves organizational procedures, skilled professionals, technical equipment, and a measurement system grounded on science, engineering, and logic. We need a **metrology** for readiness. *Regrettably, the science of metrology is absent in the field of executive decision theory and praxis.* We remedy this lacuna.

We define "metrology for readiness" as the science and practice of measuring the degree or extent of readiness of our methodology. Fundamental to any metrology is a discipline-neutral lingua franca for senior-executives and technical professionals to communicate goals, status, and progress. This exists, for example, for technology readiness (Tang and Otto 2009), but not for executive decision

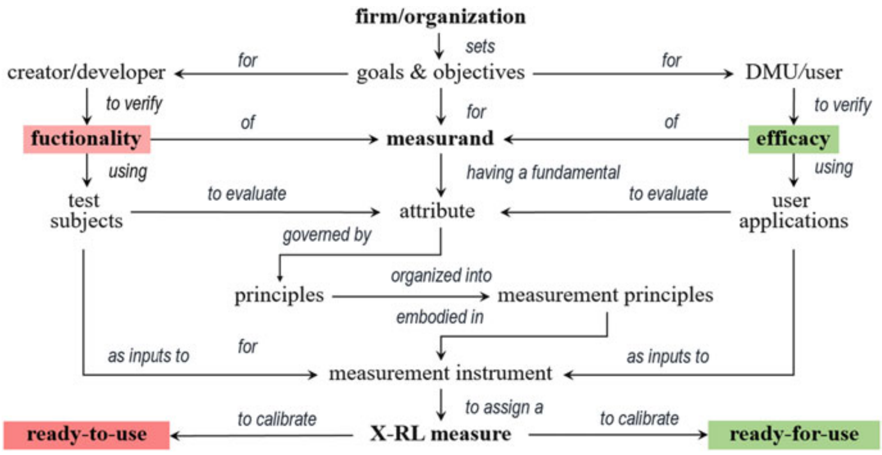

Fig. 10.3 Conceptual architecture of a readiness metrology

methodologies. Our metrology for readiness is a dynamic sociotechnical system. Its conceptual architecture is illustrated by Fig. 10.3 and the lingua franca in Table 10.2.

- Measurement. Measurement is a process or experiment for obtaining one or more quantities about attributes of outcomes that can be ascribed to our executive-decision paradigm and its methods. The quantities are also called values. The attribute of interest is readiness.
- Measure. A measure is the assignment of a numerical value that represents the intensity of the *readiness* attribute of our methodology. Our methodology is the measurand.
- Measurand. The methodology that is the subject of measurements is not a simple "dumb" artefact like a resistor. The resistor is *passive*. Complex measurands, like a car engine being measured for power, requires fuel to make the engine run in order to take measurements. The combination of engine and the fuel form a *system measurand*. The measurement unit is newton-meters, for example. Our methodology together with an experimental test case qualifies as a system measurand.
- Measurement Unit. Measurement unit is a defined scalar quantity that will be used as a basis for comparison. Our measurement for readiness is an ordinal number, *readiness level-n*, $n \in \{1,2,3,4,5\}$. Level-1 is the lowest readiness level for least ready. Level-5 is the highest for most ready.
- Measuring instrument. A measurement instrument is an artefact used for making measurements, alone or in conjunction with supplementary artefact(s). A ruler is a simple instrument. The twin Laser Interferometer Gravitational-wave Observatory (LIGO) detectors form a system instrument. Instruments can be physical, non-physical or a mixture of both.
- Measurement procedure. A measurement procedure is intended for *people* to implement. The procedure is a documented recipe that is in sufficient detail to

Table 10.2 Readiness level specifications for executive decisions

Process Phases	Our systematic process	
X-RL1 Characterize **Problem space**	Sense making—uncomplicate cognitive load	☑
	Frame problem/opportunity and clarify boundary conditions	☑
	Specify goals and objectives	☑
	Specify essential variables Managerially controllable variables Managerially uncontrollable variables	☑
X-RL2 Engineer **Solution space**	Specify subspaces of solution space Alternatives space and uncertainty space	☑
	Specify entire solution space	☑
	Specify base line and uncertainty regimes Do-nothing case and choice-decision Estimate base line and dispel bias	☑
X-RL3 Explore **Operations space**	Specify Sample orthogonal array Do-nothing case and choice decision-alternative	☑
	Predict outcomes	☑
	Design and implement robust alternative	☑
	Design and implement any what-if alternative	
X-RL4 Evaluate **Performance space**	Evaluate performance: analyze 4R	☑
	Robustness, repeatability, reproducibility	☑
	Reflect	
X-RL5 Enact **Commitment space**	Decisive executive	☑
	Approval of plan	☑
	Commit funds, equipment, organizations	☑

☑ Indicates required for Readiness

enable a measurement that is attributable to the extent of readiness of an executive-decision paradigm and its methods.

- Measurement principle. A measurement principle is a phenomenon that serves as the basis for a measurement. For example, concentration of hydrogen ions by increments of 10 in a liquid solution determine the pH value. Factors of 10 make a qualitative change in the acidity of a solution. Principles are made operational and discernible by methods within an instrument.
- Measurement method. An *instrument* implements, by design, a logical organization of operations during a measurement according to measurement principles to obtain a readiness *measure* for an executive-decision paradigm and its methods. A measurement method is intrinsic to the instrument. In contrast, a measurement procedure is extrinsic, it is intended for people to implement.
- Measurement system. We define the measurement system as the sociotechnical composite comprised of the organization, their knowledge, data bases, formal and informal procedures, and instruments, all together, as a measurement system (Figs. 10.3 and 10.4).

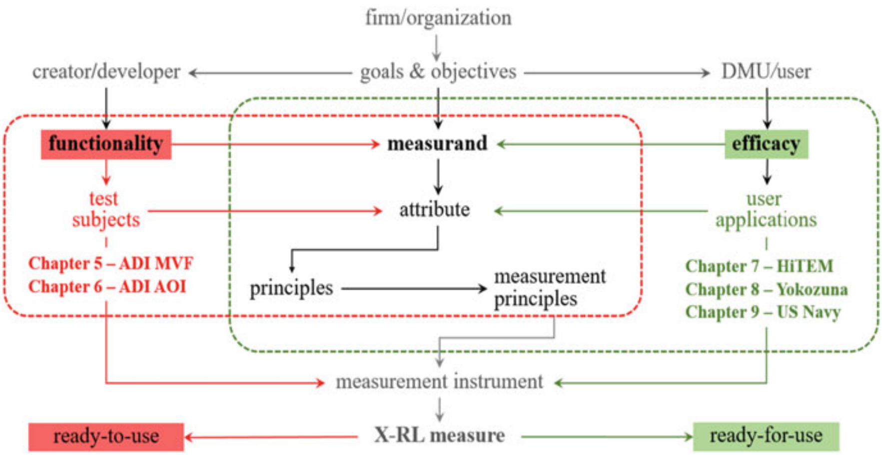

Fig. 10.4 Verifying functionality and efficacy using our metrology framework

We verified functionality in Chaps. 5 and 6. We used simulations of a real company by implementing the tasks within the box outlined by the red dashed lines. We verified **efficacy** in Chaps. 7, 8, and 9 with real world executives by implementing the tasks within the green dashed lines. The instrument used to calibrate readiness is our X-RL checklist of progressively increasing readiness, Table 10.2. Findings from Chaps. 5, 6, 7, 8, and 9 support our claim of functionality and efficacy for our prescriptive paradigm.

10.4 Does the Paradigm Produce Good Decisions?

Regarding what is a "good" decision, there are many opinions. In Sect. 2.7, we reviewed three authoritative views on that subject. The first is based on the well-known four axioms of von Neumann and Morgenstern's (vNM). Second view are Howards' criteria six of a good decision (Howard 2007). Third are Carroll and Johnson's criteria regarding a good decision process and its outcomes (Sect. 2.7.4). In this section, we will review our paradigm against Howard's criteria and then use Carroll and Johnson's criteria. We will also do so using our 4-R criteria. We will summarize our findings and close this section.

10.4.1 Review Using Howard's Criteria

Howard's six criteria of a good decision analysis process are:

- A committed decision-maker. By definition a decision is determining of what to do and what not to do with a resolute commitment to action.

- A right frame. Framing is the process of specifying the boundaries of a decision situation. What is to be included and what is going to be excluded from consideration. An articulated frame shapes a decision maker's conception of the acts, outcomes, and contingencies associated with a particular choice to be made (Kahneman and Tversky 2000).
- Right alternatives. Their development is the most "creative part of the decision analysis procedure" (Howard and Matheson 2004, 27; Simon 1997). A creative alternative is one that might resolve a conundrum, remedy defects, and improve future prospects.
- Right information. Information is a body of facts and/or knowledge that arm an executive to make more meaningful, accurate, and complete evaluations of decision alternatives. The goal is to improve judgment.
- Clear Preferences. Every alternative is more or less attractive, preferred or undesirable, to an executive by applying consistent rules.
- Right decision procedures. Having the right decision procedure means having a process like our systematic paradigm, the canonical paradigm, or a process like Howard's Decision Analysis process (Howard 2007). The goal is having disciplined and effective processes between a DMU and organizational units (Spetzler 2007).

We evaluate our prescriptive paradigm relative to Howard's criteria. The summary of our evaluation is shown in Table 10.3.

Howard's criteria concentrate on the tasks leading to the event of decision-making. The criteria are constructed around four questions: who decides? How do you decide? What do you know? And what do you want? Howard then specifies desirable attributes about who, how, and the two what's. For example, who decides? Answer: a committed decision maker. How to decide? Answer: right decision procedures. And so on. The question that is left implicit is: So what? Namely is the outcome as desired and expected? Consistent with strong normative character of Howard's decision analysis process, the implicit assumption is that a rigorous process that is predicated on the vNM axioms with the right information is

Table 10.3 Review of our paradigm relative to Howard's Criteria

Howard's criteria	Selected particulars of our prescriptive systematic process	
Committed decision maker	Decisiveness is a requirement for our executive decision maker	●
A right frame	Sense making, framing, clear goals and objectives part of our paradigm	●
Right alternatives	Design of robust solutions alternatives are part of our actionable processes	●
Right information	DMU debiased *gedanken* experiment data	●
Clear inferences	Robust solution identified by outcomes and standard deviation	●
Right decision procedures	Decision design synthesis, ANOVA, Gage R&R, strong predictive power	●

● Indicates Howard's criterion is met

by definition a good logical decision. He writes that "there is no better alternative in the pursuit of good outcome than to make good decisions" which is by his standards the "right decision procedures" (Howard 2007, 33). Good process is a good decision.

10.4.2 Review Using Carroll and Johnson's Criteria

Carroll and Johnson (1990) specify six criteria to evaluate a decision and its processes. They are:

- Discovery. "Having the power to uncover new phenomena, surprise the researcher, and lead to new creative insights."
- Understanding. Having valid constructs that uncover mechanisms. "Providing a cause-and-effect analysis that uncovers the mechanisms or processes by which decisions are made" i.e. uncovering working principles.
- Prediction. Ability to make predictions based on rules of logic, and mathematics. "Having logical or mathematical rules that predict the judgement and decisions that will be made. The rules need not represent the actual decision processes."
- Prescriptive control. Capability to modify the process including better prescriptions and hypothetical what-if and other conditions. "Providing opportunities and techniques for changing the decision process, as in prescribing better decision rules or testing potential manipulations."
- Confound control. Creating controlled situations. "Creating controlled situations so as to rule out other explanations of the results (Known as confounds)."
- Ease of use. Efficient and economic use of time and resources. "Taking less time and resources for the same progress to the other goals." This means that it must be efficient.

Table 10.4 highlights of the evaluation of our systematic process using Carroll and Johnson's criteria.

Carroll and Johnson's (1990) criteria have a strong emphasis on the quality of the process (e.g. confound control, prescriptive control, ease of use), the impact of outcomes (e.g. discovery, understanding), predictive capability, and new insights (e.g. discovery and understanding). Their criteria have strong decision life cycle perspective.

10.4.3 Review of Our Approach

10.4.3.1 Introduction

There is a lot of dogma on the issue of what are good decisions (Sect. 2.7). Given the sociotechnical complexity, messy, and wicked nature of **executive** situations, we assert that robust decisions that satisfice a decisive executive are good decisions.

Table 10.4 Review of our paradigm relative to Carroll and Johnson's Criteria

Carroll and Johnson's criteria	Selected particulars of our prescriptive systematic process	
Discovery	Executive decisions can be studied using *gedanken* experiments and DOE	●
	Decisions' production quality can be measured with Gage R&R	
Understanding	*Ex post* phenomenological system behavior can be determined	●
	Essential variables are the controllable and uncontrollable variables	
	Determine the gage, repeatability and reproducibility of production system	
	Model behavior of the sociotechnical system under any uncertainty regime	
Prediction	Can predict the outcomes and standard dev of any designed alternative	●
	Prediction of a decision alternative can be under any uncertainty regime	
Prescriptive control	Vary uncertainty conditions at will to explore decision alternatives	●
	Vary the intensity of any controllable and uncontrollable variable	
	Configure any mix of variables to predict out comes and standard deviation	
Confound control	The % contribution of variables revealed by ANOVA statistics	●
	The importance of interactions can be determined for appropriate analysis	
	Effect of any uncertainty condition or any variable condition is predictable	
Ease of use	Orthogonal array sampling is enormously efficient	●

● Indicates Carroll and Johnson's criterion is met

The aphorism about the proof of the pudding applies. The chef may offer an opinion, but the fact he chose the right recipe from Julia Child, has the right ingredients, and so on are all relevant. Moreover, the chef has undoubtedly sampled his work and judged it to be good. But the aphorism asserts other important determinants of a good pudding that need to be considered.

The judgement of *good executive decisions* must include a verdict from the executives who are responsible and accountable for the decisions they make and for the outcomes they produce. The executives who must evaluate a decision-maker's performance also contribute to this verdict. This is realistic and practical. They are the ones who have their careers, promotions. bonuses, and kid's college tuitions at risk. ***They, who have been given the power to command, must be able to explain their decisions to whom they must answer to***. And so on up the chain of command. The judgements are unlikely to be based entirely on outcomes or exclusively on process. Research shows that presenting strong arguments, to justify a decision and an outcome, is an effective managerial practice (Keren and de Bruin 2003). Thus we concur with the statement that "there is no unequivocal answer to the question how to judge decision goodness" (Keren and de Bruin 2003). The answer is situational, not categorical. By no means, are we advocating a "do nothing" approach to the question of a good decision. Research must continue to add to the cumulative knowledge about good decisions.

Howard's approach, Carroll and Johnson's reveal different emphasis—Howard more on the rigor leading to the event of decision-making, whereas Carrol and Johnson more on the process and the learning that can be accrued from outcomes. Our paradigm is a life-cycle prescriptive methodology. We can segment it into temporal phases. We start by marking the time when the decision is taken, i.e. when the executive commits to a decision specification and assigns resources to its implementation. Call this the *zero-hour*. We have the following time periods—*ex ante* (before zero-hour), *ex inter* (during zero-hour), and *ex post* (after zero-hour). In our paradigm, we consider:

- ***ex ante***. The process must consider the actions before zero-hour. For example, Howard's criteria for a decisive executive (Sect. 10.4.1) and design for Robustness (Sects. 2.7.5 and 1.3.2.5) are examples of actions taken *ex ante*. We address this by specifying XRL1, X-RL2, and X-RL3.
- ***ex inter***. The sociotechnical system must have a decisive executive who can commit at the moment of decision, zero-hour (Sect. 1.5.3 and Appendix 1.5). At the moment of decision, the executive must commit. We address with X-RL4 and X-RL5 requirements and prescriptions.
- ***ex post***. Every decision involves an outcome, it follows that it is necessary to evaluate the quality of the outcome and of the sociotechnical system that produced it. The implementing sociotechnical system is a manufacturing production system of decisions as intellectual artefacts. Repeatability and reproducibility (Sects. 2.7.5 and 1.3.2.6) are the quality measures of such a production system. Measurements are meaningless without reflecting and learning from them; therefore this is a requirement. We address with X-RL4 requirements and prescriptions.

Pushing our pudding aphorism further, we assert that our X-RL instrument and its set of actionable prescriptions are directed at the chef and the consumer of the pudding.

10.4.3.2 First Principles and Epistemic Rules

Prescriptive methodologies must not only be useful but also meaningful. Regrettably, many are of the "buy low, sell high" variety. They sound good, but are not sound. Prescriptions should not be just based on data and empirical patterns. The entire prescriptive body must be coherent as a conceptual structure, based on first-principles (Sect. 1.6). We impose four epistemic rules to test our principles:

- **Rule 1. Research Rule**. The principles must have a research base. Scholarly work that investigates these principles and closely related subjects must exist in the literature.
- **Rule 2. Falsibility Rule**. The Popper falsibility criterion must apply (Popper 1959). Science is distinct from non-science by the fact that only falsifiable claims can be considered scientific. We impose this rule because we seek to bring rigor to our prescriptive paradigm. In our case, we use Bacharach's (1999) tests of falsibility (Sect. 10.5).
- **Rule 3. Accretion Rule**. The principles must advance the research and the practice of executive-decision for complex, messy and wicked situations. Science and praxis advances through the accretion of valid and effective knowledge and the elimination of invalid information from anecdotal customs and processes.
- **Rule 4. Sciences-of-the-Artificial Rule**. Our principles must be consistent with the fundamental premises of the Sciences of the Artificial. Sciences of the Artificial dealing with manmade artefacts under bounded rationality (Simon 1997, 2001).

Our six principles follow (Sect. 1.6.2).

Principle 1. Abstraction *Reduce cognitive load, attack complexity by abstractions.*

This principle is grounded on the cognitive sciences. Reduce the cognitive load imposed on the DMU with representations that are not complicated. Whereas complexity is an inherent property of systems, complicatedness is the degree to which people make complexity cognitively unmanageable. Einstein famously said: "Make things as simple as possible, but not simpler." Complexities need not be exhaustively revealed, in their glorious detail, to those who have to deal with it. Abstraction will facilitate cognition for meaningful sense-making, decision design, and enactment. Abstracting is seeing the underlying simplicity of complexity (Simon 1997, 2001). To abstract, one must suppress non-essential features so that its essential structure and working principles are revealed, in their most parsimonious and insightful forms (Sect. 3.2). Abstraction is also necessary for implementing sociotechnical systems to attenuate operational cognitive load required.

Principle 2. Actionability *Ground abstraction on managerially controllable variables that directly influence intended outcomes.*

This principle is targeted at the frequently voiced criticism that abstractions are difficult to operationalize. Our Actionability principle is grounded on elegant engineering design-practice. Focus on the essential variables (Sect. 3.3.2). Elegant engineering design uses effective working principles using a parsimonious set of variables, to determine the behavior and the artefact to produce the intended outcomes. Good design represents an **uncomplicated** mental model of the decision situation and its specifications for action. In Sect. 1.4.3, we discussed the logic and significance of an uncomplicated system image for those faced with complex and messy situations. Concentrate on decision specifications that will satisfice. Simon (1997; 112) argues that for functional artifacts, the keys are ". . . an understanding of what are the key variables that shape system equilibrium and what policy variable can effect that equilibrium". In our paradigm, we argue the necessity of including uncontrollable variables and explicitly integrating them into the prescriptive paradigm. The entire spectrum of uncertainty is thus addressed with our actionability principle.

Principle 3. Robustness *Design decisions so that they are highly immune to uncertainty conditions even when uncontrollable conditions cannot be removed. This is robust design.*

Uncertainty is part of the universe. This means that many variables are managerially uncontrollable. Robustness is the property of a system that is high immune to the pernicious effects of uncontrollable variables even when they cannot be removed. Thus, systems and decisions must be designed for robustness. Robustness is achieved by identifying the essential uncontrollable variables and including them in the design of the decisions. Robust engineering methods for physical products are proven to be highly effective. We adopt this strategy for the design of executive decisions.

Principle 4. Unconstrained Explorability *Unconstrain actionability by enabling exploration of the entire solution space under the entire space of uncertainty conditions.*

The first idea to solve a problem is unlikely to be the most worthy. Explorations for alternative and potentially superior ideas must be permitted without constraints. Any hypothetical "what if" decision alternative must be permitted to be explored under any uncertainty condition. Actionability and Robustness are highly desirable, but not very useful if the decision can only be explored in a narrow region of the solution space and only under a very limited set of controlled conditions. A useful methodology must remove these constraints. This capability of unconstrained explorability is required for any executive decision alterative.

Principle 5. Production Quality Is R&R *Production quality is robustness, repeatability and reproducibility.*

Principles 1, 2, 3, and 4 deal with the definition, design, and exploration of design alternatives. This principle deals with the production system for executing decision specifications. The focus is on the quality of the decision-manufacturing system. This principle is grounded on performance evaluations and improvements based on measurement data of the sociotechnical system's operations. We want to know the quality of the system and pinpoint sources of production defects. Are the defects due to the measurement tools, the artefact, the people in the measurement process, or a mix of these factors? If so to what extent is each of these factors contributing to the defects? Consistently predictable outcomes must be the result of r*epeatable* and *reproducible processes*. These criteria are useful to analyze the quality of results and to identify sources of defects in the processes.

Principle 6. Decisiveness *An executive cannot be irresolute. Executives by definition must decisively formulate a plan, lead organizations to execute and commit irrevocable resources for implementation.*

Decisiveness is the ability to cross the Rubicon. Tom Furey, IBM senior executive and friend, was fond of saying that he'd rather be wrong than indecisive. Doing nothing, at the moment of decision, merely extends the state of uncertainty and prolongs ignorance. Even doing the wrong thing will produce new information that confirms or refutes. Doing something becomes a learning opportunity. An executive must be decisive, take a decision when it is required, not sooner, not later. Neither jumping the gun nor procrastinating, but acting with firmness and determination in the face of uncontrollable uncertainties. Commit irrevocable funds and equipment, lead organizations to enact, and engage existing a new critical skills to implement the plan. Timidity, indecisiveness and reluctance to make a decision are sure signs of one who should not be in a position of command. Decisiveness is a necessary condition, but insufficient for effective and efficient decisions. Finally decisiveness also means having principles for knowing when to say *yes* and when to say *no*.

10.5 We Have a Rigorous Paradigm

10.5.1 Definition of Prescriptive Paradigm

This book is about a prescriptive paradigm for executive-management decisions. The vast majority of the book has concentrated on the prescriptive parts. We began with an overview of our prescriptive methodology, followed with a review of the literature to place it in context. Then we discussed our approach to show that the methodology "works". And finally we used five cases to show functionality and efficacy. But what is a prescriptive paradigm? We define it as follows:

> A **prescriptive paradigm** is a set of systematically actionable processes, based on first-principles and epistemic rules, to produce robust outcomes under uncertainty for complex, messy, and wicked sociotechnical problems.

10.5.2 Tests of Paradigm Rigor

In this section we will test our paradigm against criteria of a theory. *We do not claim, nor do we desire to claim that our prescriptive paradigm is a theory*. But the tests of theory are meaningful to test the rigor of our prescriptive paradigm. They are the "eye of the needle", which will thread with the work of scholars and our finding in this book. We will apply three tests. Baharach's test of theory, Sutton and Staw (1995) test of what is *not* theory, and finally, Shepherd and Suddaby (2016) tests for theory and theory building.

Bacharach (1999) in a widely referenced paper discusses in detail the necessary components of a good theory and the evaluation criteria for a candidate theory

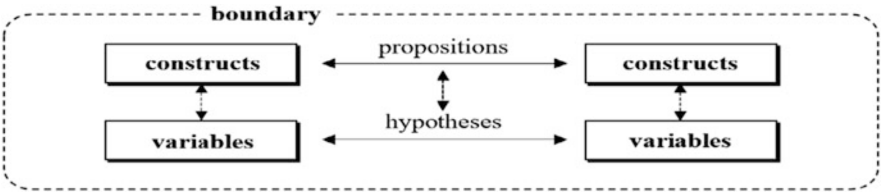

Fig. 10.5 Verifying functionality and efficacy using our metrology framework

(Fig. 10.5). We will use his test, not for theory testing, but to show that we have a rigorous paradigm. According to Bacharach (1999) theory is "statement of relationships between units observed or approximated in the empirical world" ... "Observed units mean variables, which are operationalized empirically by measurement (*op. cit.* 498)". A variable is "an observable entity which is capable of assuming two or more values" . . . "Constructs can be applied or even defined on the basis of the observables [variables]." ... "may be viewed as a broad mental configuration of a given phenomenon (*op. cit.* 500)". Finally "theoretical systems take the form of propositions and proposition-derived hypotheses. While both propositions and hypotheses are merely statements of relationships, propositions are the more abstract constructs and all-encompassing of the two . . . Hypotheses are the more concrete and operations statements of these broad relationships and are therefore built from specific variables (*op. cit* . 500).

Bacharach's criteria are listed in Table 10.5. Our prescriptive methodology satisfices all the criteria. We eschew elaborate explanations. The concepts were addressed in Chaps. 1 through 4, and demonstrated in Chaps. 5 through 9 using detailed case studies.

It can be said that Bacharach's criteria have been satisfied by our simulations in Chaps. 5 and 6, and by our *in situ* case studies in Chaps. 7, 8, and 9.

However Sutton and Staw (1995) argue that the presence of empirical data, lists of variables and constructs, hypotheses, diagrams and models are not sufficient to claim a theory. Wolpin (2013) cogently argues the point. They argue that a "why" must be able to tie all of the above into a coherent conceptual whole. Our interpretation of this statement comes from physics. Tycho Brahe spent a lifetime accumulating data about planetary trajectories. But he did not have a theory. Johannes Kepler made brilliant observations from the data. They are called Kepler's law of planetary motion. But he did not have a theory either. The "why" remained unanswered. It was Isaac Newton that provided the "why" with his inverse square law of gravitational attraction. A stupendous theory was born. Similarly, management was anecdotal and descriptive until Frederick Taylor's time-and-motion studies. Taylor invented a quantitative measurement system for production. Manufacturing has not been the same since. Taylorism was the geneses of management science and production management. This thinking has evolved to administrative theory and social science in organizations (e.g. Thompson 2004). Achterbergh and Vriens (2009) persuasively argue that organizations are social systems conducting experiments. Our thesis is that systematic *gedanken*

Table 10.5 Our prescriptive paradigm satisfies Bacharach's criteria

Criteria	Our prescriptive paradigm
Variables	• Managerially controllable variables • Managerially uncontrollable variables • Social processes • Technical processes
Constructs	• Decision = *f* (controllable variables, uncontrollable variables) • *Gedanken* experiments = set of organized • Orthogonal array is a set organized of orthogonal decisions • Uncertainty regimes = {n-tuple of uncontrollable variables} • Decision alternatives = {m-tuples of controllable variables} • Solution space = {n-tuple uncontrollable variables} × {m-tuples controllable variables} • DMU is sociotechnical system to address decisions
Hypotheses	• Decisions are an intellectual artefacts • Organizations are sociotechnical systems • Decision are specifications for action for sociotechnical systems to execute • Decision enacting organizations are manufacturing production systems • Decisions are designed intellectual artefacts • *Gedanken* experiments = *f* (controllable variables, uncontrollable variables) • Solution space = orthogonal array × uncertainty regimes • Uncertainty space can be represented by a progression of uncertainty regimes • A decision *works* if it is both ready-*for*-work and ready-*to*-work – i.e. the decision specification is functional and it is effective
Propositions	• Robust decisions are designed • Robustness can be predicted and measured • Quality of the manufacturing system is measurable using Gage R&R • Unconstrained exploration of solution space is possible • Unconstrained exploration of uncertainty space is possible • DOE (Design of Experiments) of *gedanken* experiments suffices for predictions – Predict robustness, outcomes, and standard dev. of any decision alternative • Prescriptive paradigm's capability is determined by readiness
Boundary	• Empowered decisive executives • Empowered decisive executives • Span of control—middle, up and down • Complex, messy and wicked problems

experiments for robust executive-decision management is functional and efficacious. Bacharach's (1999) criteria are an important test of rigor.

Another test for rigor are Shepherd and Suddaby's (2016) requirements for a theory and theory building. They assert that a good theory is like a good story. It requires five elements: (i) conflict, (ii) character, (iii) setting, (iv) sequence, and (v) plot and arc. We have all those elements in our executive decision life cycle of five spaces. But they have a long list of criteria under each of those elements that must be satisfied. We select seven of the most important (Table 10.6). A challenge is that the criteria are not orthogonal. Nevertheless, we construct our Table 10.6 structured as follows. Each row identifies a key theory building **element**. Under

Table 10.6 Selected key Shepherd and Suddaby criteria for theory building

Element	Notes
Paradox	**"Conflict of two statements"** . . .**individually make sense "but together are contradictory triggers**. . .**" to theorizing and paradox resolution** • Complex, messy wicked sociotech. systems representation is difficult – We reduce this complexity to using only two kinds of variables – Decisions are a Cartesian product of n-tuples of these two variables • Uncertainty is intractable space a managerially and modeling – We define uncertainty regimes that can span the entire uncertainty space • Outcome goals and uncertainty can be risky, but robustness will produce outcomes that are highly insensitive to uncertainty even when those conditions are not removed
Labeling constructs	**"Identifying and naming a core construct(s) helps to separate the phenomenon of interest from the mass of noise** . . .**"** • Decision = *f* (controllable variables, uncontrollable variables) • *Gedanken* experiments = set of organized • Orthogonal array is a set organized of orthogonal decisions • Uncertainty regimes = {n-tuple of uncontrollable variables} • Decision alternatives = {m-tuples of controllable variables} • Solution space = {n-tuple uncontrollable variables} × {m-tuples controllable variables} • DMU is sociotechnical system to address decisions
Ontology	**"Shifting the way"** . . . **conceptualization to "a new perspective from which to theorize but also requires a corresponding shift in epistomology"** • We reconceptualize . . . – Decisions as specifications for action – Decisions as the output of engineering design of a nonphysical artefact – Decision organizations and their sociotechnical systems as a factory – Decision analysis as *gedanken* experiments using DOE • A paradigm "works" if and only if it is functional and efficacious • We declared our first-principles and epistemic rules (Sect. 10.4.3.2)
Thought experiments	**"Posing problem statements, making conjectures** . . . **trialing conjectures, and selecting and retaining those that show promise** . . .**"** • It is difficult to discern from their description how it differs from thinking, analyzing alternatives and conjecturing. We think that a defining feature of *gedanken* experiments is that physical apparatus is not required • We think of thought experiments as systematic *gedanken* experiments from which epistemic rules and first principles can be applied to gain new and surprising insights. For example, Einstein's elevator *gedanken* experiment, Galileo's *gedanken* experiment • We present a systematic process to construct structured classes of *gedanken* from which robust decisions can be constructed, their outcomes predicted, and the influence of uncertainty on them quantified
Metaphors	**"Analogically connecting and blending concepts** . . . **between domains"** • We adopt the concepts from . . . – Engineering design synthesis concept for physical objects to decisions which are non-physical objects – The ideas of physical experiments to non-physical *gedanken* experiments • Concept that a prescriptive paradigm "works" from the pharmaceutical industry.

(continued)

Table 10.6 (continued)

Element	Notes
	It must be first functional, then it must be verified for efficacy. Concept of readiness from technology management and develop an analogous metrology, measurements, and instruments
Original and useful	**"Reveal something** . . . **we did not know"** • We can design and construct robust decisions, without having to . . . – *Ex ante* represent analytically the decision enacting system *ex ante* decision making – Represent analytically the uncertainty space *ex ante* decision making • We can predict the outcomes and risk over the entire spaces of any potential solutions over the entire space of uncertainty therefore, exploration of solutions over uncertainty is unconstrained • Using DOE with *gedanken* experiments we can predict outcomes and risk over the entire space of uncertainty for any design executive decision • Data collection is massively efficient. Using 243 experiments, in Chap. 9, we cover $1.374{,}389 \times 10^{12}$ possibilities. And we can predict any outcome under any uncertainty regime in this massive space • We can measure the quality of the decision enacting sociotechnical system • We developed a metrology to measure functionality and efficacy
Empirical surprise	**"Reveal data and findings** . . . **not otherwise expected, which requires theorizing for an explanation"** • We find that the predictive power of our methodology is good is supported by the case studies • We find that the sociotechnical system behavior of the organizations are quasi-linear in which the factor interactions are generally small • We find that the case study data supports the view of the decision enacting sociotechnical system is a factory whose quality is measurable • A small number of factors are very effective to model and study very large complex, messy and wicked decision situation under very complex uncertainty conditions

notes, there are two rows**.** The top half is a definition from Shepherd and Suddaby. The bottom half is comprised of bulleted examples from our prescriptive paradigm. We do not attempt to be exhaustively complete with our examples for Table 10.6. Previous sections of this chapter have already addressed many of our key ideas and claims.

10.5.3 Our Paradigm's Core Concepts

Bacharach (1999), Sutton and Staw (1995) and Shepherd and Suddaby (2016) all present demanding criteria that must be met by claims to theory or theory building. The criteria are many and their interrelationships are complex. Applying our first-principle of abstraction, we can distill their criteria to an uncomplicated question:

Can you distill your work to a fundamental idea? We said that Tycho Brahe's work, Kepler's Laws were not theory until Newton's simple idea, but genius concept of universal gravitation expressed by his inverse law was articulated. Similarly all the empirical data, experiments and their false caloric explanations about heat and temperature did not rise to a theory until simple overriding ideas could explain the "why's" of what was observed and measured. The uncomplicated ideas were heat is energy and energy is conserved.

What are the simple, uncomplicated ideas of our prescriptive paradigm? They are:

- Executive decisions can be designed so that they are robust.
- Executive decisions can be designed because they are manmade artefacts. Intellectual artefacts.
- Sociotechnical systems executing executive decisions are production systems like a factory.
- The Sciences of the Artificial serve are the governing principles.
- Sociotechnical rationality serve as the organizing and operating principles.
  QED—quod erat demonstrandum

10.6 Chapter Summary

- Salient ideas of our prescriptive executive-decision paradigm are:
  - Robust executive decisions,
  - Paradigm's grounding on the Sciences of the Artificial,
  - Decisions are manmade intellectual artefacts.
  - Executive-decision management is a life-cycle process of five spaces.
  - Decision enacting sociotechnical organization is a manufacturing production system.
  - Our paradigm is systematically prescriptive.
  - Unconstrained explorability of the entire solution space under any uncertainty regime.
  - Ability to predict outcomes and standard deviations of any designed alternative.
  - Our paradigm works because we can measure its functionality and efficacy. To this end, we developed a metrology and measuring instrument based on the notion of readiness.
- On the question whether our paradigm is a good process to produce good decision:
  - We tested against Howard's criteria and find that it satisfices his criteria.
  - We tested against Carroll and Johnson's criteria and find that it satisfices their criteria.

  - We argue that we have a functional and efficacious paradigm, based on first principles and epistemic rules, for robust executives decisions that satisfice.
  - Epistemic rules are: research rule, falsibility rule, accretion rule, sciences of the artificial rule. Executive decision first-principles are: abstraction, actionability, robustness, unconstrained explorability, Gage R&R for production quality of sociotechnical systems, and a decisive executive.
  - We can say that our prescriptive executive-decision paradigm is useful and helps executives make intelligent robust decisions.

- We have a rigorous paradigm
  - We tested our paradigm against Bacharach's (1999) theory evaluation criteria.
  - We tested our paradigm against Sutton and Staw (1995) criteria of non-theory.
  - We tested our paradigm against Shepherd and Suddaby (2016) tests of theory and theory building.

- The core concepts of our paradigm are:
  - Executive decisions can be designed so that they are robust.
  - Executive decisions can be designed because they are manmade intellectual artefacts.
  - Sociotechnical systems executing executive decisions are production systems, i.e. a factory.
  - The Sciences of the Artificial serve as governing principles.
  - Sociotechnical rationality serve as organizing and operating principles.

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