

INSTRUCTOR'S MANUAL

for

Making Hard Decisions with DecisionTools, 3rd Ed.

Revised 2013

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GENERAL INFORMATION

INTRODUCTION

Making Hard Decisions with DecisionTools, 3rd Edition presents the basic techniques of modern decision analysis. The emphasis of the text is on the development of models to represent decision situations and the use of probability and utility theory to represent uncertainties and preferences, respectively, in those models. This is a new edition of the text. New examples and problems have been added throughout the text and some chapters have either been completely rewritten (Chapters 5 & 11) or are entirely new (Chapters 6 & 13). In addition, we have added 15 cases from Darden Business Publishing. The Darden cases are grouped together at the end of each of the three sections.

The first section of the book deals with structuring decision models. This part of the process is undoubtedly the most critical. It is in the structuring phase that one comes to terms with the decision situation, clarifies one's objectives in the context of that situation, and confronts questions regarding the problem's essential elements. One must decide exactly what aspects of a problem are to be included in a model and make fundamental modeling choices regarding how to represent each facet. Discussions with decision analysts confirm that in most real-world applications, the majority of the time is spent in structuring the problem, and this is where most of the important insights are found and creative new alternatives invented. The discussion of model structuring integrates notions of tradeoffs and multiple objectives, something new to the second edition of the book. Although complete discussion of modeling and analysis techniques are put off until later, students should have enough information so that they can analyze simple multiattribute models after finishing Chapter 4. This early introduction to this material has proven to be an excellent motivator for students. Give them an interesting problem, ask them to discuss the objectives and tradeoffs, and you will have trouble getting them to be quiet!

Making Hard Decisions with DecisionTools provides a one-semester introduction to the tools and concepts of decision analysis. The text can be reasonably well adapted to different curricula; additional material (readings, cases, problems from other sources) can be included easily at many different points. For example, Chapters 8 and 15 discuss judgmental aspects of probability assessment and decision making, and an instructor can introduce more behavioral material at these points. Likewise, Chapter 16 delves into the additive utility function for decision making. Some instructors may wish to present goal programming or the analytic hierarchy process here.

The Darden cases are grouped at the end of each of the 3 sections. Instead of tying each case to a particular chapter, a group of cases are associated with a group of chapters. The goal is to show that the various concepts and tools covered throughout the section can be applied to the cases for that section. For example, to solve the cases at the end of Section One, Modeling Decisions, students will need to understand the objectives of the decision maker (Chapter 2), structure and solve the decision model (Chapters 3 and 4), perform a sensitivity analysis (Chapter 5), and, perhaps, incorporate organizational decision making concepts (Chapter 6). Instructors can either assign a case analysis after covering a set of chapters asking the students to incorporate all the relevant material or can assign a case after each chapter highlighting that chapter's material. Students need to understand that a complete and insightful analysis is based on investigating the case using more than one or two concepts.

Incorporating Keeney's (1992) value-focused thinking was challenging because some colleagues preferred to have all of the multiple-objective material put in the same place (Chapters 15 and 16), whereas others preferred to integrate the material throughout the text. Ultimately the latter was chosen especially stressing the role of values in structuring decision models. In particular, students must read about structuring values at the beginning of Chapter 3 before going on to structuring influence diagrams or decision trees. The reason is simply that it makes sense to understand what one wants before trying to structure the decision.

In order for an instructor to locate problems on specific topics or concepts without having to read through all the problems, a topical cross-reference for the problems is included in each chapter and a topical index for all of the problems and case studies is provided at the end of the manual.

INFLUENCE DIAGRAMS

The most important innovation in the first edition of *Making Hard Decisions* was the integration of influence diagrams throughout the book. Indeed, in Chapter 3 influence diagrams are presented before decision trees as structuring tools. The presentation and use of influence diagrams reflects their current position in the decision-analysis toolkit. They appear to be most useful for (1) structuring problems and (2) presenting overviews to an audience with little technical background. In certain situations, influence diagrams can be used to great advantage. For example, understanding value-of-information analysis is a breeze with influence diagrams, but tortuous with decision trees. On the other hand, decision trees still provide the best medium for understanding many basic decision-analysis concepts, such as risk-return trade-offs or subjective probability assessment.

Some instructors may want to read more about influence diagrams prior to teaching a course using *Making Hard Decisions with DecisionTools*. The basic reference is Howard and Matheson (1981, reprinted in). This first paper offers a very general overview, but relatively little in the way of nitty-gritty, hands-on help. Aside from Chapters 3 and 4 of *Making Hard Decisions with DecisionTools*, introductory discussions of influence diagrams can be found in Oliver and Smith (1990) and McGovern, Samson, and Wirth (1993). In the field of artificial intelligence, *belief nets* (which can be thought of as influence diagrams that contain only uncertainty nodes) are used to represent probabilistic knowledge structures. For introductions to belief nets, consult Morawski (1989a, b) as well as articles in Oliver and Smith (1990). Matzkevich and Abramson (1995) provides an excellent recent review of network models, including influence diagrams and belief nets.

The conference on *Uncertainty in Artificial Intelligence* has been held annually since 1985, and the conference always publishes a book of proceedings. For individuals who wish to survey the field broadly, these volumes provide up-to-date information on the representation and use of network models.

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DECISION ANALYSIS SOFTWARE

Making Hard Decisions with DecisionTools integrates Palisade Corporation's DecisionTools, version 6.0 throughout the text. DecisionTools consists of six programs (PrecisionTree, TopRank, @RISK, StatTools, NeuralTools, and Evolver), each designed to help with different aspects of modeling and solving decision problems. Instructions are given on how to use PrecisionTree and @RISK, typically, at the end of the chapter. PrecisionTree is a versatile program that allows the user to construct and solve both decision trees and influence diagrams. @RISK allows the user to insert probability distributions into a spreadsheet and run a Monte Carlo simulation. Each of these programs are Excel add-ons, which means that they run within Excel by adding their ribbon of commands to Excel's toolbar.

In the textbook, instructions have been included at the ends of appropriate chapters for using the programs that correspond to the chapter topic. The instructions provide step-by-step guides through the important features of the programs. They have been written to be a self-contained tutorial. Some supplemental information is contained in this manual especially related to the implementation of specific problem solutions.

Some general guidelines:

- To run an add-in within Excel, it is necessary to have the “Ignore other applications” option turned off. Choose *Tools* on the menu bar, then *Options*, and click on the *General* tab in the resulting *Options* dialog box. Be sure that the box by *Ignore other applications* is not checked.
- Macros in the add-in program become disabled automatically if the security level is set to High. To change the security level to Medium, in the *Tools* menu, point to *Macros* and then click *Security*.
- When the program crashes, restart the computer. It may appear as if the program has closed properly and can be reopened, but it probably has not, and it is best to restart the computer.
- The student version of PrecisionTree may limit the tree to 50 nodes. Some of the problems that examine the value of information in Chapter 12 can easily exceed this limit.
- When running @RISK simulations in the student version, make sure that only one worksheet is open at a time. Otherwise, the program will display that error message “Model Extends Beyond Allowed Region of Worksheet.”

More tips are provided throughout this manual as they relate to implementing specific problem solutions.

JOIN THE DECISION ANALYSIS SOCIETY OF INFORMS

Instructors and students both are encouraged to join the Decision Analysis Society of INFORMS (Institute for Operations Research and Management Science). This organization provides a wide array of services for decision analysts, including a newsletter, Internet list server, a site on the World Wide Web (<https://www.informs.org/Community/DAS>), annual meetings, and information on job openings and candidates for decision-analysis positions. For information on how to join, visit the web site.

CHAPTER 1

Introduction to Decision Analysis

Notes

This chapter serves as an introduction to the book and the course. It sets the tone and presents the basic approach that will be used. The ideas of subjective judgment and modeling are stressed. Also, we mention some basic aspects of decisions: uncertainty, preferences, decision structure, and sensitivity analysis.

In teaching decision analysis courses, it is critical to distinguish at the outset between good decisions and good outcomes. Improving decisions mostly means improving the decision-making process. Students should make decisions with their eyes open, having carefully considered the important issues at hand. This is not to say that a good decision analysis foresees every possible outcome; indeed, many possible outcomes are so unlikely that they may have no bearing whatsoever on the decision to be made. Often it is helpful to imagine yourself in the future, looking back at your decision now. Will you be able to say, regardless of the outcome: “Given everything I knew at the time — and I did a pretty good job of digging out the important issues — I made the appropriate decision. If I were put back in the same situation, I would go through the process pretty much in the same way and would probably make the same decision.” If your decision making lets you say this, then you are making good decisions. The issue is not whether you can foresee some unusual outcome that really is unforeseen, even by the experts. The issue is whether you carefully consider the aspects of the decision that are important and meaningful to you.

Chapter 1 emphasizes a modeling approach and the idea of a requisite model. If the notion of a requisite model seems a bit slippery, useful references are the articles by Phillips. (Specific references can be found in *Making Hard Decisions with DecisionTools*.) The concept is simple: A decision model is requisite if it incorporates all of the essential elements of the decision situation. The cyclical process of modeling, solution, sensitivity analysis, and then modeling again, provides the mechanism for identifying areas that require more elaboration in the model and portions where no more modeling is needed (or even where certain aspects can be ignored altogether). After going through the decision analysis cycle a few times, the model should provide a reasonable representation of the situation and should provide insight regarding the situation and available options. Note that the process, being a human one, is not guaranteed to converge in any technical sense. Convergence to a requisite model must arise from 1) technical modeling expertise on the part of the analyst, and 2) desire on the part of the decision maker to avoid the cognitive dissonance associated with an incomplete or inappropriate model.

Also important is that the modeling approach presented throughout the book emphasizes value-focused thinking (Keeney, 1992), especially the notion that values should be considered at the earliest phases of the decision-making process. This concept is initially introduced on pages 5-6.

To show that that decision analysis really is used very broadly, we have included the section “Where is Decision Analysis Used?” Two references are given. The *Harvard Business Review* article by Ulvila and Brown is particularly useful for students to read any time during the course to get a feel for real-world applications of decision analysis.

Finally, we have included the section “Where Does the Software Fit In?” to introduce the DecisionTools suite of programs.

Topical cross-reference for problems

| | |
|----------------------|---------------------------------------|
| Constructionist view | 1.12, Du Pont and Chlorofluorocarbons |
| Creativity | 1.8 |
| Rice football | 1.7 |
| Requisite models | 1.2 |
| Subjective judgments | 1.3, 1.5 |

Solutions

1.1. Answers will be based on personal experience. It is important here to be sure the distinction is made between good decisions on one hand (or a good decision-making process) and lucky outcomes on the other.

1.2. We will have models to represent the decision structure as well as uncertainty and preferences. The whole point of using models is to create simplifications of the real world in such a way that analysis of the model yields insight regarding the real-world situation. A requisite model is one that includes all essential elements of the problem. Alternatively, a requisite model is one which, when subjected to sensitivity analysis, yields no new intuitions. Not only are all essential elements included, but also all extraneous elements are excluded.

1.3. Subjective judgments will play large roles in the modeling of uncertainty and preferences. Essentially we will build representations of personal beliefs (probabilities) and preferences (utilities). In a more subtle — and perhaps more important — way, subjective judgments also direct the modeling process. Subjective judgments are necessary for determining the appropriateness of a model's structure, what should be included in the model, and so on. Thus, subjective judgments play central roles in decision analysis. Good decision analysis cannot be done without subjective judgments.

1.4. An appropriate answer would be that decision analysis can improve your decisions — the way you make decisions — by providing a framework for dealing with difficult decisions in a systematic way. Along with the analytical framework, decision analysis provides a set of tools for constructing and analyzing decision models, the purpose of which is to obtain insight regarding difficult decision problems.

1.5. You require her subjective judgments on a number of matters. First is the problem of identifying important aspects of the problem. Her input also will be required for the development of models of her uncertainty and her preferences. Thus, her judgments will be critical to the analysis.

This question may also lead students to consider the implications of delegating decisions to agents. How can you ensure that the agent will see things the way you do? Will the same aspects of the problem be important? Does the agent agree with you regarding the uncertainty inherent in the situation (which outcomes are more or less likely)? Does the agent have the same feeling regarding trade-offs that must be made? In many cases it may be appropriate to obtain and use an expert's information. Can you identify some specific decision situations where you would be willing to accept an agent's recommendation? Does it matter who the agent is? Can you identify other situations in which some of the agent's input can be taken at face value (a forecast, say), but must be incorporated into a model based primarily on your own judgments?

1.6. Answers will be based on personal experience.

1.7. Some of the issues are 1) the monetary costs of staying in Division 1-A and of moving to Division III, 2) impact on both alumni and local businesses of moving to Division III, 3) political and social impact on campus of changing divisions.

Alternatives include 1) stay in Division 1-A, 2) move to Division III, 3) move to Division II, 4) delay the decision for a year or more to gather information, 5) investigate other sources of funding to cover the deficit, 6) drop out from the NCAA altogether ...

There is considerable uncertainty around the impact on the school of switching divisions. What will the fallout be from the faculty, students, alumni, and local businesses if Rice went to Division III? Will it impact recruiting? If so, how? What are the financial consequences? Is the deficit due to mismanagement or is it structural? What are the long-term consequences versus the immediate uproar? Sources of information could be surveys given to each constituency and/or interviews with leaders of the constituencies. Perhaps other schools have changed divisions, and information can be found from their experience.

The objectives that different groups want to work toward include 1) minimize short-term and long-term deficit, 2) minimize social upheaval, 3) maximize enjoyment of collegiate sports, 4) maximize student

opportunity to participate in sports, 5) maximize quality of sports programs. Some students may identify still other objectives. Trading off these objectives may mean trying to balance the issues that are important to different constituent groups.

1.8. This is a creativity question. The Friends of Rice Athletics could fund raise, tuition and/or ticket prices could be increased, the stadium's name can be sold, the athletic staff could all take a pay cut, etc.

1.9. Answers will be based on personal experience.

1.10. Instead of thinking only about risk versus return, the socially responsible investor also must consider how to trade off risk and return for ethical integrity. It would not be unreasonable to suspect that to obtain a higher level of ethical integrity in the portfolio, the investor must accept a lower expected return, higher level of risk, or both.

1.11. For the most part, decision analysis is most appropriate for strategic, or one-time, decisions. These are situations that we have not thought about before and "don't know what to do." Hence, it is worthwhile to engage in some "decision making," or decision analysis, to figure out what would be an appropriate action.

This is not to say that decision analysis is inappropriate for repetitive decisions. In fact, if a decision is repeated many times, the savings that can be achieved over time by improving the decision-making process can be substantial. In fact, this is the basis of much of management science. However, the reliance on subjective judgments for the construction of tailored decision models in each decision situation may render decision analysis, as portrayed here, unsuitable for dealing with repetitive situations. The point, though, is that if one anticipates a long string of repetitive decisions in the future, and an optimal decision strategy has not been previously developed, then the situation is indeed one of "not knowing what to do." A decision-modeling approach would indeed be appropriate in that case.

1.12. Beliefs and values do appear to change and develop over time as we think about new issues. Decision analysis implicitly provides a framework for such changes through the identification and modeling of decision problems, beliefs regarding uncertainty, and preferences.

Case Study: Commercial Space Travel

A student's answer to being an early adopter or waiting until the industry matures is a personal choice and depends on many factors. Some of these are: track record of industry, affordability, health of student vis-à-vis demands of space travel, interest level, etc.

It certainly is true that new firms can come along and change an industry with leaner production or management systems. Often, these firms do not have to contend with the legacy of older systems in more established firms. In addition, the savings of a younger workforce and less established pension program can be quite significant. Thus, it is reasonable that the new furry animals can be competitive with a massive governmental organization.

On the other hand, the lack of experience of extreme situations might turn into a disaster for a newly established firm. The cost savings of the newer firms could come from more efficient operations or it could come from not having the equipment and policies in place to handle unusual situations. A space-flight disaster would make headlines across the world and probably doom the responsible for-profit company. To continue the survival-of-the-fittest analogy, it is not that every for-profit company will survive by avoiding life-threatening situations; it is that a subgroup will survive. Would you want to put your life or the life of a loved one on the line given the uncertainties surrounding early adopters in space travel?

Case Study: Du Pont and Chlorofluorocarbons

The major issues include shareholder welfare, social and environmental responsibility, and ethics. Of course, all of these might be thought of as means for ensuring the long-run profitability or survivability of the firm. The major sources of uncertainty involve research and development. Will substitute products work? Will they be accepted? The CEO might wonder whether the ozone problem really is a problem, or

whether the observed recent changes are part of a normal cycle. Finally, could Du Pont's efforts really have an effect, and how much?

It is undoubtedly the case that Du Pont's views of the situation have changed over time. Early on, the chlorofluorocarbon issue was essentially ignored; no one knew that a problem existed. In the 1970s and 1980s, it became apparent that a problem did exist, and as scientific evidence accumulated, the problem appeared to become more serious. Finally, we have arrived at a position where the ozone issue clearly matters. (In fact, it matters mostly because of consumers' views and preferences rather than because of the scientific evidence, which appears to be less than conclusive.) Du Pont appears to be asking "Can we do anything to help?" Many companies have developed a kind of "social awareness" in the past two decades as a way to maintain a high-integrity profile.

Case Study: Choosing a Vice-Presidential Candidate

A vice president tends not to have an important role in American politics except in gaining electoral votes during the election. A running mate is often chosen to balance the ticket geographically and ideologically. For example, choosing a conservative, women from Alaska helped McCain appeal to the conservative base of the Republican Party and to women. Alaska, however, has the minimum number of possible electoral votes at 3. While McCain could reasonably count on winning Alaska's 3 electoral votes, he could have chosen someone else from a more populous state for the electoral votes. McCain must have thought that Ms. Palin would provide a ticket with a wide appeal and that she could help pick up votes across the whole country.

It is hard to know how McCain's health affected his choice of Ms. Palin. Clearly, he knew how he felt, and given that he is still in office eight years later, it is reasonable to assume that his health was not a major concern when choosing Ms. Palin. A portion of the population, however, did find his age coupled with her inexperience troubling. If he personally was not concerned, he might at least have considered how the voters would perceive Ms. Palin being one heartbeat away from the presidency of the U.S.A.

The president is constantly gathering information, from the daily threat-assessment reports to meetings with his cabinet, congressional members, and world leaders. However, even with all of these intelligence reports, much uncertainty still remains, often requiring the president to make a judgment call. One of the more famous examples of this is President Obama's decision to send U.S. forces into Pakistan after Osama bin Laden. Although it was thought that bin Laden was hiding inside a residence, there was not definitive proof. Moreover, Obama also had to make judgment calls concerning the size of the force to send in and whether to alert Pakistani officials. Generally, the president's decisions are based (hopefully) on both facts and judgments. McCain's choice of Sarah Palin led many voters to question his judgment.

Choosing Sarah Palin might have turned out to be a very good choice for the United States, but it certainly had many political overtones. In all fairness, the choice of a vice-presidential running mate is a very political decision, one specially aimed at winning the election – a political event. On the other hand, appearances are of utmost importance in elections, and even an unsubstantiated rumor can completely derail a candidate. Thus, in choosing his running mate, McCain probably should have weighed the pros and cons of each candidate using his fundamental objectives, the fundamental objectives of his party, and, of course, the fundamental objectives of the United States as a whole.