Management Science

A Practical Approach to DECISION MAKING

Robert A. Dunn

Kenneth D. Ramsing

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preface

When writing a textbook on management science, the authors must determine the style to be used and where on the spectrum from pure theory to pure application to set their focus. In developing this book, we have placed our emphasis on the application of business quantitative methods while maintaining a solid theoretical base for each of the subject areas. This has been made possible through our combined academic, consulting, and managerial experience, which reflects the emphasis of solid application within this volume. It has been our attempt through the material that follows to continue a favorable trend of "bridging the gap" between practitioners and theorists.

A successful manager performs with a set of his or her own theories. Successful business decisions are more likely as the decision maker gains in experience and theoretical background. It is thus necessary that application be founded and operate on a theoretical base. It is the combined objective of the theorist and the practitioner to whom we have addressed this book.

The structure of this book consists of three distinct types of chapters: introductory, technique, and expository. The introduction chapters are descriptive in nature, introducing the reader to the concepts of decision science, operations research, and management science.

The technique chapters follow a common flow which we believe is vital to a good understanding of the decision science field and the techniques practiced therein. The common format of each technique chapter is to introduce the problem by a case in which the situation and data are developed. Although simplified, each case is a condensation of a real business situation (most of which have been drawn from the authors' personal experiences in the forest products industries). These cases are followed by a problem formulation section. It is of paramount importance that the reader recognize that problem formulation is the key to scientific management. We therefore urge you, the reader, to put forth considerable effort to understand the details of the problem formulation section of each technique chapter.

The balance of each of these chapters is devoted to an introduction, technique discussion, solution, and expansion and analysis of each management science topic. We have attempted to draw attention to the logic, limitations, and applications of each technique discussed in this book.

The concluding chapters discuss the managerial aspects of decision sciences;

one chapter is devoted to the art of selecting a technique, while another examines the questions of model implementation. Although selecting a technique is a critical question, in reality, many techniques may appropriately fit a common situation, albeit some are more appropriate than others. However, the final assessment of the manager's success is *implementing* a technique and *using* it to make profitable decisions. It is to this end that we have written the concluding chapters of this volume.

Management Science is targeted for several audiences. It is primarily designed for a one-year undergraduate or a one-semester graduate course in operations research, management science, or quantitative methods for business. However, the material can also be used by managers as a "brush-up" or as a reference volume on management science.

This project was initiated when both authors felt a need for a good, realistic text with sound theory directed toward a greater degree of application and problems of management science. We both feel that the key to improving productivity lies in the managerial efficiency of our private and public organizations. If we have inspired a manager or potential manager to reach greater heights of professionalism, then our efforts and the sacrifices of our families will have been meaningful and of value.

ROBERT A. DUNN
Longview, Washington

KENNETH D. RAMSING
Eugene, Oregon

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chapter 1

Prologue

Introduction

Hello, and welcome to Dramun Forests, Inc., a diversified firm owning several different types of small subsidiaries. During the course of reading this book, you will be introduced to a broad spectrum of problems that an organization may encounter that can be solved using quantitative techniques. From this exposure, you should be able to assess a very wide selection of problem situations and determine which technique or techniques best fit and how you can go about implementing them.

Throughout the next few chapters, you must be constantly aware of the problem that you are facing, the management decision that must be made, the assumptions of the technique that is presented to you, and the limitations of that technique, and, finally, you should be challenged to decide on your own which techniques are most appropriate. The material presented will not be easy, but you should have a rewarding experience if you persevere in learning the basic concepts of the techniques involved.

You will immediately notice the form or pattern for this text. We have set out to create for the reader a problem setting to be carried throughout the book by using a number of problem situations from a firm called Dramun Forest Products. Dramun is a fictitious firm, but its structure is based on a consolidation of several firms that actually exist. We have selected this setting because it illustrates a number of events that can be often resolved by using management science techniques.

Through the process used in this book, we shall look at a number of operations of this firm, from scheduling activities, setting inventory levels, and pricing to accounting functions and then to decisions pertaining to marketing and corporate planning. You should be able to associate the problems that you encounter in this text to other types of organizations and problems in the

"real world." For this reason, each chapter begins with a case setting from which a problem will evolve. After setting forth the problem elements or key issues, we then move on to the solution by developing a technique or model that leads systematically to that solution.

Dramun Forests, Inc. has been a highly successful firm for many years. Within the last decade the company has become a small conglomerate involved in all phases of winter recreation, sports equipment manufacture, and forest products. The firm even owns several ski resorts along with retail outlets through which it sells skis, toboggans, winter clothing, and other recreational sports equipment. Several problems seem to be mounting rapidly, as its rapid growth has caused some significant operational and strategic problems that must be resolved in the near future. For instance, in the firm's lumber and plywood manufacturing operation, it has begun to experience greater difficulty in developing the best product mix given limited materials and labor. For this problem, we will want to see how to assist the production manager by establishing a model to help allocate manufacturing capacity and materials to create the greatest profit. Another problem faced by the firm has to do with the direction that management intends to take in its pricing stategies for skis. For instance, is it strictly advisable to maintain a constant price or to change the price from year to year? Yet another problem resolves around a company-owned resort that must install new fire protection capabilities but is severely limited by its time frame. What can be done to meet the time requirements?

These are but a few of the problems with which we will deal. Each problem cannot necessarily be solved by using management science techniques, but, by using these techniques, we should be able to generate a greater amount of better information for use by management. By this process we will be able to give managers a better plan both for their day-to-day and for their strategic operations.

Management Science

In the preceding section we outlined several different problems and problem settings. The details of problems are set forth in scenarios in the subsequent chapters. However, if you are going to read a book about the use of management science, perhaps you may want to know what *management science* is.

A great deal of confusion exists among the fields of operations research, management science, and decision sciences. From a pragmatist's point of view, these terms are somewhat synonymous. From a purist's point of view, there are subtle differences among these terms. We have selected the term management science as it tends to best reflect our philosophy of quantitative techniques. Management science is an interdisciplinary approach to problem solving. Specifically, we view the quantitative aspects of problem situations and

apply scientific methods to the resolution of those quantitative problem systems.

Management science techniques are used to generate information to aid in decision making. They help to specify problem situations, but the use of such techniques also allows us to specify the variables that appear to be important to the decision situation. It requires us to formally structure our problem so that we can better visualize the factors affecting that decision and, hence, the decision to be made.

Management science techniques may be heralded as the incredible futuristic age of management decisions, or they may become a manager's nightmare. Management science is not a panacea in itself, it is merely an aid to decision making; thus, into the recommendations generated by the models, we caution you to put only the weights as are appropriate. A common fallacy existing today is the belief by some that the techniques will consistently generate the right answer when the right answer is actually a function of the manager's decision style, management style and preferences, and even the ability to identify the problem correctly.

Structure of the Text

Chapter 2 of this text introduces the concept of the model triad, setting the stage for the sequence of MODELING—MODIFYING—and APPLYING for each problem encountered in the book. Thus, Chapter 2 is important because it sets forth the elements of most common problem situations by looking to see what a problem is and then by working through steps to the point at which a solution and, finally, the analysis for decision making takes place. For this reason, we must begin by looking at what is meant by a model, as this is something with which we will be dealing quite frequently in this book. Once this is done, we can begin to better understand the need for and the value of modifying the model to answer questions posed by analysts and management. From there it is a natural response to apply the model for the purposes of problem solution.

The next 12 chapters in this book use a common format in developing the problem and in carrying out the model development. Basically, this format is

Introduction
The Case
The Problem Elements
The Technique
Developing the Model
Solution to the Case

When reading these chapters it will be helpful for you to read the case first. Then, before going further, try to make a brief statement of the problem and identify what variables must be used. At this point, you should be ready to

read and assess the problem element section. This approach to reading each of the 18 chapters should make it easier to understand and learn the material.

Chapters 3, 4, and 5 are comprised of a very important quantitative technique called linear programming. This procedure will give an optimal solution so long as a solution is feasible. It is a popular approach to solving problems in which there are limited resources and constraints—both upper and lower.

Chapter 3 is introductory to the next two chapters. It is limited to an explanation of linear programming concepts and a graphical solution. Chapter 4 builds on the prior material and then extends linear programming to handle an unlimited number of constraints. Chapter 5 permits us to use linear programming as a means of answering such questions as, "What if I change capacity by 10 percent?" or "What happens when prices go up by $2.00?"

Chapter 6, on transportation and transshipment problems, deals with a specific form of linear programming problem. Although such problems can be solved with linear programming, simpler solution techniques are presented here.

Linear programming (with the simplex method) does not guarantee that the solution to a problem will be integer. Sometimes a manager is so constrained that answers with fractional values will not suffice. When this happens, he or she must use integer programming. This is discussed in Chapter 7. Also, Chapter 7 contains a discussion of goal programming, another form of linear programming that permits us to solve problems with several, even conflicting, goals or objectives.

Sometimes we must develop solutions to problems in which a decision in one time period impinges on the approach taken in the next time period. A multiperiod solution technique that we will investigate in Chapter 8 is called *dynamic* programming.

We all know that inventories of goods are held in stock for future needs. But what is the most economical or optimal level to maintain? This is the topic of Chapter 9, Inventory Analysis.

Although this text deals with the broad topic of decision analysis, two chapters deal specifically with this area. In the case of Chapters 10 and 11 we look at the likelihood of occurrence of several things. The analysis is statistical and uses concepts of probabilities.

The discussion of waiting-line models, in Chapter 12, deals with the lines of people (or things) that form at the counter of a service center. For example, you have probably entered a supermarket when there were only a few people at the checkout stations, yet, by the time that you had gathered together the various items you wished to purchase, the checkout line had become quite long. This buildup and depletion of lines in waiting is the topic of this chapter. The material covered gives us considerable insight into average waiting time, line lengths, and utilizations under varying conditions.

Many conditions, including waiting-line problems, are very difficult to solve

using analytical techniques. Sometimes these can be solved best by using an approach called simulation. Simulation is the method by which a "look-alike" model is constructed to perform like the "real world" it represents. Then, we can change conditions in the simulation model to perform as if these conditions were changed in the real world. Chapter 13 discusses the elements of simulation.

Planning a project requires that an analyst know the interdependencies of many different activities or tasks. Yet, just the knowledge of the interrelationships is not enough for planning and control. Another pair of techniques that lend considerable planning and control value are PERT (program evaluation and review technique) and CPM (critical path method). These, together with a progress-evaluating concept called line of balance, are the topics of Chapter 14.

Not all techniques of decision analysis are treated in individual chapters. Yet, some of these must be included, if only briefly. Two concepts, game theory and markov processes, have been incorporated in Chapter 15, Potpourri.

Perhaps two of the most important chapters of this text are 16 and 17. After learning about the concepts, theory, and use of a number of quantitative techniques, we frequently become confused about what to do with them. Chapter 16 is designed to bring together each of the techniques with the specific focus of their selection for problem solving. The next step, that discussed in Chapter 17, is to look at implementation of the models. This important chapter is included because success is not registered by merely solving a problem to get answers but by its subsequent implementation. Some guidelines for this purpose are presented in Chapter 17.

Chapter 18 presents some speculation as to what the future may hold, given the current usage of these techniques of decision analysis. We hope that it will promote some thought about the future of problem solving.

We have written this book with you, the reader, in mind. By using short cases, we have tried to introduce you to the topic and to make the chapters interesting. The material may be difficult at times, but we hope that with some perseverance you will learn and understand even the most difficult material in the book.

chapter 2

The Model Triad

Glossary

Model. An abstract representation of reality.
Exogenous variables. Independent or input variables.
Parameter. An assignable quantity or constant.
Endogenous variable. Dependent or output variable.
Feedback loops. Information from an output variable being sent back to the model to adjust or modify future conditions.
Sensitivity analysis. The effect of a change in the output for a given change in the input.

Introduction

There are a number of ways in which a book on decision analysis can be written to convey methods of solution to the reader. Yet one of the important concepts is the process of decision analysis that will lead to the solution of the problem and its subsequent implementation in the organization. This book uses a modeling triad concept throughout its chapters as an approach to giving the reader a better understanding of the methods of problem solution and the resulting potential for decisions from these results.

The modeling triad follows a sequence of MODELING—MODIFYING—and APPLYING. Although it will be explained in greater detail later in this chapter, the model is an abstract representation of reality. In most cases the model will be used as a means of solving the problems that confront managers or decision makers. The level of model abstraction depends on many factors ranging from the problem itself to the method by which it is solved.

Often the decision maker is interested in asking "What if . . ." types of questions. For example, a decision maker may be interested in understanding

the effect of a change in the cost of keeping inventory as a result of alternative insurance policies. In this situation, he or she may ask, "What happens if the insurance cost for maintaining an inventory of this particular good increases by 10, or 12, or 15 percent?" The model being used may consist of a simple arithmetic problem that can be easily solved with a calculator. The model can be changed to include the proposed insurance rate change of the first 10 percent, then 12 percent, and finally 15 percent. Even if the actual insurance rate change for the inventory is 13 percent (or another value that was not actually used in the model), the decision maker should have a much better knowledge of the effect than he or she did before the effort to model and modify was made.

Once the model and modifying process has taken place, it is the responsibility of the decision maker to use and apply the results. This may actually take the form of no action at all; or it may be that the action taken is to negotiate further with other insurance companies or to merely take what has been given. At any rate, the decision maker is usually in a better position to apply the results of a solution once the modeling has taken place, and the modification process has been used so that a better understanding of the relationship of variables becomes more evident.

The process in this book uses different scenerios of a larger case. Each chapter consists of a scenario that includes a problem or its symptoms, some personalities including that of the decision maker, and a setting. It is the intent of this case approach to encourage you, the reader, to involve yourself in the problem situation and to follow through the "model triad" as a means of learning new and different techniques for problem solution. The case will be "followed" throughout the chapters from the beginning elements to the final solution and application. To understand the concept of the model triad in more depth, it will be important to develop some of the elements common to a problem situation. This will be done in the next section of this chapter.

Elements Common to a Problem Situation

It may be helpful to begin to look at the problem situation to better approach the following chapters. Several topics will be discussed that should help you with the framework being used in this book.

What Is a Problem?

The case situations at the beginning of each chapter will present a problem or the symptoms from a problem. It is sometimes difficult in real life to differentiate between the symptom and the problem. For example, something that we have all experienced is the cough. Normally, we assume that this is a symptom of the common cold. However, there are times when a cough may be symptomatic of an ailment considerably more serious that that of the