NORMATIVE
DECISION
MAKING

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FOREWORD

This volume is aimed at providing a clear and concise introduction to modern ways of conceptualizing the decision-making process— ways that have provided powerful analytic tools for the complex decision-making tasks of today's managers and organizations. Detailed treatments of the new decision-making techniques are available in several textbooks, but the student who is introduced to these ideas for the first time, and especially the student who does not intend to become a specialist in operations research, wants initially an overview of basic concepts and ideas. It is such an overview that Professor Kassouf provides in this volume.

The volume was designed to be usable as the text in that section of an introductory course on foundations of management or administration devoted to decision making, and it was developed within the limits of size and technical level appropriate to that use. In time, we hope that it will be incorporated in a series treating in a similar manner a whole range of basic management concepts—a series that can serve as the text material for a full semester course on foundations of administration. Since Professor Kassouf's manuscript provides an exceptionally clear and useful introduction to normative theories of decision making, usable as an independent unit in a variety of contexts, we have thought that it should be made available to teachers and students as promptly as possible, and without waiting for other units of the prospective series.

The interest and practical importance of normative decision theory is not limited to management situations where we can actually employ formal techniques like linear programming or Bayesian decision theory. Even in areas where we will continue, for a long time, to make our decisions in less formal and more qualitative fashion, the *ideas* underlying the formal theory—ideas of utility, constraints, probability, and so on—will be of great value in helping us to think clearly about complex problems. Formal decision theory is the logical foundation for a set of powerful mathematical techniques; but it is also a mode of thought—a point of view—that can illuminate many situations where we may not see our way to the literal application of formal techniques.

Decision theory today continues to develop vigorously and rapidly. New approaches—for example, so-called "heuristic" methods—are attracting much attention and study. In this volume, Professor Kassouf has not undertaken to depict this changing scene in detail, but rather to focus on fundamental ideas that will remain central to an understanding of the decision-making process, whatever path new developments may take. The student whose interest in decision making is sparked by studying this introduction will find no dearth of new roads to explore and new worlds to conquer.

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CHAPTER ONE

As free men we are forced to link desires with capabilities. We may do this impulsively or unconsciously but, willy-nilly, decisions must be made. How *should* an individual or group decide between alternative courses of action? This question will be explored in this book.

How decisions *should* be made, as opposed to how decisions *are* made, involves *normative* analysis. A few decades ago many social scientists became disenchanted with normative theories because they seemed "unscientific." For example, when an economist ad-

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vises that a tariff should be imposed on automobiles, he is expressing a value judgment that discriminates against consumers in favor of the auto industry. But the economist has no expertise in forming value judgments—his competence as an *economist* does not make his preferences superior to a layman's. And so it was said that normative, or prescriptive theories should be abandoned by social scientists because values are not subject to scientific analysis.

If a normative theory specifies values or goals, then there may be no "experts." If, however, goals, values, or desires are *given*, then decision makers may usefully exploit "experts" who can instruct them how they *should* behave. This will be our starting point: we assume that the decision maker starts with explicit values or goals and that he is to decide how to make the best choice among available alternatives. This assumption eliminates much of the vitality of human behavior, because desires are almost never "given" and are seldom clear. The "value [of intellect] to any man lies in the speed and strength with which it can help him to clarify his desire and to act or build according to its dictates." [1]

Some believe that institutional forces twist and distort an individual's preferences so that he no longer knows what is "good." John Kenneth Galbraith, in *The Affluent Society*, argues that advertising in our society tends to lead people away from their self-interest, implying that some of us are better judges than others concerning goals and desires—a proposition readily acceptable by most when considering adults versus children or the mentally incompetent. But this dangerous proposition has too often led to rule by elites who eventually abused their power. In this book we sidestep this issue; we pretend that the decision maker knows what is "best."

Even if we assume that desires are given, we shall have to justify the statement: You *should* do this to achieve your goal. The justification sometimes takes the form that a "rational" person would do this or that. This leads to the question: What do we

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[1] Jacques Barzun, *The House of Intellect* (New York: Harper & Row, Publishers, 1959), p. 169.

mean by "rational"? We shall show that if preferences are given and if a few assumptions (or axioms) are valid for a decision maker, then logical consequences will dictate his behavior if he does not wish to act illogically. We will call this behavior *rational*.

By a *normative theory* we mean a theory that prescribes how decisions should be made, given goals and values. By *rational behavior* we mean behavior that is logically consistent. Thus, to say that goals cannot be established scientifically, or that the theories are "value free" are not valid objections to the theories we present.

We begin in the simplest of all worlds—the never-never land of complete certainty, where each decision maker knows precisely the consequence attached to every course of action available to him. We then move to situations that are best evident in the casino; each consequence cannot be known in advance, but we can place definite probabilities on the possible consequences. Moving still closer to the real world, we next consider decision situations in which either the probabilities associated with the outcomes are a matter of individual judgment, or no judgment at all can be made about them. Along the way we consider a specific application of decision making to portfolio selection. Further on we examine decision making under conflict, and finally, collective decision making.

The treatment of these topics is neither completely rigorous nor completely intuitive but somewhere between these poles. Rigor was traded for informality to the point where (the author hopes) a beginner's understanding will be optimized. Although much use is made of symbols, the reader only needs knowledge of differential calculus.

Each chapter could easily be expanded into a large volume. The main purpose of this work is not to treat any one topic in detail, but to show the framework connecting a number of areas in modern decision making.

At least one major area of decision theory has been omitted entirely, situations in which the set of alternatives is not clearly

defined but must be found or designed. Until recently, this has been a major soft spot in the state of the art. This problem is now under concerted attack (see Ref. 8, Chap. 7).

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I am deeply grateful to Professor Herbert A. Simon for his meticulous reading of the entire manuscript and his many useful comments. He is not to be implicated for remaining errors.

DECISION MAKING UNDER CERTAINTY

CHAPTER TWO

A decision situation exists if one must choose among alternative courses of action. For those of us who believe that the future is not completely predetermined, decision situations dominate our lives: of those schools that will accept me, in which shall I enroll; of those girls who will say "yes," which shall I marry; of those jobs offered to me, which shall I take; of all the available houses, which shall I buy; etc. These decisions are often made impulsively, whimsically or, in some cases, after deliberate thought. In this

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chapter we begin to answer the question, "How *should* decisions be made?" To erase the illusion of omnipotence, we stress at the outset that we will only advise the decision maker if he is rational and if he can reveal to us his values, terms which we now try to define.

strategies, outcomes, and certainty

Let us denote the courses of action, or strategies, in any given situation by $S_1, S_2, \ldots, S_n$ and the possible outcomes by $C_1, C_2, \ldots, C_r$. Note that several strategies may have the same outcome. Strategies are means to ends; they interest us only because they lead to goals that satisfy our desires. (Desires need not be selfish or hedonistic. A parent's desire to send a son to college could involve working long, hard hours.)

We can always define an outcome so that it contains all the aspects that will add or detract from our desires. For instance, a strategy available to me in a given situation might be S_1, "go downtown and buy a suit." The outcome associated with this strategy might be, C_1, "own a blue suit at a cost of $50." But if the act of going downtown is distasteful, then C_1 might be defined "own a blue suit at a cost of $50 after an uncomfortable 45-minute ride." An outcome is so inclusively defined because we wish to compare possible outcomes and choose a strategy solely on the basis of these outcomes.

Whenever it is known in advance that every strategy will lead to an unequivocal outcome we say we are in a *state of certainty*. Conceptually, decisions under certainty are the easiest to cope with: choose that strategy which leads to your most desirable outcome. We shall examine in some detail the decision situation under certainty because it will lay the foundation for the more interesting and relevant case of uncertainty.

rational decision makers

Much economic theory is concerned with states of certainty. Almost all of this theory is dominated by a "rational" man whose actions spring from the introspective question, "How shall I behave in these circumstances?" It is not always clear whether economic theories describe actual behavior or whether they attempt to prescribe behavior. The desire to advise a decision maker how he *should* behave, does not guarantee that what follows is descriptive of anybody's behavior. We are only concerned with the rational decision maker; it is essential that we define this creature carefully. An individual who does not know his own tastes and preferences is beyond our help. He should come to us only after some combination of eugenic, parental, and societal influence has instilled in him distinct preferences that are "consistent." Specifically, for a rational individual, the following axioms are valid.

AXIOM 1. When faced with any two possible outcomes, C_i and C_j, rational man will prefer C_i at least as much as C_j, and/or C_j at least as much as C_i. (If C_i is preferred at least as much as C_j, we write $C_i \geq C_j$. If $C_i \geq C_j$ and simultaneously $C_j \geq C_i$, we write $C_i = C_j$.)

AXIOM 2. If C_i is preferred at least as much as C_j and C_j is preferred at least as much as C_k, then C_i is preferred at least as much as C_k, where C_i, C_j, and C_k are any three possible outcomes. (In the above notation: If $C_i \geq C_j$ and $C_j \geq C_k$, then $C_i \geq C_k$.)

We are not claiming that rational individuals exist, but perhaps we should dispel the fear that we may be embarking upon an enterprise that will have no earthly usefulness. Surely some decision situations exist in which these two axioms describe the vast majority of us. For example, consider outcomes that involve only sums of money ranging from $1 to $100 in increments of $.01.

There are 10,000 different outcomes in this set, but for most of us their ranking is straightforward and obeys the axioms. In many situations, of course, where outcomes include many diverse dimensions, the axioms might be questioned. For example, Axiom 1 seems to be violated very often when a woman is shopping—her hesitation suggests that she may not know whether she prefers the green hat to the feathered hat. And there is much evidence that Axiom 2 is often violated, especially when the outcomes are not of very great concern to the decision maker. Nevertheless, many decision situations probably exist in which the two axioms are valid. It is these situations that will concern us in this book.

a consumer's decision problem

Consider the decision situation facing a housewife in a supermarket. The strategies available to her are staggering: the purchase of every possible combination of food items that fall within her total food budget. For instance, S_1 might be "buy 100 quarts of milk" and C_1, "family consumes 100 quarts of milk (in given time period)." Hers is the classic problem of consumer choice under certainty.[1] Without any loss in generality, we can consider the somewhat simpler situation facing her husband who is contemplating the purchase of only steak and potatoes for a barbecue.

In addition to the rationality axioms, economists assume that, within a relatively wide range, the consumer would prefer more of a good to less of a good. (If he preferred less of a good, we might then call it a *bad* rather than a *good*.) For simplicity, we will make that assumption here. We wish to advise the consumer how

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[1] There is an implicit assumption that the housewife knows what she is buying. If there is some doubt because of misleading advertising, then there may be more than one possible outcome associated with each purchase. This would no longer be a problem of choice under conditions of certainty.

many pounds of steak and potatoes to buy. Let us first depict his preferences graphically. In Fig. 2-1 we measure pounds of steak
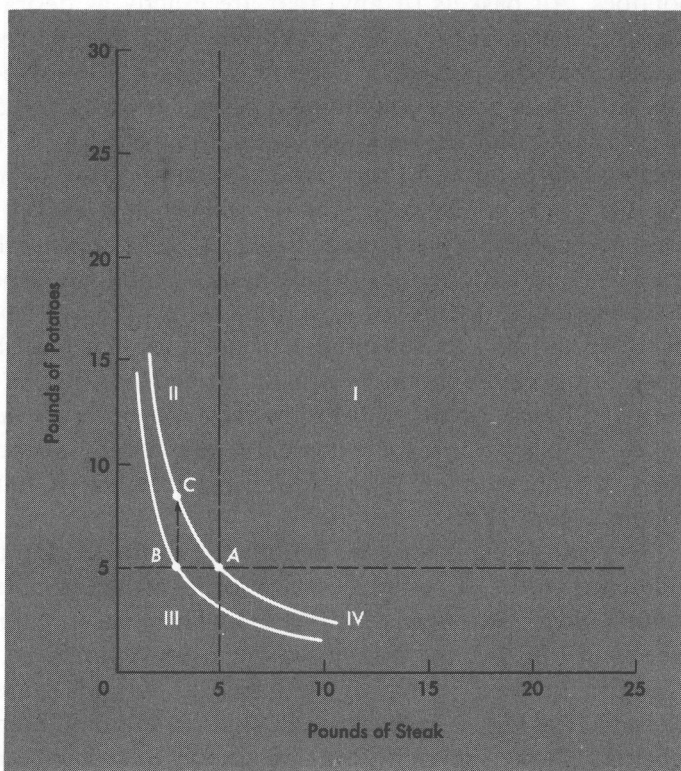

FIG. 2-1

on the horizontal axis and pounds of potatoes on the vertical axis. Every point in this quadrant represents some food basket of steak and potatoes. The point A, for example, represents the basket containing 5 pounds each of potatoes and steak. If we draw a vertical line and a horizontal line through this point, we have divided all possible food baskets into four regions. Region I, northeast of A, represents food baskets preferred to A because these baskets contain more of both steak and potatoes. Region III