Theories of Decision-Making in Economics and Behavioral Science

Herbert A. Simon

The American Economic Review, Volume 49, Issue 3 (Jun., 1959), 253-283.

The American Economic Review

VOLUME XLIX JUNE 1959 NUMBER THREE

THEORIES OF DECISION-MAKING IN ECONOMICS AND BEHAVIORAL SCIENCE

By HERBERT A. SIMON*

[*Editor's note:* This is the first of eight survey articles on recent developments in economics scheduled for appearance in the *Review* over the next few years. Financial support of the series has been generously provided by the Rockefeller Foundation. The managing editor is particularly grateful for the personal interest which the late Dr. Norman S. Buchanan, Director for the Social Sciences at the Foundation, took in the planning of the project.]

Recent years have seen important new explorations along the boundaries between economics and psychology. For the economist, the immediate question about these developments is whether they include new advances in psychology that can fruitfully be applied to economics. But the psychologist will also raise the converse question—whether there are developments in economic theory and observation that have implications for the central core of psychology. If economics is able to find verifiable and verified generalizations about human economic behavior, then these generalizations must have a place in the more general theories of human behavior to which psychology and sociology aspire. Influence will run both ways.[1]

I. *How Much Psychology Does Economics Need?*

How have psychology and economics gotten along with little relation in the past? The explanation rests on an understanding of the goals toward which economics, viewed as a science and a discipline, has usually aimed.

Broadly speaking, economics can be defined as the science that

* The author is professor of administration at the Carnegie Institute of Technology. This paper draws heavily upon earlier investigations with his colleagues in the Graduate School of Industrial Administration, carried out in library, field, and laboratory, under several grants from the Ford Foundation for research on organizations. He is especially indebted to Julian Feldman, whose wide-ranging exploration of the so-called binary choice experiment [25] has provided an insightful set of examples of alternative approaches to a specific problem of choice.

[1] The influence of economics upon recent work in the psychology of higher mental processes is well illustrated by Bruner, Goodnow and Austin [14, Ch. 3 and 4]. In this work, game theory is used to throw light on the processes of concept formation.

describes and predicts the behavior of several kinds of economic man—notably the consumer and the entrepreneur. While perhaps literally correct, this definition does not reflect the principal focus in the literature of economics. We usually classify work in economics along two dimensions: (a) whether it is concerned with industries and the whole economy (macroeconomics) or with individual economic actors (microeconomics); and (b) whether it strives to describe and explain economic behavior (descriptive economics), or to guide decisions either at the level of public policy (normative macroeconomics) or at the level of the individual consumer or businessman (normative microeconomics).

The profession and literature of economics have been largely preoccupied with normative macroeconomics. Although descriptive macroeconomics provides the scientific base for policy prescription, research emphases have been determined in large part by relevance to policy (e.g., business cycle theory). Normative microeconomics, carried forward under such labels as "management science," "engineering economics," and "operations research," is now a flourishing area of work having an uneasy and ill-defined relation with the profession of economics, traditionally defined. Much of the work is being done by mathematicians, statisticians, engineers, and physical scientists (although many mathematical economists have also been active in it).[2]

This new area, like the old, is normative in orientation. Economists have been relatively uninterested in descriptive microeconomics—understanding the behavior of individual economic agents—except as this is necessary to provide a foundation for macroeconomics. The normative microeconomist "obviously" doesn't need a theory of human behavior: he wants to know how people *ought* to behave, not how they *do* behave. On the other hand, the macroeconomist's lack of concern with individual behavior stems from different considerations. First, he assumes that the economic actor is rational, and hence he makes strong predictions about human behavior without performing the hard work of observing people. Second, he often assumes competition, which carries with it the implication that only the rational survive. Thus, the classical economic theory of markets with perfect competition and rational agents is deductive theory that requires almost no contact with empirical data once its assumptions are accepted.[3]

Undoubtedly there is an area of human behavior that fits these assumptions to a reasonable approximation, where the classical theory

[2] The models of rational decision-making employed in operations research are surveyed in Churchman, Ackoff, and Arnoff [16]; Bowman and Fetter [11]; and Vazsonyi [69].

[3] As an example of what passes for empirical "evidence" in this literature, I cite pp. 22-23 of Friedman's *Essays in Positive Economics* [27], which will amaze anyone brought up in the empirical tradition of psychology and sociology, although it has apparently excited little adverse comment among economists.

with its assumptions of rationality is a powerful and useful tool. Without denying the existence of this area, or its importance, I may observe that it fails to include some of the central problems of conflict and dynamics with which economics has become more and more concerned. A metaphor will help to show the reason for this failure.

Suppose we were pouring some viscous liquid—molasses—into a bowl of very irregular shape. What would we need in order to make a theory of the form the molasses would take in the bowl? How much would we have to know about the properties of molasses to predict its behavior under the circumstances? If the bowl were held motionless, and if we wanted only to predict behavior in equilibrium, we would have to know little, indeed, about molasses. The single essential assumption would be that the molasses, under the force of gravity, would minimize the height of its center of gravity. With this assumption, which would apply as well to any other liquid, and a complete knowledge of the environment—in this case the shape of the bowl—the equilibrium is completely determined. Just so, the equilibrium behavior of a perfectly adapting organism depends only on its goal and its environment; it is otherwise completely independent of the internal properties of the organism.

If the bowl into which we were pouring the molasses were jiggled rapidly, or if we wanted to know about the behavior before equilibrium was reached, prediction would require much more information. It would require, in particular, more information about the properties of molasses: its viscosity, the rapidity with which it "adapted" itself to the containing vessel and moved towards its "goal" of lowering its center of gravity. Likewise, to predict the short-run behavior of an adaptive organism, or its behavior in a complex and rapidly changing environment, it is not enough to know its goals. We must know also a great deal about its internal structure and particularly its mechanisms of adaptation.

If, to carry the metaphor a step farther, new forces, in addition to gravitational force, were brought to bear on the liquid, we would have to know still more about it even to predict behavior in equilibrium. Now its tendency to lower its center of gravity might be countered by a force to minimize an electrical or magnetic potential operating in some lateral direction. We would have to know its relative susceptibility to gravitational and electrical or magnetic force to determine its equilibrium position. Similarly, in an organism having a multiplicity of goals, or afflicted with some kind of internal goal conflict, behavior could be predicted only from information about the relative strengths of the several goals and the ways in which the adaptive processes responded to them.

Economics has been moving steadily into new areas where the power of the classical equilibrium model has never been demonstrated, and where its adequacy must be considered anew. Labor economics is such an area, oligopoly or imperfect competition theory another, decision-making under uncertainty a third, and the theory of economic development a fourth. In all of these areas the complexity and instability of his environment becomes a central feature of the choices that economic man faces. To explain his behavior in the face of this complexity, the theory must describe him as something more than a featureless, adaptive organism; it must incorporate at least some description of the processes and mechanisms through which the adaptation takes place. Let us list a little more concretely some specific problems of this kind:

(a) The classical theory postulates that the consumer maximizes utility. Recent advances in the theory of rational consumer choice have shown that the existence of a utility function, and its characteristics, if it exists, can be studied empirically.

(b) The growing separation between ownership and management has directed attention to the motivations of managers and the adequacy of the profit-maximization assumption for business firms. So-called human relations research has raised a variety of issues about the motivation of both executives and employees.

(c) When, in extending the classical theory, the assumptions of perfect competition were removed, even the definition of rationality became ambiguous. New definitions had to be constructed, by no means as "obvious" intuitively as simple maximization, to extend the theory of rational behavior to bilateral monopoly and to other bargaining and outguessing situations.

(d) When the assumptions of perfect foresight were removed, to handle uncertainty about the environment, the definition of rationality had to be extended in another direction to take into account prediction and the formation of expectations.

(e) Broadening the definition of rationality to encompass goal conflict and uncertainty made it hard to ignore the distinction between the objective environment in which the economic actor "really" lives and the subjective environment that he perceives and to which he responds. When this distinction is made, we can no longer predict his behavior—even if he behaves rationally—from the characteristics of the objective environment; we also need to know something about his perceptual and cognitive processes.

We shall use these five problem areas as a basis for sorting out some recent explorations in theory, model building, and empirical testing. In Section II, we will examine developments in the theory of utility and consumer choice. In Section III, we will consider somewhat parallel issues relating to the motivation of managers. In Section IV, we will deal with conflict of goals and the phenomena of bargaining. In Section V, we will survey some of the work that has been done on uncertainty and the formation of expectations. In Section VI, we will explore recent developments in the theory of human problem-solving and other higher mental processes, and see what implications these have for economic decision-making.

II. *The Utility Function*

The story of the re-establishment of cardinal utility, as a consequence of the introduction of uncertainty into the theory of choice, is well known.[4] When Pareto and Slutsky had shown that the theory of consumer demand could be derived from the properties of indifference curves, without postulating a cardinal utility function underlying these curves, it became fashionable to regard utility as an ordinal measure—a ranking of alternatives by preference. Indeed, it could be shown that only ordinal utility had operational status—that the experiments that had been proposed, and even tried in a couple of instances, to measure an individual's utilities by asking him to choose among alternatives could never distinguish between two cardinal utility functions that were ordinally equivalent—that differed only by stretchings and contractions of the unit of measurement.

It was shown by von Neumann and Morgenstern, as a byproduct of their development of the theory of games, that if the choice situation were extended to include choices among uncertain prospects—among lottery tickets, say—cardinal utilities could be assigned to the outcomes in an unequivocal way.[5] Under these conditions, if the subject's behavior was consistent, it was possible to measure cardinally the utilities that different outcomes had for him.

A person who behaved in a manner consistent with the axioms of choice of von Neumann and Morgenstern would act so as to maximize the expected value—the average, weighted by the probabilities of the alternative outcomes of a choice—of his utility. The theory could be tested empirically, however, only on the assumption that the probabilities assigned to the alternatives by the subject were identical with the "objective" probabilities of these events as known to the experimenter. For example, if a subject believed in the gamblers' fallacy, that after a run of heads an unbiased coin would be more likely to fall tails, his choices might appear inconsistent with his utility function, while the real difficulty would lie in his method of assigning probabilities. This

[4] Ward Edwards [23] provides an account of these developments from the psychologist's point of view; Chapter 2 of Luce and Raiffa [43] is an excellent introduction to the "new" utility theory. Arrow [5] contains a nonmathematical survey of this and related topics.

[5] The second edition of von Neumann and Morgenstern [50] contains the first rigorous axiomatic demonstration of this point.

difficulty of "subjective" versus "objective" probability soon came to light when attempts were made to test experimentally whether people behaved in accordance with the predictions of the new utility theory. At the same time, it was discovered that the problem had been raised and solved thirty years earlier by the English philosopher and mathematician Frank Ramsey.[6] Ramsey had shown that, by an appropriate series of experiments, the utilities and subjective probabilities assigned by a subject to a set of uncertain alternatives could be measured simultaneously.

Empirical Studies

The new axiomatic foundations of the theory of utility, which show that it is possible at least in principle to determine empirically whether people "have" utility functions of the appropriate kind, have led to a rash of choice experiments. An experimenter who wants to measure utilities, not merely in principle but in fact, faces innumerable difficulties. Because of these difficulties, most experiments have been limited to confronting the subjects with alternative lottery tickets, at various odds, for small amounts of money. The weight of evidence is that, under these conditions, most persons choose in a way that is reasonably consistent with the axioms of the theory—they behave as though they were maximizing the expected value of utility and as though the utilities of the several alternatives can be measured.[7]

When these experiments are extended to more "realistic" choices—choices that are more obviously relevant to real-life situations—difficulties multiply. In the few extensions that have been made, it is not at all clear that the subjects behave in accordance with the utility axioms. There is some indication that when the situation is very simple and transparent, so that the subject can easily see and remember when he is being consistent, he behaves like a utility maximizer. But as the choices become a little more complicated—choices, for example, among phonograph records instead of sums of money—he becomes much less consistent [21, Ch. 3] [47].[8]

We can interpret these results in either of two ways. We can say that consumers "want" to maximize utility, and that if we present

[6] Ramsey's important essay [57] was sufficiently obscure that it was overlooked until the ideas were rediscovered independently by de Finetti [26]. Valuable notes on the history of the topic together with a thorough formal treatment will be found in the first five chapters of Savage [58].

[7] Some of the empirical evidence is reviewed in [23]. A series of more recent empirical studies is reported in Davidson and Suppes [21].

[8] Some more recent experiments [57a], show a relatively high degree of transitivity. A. G. Papandreou, in a publication I have not yet seen (University of California Publications in Economics) also reports a high degree of transitivity.

them with clear and simple choices that they understand they will do so. Or we can say that the real world is so complicated that the theory of utility maximization has little relevance to real choices. The former interpretation has generally appeared more attractive to economists trained in classical utility theory and to management scientists seeking rules of behavior for normative microeconomics; the latter to behavioral scientists interested in the description of behavior.

Normative Applications

The new utility theory has provided the formal framework for much recent work in mathematical statistics—i.e., statistical decision theory.[9] Similarly (it would be accurate to say "synonymously"), this framework provides the basis for most of the normative models of management science and operations research designed for actual application to the decision-making problems of the firm.[10] Except for some very recent developments, linear programming has been limited to decision-making under certainty, but there have been far-reaching developments of dynamic programming dealing with the maximization of expected values of outcomes (usually monetary outcomes) in situations where future events can be predicted only in terms of probability distributions.[11]

Again, there are at least two distinct interpretations that can be placed on these developments. On the one hand, it can be argued: "Firms would like to maximize profits if they could. They have been limited in doing so by the conceptual and computational difficulties of finding the optimal courses of action. By providing powerful new mathematical tools and computing machines, we now enable them to behave in the manner predicted by Alfred Marshall, even if they haven't been able to in the past." Nature will imitate art and economic man will become as real (and as artificial) as radios and atomic piles.

The alternative interpretation rests on the observation that, even with the powerful new tools and machines, most real-life choices still lie beyond the reach of maximizing techniques—unless the situations are heroically simplified by drastic approximations. If man, according to this interpretation, makes decisions and choices that have some ap-

[9] The systematic development of statistics as decision theory is due largely to A. Wald [70] on the basis of the earlier work of J. Neyman and E. Pearson. Savage [58] carries the development further, erecting the foundations of statistics solidly on utility and probability theory.

[10] This work relates, of course, to profit maximization and cost minimization rather than utility maximization, but it is convenient to mention it at this point. See [11] [16] [69].

[11] Arrow, Harris and Marschak [3] were among the first to treat inventory decisions dynamically. A general treatment of the theory of dynamic programming will be found in Bellman [9].

pearance of rationality, rationality in real life must involve something simpler than maximization of utility or profit. In Section VI, we will see where this alternative interpretation leads.

The Binary Choice Experiment

Much recent discussion about utility has centered around a particularly simple choice experiment. This experiment, in numerous variants, has been used by both economists and psychologists to test the most diverse kinds of hypotheses. We will describe it so that we can use it as a common standard of comparison for a whole range of theories and empirical studies.[12]

We will call the situation we are about to describe the *binary choice* experiment. It is better known to most game theorists—particularly those located not far from Nevada—as a two-armed bandit; and to most psychologists as a partial reinforcement experiment. The subject is required, in each of a series of trials, to choose one or the other of two symbols—say, plus or minus. When he has chosen, he is told whether his choice was "right" or "wrong," and he may also receive a reward (in psychologist's language, a reinforcement) for "right" choices. The experimenter can arrange the schedule of correct responses in a variety of ways. There may be a definite pattern, or they may be randomized. It is not essential that one and only one response be correct on a given trial: the experimenter may determine that both or neither will be correct. In the latter case the subject may or may not be informed whether the response he did not choose would have been correct.

How would a utility-maximizing subject behave in the binary choice experiment? Suppose that the experimenter rewarded "plus" on one-third of the trials, determined at random, and "minus" on the remaining two-thirds. Then a subject, provided that he believed the sequence was random and observed that minus was rewarded twice as often as plus, should always, rationally, choose minus. He would find the correct answer two-thirds of the time, and more often than with any other strategy.

Unfortunately for the classical theory of utility in its simplest form, few subjects behave in this way. The most commonly observed behavior is what is called *event matching*.[13] The subject chooses the two alternatives (not necessarily at random) with relative frequencies roughly proportional to the relative frequencies with which they are rewarded.

[12] My understanding of the implications of the binary choice experiment owes much to conversations with Julian Feldman, and to his unpublished work on the experiment. See also, Bush and Mosteller [15] particularly Chapter 13.

[13] An example of data consistent with event-matching behavior is given on page 283 of [15].

Thus, in the example given, two-thirds of the time he would choose minus, and as a result would make a correct response, on the average, in 5 trials out of 9 (on two-thirds of the trials in which he chooses minus, and one-third of those in which he chooses plus).[14]

All sorts of explanations have been offered for the event-matching behavior. The simplest is that the subject just doesn't understand what strategy would maximize his expected utility; but with adult subjects in a situation as transparent as this one, this explanation seems far-fetched. The alternative explanations imply either that the subject regards himself as being engaged in a competitive game with the experimenter (or with "nature" if he accepts the experimenter's explanation that the stimulus is random), or that his responses are the outcome of certain kinds of learning processes. We will examine these two types of explanation further in Sections IV and V respectively. The important conclusion at this point is that even in an extremely simple situation, subjects do not behave in the way predicted by a straightforward application of utility theory.

Probabilistic Preferences

Before we leave the subject of utility, we should mention one recent important development. In the formalizations mentioned up to this point, probabilities enter only into the estimation of the consequences that will follow one alternative or another. Given any two alternatives, the first is definitely preferable to the second (in terms of expected utility), or the second to the first, or they are strictly indifferent. If the same pair of alternatives is presented to the subject more than once, he should always prefer the same member of the pair.

One might think this requirement too strict—that, particularly if the utility attached to one alternative were only slightly greater or less than that attached to the other, the subject might vacillate in his choice. An empirical precedent for such vacillation comes not only from casual observation of indecision but from analogous phenomena in the psychophysical laboratory. When subjects are asked to decide which of two weights is heavier, the objectively heavier one is chosen more often than the lighter one, but the relative frequency of choosing the heavier approaches one-half as the two weights approach equality. The probability that a subject will choose the objectively heavier weight depends, in general, on the ratio of the two weights.

Following several earlier attempts, a rigorous and complete axiom system for a utility theory incorporating probabilistic preferences has been constructed recently by Duncan Luce [cf. 43, App. 1]. Although

[14] Subjects tend to choose the more highly rewarded alternative slightly more frequently than is called for by event matching. Hence, the actual behavior tends to be some kind of average between event matching and the optimal behavior. See [15, Ch. 13].

the theory weakens the requirements of consistency in preference, it is empirically testable, at least in principle. Conceptually, it provides a more plausible interpretation of the notion of "indifference" than does the classical theory.

III. *The Goals of Firms*

Just as the central assumption in the theory of consumption is that the consumer strives to maximize his utility, so the crucial assumption in the theory of the firm is that the entrepreneur strives to maximize his residual share—his profit. Attacks on this hypothesis have been frequent.[15] We may classify the most important of these as follows:

(a) The theory leaves ambiguous whether it is short-run or long-run profit that is to be maximized.

(b) The entrepreneur may obtain all kinds of "psychic income" from the firm, quite apart from monetary rewards. If he is to maximize his utility, then he will sometimes balance a loss of profits against an increase in psychic income. But if we allow "psychic income," the criterion of profit maximization loses all of its definiteness.

(c) The entrepreneur may not care to maximize, but may simply want to earn a return that he regards as satisfactory. By sophistry and and adept use of the concept of psychic income, the notion of seeking a satisfactory return can be translated into utility maximizing but not in any operational way. We shall see in a moment that "satisfactory profits" is a concept more meaningfully related to the psychological notion of aspiration levels than to maximization.

(d) It is often observed that under modern conditions the equity owners and the active managers of an enterprise are separate and distinct groups of people, so that the latter may not be motivated to maximize profits.

(e) Where there is imperfect competition among firms, maximizing is an ambiguous goal, for what action is optimal for one firm depends on the actions of the other firms.

In the present section we shall deal only with the third of these five issues. The fifth will be treated in the following section; the first, second, and fourth are purely empirical questions that have been discussed at length in the literature; they will be considered here only for their bearing on the question of satisfactory profits.

Satisficing versus Maximizing

The notion of satiation plays no role in classical economic theory, while it enters rather prominently into the treatment of motivation in psychology. In most psychological theories the motive to act stems from

[15] For a survey of recent discussions see Papandreou [55].

drives, and action terminates when the drive is satisfied. Moreover, the conditions for satisfying a drive are not necessarily fixed, but may be specified by an aspiration level that itself adjusts upward or downward on the basis of experience.

If we seek to explain business behavior in the terms of this theory, we must expect the firm's goals to be not maximizing profit, but attaining a certain level or rate of profit, holding a certain share of the market or a certain level of sales. Firms would try to "satisfice" rather than to maximize.[16]

It has sometimes been argued that the distinction between satisficing and maximizing is not important to economic theory. For in the first place, the psychological evidence on individual behavior shows that aspirations tend to adjust to the attainable. Hence in the long run, the argument runs, the level of aspiration and the attainable maximum will be very close together. Second, even if some firms satisficed, they would gradually lose out to the maximizing firms, which would make larger profits and grow more rapidly than the others.

These are, of course, precisely the arguments of our molasses metaphor, and we may answer them in the same way that we answered them earlier. The economic environment of the firm is complex, and it changes rapidly; there is no a priori reason to assume the attainment of long-run equilibrium. Indeed, the empirical evidence on the distribution of firms by size suggests that the observed regularities in size distribution stem from the statistical equilibrium of a population of adaptive systems rather than the static equilibrium of a population of maximizers.[17]

Models of satisficing behavior are richer than models of maximizing behavior, because they treat not only of equilibrium but of the method of reaching it as well. Psychological studies of the formation and change of aspiration levels support propositions of the following kinds.[18] (a) When performance falls short of the level of aspiration, search behavior (particularly search for new alternatives of action) is induced. (b) At the same time, the level of aspiration begins to adjust itself downward until goals reach levels that are practically attainable. (c) If the two mechanisms just listed operate too slowly to adapt aspirations to performance, emotional behavior—apathy or aggression, for example—will replace rational adaptive behavior.

[16] A comparison of satisficing with maximizing models of decision-making can be found in [64, Ch. 14]. Katona [40] has independently made similar comparisons of economic and psychological theories of decision.

[17] Simon and Bonini [66] have constructed a stochastic model that explains the observed data on the size distributions of business firms.

[18] A standard psychological reference on aspiration levels is [42]. For applications to economics, see [61] and [45] (in the latter, consult the index under "aspiration levels").

The aspiration level defines a natural zero point in the scale of utility—whereas in most classical theories the zero point is arbitrary. When the firm has alternatives open to it that are at or above its aspiration level, the theory predicts that it will choose the best of those known to be available. When none of the available alternatives satisfies current aspirations, the theory predicts qualitatively different behavior: in the short run, search behavior and the revision of targets; in the longer run, what we have called above emotional behavior, and what the psychologist would be inclined to call neurosis.[19]

Studies of Business Behavior

There is some empirical evidence that business goals are, in fact, stated in satisficing terms.[20] First, there is the series of studies stemming from the pioneering work of Hall and Hitch that indicates that businessmen often set prices by applying a standard markup to costs. Some economists have sought to refute this fact, others to reconcile it—if it is a fact—with marginalist principles. The study of Earley [22a, pp. 44-70] belongs to the former category, but its evidence is suspect because the questions asked of businessmen are leading ones—no one likes to admit that he would accept less profit if he could have more. Earley did not ask his respondents how they determined marginal cost and marginal revenue, how, for example, they estimated demand elasticities.

Another series of studies derived from the debate over the Keynesian doctrine that the amount of investment was insensitive to changes in the rate of interest. The general finding in these studies has been that the rate of interest is not an important factor in investment decisions [24] [39, Ch. 11] [71].

More recently, my colleagues Cyert and March, have attempted to test the satisficing model in a more direct way [19]. They found in one industry some evidence that firms with a declining share of market strove more vigorously to increase their sales than firms whose shares of the market were steady or increasing.

Aspirations in the Binary Choice Experiment

Although to my knowledge this has not been done, it would be easy to look for aspiration-level phenomena in the binary choice experiment.

[19] Lest this last term appear fanciful I should like to call attention to the phenomena of panic and broken morale, which are well known to observers of the stock market and of organizations but which have no reasonable interpretation in classical utility theory. I may also mention that psychologists use the theory described here in a straightforward way to produce experimental neurosis in animal and human subjects.

[20] A comprehensive bibliography of empirical work prior to 1950 will be found in [37]. Some of the more recent work is [19] [24] [39, Ch. 11].

By changing the probabilities of reward in different ways for different groups of subjects, we could measure the effects of these changes on search behavior—where amount of search would be measured by changes in the pattern of responses.

Economic Implications

It has sometimes been argued that, however realistic the classical theory of the firm as a profit maximizer, it is an adequate theory for purposes of normative macroeconomics. Mason, for example, in commenting on Papandreou's essay on "Problems in the Theory of the Firm" [55, pp. 183-222] says, "The writer of this critique must confess a lack of confidence in the marked superiority, *for purposes of economic analysis,* of this newer concept of the firm over the older conception of the entrepreneur." The italics are Mason's.

The theory of the firm is important for welfare economics—e.g., for determining under what circumstances the behavior of the firm will lead to efficient allocation of resources. The satisficing model vitiates all the conclusions about resource allocation that are derivable from the maximizing model when perfect competition is assumed. Similarly, a dynamic theory of firm sizes, like that mentioned above, has quite different implications for public policies dealing with concentration than a theory that assumes firms to be in static equilibrium. Hence, welfare economists are justified in adhering to the classical theory only if: (a) the theory is empirically correct as a description of the decision-making process; or (b) it is safe to assume that the system operates in the neighborhood of the static equilibrium. What evidence we have mostly contradicts both assumptions.

IV. *Conflict of Interest*

Leaving aside the problem of the motivations of hired managers, conflict of interest among economic actors creates no difficulty for classical economic theory—indeed, it lies at the very core of the theory —so long as each actor treats the other actors as parts of his "given" environment, and doesn't try to predict their behavior and anticipate it. But when this restriction is removed, when it is assumed that a seller takes into account the reactions of buyers to his actions, or that each manufacturer predicts the behaviors of his competitors—all the familiar difficulties of imperfect competition and oligopoly arise.[21]

The very assumptions of omniscient rationality that provide the basis for deductive prediction in economics when competition is present lead

[21] There is by now a voluminous literature on the problem. The difficulties in defining rationality in competitive situations are well stated in the first chapter of von Neumann and Morgenstern [50].

to ambiguity when they are applied to competition among the few. The central difficulty is that rationality requires one to outguess one's opponents, but not to be outguessed by them, and this is clearly not a consistent requirement if applied to all the actors.

Game Theory

Modern game theory is a vigorous and extensive exploration of ways of extending the concept of rational behavior to situations involving struggle, outguessing, and bargaining. Since Luce and Raiffa [43] have recently provided us with an excellent survey and evaluation of game theory, I shall not cover the same ground here.[22] I concur in their general evaluation that, while game theory has greatly clarified the issues involved, it has not provided satisfactory solutions. Not only does it leave the definition of rational conduct ambiguous in all cases save the zero-sum two-person game, but it requires of economic man even more fantastic reasoning powers than does classical economic theory.[23]

Power and Bargaining

A number of exploratory proposals have been put forth as alternatives to game theory—among them Galbraith's notion of countervailing power [30] and Schelling's bargaining theory [59] [60]. These analyses draw at least as heavily upon theories of power and bargaining developed initially to explain political phenomena as upon economic theory. They do not lead to any more specific predictions of behavior than do game-theoretic approaches, but place a greater emphasis upon description and actual observation, and are modest in their attempt to derive predictions by deductive reasoning from a few "plausible" premises about human behavior.

At least four important areas of social science and social policy, two of them in economics and two more closely related to political science, have as their central concern the phenomena of power and the processes of bargaining: the theory of political parties, labor-management relations, international politics, and oligopoly theory. Any progress in the basic theory applicable to one of these is certain to be of almost equal importance to the others. A growing recognition of their common concern is evidenced by the initiation of a new cross-disciplinary journal, *Journal of Conflict Resolution*.

[22] Chapters 5 and 6 of [43] provide an excellent survey of the attempts that have been made to extend the theory of games to the kinds of situations most relevant to economics.

[23] In a forthcoming volume on *Strategy and Market Structure*, Martin Shubik approaches the topics of imperfect competition and oligopoly from the standpoint of the theory of games.

Games against Nature

While the binary choice experiment is basically a one-person game, it is possible to interpret it as a "game against nature," and hence to try to explain it in game-theoretic terms. According to game theory, the subject, if he believes in a malevolent nature that manipulates the dice against him, should minimax his expected utility instead of maximizing it. That is, he should adopt the course of action that will maximize his expected utility under the assumption that nature will do her worst to him.

Minimaxing expected utility would lead the subject to call plus or minus at random and with equal probability, regardless of what the history of rewards has been. This is something that subjects demonstrably do not do.

However, it has been suggested by Savage [58] and others that people are not as interested in maximizing utility as they are in minimizing regret. "Regret" means the difference between the reward actually obtained and the reward that could have been obtained with perfect foresight (actually, with perfect hindsight!). It turns out that minimaxing regret in the binary choice experiment leads to event-matching behavior [64, Ch. 16]. Hence, the empirical evidence is at least crudely consistent with the hypothesis that people play against nature by minimaxing regret. We shall see, however, that event-matching is also consistent with a number of other rules of behavior that seem more plausible on their face; hence we need not take the present explanation too seriously—at least I am not inclined to do so.

V. *The Formation of Expectations*

While the future cannot enter into the determination of the present, expectations about the future can and do. In trying to gain an understanding of the saving, spending, and investment behavior of both consumers and firms, and to make short-term predictions of this behavior for purposes of policy-making, economists have done substantial empirical work as well as theorizing on the formation of expectations.

Empirical Studies

A considerable body of data has been accumulated on consumers' plans and expectations from the Survey of Consumer Finances, conducted for the Board of Governors of the Federal Reserve System by the Survey Research Center of the University of Michigan [39, Ch. 5]. These data, and similar data obtained by others, begin to give us some information on the expectations of consumers about their own incomes, and the predictive value of their expenditure plans for their actual subsequent behavior. Some large-scale attempts have been made, notably by Modigliani and Brumberg [48, pp. 388-436] and, a little later, by Friedman [28] to relate these empirical findings to classical utility theory. The current empirical research on businessmen's expectations is of two main kinds:

1. Surveys of businessmen's own forecasts of business and business conditions in the economy and in their own industries [24, pp. 165-88] [29, pp. 189-98]. These are obtained by straightforward questionnaire methods that assume, implicitly, that businessmen can and do make such forecasts. In some uses to which the data are put, it is also assumed that the forecasts are used as one basis for businessmen's actions.

2. Studies of business decisions and the role of expectations in these decisions—particularly investment and pricing decisions. We have already referred to studies of business decisions in our discussion of the goals of the firm.[24]

Expectations and Probability

The classical way to incorporate expectations into economic theory is to assume that the decision-maker estimates the joint probability distribution of future events.[25] He can then act so as to maximize the expected value of utility or profit, as the case may be. However satisfying this approach may be conceptually, it poses awkward problems when we ask how the decision-maker actually estimates the parameters of the joint probability distribution. Common sense tells us that people don't make such estimates, nor can we find evidence that they do by examining actual business forecasting methods. The surveys of businessmen's expectations have never attempted to secure such estimates, but have contented themselves with asking for point predictions—which, at best, might be interpreted as predictions of the means of the distributions.

It has been shown that under certain special circumstances the mean of the probability distribution is the only parameter that is relevant for decision—that even if the variance and higher moments were known to the rational decision-maker, he would have no use for them.[26] In these cases, the arithmetic mean is actually a certainty equivalent, the optimal decision turns out to be the same as if the future were known with certainty. But the situations where the mean is a certainty equival-

[24] See the references cited [12, p. 160].

[25] A general survey of approaches to decision-making under uncertainty will be found in [2] and in [43, Ch. 13].

[26] The special case in which mean expectations constitute a certainty equivalent is treated in [62]. An alternative derivation, and fuller discussion is given by Theil [67, Ch. 8, sect. 6].

ent are, as we have said, very special ones, and there is no indication that businessmen ever ask whether the necessary conditions for this equivalence are actually met in practice. They somehow make forecasts in the form of point predictions and act upon them in one way or another.

The "somehow" poses questions that are important for business cycle theory, and perhaps for other problems in economics. The way in which expectations are formed may affect the dynamic stability of the economy, and the extent to which cycles will be amplified or damped. Some light, both empirical and theoretical, has recently been cast on these questions. On the empirical side, attempts have been made: (a) to compare businessmen's forecasts with various "naïve" models that assume the future will be some simple function of the recent past, and (b) to use such naïve models themselves as forecasting devices.

The simplest naïve model is one that assumes the next period will be exactly like the present. Another assumes that the change from present to next period will equal the change from last period to present; a third, somewhat more general, assumes that the next period will be a weighted average of recent past periods. The term "naïve model" has been applied loosely to various forecasting formulae of these general kinds. There is some affirmative evidence that business forecasts fit such models. There is also evidence that elaboration of the models beyond the first few steps of refinement does not much improve prediction; see, for example, [20]. Arrow and his colleagues [4] have explored some of the conditions under which forecasting formulae will, and will not, introduce dynamic instability into an economic system that is otherwise stable. They have shown, for example, that if a system of multiple markets is stable under static expectations, it is stable when expectations are based on a moving average of past values.

The work on the formation of expectations represents a significant extension of classical theory. For, instead of taking the environment as a "given," known to the economic decision-maker, it incorporates in the theory the processes of acquiring knowledge about that environment. In doing so, it forces us to include in our model of economic man some of his properties as a learning, estimating, searching, information-processing organism [65].

The Cost of Information

There is one way in which the formation of expectations might be reincorporated in the body of economic theory: by treating information-gathering as one of the processes of production, so to speak, and applying to it the usual rules of marginal analysis. Information, says price theory, should be gathered up to the point where the incremental cost of additional information is equal to the incremental profit that can be earned by having it. Such an approach can lead to propositions about optimal amounts of information-gathering activity and about the relative merits of alternative information-gathering and estimating schemes.[27]

This line of investigation has, in fact, been followed in statistical decision theory. In sampling theory we are concerned with the optimal size of sample (and in the special and ingenious case of sequential sampling theory, with knowing when to stop sampling), and we wish to evaluate the efficiencies of alternative sampling procedures. The latter problem is the simpler, since it is possible to compare the relative costs of alternative schemes that have the same sampling error, and hence to avoid estimating the value of the information.[28] However, some progress has been made also toward estimating the value of improved forecast accuracy in situations where the forecasts are to be used in applying formal decision rules to choice situations.[29]

The theory of teams developed by Marschak and Radner is concerned with the same problem (see, e.g., [46]) It considers situations involving decentralized and interdependent decision-making by two or more persons who share a common goal and who, at a cost, can transmit information to each other about their own actions or about the parts of the environment with which they are in contact. The problem then is to discover the optimal communication strategy under specified assumptions about communication costs and payoffs.

The cost of communication in the theory of teams, like the cost of observations in sampling theory, is a parameter that characterizes the economic actor, or the relation of the actor to his environment. Hence, while these theories retain, in one sense, a classical picture of economic man as a maximizer, they clearly require considerable information about the characteristics of the actor, and not merely about his environment. They take a long stride toward bridging the gap between the traditional concerns of economics and the concerns of psychology.

Expections in the Binary Choice Experiment

I should like to return again to the binary choice experiment, to see what light it casts on the formation of expectations. If the subject is told by the experimenter that the rewards are assigned at random, if he

[27] Fundamental and applied research are examples of economically significant information-gathering activities. Griliches [34] has recently made an attempt to estimate the economic return from research on hybrid corn.

[28] Modern treatments of sampling theory, like Cochran [17] are based on the idea of minimizing the cost of obtaining a fixed amount of information.

[29] For the theory and an application to macroeconomics, see Theil [67, Ch. 8, sects. 5 and 6].

is told what the odds are for each alternative, *and if he believes the experimenter,* the situation poses no forecasting problem. We have seen, however, that the behavior of most subjects is not consistent with these assumptions.

How would sequential sampling theory handle the problem? Each choice the subject makes now has two consequences: the immediate reward he obtains from it, and the increment of information it provides for predicting the future rewards. If he thinks only of the latter consequences, he is faced with the classical problem of induction: to estimate the probability that an event will occur in the future on the basis of its frequency of occurrence in the past. Almost any rule of induction would require a rational (maximizing) subject to behave in the following general manner: to sample the two alternatives in some proportion to estimate the probability of reward associated with each; after the error of estimate had been reduced below some bound, always to choose the alternative with the higher probability of reward. Unfortunately, this does not appear to be what most subjects do.

If we give up the idea of maximization, we can make the weaker assumption that the subject is adaptive—or learns—but not necessarily in any optimal fashion. What do we mean by adaptation or learning? We mean, gradually and on the basis of experience responding more frequently with the choice that, in the past, has been most frequently rewarded. There is a whole host of rules of behavior possessing this characteristic. Postulate, for example, that at each trial the subject has a certain probability of responding "plus," and the complementary probability of responding "minus." Postulate further that when he makes a particular response the probability of making the same response on the next trial is increased if the response is rewarded and decreased if the response is not rewarded. The amount of increment in the response probability is a parameter characterizing the learning rate of the particular subject. Almost all schemes of this kind produce asymptotic behaviors, as the number of trials increases, that are approximately event-matching in character.

Stochastic learning models, as the processes just described are usually called, were introduced into psychology in the early 1950's by W. K. Estes and Bush and Mosteller [15] and have been investigated extensively since that time. The models fit some of the gross features of the observed behaviors—most strikingly the asymptotic probabilities—but do not explain very satisfactorily the fine structure of the observations.

Observation of subjects in the binary choice experiment reveals that usually they not only refuse to believe that (or even to act as if) the reward series were random, but in fact persist over many trials in searching for systematic patterns in the series. To account for such behavior, we might again postulate a learning model, but in this case a model in which the subject does not react probabilistically to his environment, but forms and tests definite hypotheses about systematic patterns in it. Man, in this view, is not only a learning animal; he is a pattern-finding and concept-forming animal. Julian Feldman [25] has constructed theories of this kind to explain the behavior of subjects in the binary choice experiment, and while the tests of the theories are not yet completed, his findings look exceedingly promising.

As we move from maximizing theories, through simple stochastic learning theories, to theories involving pattern recognition our model of the expectation-forming processes and the organism that performs it increases in complexity. If we follow this route, we reach a point where a theory of behavior requires a rather elaborate and detailed picture of the rational actor's cognitive processes.

VI. *Human Cognition and Economics*

All the developments we have examined in the preceding four sections have a common theme: they all involve important modifications in the concept of economic man and, for the reasons we have stated, modifications in the direction of providing a fuller description of his characteristics. The classical theory is a theory of a man choosing among fixed and known alternatives, to each of which is attached known consequences. But when perception and cognition intervene between the decision-maker and his objective environment, this model no longer proves adequate. We need a description of the choice process that recognizes that alternatives are not given but must be sought; and a description that takes into account the arduous task of determining what consequences will follow on each alternative [63, Ch. 5] [64, Part 4] [14].

The decision-maker's information about his environment is much less than an approximation to the real environment. The term "approximation" implies that the subjective world of the decision-maker resembles the external environment closely, but lacks, perhaps, some fineness of detail. In actual fact the perceived world is fantastically different from the "real" world. The differences involve both omissions and distortions, and arise in both perception and inference. The sins of omission in perception are more important than the sins of commission. The decision-maker's model of the world encompasses only a minute fraction of all the relevant characteristics of the real environment, and his inferences extract only a minute fraction of all the information that is present even in his model.

Perception is sometimes referred to as a "filter." This term is as misleading as "approximation," and for the same reason: it implies that what comes through into the central nervous system is really quite a bit like what is "out there." In fact, the filtering is not merely a passive selection of some part of a presented whole, but an active process involving attention to a very small part of the whole and exclusion, from the outset, of almost all that is not within the scope of attention.

Every human organism lives in an environment that generates millions of bits of new information each second, but the bottleneck of the perceptual apparatus certainly does not admit more than 1,000 bits per second, and probably much less. Equally significant omissions occur in the processing that takes place when information reaches the brain. As every mathematician knows, it is one thing to have a set of differential equations, and another thing to have their solutions. Yet the solutions are logically implied by the equations—they are "all there," if we only knew how to get to them! By the same token, there are hosts of inferences that *might* be drawn from the information stored in the brain that are not in fact drawn. The consequences implied by information in the memory become known only through active information-processing, and hence through active selection of particular problem-solving paths from the myriad that might have been followed.

In this section we shall examine some theories of decision-making that take the limitations of the decision-maker and the complexity of the environment as central concerns. These theories incorporate some mechanisms we have already discussed—for example, aspiration levels and forecasting processes—but go beyond them in providing a detailed picture of the choice process.

A real-life decision involves some goals or values, some facts about the environment, and some inferences drawn from the values and facts. The goals and values may be simple or complex, consistent or contradictory; the facts may be real or supposed, based on observation or the reports of others; the inferences may be valid or spurious. The whole process may be viewed, metaphorically, as a process of "reasoning," where the values and facts serve as premises, and the decision that is finally reached is inferred from these premises [63]. The resemblance of decision-making to logical reasoning is only metaphorical, because there are quite different rules in the two cases to determine what constitute "valid" premises and admissible modes of inference. The metaphor is useful because it leads us to take the individual *decision premise* as the unit of description, hence to deal with the whole interwoven fabric of influences that bear on a single decision—but without being bound by the assumptions of rationality that limit the classical theory of choice.

Rational Behavior and Role Theory

We can find common ground to relate the economist's theory of decision-making with that of the social psychologist. The latter is particularly interested, of course, in social influences on choice, which determine the *role* of the actor. In our present terms, a role is a social prescription of some, but not all, of the premises that enter into an individual's choices of behavior. Any particular concrete behavior is the resultant of a large number of premises, only some of which are prescribed by the role. In addition to role premises there will be premises about the state of the environment based directly on perception, premises representing beliefs and knowledge, and idiosyncratic premises that characterize the personality. Within this framework we can accommodate both the rational elements in choice, so much emphasized by economics, and the nonrational elements to which psychologists and sociologists often prefer to call attention.

Decision Premises and Computer Programs

The analysis of choice in terms of decision premises gives us a conceptual framework for describing and explaining the process of deciding. But so complex is the process that our explanations of it would have remained schematic and hypothetical for a long time to come had not the modern digital computer appeared on the scene. The notion of decision premise can be translated into computer terminology, and when this translation has been accomplished, the digital computer provides us with an instrument for simulating human decision processes —even very complex ones—and hence for testing empirically our explanations of those processes [53].

A fanciful (but only slightly fanciful) example will illustrate how this might be done. Some actual examples will be cited presently. Suppose we were to construct a robot incorporating a modern digital computer, and to program (i.e., to instruct) the robot to take the role of a business executive in a specified company. What would the program look like? Since no one has yet done this, we cannot say with certainty, but several points are fairly clear. The program would not consist of a list of prescribed and proscribed behaviors, since what an executive does is highly contingent on information about a wide variety of circumstances. Instead, the program would consist of a large number of *criteria* to be applied to possible and proposed courses of action, of routines for *generating* possible courses of action, of computational procedures for *assessing* the state of the environment and its implications for action, and the like. Hence, the program—in fact, a role prescription—would interact with information to produce concrete behavior adapted to the situation. The elements of such a program take the form of what we have called decision premises, and what the computer specialists would call instructions.

The promise of constructing actual detailed descriptions of concrete roles and decision processes is no longer, with the computer, a mere prospectus to be realized at some undefined future date. We can already provide actual examples, some of them in the area of economics.

1. *Management Science.* In the paragraphs on normative applications in Section II, we have already referred to the use of such mathematical techniques as linear programming and dynamic programming to construct formal decision processes for actual situations. The relevance of these decision models to the present discussion is that they are not merely abstract "theories" of the firm, but actual decision-making devices. We can think of any such device as a simulation of the corresponding human decision-maker, in which the equations and other assumptions that enter into the formal decision-making procedure correspond to the decision premises—including the role prescription—of the decision-maker.

The actual application of such models to concrete business situations brings to light the information-processing tasks that are concealed in the assumptions of the more abstract classical models [65, pp. 51-52]:

(1) The models must be formulated so as to require for their application only data that are obtainable. If one of the penalties, for example, of holding too small inventories is the loss of sales, a decision model that proposes to determine optimal inventory levels must incorporate a procedure for putting a dollar value on this loss.

(2) The models must call only for practicable computations. For example, several proposals for applying linear programming to certain factory scheduling problems have been shown to be impracticable because, even with computers, the computation time is too great. The task of decision theory (whether normative or descriptive) is to find alternative techniques—probably only approximate—that demand much less computation.

(3) The models must not demand unobtainable forecast information. A procedure that would require a sales department to estimate the third moment of next month's sales distribution would not have wide application, as either description or prescription, to business decision-making.

These models, then, provide us with concrete examples of roles for a decision-maker described in terms of the premises he is expected to apply to the decision—the data and the rules of computation.

2. *Engineering Design.* Computers have been used for some years to carry out some of the analytic computations required in engineering design—computing the stresses, for example, in a proposed bridge

design. Within the past two years, ways have been found to program computers to carry out synthesis as well as analysis—to evolve the design itself.[30] A number of companies in the electrical industry now use computers to design electric motors, transformers, and generators, going from customer specifications to factory design without human intervention. The significance of this for our purpose here is that the synthesis programs appear to simulate rather closely the processes that had previously been used by college-trained engineers in the same design work. It has proved possible to write down the engineers' decision premises and inference processes in sufficient detail to produce workable computer programs.

3. *Human Problem Solving*. The management science and engineering design programs already provide examples of simulation of human decision-making by computer. It may be thought that, since in both instances the processes are highly arithmetical, these examples are relevant to only a very narrow range of human problem-solving activity. We generally think of a digital computer as a device which, if instructed in painful detail by its operator, can be induced to perform rather complicated and tedious arithmetical operations. More recent developments require us to revise these conceptions of the computer, for they enable it to carry out tasks that, if performed by humans, we would certainly call "thinking" and "learning."

Discovering the proof of a theorem of Euclid—a task we all remember from our high school geometry course—requires thinking and usually insight and imagination. A computer is now being programmed to perform this task (in a manner closely simulating the human geometer), and another computer has been successfully performing a highly similar task in symbolic logic for the past two years.[31] The latter computer is programmed to learn—that is to improve its performance on the basis of successful problem-solving experience—to use something akin to imagery or metaphor in planning its proofs, and to transfer some of its skills to other tasks—for example, solving trigonometric identities—involving completely distinct subject matter. These programs, it should be observed, do not involve the computer in rapid arithmetic—or any arithmetic for that matter. They are basically non-numerical, involving the manipulation of all kinds of symbolic material, including words.

Still other computer programs have been written to enable a computer to play chess.[32] Not all of these programs, or those previously

[30] A nontechnical description of such a program will be found in [33].

[31] The program for proving theorems in logic is discussed in [51] and [52], Gelernter and Rochester's geometry program in [31].

[32] A survey of computer chess programs can be found in [54].

mentioned, are close simulations of the processes humans use. However, in some direct attempts to investigate the human processes by thinking-aloud techniques and to reproduce in computer programs the processes observed in human subjects, several striking simulations have been achieved.[33] These experiments have been described elsewhere and can't be reviewed here in detail.

4. *Business Games.* Business games, like those developed by the American Management Association, International Business Machines Corporation, and several universities, represent a parallel development.[34] In the business game, the decisions of the business firms are still made by the human players, but the economic environment of these firms, including their markets, are represented by computer programs that calculate the environment's responses to the actions of the players. As the games develop in detail and realism, their programs will represent more and more concrete descriptions of the decision processes of various economic actors—for example, consumers.

The games that have been developed so far are restricted to numerical magnitudes like prices and quantities of goods, and hence resemble the management science and engineering design programs more closely than they do those we have described under the heading of human problem solving. There is no reason, however, to expect this restriction to remain very long.

Implications for Economics

Apart from normative applications (e.g., substituting computers for humans in certain decision-making tasks) we are not interested so much in the detailed descriptions of roles as in broader questions: (1) What general characteristics do the roles of economic actors have? (2) How do roles come to be structured in the particular ways they do? (3) What bearing does this version of role theory have for macroeconomics and other large-scale social phenomena?

Characterizing Role Structure. Here we are concerned with generalizations about thought processes, particularly those generalizations that are relatively independent of the substantive content of the role. A classical example is Dewey's description of stages in the problem-solving process. Another example, of particular interest to economics, is the hypothesis we have already discussed at length: that economic man is a *satisficing* animal whose problem solving is based on search activity to meet certain aspiration levels rather than a *maximizing* animal whose problem solving involves finding the best alternatives in terms of specified criteria [64]. A third hypothesis is that operative goals (those

[33] Much of this work is still unpublished, but see [53] and [54].

[34] Two business games are described by Andlinger [1].

associated with an observable criterion of success, and relatively definite means of attainment) play a much larger part in governing choice than nonoperative goals (those lacking a concrete measure of success or a program for attainment) [45, p. 156].

Understanding How Roles Emerge. Within almost any single business firm, certain characteristic types of roles will be represented: selling roles, production roles, accounting roles, and so on [22]. Partly, this consistency may be explained in functional terms—that a model that views the firm as producing a product, selling it, and accounting for its assets and liabilities is an effective simplification of the real world, and provides the members of the organization with a workable frame of reference. Imitation within the culture provides an alternative explanation. It is exceedingly difficult to test hypotheses as to the origins and causal conditions for roles as universal in the society as these, but the underlying mechanisms could probably be explored effectively by the study of less common roles—safety director, quality control inspector, or the like—that are to be found in some firms, but not in all.

With our present definition of role, we can also speak meaningfully of the role of an entire business firm—of decision premises that underlie its basic policies. In a particular industry we find some firms that specialize in adapting the product to individual customer's specifications; others that specialize in product innovation. The common interest of economics and psychology includes not only the study of individual roles, but also the explanation of organizational roles of these sorts.

Tracing the Implications for Macroeconomics. If basic professional goals remain as they are, the interest of the psychologist and the economist in role theory will stem from somewhat different ultimate aims. The former will use various economic and organizational phenomena as data for the study of the structure and determinants of roles; the latter will be primarily interested in the implications of role theory for the model of economic man, and indirectly, for macroeconomics.

The first applications will be to those topics in economics where the assumption of static equilibrium is least tenable. Innovation, technological change, and economic development are examples of areas to which a good empirically tested theory of the processes of human adaptation and problem solving could make a major contribution. For instance, we know very little at present about how the rate of innovation depends on the amounts of resources allocated to various kinds of research and development activity [34]. Nor do we understand very well the nature of "know how," the costs of transferring technology from one firm or economy to another, or the effects of various kinds and amounts of education upon national product. These are difficult questions to answer from aggregative data and gross observation, with the result that our views have been formed more by arm-chair theorizing than by testing hypotheses with solid facts.

VII. *Conclusion*

In exploring the areas in which economics has common interests with the other behavioral sciences, we have been guided by the metaphor we elaborated in Section I. In simple, slow-moving situations, where the actor has a single, operational goal, the assumption of maximization relieves us of any need to construct a detailed picture of economic man or his processes of adaptation. As the complexity of the environment increases, or its speed of change, we need to know more and more about the mechanisms and processes that economic man uses to relate himself to that environment and achieve his goals.

How closely we wish to interweave economics with psychology depends, then, both on the range of questions we wish to answer and on our assessment of how far we may trust the assumptions of static equilibrium as approximations. In considerable part, the demand for a fuller picture of economic man has been coming from the profession of economics itself, as new areas of theory and application have emerged in which complexity and change are central facts. The revived interest in the theory of utility, and its application to choice under uncertainty, and to consumer saving and spending is one such area. The needs of normative macroeconomics and management science for a fuller theory of the firm have led to a number of attempts to understand the actual processes of making business decisions. In both these areas, notions of adaptive and satisficing behavior, drawn largely from psychology, are challenging sharply the classical picture of the maximizing entrepreneur.

The area of imperfect competition and oligopoly has been equally active, although the activity has thus far perhaps raised more problems than it has solved. On the positive side, it has revealed a community of interest among a variety of social scientists concerned with bargaining as a part of political and economic processes. Prediction of the future is another element common to many decision processes, and particularly important to explaining business cycle phenomena. Psychologists and economists have been applying a wide variety of approaches, empirical and theoretical, to the study of the formation of expectations. Surveys of consumer and business behavior, theories of statistical induction, stochastic learning theories, and theories of concept formation have all been converging on this problem area.

The very complexity that has made a theory of the decision-making process essential has made its construction exceedingly difficult. Most approaches have been piecemeal—now focused on the criteria of choice, now on conflict of interest, now on the formation of expectations. It seemed almost utopian to suppose that we could put together a model of adaptive man that would compare in completeness with the simple model of classical economic man. The sketchiness and incompleteness of the newer proposals has been urged as a compelling reason for clinging to the older theories, however inadequate they are admitted to be.

The modern digital computer has changed the situation radically. It provides us with a tool of research—for formulating and testing theories—whose power is commensurate with the complexity of the phenomena we seek to understand. Although the use of computers to build theories of human behavior is very recent, it has already led to concrete results in the simulation of higher mental processes. As economics finds it more and more necessary to understand and explain disequilibrium as well as equilibrium, it will find an increasing use for this new tool and for communication with its sister sciences of psycology and sociology.

References

1. G. R. Andlinger, "Business Games—Play One," *Harvard Bus. Rev.*, Apr. 1958, *36*, 115-25.
2. K. J. Arrow, "Alternative Approaches to the Theory of Choice in Risk-Taking Situations," *Econometrica*, Oct. 1951, *19*, 404-37.
3. K. J. Arrow, T. E. Harris, and J. Marschak, "Optimal Inventory Policy," *Econometrica*, July 1951, *19*, 250-72.
4. K. J. Arrow and M. Nerlove, "A Note on Expectations and Stability," *Econometrica*, Apr. 1958, *26*, 297-305.
5. K. J. Arrow, "Utilities, Attitudes, Choices," *Econometrica*, Jan. 1958, *26*, 1-23.
6. D. Bakan, "Learning and the Principle of Inverse Probability," *Psych. Rev.*," Sept. 1953, *60*, 360-70.
7. A. Bavelas, "A Mathematical Model for Group Structures," *Applied Anthropology*, Summer 1948, *7*, 16-30.
8. M. Beckmann, "Decision and Team Problems in Airline Reservations," *Econometrica*, Jan. 1958, *26*, 134-45
9. R. Bellman, *Dynamic Programming*. Princeton 1957.
10. H. R. Bowen, *The Business Enterprise as a Subject for Research*. New York 1955.
11. E. H. Bowman and R. B. Fetter, *Analysis for Production Management*. Homewood, Ill., 1957.
12. M. J. Bowman, ed., *Expectations, Uncertainty, and Business Behavior*. New York 1958.
13. H. Brems, "Response Lags and Nonprice Competition," in Bowman [12], Ch. 10, pp. 134-43.

14. J. Bruner, J. J. Goodnow and G. A. Austin, *A Study of Thinking.* New York 1956.
15. R. R. Bush and F. Mosteller, *Stochastic Models for Learning.* New York 1955.
16. C. W. Churchman, R. L. Ackoff and E. L. Arnoff, *Introduction to Operations Research.* New York 1957.
17. W. G. Cochran, *Sampling Techniques.* New York 1953.
18. R. M. Cyert and J. G. March, "Organizational Structure and Pricing Behavior in an Oligopolistic Market," *Am. Econ. Rev.,* Mar. 1955, *45,* 129-39.
19. ——— and ———, "Organizational Factors in the Theory of Oligopoly," *Quart. Jour. Econ.,* Feb. 1956, *70,* 44-64.
20. W. Darcovich, "Evaluation of Some Naive Expectations Models for Agricultural Yields and Prices," in Bowman [12], Ch. 14, pp. 199-202.
21. D. Davidson and P. Suppes, *Decision Making: An Experimental Approach.* Stanford 1957.
22. D. C. Dearborn and H. A. Simon, "Selective Perception: A Note on the Departmental Identification of Executives," *Sociometry,* June 1958, *21,* 140-44.
22a. J. S. Earley, "Marginal Policies of 'Excellently Managed' Companies," *Am. Econ. Rev.,* Mar. 1956, *66,* 44-70.
23. W. Edwards, "The Theory of Decision Making," *Psych. Bull.,* Sept. 1954, *51,* 380-417.
24. R. Eisner, "Expectations, Plans, and Capital Expenditures," in Bowman [12], Ch. 12, 165-88.
25. J. Feldman, "A Theory of Binary Choice Behavior," Carnegie Inst. of Tech., Grad. Sch. Indus. Admin., Complex Information Processing Working Paper No. 12, rev., May 5, 1958. Unpublished ditto.
26. B. de Finetti "La prevision: ses lois logiques, ses sources subjectives," *Annales Inst. Henri Poincare,* 1937, *7,* 1-68.
27. M. Friedman, *Essays in Positive Economics.* Chicago 1953.
28. ———, *A Theory of the Consumption Function.* New York 1956.
29. I. Friend, "Critical Evaluation of Surveys of Expectations, Plans, and Investment Behavior," in Bowman [12], Ch. 13, pp. 189-98.
30. J. K. Galbraith, *American Capitalism: The Concept of Countervailing Power.* Boston 1952.
31. H. L. Gelernter and N. Rochester, "Intelligent Behavior in Problem-Solving Machines," *IBM Jour. Research and Develop.,* Oct. 1958, *2,* 336-45.
32. N. Georgescu-Roegen, "The Nature of Expectation and Uncertainty" in Bowman [12], Ch. 1, pp. 11-29.
33. G. L. Godwin, "Digital Computers Tap Out Designs for Large Motors—Fast," *Power,* Apr. 1958.
34. Z. Griliches, "Hybrid Corn: An Exploration in the Economics of Technological Change," *Econometrica,* Oct. 1957, *25,* 501-22.
35. H. Guetzkow and H. A. Simon, "The Impact of Certain Communication

Nets in Task Oriented Groups," *Management Sci.*, July 1955, *1*, 233-50.
36. B. F. HALEY, ed., *A Survey of Contemporary Economics*, Vol. II. Homewood, Ill. 1952.
37. S. P. HAYES, "Some Psychological Problems of Economics," *Psych. Bull.*, July 1950, *47*, 289-330.
38. C. C. HOLT, F. MODIGLIANI AND H. A. SIMON, "A Linear Decision Rule for Production and Employment Scheduling," *Management Sci.*, Oct. 1955, *2*, 1-30.
39. G. KATONA, *Psychological Analysis of Economic Behavior.* New York 1951.
40. ———, "Rational Behavior and Economic Behavior," *Psych. Rev.*, July 1953, *60*, 307-18.
41. H. J. LEAVITT, "Some Effects of Certain Communication Patterns on Group Performance," *Jour. Abnormal and Soc. Psych.*, Feb. 1951, *46*, 38-50.
42. K. LEWIN, AND OTHERS, "Level of Aspiration," in J. McV. Hunt, *Personality and the Behavior Disorders*, New York 1944, pp. 333-78.
43. R. D. LUCE AND H. RAIFFA, *Games and Decisions.* New York 1957.
44. R. MACK, "Business Expectations and the Buying of Materials," in Bowman [12], Ch. 8, pp. 106-18.
45. J. G. MARCH AND H. A. SIMON, *Organizations.* New York 1958.
46. J. MARSCHAK, "Elements for a Theory of Teams," *Management Sci.*, Jan. 1955, *1*, 127-37.
47. K. O. MAY, "Intransitivity, Utility, and the Aggregation of Preference Patterns," *Econometrica*, Jan. 1954, *22*, 1-13.
48. F. MODIGLIANI AND R. E. BRUMBERG, "Utility Analysis and the Consumption Function," in K. K. Kurihara, *Post Keynesian Economics*, New Brunswick, N.J., 1954, pp. 388-436.
49. F. MOSTELLER AND P. NOGEE, "An Experimental Measurement of Utility," *Jour. Pol. Econ.* Oct. 1951, *59*, 371-404.
50. J. VON NEUMANN AND O. MORGENSTERN, *Theory of Games and Economic Behavior.* Princeton 1947.
51. A. NEWELL AND H. A. SIMON, "The Logic Theory Machine," *IRE Transactions of Information Theory*, Sept. 1956, IT-*2*, 61-79.
52. A. NEWELL, J. C. SHAW AND H. A. SIMON, "Empirical Explorations of the Logic Theory Machine," *Proceedings of the Western Joint Computer Conference, Feb. 26-28, 1957*, pp. 218-30.
53. ———, ———, ———, "Elements of a Theory of Human Problem Solving," *Psych. Rev.* May 1958, *65*, 151-66.
54. ———, ———, ———, "Chess-Playing Programs and the Problem of Complexity," *IBM Jour. Research and Develop.*, Oct. 1958, *2*, 320-35.
55. A. G. PAPANDREOU, "Some Basic Problems in the Theory of the Firm," in Haley [36], Ch. 5, pp. 183-222.
56. M. J. PECK, "Marginal Analysis and the Explanation of Business Behavior Under Uncertainty," in Bowman [12], Ch. 9, pp. 119-33.
57. F. P. RAMSEY, "Truth and Probability," in the *Foundations of Mathematics and Other Logical Essays*, London 1931, pp. 156-98.

57a. A. M. ROSE, "A Study of Irrational Judgments," *Jour. Pol. Econ.*, Oct. 1957, *65*, 394-402.

58. L. J. SAVAGE, *The Foundations of Statistics*. New York 1954.

59. T. C. SCHELLING, "Bargaining, Communication, and Limited War," *Jour. Conflict Resolution*, Mar. 1957, *1*, 19-36.

60. ———, "An Essay on Bargaining," *Am. Econ. Rev.*, June 1956, *46*, 281-306.

61. S. SIEGEL, "Level of Aspiration and Decision Making," *Psych. Rev.*, July 1957, *64*, 253-62.

62. H. A. SIMON, "Dynamic Programming Under Uncertainty with a Quadratic Criterion Function," *Econometrica*, Jan. 1956, *24*, 74-81.

63. ———, *Administrative Behavior*. New York 1957.

64. ———, *Models of Man*. New York 1957.

65. ———, "The Role of Expectations in an Adaptive or Behavioristic Model," in Bowman [12], Ch. 3, pp. 49-58.

66. H. A. SIMON AND C. P. BONINI, "The Size Distribution of Business Firms," *Am. Econ. Rev.*, Sept. 1958, *48*, 607-17.

67. H. THEIL, *Economic Forecasts and Policy*. Amsterdam 1958.

68. L. L. THURSTONE, "The Indifference Function," *Jour. Soc. Psych.* May 1931, *2*, 139-67.

69. A. VAZSONYI, *Scientific Programming in Business and Industry*. New York 1958.

70. A. WALD, *Statistical Decision Functions*. New York 1950.

71. T. WILSON AND P. W. S. ANDREWS, *Oxford Studies in the Price Mechanism*. Oxford 1951.