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TEN-YEAR OUTLOOK ON RESEARCH OPPORTUNITIES IN THE BEHAVIORAL AND SOCIAL SCIENCES

WORKING GROUP ON INFORMATION AND DECISION MAKING

Professor Mark Machina (Chair)
Department of Economics
University of California, San Diego

Professor Robin Hogarth
Graduate School of Business
University of Chicago

Professor Kenneth MacCrimmon
Faculty of Commerce and Business Administration
University of British Columbia

Professor John Roberts
Graduate School of Business
Stanford University

Professor Alvin Roth
Department of Economics
University of Pittsburgh

Dr. Paul Slovic
Decision Research, Inc.
Eugene, Oregon

Professor Richard Thaler
Graduate School of Business
Cornell University

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INTRODUCTION

The field of information and decision theory has changed dramatically over the past ten years in ways that will profoundly influence the direction of research for the next ten. A decade ago, although the "expected utility" approach provided the model of individual choice under uncertainty on which virtually all of decision theory, game theory, and the economics of uncertainty were based, researchers in these areas had undertaken almost no empirical testing of the underlying assumptions of that model. While psychological models of choice under uncertainty (which typically took a more cognitive, information-processing approach) were regularly subjected to testing, there was little communication between psychologists and economists. Today there is a much greater degree of interaction between the two disciplines. Psychologists have identified several behavioral aspects of decision making that challenge some of the very foundations of classical decision theory, and economists are beginning to develop, test, and analyze the economic implications of choice models that depart from the expected utility approach as well as incorporate some well-established psychological aspects of decision making.

The last decade has also seen much activity in the areas of multi-person bargaining and the theory of games. We now possess a better and more formal understanding of the phenomena of "disagreement" and "reputation" in situations of bargaining or strategic interaction. Another important development has been the explicit incorporation of the structure of information among agents and the recognition of its effect on the outcomes of single play or repeated games. Models of imperfect and/or asymmetric information are now being applied to, and yielding new insight into, such problems as the Prisoner's Dilemma, predatory pricing, auctions, product quality, and other economic and strategic issues.

Finally, the area of information and decision making has come to place a much greater emphasis on both laboratory and field testing. Economists in particular have increasingly come to recognize the importance of experimentation and field observation in both the testing *and generation* of theories of individual choice and market behavior, and this trend is likely to continue at an increasing rate in the future.

At the expense of omitting other important developments, as well as possibly drawing some misleading boundaries, we have identified five areas in the field of information and decision making that have seen the most dramatic advances in research methods or theories, and that in our view hold the greatest promise for continued contributions over the next decade: the development and application of non-expected utility models of choice under uncertainty; the integration of "framing," "heuristics," and other psychological phenomena into decision making models; theoretical and empirical studies of multi-person bargaining; the theory of games of incomplete information; and game-theoretic field studies. For more complete overviews of these (as well as related) areas, the reader is referred to MacCrimmon and Larsson (1979) and Machina (1983a, 1983b) (non-expected utility models); Einhorn and Hogarth (1978, 1981), Slovic, Fischhoff and Lichtenstein (1977), and Kahneman, Slovic and Tversky (1982) (psychological decision theory); Roth (1979, 1983, 1985b) (bargaining); Milgrom and Roberts (1982a) and Wilson (1985) (games of incomplete information); and Graham and Marshall (1987) and Roth (1984) (game-theoretic field studies). Our report concludes with some brief remarks on the interaction of these different branches of inquiry as well as some general remarks regarding funding.

I. THE DEVELOPMENT OF NON-EXPECTED UTILITY MODELS OF DECISION- MAKING

From the late 1940's to the late 1970's, the "expected utility" approach proposed by Bernoulli (1738) and axiomatized by von Neumann and Morgenstern (1947) provided the framework for virtually all theoretical and applied work in decision theory, game theory, and the economics of uncertainty (e.g., gambling and insurance decisions, portfolio choice, job search). Essentially, this model postulates that individuals assign (or act as if they assign) a utility value U(x) to each possible monetary or non-monetary outcome x, and when faced with a set of alternative risky prospects, choose the one that yields the highest mathematical expectation of utility. Adopted primarily because of the normative appeal of its axioms, the elegance and tractability of its characterizations of behavior, and the large number of theoretical results it has produced, the expected utility model never received the type of careful empirical testing by economists that they typically accord their other theories or that had been routinely carried out by psychologists (e.g., Edwards, 1953, 1954, 1955). Throughout this period, practically the only empirical matter to receive any attention was a single example due to Allais (1953) that has come to be known as the "Allais Paradox." This example consists of asking a person to choose a risky prospect out of each of the following pairs:

$$\text{1.00 chance of \$1M} \;\succ\; \begin{cases} \text{.10 chance of \$5M} \\ \text{.89 chance of \$1M} \\ \text{.01 chance of \$0} \end{cases}$$

and

$$\begin{cases} \text{.10 chance of \$5M} \\ \text{.90 chance of \$0} \end{cases} \;\succ\; \begin{cases} \text{.11 chance of \$1M} \\ \text{.89 chance of \$0} \end{cases}$$

While the expected utility model explicitly predicts that an individual would either make the respective choices of a_1 and a_4 (if the term [-.10U(5M) + .11U(1M) - .01U(0)] were positive) or else a_2 and a_3 (if it were negative), experimenters such as Allais (1953), Morrison (1967), Moskowitz (1974), Raiffa (1968), Slovic and Tversky (1974), and others have found that the modal if not majority choice of subjects has been for a_1 in the first pair and a_3 in the second. Although this finding might have been expected to stimulate further empirical inquiry, it was with few exceptions (e.g., MacCrimmon 1968) treated largely as an isolated example, and such preferences were universally considered to be "mistakes" on the part of the subjects who expressed them.

The last ten years have seen a blossoming of economists' interest in the empirical validity of the expected utility hypothesis and the development of alternative models of individual choice under uncertainty. This phenomenon, and its growing acceptance in a field traditionally wedded to the expected utility model, is due to two parallel developments. The first is the recognition of the systematic nature of observed departures from expected utility maximization, in particular, of violations of the key "independence axiom" of the theory. Experimenters have now identified four types of violations of the independence axiom: the "common consequence effect" (e.g.,

MacCrimmon, 1968; MacCrimmon and Larsson, 1979); the "common ratio" or "certainty" effect (Hagen, 1979; Kahneman and Tversky, 1979; MacCrimmon and Larsson, 1979); "oversensitivity to small probabilities" (Edwards, 1955; Ali, 1977; Yaari, 1965); and the "utility evaluation effect" (Karmarkar, 1974; McCord and de Neufville, 1983, 1984). Each of these have been independently observed, and sometimes independently discovered, by researchers in various fields (economics, psychology, operations research). More significantly, each of these four "effects" has been shown to follow from the *same* qualitative form of departure from expected utility preferences (Machina, 1983a, 1983b). This particular type of departure from expected utility preferences has also been observed in laboratory rats choosing over alternative "lotteries" (random reinforcement schemes for food) (Battalio, Kagel and MacDonald, 1985).

The second advance in the last decade has been the development and analysis of non-expected utility models of choice under uncertainty, for the most part, generalizations of the expected utility model (Chew, 1983; Chew and MacCrimmon, 1979a, 1979b; Fishburn, 1983b; Hagen, 1979; Machina, 1982a; Quiggin, 1982; Selden, 1978; Yaari, 1987). These models preserve the standard economic framework of maximization, and allow for the study of the behavioral properties of monotonicity (first order stochastic dominance preference), risk aversion, comparative risk aversion, asset and insurance demand, etc., in a more general framework, giving us a much better idea of which aspects of the expected utility model (and the tremendous body of economic and game-theoretic analysis based on it) are robust to violations of the expected utility hypothesis and which are not. In addition, most of these models have the ability to incorporate the systematic nature of preferences revealed by the above mentioned departures from expected utility, allowing for a more structured (e.g., parametric) testing and measurement of such effects.

Economists have now begun to take seriously observed violations of another of the expected utility axioms, namely, transitivity. In what was at first a skeptical reaction to findings by psychologists that pairwise preferences over certain types of lotteries are intransitive (Lichtenstein and Slovic, 1971, 1973), economists set out to test this phenomenon for themselves, and indeed found it (Grether and Plott, 1979; Pommerehne, Schneider and Zweifel, 1982; Reilly, 1982) (this effect is discussed further in Section II below). Since transitivity also constitutes one of the cornerstones of the economic theory of choice under *certainty*, the implications of this finding (and more important, of economists' acceptance of it) for economic research are great indeed.

Motivated in large part by the above empirical results, another class of new theoretical models (Bell, 1982; Fishburn, 1983a; Loomes and Sugden, 1982) have dropped the property of transitivity and offer consistent explanations of a large variety of other phenomenon as well as formal characterizations of the concept of "regret" in economic choice.

Given the existing developments in this area, we feel that the two most promising avenues for future work are the application of non-expected utility models to economic issues and empirical inquiry of a more structured and directed nature. Regarding the former, researchers have begun to apply non-expected utility models to the analysis of important economic questions, including some that could not be satisfactorily answered by the traditional expected utility framework (Kreps and Porteus, 1978, 1979; Machina, 1982b, 1984; Rossman and Selden, 1979; Selden 1979a, 1979b), and such work can be expected to lead to more satisfactory models of asset and insurance markets, optimal lottery design, etc. These newer models also provide a more flexible framework for the elicitation of preferences in decision

analysis contexts, and to the extent that they better represent the attitudes of decision makers, they possess prescriptive value. Finally, the common nature of observed departures from expected utility preferences allows for the construction of more empirically grounded policy prescriptions (Machina, 1983a).

We feel that those studies that incorporate systematically varying parameters (e.g., MacCrimmon and Larsson, 1979) as well as realistic economic incentives (e.g., Lichtenstein and Slovic, 1973; Grether and Plott, 1979; MacCrimmon and Wehrung, 1985) hold the greatest promise for a better qualitative and quantitative understanding of the actual nature of individual preferences over lotteries. A natural and important next step would be the design and implementation of field studies involving the interaction of agents in "real world" markets and institutions, corresponding to the type described in Section V below.

II. THE INTEGRATION OF "FRAMING," "HEURISTICS," AND OTHER PSYCHOLOGICAL PHENOMENA INTO DECISION-MAKING MODELS

In addition to the above rather sharply defined departures from the traditional economic model of choice under uncertainty, researchers over the past decade have uncovered several aspects of decision making that challenge the very foundations of classical decision theory.

The principal finding in this area has been the sensitivity of individuals' responses to the manner in which probabilistically or actuarially identical problem situations (decisions, choices or judgments) are presented or "framed" (Slovic, 1969; Payne and Braunstein, 1971; Moskowitz, 1974; Kahneman and Tversky, 1979; Schoemaker and Kunreuther, 1979; Hershey and Schoemaker, 1980; Tversky and Kahneman, 1981; Hershey, Kunreuther and Schoemaker, 1982; Slovic, Fischhoff and Lichtenstein, 1982).

A dramatic illustration of such an effect is given by McNeil, Pauker, Sox and Tversky (1982), who asked people to imagine that they had lung cancer and had to choose between two therapies: surgery or radiation. Each therapy was described in some detail. Then, some subjects were presented with the cumulative probabilities of surviving for varying lengths of time after each type of treatment. Other subjects received the same cumulative probabilities expressed in terms of dying rather than surviving (e.g., instead of being told that 68% of those having surgery will have survived after one year, they were told that 32% will have died). Framing the statistics in terms of dying dropped the overall percentage of subjects choosing radiation therapy over surgery from 44% to 18%. In fact, of the three groups of subjects used in the study: patients, students, and physicians, this effect was found to be the strongest among physicians. Numerous other examples of this type may be found in the above cited studies.

A related group of findings are what may be termed "response mode effects." One distinction in experimental work, for example, is whether a task is presented as one of judgment or evaluation of individual options, or of choice among two or more options. Although classical decision theory views these processes as equivalent, studies have found that the information-processing strategies used in making choices are quite different from those employed in valuing individual options. As a result, choices and evaluative judgments over the same sets of options often differ, sometimes dramatically.

An early demonstration of this effect was conducted by Lichtenstein and Slovic (1971), who offered subjects two types of gambles: one type featuring a high probability of winning a

modest sum of money (the "P-bet") the other type featuring a low probability of winning a larger sum of money (the "$-bet"). They found that people often *chose* the P-bet but assigned a *greater monetary value* to the $-bet. Similar "preference reversals" have subsequently been observed by Lichtenstein and Slovic (1973), Grether and Plott (1979), Pommerehne, Schneider and Zweifel (1982), and Reilly (1982) (see also Slovic and Lichtenstein, 1983). This phenomenon is of particular interest to economists since it implies that preferences over the two bets and their respective certain monetary equivalents form an intransitive cycle.

Another class of phenomena is the use of "heuristics" in judgment under uncertainty. While such "rules of thumb" typically serve to lower the informational and cognitive costs of decisions, they can be shown to lead to incorrect conclusions in certain situations. Among those systematic tendencies that researchers have uncovered are "availability" (where the estimated frequencies or probabilities of events are unduly influenced by the ease with which examples can be brought to mind), "representativeness" (where judgment on the basis of similarity can lead to insufficient incorporation of prior probabilities and systematic violations of Bayes' Law), and "anchoring" (where estimates or judgments are insufficiently adjusted from initially computed or considered values) (e.g., Kahneman, Slovic and Tversky, 1982). Indeed, it was the finding that subjects would anchor on the prize levels in generating monetary values and on the success probabilities in outright choice (Slovic and Lichtenstein, 1968) that originally led these researchers to predict the existence of the "preference reversal phenomenon" of the previous paragraph.

Needless to say, framing and related phenomena possess important potential implications for public policy. One recent example is the lobbying effort by the credit card industry to have differentials between cash and credit prices labeled "cash discounts" rather than "credit surcharges" (Thaler, 1980). Similarly, there is evidence that the way unit prices are presented in supermarkets can have significant effects on consumers' choices (Russo, 1977). In general, if individuals' preferences over alternative social and political choices depend on how these issues are framed, it is not clear how best to promulgate social policies such as cigarette warning labels, truth-in-lending laws, or informed consent laws. If, as we have seen, reporting survival rates results in different choices than reporting mortality rates, what is the "right" thing to do? The possibility that there may be no "neutral" way to frame a decision problem or to present information, coupled with the ease with which preferences can be manipulated, has important ethical and political implications that need to be examined. In the extreme case, such issues become critical in a democracy if, for example, votes are significantly affected by the way in which issues are phrased on ballots.

We feel that the most productive future work in this area will proceed along two lines. First, although several major psychological phenomena have been identified and numerous explanations for these effects have been proposed, we continue to lack any sort of unifying explanatory or predictive principle behind such effects comparable to the essential unity of the observed departures from expected utility maximization discussed in Section I above. Such a unified understanding of these effects (and the conditions under which they are most likely to arise) must come from a more holistic approach to the process of choice, linking framing and response mode effects to the mechanisms whereby stimulus information is perceived, encoded, and processed, and the resulting response is expressed. In particular, approaches that view choice or evaluation behavior as being generated by a multi-stage process that involves the encoding (e.g., framing) of information, its evaluation, and the expression of choice or valuation seem to

hold the greatest promise for a unified understanding of these diverse yet well-established phenomena.

A second area of future research concerns the incorporation of these and other psychological phenomena (unified or otherwise) into economic models, both at the individual and at the market level. The growing acceptance of experimental data and of alternatives to the expected utility model reported in Section I reflects a level of receptiveness among economists unknown ten years ago. Indeed, most (though by no means all) of the pioneering efforts along these lines have been conducted by economists themselves.

At the individual level, Thaler and Shefrin (1981) have formalized the behavioral concept of "self control" and incorporated it into a model of intertemporal choice capable of explaining institutions such as Christmas Clubs and whole life insurance, both of which offer extremely low rates of return and cannot be explained by standard economic theories. This model can also explain the observed (and heretofore puzzling) tendency for increases in mandatory pension contributions to be less than fully offset by decreases in other forms of savings, a finding that has implications for both national saving and national health insurance policy (see also Schelling, 1984, and Winston, 1980). Similarly, Akerlof and Dickens (1982) present a formal model of cognitive dissonance in economic behavior, with applications to job safety and social security policy, and Hogarth and Kunreuther (1985, 1989) develop a formal model of the concept of "ambiguity" and its implications for the demand for insurance.

At the market level, the existence (prevalence?) of agents who are "quasi-rational" (i.e. who systematically violate the expected utility axioms and Bayes' rule, but are consistent in other respects) raises many questions for economic theory and practice. Theoretical studies by Akerlof and Yellen (1985), Haltiwanger and Waldman (1985), Kreps, Milgrom, Roberts and Wilson (1982), Russell and Thaler (1985), and others have addressed such issues as the robustness of standard market efficiency properties to the number of such agents and to the magnitude of their departures from standard economic rationality. It is also possible to determine those characteristics of markets (e.g., the possibility of short sales) that affect their relative sensitivity to quasi-rational behavior.

Empirically, researchers are now beginning to investigate whether actual markets do or do not show evidence of quasi-rational behavior and whether it affects the performance of these markets. Dreman (1982), for example, has shown how the prevalence of the representativeness heuristic and consequent departures from Bayes' rule can explain the well-documented above-normal returns that can be obtained from investing in stocks with low price/earnings ratios. De Bondt and Thaler (1985) have used these same principles to predict the existence of a new anomaly, namely, that contrary to the maxims of the standard "efficient markets/random walk" theory of financial markets, stocks that have done poorly for several years later yield excess returns (this phenomenon was in fact subsequently observed).

III. THEORETICAL AND EMPIRICAL STUDIES OF BARGAINING

In addition to the relatively impersonal forces of the marketplace, many aspects of both the national and the international economy (e.g., wage bargaining, terms of access to international markets) are influenced by the outcome of negotiations. Bargaining, of course, also

plays a key role in many if not most non-economic (e.g., social or political) interactions such as the legislative process and arms control negotiation.

Because pure bargaining is the economic situation in which the personal attributes of individual agents have the most potential to influence the outcome, standard modes of economic analysis have traditionally classified bargaining problems as fundamentally "indeterminate" (Edgeworth, 1881; Hicks, 1935), while modern attempts to resolve this indeterminacy have depended on more detailed models of individuals, either in terms of their risk preferences (Nash, 1950; Roth, 1979), their time preferences (Rubinstein, 1982), their information (Fudenberg, Levine and Tirole, 1985), or some combination of these. Recent progress in the strategic approach to the theory of bargaining has been due in large part to two developments in the general theory of noncooperative games. One of these developments, originating in the work of Harsanyi (1967, 1968a, 1968b), extends the theory to include games of "incomplete information," which allow more realistic modeling of bargaining situations in which a bargainer holds private information (see Section IV below). The other development, originating in the work of Selten (1973, 1975) on "perfect equilibria," offers a technique for reducing the multiplicity of possible equilibria found in many noncooperative games by considering the credibility of the implicit or explicit "threats" involved. An important reformulation of some of these ideas on credible equilibria, which makes explicit how behavior may depend on agents' beliefs about one another's reactions, has been given by Kreps and Wilson (1982a).

As mentioned above, one of the fundamental recent advances in this area is an improved understanding of the nature and causes of disagreement in negotiations, even when both sides recognize that there might be gains from mutual cooperation. Whereas earlier models interpreted disagreements as resulting entirely from mistakes or misperceptions on the part of the bargainers, current models frequently predict a positive probability of disagreement in equilibrium. Basically, what has been captured in these models is the idea that, if you bargain in such a way that you always reach an agreement whenever a mutually profitable agreement is possible, you are probably not getting as good terms as you could have (e.g., Myerson and Satterthwaite, 1983; Chatterjee, 1985). The price of holding out for better terms is that you will have to forgo some worthwhile agreements.

The nature and role of precedents and historical relationships in determining the outcome of bargaining and strategic interaction has also come to be much better understood. Recent work demonstrates, for example, that the role of reputation is different in repeated bargaining involving the same parties than in in bargaining between parties whose past histories involved other bargaining relationships. One example is the influence of the Falklands War on England's respective relationships with Argentina and, say, Spain (see Wilson, 1985, and Rosenthal, 1985, for surveys of this subject).

Another theoretical advance has been the systematic analysis of the effect of a bargainer's risk aversion on his or her predicted bargaining success (Roth, 1979, 1985a; Kihlstrom, Roth and Schmeidler, 1981; and Roth and Rothblum, 1982). Apart from its implications for bargaining theory itself, this work is important in that it serves to connect the theory with the substantial literature on choice under uncertainty. One potentially fruitful line of further work in this area is the application of the non-expected utility models of Section I to bargaining theory (e.g., Crawford, 1989).

These theoretical developments have been matched by a corresponding advance in experimentation. Paradoxically, the designs of early experiments were such that they could only

be interpreted as tests of bargaining models under the assumption that all parties had identical risk-neutral preferences, even though the theories they sought to test implied that differences in the bargainers' success were due to differences in their risk posture. However, starting with Roth and Malouf (1979), techniques have been developed that allow experimenters to control for differences in risk posture and thus to test these theories properly. These techniques have recently been extended by Daley, Dickhaut, and O'Brien (1985). Although experimental tests have falsified some of the major predictions of bargaining models (Roth, Malouf and Murnighan, 1981; Roth and Murnighan, 1982; Roth and Schoumaker, 1983), they have demonstrated that there are a number of observable regularities in bargaining, concerning, for example, the establishment of "focal points," the criteria that determine "credible" bargaining positions, and the roles of bargainers' expectations of one another and the structure of their shared information. Finally, although not experimental, Raiffa (1982) has applied bargaining theory to the analysis of such important political issues as the Panama Canal negotiations, the Camp David Accords, and the Law of the Sea Conference.

Besides applied studies of the type discussed in Section V below, perhaps the most promising avenue of future research lies in the application of computer technology, which offers the opportunity of more thorough interactive experiments. The possibilities of more control in multiple-person situations are obvious. The development of standardized software and operating systems would greatly lower the cost of performing experiments and go far toward generating a large body of empirical data free from the effects of differing experimental design.

IV. GAME THEORY: GAMES OF INCOMPLETE INFORMATION

The last decade has seen a remarkable burst of activity in game theory and its applications, mostly in economics and related fields but also in political science and biology. This work has provided both striking new theorems of general applicability and explanations for specific observed patterns of behavior that could not be understood in terms of earlier analyses.

Two factors have been central in this success. The first is explicit attention to the timing of opportunities for action and to the information available to decision-makers when they act. This is done by working with games expressed in their more detailed or "extensive" form (Luce and Raiffa, 1957) where these aspects are made explicit, and by considering games with repeated opportunities for play. The second factor has been the recognition that differences in the information available to the players is a key determinant of their strategic behavior (Harsanyi, 1967, 1968a, 1968b).

A simple example involving three different card games can illustrate the importance of the structure of information. In Game 1, each player is dealt two cards face up. As many rounds of betting as are desired follow, then the best hand wins. This (trivial) game involves perfect public information, which historically has been the framework of much economic analysis. Game 2 is similar except each player gets one card face up and one face down and cannot look at the latter until the betting is completed. This game, which involves uncertainty but no private information, is not trivial, but would not generate any really interesting behavior. In Game 3, each person gets one card face up and one face down and can look at his or her "hole card." Here there is private information, and one can imagine that actual play would involve a variety

of phenomena that would not have arisen before, such as bluffing, reputation formation, and attempts to infer others' private information from their behavior.

		Player II	
		C	S
Player I	C	(3,3)	(0,5)
	S	(5,0)	(1,1)

A game that has received much attention is the well-known "Prisoner's Dilemma" (e.g., Luce and Raiffa, 1957). Here, each player has two options: C ("cooperate") or S ("sell out"), and they must make their choices simultaneously and independently. As seen from the example payoff matrix (which specifies the respective payoffs of the players depending upon their choices), each player can do better by playing S rather than C no matter what action his or her opponent takes. Yet the payoffs obtained when both play S are strictly less than when both play C: making the "rational" choices yields a socially inefficient outcome. This class of games has been widely studied and applied in economics, ethical theory, political science, sociology, and biology. It has been used to model such disparate problems as industrial competition on prices, advertising, and new product introduction; the provision of collective benefits such as pollution control; the formulation of alliances; arms races and nuclear deterrence; altruistic behavior within species; and competition between species (Axelrod, 1984; Maynard Smith, 1982; Kreps, Milgrom, Roberts and Wilson, 1982; Scherer, 1980).

Many of these applications involve repeated play of this game, with the payoffs aggregated over the rounds. A pattern that has been widely observed in practice, and almost universally in the laboratory, is that (except possibly in the last rounds of play) cooperative behavior is adopted (Rapoport and Chammah, 1965; Worchel, 1969). This has been seen as a fundamental problem, since playing S at each stage can be proven to be the unique stable pattern of action that would arise from individually self-interested behavior.

Recently, it has been shown that introducing a "small amount" of the "right kind" of incomplete information can generate equilibrium behavior that exhibits the patterns of cooperation observed empirically (Kreps, Milgrom, Roberts and Wilson, 1982). Specifically, it is assumed that while each player is "rational" in the classical sense, neither is completely certain that his or her opponent is. For example, each player might allow some slight possibility that the other enjoys cooperating, or than he or she follows a conditionally cooperative behavioral rule such as tit-for-tat. In such cases the unique equilibrium behavior will be to choose C early in the interaction in the hope that this cooperation will be reciprocated. Any failure to cooperate destroys the possibility of future cooperation, because the uncertainty disappears and one is back in the full-information situation. If there are enough opportunities for future mutual gain, the short-run advantages to playing S are overwhelmed by the loss of these opportunities, and cooperation results. This is important because it reconciles the hypothesis of rational self-interested behavior (which has elsewhere proven so powerful) with the empirical observations of cooperation, and it does so in a manner that offers promise of wider applicability.

When such informational asymmetries are present, it becomes necessary to infer others' private information in order to be able to forecast their behavior. This provides the basis for

reputations, which are essentially estimates of motivation and future behavior based on inferences from past observations (Kreps and Wilson, 1982b; Milgrom and Roberts, 1982b; Wilson, 1985). Essentially, reputations can be expected to arise whenever there are these types of informational asymmetry plus the opportunities for repeated dealing and for observing past behavior. The possibility of developing a reputation for aggressive responses to competition that would deter challenges from competitors provides an explanation for predatory pricing. The possibility of obtaining future credit at better interest rates if one has a reputation for prompt repayment provides an important motivation for paying on time, even when it is painful to do so. Similarly, reputational concerns provide incentives for the maintenance of product quality and for living up to agreements. Moreover, although formal analyses have yet to be undertaken, similar arguments would seem to provide insight into the variety of phenomena in political science and international relations known as the "rationality of appearing irrational," which suggests that apparently extreme overreactions to slight provocations can be useful in deterring more serious challenges.

This result, that informational asymmetries can generate rich, complex patterns of strategic behavior that would not otherwise arise, is the key to understanding a wide variety of phenomena. Formal work in this area has begun to identify certain recurrent phenomena: "moral hazard" (the problem of unobservability of actions), "adverse selection" (the problem of unobservability of privately known information), "incentive compatibility" (the problem of designing contracts, offers, or institutions so as to induce individuals to truthfully reveal their information or preferences through their choices or actions), and "signaling" (costly and possibly unproductive actions taken to aid others in inferring one's private information) (e.g., Akerlof, 1970; Arrow, 1968; Groves and Ledyard, 1977, Pauly, 1968; Spence, 1974). Current and potential applications include optimal regulation of industries under imperfect information; improved voting procedures; optimal bidding mechanisms for government contracts, oil-leases or Treasury bills; optimal design of employee-management schemes; and stability and detection in cartels or collusive groups (e.g., Baron and Myerson, 1982; Brams and Fishburn, 1983; Hamburger, 1979; Milgrom and Weber, 1982).

This area is developing so rapidly that it is difficult to identify the most fruitful lines of research, even over the next few years. It is safe to say, however, that it will continue to be characterized by important theoretical advances along the lines outlined above.

V. GAME THEORY: FIELD STUDIES

In addition to its use as a theoretical tool in economics and political science, game theory has recently begun to emerge as a tool in applied economics, yielding surprising new insights into "real world" phenomena. Roth (1984, 1986) for example studied the labor market facing graduating medical students seeking internships and residencies at U.S. hospitals. From 1900 to 1951, this market was in considerable disarray, and by the 1940's the rules by which it was organized were being changed every few years in an effort to avoid massive market failure. In 1951 a new procedure was adopted which immediately stabilized the market, and it remains in use to this day. However, since the mid 1970's the market has once again begun to exhibit problems reminiscent of those prior to 1951. Working from minutes of the meetings of medical organizations attempting to deal with these problems, Roth was able to reconstruct the various

rules by which this market had been organized over time, and to demonstrate that the market failure prior to 1951 was due to the fact that the market did not produce an allocation in the "core" (the set of strategically stable arrangements), that the procedure adopted in 1951 did produce a core allocation, and that changes in the demographics of the market that became significant in the mid 1970's prevented the procedure from continuing to do so. Thus a standard set of game-theoretic tools was able to explain the operation of this market since its inception at the turn of the century, and to diagnose its current ills (in fact, several other contemporary problems facing the market were also illuminated by this analysis).

A similar analysis was conducted by Graham and Marshall (1987), who examined the institution of bidder "rings" at machine-tool auctions, obtaining detailed information on the organization and operation of these rings from informants among dealers who are regularly involved in such arrangements. Other such studies of real world institutions and practices include Wolfson (1985) on the lease-versus-buy question and Staten and Umbeck (1982) on disability compensation for air traffic controllers.

Once again, the nature of this topic is such that it is almost impossible to predict those *particular* areas in which the most useful future progress will be made. We feel, however, that serious proposals of this kind that show evidence of both theoretical sophistication and careful attention to the quantitative and qualitative aspects of institutions are likely to lead to an improved understanding of many real-world phenomena.

VI. CONCLUSION

It would be unrealistic to pretend that there is no tension between the above branches of inquiry, or that they will not continue to develop in at least some isolation from each other. Economists studying the market implications of non-expected utility models are likely to ignore at least some of the psychological phenomena discussed above, and bargaining and game theorists will continue to use the expected utility framework for much of their work. Accordingly, it would be naive to expect that most topics worthy of funding over the next decade (such as the ones we have suggested above) will not continue to reflect these divisions.

Nonetheless, researchers in these areas are in closer contact and are experiencing more cross-stimulation than ever, and we feel that there are at least some specific opportunities to further this trend. At a very basic level, proposals should be judged in part on whether their authors are at least cognizant of the above-mentioned psychological phenomena as well as the potential economic implications of their findings. Similarly, although the usefulness of the laboratory is far from being exhausted, another positive action would be the encouragement of the types of field studies discussed in Section V. Though not always possible or appropriate, another potentially fruitful type of approach might be joint experimental/field studies of a particular aspect or phenomenon. Besides yielding methodological insights that would undoubtedly carry over to the study of other phenomena, the funding of this type of work may well encourage researchers from different traditions to join forces in the design and execution of such combined endeavors.

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