HARSANYI, JOHN C. (1920-2000)

John Harsanyi worked to extend the general theoretical framework of economic analysis. He established the modern basis for utilitarian ethics. He developed a general bargaining solution to that included the Nash bargaining solution and the Shapley value as special cases. He became a leading advocate of non-cooperative game theory as the general framework for analysis of social interactions among rational individuals. He developed the tracing procedure to select among multiple equilibria of games. He showed how to interpret mixed-strategy equilibria in game theory. His general model of Bayesian games with incomplete information became a cornerstone of information economics.

John Harsanyi extended the theoretical framework of economic analysis with major contributions to game theory and welfare economics. His general approach to social theory was based on a fundamental assumption that people are rational decision-makers who share a basic understanding of the things that they value in the world. His personal experiences made him profoundly skeptical of theories that try to justify social systems from other assumptions, without respecting the values, the rationality, and the intelligence of all individuals in society. He understood that social institutions and policies should be evaluated by carefully analyzing their impact on individuals' welfare. From his training in philosophy, he appreciated the basic importance of general unified frameworks in social theory. He recognized the foundations for such a framework in Bayesian decision theory, with its compelling axiomatic characterizations. So he devoted his career to the development of a general framework for economic analysis based on these principles. His best-known contribution is the general model of Bayesian games with incomplete information, which became a cornerstone of information economics.

Harsanyi grew up in Budapest, Hungary, where his distinction as a student was marked in 1937 by first prize in Hungary's national mathematics competition. But at the university he chose to study pharmacy, so that he could share his father's business, as other options were then clouded by the threat of war. He was forced into hiding by Nazi racial policies during the last months of the German occupation. After the war, he studied philosophy and earned a doctorate from University of Budapest in 1947, but his intellectual independence led to political difficulties with the Communist regime, which forced him out of the university. In 1950, he fled from Hungary and found refuge in Australia.

He began studying economics at Sydney University, earning an M.A. in 1953. He then held a lectureship at the University of Queensland, where he began to read game theory. In 1956, when he already had published articles on welfare economics, he enrolled as a student at

Stanford University, earning his second doctorate in 1959. He then held faculty positions at the Australian National University, Wayne State University, and, from 1965 on, in the School of Business Administration at the University of California, Berkeley.

In his early contributions to welfare economics, Harsanyi established the modern basis for utilitarian ethics. Von Neumann and Morgenstern (1947) had shown axiomatically that a rational individual should choose among risky alternatives by maximizing the expected value of a cardinal utility function, but some economists doubted whether this cardinal utility, defined for individual risk analysis, had any relevance for social welfare analysis. Harsanyi (1953) argued that, in ethical decision-making, to avoid any dependence on our particular roles in society, we must imagine ourselves in an initial position before social roles have been assigned, when we could only anticipate getting the role of someone drawn at random from the whole population. Thus, ethical decision-making involves an essential element of risk, and we naturally get a social welfare function equal to the average utility of all members of society.

This average requires interpersonally comparable utility scales, assessed by sympathetically comparing the prospect of being in one person's position or another's. Harsanyi argued, as his *similarity postulate*, that such comparable utilities for all individuals can be generated by a common utility function, based on shared human values, once the factors that cause apparent differences among individuals' tastes are included as parameters of the function. Harsanyi (1955) showed that, even without this similarity postulate, the Neumann-Morgenstern utility axioms (applied to individual and social decision-making) and the Pareto welfare axiom (that social preferences should be consistent with any unanimity of individual preferences) together imply that social utility can only be defined as some linear function of individual utility values.

In his later work on welfare economics, Harsanyi (1977a, chapter 4; 1977b; 1977c), argued that ethical analysis should be used to evaluate general social rules or institutions, rather than specific acts. That is, we may consider ethical rules that prescribe people's behavior in a wide range of situations, recognizing that behavior in other situations could be determined by self-interest according to some Nash equilibrium. Then, as rule utilitarians, we should advocate rules that yield the highest average of expected utilities for all individuals.

Harsanyi began working on cooperative game theory in the mid 1950s, when many different cooperative solution theories were being studied. But most of these theories could yield multiple solutions or no solutions for a game, or could not even be defined without some special structures like transferable utility. Harsanyi's view of the field was clarified by his insistence that a good solution concept should yield one well-defined solution to any game. At that time, there were only two cooperative solution concepts that yielded unique solutions to broad classes of games: the Shapley (1953) value for games with transferable utility, and the Nash (1950) bargaining solution for two-person games without transferable utility. Harsanyi (1956) showed that the Nash bargaining solution could be derived from an earlier theory of Zeuthen (1930). Then Harsanyi (1963) developed a general bargaining solution that included the Nash bargaining solution and the Shapley value as special cases.

In the mid 1960s, Harsanyi shifted from cooperative to noncooperative game theory. The basic definition of noncooperative equilibrium had been introduced by Nash (1951). But there was little further development of noncooperative theory until Schelling (1960) analyzed bargaining processes as games with multiple equilibria, where any cultural or environmental factor that focuses the players' attention on one equilibrium can become a self-fulfilling prophecy. Harsanyi (1961) argued that the distribution of power that is measured by a cooperative solution could be the focal factor that selects among the many noncooperative equilibria of a bargaining game. But then Harsanyi began to recognize the force of Nash's early arguments for the greater generality of the noncooperative approach, which is based on a precise specification of each player's individual decision problem, which is lacking in cooperative models. Thus Harsanyi became a leading advocate of noncooperative game theory.

Harsanyi understood that the noncooperative approach could not become a standard methodology for applied economic analysis without some refinements of Nash's equilibrium concept, because it can yield very large sets of equilibria for many games. So he began a search for theoretical criteria to select among multiple equilibria, which culminated in his book with Selten (1988). Their selection theory is based on Harsanyi's (1975) tracing procedure, which can select a unique equilibrium from a given initial hypothesis about the players' strategic behavior. For each number t between 0 and 1, we define a t-auxiliary game that differs from the original game in that each player thinks that the other players have probability 1-t of behaving according to the initial hypothesis; otherwise, with probability t, they choose their strategies rationally. The tracing procedure finds a continuous path of equilibria for these auxiliary games, starting from the trivial 0-auxiliary game, and ending at a unique equilibrium of the original game when t=1.

Harsanyi's work on incomplete information in games began (1962) with the problems of extending Nash's bargaining solution to situations where players do not know each other's payoffs. In this work, he began to recognize the problems of modeling players' beliefs about each other's beliefs in a game. Harsanyi (1967-8) confronted these modeling problems at the most general and fundamental level, showing how the basic definition of normal-form games should be modified to analyze situations where individuals have different information.

The early development of game theory was based on von Neumann's (1928) argument that any dynamic game in extensive form can be represented by a conceptually simpler one-stage game in normal form. In this normal-form game, each player chooses a strategy that is a complete contingent plan of action, specifying what the player would do at each stage of the dynamic game, as a function depending on any information that the player might learn during the game. In normal-form analysis, we assume that the players choose their strategies simultaneously and independently at the start of the game, before anyone gets any private information, and thereafter their behavior in the dynamic game can be determined mechanically by their strategies. Thus, questions about the players' private information are suppressed in normal-form analysis.

Harsanyi (1967-8) showed how to correct this deficiency by developing a more general game model that allows players to have different initial information, without losing the analytical simplicity of the normal form. Each player's private information at the start of the game is represented by a random variable that is called the player's *type*. Harsanyi defined a *Bayesian game* to be a mathematical model that specifies (1) the set of players, (2) the set of feasible actions for each player, (3) the set of possible types for each player, (4) each player's expected payoff for every possible combination of all players' actions and types, and (5), for each possible type of each player, a probability distribution over the other players' possible types, which describes what each type of each player would believe about the others' types.

The beliefs in a Bayesian game are said to be *consistent* if the players' type-contingent beliefs can all be derived by Bayes's rule from some common prior distribution over types. Although not analytically essential, this assumption of consistent beliefs has been regularly used in applied economic analysis, because it allows that differences in players' beliefs may be explained by different previous experiences.

To represent dynamic extensive-form games by games in Bayesian form, each player's action in a Bayesian game may be interpreted as a plan that describes what the player would do in any situation after the beginning of the game, as a function of what the player may learn during the game. A player's strategy, in von Neumann's original sense, would then be a function that specifies a feasible action for each of the player's possible types. But each player is assumed to know his type already when the game begins, and so Harsanyi worked to avoid the fiction of strategic decision-making by players who have not yet learned their types. It would be better, he argued, to imagine that a player's different possible types correspond to different agents, one of whom will be randomly selected to be active in the game. The point is that each player's optimal decisions will maximize his conditional expected payoff given his actual type, and there is no significance to any expected value that is not conditioned on such type information.

Harsanyi emphasized that games must be analyzed from the perspective of someone who only knows the information common to all players, which is summarized in the Bayesian game model. Game-theoretic analysis requires us to deny ourselves any knowledge of any player's actual type, so that we can appreciate the uncertainty of the other players who do not know it. The actual type of each player, being private information, must be treated as an unknown quantity or random variable in our analysis. So an equilibrium of a Bayesian game specifies a feasible action for every possible type of every player, such that the specified action for each type of each player maximizes his conditional expected payoff, given his type, given his beliefs about the others' types, and given the type-contingent actions of the other players according to this equilibrium.

Applications of Bayesian games developed quickly. Harsanyi and Selten (1972) defined a generalization of Nash's bargaining solution for Bayesian games, where players have incomplete information about each other. By embedding normal-form games in the larger space of Bayesian games, Harsanyi (1973) showed how to interpret mixed-strategy equilibria in noncooperative game theory. Such equilibria had seemed to imply paradoxically that rational players should base their decisions on randomizing devices like roulette wheels, but this apparent paradox was a consequence of the normal-form assumption that players choose strategies before they get any private information. By letting each player have some minor private information that changes payoffs only slightly, Harsanyi could transform any mixed-strategy equilibrium into a Bayesian equilibrium where each type chooses an optimal action without randomization.

Harsanyi's Bayesian games have become the standard economic model for analyzing transactions among individuals who have different information. Before 1967, the lack of a general framework for informational problems had inhibited economic inquiry about markets where people do not share the same information. The unity and scope of modern information economics were found in Harsanyi's framework.

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