Equilibrium analysis

Essays in honor of Kenneth J. Arrow, Volume II

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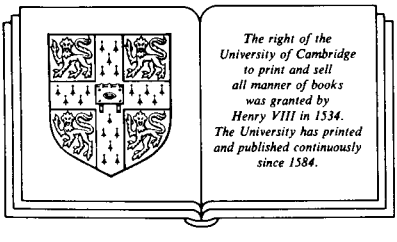

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Editors' preface

This three-volume work is composed of essays written by many of Kenneth Arrow's students and collaborators. Although it is impossible to cover the entire range of his contributions to economics, we have organized the presentation around the major topics of his research career: Volume I treats "Social Choice and Public Decision Making," Volume II covers "Equilibrium Analysis," and Volume III deals with "Uncertainty, Information, and Communication."

We would like to thank all contributors to these volumes not only for their cooperation in helping expedite on-time production but also for voluntary efforts contributed in reading and commenting on each other's essays. In addition, we acknowledge with thanks the help of the following outside referees: Chuck Blackorby, Mark Johnson, Mark Machina, John McMillan, and Joel Sobel.

Special thanks go to Deborah Bailey who coordinated our (sometimes chaotic) correspondence among authors, editors, and publisher; she cheerfully dealt with potential disasters and enabled us to deliver the completed manuscript as scheduled. Also, we would like to thank Colin Day and his staff at Cambridge University Press for a highly professional effort at their end.

Finally, and most importantly, we speak for all contributors in thanking Kenneth Arrow for being an inspirational teacher and colleague over the years. The intellectual standards he set and the enthusiasm with which he approaches our subject are surely part of all of us. We can only hope that these essays convey some sense of our appreciation and esteem.

Kenneth J. Arrow

The impact of Kenneth Arrow's work on twentieth century economics has been to change fundamentally economists' understanding of their discipline and their view of several major classes of problems.[1] Arrow was a leader in the post–World War II push to bring the full power of mathematics and statistics to bear on economic analysis. The fields of general equilibrium, social choice and welfare economics, mathematical programming, and economics of uncertainty have been fundamentally altered by his contributions. In addition, Arrow is a man of wide learning, refreshing spontaneity, personal warmth, and remarkable absence of pretension.

Born in 1921 to Harry and Lillian Arrow of New York City, Kenneth Arrow was raised in and around New York. He pursued his undergraduate studies at City College of New York. On graduation from CCNY in 1940, he was awarded the Gold Pell Medal for highest grades in the graduating class. He studied then at Columbia, in particular with Harold Hotelling, and received an M.A. in mathematics in 1941.

Arrow's studies were interrupted by World War II. He served with the Weather Division of the Army Air Force and there wrote his first scientific paper ("On the use of winds in flight planning"). However, his other professional activities in the division almost prevented this line of research. The new young group of statisticians in the Weather Division subjected the prevailing prediction techniques to statistical test against a simple null hypothesis based on historical averages for the date in question. Finding that prevailing techniques were not significantly more reliable, several junior officers sent a memo to the general in charge suggesting that the unit be disbanded and the manpower reallocated. After a succession of such memos, the general's secretary is reported to have replied brusquely on his behalf, "The general is well aware that your division's forecasts are worthless. However, they are required for planning purposes." The division remained intact.

[1] Arrow has a rich personal intellectual history. This is best summarized in the headnotes to his research papers in the *Collected papers of Kenneth J. Arrow*. We have borrowed freely from this material. A discussion of Arrow's contributions to each of the topics treated in this collection appears in the introductions to the individual sections.

In 1946, Arrow returned to Columbia for doctoral study with Hotelling. In 1947, he joined the Cowles Commission at the University of Chicago, then under the direction of Jacob Marschak. Cowles was then virtually synonymous with mathematical economics and econometrics in North America. With Hurwicz, Klein, Koopmans, and Marschak there, it formed an active research environment. Arrow was unsure then of his vocation. He considered the possibility of pursuing a nonacademic career as an actuary. Tjalling Koopmans advised him that actuarial statistics would prove unrewarding, saying, with characteristic reticence, "There is no music in it." Fortunately for economic science, Arrow followed this advice and decided to continue a research career.

In 1947, Arrow married Selma Schweitzer, then a graduate student in economics at the University of Chicago. Jacob Marschak, in his capacity as Cowles Commission Research Director, had arranged for the Commission to administer the Sarah Frances Hutchinson Fellowship. This fellowship was held by Sonia Adelson (subsequently married to Lawrence Klein) and then by Selma Schweitzer. The succession of fellows generated some administrative scrutiny. Upon review, it was determined that the terms of the bequest establishing the fellowship required the fellows to be women of the Episcopal Church of Seneca Falls, New York, and the fellowship was withdrawn from Cowles' administration. Nevertheless, the fellowship was clearly a great social success while at Cowles.

In 1948, Arrow joined the recently formed RAND Corporation in Santa Monica, California. RAND was then an active center for fundamental research, particularly in the fast-developing area of mathematical game theory. He returned to RAND during several subsequent summers. There, in the summers of 1950 and 1951, the collaboration with Leonid Hurwicz was initiated.

In 1949, Arrow accepted an assistant professorial appointment in economics and statistics at Stanford University. The research work and publications of the next decade represent an extraordinary burst of creativity and scientific progress. In the space of four years, 1951–4, three of Arrow's most important works of economic theory appeared: *Social choice and individual values* (1951), "An extension of the basic theorems of classical welfare economics" (1951), and "Existence of equilibrium for a competitive economy" (with G. Debreu, 1954). Work on the theory of social choice, started at RAND, was a particularly distinctive act of creation, since the theory was developed with very few antecedents. Arrow describes it as "a concept that took possession of [him]... development of the theorems and their proofs... required only about three weeks, although writing them as a monograph... took many months" (Arrow, *Collected papers*).

The Ph.D. from Columbia was awarded in 1950; and the dissertation, *Social choice and individual values,* was published in 1951. "Extension of the basic theorems of classical welfare economics" was developed for the Second Berkeley Symposium on Mathematical Statistics and Probability to which Arrow was invited in his capacity as a statistician.

In the early 1950s, Arrow pursued – largely by correspondence – joint work on general equilibrium theory with Gerard Debreu, who was then at the Cowles Commission in Chicago. Abraham Wald, with whom Arrow had studied at Columbia, had written several papers in the field but had run up against fundamental mathematical difficulties. It was the recognition by Arrow and Debreu of the importance of use of a fixed point theorem that led to major progress in this area.[2] Publication of Arrow and Debreu's "Existence of equilibrium for a competitive economy" represented a fundamental step in the revision of economic analysis and modeling, demonstrating the power of a formal axiomatic approach with relatively advanced mathematical techniques.

During the mid-1950s, Leonid Hurwicz was a frequent academic visitor to Stanford. In 1955–6 Hurwicz was at the Center for Advanced Study in the Behavioral Sciences at Stanford, and in 1957–8 he was a visiting faculty member in the economics department. Collaboration with Hurwicz led to papers in mathematical programming, decentralization, and classic work on the stability of competitive equilibrium. The research faculty in mathematical economics was housed in a converted residence, Serra House. Colleagues there included Herbert Scarf and Hirofumi Uzawa. The informal, quiet, and somewhat isolated setting resulted in a particularly friendly atmosphere and esprit de corps.

Arrow was rapidly promoted at Stanford: to associate professor in 1950 and to full professor in 1953. The full professorship included appointment to the new Department of Operations Research, in addition to economics and statistics. Mathematical programming is a recurrent area of Arrow's research interest, and the new department was founded with Arrow's vigorous support. Although the profession is used to it now, the mathematical complexity of the body of work was then regarded as a bit forbidding. This reputation was a source of some humor when Arrow received the 1957 John Bates Clark Award of the American Economic Association. At the presentation ceremony, introductory remarks were made by George Stigler, who reportedly advised Arrow, in a loud stage-whisper, "You should probably say, 'Symbols fail me.'"

[2] Credit for independent discovery of the importance of fixed point theorems in this context is due to Lionel McKenzie ["On equilibrium in Graham's model of world trade and other competitive systems," *Econometrica,* 22: 147–61 (1954)].

In 1962, Arrow served on the research staff of the Council of Economic Advisers. In 1963–4, he was visiting fellow at Churchill College, Cambridge. The collaboration with Frank Hahn on *General competitive analysis* was pursued there and continued at Stanford in 1967. During the late 1960s, Arrow took up a research program in continuous-time optimal control (a topic touched on twenty years earlier in his Army Air Force service). In collaboration with Mordecai Kurz of Stanford, the result was *Public investment, the rate of return, and optimal fiscal policy*.

In 1968, Arrow accepted a professorship at Harvard and moved to Cambridge, Massachusetts. For the next decade, Harvard was the center of his activity, though he returned to Stanford annually for summer-long seminar series.

When the Nobel Prize in Economics was created in the mid-1960s, a common parlor game among professional economists was to forecast the next recipient. Arrow was on virtually everyone's short list. It was hence no surprise when the 1972 Nobel Prize in Economic Sciences was announced. Arrow was the laureate, jointly with the distinguished British economic theorist, John Hicks of Oxford. Age 51 at the time of the award, he is (at this writing) by far the youngest recipient of the Nobel Prize in Economics.

In 1979, Arrow returned to Stanford; he has been on the faculty there continually since then. Arrow lives on the Stanford campus with his wife, Selma. They have two sons, David and Andrew.

At both Stanford and Harvard, Arrow has been active in the affairs of the faculty and institution. Indeed, he has sometimes advised students, "true academic freedom is freedom from committee assignments." At both institutions and within the profession at large, he has been a source of intellectual excitement and ferment. He holds honorary doctorates from a variety of universities around the globe, including his alma mater, CCNY. He is a fellow of the Econometric Society, Institute of Mathematical Statistics, and American Statistical Association and a distinguished fellow of the American Economic Association. He is past president of the Econometric Society, American Economic Association, Institute of Management Sciences, and Western Economic Association. He holds the distinction, particularly rare among non-Japanese, of membership in the Second Class Order of the Rising Sun, an award presented by the Emperor of Japan.

Arrow is personally accessible and unpretentious, addressed as Ken by students, colleagues, and staff. The student, however junior, who steels his nerve to talk with the distinguished professor discovers that he has Arrow's undivided attention. To devoted students and colleagues, Arrow is a legendary figure, larger than life. Stories abound, highlighting his abilities:

- Arrow thinks faster than he – or anyone else – can talk. Hence conversation tends to take place at an extremely rapid pace; no sentence is ever actually completed.
- The breadth of Arrow's knowledge is repeatedly a surprise, even to his friends. By the end of an evening's dinner party whose guests included a professor of art specializing in the art of China, it seemed clear to the host that Arrow was as well versed as the specialist in this subject.
- Arrow can quote passages of Shakespeare and facts of English history accurately and at length.
- Arrow's presence in seminars is legendary. He may open his (abundant) mail, juggle a pencil, or give every evidence of inattention. He will then make a comment demonstrating that he is several steps ahead of the speaker.

Those of us who have had the chance to know him well are particularly fortunate. We are far richer for the experience.

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