

Paul Samuelson 1915-2009
By Avinash Dixit, Princeton University

Alexander Pope composed the following epitaph for Isaac Newton:

Nature and Nature's laws lay hid in night:
God said, "Let Newton be!" and all was light.

The same could be said of Paul Samuelson. He took numerous principles of economics that were hidden in obscure verbiage by previous generations, and reformulated them with crystal clarity in the language of mathematics. In the process he always found new results, many of which launched new fields, or revolutions in stagnant fields. He molded several generations of graduate students at MIT and researchers throughout the profession. His introductory textbook shaped the thinking of millions throughout the world, and shaped all the textbooks that followed. His advice to presidents and popular writings helped shape policy. More than anyone else in the latter half of the twentieth century, Samuelson changed the way economists think and write.

If the depth of Samuelson's research resembles Newton's, the volume of his output rivals Bach, Picasso, or Trollope. In every decade since the 1930s, he made fundamental contributions that enlightened, corrected, and challenged the rest of us. Even though we all know these works thoroughly well, we should pause to remember them and pay fresh tribute.

In the 1930s Samuelson was still under 25. At an age when most of us are struggling to find our research feet, he gave us:

[1] the foundations of modern consumer theory, in articles such as "A note on the pure theory of consumer's behavior" and "The empirical implications of utility analysis";

[2] clear statements of very general relationships among intertemporal prices and interest rates, in articles such as "Some aspects of the pure theory of capital" and "The rate of interest under ideal conditions";

[3] the first general statements and proofs of "The gains from international trade"; and

[4] the first workhorse model of business cycles in "Interactions between multiplier analysis and the principle of acceleration."

The 1940s brought a culmination of the work on consumer theory in *The Foundations of Economic Analysis* and in more articles. Concepts that have become ingrained in our thinking and our modeling, such as revealed preference and integrability, the correspondence principle of constrained optimization and comparative statics, the envelope theorem, the Le Chatelier Principle, and maximization of a (Bergson-Samuelson) welfare function implying the marginal conditions of Pareto optimality, all date from this period. In international trade we got the Stolper-Samuelson theorem and the conditions for factor price equalization.

Various papers on stability conditions, arising from the work in consumer theory, equilibrium theory, and the multiplier-accelerator model, also belong to this decade. Finally, the masterful RAND memo, "Market Mechanisms and Maximization," elucidated many of the themes of competitive equilibrium and Pareto efficiency that were generalized and axiomatized by Arrow and Debreu.

The 1950s were perhaps the peak of Samuelson's output, even by his amazing standards. This decade saw the work on capital and growth, developing concepts like the nonsubstitution theorem and turnpike theorems, in important articles many of which were coauthored with Robert Solow, and culminated in the classic *Linear Programming and Economic Analysis*. The article with the modest title of "An exact consumption loan model" became the foundation for many applications important in their own right, using the overlapping generations framework he developed: Peter Diamond's paper on the burden of the national debt, and the work of David Cass, Karl Shell and others on sunspots, is based directly on Samuelson's model, while Barro added bequests that resulted in dynastic utility, to get Ricardian equivalence. International trade got a rigorous analysis of the transfer problem, and my personal favorite, "Prices of goods and factors in general equilibrium," which in the process of developing the specific application, also built much of the general theory of duality for which others get more credit. Welfare economics continued its advance toward genuine policy applicability, with articles like "Evaluation of real national income" and "Social indifference curves." The theory of public goods got its start with "The pure theory of public expenditure" and its "Diagrammatic exposition". Public economics received an important impetus, with a memo to the U.S. Treasury in which he explained Ramsey's optimal tax analysis. This was not published until 1986, but many of his classes got it as a typed handout. I have preserved and cherish my copy still.

The 1960s should be remembered most of all for his contributions to financial theory. He gave rigorous analyses of the benefits of diversification and of the random walk hypothesis, and the model of warrant pricing that in the hands of his student Robert Merton, and Fischer Black, Myron Scholes and others, brought us the general theory of pricing of derivative securities (like it or not!). As an incidental appendix to the warrant pricing paper, he developed the mathematics of the higher order contact or smooth pasting condition that is now an important part of stochastic optimization. The sixties also brought his paper with Solow on the Phillips Curve, which was much more cautious about its policy implications than the literature that followed.

In the early 1970s, Samuelson turned to international trade again and produced two more highly influential models. In "An exact Ricardo-Hume model" and "Ohlin was right!" he introduced the sector-specific capital (Ricardo-Viner) model, and (with Rudiger Dornbusch and Stanley Fischer) he published a pair of Ricardian and Heckscher-Ohlin models with a continuum of goods.

In 1980 Samuelson was 65, and a Nobel laureate. He would have been fully justified if he had rested on his laurels and spent the rest of his life savoring the honors and accolades that continued to accumulate, including dozens of honorary doctorates, and the National Medal of Science in 1996. Instead, he remained energetic and active in research, and produced further important and thought-provoking papers. A theme common to many of them was personal finance. In papers like “A case at last for age-phased reduction in equity” and “Why we should not make mean log of wealth big though years to act are long,” he debunked some common beliefs about superiority of equities over bonds, and about maximization of the expected geometric rate of growth of wealth. In “Where Ricardo and Mill rebut and confirm arguments of mainstream economists supporting globalization,” he showed that innovation can have perverse effects on wages and total output, and that foreign technical progress can lower domestic welfare in a trading economy, although this does not support protectionists who tried to hijack his argument to their own ends.

Most modern economists are disdainful of the history of thought in their subject, often because they are ignorant of it. Samuelson had not only respect for the ancients, but healthy scientific curiosity about how their arguments would translate and how far they would survive in the modern mathematical language. He modeled the systems of Ricardo, Marx, Sraffa, von Thünen, Ohlin, and many others, and in doing so demolished some of their arguments, made others rigorous, and advanced some beyond their originators’ wildest dreams. In the latter category, his work on factor price equalization in the Heckscher-Ohlin and Ricardo-Viner models has become a classic of its own. He wrote generous appreciations and exegeses of the work of many older and contemporary economists: Gustav Cassel, Irving Fisher, Schumpeter, Frank Knight, Jacob Viner, Alvin Hansen, Sir John Hicks, Gottfried Haberler, Jan Tinbergen, and Harry Markowitz, to name just a few.

I have dwelt on Samuelson’s research, and left little space for his writings that influenced a much larger audience than professional economists. Millions for over half a century have learned their economics from his textbook (later editions were coauthored with William Nordhaus). Large numbers also read his columns in Newsweek and other popular writings. He was an important influence behind the Kennedy-Johnson tax cut, and gave policy advice on many other occasions.

Despite all these activities, any one of which would have taken up all the time of a normal person, Samuelson always had time for his colleagues, students, and even strangers who asked him for comments or advice on their research. He also initiated contact and detailed discussions with people whose writing had intrigued or provoked him. Numerous scholars owe him a personal debt for correcting their errors, guiding them to new research ideas, and often helping launch their careers. And he managed all of this without shortchanging his large family.

I am one of the legions of students and researchers whose careers he did so much to shape. Much of my style of research, and many of the techniques I have

used in my modeling, comes from him. The whole idea of modeling full equilibrium of a specific applied context (the so-called “toy models”) lies behind my work with Joe Stiglitz on monopolistic competition and with Victor Norman on international trade. As to the techniques I learned from him and used: comparative statics of constrained optimization, the correspondence principle and the envelope theorem, factor price equalization in international trade, valuation of real options, the list could go on and on. This makes his passing a very personal bereavement for me.

But I cannot help smiling as I remember the student days when we waited at 9 a.m. for him to appear, carrying the handouts he had just handwritten on blue spirit duplicator masters, and had run off himself in the department’s machine room, so they were uncollated and still damp. The ensuing hour would be a brilliant performance, where complex proofs of theorems were interspersed with anecdotes about the economists whose work led to the ideas and results being discussed. He showed us the subtleties and nuances of the subject, gave an account of how modern economic theory came into being (after all, he had created so much of it and had been present at the creation of the rest), and most importantly, conveyed a way of thinking about economics that would last us a lifetime. In short, we learned all the methods and skills for research that the cut-and-dried world of the textbooks left out. And then there were his anecdotes about economists. Smith, Ricardo, Marshall, Edgeworth, Keynes, Schumpeter, Irving Fisher, and above all Frank Ramsey, came alive for us in a way that taught us to respect the history of the subject and to appreciate the height of the shoulders of these giants, while at the same time making us smile at their human foibles.

His story about Ramsey is especially memorable. On his first day as an undergraduate at Cambridge, Ramsey went to his philosophy tutor Ogden, to discuss some ideas he had about essence and being. After listening, Ogden said, “These notions are rather like those of Kant.” “Kant? Who is he?” “Immanuel Kant was the author of this book I’ll lend you, *Kritik der reinen Vernunft*.” “But it’s in German, sir, and I don’t know any German.” “That’s all right, I’ll lend you this dictionary.” A couple of weeks later Ramsey came back to Ogden saying “Kant has it almost right, but ...” Paul took special and visible delight in telling this story, clearly recognizing in Ramsey a kindred spirit in precocity and genius.

If there is a heaven, and if I am fortunate enough to make it there one day, I hope to take classes from him again. I am sure that, with his brilliant and precocious mind, he will have developed a beautiful heavenly model of it all, and will be able to say: “God has it almost right, but ...”

Acknowledgement: I thank Peter Diamond and Robert Solow for corrections and useful suggestions.