Yale Economic Review

A Yale College Publication
Vol. III Issue 2 | Winter 2007

Voter I.Q.
How to Increase Yours

Monkeys vs. Fund Managers
Evolution's New Twist

Wages Of Wins
The Price of a Jump Shot in the NBA

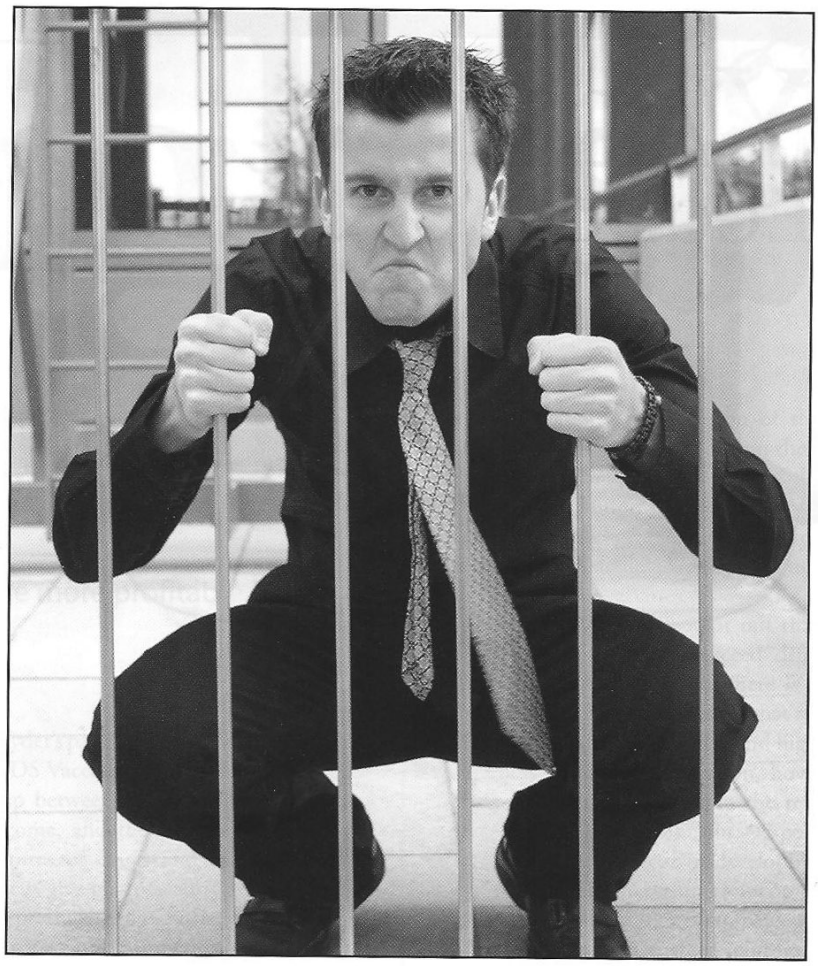
+

China's I.T.
The next big thing?

The Economy Of Cities
Thoughts On Jane Jacobs' Legacy

PLUS Nobel Prize Winners Robert Solow & Joseph Stiglitz

Academics

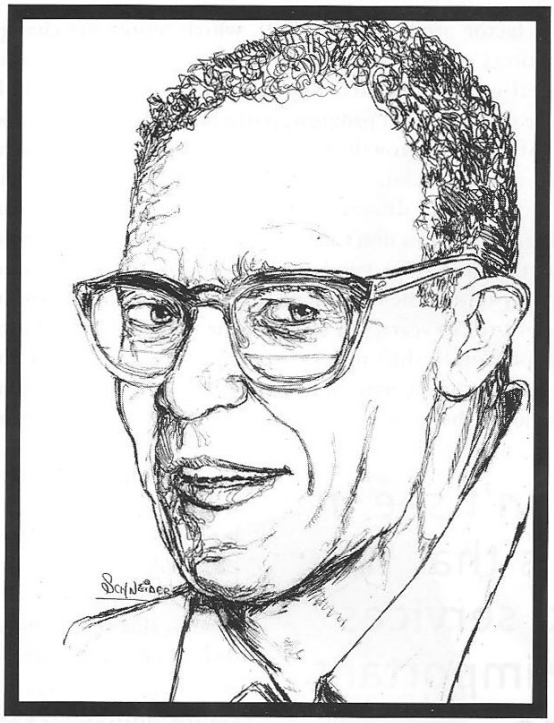


YER talks with the father of modern growth theory about the Solow model, working with the President, and the current state of economics.

In Every Issue

"Everything reminds Milton [Friedman] of the money supply. Well, everything reminds me of sex, but I keep it out of the paper.

- Robert Solow



Great Minds in Economics: ROBERT SOLOW

By Mark Schneider

ROBERT SOLOW MAY VERY WELL BE THE MOST important name in studying the wealth of nations. His dynamic model introduced quantitative rigor into the study of economic growth, elucidating the factors affecting wellbeing across nations. To this day, his ideas serve as the starting point for virtually any study of the long-run. Since the publication of his landmark papers 50 years ago, he has earned a fundamental place in the history of macroeconomic thought, providing a basis for much of the free world's long-term economic policies.

Although officially retired since 1995, Solow still retains his office at the Massachusetts Institute of Technology, adjacent to that of fellow Nobel laureate and friend, Paul Samuelson. Solow met with YER to discuss his life in economics, the future of the field, and the work which earned him a Nobel Prize.

Solow's landmark 1956 paper A Contribution to the Theory of Economic Growth remains highly influential to this day, often serving as the rubric used to assess the long-run progress of an industrial economy. This model challenged conventional Malthusian economic thought, which doomed workers to a life of subsistence incomes, by introducing a quantitative framework to project the impact of government policies on economic growth. The Solow model is principally employed to study the relationship between the long-term living standard in an economy and its three main determinants: the rate of savings, the rate of population growth, and the rate of technological progress. It has also been used to illustrate how poor countries can theoretically "catch up" to richer countries.

Historically, however, the model has not been effective for predicting economic growth in poorly developed economies. Solow admits that his belief had always been that the model did not extend to developing nations. "I had thought of it as a model of an advanced industrial capitalist society, where markets function, and businesses at least care about their profits," he said. "In a poor, developing country, the very institutions were in question; profit seeking might not be so well developed, knowledge doesn't percolate, borrowing and lending are not developed, and transportation and communication are inefficient, so that you could have different prices ruling in places that are really not so far apart, without any possibility of arbitrage."

But Solow also agrees that, 50 years later, conditions are different. "Countries that we now think of as developing economies are more nearly in the modern world. I still don't think that a model like that would apply very well to the Central African Republic, but it probably does apply to Caribbean countries, to Costa Rica, to Nicaragua, or to Latin America." His change of opinion emerged through discussions with colleagues involved in economic development and through his work as a member of an outside commission of the World Bank. "There are only two economists on it, and the rest are all former officials in developing countries. They don't blink an eye at the idea of studying the growth of their economies by the same class of models that come from that original one. I'm coming around to the view that maybe it is now, even if it wasn't in 1956, useful in economic development."

A key component of many versions of the Solow model is total factor productivity (TFP), which represents changes in a nation's output not accounted for by the mere quantity of capital or labor inputs. Key elements contained in TFP include technological progress, particularly as it affects efficiency. After rapid growth in TFP for several decades, there has been some speculation that America now approaches a natural limit, but Solow disagrees. "I don't see it," he said. "One of the things which you don't see in the original one-sector model is that the shift from goods production to services production is really one of the important things that has happened in the past 40-to-50 years." In terms of the sustainability of growth, this purported shift means two things. For one, there should be less strain on natural resources and on the environment. Secondly, the application of new technology in much of the service sector is still young. "The picture I had when I was doing that kind of work long ago is that technological change consists of ways of bending metal more efficiently. But the truth is that technological change consists largely of ways of operating institutions more efficiently," he continued, "so it may be that as we learn to innovate in the production of services, the accelerated growth will continue."

One of the things which you don't see in the original one-sector model is that the shift from goods production to services production is really one of the important things that has happened in the past 40-50 years.

Solow did, however, concede another way for a growth limit to exist. "A country like the U.S. might be approaching a situation in which increased consumption is not as urgent as it once was," he explained. "If my real consumption expenditure never increased, I would be perfectly happy; I don't see anything that I need that I can't have at my current level of consumption. So it may be that upper middle-class people and higher in rich countries don't need to consume anymore in which case, they don't need a lot more productive capacity. I don't see growth as stopping from the demand side soon, but I can easily imagine that might happen at some point in the future."

IN THE 1960'S, SOLOW, A NATIVE OF BROOKLYN, New York, worked on the staff of one of the most remarkable Councils of Economic Advisers ever assembled.

Solow cheerfully recounts his experiences in Camelot. "So, Kennedy is elected in 1960, and I'm 36 years old. One late evening the phone rings, and on the other line are Jim Tobin, Walter Heller, and Kermit Gordon, who have been named as the members of the Council of Economic Advisers. This is well before Kennedy's inauguration in January. They said, How would you like to come to Washington and join the staff of the council? And I said, You know I have no experience doing economic policy. I'm a brow or middlebrow theorist. They made the standard pitch you would make if you were recruiting staff," he said. "My first thought was I need this like I need a hole in my head." Then, he remembered, "My wife uttered the immortal words. She said, All during the Eisenhower years I heard you complain about economic policy. Don't you think it's time you put your money where your mouth is? I had no answer to that."

Solow ended up spending just over one year at the council. "It was a wonderful experience for me as an economist," he said. "I got not only an insight into the way the U.S. government works, but I got exposed to lots of interesting problems about economics that I had not thought of before.

"Kennedy was a wonderful president from the point of view of the council, in the sense that he read, and wanted to understand, memos. Walter Heller started something which probably ended with him. Every memo that went to the president was signed by Walter, but Walter made a practice of saying somewhere who had actually written and worked on that memo. So it was not uncommon either for Art Okun, a one-time Yale person, or for me, to get a telephone call from Kennedy. And Kennedy would say, I've been reading this memo and I've got to the third paragraph on page two and the memo says thus and such and I don't understand that. I don't know what the reasoning is. Would you explain it to me? That's a very healthy stimulus to your capacity to explain."

During his time on the council, Solow was involved in determining effective policies to reduce unemployment in the United States. "When Kennedy took office," he said, "the unemployment rate was about 6.7 percent. That's high." The Republican view at the time was that the rate could not be lowered because the unemployment was structural, meaning the unemployment rate was high not because the economy was in a recession, but because there was a mismatch between the quality of labor and the skills that were being demanded. "If that were true, then expanding demand would only lead to inflation, because the appropriate labor wouldn't be there," Solow explained. "I was given the job of evaluating this, and in five or six weeks I convinced myself that it really wasn't so, and that section went into that mini-report. I worked on that problem for a couple years after and I never would have thought of it had I not been on that council."

"Although I worked harder than I ever did, my wife says I was less irritable than I normally was," Solow reminisced, "so I must, in some way, have been enjoying it."

Since his retirement, Solow has remained active in economics, serving on professional, state, national and international commissions. In a 2000 article in the Journal of Economic Perspectives entitled "Toward A Macroeconomics of the Medium Run," Solow overviews the developments in macroeconomics in the last few decades, outlining key areas of future research. In his discussion on modeling consumer choices, he expresses concerns both with rational choice theory and with behavioral economics—essentially the Venn diagram intersection between psychology, cognitive science, and economics. Many economists of Solow's era have discarded behavioral economics because it challenges the assumptions of rational choice theory but has not yet supplied a generalized alternative set of assumptions.

Solow expressed great interest in this emerging field. "I am fascinated by behavioral economics—I think if I were younger, I would be doing some." But he did issue a caveat for that line of research. "I think that there is a deep problem with behavioral economics," he said. "The standard economics of 'rational' behavior has the advantage that in any problem, it tells you what to do. There is no corresponding general principle in behavioral economics. It says instead, 'Don't assume that everybody is behaving in a deeply rational way,' but it doesn't tell you why. I'm perfectly prepared to believe that even financial behavior, securities market behavior, doesn't follow the principles of 'rational choice,' but there must be some more general principles than rational choice that are fair descriptions of the way people

An Overview of the Solow Model

The Solow model takes a dynamic view of a classical economy in the long-run—it mathematically relates economic growth to the production function, labor growth, investment, and capital accumulation. The model consists primarily of two equations: a production function, describing how capital and labor combine to produce output, and a capital accumulation equation, relating capital accumulation to investment and depreciation. Depreciation is the loss in value over time in a unit of capital, such as the loss in value of a car as its mileage and age increase. The model critically assumes that capital inputs exhibit diminishing returns, such that increased capital inputs increase output at a decreasing rate. To simplify matters, it also assumes constant returns to scale of all factors, such that doubling all inputs will double total production. In this manner, the model is free to investigate growth per worker, rather than for the economy as a whole.

The model takes the long run growth rate of a nation as given, predicting that the economy will converge to a rate of steady state growth. Specifically, an economy growing at a level below its steady state growth rate will accelerate to the steady state, and an economy growing above the steady state level will slow down.

The Solow Growth Diagram plots a production function and a breakeven investment function. The per-worker production function represents a level of per-worker output for each value of the capital-labor ratio. The breakeven investment function represents the per worker investment required to maintain a steady-state equilibrium.

Key insights from the model hold that countries with relatively high savings rates and/or large amounts of technological progress will enjoy higher rates of economic growth, keeping all else fixed. Edmund Phelps, the 2006 Nobel Laureate in economics, contributed to the model in 1961 by determining the Golden Rule savings rate which maximizes consumption in the economy. This metric can be used to determine whether an economy is theoretically under-saving or over-saving, so that appropriate economic policy can be implemented.

The Solow Model has several limitations. It does not take into account entrepreneurship or the strength of institutions that could bring about economic growth. Additionally, the Solow Growth model does not explain how or why technological growth will occur. The model is, nonetheless, a key step in the development of endogenous models, which attempt to take into account the factors which prompt such growth.

behave," Solow insisted. "If every problem that you study is going to end up having its own rules of behavior then you're not going to get very far. That kind of economics is simply going to become a book of interesting stories."

Some economists go so far as to completely discount the value of behavioral economics and reject the very existence of overheated economies, panics, crashes, bubbles—in short, anything that even hints at irrational behavior. But even Sir Isaac Newton recognized that rationality might be too simple an assumption to consistently govern the behavior of such complex creatures. "I can calculate the motions of heavenly bodies, but not the madness of men," he remarked in 1720 after losing 20,000 pounds in the South Sea speculative bubble.

But despite the concerns raised by Solow and other economists, Solow remains optimistic on behavioral economics. "It's really a young study. We've been doing behavioral economics on a reasonable scale for only a couple years. So maybe people in the field will come up with some laws or common rules of thumb."

SOLOW'S EARLY WORK EXHIBITED A CLEAR SCIENTIFIC approach to economics. But should economics be considered a science? Will it have—or has it had—an Einstein or Newton? What fundamental laws can it reveal about human nature or human institutions? While Solow has been a life-long proponent of analytic modeling of economic processes, he was quick to affirm that economics is not a science like physics or chemistry. "I don't think that physics is a good model for economics for a number of reasons," he explained. "One reason is that the key parameters in the physical world are the same now as they were when the Pharaohs ruled Egypt. The velocity of light has not changed; but there probably is no economic parameter that has the same value now that it had in ancient Egypt. A second reason why I think physics and also other natural sciences may not be a good model for economics is that we don't do experiments in economics on the same scale, and the result of that is that it's very hard to make causal inferences."

Solow continued, citing one of Milton Friedman's favorite phrases: "Here or there, life has performed a natural experiment for economists." Added Solow, "I don't think that any of those events were natural experiments in the sense that only one causal factor has changed; there's always more going on than that in the world. In fact, you wonder how it is that economics makes progress at all. But I think that, over the years, there are hypotheses about economic life that, on the whole, don't work out very well and they fall out of what people believe, whereas in biology or chemistry or physics, you can do that practically overnight by conducting an experiment. On one hand, I balk at the notion that economics is a science. But on the other hand, if you tell me that it's okay to be unscientific, I will balk even more. Being scientific means you have to respect logic and you have to respect whatever facts you know. And in that sense, I think economics can be scientific, something more like geology, or meteorology."

Geology, meteorology, epidemiology, and economics study events which are stochastic or random in nature, in that the future events depend only partially on the current state. Economics necessarily involves the study of people and the parameters governing human behavior, so the difficulty of collecting reliable data may render economics to be even more challenging than predicting earthquakes, the weather, or the spread of a pathogen. Due to the greater degree of imprecision that characterizes many aspects of economics, Solow has been skeptical of bold assertions made by fellow economists. In the current edition of their Macroeconomics textbook, Paul Samuelson and William Nordhaus note that "Solow criticized economists for 'an apparently irresistible urge to push their science further than it will go, to answer questions more delicate than our limited understanding will allow.'"

The tendency to treat economics as a precise science has resulted in an increasing emphasis on mathematics, with standard economics graduate programs noting that undergraduate preparation in economics is not necessary, but a strong mathematical background is essential to be a competitive candidate. Solow acknowledged this, noting that graduate programs in economics tend to attract more physicists and engineers to the field than people purely interested in the social sciences. "I think the selection bias is there, and I think it's unfortunate, because the amount of abstract thinking and mathematical thinking that you need to do in economics is really very small," he lamented. "There is not only a selection bias, but there is an unnecessary selection bias. It's not rocket science."

Economics has long had an ambiguous relationship with the natural sciences. Tjalling Koopmans, who won the 1975 Nobel Prize in economics for his work on transportation routing, also developed a theorem which has been used in quantum chemistry to approximate a molecules' first ionization energy. The Nobel Prize winning Black-Scholes theorem incorporated Brownian motion to predict asset price movements, and an emerging area of economics, called "Econo-physics," uses, for instance, seismic models to approximate the stock market. Even Daniel Bernoulli, an early and significant contributor to thermodynamics, was also a leading architect of the economic notion of utility.

But Isaac Newton's statement regarding the unpredictability of human behavior provides an important context for understanding the relationship of economics to the natural sciences. The fundamental laws which govern heavenly bodies are deterministic in nature. Given specifications for relevant parameters we can predict precisely how these heavenly bodies will move, how fast, over what course, and so forth. But economics concerns people. Economics' laws of reason are far more stochastic than science's laws of nature.

"In economics, you're depending on statistical regularities," Solow concluded. "You want to make sure that the statistical regularity you're depending on is not nonsense. Economics has to try to be as scientific as it can, without pretending to be physics."

Solow has deeply enjoyed his experiences as a researcher, a teacher, a mentor, an author, and a leader in his field. He has never pursued the spotlight and often shied away from it, perfectly content to research, spend time with his family, and go sailing at Martha's Vineyard. He has always placed the integrity of economics and the importance of scientific inquiry in economics above the personalities who fuel the engine of academic progress. "I'm a modeler by nature," he said candidly; after all, no macroeconomics textbook can be considered remotely complete without a considerable discussion of his growth model. But after a few hours of conversation with the architect, it's difficult to remember that Solow's model is one of the few most important economic innovations in history. He'll talk about the short-comings of the model and praise the other theorists whose work paved the way for his ground-breaking papers.

Some people may be more familiar with his model than with Solow, but anyone involved in the field is aware that Solow is himself a model from whom there is much to learn.□