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ABSTRACT

This paper, prepared for the *Biographical Memoirs* of the National Academy of Sciences, presents an account of the scholarly career of Simon S. Kuznets. Among the issues considered are his contribution to the development of the empirical tradition in economics, his transformation of the field of national income accounting, his use of national income accounting during World War II to set production targets for both the military and civilian sectors of the economy, and to guide the implementation of those targets; his development of a theory of economic growth, his investigation of the interrelationship between economic growth and population growth, his contribution to methods of measurement in economics, and his legacy to the economics profession.

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Simon S. Kuznets
April 30, 1901–July 9, 1985

BY ROBERT W. FOGEL

Simon S. Kuznets, recipient of the third Nobel Memorial Prize in economics, was a pivotal figure in the transformation of economics from a speculative and ideologically-riven discipline into an empirically based social science. Born in Pinsk, Russia, on April 30, 1901, he received his education in primary school and *gymnasium* in Kharkov. He served briefly as a section head in the bureau of labor statistics of the Ukraine before emigrating to the United States in 1922. He entered Columbia University where he received his B.A. in 1923, his M.A. in 1924, and his Ph.D. in 1926. His principal teacher at Columbia and his life-long mentor, was Wesley Clair Mitchell, a founder of the National Bureau of Economic Research (NBER) and its director of research from 1920 to 1946.

Kuznets was a member of the research staff of NBER from 1927 to 1961. It is there that he met Edith Handler. They were married in 1929 and had two children, Paul and Judith. Kuznets also held professional appointments in economics and statistics at the University of Pennsylvania (1930-1954) and in economics at Johns Hopkins (1954-1960) and Harvard (1960-1971). During 1932-1934 he served in the Department of Commerce where he constructed the first official estimates of U.S. national income and laid the basis for the National Income Section. During World War II he served as the associate director of the Bureau of Planning and Statistics of the War Production Board. Kuznets was instrumental in establishing in 1936 the Conference on Research in Income and Wealth (which brought together government officials and academic economists engaged in the development the of U.S. national income and product accounts) and in

1947 helped to establish its international counterpart, the International Association for Research in Income and Wealth. He served as advisor to the governments of China, Japan, India, Korea, Taiwan, and Israel in the establishment of their national systems of economic information.

Despite his extensive activities in the design of government programs of economic intelligence, and his work in consulting with such private agencies as the Growth Center of Yale University and the Social Science Research Council, Kuznets was a prolific analyst of economic processes and institutions. During the course of his career he produced 31 books and over two hundred papers, many of which set off major new streams of research. Among the fields in which he pioneered, in addition to national income accounting, were the study of seasonal, cyclical, and secular fluctuations in economic activity; the impact of population change on economic activity; the study of the nature and causes of modern economic growth based on the measurement of national aggregate statistics; the household distribution of income and its trends in the United States and other countries; the measurement and analysis of the role of capital in economic growth; the impact of ideology and other institutional factors on economic growth; changing patterns in consumption and in the use of time; and methods of economic and statistical analysis. Kuznets's intellectual contributions were acknowledged by his colleagues in many ways, including his election as president of the American Statistical Association in 1949 and of the American Economic Association in 1954.

The Context of Kuznets's Work

To appreciate the magnitude of Kuznets's contributions to the empirical tradition in economics it is necessary to understand the intellectual currents in the American social sciences when he first encountered them in the early 1920s, and the social and political movements that promoted the social sciences during the last quarter of the nineteenth and the early decades of the twentieth century. Social sciences were just beginning to emerge as disciplines before the Civil War. Even though economics was the most articulated of the nascent social sciences, it was treated, not as an independent subject, but as a segment of a year-long required course in "moral philosophy," which was usually taught to seniors by an ordained minister who surveyed revealed knowledge about the operation of the temporal world. The textbook in the economics portion of this course most widely used in American Universities during the 1840s and 1850s was written by Reverend Francis Wayland, president of Brown University and a principal leader of the Northern Baptist Church. The objective of his textbook, he wrote, was to set forth God's laws, so far discovered, regarding the production and distribution of those products that constitute the material wealth of a nation.

The primacy of religious crusaders in economics and the other principal social sciences continued down to the beginning of the twentieth century. About 40 percent of those who founded the American Economic Association (AEA) in 1885 were either ordained ministers or lay activists in evangelical churches. The platform adopted at that meeting called for the united effort of churches, the state, and science to promote Christian social reform. The influence of Richard T. Ely, an economist at the University of Wisconsin, and other academic leaders of the Social Gospel movement (the name

given by historians to a religious/political movement that was influential between 1880 and 1930) in the AEA remained strong down to World War I. That influence was made conspicuous by the organizational identification of the AEA with issues that were at the time as highly controversial as the limitation of female participation in industry, the promotion of state and local taxes to fund entitlements, and the promotion of severe restrictions on immigration. This crusading posture was challenged by more secular economists, by those with affiliations to non-evangelical churches, and by those whose economic analysis was orthodox. Although the more orthodox economists gradually became ascendant, it took decades for the AEA to free itself from a lingering commitment to Social Gospel ideology and to become dedicated to objective presentation of evidence and rival theories regarding the functioning of the economy.

There was an important but smaller group of empirically oriented economists. Some of them were associated with the Bureau of the Census, which included a survey of economic activity in the decennial census of 1840. As the economy became transformed by accelerating technological change, the subsequent censuses collected increasingly detailed information on the agricultural, manufacturing, and transportation sectors. The economists associated with these efforts also produced illuminating analyses of the structure and development of such pivotal industries as iron and steel, cotton textiles, and meat packing.

After the Civil War, a number of states set up bureaus that inquired into the conditions of labor and the standard of living of industrial workers. Led by Massachusetts, these agencies, beginning about 1875, began collecting samples on the income, expenditures, and housing of industrial workers. Toward the turn of the century,

a similar program was established at the federal level with Carroll D. Wright, the economist who pioneered such studies in Massachusetts, serving as the first Commissioner of Labor. Between 1880 and World War I, a number of factors provoked alarm about the deterioration in the conditions of industrial labor. These included technological changes that promoted large-scale enterprises at the expense of small ones, huge waves of immigration that depressed wages, pitched battles between workers and factory owners that required federal troops to quell them and that resulted in large losses of life and property, and the increasing severity in business cycles, culminating with the depression of 1893-98, when one out of every six workers was unemployed. The belief that (despite many remarkable technological advances and the obvious affluence of the upper classes) conditions of life had deteriorated for urban workers and for farmers persisted down to the outbreak of World War I.

A number of economists who served in the War Production Board and other agencies involved in mobilization of the economy during World War I, were appalled at the lack of relevant economic information. Several of them concluded that this problem was unlikely to be solved within the federal government and in 1920 established a private, nonprofit, nonpartisan agency called the National Bureau of Economic Research (NBER) to construct national income accounts, collect information on business cycles, and to study the distributions of the national income among households, with the aim of making such information available to both public and private agencies that could use them in the formulation of their policies.

The leader of NBER from its inception to 1946 was Wesley C. Mitchell, professor of economics at Columbia University. Mitchell was critical of orthodox theory because

its generalizations pertained to a nonexistent world, based on speculations about how individuals who adhered strictly to the logic of profit and utility maximization would behave. He sought a comprehensive study of the economic institutions that had actually shaped production and distribution, and the forces that caused such institutions to vary over time and place. He emphasized that the study of aggregate economic behavior under diverse and changing institutional circumstance had to be rooted in the collection and analysis of quantitative information. While he rejected what he called Ricardian and neo-Ricardian theories (hypothetico-deductive models of economic behavior) because he believed they were based on naïve assumptions of human motivations, he did not reject theory per se. His objective was the formulation of an economic theory that used postulates based on statistical analysis of existing institutions and of the historical forces that caused them to change over time. Keenly aware of the imperfections of the available data on economic life, he sought to develop procedures that could increase the reliability of the statistics derived from them and establish the range of probable error.

While Kuznets shared Mitchell's skepticism of neo-Ricardian theory, his thrust toward theoretical generalization was much stronger than Mitchell's. Throughout his career Kuznets was influenced by the work of such leading theorists as Joseph A. Schumpeter (who probed the relationship between technological change and business cycles), A. C. Pigou (who identified circumstances under which markets failed to maximize economic welfare), and Vilfredo Parato (who propounded a law governing the distribution of income among households). Kuznets's theoretical inclination is revealed in his second book, *Secular Movements in Production and Prices* (1930), which set forth a prescient theory of steady long-term modern economic growth in Europe and America.

beginning toward the end of the eighteenth century. Although growth was steady at highly aggregated levels, at the level of particular industries there was a tendency toward retardation in growth. The logistic curve gave a good fit to the growth pattern of an industry over its life cycle. The main engine of this process, he said, was technological change, although he also acknowledged the role of population growth and changes in demand.

Another important aspect of *Secular Movements* was Kuznets's discovery of "secondary trend," a cyclical movement much longer than a business cycle, which typically ran 3 to 5 years. The periodicity of secondary trend ran between 15 and 25 years. Kuznets probed the links between primary trends, secondary trends, and short-term cyclical fluctuations, considering the correlations between the rapidity of the primary growth rates and the tendency toward both secular and short-term cycles. His analysis was based on examination of evidence for several industries in the United States and several European countries.

Still another notable feature of *Secular Movements* was Kuznets's concern with mathematical functions that could adequately describe the regularities he had uncovered. He argued that mathematical functions were needed for forecasting purposes, which he emphasized was the central purpose of the analysis of time series. In this connection he introduced into economics, the logistic curve that had been developed by Raymond Pearl only a few years earlier for the study of the growth of populations of fruit flies in closed containers. He also introduced to economics the curve that Benjamin Gompertz, an English actuary, had published in 1825 to describe the increase in mortality rates with age. Kuznets's discussion ranged not only over issues of the suitability of these and other

mathematical functions for forecasting specific processes, but also dwelt on the merits of alternative methods of fitting such functions. As notable as the care with which he pursued these issues, was the extraordinary breadth and depth of his reading not only in matters of economics and business, but also in history, demography, biology, statistics, and the physical sciences.

National Income Accounting

In 1931, at Mitchell's behest, Kuznets took charge of the NBER's work on U.S. national income accounts that had previously been conducted mainly by Willford I. King. The next 15 years of Kuznets's career was concerned primarily with the construction of U.S. national income accounts. Residual tasks in this line of work, concerned mainly with the measurement of capital formation, continued down to 1961. His first major project was the estimation of U.S. national income for 1929-1932, begun at the NBER but completed in the federal government and published (1934) by the Superintendent of Documents, as the result of a resolution by the U.S. Senate requesting such information. Kuznets then extended those accounts backward to 1919 and forward to 1938. The two volumes containing this work (1941) included an extended and thorough discussion of the theoretical foundations for national income accounting and of the practical difficulties of moving from the available sources to the desired measures. Kuznets also evaluated a variety of omissions and other mismeasurements, including estimates of the probable range of error by specific categories and for the annual totals. Kuznets estimated the national income accounts during World War II and compared them with national product during World War I (1945), especially with respect to whether the war effort impinged on

the civilian economy or came out of an expansion of total product. In 1946 he published a volume that extended the national income accounts back to 1869.

Kuznets transformed the field of national income accounting by bringing to it a far greater precision than had previously been achieved, by rooting it firmly in welfare theory (which distinguishes between private and social values), and by solving numerous problems related to moving from the imperfect sources containing the raw data to the theoretical conception of "national income." Among the difficult problems that he probed were the impact of monopolistic control of some professions on income, the impact of changes in the distribution of income on the market valuation of particular goods and services, the structure of national product (its distribution across industry) as measured both by income and by employment, the determination of which activities by the government properly belonged in a welfare-theoretic concept of "national income," the estimation of the contribution to national income of the increase in leisure time, and the identification and estimation of the bias imparted to national income estimates (especially when used to measure changes in income over time) by the choice of end-period or base-period prices, by the inclusion in income of costs of production (such as the increased cost of controlling crime in large cities), by the omission of home production, and by the difficulties of distinguishing between net and gross capital formation because, among other reasons, capital replacement frequently involved technological improvements.

The depth of Kuznets's theoretical probing was well understood by other specialists in national income accounting. His 1933 article on national income for the *Encyclopaedia of the Social Sciences* served for several decades as a guide on theoretical

issues to those constructing national income accounts. His agility at theory became more obvious to others with his critique of a number of issues about the measurement of national income raised by J. R. Hicks (one of the preeminent economic theorists and the co-winner of the fourth Nobel Prize in Economic Sciences).

One of the most important books that arose from the work on U.S. national income accounts during the 1930s and 1940s was *Income from Independent Professional Practice* (1946) written jointly with Milton Friedman. That book developed age-earnings profiles for specific professions, a device that subsequently became one of the main analytical tools of labor economics. The book also developed and applied the concept of human capital to explain differences in average earnings by professionals. Human capital is today recognized as being far more important than physical capital in the contribution to national income. Its integration into the mainstream of economic theory and measurement has been one of the main advances in economic analysis since World War II, and was an important part of the work of two other Nobel Laureates, Theodore W. Schultz and Gary S. Becker. Thirdly, that book set forth the distinction between transitory and permanent income (expected income over the life cycle), a distinction developed by Friedman, which he subsequently extended to explain anomalies between cross-sectional and longitudinal measures of consumption and savings rates by income, and which was recognized as a seminal contribution in the citation for his Nobel prize in 1976. Interestingly, these far-reaching contributions were passed over by reviewers of the book at the time of its publication.

Service During World War II

The power of national income accounting as an instrument of public policy was dramatically demonstrated during the course of World War II. In 1940 Robert Nathan, a former student of Kuznets, subsequently chief of the National Income Section of the Department of Commerce, became the chief of Military Requirements and Industrial Studies in the Defense Commission (later called the War Production Board) that President Roosevelt established with the aim of making the United States the "Arsenal of Democracy." In assessing the capacity to expand military production, Nathan in 1941, and beginning in 1942, in conjunction with Kuznets, used national income accounting together with a rough form of linear programming to measure the potential for increased production and the sources from which it would come, and to identify the materials that were binding constraints on expansion. Nathan's estimates of the potential for military production before Pearl Harbor, which were far greater than the military thought was possible, were adopted by Roosevelt. After Pearl Harbor, the military set forth ambitious new estimates, which Kuznets determined could not be met within the specified time period, pointing out that the effort to do so might result in severe parts shortages and also place unacceptable pressures on the civilian economy. The Kuznets analysis was adopted as the basis for both civilian and military targets.

In an article written in 1944 Paul A. Samuelson called World War II "an economist's war." This was no idle boast. Economists not only played a vital role in the War Production Board, but also in the Office of Price Administration, which regulated the civilian sector of the economy, and in the Department of the Treasury, which was charged with designing the methods of financing the war (inventing, among other

devices, the current withholding system for paying taxes concurrent with the receipt of income). Other agencies in which economists were prominent included the Office of Strategic Services, the predecessor to the CIA. Economists in that agency planned the daily bombing strikes of Nazi territory on the basis of an analysis of which targets, if destroyed, would most damage war-making capacity. The work of economists during the war so impressed national leaders that Congress passed the Employment Act of 1946, which established the Council of Economic Advisors to the President.

Modern Economic Growth

Immediately after completing his governmental services during World War II, Kuznets shifted the focus of his research to making use of national aggregate data to analyze international differences in the process of modern economic growth. His analysis focused on 14 nations in Europe and America and on Japan, for which time series went back at least 60 years. There were several aspects to that project. At Kuznets's suggestion in 1948, the Social Science Research Council established a Committee on Economic Growth, with Kuznets as chairman, which recruited leading economists in eleven countries to study the long-term patterns of growth in their respective countries.

At the same time Kuznets began to study the available aggregate statistics and produced a series of ten monographs that were published as supplements to the journal *Economic Development and Cultural Change* between 1956 and 1967. These monographs covered such topics as levels and variabilities of growth rates, industrial distribution of national product and labor input, the structure of consumption, trends in capital formation, the distribution of income by households, and the structure of foreign

trade. This body of research was subsequently integrated and extended in two books, *Modern Economic Growth* (1966) and *Economic Growth of Nations* (1971).

In these volumes Kuznets set forth an historically-based theory of modern economic growth. The modern epoch of growth, which began toward the end of the eighteenth century, was defined as a sustained increase in per capita income accompanied by an increase in total population and sweeping changes in the structure of the economy. The paramount feature that distinguished the modern economic epoch was the systematic application of scientific knowledge to problems of economic production and the development of a science-based technology. By science-based technology he meant that the technology was no longer merely a response to longstanding practical issues, but was often produced by scientific knowledge well in advance of bottlenecks. In the case of electricity, for example, theory preceded the technology for electrical generation and communications by many decades. The development of these technologies induced new demands for a wide range of consumer durables. Moreover, technological applications of science provided a powerful stimulus to the growth of scientific knowledge by providing both new information about previously unknown aspects of nature and by greatly expanding the resource base for the growth of scientific studies.

This complex interaction between scientific knowledge, technological applications, and rapid economic growth, Kuznets argued, required a proper cultural and institutional environment, which in turn required a new set of attitudes. The three key elements of the new *Weltanschauung* were secularism, egalitarianism, and nationalism. By secularism Kuznets meant a concentration on life on earth with an emphasis on material attainment. By egalitarianism he meant a denial of inborn differences among

human beings except as they manifested themselves in achievements: in other words a distribution of rewards according to accomplishments rather than by family connections and social status. By nationalism he referred not only to the capacity of the state to provide the stability needed for the flowering of modern economic growth within a well-defined territory but also to an historically formed community of feeling, with an elite dedicated to modernization.

Kuznets saw no necessary end to the opportunities for continued economic growth. He pointed out that the stock of knowledge was increasing at an accelerating rate without any signs of diminished aggregate returns (although the payoff to particular lines of investment usually eventually declined). He saw no limit to the potential for economic growth because of a petering of the rate of technological change. Although he recognized the pressure of population on depletable resources and the environment, he thought that population would reach a limit well within the carrying capacity of the earth, and he expected technological advances to provide substitutes for depletable resources and to curtail environmental degradation.

Kuznets did, however, envisage a limit to the growth of conventionally defined economic product (those items covered by the national income and product accounts [NIPA]). He recognized that at very high levels of per capita product, preferences for leisure and immaterial products omitted by NIPA might come to predominate in an economy. In a prescient computation published in 1952 he estimated that when the increase in each hour of leisure was valued at the average wage, the per capita income of individuals increased by about 40 percent. Other items omitted from the NIPA accounts included improvements in health and increases in longevity. Of course, there were costs

of production that were improperly included in NIPA, such as the increase in expenditures on crime prevention associated with urbanization, but the omitted benefits far exceeded the unexcluded costs.

The Role of Population Growth

Few economists of his era investigated the interrelationships between economic growth and population growth as fully as Kuznets. He was impressed more by the salutary effects of rapid population growth than by its negative effects. The evidence, he noted, indicated no cases in which large increases in population were accompanied by declines in per capita income. Rapid population growth tended to increase per capita income because it increased the number of contributors to useful knowledge. It tended to increase savings both because it increased the ratio of savers to dissavers and increased the amounts saved by upper income groups. Larger populations also promoted economies of scale and the responsiveness to new products (because of changes in the age structure of the population). Despite these generally positive aspects of high rates of population growth, Kuznets recognized that the sharp acceleration in the populations of less developed nations, generally brought about by sharp declines in death rates, sometimes overwhelmed the economies and impeded growth in per capita income.

Kuznets pointed out the economic significance of the fact that accelerated population growth was due primarily to a decline in death rates. The associated decline in morbidity rates served to increase labor productivity, to increase the payoff on investment in the raising and education of children, and to improve the quality of life. Moreover, the more rapid decline of death rates in cities than in rural areas promoted urbanization and speeded industrialization. The tendency of declining death rates to

induce lower fertility rates and promote migration also contributed to economic growth by adapting social institutions to new economic opportunities. The reduction in completed family size and the fact that this occurred at differential rates in rural and urban areas led to a removal of younger generations from the influence of the family and exposed them to modern ethics that promoted participation in a rapidly changing economic system. He saw this break between ties of blood and economic rewards as a central factor in the victory of objective tests of economic performance over the more traditional rewards to family connections.

Kuznets's investigations of the synergism between economic and demographic change were so many-faceted they defy a brief summary. I have therefore selected one of his various lines of investigation for further comment. It pertains to the impact of demographic factors on the measured inequality of the distribution of income. Early in his career Kuznets began to struggle with problems of how to measure the degree of inequality in the distribution of income and to identify the factors contributing to the inequality. Such decomposition would point to policies that could relieve the appalling economic conditions of the poor that prevailed in all countries at the beginning of the twentieth century. Kuznets believed that unless the poor shared in the benefits of economic growth at least as fully as the more well-to-do, the stability of society was at risk. He regarded rapid economic growth and greater distributional equality as desirable and generally consistent goals.

During the 1960s and 1970s when it was apparent that a number of Asian nations had entered onto the paths of both rapid population growth (due to rapidly declining mortality) and rapid growth in per capita income, some of the available evidence seemed

to indicate that these developments were increasing the inequality of the income distribution, and hence vitiating the benefits of the modernization of these countries for the poor. Studying the evidence on which this conclusion was based, Kuznets noted that the mechanical application of procedures used for the U.S. and other developed nations were inappropriate in the Asian context, because they failed to take account of the differences in institutions. A key point related to the nature of Asian family cultures which were different from Western family cultures. As a consequence, the variance in the size of the Asian family (or household) was much larger than in the United States and Western Europe. Not only were the household arrangements of the extended family different, but intra-family income flows were different, and these differences were not reflected in standard measures of household income.

When these differences were explicitly acknowledged, a number of important statistical relationships emerged. For example, there was a negative correlation between the number of persons per family and the per capita income of families. Consequently, the very identity of the lower and upper income groups changed, depending on whether the size distribution of income was measured by the total income per household, or by the average income per person in the household. Moreover, the rate of population growth changed the age structure of households. Countries with rapidly growing populations and high fertility rates had a higher proportion of younger household heads and lower shares of heads over age 65 than countries with low population growth. Such demographic variations might increase inequality measured in cross section, even though lifetime income distributions were relatively equal. All of these issues could be adequately

addressed, Kuznets pointed out, if the sample surveys were designed on the basis of an appropriate theory of the impact of demographic factors on income distributions.

Measurement in Economics

To many colleagues and students, Kuznets's most compelling contribution was his mastery of the art of measurement. This art required not merely a thorough grounding in statistical theory. A more difficult achievement was understanding how to apply statistical methods and economic models to the incomplete and biased data with which economists normally work and still produce reliable estimates of key economic variables and parameters. That skill cannot be encapsulated in a simple list of rules because the circumstances under which a given set of defects in the data is tolerable depends on the issues that are being addressed, on the statistical and analytical procedures that are being employed, and on the sensitivity of the results to systematic errors in the data, to the choice of behavioral models, and to the choice of statistical procedures.

Although Kuznets was a quintessential empiricist and a standard bearer for empirical research, his empiricism did not imply hostility to theory. He continually emphasized that a sound theory was needed to identify the variables that had to be measured, and theory had to be invoked in order to determine how the raw data thrown up by normal business or governmental activities should be combined in order to create the desired measures. Since measurement was dependent on theory, as theory advanced, due to either deeper insights or sounder empirical knowledge, past measures would have to be revised. Thus theoretical and empirical knowledge are at any point in time only asymptotically valid, subject to changing knowledge in both areas as well as to changing social goals, values, and priorities.

Although statistical analysis of quantitative data was a powerful tool in addressing issues of economic policy and in identifying both short- and long-term changes in the economy, it provided no magical solutions. Kuznets repeatedly emphasized that study of quantitative data is filled with pitfalls that have entrapped the most able practitioners of the art at one time or another. Even when the data are relatively good, the procedures appropriate, and the results fairly unambiguous, great care had to be taken in drawing conclusions about the domain to which the findings applied and the predictions that could be reliably based upon them. High on his list of major dangers was the superficial acceptance of primary data without an adequate understanding of the circumstances under which the data are produced. Adequate understanding involved detailed historical knowledge of the changing institutions, conventions, and practices that affected the production of the primary data but that were difficult to ascertain and to quantify.

Another point high on Kuznets's list of major dangers was the easy assumption that a good fit of a mathematical model to the data made it an adequate description of significant features of the data. Because of the limitations of data, especially in time series, many different mathematical models, varying in complexity and structure, may give fairly good statistical fits to a given body of data when conventional statistical measures of goodness of fit are invoked. Nor can Occam's razor be glibly invoked to settle such issues, since it is possible that the curve that gives the best fit incorrectly leads to the conclusion that the data were generated a simple process, an elegant "law" of behavior embodied in a single equation, when they were actually generated by complex processes that are badly distorted by the simple function.

Kuznets's choice of estimating procedures was deeply embedded in evaluations of the objectives of a particular investigation. Whether a given body of data was adequate depended not only on inherent limitations of the data set but on the types of measures that were being constructed from it and the issues to which these measures were addressed. Preliminary analyses of defective data were useful, because they increased the likelihood of upgrading the available data sets or closing gaps in them by demonstrating the social usefulness of such efforts. Indeed, he viewed the preliminary analyses of the available data as an essential part of an asymptotic process of discovery, during which both the underlying data sets and the analytical procedures were perfected and made more suitable to the resolution of the substantive issues.

Like many other statisticians, Kuznets worried about imposing so much structure on the data that the *a priori* assumptions of the investigation overwhelm whatever information there is in the data. He was skeptical about fitting simple high-order curves to data sets with relatively few observations of questionable quality. Consequently he tended to work with looser forms of data analysis, often preferring frequency distributions with one-, two-, or three-way classifications to regression analysis. Kuznets objected to the cavalier ways in which regression analysis was often applied, especially when highly restrictive functional forms were applied to data sets without adequate investigation of the underlying process or institutions under investigation. Too often, functional forms were imposed with inadequate consideration as to whether the data set could bear the weight of the structure imposed on it. Kuznets's evaluation of the validity of substantive findings tended to be cast less as simply right or wrong, but more often focused on the reliability of the results and their domain of applicability. He was

particularly concerned with the detection and measurement of systematic errors in the data: systematic misreporting, sample selection biases, the impact on results of the underlying behavioral models that circumscribed the collection and analysis of the data, and the impact of the statistical techniques that were employed in the measurement process.

Although he placed great emphasis on the development of data bases of the highest quality, Kuznets was not a purist who insisted on working only with "perfect" data. Since no data set is ever perfect, his emphasis was on how to exploit the data at hand in order to extract from them whatever useful information they might contain. But then the limitation on the resulting analysis had to be specified, with some results treated as conjectural, and still others treated as illustrative computations.

In assessing the reliability of particular estimates, Kuznets stressed the importance of systematically investigating their relationships to other series and other kinds of information that were logically related to them. He was, in this connection, a master of devising algebraic identities that brought other available data to bear on the estimates at issue in a particularly illuminating way. Such identities were also effective devices for revealing implicit and unsupported assumptions, and thus contributed to the social research agenda.

The most powerful technique that Kuznets employed to evaluate attempts to measure key aspects of economic life was sensitivity analysis. Most measurements in economics are complex combinations of data and *a priori* assumptions. Much argument about the result of quantitative analysis turns on these *a priori* assumptions. Moreover, because the arguments used to champion one procedure over another are also *a priori*,

these arguments often produce more heat than light. Kuznets's solution to such problems was sensitivity analysis, by which he meant a careful examination of both the procedures and the data in order to see if plausible ranges of systematic errors in the data, if changes in the *a priori* assumptions that shaped the analysis, or if the substitution of reasonable alternative estimation procedures make a material difference in the finding. If they do not, the finding is robust; otherwise the data add little to the theoretical considerations that preceded the measurement. The original hypothesis remains an untested hypothesis, despite the gloss provided by the data. Kuznets was persistent in searching for methods of evaluating the sensitivity of measures of economic variables and parameters and ingenious in devising such tests.

Kuznets's Legacy

Kuznets's greatest legacy is his theory of modern economic growth. The proposition that the high growth rate since the eighteenth century in population and per capita income, the sharp changes in the structure of the economy, and the concomitant changes in social institutions and culture are a unique epoch in human history is no longer a theory. It is now a part of the confirmed knowledge of economic science. The research of the past three decades has added important detail to Kuznets's summary of the evidence available in the 1960s and also modified or corrected some conjectures.

The enhancement of human capital by the environmental controls made possible by modern economic growth may have been more far-reaching than Kuznets realized. Evidence accumulated during the last three decades indicates that the period of modern economic growth was one of major improvements in human physiology induced by accelerating technological change and greater mastery of the environment. This

physiological improvement has manifested itself not only in the continuing increase in life expectancy since the 1960s, when it was widely assumed that the century-long increase in life expectancy had come to an end. It is also evident in the steady decline in mortality rates at ages 80 and over, an accelerating decline in the age-specific burden of chronic diseases at older ages, and a fifty percent increase in body size since the eighteenth century, indicative of improvements in the functioning of the principal organ systems.

Recent evidence also indicates that at least in England, modern economic growth may have begun about half a century earlier than Kuznets specified. Rapid increases in agricultural productivity were relatively high from the beginning of the eighteenth century and the shift of labor from agricultural to nonagricultural occupations over the course of the century was substantial. These new findings, mainly for England but also for France, provide a stronger connection between rising productivity and declining mortality rates in the nations that initiated modern economic growth. The high plateau of mortality rates during the middle of the nineteenth century now appears to be a pause in a downward secular trend that was more than a century old when it resumed. The pause appears to be explained by the great difficulty in solving the problems of public sanitation created by the remarkable spurt in urbanization during the nineteenth century.

What is impressive about *Modern Economic Growth* 35 years after its publication is not its faults but how well its major findings have held up. Indeed, some of Kuznets's forecasts, controversial at the time they were made, such as the continuing acceleration of technological change, now seem so obvious it is difficult for those who did not live through the 1950s and 1960s to recognize their path-breaking character. When Kuznets

first made this forecast, modern information technology was still in its infancy, organ transplantation and reproductive technology were still largely topics of science fiction, and mapping the human genome, let alone engaging in genetic engineering, was not even encompassed in science fiction. Equally impressive is Kuznets's prescience in recognizing the growing dominance of the non-market sectors of the economy. The failure of the official national income accounts to measure the growth of leisure, the value of the increase in life expectancy, and the decline in age-specific chronic disabilities has obscured the continuing acceleration in the secular trend of economic growth. Also obscured is the exceedingly high rate of capital formation due to the remarkable expansion of human capital relative to physical capital. Although physiological capital and knowledge capital are admittedly difficult to measure, the challenge has been accepted by some of the most talented empirical economists today and constitutes one of the most impressive new frontiers of empirical economics.

Another controversial forecast of Kuznets that has held up is the closing of the economic gap between the OECD economies and many Third World economies, particularly in Southeast Asia and Latin America. Kuznets's prediction that food supply would expand more rapidly than population has also been confirmed. Today, the global per capita consumption of food has increased by 15 percent since 1960, despite the doubling of population over the past four decades.

Kuznets's approach to the measurement of economic variables is another major facet of his legacy. He did not believe in either economic theory or economic measurement for their own sake. His economic analysis was directly or indirectly shaped by his perception of the major issues of public policy. Kuznets recognized that formal

modeling was a useful instrument in the search for theories that could guide economic policy. However, he favored theorizing that, while it made use of hypothetico-deductive modeling, was based on postulates consistent with historical evidence.

The Kuznetsian approach has grown in strength in recent years, not only at the macro level of analysis but also at the micro level. Historically (evidentially) based analysis has been given a considerable fillip by the reinvigoration of NBER after Martin Feldstein became its president and CEO in 1978. Although the Kuznetsian blend of theory and historical evidence is evident in all of the NBER programs, it is particularly marked in those dealing with secular trends in the economy, life-cycle and intergenerational processes in economics, health economics, labor economics, and the economics of aging.

Kuznets's contention that imposing too much structure on data obscures rather than reveals their information content is widely accepted as a guiding principle in empirical economics. In research on many of the most urgent issues of current policy, investigators are increasingly exploiting the properties of frequency distributions and their decomposition. Although regression analysis remains a powerful tool, its limitations and the virtues of less structured forms of data analysis are now widely recognized by empirical economists.

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