Press Release - The Sveriges Riksbank (Bank of Sweden) Prize in Economics in Memory of Alfred Nobel

KUNGL. VETENSKAPSAKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

21 October 1987

The Royal Swedish Academy of Sciences has decided to award the 1987 Alfred Nobel Memorial Prize in Economic Sciences to Professor Robert M. Solow, Massachusetts Institute of Technology, Cambridge,USA, for his contributions to the theory of economic growth.

The study of the factors which permit production growth and increased welfare has been a central feature in economic research for many years. Robert M. Solow's prize recognizes his exceptional contributions in this area.

It is eminently reasonable to imagine that increased per capita production in a country may be the result of more machines and more factories (a greater stock of real capital). But this increased production may also be due to improved machines and more efficient production methods (which may be termed technical development). In addition, better education and training, and improved methods of organizing production may also give rise to increased productivity. The discovery of fresh natural resources, or improvements in a country's position on the world market, may also lead to higher standards of living.

Solow has created a theoretical framework which can be used in discussing the factors which lie behind economic growth in both quantitative and theoretical terms. This framework can also be exploited to measure empirically the contributions made by various production factors in economic growth.

Solow's Growth Model

Solow's growth model was presented in an article entitled, A Contribution to the Theory of Economic Growth (1956). **The article contains a mathematical model (in the form of a differential equation) describing how increased capital stock generates greater per capita production.** Solow's starting point

is that society saves a given constant proportion of its incomes. The population and the supply of labor, grow at a constant rate and capital intensity (capital per employee) can be regulated. Capital intensity is determined by the prices of production factor.

Due to diminishing yields, however, additional capital injections (increasing capital intensity) will make ever smaller contributions to production. This means that, in the long term, the economy will approach a condition of identical growth rates for capital, labor and total production (on condition that there is no technological progress). This involves a situation in which per capita production and real wage no longer increase. An increase in the proportion of incomes which is saved cannot, therefore, lead to a permanent increase in the rate of growth. In contrast, an economy with a higher savings ratio, experiences higher per capita production, and thus higher real income. But, in the absence of technological progress, the rate of growth will be the same, irrespective of the savings quotient, and will be purely dependent on an increased supply of labor.

As a result, technological development will be the motor for economic growth in the long run. In Solow's model, if continuous technological progress can be assumed, growth in real incomes will be exclusively determined by technological progress.

The preceding discussion has assumed that a given proportion of economic income is saved and that savings correspond to an equivalent amount of planned investment. Solow proves, however, that if corporations had perfect foresight and if the labor and capital markets function satisfactorily, corporations will wish to invest to the extent that their total investment plans correspond to the given value of savings. This means that Solow ignores the conditions that may underlie, for example, a Keynesian analysis of unemployment. However, while Keynesians focus on short term instability, Solow is interested in an analysis of long term development.

Solow's theoretical model had an enormous impact on economic analysis. From simply being a tool for the analysis of the growth process, the model has been generalized in several different directions. It has been extended by the introduction of other types of production factors and it has been reformulated to include stochastic features. The design of dynamic links in certain "numerical" models employed in general equilibrium analysis has also been based on Solow's model. But, above all, Solow's growth model constitutes a framework within which modern macroeconomic theory can be structured.

Empirical Growth Analysis

The empirical estimation of the contributions of various production factors to GNP is linked with the work of several other economists. **Solow's contributions in two articles, Technical Change and the Aggregate Production Function, published in 1957, and in Investment and Technical Progress, from 1960, laid the foundations for what was later to develop into "growth accounting".**

In his first article, Solow based his model on time series figures for total production, the total input of labor and the cost shares of these factors in total production. Solow thus achieved a measure for continuous change in production technology over time by calculating the difference between the relative development of production and the development of the supply of labor and capital, weighted by factor shares. On the basis of this estimated series, Solow could assess the production function, (ie the mathematical relationship between production, on the one hand, and the input of production factors, on the other).

The change in production technology (the change in production which could not be interpreted as changed inputs of labor and capital) was interpreted as the result of changes in production techniques, that is to say, technical progress.

Solow's analysis showed that technical improvements were neutral over time (the distribution of GNP between earnings and capital yield was not affected by technical change). He also demonstrated that only a small proportion of annual growth could be explained by increased inputs of labor and capital.

Solow's study had a dramatic impact - similar analyses were undertaken in a great many other countries. Access to better statistical data in the form of time series for capital and labor has permitted more reliable results to be achieved.

The first attempts at measuring the contributions of production factors to total production were based on given series for the supply of labor and the stock of capital. Both these aggregates are somewhat controversial, however. Robert Solow participated actively in lengthy discussions about the measurement of aggregated capital stock (the "capital controversy" of the 1960s and 1970s). In an article published in 1960, Investment and Technical Progress, Solow presents a new method of studying the role played by capital formation in economic growth. His basic assumption was that technical progress is "built into" machines and other capital goods and that this must be taken into account when making empirical measurements of the role played by capital. This idea then gave birth to the "vintage approach" (a similar idea was discussed by Leif Johansen in Norway at about the same time). The vintage approach assumes that new investments are characterized by the most modern technology and that the capital that is formed as a result does not change in qualitative terms over its remaining life. Thus, the investment decision ties up future technology to some extent, since technological knowledge is rooted in the physical capital object. Solow's formulation of a mathematical model based on these ideas enabled him to develop a theory which permitted empirical calculations to be made. In principle, the model established a new way of aggregating capital from different periods. Solow's empirical results naturally gave the formation of capital a markedly higher status in explaining the increase in production per employee.

The most important aspect of Solow's article was not so much

the empirical outcome, but the method of analysing "vintage capital". Nowadays, the vintage capital concept has many other applications and is no longer solely employed in analyses of the factors underlying economic growth. For example, many numerical general equilibrium models utilize Solow's approach in the study of the sensitivity of economies to certain types of disruptive effects. The vintage approach has proved invaluable, both from the theoretical point of view and in applications such as the analysis of the development of industrial structures.

Other Works

Professor Robert Solow has worked actively within many vital areas of economic theory. For example, he has published important contributions in the area of natural resource economics. Conventional economic growth theories assume that the only factors which can affect economic growth are labor, capital and technology. In recent years, the role of natural resources has also attracted considerable attention. Is it possible to imagine continued economic growth when we know that natural resources are finite? Solow studied this question from a theoretical perspective in an article published in 1974 and found that the key to this problem lay in assumptions made about the substitution elasticity for capital and natural resource inputs. Solow has also studied the environmental consequences of growth in other works.

Over the last decade, Professor Solow has largely devoted his research efforts to macroeconomic questions involving unemployment and economic policy and he has been a member of the US President's Council of Economic Advisers.