# Economic Growth

## How it works and how it transformed the world

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Vernon Press

www.vernonpress.com

*In the Americas:*
Vernon Press
1000 N West Street,
Suite 1200, Wilmington,
Delaware 19801
United States

*In the rest of the world*
Vernon Press
C/Sancti Espiritu 17,
Malaga, 29006
Spain

Library of Congress Control Number: 2014958349

ISBN 978-1-62273-021-6

PAGES MISSING

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**Chapter 7**

# Past theories of economic growth

## 7.1 Adam Smith

Adam Smith's book, *An Inquiry into the Nature and Causes of the Wealth of Nations*, published in 1776, was the foundation of modern economics. Smith was writing at a time when Mercantilism was the prevailing philosophy, guiding thinking on economics and government policy. Mercantilism in effect equated a nation's wealth to the money and treasure it owned. Smith argued instead that the wealth of a nation was its ability to produce useful goods and services. *The Wealth of Nations* was devoted to exploring what generated this wealth and how it could be increased. The wealth of a nation is its total production (what would be known today as Gross Domestic Product) and not the value of its treasure.

Smith recognizes that the modern economy is based on specialization and exchange. Book III, Chapter I, titled "Of the Natural Progress of Opulence" includes:

> "The great commerce of every civilized society is that carried on between the inhabitants of the town and those of the country. It consists in the exchange of crude for manufactured produce, either immediately, or by the intervention of money, or of some sort of paper which represents money. The country supplies the town with the means of subsistence and the materials of manufacture. The town repays this supply by sending back a part of the manufactured produce to the inhabitants of the country. .... The gains of both are mutual and reciprocal, and the division of labour is in this, as in all other cases, advantageous to all the different persons employed in the various occupations into which it is subdivided."

Specialization allows the division of labor. This is the key to increased production. From Book I, Chapter I:

> "The greatest improvement in the productive powers of labour, and the greater part of the skill, dexterity and judgement with which it is anywhere directed, or applied, seem to have been the effects of the division of labour."

Smith lists three causes for the greater productivity flowing from the division of labor:

- improvements in productivity from experience or learning by doing, "the improvement of the dexterity of the workman necessarily increases the quantity of the work he can perform; and the division of labour, by reducing every man's business to some simple operation, and by making this operation the sole employment of his life, necessarily increases very much the dexterity of the workman."
- the saving of time which would be "lost in passing from one sort of work to another"; and
- the application of capital or "every body must be sensible how much labour is facilitated and abridged by the application of the proper machinery."

Smith even mentions (still in Book I, Chapter I) three ways in which productive innovations are made. First, workmen come up with ideas for better ways of working:

> "A great part of the machines made use of in those manufactures in which labour is most subdivided, were originally the inventions of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts towards finding out easier and readier methods of performing it."

Second, specialized equipment manufacturers improve the design and performance of their machines:

> "Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade;"

And third, inventors come up with new machines:

> "and some [improvements have been made] by those who are called philosophers or men of speculation, whose trade it is not to do any thing, but to observe every thing; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects."

The greater the division of labor, the more productive the economy. The division of labor though is limited by the extent of the market. From Book I, Chapter III:

> "As it is the power of exchanging that gives occasion to the division of labour, so the extent of this division must always be limited by the extent of that power, or, in other words, by the extent of the market."

Changes which increase the extent of the market therefore allow further increases in productivity. Smith notes several ways in which a market can be extended; he notes the favorable effects in expanding the market of improvements in transport (for example in Book I, Chapter III); he notes the unfavorable effects of restrictions on international trade (for example in Book IV, Chapter II); he notes the problems caused by restrictions on employment and restrictive work practices (for example in Book I, Chapter X); and he stresses the detrimental effect of monopolies (for example in Book I, Chapter VII).

Smith recognizes that the division of labor involves specialization and that in turn it requires an efficient system of exchange. Money is the key to effective exchange as it supplants barter and minimizes transaction costs (Book I, Chapter IV). Smith identifies the existence of capital and the source of capital as savings – that part of income which is in excess of consumption (Book II, chapter I). (These are the modern words for Smith's arguments; Smith never mentions transaction costs, income or consumption.)

He suggests that output depends on labor and capital inputs (see Introduction and Plan of the Work): The annual consumption of a nation is determined

> "first by the skill, dexterity and judgement with which its labour is generally applied; and secondly, by the proportion between the number of those who are employed in useful labour, and that of those who are not so employed. . . . The number of useful and productive labourers . . is every where in proportion to the quantity of capital stock which is employed in setting them to work, and to the particular way in which it is so employed."

Smith's first concern is with production and productive effectiveness. For this production to be economically efficient it must be directed to what people want to consume. Smith recognized the role of markets in allocating resources in a useful way. He even appears to be groping towards a simple model of supply and demand (in Book I, Chapter VII). He develops the concept of natural price, a sort of long run competitive equilibrium price, and shows that an increase in demand will lead to higher prices which will stimulate supply with competitive forces then driving the market price back to the natural price.

Smith goes on to explore the market system. The crucial concept here is "the invisible hand". The key paragraphs describing the power of the market are (from Book IV, Chapter II):

> "Every individual is continually exerting himself to find the most advantageous employment for whatever capital he can command. It is his own advantage, indeed, and not that of the society which he has in view. . . . But the study of his own advantage naturally, or rather necessarily leads him to prefer that employment which is most advantageous to the society. . . . every individual . . endeavours . . to employ his capital . . so to direct that industry that its produce may be of the greatest value . . . and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention."

Smith linked the pursuit of self interest in production to the public interest in producing the right things. This idea of "the invisible hand" is the intellectual precursor to the systematic study of the market leading ultimately, although this took almost 200 years, to the concept of general equilibrium and proof of the welfare properties of a competitive equilibrium (see, for example, Kenneth Arrow (1951)).

Adam Smith was not concerned with economic growth per se; indeed, the concept of economic growth was unknown when he was writing. Smith was tackling the pressing problem of his time – rejecting society's emphasis on treasure and instead trying to clear the decks for people to get on with production and increasing production. He was concerned with (in modern jargon) maximizing GDP, the production of goods and services which people wanted. In investigating how to maximize production, Smith identified the central roles of incentives, self-interest, competition, money and the market; he also investigated the role of capital and productivity. Smith's intellectual approach laid the foundation for modern economics. Although unforeseen by Smith, the forces unleashed by incentives, competition and free markets have been vital to economic growth.

## 7.2 David Ricardo

David Ricardo, an English political economist, published *On the Principles of Political Economy and Taxation* in 1817. This book set out what has become known as the law of comparative advantage. Ricardo showed that there is mutual benefit from trade, regardless of absolute productive potential, as long as each party concentrates on the activities in which it has a relative advantage – the product for which it has a lower opportunity cost. This is the underlying efficiency argument in favor of specialization and trade. It applies to free trade among all trading parties whether individuals, businesses or countries.

England at the time protected its agriculture from import competition by means of tariffs, the "Corn Laws". These tariffs raised the price of all food as well as creating rents (higher incomes) to landowners; indeed, the purpose of the Corn Laws was to protect English agriculture and to raise the incomes of landowners. Ricardo opposed these restrictions on international trade for two reasons, one to do with comparative advantage and the other to do with investment. The comparative advantage argument was essentially that England should concentrate on what it did well (at the time textiles and metal goods) and import what others did relatively well (in particular foodstuffs). He also argued that the Corn Laws caused less-productive domestic land to be worked and rents to landowners to increase. Thus, income would be directed more toward rural landlords and away from the emerging industrial capitalists. Since landlords tended to spend on conspicuous consumption rather than investments, Ricardo believed that the Corn Laws were restraining the growth of the British economy. Ricardo provided the intellectual firepower to the argument against the Corn Laws. The Corn Laws were eventually repealed although only in 1846, many years after the publication of his book. (And it is more likely to have been political machinations rather than dispassionate intellectual argument which prevailed in the repeal of the Corn Laws.)

International trade, allowing comparative advantage to find expression, went on to become one of the essential features of British economic growth. Britain produced coal, iron and steel, it imported cotton and foodstuffs, and it exported textiles, transportation equipment and machinery. Britain depended on foreign markets for sales of the textiles and metal goods on which its growth was based just as it depended on foreign producers for many of its raw materials.

More recent examples of rapid economic growth - in countries such as Australia, Canada, China, Japan, New Zealand, Singapore, South Korea and Taiwan – similarly depended on international trade. Australia, Canada and New Zealand grew on the back of trade with Britain and the United States. The east Asian countries have grown by catching up, exploiting their cost advantages to supply American and European markets while buying equipment and services from these high income countries.

Ricardian comparative advantage (and its cousin, the Heckscher-Ohlin theorem) provided the theory while the experience of Europe and the United States provided the practical demonstration of the benefits of free markets and international trade. Free markets and international trade have been central in enabling the economic growth of the past 200 years.

## 7.3 Karl Marx

Karl Marx was a German philosopher who, having been hounded out of various European countries, ended up in London where he wrote his most influential economic works. The first volume of his *Capital* was published, in German, in 1867. Marx's subsequent work on *Capital* was published posthumously by his friend and patron, Friedrich Engels, as Volumes II and III.

The heart of *Capital* is Marx's labor theory of value. Marx attributed prices to the labor contained in the good or service being sold. But, labor content, even if indirect labor is taken into account, does not account for the entire price. The difference between the labor content and price was termed by Marx "surplus value". This surplus value is what today we would call profits plus interest plus tax. As there were no company income taxes or general sales taxes in Marx's time, this surplus value was income to capital.

This surplus Marx viewed as being created by labor but not paid to labor. Labor created the value but was paid only the amount needed to subsist. The presence of a "reserve army of the unemployed" would hold wages down to the survival level. This surplus value was seen by Marx as evidence of exploitation – exploitation of the proletariat by capitalists or "the dictatorship of the bourgeoisie". Marx viewed the prevailing capitalist system as being run by the wealthy business classes for their own benefit with their wealth being based on expropriation of this surplus value. This created one of the destructive pressures inherent in capitalism. Marx termed this the dialectic of "class struggle", pitting labor against capital.

These tensions would be heightened by the tendency of the rate of profit to fall. Marx argued that the growth of capital relative to labor would reduce the rate of profit. Any attempt to raise profits by investing still more would accelerate this process in a vicious circle of diminishing returns.

Competition among capitalists would grow so fierce that most would fail, leaving only a handful of monopolists controlling nearly all production. Marx saw this as one of the contradictions of capitalism - competition, instead of benefiting consumers, in the long run would create monopolies, harming those consumers.

These internal tensions would result in the destruction of capitalism.

This was part of the evolution of society through six stages – primitive communism, slavery, feudalism, capitalism, socialism and communism. Primitive communism was based on self-sufficient villages without a market economy. Slavery was based on landowners also owning labor. Feudalism was an agricultural economy wherein the masses worked on rented land. Capitalism encompassed agriculture, manufacturing and services with production based on workers employed by capitalists - the owners of land and physical capital. Socialism featured social ownership of the means of production. The socialist state served to take control of capital and the means of production. This would be "the workers’ state" or "workers' democracy" or "dictatorship of the proletariat".

Pure communism was the utopian final stage. Pure communism would emerge when the productive power of the economy was so great that there would be freedom from need, freedom from wage labor and freedom from private property. In this classless society, production and consumption would be fully socialized, relationships between people would be based on free association and free access to goods. This would be an age of superabundance in which everyone’s needs would be satisfied and so there would be no internal tensions and even no need for government. Among the features of pure communism is “from each according to his ability, to each according to his need”.

This was Marx’s theory of economic growth. The high income countries of the day, such as Britain and Germany, had long since passed through the initial stages of growth and were well into the age of capitalism. The later stages, of socialism and communism, would arrive in the future the result, Marx argued, of the tensions already contained in the capitalist system. The final stage, pure communism, would feature superabundance in which everyone had all the economic goods they wanted. Economic growth would (somehow, it was not explained how) proceed into the long term when incomes would be so high that no-one would have to do wage labor. (The slight drawback to this theory was that Marx never explained the economic mechanisms whereby this utopia would emerge or operate.)

Marx's economic predictions did not come to pass. The capitalism of 19th century Britain evolved into new system with a hugely expanded role of government. But this was a new creature – government became involved in providing infrastructure, public goods and an income safety net but not in social ownership of the means of production. The modern welfare state was not envisaged by Marx. Britain did experiment with socialization of the large scale industrial system (under Clement Attlee, Prime Minister 1945 – 51) but this public ownership was later dismantled (under Margaret Thatcher, Prime Minister 1979 – 90). Communism was tried by several countries, most notably in the Soviet Union. This communism was imposed by political dictatorship on essentially feudal societies; it did not evolve from capitalism and socialism. The leap from feudalism to a communist economy was not successful. Communism in the Soviet Union, for example, for decades was kept in place by political and police force but even so it finally collapsed. This collapse was the result of worker and citizen displeasure, the same sorts of pressures from within which Marx had prophesied would destroy capitalism in fact came to destroy communism.

Socialist revolutions have occurred in many countries but not where Marx predicted. Marx predicted that socialism would emerge in high income capitalist countries but, in fact, socialism was forced on many low income countries, closer to feudal than capitalist in nature. These revolutions unwittingly condemned the masses to continuing poverty and political dictatorship. These revolutions failed to create the classless society, failed to create a high income economy and failed to create personal freedoms.

Marx's system fares just as badly at a theoretical level. Marx did not understand markets. He did not have the tools of marginal analysis, embodied for example in demand and supply curves or partial and general equilibrium analysis, with which to understand prices. His surplus value corresponds essentially to income to capital or profit; profit is now known to be the residual between price and expenses, it is a consequence rather than a cause of price. Economic growth increases the demand for labor and the market price of labor; growth also increases the wage rate which can be negotiated through collective bargaining. The result of these developments has been that wages and labor income have increased over time, not, as Marx would have it, decreased. Labor has done well out of economic development just as has capital. Both labor and capital have an interest in maintaining the capitalist system, not in overthrowing it by (physical or political) force.

Marx did not properly analyze incentives. Profit is needed to generate investment; everybody gains from the resulting growth. The incentive is to get on board the growth train, not to derail it by force. Industries which have been socialized have been found to perform poorly and this too is due to incentives - the incentives created for sloth, resistance to change, featherbedding, lack of investment and inattention to quality. And, pure communism will not work simply because of the incentives – if consumption is independent of income, where is the incentive to work or to invest and so produce the goods which everyone wants to consume?

Marx's view of economics was fundamentally flawed and his predictions bound to fail.

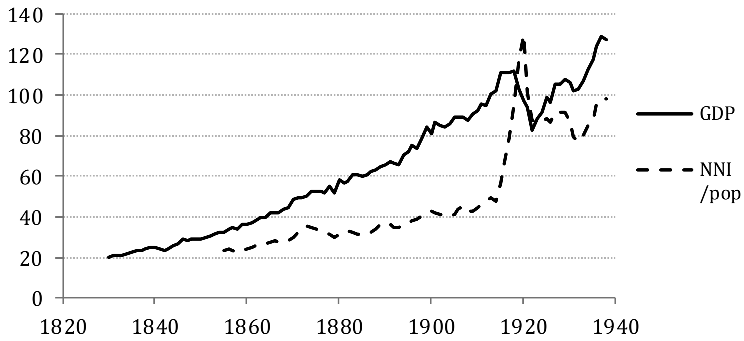
Nonetheless, Marx's theories were hugely influential. A number of revolutionary governments, including Russia, the Soviet Union and China, found in Marx an intellectual way of legitimizing their power, of justifying government control of the economy and society. A large part of 20th century world history was influenced by Marx's ideas. Ultimately though the inherent failings in Marxism came to the fore; it was essentially the matter of incentives and economic stagnation which undid the Soviet Union as well as Chinese central control of the economy.

## 7.4 John Maynard Keynes

John Maynard Keynes was an English economist and government adviser, prominent in the years from World War I until his death in 1946. His *General Theory of Employment, Interest and Money*, published in 1936, established what came to be known as macroeconomics. Keynes was concerned with the problem of a country's overall stability. He solved analytically the determination of the level of aggregate income; this analysis could then be applied to the design of stabilization policy.

Keynes' concerns can be understood from a glance at Figure 7.1. This shows constant price GDP for the United Kingdom for the years 1830 to 1938 and current dollar Net National Income per capita for 1855 to 1938. The economy followed a relatively steady growth path until World War I. For the rest of the period though the trend was lost, production quantities and prices and so real incomes moved in unprecedented swings.

Figure 7.1 U.K. economic growth and stability
Indexes of constant price GDP and current price Net National Income per capita




Source: Data from Mitchell and Deane (1971).

This history suggests why no-one previously had been too worried about economic stability. Production and incomes had been increasing relatively steadily since 1831 or even earlier (1831 is the earliest year of this annual data series) until World War I. There had been minor variations but the broad picture had been one of steady growth. It so happens that this growth was unprecedentedly rapid (the average annual growth rate from 1830 to 1913 was 2.0%) but the point here is the relative stability of the growth path rather than the growth rate. Until 1913, then, there was not really a macroeconomic stability problem. Beginning in 1914, however, a variety of problems arose. The rapid increase in production and inflation in World War I, the instabilities in Germany and Europe in the 1920s then the Great Depression of the 1930s shook the European world to the core. Economic stability was now recognized as the pre-eminent economic problem of the age.

Traditional economics was unable to explain these events. Classical doctrine, such as Say's Law, held that as long as prices including wages were flexible, the market would establish full employment equilibrium. This view was that "supply creates its own demand"; as such the productive potential of the economy, or supply, was seen as the driving force in determining economic performance. Keynes turned the logic around – demand was now the driving force. The interaction of aggregate demand and aggregate supply will lead to a macroeconomic equilibrium which may or may not involve full employment of resources. Insufficient demand, regardless of supply, could lead to an unemployment equilibrium.

The core Keynesian ideas can be expressed in terms of the following concepts. (Keynes gave a verbal presentation of these ideas; the expression in mathematical form and the emphasis on the equilibrium condition came later as people such as John Hicks (1937) and Alvin Hansen (1941) refined Keynes' ideas.) The core variable is total income, referred to as Y. Consumption spending depends on income; investment spending depends on the interest rate; government spending, exports and imports are taken as given in the simple model. Total spending is:

$$\text{Spending} = C + I + G + X - M$$

The core idea is the equilibrium between spending and income (or demand and supply); income adjusts until:

$$Y = \text{Spending}$$

The simple model can readily be extended to include taxation so that consumption depends on disposable income (which is income less taxation, Y – T). This model can be solved for the equilibrium Y, giving the total value of income, spending and production. Demand or spending is the key driving force. In turn, resource use, such as employment, follows from total production which is the same as total income. If the willingness to spend is low it is possible to have a stable equilibrium with less than full use of resources.

Two things followed from this view of the world. First, it was possible to understand that the economy could, and how it could, become trapped in a situation of less than full resource use. Second, the Keynesian approach provided a framework for designing government policy to try to alter the level of economic activity. To move the economy out of a low employment equilibrium, such as the Great Depression, the prescription was to use appropriate fiscal policy (more G and less T in this model) and appropriate monetary policy (lower interest rates in this model).

Keynesian theory is concerned with determining the level of economic performance at one point in time rather than with growth of the economy over time. The application of Keynesian theory to date has been concerned with the design of stabilization policy and with short term forecasting of general economic conditions.

However, Keynesian economics can help with economic growth. Growth is helped by total demand increasing at a moderate rate. Moderate growth in spending helps avoid inflation (when rising asset prices divert investment into asset plays and away from productive capital formation). Moderate growth in spending helps avoid depressions (when low demand discourages investment and discourages new product development). And moderate growth in spending helps to increase demand, including demand for new types of goods and services. It is no coincidence that the strong economic growth of the United States and Europe since World War II took place in a favorable macroeconomic environment of (for the most part) steadily rising spending and modest inflation. Helping create a stable macroeconomic environment with moderate spending growth is the important contribution that Keynesian economics has made to economic growth.

## 7.5 Milton Friedman

Milton Friedman led the development of monetary economics. (See, for example Friedman (1959) and (1968), and Friedman and Anna Schwartz (1963).) Initially focussing on the supply of money but later encompassing also banking and the supply of credit, monetary economics examines the influence of money and credit on aggregate economic activity.

Monetary economics has led to the rise in the use of monetary policy whereby a country's central bank influences the availability and cost of credit so as to try to manage the growth in spending. In turn, the growth in spending influences inflation and the growth in constant price production and incomes.

Monetary economics is not a theory of growth. However, like Keynesian economics, monetary economics has underpinned the development of government stabilization policies which have diminished macroeconomic instabilities, creating conditions which are conducive to growth. In particular, monetary policy has been effective in combating inflation – an enemy of growth – and in ensuring that total spending increases at a moderate rate. To promote these objectives, many countries have established central banks to manage monetary policy independent of political interference. As fiscal policy (government spending and revenue) operates through government revenues and expenditures and can be directed to objectives other than economic stability, an independent monetary policy has often carried the burden of economic stabilization.

## 7.6 Wassily Leontief

Wassily Leontief developed input-output or inter-industry economics, starting with his 1941 work - *The Structure of the American Economy, 1919–1929*. The input-output model divides the economy into industries and is based on actual transactions between these industries. For example, the 2009 Input-Output Accounts for the United States have 70 inputs (provided by 66 industries as well as non-comparable imports, labor, capital and sales taxes) supplying outputs to 72 users (each of the 66 producing industries as well as six types of final demand - personal consumption, private fixed investment, change in private inventories, exports, comparable imports, which are a negative use, and government purchases). The Leontief model works as:

(1) Inputs. Production in each industry is represented by a fixed proportions model of its purchases from other industries and from primary inputs such as capital services and labor. Therefore, the input to industry j from source i is $A_{ij} \times X_j$ where $X_j$ is the output from industry j and $A_{ij}$ is the input-output coefficient.

(2) Demand. The demand for the output from each industry is the sum of its inputs to other industries and final demand for its products. Demand for output from industry i is $\sum_j A_{ij} \times X_j + Y_i$ where the summation term covers inter-industry demand and $Y_i$ is total final demand for product i.

(3) Equilibrium. Demand must equal supply for every industry. (This is a static, linear, general equilibrium model.) The equilibrium condition implies:

$$AX + Y = X$$

where A is the matrix of input-output coefficients, X is the vector of industry outputs and Y is the vector of total final demands. Solution of this system of equations gives the set of industry outputs:

$$X = (I - A)^{-1} Y$$

This is the central Leontief result. As A is known from the data and Y is the target set of final outputs; the model solves for the set of required industry output levels. Inter-industry transactions are then found as AX.

(4) Accounting. The industry outputs, X, are gross outputs. The national income aggregates such as GDP are based on value added which is, for each industry, gross output less intermediate purchases. The national income aggregates can be derived directly from the table of input-output transactions – GDP is the sum of value added across industries and Gross Domestic Expenditure is the sum of the final demands.

The Leontief model is not a model of economic growth, rather, it deals with the structure of the economy at a given time. (Dale Jorgenson has extended the Leontief model in several ways, including to introduce prices and considerations of growth; see, for example, Edward Hudson and Jorgenson (1974).) However, the Leontief model provides a framework for analyzing the interactions between industries. A growth industry will pull many industries along in its wake both by purchasing inputs from the other industries and by generating income which is then spent across the entire economy. The Leontief model traces these links between spending and industry outputs.

## 7.7 Simon Kuznets

Simon Kuznets (1973) viewed economic growth as “a long-term rise in capacity to supply increasingly diverse economic goods to its population, this growing capacity based on advancing technology and the institutional and ideological adjustments that it demands.”

Kuznets was a leading figure in developing national income accounting in the United States. He also investigated economic development and growth using quantitative data to supplement the traditional qualitative analysis.

Kuznets identified six characteristics of modern economic growth. (1) There is rapid growth in income per capita and population. (2) There is rapid growth in productivity. (3) There is structural change such as the shift from agriculture to manufacturing to services, the shift of production from individuals to companies and the shift of labor from self-employed to employee. (4) The structure of society changes as a result of education, secularization and urbanization. (5) The world becomes more interdependent. (6) Economic growth has been limited to a minority of the world's population.

The fact that only some countries have achieved growth shows that growth is not automatic. Kuznets argued that conditions necessary to allow growth include a flexible social and political framework, and incomes above some floor level. The central feature of growth, once it starts, is productivity growth. In turn, productivity growth results from innovation. Kuznets places the driving force behind innovation in science (see Kuznets' (1973)):

> "some new major growth source, some new epochal innovation, must have generated these radically different patterns. And one may argue that this source is the emergence of modern science as the basis of advancing technology - a breakthrough in the evolution of science that produced a potential for technology far greater than existed previously."

This is a self-sustaining process:

> "Mass application of technological innovations, which constitutes much of the distinctive substance of modern economic growth, is closely connected with the further progress of science, in its turn the basis for additional advance in technology. . . "

Kuznets also was concerned with income distribution. Economic growth brings about a decline in the relative position of some groups - farmers, small scale producers and landowners – and an increase in the position of other groups - owners of produced capital, managers and entrepreneurs. Kuznets looked at the evolution of income distribution and postulated what has become known as the Kuznets curve – as growth proceeds the inequality of income distribution at first increases and then, as average incomes continue to increase, begins to decrease.

Kuznets attributed economic growth to continuing technological advance. In turn, technological advance was based on science. Scientific knowledge is available to all so presumably the answer to the question of why only some countries move into economic growth is that the social structure, personal skills and attitudes in some countries are permissive of growth whereas in others they work to prevent growth.

However, Kuznets did not link his arguments into a consistent theory of growth. It was too easy just to attribute growth to science. What gives rise to scientific advance? Is scientific advance the cause of growth or the result of growth? What causes scientific advance to be translated into technological advance? Why do people behave in a way that generates growth? What are the practical mechanisms of growth? Kuznets did not create a practical view of the growth process. But, Kuznets greatly advanced the measurement of growth, and clarified the social characteristics and social effects of economic growth.

## 7.8 Walt Rostow

Walter Whitman Rostow (1960) set out a structured picture of the growth process with countries going through five stages of development. The growth process is led by a small number of industries; it is not a broad, economy-wide process although subsequent advances do spread through the economy. Rostow's five stages are: (1) Traditional society, (2) Preconditions for take-off, (3) Take-off, (4) Drive to maturity, and (5) Age of High mass consumption.

Stage 1 - Traditional Society. Traditional societies are marked by their pre-Newtonian understanding and use of technology. Attitudes, behavior and organization are static – resource allocation and productive activities follow traditional patterns based on agriculture. Production is labor-intensive and incomes are close to subsistence.

Stage 2 - Preconditions for take-off. Rostow distinguished between two cases – Britain, the first industrial country, and other countries which followed the path pioneered by Britain.

> "The preconditions for take-off were initially developed . . in Western Europe of the late seventeenth and early eighteenth centuries as the insights of modern science began to be translated into new production functions in both agriculture and industry, in a setting given dynamism by the lateral expansion of world markets and the international competition for them. . . . . Among the Western European states, Britain, favored by geography, natural resources, trading possibilities, social and political structure, was the first to develop fully the preconditions for take-off. . . . . The more general case in modern history, however, saw the stage of preconditions arise not endogenously but from some external intrusion by more advanced societies."

More specific elements in the preconditions seem to be a rise in secular education, increasing specialization in production, improvement in agriculture and in transport infrastructure, the emergence of an entrepreneurial class, the beginnings of capital mobilization (the establishment of banks and currency) and an increase in investment.

Stage 3 – Take-off. Here, "Growth becomes its normal condition. Compound interest becomes built, as it were, into its habits and institutional structure." Growth is led by a small number of industries and is concentrated in a small number of regions within the country. This growth is probably in manufacturing. This growth reflects the interaction of demand and supply. New capital and new technology is employed to produce certain goods more efficiently but there has to be a demand for these goods.

> "The stages-of-growth also require, however, that elasticities of demand be taken into account, and that this familiar concept be widened; for these rapid growth phases in the sectors derive not merely from the discontinuity of production functions but also

> from high price- or income-elasticities of demand. Leading sectors are determined not merely by the changing flow of technology and the changing willingness of entrepreneurs to accept available innovations: they are also partially determined by those types of demand which have exhibited high elasticity with respect to price, income, or both."

Feedback loops reinforce and spread growth. Profits from the expanding industries are invested so capacity continues to expand. Rostow sees productive investment increasing from less than 5% to more than 10% of national income. Rising incomes are then spent, stimulating the growth of other new industries. Growth spreads over industries and regions. The new class of entrepreneurs expands while political and social institutions change to accommodate change and the new creators of wealth. Take-off occurs when industry-led growth becomes common and society is driven by economic processes and not by traditions.

Stage 4 - Drive to Maturity. Rostow characterizes the drive to maturity as:

> "After take-off there follows a long interval of sustained if fluctuating progress, as the now regularly growing economy drives to extend modern technology over the whole front of its economic activity."

> "Formally, we can define maturity as the stage in which an economy demonstrates the capacity to move beyond the original industries which powered its take-off and to absorb and to apply efficiently over a very wide range of its resources - if not the whole range - the most advanced fruits of (then) modern technology. This is the stage in which an economy demonstrates that it has the technological and entrepreneurial skills to produce not everything, but anything that it chooses to produce."

The economy changes now on a broad front, incomes and wages increase, and living standards improve across the board.

Stage 5 - High Mass Consumption. The entire society has unprecedented levels of purchasing power. Personal incomes are high, people have the ability to purchase a wide range of goods and services, consumers concentrate on durable goods and on services, and governmental activity expands as collective wants share in the productive abundance.

The nature of government activity also changes:

> "In addition to these economic changes, the society ceased to accept the further extension of modern technology as an overriding objective. It is in this post-maturity stage, for example, that, through the political process, Western societies have chosen to allocate increased resources to social welfare and security. The emergence of the welfare state is one manifestation of a society's moving beyond technical maturity.“

Rostow describes and systematizes the growth process followed by the leading industrialized countries. Furthermore, he provides several important insights into how the growth process works.

Rostow stresses the roles of technology and investment but makes it clear other changes in behavior and institutions also are essential. He does not, though, investigate which institutional changes are necessary for growth and which are the result of growth. Nor does he investigate how or why technology and productivity increase. His stages seem to be a mixture of describing the results of growth and searching for the causes of growth.

Perhaps his most important insight was that growth operates at the industry level, not the economy-wide level. Rostow stresses that the take-off to growth is concentrated in a small number of industries and only later, once the transition to growth has been completed, does the economy move forward on a broad front. At the industry level he identifies the vital role of new technology in creating new products or in making existing products cheaper. He identifies the interaction between supply (new technology and more capital leading to lower prices) and demand (increasing due to lower prices and to higher incomes) and saw that growth involves demand and not just production and technology. He also considers the feedback loops whereby growth in these leading industries spreads to the rest of the economy.

However, the development of growth theory had started on a different direction by the time Rostow's book was published. This new direction stressed mathematical elegance rather than a concern with the causes and mechanics of growth. Rostow's work passed out of, or perhaps never got into, the mainstream of economic thought.

## 7.9 Modern growth theory

### 7.9.1 Frank Ramsey

Frank Ramsey (1928), a mathematical philosopher at Cambridge University, was the first to formulate a mathematical model of economic growth. Ramsey applied a one-sector model to the question of optimal behavior – what was the optimal consumption/saving plan over an infinite decision horizon?

Ramey's approach can be e*x*pressed as follows. Output of the single good at any time is a function of capital stock and labor input at that time; output is split between consumption and investment; income is split between consumption and saving; therefore investment is equal to saving; the change in capital stock is investment less depreciation. This will model economic growth once the time sequence of the consumption/saving split is determined.

Ramsey approached the saving choice through utility maximization: households choose their savings plan so as to optimize their utility. Ramsey assumed that utility was bounded above (which is needed for there to be a determinate solution to the infinite-horizon optimization problem) at a "bliss" level. He then formulated the decision problem as choosing savings behavior so as to minimize the present value of the shortfall between actual utility and the bliss level.

This model was solved through the calculus of variations and yielded a result which came to be called the Ramsey rule – the optimal savings plan is such that the "rate of saving multiplied by the marginal utility of consumption should always equal bliss minus the actual rate of utility enjoyed" (Ramsey, p547). Ramsey's article included an equivalent rule which he attributed to discussions with John Maynard Keynes and which came to be called the Keynes-Ramsey rule - "the marginal utility of consumption falls at a proportionate rate given by the rate of interest" (Ramsey, p546).

Ramsey's interest was in describing household behavior but in doing so he formulated the first modern growth model. However, Ramsey did not investigate the growth properties of the model. Nor, initially, did anyone else. Ramsey's approach lay unrecognized for many years. Perhaps people were too concerned with pressing economic issues – such as the roaring 20s then the Great Depression then World War II. Or, perhaps economists did not understand the use of advanced mathematics in a discipline in which analysis had been verbal or graphical.

It was not until Robert Solow (1956) formulated a simple one sector growth model directed to "explaining" aggregate economic growth that the study of growth moved into the mainstream of economic thought. (Subsequent work in the Ramsey tradition, the so-called "Ramsey-Cass-Koopmans" models, and in the Solow tradition, the so-called "golden rule" and "turnpike" models, did bring some sort of convergence of the two approaches to the question of optimal growth.)

### 7.9.2 The stylized facts

The efforts of Solow and others in the 1950s to model economic growth were shaped to a considerable extent by a set of "stylized facts", general patterns observed in the records of some countries which have experienced sustained economic growth. For example, Nicholas Kaldor (1957) noted six "remarkable historical constancies revealed by recent empirical investigations". These stylized facts were:

(1) The shares of national income received by labor and capital are roughly constant over long periods of time;

(2) The rate of growth of the capital stock is roughly constant over long periods of time;

(3) The rate of growth of output per worker is roughly constant over long periods of time;

(4) The capital/output ratio is roughly constant over long periods of time;

(5) The rate of return on investment is roughly constant over long periods of time;

(6) Real wages increase over time.

### 7.9.3 The Solow Growth Model

"Modern growth theory" is based on models following from Robert Solow's 1956 paper. The approach has evolved considerably since Solow's original formulation but this theory retains the Solow view of the world. The expression of the Solow model in the present section draws on that of David Romer (1996). The model today referred to as the Solow model is based on the production function:

$$Y(t) = F(K(t), A(t) \times L(t)) \tag{7.1}$$

where

Y = output in constant prices
K = capital quantity input
L = labor quantity input
A = effectiveness of labor
t = time

$A \times L$ is the effective labor input or labor in effectiveness terms. The level of technology, represented by $A(t)$ is thus labor-augmenting or labor-embodied (also known as Harrod-neutral). Capital-augmenting or capital-embodied technological progress (known as Hicks-neutral progress) is ruled out by this specification. This feature of no capital-augmenting technical progress corresponds to the capital-output ratio ($K(t)/Y(t)$ or $K/Y$) being constant over time which is consistent with the stylized facts.

The model assumes that capital and effective labor are the only constraints on output so that demand for output is not a constraint nor is the availability of natural resources. All capital and labor inputs are assumed to be used just as aggregate demand is assumed to equal potential supply. The model is not concerned with macroeconomic stability or with the demand side of the economy.

The production function assumes constant returns to scale in its two arguments, capital and effective labor inputs, so:

$$F(c \times K, c \times A \times L) = c \times F(K, A \times L)$$

Using this assumption of constant returns, equation (7.1) can be written with the arguments expressed per unit of effective labor:

$$Y / A \times L = F(K/(A \times L), 1)$$

or $$y(t) = f(k(t)) \qquad (7.2)$$

where $y = Y/(A \times L)$ and $k = K/(A \times L)$.

This production function is assumed to have these features:

(1) $f(0) = 0$ if there are not inputs there is no output;

(2) $f'(k) > 0$ the marginal product of capital per unit of effective labor is positive so the input of more capital causes output to increase. It is assumed also that $\lim_{k \to 0} f'(k) = \infty$ and that $\lim_{k \to \infty} f'(k) = 0$ (the Inada conditions).

(3) $f''(k) < 0$ the marginal product of capital per unit of labor declines as capital per unit of labor increases.

Labor quantity and the level of technology, or labor effectiveness, are assumed to grow at constant rates. In continuous time, these growth assumptions are:

$$L^{\bullet}(t) = n \times L(t) \quad \text{or } L^{\bullet}/L = n$$

$$A^{\bullet}(t) = g \times A(t) \quad \text{or } A^{\bullet}/A = g$$

where n and g are externally given (exogenous) growth rates and a dot next to a variable denotes the time derivative so that, for example, $L^{\bullet}(t) = dL(t)/dt$.

The model assumes that output is divided between consumption and investment (all in constant prices):

$$Y = C + I$$

The fraction of output devoted to investment (or, in this simple model, saved) is constant at an externally given value s (the saving share). Therefore,

$$I(t) = s \times Y(t)$$

and $$C(t) = (1 - s) \times Y(t)$$

Investment adds to the capital stock but at the same time capital depreciates at rate $\delta$. The change in the capital stock is:

$$K^{\bullet}(t) = I(t) - \delta \times K(t)$$

$$= s \times Y(t) - \delta \times K(t)$$

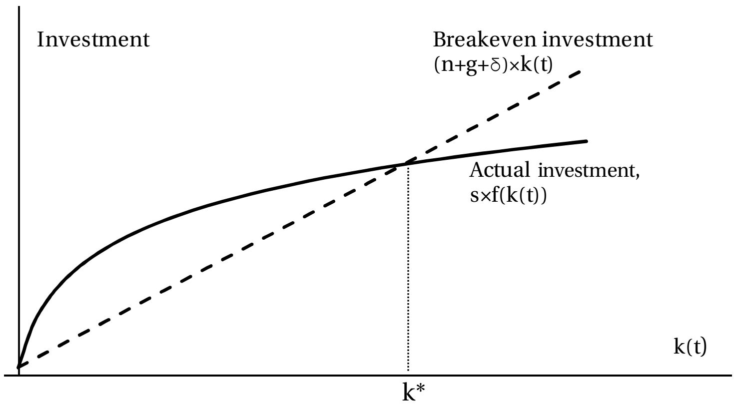
This completes the specification of the model. The next step is to solve for the economic growth path predicted by the model. The model treats the growth of effective labor as given and the investment share in output as given; accordingly, the only things left to determine are the behavior of capital and of output. Furthermore, as the production function links capital and effective labor to output, it is only capital that really emerges from the model. Thus, solving the model boils down to solving for the time behavior of capital, whether K or k. The growth of capital per unit of effective labor is given by:

$$k^{\bullet}(t) = s \times f(k(t)) - (n + g + \delta) \times k(t) \qquad (7.3)$$

This is the fundamental equation of the Solow model. It describes the change over time in capital per unit of effective labor. This change is the net effect of investment during time t which is found as the part of output that is invested, $s \times f(k(t))$, less the capital absorbed in maintaining the capital:labor ratio for an expanding input of effective labor, $(n + g) \times k(t)$, and less the capital lost to depreciation, $\delta \times k(t)$. The investment per unit of effective labor needed to maintain the existing level of capital per unit of effective labor is termed the breakeven level of investment. Equation (7.3) implies that k increases when actual investment exceeds the breakeven level, falls when actual investment is less than breakeven and remains the same when the two are equal.

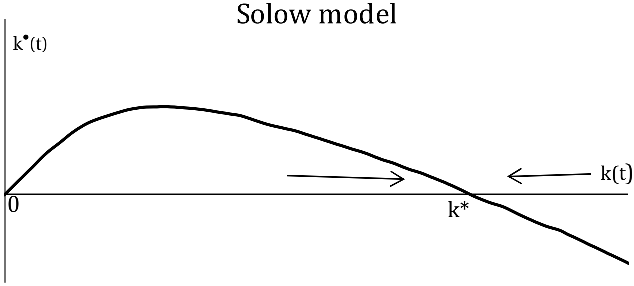
Figure 7.2 shows actual investment and breakeven investment as functions of k(t). Breakeven investment is a straight line as it is proportional to k(t). The graph of actual investment follows from the model's assumptions about the nature of the production function. As $f(0) = 0$ so the graph starts from the origin. The Inada conditions imply that $f'(0)$ is large so the $s \times f(k)$ line must be steeper than the $(n+g+\delta) \times k(t)$ line for small values of k(t). The assumptions also imply that $f'(k(t))$ falls steadily, ultimately towards zero, as k(t) rises. Therefore, the actual investment line must cross the breakeven investment line from above then continue to increase but at an ever-decreasing rate. The cross-over level of capital per unit of effective labor is denoted by k*. The assumptions ensure that k* exists and is unique.

Figure 7.2 Investment in the Solow model



The behavior of $k^{\bullet}(t)$ is shown by means of the phase diagram in Figure 7.3. This shows the implications of the investment components in equation (7.3) and Figure 7.2 in terms of the change in capital per unit of effective labor.

Figure 7.3 Capital dynamics in the Solow model




If k(t) is less than k*, actual investment exceeds breakeven investment and   is positive; k(t) approaches k*. Similarly for other values of k(t). The implications are that k(t) converges to k* from any starting point and that, once k(t) = k*, it will not move from k*.

The Solow model implies that there is a unique growth path to which the economy will converge. Everything on this path grows at a constant rate – it is a steady path. This steady growth path is consistent with the stylized facts. The crucial growth rates are of total income, Y, which grows at the rate n + g, and income per capita, corresponding to income per unit of labor, Y/L, which grows at rate g. Living standards grow at the externally given rate of increase in labor effectiveness, g, or, in the jargon often surrounding the model, with technical progress.

The share of output saved, or directed to investment, does not affect the balanced growth rate. However, an increase in the saving share will raise the level of output between the two corresponding growth paths. From equation (3), an increase in the saving share when the economy is initially on a balanced growth path, will mean that $k^{\bullet}(t) > 0$. The economy will then converge to a new balanced growth path with higher k*. Growth rates on this higher balanced growth path will be the same as before but the levels of output, consumption and capital will be higher. An increase in the saving rate will increase the rate of economic growth in the short run but not in the long run, once the economy is on its new balanced growth path. From a policy point of view, investment will not buy economic growth although it will buy a short term acceleration in growth. From the point of view of understanding actual economic growth (at least as represented by the Solow model), more investment is not the cause of economic growth.

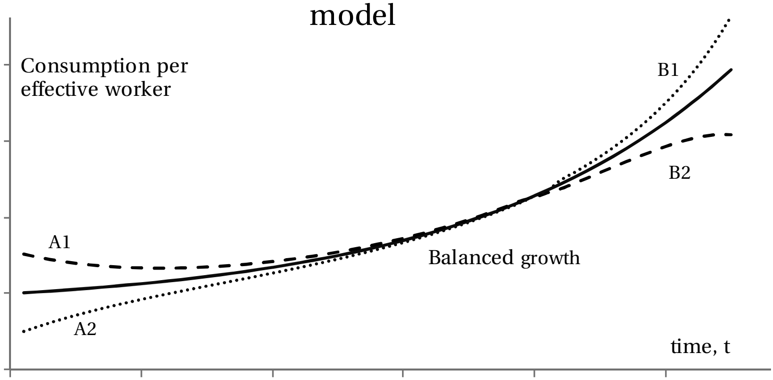
Although balanced growth rates are not affected by the saving/investment rate, s, the levels of output and consumption are affected. This gives rise to the question: for which saving rate is consumption per worker highest? The consumption maximizing saving rate has come to be called the “golden rule”. Balanced growth will satisfy the golden rule when the capital/labor ratio has a particular value which can be found from the features and parameters of the model. On the golden rule growth path, the competitive interest rate, which is the marginal product of capital less the depreciation rate, is n + g, which is equal to the rate of growth of output. Whether any particular specification of the model has a balanced growth path that satisfies the golden rule depends on the numerical features of the model. There is no mechanism to drive the balanced growth path to the golden rule path if the two paths are different.

The Solow model has been extended to allow for household behavior in the form of the consumption/saving choice. This has the effect of modeling the saving rate rather than having it fixed externally. Modeling the saving rate involves defining household welfare, as a function of consumption, then allowing households to plan their consumption over time so as to maximize the present value of the future time stream of welfare. The growth patterns predicted from this class of model have been termed “optimal economic growth”.

The optimal growth path with endogenous saving behavior has an associated balanced growth path with the same features as in the simpler form of the Solow model; in particular, output increases at rate n + g while income per worker and consumption per worker increase at rate g. This optimal growth path coincides with the earlier golden rule path if the household discount rate is zero. If the discount rate is positive, probably a more likely situation, there is less saving so the balanced growth path is below the golden rule path.

The economy can have an initial position which may be away from the balanced growth path but the optimal growth path converges to the balanced path. If the planning horizon is finite, the optimal growth path moves along the balanced path and then, late in the planning period, departs from the balanced path to move to the target terminal position. If the planning horizon is infinite, the optimal path converges to and then travels along the balanced growth path. This dynamic behavior is illustrated in Figure 7.4. This is known as “turnpike” behavior – regardless of the starting and finishing positions, the optimal growth path always involves getting onto, moving along, then if need be getting off, the turnpike, the balanced growth path. There is only one optimal long run growth path for the economy.

Figure 7.4 Turnpike behavior of the Solow model




The labor/leisure choice can also be brought into the model. Optimal growth in this case has households making two types of decisions; the first involves the time pattern of consumption, which is the saving decision, while the second is the labor/leisure decision, which determines the supply of labor. Households make these decisions in order to maximize the present value of their future stream of welfare (where welfare results from consumption of goods and consumption of leisure). The resulting growth path has the same properties as the growth path in the simpler Solow model – an optimal growth path exists and, for long time horizons, it exhibits turnpike behavior (the optimal path converges to and travels along a balanced growth path). The turnpike has the usual features; in particular, output grows at rate n + g while income and consumption per worker each grow at rate g.

This completes the development of the Solow model in its basic form. It is an elegant theoretical framework which provides insights into economic growth in this stylized world (sometimes referred to as "Solovia"). The main conclusions from this class of model can be summarized as follows.

(1) Existence. There is a balanced long term growth path.

(2) Uniqueness. There is only one balanced growth path. Output grows on this path at the constant rate n + g while output per unit of labor, typically interpreted as income per capita, grows at rate g.

(3) Stability. The economy converges to this balanced growth path. With household decision-making, the economy exhibits turnpike behavior – the growth path always moves towards then travels along the same balanced growth path.

(4) Optimality. The balanced growth path is the optimal path in terms of household welfare.

(5) Investment and capital. The balanced growth path has a constant capital:output ratio and constant capital per effective worker. Balanced growth rates do not depend on saving/investment behavior although an increase in the investment share will move the economy to a higher growth path and, during the transition period, will increase the growth rate.

(6) Source of economic growth. The long term rate of growth in output per worker is equal to g, the growth rate of labor

effectiveness. Thus long term growth depends entirely on increasing labor effectiveness, what has come to be referred to as technical progress. g is external to the model.

### 7.9.4 Extensions to the Solow approach

The core Solow model concluded that increasing productivity, rather than more capital and labor, is the source of long run economic growth - the long run growth rate in output per worker is equal to g, the rate of increase in labor effectiveness.

Theoretical work then shifted to try to make the model more general and in particular to explore the source of productivity advance. Capital began to receive more attention with modeling to allow the effectiveness of capital to increase and then to allow for human as well as physical capital. Subsequently, attention shifted to so called "endogenous technical change" or "endogenous growth theory", trying to model the technology term A(t) - to explain the crucial but fixed, exogenous g parameter of the core Solow model.

#### *Endogenous saving*

Ramsey's early (1928) paper featured a representative household formulating a saving plan to optimize utility over an infinite horizon. This approach was extended by David Cass (1965) and Tjalling Koopmans (1966), resulting in the Ramsey-Cass-Koopmans class of models. These models incorporate exogenous technical change, the A variable of the Solow model. If A increases at rate g, there exists a steady state growth path with per capita income increasing at rate g. This provides a behavioral interpretation for savings in Solow-type models.

#### *Learning by doing*

Observed productivity improvements in several industries show that labor effectiveness often increases as a function of cumulative output. This has been termed "learning by doing", following the initial work by Kenneth Arrow (1962). Learning by doing has been incorporated into the Solow model by driving labor effectiveness off of the total capital stock with the growth rate $A^{\bullet}(t) = \varphi \times K^{\bullet}(t)$. If $\varphi$ is less than one, which appears to be the most plausible case, there is a balanced growth path for Y at a rate which is a function of n, the rate of growth of population.

### *Capital-embodied technical change*

Capital-embodied technical change has new capital goods being more effective than existing capital. The improvement in effectiveness proceeds at a constant rate. The capital stock existing at any point in time, therefore, is made up of units of different vintages, each vintage having its own effectiveness. Solow (1960), in his original capital-embodiment paper, derived an aggregate production function in which the quantity of capital K(t) in the simple model is replaced by an index of effective capital input. Edmund Phelps (1962) constructed a growth model with both capital-embodied and disembodied technical progress. This economy converges to a steady growth path whose growth rate depends on both embodied and disembodied rates of improvement. As in the initial Solow model, the steady state growth rate is not influenced by the share of output devoted to saving and investment although the level of the growth path is higher for higher saving shares.

These vintage models assume that the capital:labor ratio can be varied, even for the existing capital stock. A more realistic assumption may be the so called "putty-clay" world in which new capital can be designed for any capital:labor ratio (it is flexible, like putty) but once produced it is locked into its particular ratio (it is inflexible, like baked clay). (See, for example, L. Johansen (1959) and Robert Solow (1962).) However, C.J. Bliss (1968) showed that steady growth in a putty-clay model is possible if and only if technical progress is labor-augmenting at a constant rate. This suggests that the capital-embodied form is at best a partial generalization of the initial Solow model.

### *Human capital*

Modern economies are characterized by considerable human capital, the value of the abilities and skills which result from the learning and experience of workers. Indeed, the total value of human capital appears to be of similar magnitude to the total value of physical capital while income to human capital appears to be similar to income to physical capital and possibly larger than income to unskilled labor. It seems important, therefore, to introduce human capital into models of economic growth.

The Solow model can be extended to cover human as well as physical capital. Two examples are Robert Lucas (1988) and Gregory Mankiw, David Romer and David Weil (1992). Production now becomes a function of human capital, physical capital and unskilled labor; investment is directed to the two different types of capital at fixed investment shares; and technology still augments the input of unskilled labor. This economy converges to a balanced path. The key features of this growth path are the same as in the simple Solow model - the growth in output per worker is g, the rate of increase in labor effectiveness and an increase in the investment rate, for either human or physical capital, leads to a higher growth path but does not change the steady state growth rate.

***Endogenous technical change***

Endogenous technical change expresses labor effectiveness as a function of other variables in the model. Paul Romer (1986) created a model in which the level of labor effectiveness, A, follows from the stock of capital. (This is an example of the so called “AK” models.) This introduces a complexity as firms carrying out research generate external effects – advances in technology from which everyone benefits. If there are constant total (internal and external) returns to capital there is a steady growth rate which depends on other parameters in the model such as the rate of time preference and the size of the economy (represented by the number of firms).

More general models were then developed, for example by Paul Romer (1990), Gene Grossman and Elharan Helpman (1991), and Philippe Aghion and Peter Howitt (1992). A(t) here is “produced” by the input of capital and/or labor. This is seen as a proxy for productivity improvements flowing from research and development activity. The economy now has two sectors, one producing finished goods and services, Y(t), and the other producing improvements in labor effectiveness. Available capital and labor are allocated between these two sectors. This economy has a steady state growth path at rate g where g is now a function of other parameters in the model. This g increases with the productivity of research and with the size of the economy, and decreases with the rate of time preference. The balanced growth path is not affected by the share of capital which is invested nor is it affected by the fractions of capital and labor devoted to R&D although these parameters do affect the level of the growth path. The nature of these conclusions is similar to the properties of the initial Solow model.

### 7.9.5 Assessment of Solow-type models

The theory of economic growth based on Solow-type models is a magnificent intellectual construct. It is an elegant framework, encompassing the main aggregate indicators of economic growth and giving the impression of great precision. But, how well does the model explain the origins and processes of economic growth in the real world?

The central conclusion of these models is that the essence of economic growth lies in productivity growth rather than in more inputs of basic resources. We now examine the Solow model in which economic growth (in Y/L) comes entirely from increases in labor effectiveness, the A(t) term. A(t) is external to the Solow model, its numerical values or numerical features are entered into the model by assumption. The model can be made to fit the data by selecting A(t) appropriately but this means that the model "explains" growth only in a tautological sense. The model can describe after the fact the growth performance of a country but cannot predict growth other than by assuming that previous trends will continue. Crucially, the model does not explain – it does not have or cover causal mechanisms which can account, before the fact, for the level and growth in A(t). Even with endogenous technical change, the growth rate g is a mechanical function of other parameters in the model and these may or may not have any relationship to the practical features of the economy.

Many presentations of Solow-type models have viewed g, or increases in labor effectiveness, as technical progress. However, our review of actual growth suggests that technical progress is complex and certainly is not a simple labor-augmenting process. Innovation in economic growth is of two kinds – there are new products for which there are large potential markets and there are efficiency improvements in the production of existing products. Demand for new products pulls the economy forwards; productivity improvements in existing production allow income per capita to increase and also release resources to allow the growth of the new industries. These changes take place in a complex way at the industry level, not at the economy-wide level. Innovation in successful new products has nothing really to do with improving productive efficiency, it has everything to do with coming up with new products which consumers want to buy. And, improvement in existing industries appears to have more to do with management and capital, physical capital and human capital, than with simply making labor more productive.

Similarly, there has been a widespread tendency to associate g with science and research. The driver of growth is the creation of (a sequence of) new products for which there are huge potential demands. These new products are innovative but the nature of the innovation is that they satisfy a (large potential) demand which was previously not being catered to, not that they necessarily follow from research. These new products may have something to do with research but are much more likely to have much more to do with practical engineering and design and then with good marketing. Productivity improvement in established industries similarly is essential for growth. Although there may be some research-led process improvements, most process improvements appear to be incremental improvements to existing processes, led by managers and engineers rather than by fundamental researchers.

We turn now to a basic scientific test of a theory – does it generate practical predictions which square with the facts and, if it does, does it provide the best explanation of the facts of all the theories which square with the facts?

Solow-type models conclude that a country cannot invest its way to long term economic growth. All versions of the model say that the long term balanced growth rate is independent of the share of income which is invested even though the level of income on the growth path is directly related to the investment share. This prediction corresponds to what was learnt so painfully by the Soviet Union and by Mao Zedong's China – a government can force investment but cannot force long term growth. It is possible, though, that a sufficient explanation of the economic failure of the Soviet Union and of Mao Zedong's China lay in the adverse incentive structures of those countries. It is not necessarily the case that the economic failure of those countries demonstrates the veracity of Solow growth models.

The economic growth literature has considered the question of convergence as an empirical test of Solow models. Convergence refers to actual growth paths approaching the steady state growth path for the country. Tests of convergence have looked at whether growth rates of lower income countries are more rapid than growth rates of high income countries. There is little evidence of convergence in the basic Solow model (see, for example, Robert Summers and Alan Heston (1991)). However, a Solow-type model which includes human capital generates cross-country results which are consistent with convergence as predicted by the model (see, for example, Mankiw et al (1992)).

This test for convergence provides some practical support for Solow-type models. However, this does not appear to be definitive support as there could be a different explanation for the more rapid growth of low income countries. This alternative possible explanation is the operation of comparative advantage - low income countries import capital goods and management services from and export low value manufactures to the high income countries. The exporting countries grow rapidly as they penetrate the large markets in the high income countries and then move on to export slightly higher value goods. As their advantage in manufactures diminishes, their growth rate slows, converging towards the growth rate of their high income markets. This is similar to catch-up growth discussed in other chapters, the process by which, for example, several east Asian countries have achieved rapid growth over the past half century.

We now look at the growth predictions of Solow-type models and ask whether these are realistic in terms of the experience of the United States. Table 7.1 shows the predicted growth rates for a steady growth path for an economy calibrated to the U.S. The data is from Jorgenson (2005); we calibrate a Solow-type model to this data by using the data values for the two basic, and exogenous, growth rates, n and g. The other growth rates in Solow steady state growth follow from n and g.

Table 7.1 Growth on the balanced growth path

| | Solow model | | Actual | Difference |
|---|---|---|---|---|
| Y | n + g | 2.58 | 3.46 | 34% |
| Y/L | g | 1.36 | 2.24 | 64% |
| Y/K | 0 | 0 | 0.17 | nm |
| K/L | g | 1.36 | 2.07 | 52% |
| K | n + g | 2.58 | 3.29 | 27% |
| L | n | 1.22 | 1.22 | nm |

Inputs of labor (L) and capital (K) are of quantities; n is the growth rate of input of Labor quantity; g is growth not due to input quantities; nm is not meaningful.

The final column of this Table shows the relative differences between the predicted and actual growth rates. The growth difference for Y/K is not meaningful because the reference point is 0; for L the difference is not meaningful because the two rates are the same by assumption. The differences which can be tested are all considerable. (The differences are still larger if the model is formulated in terms of the input of factor services rather than factor quantities.)

The differences are so large that it is difficult to think that the economy implied by the Solow model is consistent with the facts. Another way of looking at this is to suspect that the “stylized facts” underlying the specification of the Solow model are not really the facts that characterize the United States economy.

These Solow-type models operate at the economy-wide level. Their conclusion is that productivity improvement is at the heart of the growth process. However, they have not really delved into the mechanics of the growth process such as the changing structure of a growth economy and what drives growth. Productivity advance permits growth but does it drive growth? There is a need to get down to a more detailed level where decisions are made about spending, production, new products and new processes. This suggests that an industry-level approach to growth would be better suited to examining the growth mechanisms. Also, it suggests that demand and spending need to be brought into the picture. After all, spending comes first – Keynes taught us that production responds to demand rather than creates demand. The theory of growth would gain from considering demand and supply, spending and production, as equal parts of the broad picture rather than focussing just on production.

Our conclusion is that Solow models represent a huge step in looking at economic growth but that they are just the first steps, not the last word. The models fit actual growth paths by assumption rather than by explanation. We need to extend these models if we are to gain a better understanding of the causes and mechanisms of growth. Two particularly promising directions to extend the conventional theory are (1) to operate at the industry level, arriving at GDP through aggregation rather than as the sole level of analysis, and (2) to consider demand and bring spending onto center stage alongside production.

## 7.10 Growth accounting

### 7.10.1 Growth accounting

The Solow representation of the economy can be applied to measure the sources of growth – how much came from labor input, how much from capital input and how much from everything else, the residual.

This residual in the growth accounting context is Total Factor Productivity (TFP).

In a simple approach to growth accounting, such as used by Kendrick (1961 and 1973), the data or growth variables are the number of workers or, preferably, hours worked (denoted by L), capital stock (K), GDP in constant prices (Y), population (Pop) and factor input (I, where I is the composite of labor and capital inputs). Using a simple, Cobb-Douglas production function with constant returns to scale we can indicate the growth of factor input as:

$$gr(I) = b \times gr(K) + (1-b) \times gr(L)$$

where gr( ) denotes the growth rate and b is the elasticity of output to capital. Everything else follows by arithmetic. Total Factor Productivity is the growth residual so:

$$gr(TFP) = gr(Y) - gr(I)$$

$$gr(Y) = gr(TFP) + b \times gr(K) + (1-b) \times gr(L)$$

$$gr(Y/L) = gr(TFP) + b \times gr(K/L)$$

and growth in GDP per capita is:

$$gr(Y/Pop) = gr(TFP) + b \times gr(K/L) + gr(L/Pop)$$

The economic growth rate depends on the growth of productivity, increases in capital per input of labor (the capital:labor ratio) and changes in hours worked per person. Capital and labor in this simple approach refer to quantities; the quality increases in these inputs are subsumed into productivity advance.

This approach can decompose the actual growth in production into its sources. Table 7.2 does this for growth in the United States since World War II. This Table is based on the results of Jorgenson (2005).

Table 7.2 Growth accounting for the U.S., 1948 - 2002

| | Growth rate | Contribution to growth | Share of growth |
|---|---|---|---|
| Capital stock per person hour | 2.05% | 0.85% | 39% |
| Total Productivity | 1.36% | 1.36% | 63% |
| GDP per person hour | 2.21% | 2.21% | 102% |
| Labor hours per capita | -0.04% | -0.04% | -2% |
| GDP per capita | 2.17% | 2.17% | 100% |

Source: Data from Jorgenson (2005).

GDP per capita grew at 2.2% a year; this was enabled by more capital per worker (which contributed 0.85 percentage points of this growth) and productivity growth (contributing 1.36 percentage points); a reduction in hours worked per person subtracted slightly from the overall growth rate. Total productivity in this Table incorporates both TFP and the effects of improved qualities of capital and labor inputs. Income growth, in essence, came from more capital and increasing productivity.

### 7.10.2 John Kendrick

John Kendrick carried out a pioneering growth accounting for the United States. Kendrick's method was straightforward, measuring just input quantities and calculating TFP as the residual, analogous to the simple procedure set out in the previous section. Kendrick's results are summarized in Table 7.3.

Table 7.3 Kendrick's growth accounting, 1899 - 1966

| | Growth rate | Contribution to growth | Share of growth |
|---|---|---|---|
| Labor quantity | 1.5% | 1.1% | 32% |
| Capital quantity | 2.6% | 0.6% | 19% |
| Factor input | 1.8% | 1.8% | 51% |
| Total factor productivity | 1.7% | 1.7% | 49% |
| Output | 3.5% | 3.5% | 100% |

Sources: Data from Kendrick (1961) and (1973).

These results show that fully half the growth in GDP came from unknown sources – the residual or TFP. They also suggest that capital has an important but secondary role in growth. Kendrick’s results suggest that the Solow approach is not particularly effective in revealing the sources or nature of growth as 71% of the growth in GDP per worker comes from TFP, which is unexplained.

### 7.10.3 Dale Jorgenson

Dale Jorgenson has led the recent development of growth accounting. Jorgenson has developed theoretically well founded procedures for measurement and aggregation. Jorgenson separates capital and labor input into quantity and quality components with overall input being the input of effective services, the combination of both quantity and quality. Input qualities therefore are tracked explicitly, not incorporated with everything else in the residual.

Jorgenson (2005) presents results for a growth accounting for the United States for the years 1948 – 2002. These results are summarized in Table 7.4.

Table 7.4 Contributions to U.S. growth, 1948 - 2002

| | Growth rate | | Contribution to GDP growth | | |
|---|---|---|---|---|---|
| | % pa | % pa | % pa | % pa | % of total |
| GDP | 3.46 | | 3.46 | | 100% |
| Input of labor services | 1.81 | | 1.05 | | 30% |
| Quantity | | 1.22 | | 0.71 | |
| Quality | | 0.58 | | 0.34 | |
| Input of capital services | 4.13 | | 1.75 | | 51% |
| Quantity | | 3.29 | | 1.39 | |
| Quality | | 0.84 | | 0.36 | |
| Total Factor Productivity | 0.67 | | 0.67 | | 19% |
| Input quantities | | | 2.10 | | 61% |
| Input qualities | | | 0.69 | | 20% |
| Total Factor Productivity | | | 0.67 | | 19% |

Source: Data from Jorgenson (2005).

GDP growth averaging 3.46% a year was generated by more input services (2.80%) and an increase in Total Factor Productivity of 0.67%. Taking both quantity and quality into account, 81% of economic growth came from more inputs. Productivity increases were important but not overwhelming. Rising input quantities generated 61% of GDP growth while input qualities accounted for 20%. Capital, quantity together with quality, was the principal source of growth, accounting for 51% of the total.

Jorgenson's accounts give a more thorough summary of the growth record and how this growth was sustained in terms of inputs and productivity. His analysis of labor quality and capital quality has been able to reduce substantially the growth residual, attributed simply to productivity growth, in Solow-type models. The residual accounted for just under half of GDP growth in Kendrick's accounts; Jorgenson has reduced this to less than one fifth.

### 7.10.4 Assessment of growth accounting

Growth accounting helps clarify what sustained the growth in production. But it is based on supply; it does not ask why these goods and services were produced. This is looking backwards at the results of growth and how final outputs were produced; it does not reveal the causes of growth.

This is like looking at a business' accounts and trying to work out why the business performed well. For example, the Coca-Cola Company (see Coca-Cola Annual Report for 2012) earned $9 billion for shareowners but the accounts do not show how it generated these earnings. In a mechanical sense the company obtained revenues and paid expenses as set out in the accounts. But, these financial results do not reveal that Coca-Cola has developed new products and sophisticated marketing techniques which have created substantial value for its labor and capital.

Just like a business' accounts, growth accounting records the results but does not explain the causes of growth. In fact, much of the growth is due to the unexplained residual although Jorgenson has succeeded in measuring the increases in labor and capital quality and in allowing for the changing mix of production, greatly reducing the unexplained residual in production growth. Growth accounting, like Solow-type models, provides insights into how production was sustained but does not consider why production increased or what was produced. We must look elsewhere for the drivers of economic growth and the mechanisms of economic growth.

## 7.11 Economic theory in the world

Economic theory tends to follow changes and problems in the real world - theory is developed to try to understand these events and, possibly, to help resolve these practical problems.

Adam Smith, the founder of economics, was trying to get people's thinking straight on the very nature of economics. He saw that the objective of business and government commercial policy should be production and income, not the holding of treasure. Smith was writing in 1776, as the Industrial Revolution was taking hold. He provided an intellectual justification for industry, markets and the pursuit of income. Possibly due to Smith but more probably due to the irresistible force of human initiative in a capitalist system, Britain let the free market reign and economic growth proceeded at an accelerating pace.

In Britain after the Napoleonic Wars, international trade emerged as a contentious political issue. Tariffs were forcing up the price of food imports, helping landowners but harming the workers. David Ricardo's treatise appeared in 1817, making the intellectual case for free trade. But, the issue was decided by politics rather than by dispassionate analysis when, after decades of debate, the Corn Laws were repealed in the 1840s. In the following half century Britain reached the zenith of its economic success. Under a regime of free trade, Britain exported its textiles and machinery while importing foodstuffs; trade-related industries such as shipping, insurance and banking also thrived.

The next stage in economic thought was the "marginal revolution", led by British thinkers such as Alfred Marshall (1890). These developments led to the concept of demand and supply, the partial equilibrium model which remains at the heart of microeconomics. These developments extended the understanding of the market system and buttressed support for the market and the unrestricted capitalism which drove the British economy through the Industrial Revolution and to its height in the years before World War I.

The first half of the 20$^{th}$ century was dominated by conflict and instability. World War I involved unprecedented human losses. The Great Depression involved unprecedented economic losses. Economic recovery was spurred by Franklin Delano Roosevelt's New Deal policies but it was only with World War II that the United States returned to full employment. Post war reconstruction led Europe and Japan back to full employment. Keynes' theory, published in 1936, provided the intellectual framework needed to understand macroeconomic instability. In the 1950s and 1960s governments began to use this theory to try to promote stability. Friedman's theories led to the development of active monetary policies; these were deployed beginning in the 1980s in the pursuit of stability. The result has been a more steady (than historically) growth path over the past 60 years.

With this new era of economic expansion, interest turned to trying to understand economic growth. Development economics, with low income countries trying to get onto their own growth paths, heightened this interest. And the importance of growth was further accentuated by the Cold War, the struggle for supremacy between the Soviet Union and the United States, where economic strength was the basis both of military power and of political popularity.

The course of events clarified economic thinking. The Cold War ended - the Soviets lost. Centrally planned economies stagnated while the market economies of the West surged ahead. A number of countries in Africa and South America started to grow after governments stabilized their economies and allowed markets to operate. And, several east Asian countries moved onto rapid growth trajectories by producing manufactured commodities for export to the high income countries. Economic growth in the high income countries continued, led by the United States.

Research into growth theory took two different paths. The process path described the growth experience of the high income countries and tried to identify the structures and processes involved. Kuznets and Rostow followed this approach. The mathematical approach, led by Solow, sought to capture the growth process in simple equations involving aggregate economic indicators. The mathematical approach soon gained the upper hand; this approach became the standard theory of economic growth.

There is no question but that actual economic developments have prompted the development of economic theories. But the reverse path, of economic theory changing the real word, has been less well travelled. Adam Smith, Ricardo, the development of neoclassical economics and even growth theory have not lead to any specific real world successes. The main lesson from the real world has been that markets work. The development of theory has provided intellectual support and justification for the market economy. The exception concerns economic stability – the theories inspired by Keynes and Friedman have led to governments achieving some success in avoiding major macroeconomic instability.

Economic growth has continued in the leaders – Britain, the United States and what Maddison (2006b) calls “western offshoots”. Some other countries in east Asia and South America have achieved rapid growth. But these achievements owe much to the operation of markets and international trade and apparently little to growth theory. The Soviet Union and Maoist China provided case studies of how not to grow – by denying the use of markets – at great cost to their citizens. The undoubted economic growth successes of the past century have not achieved their success by using growth theory.

One reason for the lack of practical effect of growth theory may be that established theory, typified by the Solow model, essentially describes the results of growth. Established theory does not come to grips with the causes of growth. Growth theory is still searching for foundations in practicality and trying to understanding the process of economic growth.

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