CHAPTER 3

EXOGENOUS AND ENDOGENOUS GROWTH

Neo-classical theory, in all its forms, shows a strong tendency to reduce the economic complexity of the analysis, doing so by holding the institutional framework constant.
Choi (1983:33)

3.1 INTRODUCTION

In terms of the initial neoclassical theory described by Solow (1956) and augmented by others, sustained economic growth occurs through an exogenous factor of production, that is, the passage of time. The neoclassical production function used in this theory relates output to factor inputs, which consist of the stock of accumulated physical capital goods (buildings, machinery, transport equipment, computers, and so on) and labour, which is regarded as only one type. The theory imposes decreasing returns with respect to the use of each (reproducible) factor of production (and constant returns overall). From these assumptions it follows that an increase in the stock of capital goods will result in a less than proportionate increase in output, provided the amount of labour employed stays the same (Van der Ploeg and Tang 1992:15). Eventually more capital stock will produce no more output, resulting in lower profits, and for this reason output growth cease.

If new technologies improve the productivity of labour and of capital and so prevent a decrease in the rate of return on investment, the labour force will grow at an exogenous rate. The growth of output is accordingly related to the amount and quality of the stocks of production factors. That part of output growth that cannot be explained by the growth in production factors is often called the Solow residual by economic researchers and/or total factor productivity in applied work. The calculation of total factor productivity assumes perfect competition in labour and capital markets, but also in product and service markets. This assumption allows the calculation of multifactor inputs by weighing labour and capital input increases in terms of their national income shares (remuneration of employees and gross operating surplus respectively). This joint factor contribution to output is usually substantially less than the growth in output.

This unexplained part of output growth is often called the Solow residual, which he termed the "measure of our ignorance". This is a rather ambiguous phrase, because it refers to the nebulous knowledge of economists on the matter, but signifies improvement in the knowledge base of the workforce in general.

The labour force grows in accordance with population growth and is augmented by technical progress, both exogenously determined. Eventually capital, output and consumption will also grow at this exogenous rate and converge to an equilibrium growth path. Accumulation of capital in exogenous growth theory is a vehicle for ongoing technical development. Neoclassical theory gives no economic explanation for such development, but instead includes a time trend (usually representing technical progress) in the model for the long-run rate of economic growth.

The exogenous technical progress assumed in the older versions of growth theory limits the explanation of the growth process. When the standard Solow model is used with real data in order to explain adjustment to balanced growth paths, predictions for the speed of convergence and the capital income share in national income are generally too high.

3.2 KALDOR'S STYLISED FACTS

Stylised facts are "broad generalizations that are true in essence, though not always in detail" (Bannock 1998:396). Bannock states: "this is one of the most important, but least acknowledged forms of empirical testing in economics…. Many models are designed simply to explain behaviour at its simplest, and can be judged only against the broad truth, rather than the detail".

The broad facts about the growth of advanced industrial economies, which a well-specified growth model should be able to explain, are summed up in Kaldor's (1961:178-179) "stylised facts". Solow (1970:2) agrees with the stylised label, but casts doubt on the factual claim. He nevertheless concedes that "they are what most of the theory of economic growth actually explains". The exogenous technical progress of the neoclassical theory fits into Kaldor's stylised facts (Van der Ploeg and Tang 1992:16).

Kaldor's (1961:178-179) "stylised facts" are as follows:

- continued growth in the aggregate volume of production and in labour productivity;
- continued increase in the amount of capital per worker, over fairly long periods;
- a steady rate of profit on capital;
- a steady capital-output ratio over long periods (this is contested by Jorgensen and Grilliches (1967:265-267) who pointed out short-term cyclical variations and that one should rather use flows of capital services instead of capital stocks. Solow (1970:3) pointed out that capital and output could vary substantially as a result of shift work, downtime and running speed);
- economies with a high share of profits in income tend to have a high ratio of investment to output;
- appreciable differences in the rate of growth of labour productivity and total output in different societies.

Solow (1970:3) is less interested in the latter two facts "because they relate more to comparisons between different economies than to the course of events within one economy". The statement could relate to the fact that international comparisons in the form of cross-country analyses requiring internationally comparable data are a rather recent event, dating to the ground-breaking work of Summers and Heston (1991, 1988) in the late1980s and early 1990s.

Although many of these facts feature in the neoclassical theory, Kaldor (1961:179) maintains that "none of these 'facts' can plausibly be 'explained' by the theoretical constructions of neoclassical theory". For example, according to the neoclassical marginal productivity theory, one should expect a continued fall in the rate of profit with capital accumulation, not a steady rate of profit. Kaldor's purpose is therefore to present a model of income distribution and capital accumulation that is capable of explaining at least some of the above stylised facts (Choi 1983:44-45).

Kaldor (1978b:76) makes use of a virtuous growth spiral involving cumulative causation that was often used by Myrdal (1957:11-16), and the concept of increasing returns described by Allyn Young (1928:2). With the concept of the virtuous spiral and cumulative causation, success breeds success whereas failure begets more failure. Kaldor constructed a two-sector model as a tool to explain the differences in growth rates as well as the seemingly permanent gaps in growth rates among different economies and regions in a country.

3.3 STYLISED FACTS USED BY OTHER RESEARCHERS

Some contemporary researchers refer to Kaldor's stylised facts and amend the original six facts for their purposes or create entirely new ones. Boltho and Holtham (1992:2) are two researchers who followed the tradition of borrowing from Kaldor but also collecting and creating their own facts. The following are their stylised questions (facts), which they contend a useful model should be able to explain:

- Why have countries, or groups of countries, been able to grow for decades in succession with no apparent tendency to slow down, despite rising capital-labour ratios?
- Why has convergence in per capita incomes across the world seemingly failed to materialise?
- Why have countries or groups of countries generally exhibited medium- to long-term accelerations or decelerations in their growth? (Also see Van der Ploeg and Tang 1992:21.)

Romer (1989b:54) quotes Kaldor’s stylised facts and agrees with Kaldor’s idea that these broad tendencies are essential in the conceptual stages of a body of theory. He is of the opinion that without stylized facts to aim at, “theorists would be shooting in the dark”. Romer paraphrased Kaldor’s stylized as follows:

- Wide differences are observed in growth rates of productivity between countries;
- There is no apparent tendency for productivity growth rates to decline over time;
- Capital per worker seems to grow continuously;
- The capital/output ratio is steady;
- The rate of return on capital is steady;
- The shares of capital and labour in the total income remains virtually constant;

Romer (1989b:55) is of the opinion that the basic questions about growth need to be re-examined. He then extends Kaldor's stylized facts to "make sure not only that the facts have some connection with measured data but also that the list be as inclusive as possible". He augments the original facts by observing that there are five other prominent features that characterise economic data:

- There appears to be no correlation between the mean growth rate and the level of output per head in cross section analyses
- The contribution of measurable factor inputs leaves a substantial residual in growth accounting;
- Growth in trade volumes are positively correlated with the level of income;
- Population growth rates show a negative correlation with the level of income;
- Both skilled and unskilled workers tend to migrate to high income countries.

Easterly and Levine (2000:1) produced the following stylised facts of economic growth:

- The "residual" rather than factor accumulation accounts for most of the income and growth differences across nations;
- Income diverges in the long run;
- Factor accumulation is persistent whereas growth is not persistent;
- Economic activity is highly concentrated, with all factors of production flowing to the richest areas;
- National policies exert a considerable influence on long-run economic growth rates.

Easterly and Levine (2000:37) suggest that these facts are more consistent with a technology explanation of growth and income differences than a factor accumulation explanation. Empirical work, however, does not yet decisively distinguish between different theoretical conceptions of “total factor productivity growth”. Economists should devote more effort to modeling and quantifying total factor productivity. Klenow (2000:221) agrees with the first four of Easterly and Levine’s stylised facts and believes that facts 1 and 3 provide strong support for the conclusion that total factor productivity should become a priority area for economic research.

3.4 CONCLUSIONS REGARDING STYLISED FACTS

Stylised facts give a structured and demarcated area for research on economic growth as these facts are formulated to connect informally with observed data. What seems common to most sets of stylised facts is the observed differences in growth rates across countries and the fact that there is no consistent tendency for the decline in growth rates. Most sets of stylised facts somehow include the importance of productivity growth. The widening of the array of stylised facts by Romer is in line with the wider availability and scope of international data, notably work on growth accounting, international trade, population growth and migration trends. Regarding the latter, Lucas (1988:25, 40) has shown that migration trends are a crucial piece of evidence in distinguishing between theories based on constant and on increasing returns to scale.

3.5 EXOGENOUS GROWTH

The neoclassical model states that in the long term, the growth rate of output per worker is dependent on the rate of labour-augmenting improvement in technology, which is determined by factor(s) not contained in the model (also known as exogenous factors). The model implies that all economies that use similar technology, which could improve over time, should have converging productivity growth rates (Solow 1991:398). Permanent differences in productivity levels are caused by faster/slower population growth or a higher/lower savings rate. Lower productivity could be due to climate deficiencies or other factors not accounted for in the model (Solow 1991:398).

The Cobb-Douglas (1928) production function, also called the neoclassical production function, is expressed as follows:

$$Y = L^a K^b T \qquad \text{where } a+b=1 \qquad (1)$$

where:
Y= output
L= labour
K= capital
T= time or the rate of technological progress which changes over time

The weights a and b represent the proportion of Y that accrues to labour (L) and capital (K) respectively. The inclusion of the technology variable freed the neoclassical theory from the doomsaying of Malthus and Ricardo and formulated the ultimate destiny of mature economies in terms of the more acceptable but still rather conservative stationary state, where all real variables grow at a constant, proportional rate. Robert Solow (1970:7) remarked that "the steady state is not a bad place for the theory of growth to start, but may be a dangerous place for it to end".

The simple Solow (1956:85) model depicts the output, Y, of a business, as a function of three variables: capital, K, labour, L, and knowledge or the "effectiveness of labour", A_t.

$$Y = K^a (A_t L)^{1-a} \qquad 0 < a < 1 \qquad (2)$$

Knowledge or technical progress is assumed to be independent of both the capital and labour inputs and to be a nonrival good, which is free for all businesses. It appears multiplicatively with labour in (1), denoting that knowledge contributes by "augmenting" labour and not affecting capital. The exponents a and (1-a) measure the relative contribution of the two inputs of capital and "effective labour". These exponents add to unity, to comply with the constant-returns-to-scale assumption for production (e.g. doubling of factor inputs resulting in output also increasing by 100 per cent). Equation (1) describes how actual output is determined. The equation is simplified by taking logs, after which the equation indicates output growth so that:

$$y = ak + (1-a)(a + l) \qquad (3)$$

Lower-case letters represent the proportional growth rates of their upper-case equivalents. This equation may be rewritten as:

$$y - l = ak' + a \qquad (4)$$

where: $y - l$ = the growth of output per worker
k' = the growth of capital per effective worker (K/AL)

To see what the neoclassical growth model predicts, we can simplify matters by assuming that there is no labour force growth (annual entry to the labour market is equal to annual retirement) - a situation not too far removed from the reality in many countries. This means that, in terms of equation (2), y equals the growth of income **per worker** (i.e. labour productivity).

This model has three important features which recent growth theories have challenged:

- If markets are competitive, the contributions of each factor input to output (i.e. a and (1-a)) are equal to their respective shares in the total income (output). For all businesses in an economy taken together, this could be approximated by the national accounts breakdown into wage and non-wage income.
- If people were to save a constant proportion of their income, capital per effective worker would be constant in the long run, so that $k' = 0$ in (2) and per capita income growth is therefore entirely determined by knowledge growth, a.
- Increasing the savings (i.e. investment) ratio could raise an economy's income level (permanently) by raising the growth rate of capital (and income) in the short run, but since the ratio of savings to income cannot continue to increase indefinitely, investment cannot cause income to grow permanently. Countries that invest more would be wealthier but would

not grow faster since the only source of long-term growth is technical progress (or "knowledge accumulation"), which is assumed to occur at an exogenous rate. According to this model, income growth rates are beyond business and government control. This is a disappointing and dubious outcome because real-life experiences point to the contrary, especially in the case of businesses.

3.6 GROWTH ACCOUNTING

Growth accounting is an attempt to allocate growth rates in national output or output per person employed to the determinants of output in order to isolate the causes of growth. The aims are to determine the causes of international differences in output levels and the determinants responsible for differences in growth rates. This is also a method to organise quantitative information conveniently and systematically.

Growth accounting stems from an investigation by Denison (1987:572) of the sources of growth in the USA from 1909 to 1958. It has also been used to estimate probable future growth potential (obtained by adding the expected contributions of these sources) and the extent to which the future growth rate could be altered by each of a list of alternate sources.

Among the output determinants that were examined were the characteristics of labour that affect its knowledge, skills and energy. This was criticised by Schultz 1961:3) who made the point that "treating a count of (employed persons) as a measure of the quantity of an economic factor is no more meaningful than it would be to count the number of all manner of machines to determine their economic importance either as a stock of capital or as a flow of productive services".

Denison (1987:572) nevertheless found the following to be the most positive sources of growth:

- increased employment;
- improved education of the employed;
- more and better capital stock;

- growth in the size of markets;
- improved resource allocation;
- advances in the extent of knowledge relevant to production.

The study's most important lesson was that extensive and costly changes would be required if policies were to be adopted to raise the high-employment growth rate (by one per cent) above its normal level. This finding contrasted with the common view that it would be easy to add a whole percentage point to the growth rate.

Growth accounting starts by recognising that many different determinants govern the size of a country's output at any given time. It deals in the first instance with:

- different determinants of output such as the number, hours, demographic composition and education of employed persons;
- quantities of land and capital;
- the stock of knowledge;
- the size of market;
- the extent to which actual practice departs from lowest-cost practice;
- the extent to which resource allocation departs from the output-maximising allocation;
- the intensity with which factor inputs are used.

Changes in these determinants caused changes in output – or growth. Sources-of-growth tables are obtained by measuring changes in each determinant and the effect this change had on output.

Direct determinants of output are of course influenced by a host of indirect determinants such as tax structure, attitudes to work, inflation, deaths in war or birth control information. Growth accounting studies do not ignore such indirect determinants of output, but measure them indirectly by first judging the extent to which a change in any one (or a difference between two situations, e.g. two tax structures) alters all the direct determinants, and then calculating the effect of these changes on output.

Maddison (1982:22) states that Denison is the most ambitious and successful of the modern analysts and has used production functions to cast light on the relative importance of the factors that contribute to growth. Maddison (1982:23) points out that Denison uses land, labour and capital for his calculations and subdivides them where possible. He adjusts labour input in terms of differences in age, sex and education but does not adjust capital stock. He makes allowances for gains due to economies of scale, sectoral shifts in production, international specialisation and disembodied technical progress. All these factors aggregate into what he calls "total factor productivity" and an unexplained residual.

Maddison (1982:24) mentions major problems with Denison's method, which understates the weight of capital in the production process. Denison (1967:135-136) also gives zero weight to government capital because no return is attributed to such capital in the national accounts. This means that capital invested in roads, schools, railways and protection services is ignored because governments do not generally charge for the use of such facilities. Denison also excludes depreciation from his capital weights.

Maddison (1982:24) quantifies the understatement of capital by using Denison's (1967) basic data to compile results for the same period with Denison's methodology as well as his own. For the period 1950 to 1962, the average GDP growth rate in the nine countries (Italy, France, Germany, Denmark, Norway, the Netherlands, Belgium, the UK and the USA) was 4.29 per cent per year according to Denison. He explained 0.87 percentage points of this growth as originating from capital inputs, 0.76 from augmented labour input and 2.66 from total factor productivity.

Maddison used his own methodology and calculated the average GDP growth rate in the nine countries marginally higher at 4.39 per cent per year, with capital input explaining 2.14 percentage points, thus considerably higher than the 0.87 percentage points of Denison and the augmented labour input of 0.83 percentage points which is more or less in line with Denison's 0.76 percentage points and 1.42 points for the rest which he deliberately did not ascribe to total factor productivity.

More recent growth accounting figures for the period 1960 to 1995 show that technological progress in the European countries contributed between 40 and 65 per cent to growth, whereas this source played a less significant role in the East Asian economies. In fact, in some of the latter countries, technological progress contributed negatively to growth.

Table 3.1: Sources of growth for nine newly industrialised Asian economies and non-Asian G-5 countries, 1960-95

Country	Capital	Labour	Technical progress
China	92.2	9.2	-1.4
Hong Kong	55.8	16.0	28.2
Indonesia	115.7	11.5	-27.2
Japan	62.9	4.7	32.4
Malaysia	70.9	18.7	10.4
Philippines	99.5	18.0	-17.5
Singapore	60.0	20.9	19.1
South Korea	86.3	12.7	1.0
Taiwan	88.9	8.6	2.5
Thailand	71.9	12.7	15.4
France	37.8	-1.3	63.5
West Germany	43.7	-6.3	62.6
UK	46.0	3.7	50.3
USA	32.9	26.2	40.9

Source: Lau (2000:5)

Lau (2000:20) attributes the negative contribution of technology to growth in some newly industrialised economies to the fact that the utilisation of intangible assets in countries other than those that invented it, is not costless, because technology and its development are fully priced for secondary users. In many instances this means monopolistic pricing of new capital equipment as well as critical components and license fees.

3.6.1 Growth accounting in South Africa

Du Plooy and Fourie (1992:83) performed a growth accounting exercise. It showed that output during the period 1960 to 1985 grew by 4.65 per cent on average, of which 1.76 percentage points (or 37.8 per cent) were contributed by additional input of labour and 2.46 percentage points (or 52.9 per cent) by additional capital input. The remaining 0.43 percentage points (or 9.3 per cent) was contributed by total factor productivity. The only other notable contributor was economies of scale, which contributed 0.58 percentage points (or 12.5 per cent) of total growth.

3.7 ENDOGENOUS GROWTH THEORY

According to Romer (1994:31) "Endogenous growth embraces a diverse body of theoretical and empirical work. The empirical work does not settle for measuring a growth accounting residual that grows at different rates in different countries. It tries instead to uncover the private and public sector choices that cause the rate of growth of the residual to vary across countries."

The endogenous growth theory has sparked and retained the interest of social scientists since the publication of Romer's article in 1986. This interest is witnessed by the spurt of research papers during the late 1980s and 1990s. Two mainstreams of endogenous growth theories have emerged, namely those focused on technological change and those mainly concerned with human capital.

3.7.1 Endogenous growth through technological innovation

According to Romer (1994:13), technological advances occur as a result of "things that people do". He explained the endogeniety of technological progress by observing that no economist is willing to "make a serious defense of the proposition that technological change is literally a function of elapsed calendar time". Even if discoveries are made only by chance, more discoveries will be made if more researchers work to produce them.

A factor that induces research in the private sector is the fact that discoveries are partially excludible and as such do not meet one of the criteria needed to be classified as a public good. Individuals or firms have some control over the information produced by most discoveries. This mere fact enables the individual or firm that makes a discovery to charge a price that is higher than zero and so earn monopoly profits because information has no opportunity cost.

While the traditional growth theory considered only two factors of production, namely capital and labour, this new growth theory adds a third, technology. Edogenous growth theory focuses on the wider concept of technology, which is expressed through ideas, instead of objects or products. It necessitates a different set of institutional arrangements, like pricing systems, taxation or incentives to ensure the efficient allocation of ideas. These types of models are sometimes called Schumpeterian models because Schumpeter emphasised the importance of temporary monopolistic power over discoveries, as a motivating force for continued innovative processes (see 2.8.1).

Large research and development and technology-intensive companies such as Microsoft and IBM, expressed interest in the new growth theory because of its view of monopolistic power and changes in institutional arrangements suggested by the theory. IBM (1999:3) highlights the importance of having some monopolistic power (as proposed by the new theory) by pointing out that no one would “spend their own resources to produce a new idea if they didn’t have any monopoly power over it. Allowing companies monopoly power over their new ideas, through patents, creates incentives for other firms to go out and make discoveries of their own”. Financial analysts have also taken note of this “ideas versus objects” point and are following through on it in their valuations of the companies listed on stock markets.

Romer (1998:116) makes a convincing argument for perpetual and even accelerating growth as he is of the opinion that: “We will never run out of things to discover, a reassuring fact since the process of discovery is the mainspring of economic growth.” He gives an idea of the scope for new ideas by pointing out that with 60 basic elements there are about 100 billion billion mixtures. If all laboratories around the world were each to evaluate a thousand of these mixtures every day, they would only have evaluated about 330 billion in a million years (Romer 1998b:2).

Despite the purported tendencies to converge indicated by the Solow model, this seems unlikely between advanced industrial countries and most of the nations of Latin America, Africa and much of Asia – especially if such convergence is to come about merely as a result of the passage of time as the Solow model would have it. This realisation motivated Romer (1986) and Lucas (1988) to explore other possibilities. Their research gave rise to the endogenous growth theory or what is also referred to as the "new growth theories". Their point of departure was that if convergence did not occur, then the growth rate itself should be endogenous (implying that it could be determined by factors within countries, including different sets of policy alternatives – Solow (1991:398)).

King and Robson (1992:45) observe that exogenous growth models provide no analytical tools to determine the role government policy might play in influencing the growth rate. They contend that in the absence of economic growth models, which include a role for government, "many policies might be misguided at best and counterproductive at worst". Romer (1989:51) stated: "In models with exogenous technological change ... it never really mattered what the government did."

3.7.2 Endogenous growth with human capital

One way to explain differences in national economic growth rates is to introduce the stock of human capital or alternatively, technology improvement as a causal factor or producible input (see Young 1928:3-4; Arrow 1962:155-157; Uzawa 1965:26-28; Solow 1991:398; Conlisk 1967:349; and Choi 1983:99). Arrow's (1962:155) point of departure is the neoclassical theory and he does not contradict the "production function as an expression of technological knowledge". All that has to be added is that "knowledge is growing in time". He concludes that time as an explanatory variable is intellectually and empirically unsatisfactory and basically a confession of ignorance. Moreover, it contributes nothing in terms of policy variables. He wants to analyse the human knowledge, which underlies the production function, as it accumulates over time.

Arrow (1962:157) devised a model of learning-by-doing, which shows that experience in production, results in higher productivity and economic growth. The question then arises how "experience" should be measured for these purposes. The model Arrow chose, from various alternatives, assumed that learning-by-doing is embodied in the technology of capital equipment during a specific period. Arrow (1962:156,157) wrote: "Learning is a product of experience ... (However,) learning associated with repetition ... is subject to sharply diminishing returns ... To counteract this tendency so as to produce continuous improved performance implies that the stimulus situations must themselves be steadily evolving rather than merely repeating ... I therefore take ... cumulative gross investment ... as an index of experience. Each new machine produced and put into use, is capable of changing the environment in which production takes place, so that learning is taking place with continually new stimuli" (Arrow 1962:155-157).

The effect on productivity of learning-by-doing is external to the individual company. Arrow (1962:156,157) assumes that companies do not incorporate the effects of investment on learning possibilities, and thus reconciles increasing returns to scale at an aggregate level with perfect competition. Van der Ploeg and Tang (1992:18) observe that because learning-by-doing is subject to fast decreasing returns in the Arrow model, economic growth is still exogenous and determined by population growth.

King and Robson (1992:45) point out that "Arrow's model cannot generate endogenous growth". Fonseca (1998:18) argues that "Arrow's model can indeed provide endogenous growth if both capital and labour expand simultaneously". He adds that Arrow's original model "exhibits non-increasing returns to scale in aggregate if the rate of growth in an economy is steady". This might be one of the problems in the South African economy during recent years because investment as a percentage of GDP remains too low and too little learning-by-doing occurs to allow the economy to break out of the unemployment/poverty trap.

What might be needed are the new inventions described by Young (1928:534), or actions that involve "a fresh application of the fruits of scientific progress to industry, (which) alters the conditions of industrial activity and initiates responses elsewhere in the industrial structure which in turn have a further unsettling effect. Thus change becomes progressive and propagates itself in a cumulative way".

Boltho and Holtham (1992:5) observe that what seems to be missing in Arrow's formulation is that optimal investment cannot be assumed to prevail in an uncertain world, as Arrow presupposes. In the current tepid investment climate and its attendant slump in employment opportunities, South Africans can testify to the validity of this argument. In practice, fixed investment is likely to be stimulated by growth. This reiterates the importance of the circular growth path described by Young (1928:542) and by Kaldor (1978:76). What remains to be "invented" is the initial spurt of growth that would bring poor or stagnating countries to above the take-off threshold and into the virtuous spiral of growth, investment, innovation and more growth.

The aggregate production function of Uzawa (1965:18) determines annual output by using the existing capital stock and the quantity of labour employed. All changes in technological knowledge are embodied in labour. The improved efficiency of labour is not dependent on the amount of capital employed, but on activities in the form of education, health, construction and maintenance of public goods. All these activities are aggregated in an education sector and the impact of this sector is diffused uniformly over the whole economy.

Uzawa's inclusion of human capital through the education sector breaks the constraint of diminishing returns to capital where capital is defined in the broader sense to include human capital. Long-term per capita growth can therefore be achieved in the absence of exogenous technological progress. The production of human capital is an alternative to improvements in technology as a mechanism to generate long-term endogenous growth (Barro and Sala-i-Martin 1995:172).

Human capital accumulation differs from the creation of knowledge in the form of technological progress. If human capital is defined as the skills embodied in a worker, then the use of these skills in one activity precludes their use in another, making human capital a rival good. Human capital is also an excludable good since people have property rights over their own skills and their raw labour. People's ideas or knowledge may be non-rival as they can be spread freely over activities on an arbitrary scale and may in some circumstances be non-excludible (Barro and Sala-i-Martin 1995:172).

Conlisk (1967:349) modified the neoclassical model slightly to construct a growth model in which technological progress is affected by investment and in which the share of investment affects the long-term growth rate. His model contains both endogenous and exogenous capital to augment technological progress.

In the first instance, labour grows in proportion to the population. However, this growth is enhanced by a labour-augmenting technology multiplier measured in technology-augmented (or efficiency or productivity) units. The first labour growth component grows exogenously at a constant and non-negative rate, whereas the second growth component is the endogenous labour-augmenting technology multiplier. The endogenous component takes the form of labour-augmenting technical change. The productivity sector's outputs are new capital and technical change, and these are the mechanisms in the model by which output or productivity per worker may be increased. The mechanisms behind the productivity sector may be viewed as an aggregation of various interrelated activities such as research and development, education, capital construction, and so on.

Wading through the mathematics of the models of Arrow (1962), Uzawa (1965) and Conlisk (1969), the following observation by Choi (1983:33) becomes appropriate. He believes that the absorption with mathematical elegance diverted the attention, intellect and effort of subsequent generations of economists from important real issues. Economic growth theory has been shrouded by a spell of "technical" economic thinking, and empirical testing was neglected.

Analyses in terms of the neoclassical theory and its variants generally show a strong tendency to simplify the economic complexity, usually by assuming that institutional influence remains neutral. In addition, the practical value of the theories was reduced by inadequate practical incorporation of important economic phenomena encountered in the real world (Choi 1983:33).

Blaug (1992:238) is exasperated by the absence of practical application of intricate growth theories, and laments: “Consider, for example, the pre-occupation since 1945 of some of the best brains in modern economics with the esoterica of growth theory, when even practitioners of the art admit that modern growth theory is not as yet capable of casting any light on actual economies growing over time. The essence of modern growth theory is simply old-style stationary state analysis in which an element of compound growth is introduced by adding factor-augmenting technical change and exogenous increases in labour supply to an otherwise static, 1-period, general equilibrium model of the economy ... To put it bluntly: no economy has ever been observed in a steady-state growth and, besides, there are deep, inherent reasons why actual growth is always unsteady and always unbalanced.”

Romer (1994:11) observes that “too many theories are consistent with the same small number of facts”. He takes it a step further to include subsequent empirical regression overload by saying that “many recent attempts at testing models of growth proceed without making any reference to evidence from economic history ... they focus on questions about models instead of the questions about the world” (Romer 1996:202). Furthermore, “As is usually the case in macro economics, many different inferences are consistent with the same regression statistics” (Romer 1994:10).

He then redirects attention by employing Einstein, Podolsky and Rosen’s (1935) method of thought experiments and combining them with Kaldor’s (1961:178-179) stylised observations. He uses the observation by Lucas (1988:25) “that international patterns of migration and wage differentials are difficult to reconcile with the neoclassical model. If the same technology were available in all countries, human capital would not move from places where it is scarce to places where it is abundant and the same worker would not earn a higher wage after moving from the Philippines to the United States”.

He recommends that when models are evaluated, observations such as those of Lucas are “as powerful a piece of evidence as all the cross-country growth regressions combined. But this kind of fact, like the fact about intra-industry trade or the fact that people make discoveries, does not come with an attached t-statistic ... (they) tend to be neglected in discussions that focus too narrowly on testing and rejecting models" (Romer 1994:19).

He uses the following observations to describe the growth process and its important determinants:

Fact 1: There are many businesses in a market economy.

Fact 2: Discoveries differ from other inputs in the sense that many people can use them at the same time. Ordinary goods are rival goods, but information is non-rival.

Fact 3: It is possible to replicate physical activities. However, there are no economies of scale from building a single plant that is twice as large as an existing one using the same technology.

Fact 4: Technological advance comes from things that people do. There is no serious defence of the proposition that technological change is literally a function of elapsed calendar time. Even if discoveries occur by chance, if more people set out to make discoveries, more would be made, so that the aggregate rate of discoveries would be endogenous.

Fact 5: Many individuals and businesses have market power and earn monopoly rents on discoveries. Information from discoveries is non-rival but partially excludable for at least some period of time. If a person or business can control access to a discovery, he/she or it can charge a price for it and even a very low price earns monopoly profits because information has no opportunity costs (Romer 1994:2-13).

Neoclassical theory incorporated facts 1 to 3, but did not take facts 4 and 5 into account. Romer's (1986:1005-1008) analysis resembles the work of Arrow (1962) on learning-by-doing. However, Romer enhances the concept of physical capital by adding investment in knowledge. Knowledge cannot be patented perfectly to obscure it from rivals in the industry or the economy. Investment in knowledge by one business would therefore spill over to its rivals and enhance their production possibilities. This could, for example, happen through reverse engineering or the movement of workers between rival businesses companies.

In the Romer model (1994:12-16), production of consumption and capital goods could yield constant or increasing returns on reproducible physical capital and knowledge at macro level, but decreasing returns at micro or business level. This goes beyond the rapidly decreasing returns at micro level in the Arrow (1962) model. Romer (1990:74) argues that as a result of an imperfect patent market, the stock of knowledge is virtually free (partially excludable and non-rival) like a public good.

The Arrow (1962) and Romer (1986) models incorporate human capital as consequences of investment rather than the intentional accumulation of knowledge. Subsequent models formulate the concept of human capital precisely and describe knowledge explicitly as a non-rival productive factor, almost a public good – like language or computer software, which is of use only with people who have similar or the same skills. (Van der Ploeg and Tang 1992:19).

Lucas (1988:19) constructs his model on the intentional accumulation of knowledge. Individuals can increase their human capital by devoting time to learning, which would reduce the time available for work or leisure. Human capital (training, education, etc.) is considered an asset, and financial return on this investment can be compared to the return on non-human financial assets. In line with Uzawa’s (1965) pioneering approach, Lucas (1988:17-28) proposes that the accumulation of human capital is subject to constant (or increasing) returns to scale (Van der Ploeg and Tang 1992:19).

Research by Mankiw, Romer and Weil (1992:414-415) tested the Solow model by using international data. They conclude that capital’s share of national income as estimated by the Solow model is too high and labour’s share too low. They then included the ratio of working age population attending secondary school as a measure of investment in human capital and have found that this model, which assigns a more definite role to labour-related or human capital, offers a better explanation of the data (Romer 1994:7-10).

A common feature of all endogenous growth models with human capital is the concept that the individual yield on investment in human capital is higher when the aggregate stock of human capital in the economy is larger. These models therefore explain why a South African medical doctor with a valuable and scarce skill in this country will earn more if he emigrates to the Canada or the USA where his skills are plentiful.

Romer (1986:1018-1020) assumes that human capital displays increasing marginal productivity (Solow 1991:399). This divergent process causes small shifts in initial conditions and small adaptations due to in-process corrections to magnify themselves into growing differences over time. This process provides scope for policy to have considerable and enduring effects of the sort that seem to be suggested by the observed data (Solow 1991:400). The increasing returns to scale make increasing returns to (human) capital easier to achieve.

This growth hypothesis makes a substantial difference because it theoretically allows the growth rate to increase indefinitely, despite reaching a ceiling during each successive phase. This is technically true, but not very important in the long term. An upper limit is the human capacity to work faster, harder or for longer hours. Eventually only new machinery or technology can further improve on human effort. The fastest walker cannot keep up with a man on horseback (who has better equipment and enhanced human skills, namely the ability to ride). This rider is in turn left behind by a man in a motorcar, who cannot overtake an air traveller, and so on. There is also an upper limit to the accumulation of human capital since it is not viable to keep on accumulating capital and postponing consumption forever (Solow 1991:401).

As in the basic neoclassical model, the possibility of a low-level equilibrium trap arises (Solow 1991:399). In view of South Africa's below par education system, low skills base, high unemployment rate, exacerbated by continued job losses, the country appears to be in the grip of just such a low-level equilibrium trap.

When human capital is defined as the phenomenon inherent in people, it is rival and mortal and can be lost. Human capital is therefore defined as the stock of knowledge of a business and refers to a body of endogenous technological progress. This definition of human capital obviates the human mortality and attrition problems (Lucas 1988:28; Solow 1991:401).

In the endogenous growth theories it is possible for growth rates to increase indefinitely over time and for larger economies to grow faster than small ones as has been illustrated by the strong and sustained growth of Japan for many decades and by the USA in the 1990s. Temporary reversals in trends, for example, due to inadequate public or private policies, are also possible. The effects of these policies could magnify themselves over time instead of subsiding (Solow 1991:402). Another feature of endogenous growth models is that the "state of knowledge" is invariably related to the physical or human capital stock. Both physical and human capital stock could therefore be expanded or contracted or sidelined through public policies or collective consensus – apartheid education and freedom before education are both local examples of this phenomenon (King and Robson 1992:45).

With constant returns to scale and exogenous technological progress, national boundaries have little effect on the growth. With increasing returns, on the other hand, international trade becomes an extremely important factor, because anything that enlarges the market can increase the level and rate of output growth (Solow 1991:407). The allocation of comparative advantage thus widens. The familiar concept of comparative advantage being dominated by the historical accident of who came first, or jointly either through pure scale effects, is now further enhanced through learning-by-doing.

Scott (1992:37) challenges the growth accounting approach as well as some of the new growth theories by contending that they underestimate the role of investment in growth. He says that the way to measure the contribution of investment to growth is in proportion to gross investment, and not the customary net addition - in other words, in proportion to the *change* in capital stock. Since the former may double or treble the latter, the difference is bigger and can easily explain the "unexplained residual" in conventional growth accounting.

Denison (1987:572) estimated, with conventional growth accounting techniques, that investment in the USA between 1948 and 1973 accounted for less than one-fifth of the growth in non-residential business, including an allowance for economies of scale, whereas the estimates by Scott (1992:37) put the share at over half. Scott contends that his estimates represented an econometric test of his theory, which is superior to growth accounting, which provides no test of any theory. In his model, a constant that had been added to the question to allow for independent technical progress was negative and differed insignificantly from zero (Scott 1992:37).

Blaug (1980:244) remarked that “economics continually touches on questions that are subject to government policy, so that ... the attempt to separate positive from normative propositions in economics, and clearly to specify the conditions for submitting positive propositions to the text of experience, remains a task which is as important to the progress of economics today as it ever was”.

Manuelli (1994:299) suggests that research in the growth area “should not try to find an endogenous factor (like capital) that accounts for other endogenous variables.” Research should instead emphasise both careful modeling and measurement of a candidate exogenous factor. Manuelli believes that “the” candidate exogenous factor should be government policy. He suggests that it would be appropriate to look for a set of policies and institutions that affect all the endogenous variables and, through these effects, influence both the level and growth rate of income. However, as he remarks: “a reasonable objection that can be raised to this interpretation is that policies and institutions are not exogenous”. The best candidates to account for cross-country differences in income levels and rates of growth are broadly understood to include taxation, spending and regulatory policies and institutions. He states that much more work is needed before these true measures of government policies would be available, but emphasises that “the payoff is likely to be very high”.

3.8 CONCLUSIONS

The growth accounting approach to economic growth delivers rather limited insights about the process because it is rather static, and depending on the periods that it spans, could be influenced by business cycles and could therefore measure cyclical swings rather than growth trends. Furthermore, it assumes that capital and labour and the unexplained residual are rather parallel streams or separate pockets, while economists are acutely aware of the integrated nature of these factors. This is equally true of the exogenous growth models, which are closely linked to growth accounting. These calculations nevertheless contributed by giving insight into the relative importance of the factors that are measured. The unexplained residual posed a challenge to researchers to explain the unexplained.

Endogenous growth theories widened the research ambit, by breaking the growth constraint of constant or even decreasing returns and expanding it to perpetual or even accelerating growth. It also renovated, widened and diversified the concepts of technology and of human capital, adding to the spectrum of prospective growth-enhancing variables.

Nevertheless growth theories, from growth accounting through exogenous growth and endogenous growth, remains fragmented with pockets of insight and rather nebulous and even speculative indications of how the theory could steer policy directions towards higher growth achievement. Currently there is little or no direct empirical evidence of how policy instruments such as higher or lower direct or indirect taxes used by ministers of finance or monetary policy instruments such as interest rates and exchange rates used by governors of reserve banks, impact on growth. Where such policy instruments exist, the question still remains whether the same policies are applicable to countries at the same level of development, but with different physical environments in the form of location and raw materials, let alone countries that are at different stages of growth or development. At this stage, growth theory may be likened to a horse and carriage in the age of space flight, despite its mathematical intricacies and elegance.

Chapter 4 investigates South Africa’s growth performance in the light of some of the factors that have been identified in growth theory as being of importance in the growth process. Chapter 5 investigates and identifies statistically significant growth factors that have been empirically tested in cross-country studies as explaining economic growth internationally. In chapter 6, time series analysis is used to test the factors identified in chapter 5 to ascertain their contribution to South Africa’s growth history.