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GROWTH THEORY AND APPLICATION:
THE CASE OF SOUTH AFRICA

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Abstract

This essay is a comparison study of traditional Neoclassical growth theory and new growth theory. It also discusses growth theory in the real world by investigating the so called "growth miracles" and "growth disasters" scenarios in the developing world. Finally, the essay performs a standard growth accounting exercise on South African economy mainly focuses on the importance of human capital in growth process. Growth accounting exercise shows that South Africa experiences a capital-accumulated growth in the 1970s and 80s, while sharply shifts to technology-accumulated growth in the 1990s and early 2000s.

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Keywords: Economic growth, Solow growth model, Growth accounting

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1. INTRODUCTION

"To account for sustained growth, the modern theory needs to postulate continuous improvements in technology or in knowledge or in human capital (I think these are all just different terms for the same thing) as an 'engine of growth'." (Lucas, 2003: [9])

Over the past few centuries, output growth has been raising world widely. However, cross-country income differences on average have been widened. Economists use the word "growth miracles" and "growth disasters" to illustrate output growth differs in individual countries. The scenarios of Japan from the end of World War Two and "four tigers"[1] from 1960 are referred to "growth miracles". The income per capita of the "four tigers" increased more than fourfold from 1960 to 1990. On the other side, scenarios in many Sub-Saharan African countries during the same time period are regarded as "growth disasters". During the time period from 1965 to 1990, the growth rate of income per capita of Sub-Saharan Africa is 0.5 percent, while the figure of other less developed countries is 1.7 percent (Collier and Gunning, 1999: 6).

The objective of this essay is to first have a comparison study of traditional Neoclassical growth theory and new growth theory. The essay is then to discuss growth theory in the real world by investigating the so called "growth miracles" and "growth disasters" scenarios in the developing world. Finally, the essay performs a standard growth accounting exercise on South African economy mainly focuses on the importance of human capital in growth process since human capital is a key means of improving the economic growth in the long run.

Besides the introduction and conclusion, the essay is organized as follows: Section 2 and 3 review the traditional Neoclassical growth theory as well as the new growth theory. Section 4 applies growth accounting technique to investigate the growth performance of the South African economy.

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[1] Four tigers: Hong Kong, South Korea, Singapore, and Taiwan.

2. TRADITIONAL NEOCLASSICAL GROWTH THEORY

2.1 The Solow Growth Model

The Neoclassical growth model developed by Solow (1956) is built on production function with constant returns to scale (CRS, hereafter) in its two arguments, capital and labor:

$$Y_t = F(K_t, L_t) \tag{2.1}$$

The notation is as same as in the textbook, where Y is output, K capital, and L labor. L is assumed to grow at rate of n, exogenously:

$$\frac{L_{t+1}}{L_t} = 1 + n \tag{2.2}$$

The assumption of CRS says:

$$F(\lambda K, \lambda L) = \lambda F(K, L) = \lambda Y \tag{2.3}$$

And it makes easier to work with the production function in intensive form:

$$\frac{Y}{L} = F(\frac{K}{L}, \frac{L}{L}) = F(\frac{K}{L}, 1) \tag{2.4}$$

By defining $y = \frac{Y}{L}$, $k = \frac{K}{L}$, and $f(k) = F(k,1)$, (2.4) can be written as:

$$y = f(k) \tag{2.5}$$

The intensive form of production function says that the output per unit of labor, y, is a function of the amount of capital per unit of labor, k. It implies that y depends only on the quantity of k, regardless of the overall size of the economy (Romer, 2006:10).

The model assumes that a constant fraction of output, s, is invested, that is, $S = sY$. Further assuming the existing capital depreciates at rate, δ, the competitive equilibrium of the Solow model can be written as the following:

$$k_{t+1} - k_t = \frac{1}{1+n}[sf(k_t) - (\delta + n)k_t] \tag{2.6}$$

This equation states that the change in capital stock per unit of labor, the left-hand side of the equation, is determined by two terms in the right-hand side of the equation, where the first term, $sf(k_t)$, is the actual investment per unit of labor, and the second term, $(\delta + n)k_t$, is the so called breakeven investment, the amount of capital stock must be invested to keep the capital per unit of labor at its existing level. In steady state:

$$k_{t+1} = k_t \quad \Rightarrow \quad sf(k_t) = (\delta + n)k_t \tag{2.7}$$

When the actual investment per unit of labor exceeds the breakeven investment, $k_{t+1} - k_t > 0$, k increases until it reaches the steady state level, and vice versa. Eventually, k will converge to its steady state level regardless where it starts (Romer, 2006).

In the long run, when the economy converges to its steady state level of capital stock per unit of labor, real output is growing at the same rate as population growth rate, n. That is,

$$\frac{Y_{t+1}}{L_{t+1}} = \frac{Y_t}{L_t} \quad \Rightarrow \quad \frac{Y_{t+1}}{Y_t} = \frac{L_{t+1}}{L_t} = (1+n) \tag{2.8}$$

Given the assumption of constant growth rates of saving rate, population growth rate, and the CRS, Solow growth model states that growths in key macroeconomic variables are determined by the population growth rate.

In his classical paper, Solow (1956) also extends the basic model with technical progress, A, which is assumed to growth at a constant rate, g. The technical progress and labor enter into the production function multiplicatively[2]:

$$Y_t = F(K_t, A_t L_t) \tag{2.9}$$

In steady state, growths in key macroeconomic variables are determined by the growth rates of population and technical progress:

$$\frac{Y_{t+1}}{Y_t} = \frac{A_{t+1} L_{t+1}}{A_t L_t} = (1+n)(1+g) \tag{2.10}$$

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[2] So called labour-augmenting or Harrod-neutral.

Both basic Solow model and Solow model with technical progress are exogenous growth models. The Solow growth model predicts that the long run improvement of living standard depends on the economy's fundamental characteristics including the population growth rate, the savings rate, the rate of technical progress, and the rate of capital depreciation. Therefore the structural policy implication for traditional Neoclassical growth models are the following: reducing the growth rate of population; encouraging saving; promoting technology and reducing the depreciation rate of capital.

Capital accumulation plays an important role in the Solow growth model. It is the only endogenous factor of production. Capital is however determined by the saving rate exogenously. In the Solow model, saving rate is the most likely parameter that policy can affect. An increase in the saving rate causes an increase in the output per unit of labor. Romer (2006) emphasizes that this increase in saving rate only causes an increase in the level of output per unit of labor not the growth rate. Indeed, aggregate output, aggregate consumption, and aggregate investment grow at the same rate at the labor force growth rate, n. The real output per unit of labor is not growing in the long run![3]

The diminishing marginal return to capital assures the "conditional convergence" of capital per unit of labor. Since the intensive form of production function implies that output per unit of labor depends only on the quantity of capital per unit of labor regardless of the overall size of the economy, countries have roughly the same fundamental characteristics should converge to similar steady state levels of output per unit of labor. In addition, the "conditional convergence" property implies that the initially "poor"[4] countries grow faster than the initially "rich" countries (Agenor and Montiel, 1999: 673).

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[3] In the Solow model with technical progress, the growth rate of real output per unit of labour is determined solely by the rate of technical progress, g.

[4] In terms of capital per unit of labour.

2.2 Solow Model in the Real World

Does the traditional Neoclassical growth model explain the scenarios of "growth miracles" and "growth disasters" discussed in the beginning of this section? This section is to answer the question by employing growth accounting literature as well as empirical evidence.

Growth accounting literature (Solow, 1957) provides a simple way of decomposing output growth into different factors in the aggregate production function:

$$Y = zF(K^\alpha L^{1-\alpha}); \qquad 0 < \alpha < 1 \qquad\qquad (2.11)$$

where α is the fraction of output that is contributed by the capital input, and $1-\alpha$ is the fraction that is contributed by the labor input. Output growth is segregated into three factors, the capital input K, the labor input L, and the total factor productivity z [5]. Total factor productivity (TFP hereafter) is also called "Solow residual" since it is measured as a residual in the Cobb-Douglas production function:

$$z = \frac{Y}{K^\alpha L^{1-\alpha}} \qquad\qquad (2.12)$$

As a residual, TFP captures the rest factors other than capital and labor input, such as technical change, the relative price change of energy, and so on. One key insight of the Solow growth model is that if the growth in TFP continues, capital per unit of labor will increase continuously. So does output per unit of labor. This is because given the quantity of capital and labor input, an increase in TFP will increase the marginal product of labor.

Given the fact that real output per unit of labor is not growing in steady state, macroeconomists may consider that the Eastern Asian "growth miracles" is mainly driven by higher TFP than the rest of world. However, empirical evidence suggests that the Eastern Asia's rapid growth does not appear to have been a

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[5] Solow refers it as "technical change" in his 1957 paper.

story of strong gains in TFP due to adopting existing technologies and catching up to the efficiency frontier. Young (1995) shows that during the period from 1966 to1990, the "growth miracles" are mainly explained by the high growth rate in the capital stocks. As shown in table 2.1, the average growth rates in capital are 7.7%, 10.8%, 12.9%, and 11.8% for Hong Kong, Singapore, South Korea, and Taiwan respectively. These numbers are extremely high compared to 3.2% in United States. On the other hand, the average growth rates in TFP range from 0.2% in Singapore to 2.6% in Taiwan, whereas 0.6% in United States. The difference is not as impressive as the difference in capital. Regarding to labor, there is no big gap between the "Four Tigers" and United States either.

Table 2.1 East Asian Growth Miracles: 1966-1990

	GDP/pc	Capital	Labor	TFP
Hong Kong	7.3%	7.7%	2.6%	2.3%
Singapore	8.7%	10.8%	4.5%	0.2%
South Korea	10.3%	12.9%	5.4%	1.7%
Taiwan	9.4%	11.8%	4.6%	2.6%
United States	3.0%	3.2%	2.0%	0.6%

NB: Average annual growth rate; data period for Hong Kong: 1966-1991.
Source: Young (1995)

For the developing countries as a whole, Agenor and Montiel (1999) study the "sources-of-growth" in the developing world geographically[6]. Table 2.2 shows, in general, capital has a greater contribution to the growth during the study period of 1970s and 1980s. The contribution of labor to growth is more or less the same in different groups. However, the contribution of TFP differs in different regions. In Asia, it is as important as capital, whereas it only accounts half of capital in all developing countries. As far as Wetern Hemisphere and Africa are concerned, TPF is negligible comparing to capital and labor.

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6 The authors separate developing countries into 4 groups: Africa, Asia, Middle East and Europe, and Western Hemisphere.

Table 2.2 Decomposition of Trend Output Growth : 1971-1992

	Output	Capital	Labor	TFP
All Developing Countries	5.2%	2.5%	1.3%	1.3%
Asia	6.5%	2.8%	1.1%	2.6%
Middle East and Europe	5.0%	3.3%	1.6%	-
Western Hemisphere	4.0%	1.9%	1.5%	0.5%
Africa	3.4%	1.9%	1.3%	0.2%

NB: Trend output is defined as a three-year moving average of real GDP.
Source: Agenor and Montiel (1999: 676)

Both studies suggest that the empirical evidence is consistent with the Solow growth model that capital accumulation contributes the most for output growth. This is especially the case for the "Four Tigers", where the capital contribution is about four times the TFP. The lower growth in Asia as a whole comparing to the "Four Tigers" is probably because of the crucial decline in the contribution of capital as well as labor[7]. In general, "growth miracles" is obviously due to the fact that the contributions of all these three "resources" are much higher than that in the rest of world.

In sum, the Solow growth model is a Neoclassical form of the production function with constant returns to scale. In addition, the saving rate is assumed to be constant. The basic property of traditional Neoclassical growth models is that , other things being equal, countries with lower starting level of output per capita should growth faster, so called "conditional convergence". However, empirical evidence, such as the "growth miracles" and "growth disasters", indicates that although capital accumulation has a greater impact on growth and "conditional convergence" appears in homogenous groups of economies only (Barro and Sala-i-Martin, 1992), but it is not sufficient to explain either the considerable growth over time or the cross-country differences in output per capita.

One crucial shortcoming of the traditional Neoclassical growth models is those models are exogenous models in the sense that the long run output per capita growth rate depends on the population growth rate, whereas the rate of

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[7] Strictly speaking, the results from these two studies are not comparable due to the measurement problem. But this is not the concern here.

technology progress in the Solow growth model with technology progress. Therefore, the model itself can neither explain the mechanisms that generate long run growth, nor evaluate the efficiency of government growth policies.

3. NEW GROWTH THEORY

The traditional Neoclassical growth models became more and more technical and lack of empirical applications (eg. the Ramsey-Cass-koopmans model). During the time period from the late 1960s to early 1980s, macroeconomic research shifted from long run growth theory to the short run fluctuations, and business cycle models with rational expectations (Barro and Sala-i-Martin, 1995: 12). Since the mid-1980s, new growth theory (Romer, 1986, 1990; Lucas, 1988) addresses the limitations of the Neoclassical model by proposing two main channels, human capital and knowledge, through which long run growth is generated endogenously.

3.1 The Solow Growth Model with Human Capital

The growth model presented here consists of introducing human capital as an additional production input which is accumulated in the same way as physical capital. Every year a constant share of output is invested in education, training of the labor force, i.e. human capital. In contract to Lucas (1988) that production function of human capital differs from other goods, here, human capital, physical capital, and consumption are produced by same technologies (Mankiw et al, 1992: 416). The production function takes the form:

$$Y = K^{\alpha} H^{\theta} (AL)^{1-\alpha-\theta} ; \qquad 0 < \theta < 1, \quad \alpha + \theta < 1 \,^{8} \qquad (3.1)$$

where H is the stock of human capital, and other variables are defined as in the previous section. Households now choose the fractions of their income to consume and invest in physical or human capital. Assuming both physical and

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[8] $\alpha + \theta < 1$, implies decreasing returns to K and H. The Solow model with human capital becomes endogenous if constant returns to scale applies, $\alpha + \theta = 1$ (see Mankiw, et al, 1992).

human capital depreciate at the same rate [9], δ, the capital accumulation equations become:

$$K_{t+1} = I_{kt} + (1-\delta)K_t \; ; \qquad I_{kt} = s_k Y_t \qquad \Rightarrow \qquad K_{t+1} = s_k Y_t + (1-\delta)K_t$$

$$H_{t+1} = I_{ht} + (1-\delta)H_t \; ; \qquad I_{ht} = s_h Y_t \qquad \Rightarrow \qquad H_{t+1} = s_h Y_t + (1-\delta)H_t \tag{3.2}$$

where s_k and s_h are the fractions of income that households decide to invest in physical and human capital respectively[10]. Dividing on both sides by $A_{t+1}L_{t+1}$, and substituting the intensive form of production function [11], gives the transition equations:

$$k_{t+1} = \frac{1}{(1+g)(1+n)}[s_k k_t^\alpha h_t^\theta + (1-\delta)k_t]$$

$$h_{t+1} = \frac{1}{(1+g)(1+n)}[s_h k_t^\alpha h_t^\theta + (1-\delta)h_t] \tag{3.3}$$

Subtracting k_t and h_t on both sides of the transition equations respectively gives the Solow type equation of motion:

$$k_{t+1} - k_t = \frac{1}{(1+g)(1+n)}[s_k k_t^\alpha h_t^\theta - (n+g+\delta+ng)k_t]$$

$$h_{t+1} - h_t = \frac{1}{(1+g)(1+n)}[s_h k_t^\alpha h_t^\theta - (n+g+\delta+ng)h_t] \tag{3.4}$$

Equation (3.4) states that the changes in physical and human capital stock per effective labor, is the actual investment per effective labor minus the replacement requirement from technological growth, population growth, and depreciation of capital stock.

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[9] The depreciation of human capital refers to such as losses from skill deterioration and net of benefits from experience. Different depreciation rates for physical and human capital do not add that much of insight (Barro and Sala-i-Martin, 1995: 173)

[10] Restrictions on s_k and s_h: $I_t = S_t = (s_k + s_h)Y_t$; $I_t = I_{kt} + I_{ht}$

[11] The intensive form of production function: $y_t = k_t^\alpha h_t^\theta$; where $y_t = \dfrac{Y_t}{A_t L_t}$, $k_t = \dfrac{K_t}{A_t L_t}$,

$h_t = \dfrac{H_t}{A_t L_t}$

In steady state, the economy converges to its general equilibrium:

$$k_{t+1} - k_t = 0 \quad \Rightarrow \quad s_k k_t^{\alpha} h_t^{\theta} = (n+g+\delta+ng)k_t \quad \Rightarrow \quad k^* = [\frac{s_k^{1-\theta} s_h^{\theta}}{(n+g+\delta+ng)}]^{\frac{1}{1-\alpha-\theta}}$$

$$h_{t+1} - h_t = 0 \quad \Rightarrow \quad s_h k_t^{\alpha} h_t^{\theta} = (n+g+\delta+ng)h_t \quad \Rightarrow \quad h^* = [\frac{s_k^{\alpha} s_h^{1-\alpha}}{(n+g+\delta+ng)}]^{\frac{1}{1-\alpha-\theta}}$$

$$y^* = (k^*)^{\alpha}(h^*)^{\theta} = [\frac{s_k}{(n+g+\delta+ng)}]^{\frac{\alpha}{1-\alpha-\theta}}[\frac{s_h}{(n+g+\delta+ng)}]^{\frac{\theta}{1-\alpha-\theta}} \qquad (3.5)$$

Taking logs of the output per capita equation, gives:

$$\ln y^* = \frac{\alpha}{1-\alpha-\theta}[\ln s_k - \ln(n+g+\delta+ng)] + \frac{\theta}{1-\alpha-\theta}[\ln s_h - \ln(n+g+\delta+ng)] \qquad (3.6)$$

Equation (3.6) states that the growth of output per effective labor depends on the growth rate of population as well as the accumulation of physical and human capital. The elasticity of the steady state value of output per effective labor, y^*, with respect to physical capital stock per effective labor , is $\frac{\alpha}{1-\alpha-\theta}$. Whereas in the basic Solow growth model it is $\frac{\alpha}{1-\alpha}$. Algebraically, $\frac{\alpha}{1-\alpha-\theta} > \frac{\alpha}{1-\alpha}$, in other words, other things being equal, Solow model with human capital predicts a higher growth rate than the basic Solow model does. Also (3.6) predicts that in steady state a higher saving leads to a higher physical capital stock, therefore a higher output. The higher the output, the bigger fraction of output will be invested in human capital, which in turn generates a higher level of output.

The Solow model with human capital performs very well empirically (see Mankiw, et al, 1992; Barro and Sala-i-Martin, 1995), in terms of steady state prediction and convergence prediction[12]. For instance, Mankiw et al (1992: 408) find the omitting human capital accumulation biases, that is, the estimated influences of saving and population growth will become too large if excluding human capital from the basic Solow model. However, the model itself does not explain the important parameters like s_k and s_h. In particular, the rate of technological

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[12] Once again, it is "conditional convergence".

process, g, which determines the long run growth rate per effective labor remains unexplained. The following section illustrates how the Solow model with research and development (R&D) resolves this issue.

3.2 The Solow Model with R&D

One approach[13] to generating growth endogenously is proposed by Paul Romer (1986, 1990). The model offers an alternative view of long run prospects for growth. It rules out the exogenous technological process and the long run growth is driven primarily by the accumulation of knowledge (Romer, 1986: 1003). The basic structure for Solow growth model is applied here, except there are two production sectors in the model: good-producing sector, where output is produced; R&D sector, where stock of knowledge is generated:

$$Y_t = [(1-a_K)K_t]^{\alpha}[A_t(1-a_L)L_t]^{1-\alpha}$$

$$A_{t+1} - A_t = B(a_K K_t)^{\beta}[(a_L L_t)^{\gamma} A_t^{\theta}] \tag{3.7}$$

where a_K and a_L are the fractions of capital stock and labor used in R&D, and fractions $1-a_K$ and $1-a_L$ in goods production respectively; B is a shift parameter; θ represents the effect of the existing stock of knowledge on the success of R&D. The restrictions on the parameters are the following: $0 < \alpha < 1, \beta \geq 0, \gamma \geq 0,$ no restriction on θ.

The equation of motion becomes[14]:

$$K_{t+1} - K_t = I_t = sY_t = s\ [(1-a_K)K_t]^{\alpha}[A_t(1-a_L)L_t]^{1-\alpha} \tag{3.8}$$

Then the dynamics of the growth rates of K and A are derived by dividing (3.8) and R&D equation in (3.7) by K_t and A_t respectively:

$$g_{Kt} = \frac{K_{t+} - K_t}{K_t} = s(1-a_K)^{\alpha}(1-a_L)^{1-\alpha}(\frac{A_t L_t}{K_t})^{1-\alpha}$$

$$g_{At} = \frac{A_{t+1} - A_t}{A_t} = Ba_K^{\beta}a_L^{\gamma}K_t^{\beta}L_t^{\gamma}A_t^{\theta-1} \tag{3.9}$$

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[13] Another approach is Arrow's (1962) learning-by-doing model, which is not discussed here.
[14] For simplicity purpose, the depreciation rate is assumed to zero, $\delta = 0$.

where g_{Kt} and g_{At} represent growth rate of capital stock and knowledge. Defining $c_K = s(1-a_K)^\alpha(1-a_L)^{1-\alpha}$, $c_A = Ba_K^\beta a_L^\gamma$, and taking logs of both sides of equation g_K and g_A, gives:

$$\ln g_{Kt} = \ln c_K + (1-\alpha)[\ln A_t + \ln L_t - \ln K_t]$$

$$\ln g_{At} = \ln c_A + \beta \ln K_t + \gamma \ln L_t + (\theta - 1)\ln A_t \tag{3.10}$$

Therefore:

$$\ln g_{Kt} - \ln g_{Kt-1} = (1-\alpha)[(\ln A_t - \ln A_{t-1}) + (\ln L_t - \ln L_{t-1}) - (\ln K_t - \ln K_{t-1})] = (1-\alpha)(g_A + n - g_K)$$

$$\ln g_{At} - \ln g_{At-1} = \beta(\ln K_t - \ln K_{t-1}) + \gamma(\ln L_t + \ln L_{t-1}) + (\theta-1)(\ln A_t - \ln A_{t-1}) = \beta g_k + \gamma n + (\theta-1)g_A \tag{3.11}$$

In steady state:

$$\ln g_{Kt} - \ln g_{Kt-1} = 0 \quad \Rightarrow \quad g_K^* = g_A^* + n \tag{3.12}$$

$$\ln g_{At} - \ln g_{At-1} = 0 \quad \Rightarrow \quad g_K^* = -\frac{\gamma n}{\beta} + \frac{1-\theta}{\beta}g_A^* \tag{3.13}$$

Substituting (3.12) into (3.13) gives the steady state values of g_A and g_K:

$$g_A^* = \frac{\gamma+\beta}{1-\theta-\beta}n; \qquad g_K^* = \frac{\gamma+1-\theta}{1-\theta-\beta}n \tag{3.14}$$

In steady state, the output growth rate is:

$$g_y^* = \ln Y_t - \ln Y_{t-1} = g_A^* + n \tag{3.15}[15]$$

Equation (3.15) together with (3.12) implies that in equilibrium[16] K and A are growing at rates shown in (3.14), and output is growing at the same rate as capital, $g_y^* = g_K^*$. Output per capita is growing at rate g_A^* (Romer, 2006: 111).

The Solow growth model with R&D is an endogenous growth model in the sense that the long run growth rate is constant and determined within the model, $g_y^* = g_K^* = g_A^* + n$, where the growth of knowledge is determined by parameters,

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[15] $\ln Y_t = \alpha[\ln(1-a_K) + \ln K_t] + (1-\alpha)[\ln A_t + \ln(1-a_L) + \ln L_t] \Rightarrow$
$\ln Y_t - \ln Y_{t-1} = \alpha(\ln K_t - \ln K_{t-1}) + (1-\alpha)[(\ln A_t - \ln A_{t-1}) + (\ln L_t - \ln L_{t-1}) = \alpha g_K + (1-\alpha)(g_A + n)$
$= \alpha(g_A + n) + (1-\alpha)(g_A + n) = g_A + n$

[16] The necessary condition to guarantee the equilibrium exists is $\beta + \theta < 1$ (Romer, 2006:110).

β, γ, and θ. Neither the fractions of labor force and capital stock engaged in R&D, a_L and a_K, nor does the saving rate, s, have effect on the long run growth (Romer, 2006: 111).

3.3 Neoclassical vs. New Growth Theory

The traditional Neoclassical growth models play a major and essential role in the development of dynamic general equilibrium analysis. However, as a theory of growth, it fails to explain the basic facts of actual growth behavior. Also empirical evidence indicates a persistent different per capita growth rates over long period across nations, i.e. the "conditional convergence" does not appear (McCallum, 1996: 50-52). One explanation of this can be the fact that different countries may not be able to access the same technology. Generally speaking, the technology level in developed countries is relatively higher than that in developing countries. Also the technological innovation often occurs in developed countries and countries who own new technologies usually prevent them from being adopted by others. Even though assuming the new technologies were able to be accessed by other countries, there is always a long time lag. This difference in technology process can explain the persistent differences in the standards of living across nations. Williamson (2005: 213-218) argues that there are two good reasons why significant barriers to the adoption of new technology exist. First, a powerful union has a strong incentive to prevent its members losing jobs due to their obsolete skills made by new technologies. The second one is the trade restrictions introduced by government in order to shield domestic infantile industries from foreign competition, which are the cases in most of the developing countries. These barriers reduce the incentive of technological innovations and have a negative effect on total factor productivity.

Alternatively new growth theory models explain the failure of "conditional convergence" by proposing the externalities and spillover effects of human capital and knowledge. Human capital is the accumulated stock of skills and

education embodied in labor force. Empirical literature takes education (schooling) as a proxy of human capital. The externality of human capital exists because public learning or education increases the stock of human capital of labor force. A more highly skilled labor force becomes more productive, and hence produces more. In addition, individuals who have higher skills can pass on their skills to others, therefore the higher level of human capital, the more efficient the human capital accumulates. Intuitively, since the skills of the labor force is an important input factor, adding human capital to the Solow model improves the growth model itself.

Empirics suggest that investing in human capital is as important as investing in physical capital. However, for households, there are associated opportunity costs for them to invest in human capital. For instance, the opportunity cost of investing in education takes the form of forgone labor earning. The opportunity cost varies from individual to individual. It is much higher for an individual with more human capital than the one with little.

The virtue of new growth theory models is attempting to explain growth endogenously. However as argued by MaCallum (1996), there is a logical difficulty with these models. As human capital cannot be separated from labor force, it is a private good and rival. Therefore, the accumulated human capital which generates the never-ending growth in the Lucas model cannot be automatically passed on to workers in succeeding generations. In contrast, knowledge is semi-public good [17]. Unlike human capital, an individual's acquisition of knowledge does not prevent others to acquire the same knowledge. Knowledge is "semi" public good in the sense that new knowledge can be partially or temporarily kept secret due to the patent and certain degree of monopoly power owned by individuals or firms who engaged in the innovation of new knowledge (Romer, 1990). Thus as shown by (3.15), it is the accumulated

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[17] Some authors refer knowledge is completely nonrival in favour of discussing the spillover effects of knowledge.

knowledge which can be passed on from generation to generation, can plausibly generate the never-ending growth endogenously (also see McCallum, 1996: 59-61; Grossman and Helpman, 1994: 35). Nevertheless, it is important to realize that:

> "Growth in the stock of useful knowledge does not generate sustained improvement in living standards unless it raises the return to investing in human capital in most families. This condition is a statement about the nature of the stock of knowledge that is required, about the kind of knowledge that is 'useful.' But more centrally, it is a statement about the nature of the society." (Lucas, 2001: [3])

4. THE SOUTH AFRICAN CONTEXT

4.1 A Standard Growth Accounting Exercise

In order to explain South Africa's economic growth over the last few decades, a first step is to identify the relative contributions of capital, labor, and the overall productivity. The methodology on which the standard growth accounting exercise is based on can be described as follows (Solow, 1957; Barro, 1998):

$$Y = zK^{\alpha}(HL)^{1-\alpha} \tag{4.1}$$

where z represents TFP, α and $1-\alpha$ refer to the share of physical capital and labor respectively in national output[18], Y, K, and L are output, physical capital and labor respectively. H is the human capital measure which takes the form as the following:

$$H = (1.07)^{S} \tag{4.2}$$

where s is the average years of schooling. The series of average years of schooling is generated based on the censuses of 1985, 1991, 1996, and 2001 (Louw et al, 2006). The return to schooling for each year is assumed at 7 percent[19], which is a value near the lower boundary of the results from the microeconomics studies (Bosworth and Collins, 2003).

Solow (1957) shows that (4.1) yields the following identity:

$$\hat{z} = \hat{y} - \alpha\hat{k} - (1-\alpha)\hat{l} \tag{4.3}[20]$$

where lower letter with a hat denotes growth rate. The growth rates of TFP are obtained from the discrete version of (4.2). Data for the TFP decompositions are

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[18] Given the assumption of perfect competition and CRS, capital and labor output share sum to unity.

[19] Using a global data set, coving 95 countries, Cohen and Soto (2001) estimate returns to schooling in the range of 7 to 10 percent, close to the average of the microeconomic studies. Also see du Plessis and Smit (2006).

[20] Both labor adjusted and not adjusted for changes in human capital are considered in the growth accounting exercise.

drawn from the South African Reserve Bank (SARB) and Trade and Industry Policy Secretariat (TIPS) data bases.

Alternatively, Liu and Gupta (2006) use a version of Hansen's real business cycle benchmark model to calibrate the South African economy. The authors obtain the calibrated capital output share, 0.26. This number is relatively small compared to 0.48, which is computed based on the data from TIPS.

Table 4.1 reports the results of the growth accounting exercise for different intervals. It is clearly that the output growth is mainly explained by the high growth in the capital stock compared to labor and TFP for the 1970s and 1980s. This finding is the same as the one that discussed in Section 2.2, the Eastern Asian "growth miracles" is mainly driven by the growth of physical stock, not the TFP. In this case, both empirics support the view of capital-accumulation-determined growth theory as in the traditional Neoclassical growth models, rather than the Solow residual "school of though", in which the growth is determined mainly by the TFP (Islam, 1995; Hall and Jones, 1999; Easterly and Levine, 2000). However, as shown in Figure 4.1 and 4.3[21], the situation for the 1990s

Table 4.1 Decomposition of Output Growth (%)

		Output	Capital	Labor	Labor(H)	TFP	TFP(H)
1970s	ρ=0.48	3.79	2.74	1.02	2.49	0.03	-1.43
	ρ=0.26	3.79	1.47	1.46	3.56	0.86	-1.24
1980s	ρ=0.48	1.36	1.14	0.45	1.37	-0.24	-1.16
	ρ=0.26	1.36	0.62	0.65	1.96	0.10	-1.22
1990s	ρ=0.48	1.49	0.51	-0.38	-0.52	1.36	1.51
	ρ=0.26	1.49	0.27	-0.54	-0.74	1.76	1.96
2000-2005	ρ=0.48	4.29	0.77	0.42	1.07	3.10	2.45
	ρ=0.26	4.29	0.41	0.60	1.52	3.27	2.35
1970-1990	ρ=0.48	2.68	1.89	0.74	1.92	0.05	-1.14
	ρ=0.26	2.68	1.02	1.05	2.75	0.61	-1.10
1970-2005	ρ=0.48	2.62	1.33	0.36	1.09	0.93	0.20
	ρ=0.26	2.62	0.72	0.52	1.55	1.39	0.36

Source: Capital output share (ρ=0.48) is calculated using data output (real GNP) and capital from SARB, wage & labor (employment) from TIPS; capital output share (ρ=0.26) is calibrated using data from SARB. Where H denotes labor and TFP adjusted for changes in human capital via years of schooling measure.

[21] In Figure 4.1 – 4.4, the height of each bar shows the average annual growth rate of output over different intervals. Each bar is broken into blocks showing the contributions from capital growth, from labor growth, and from technological change.
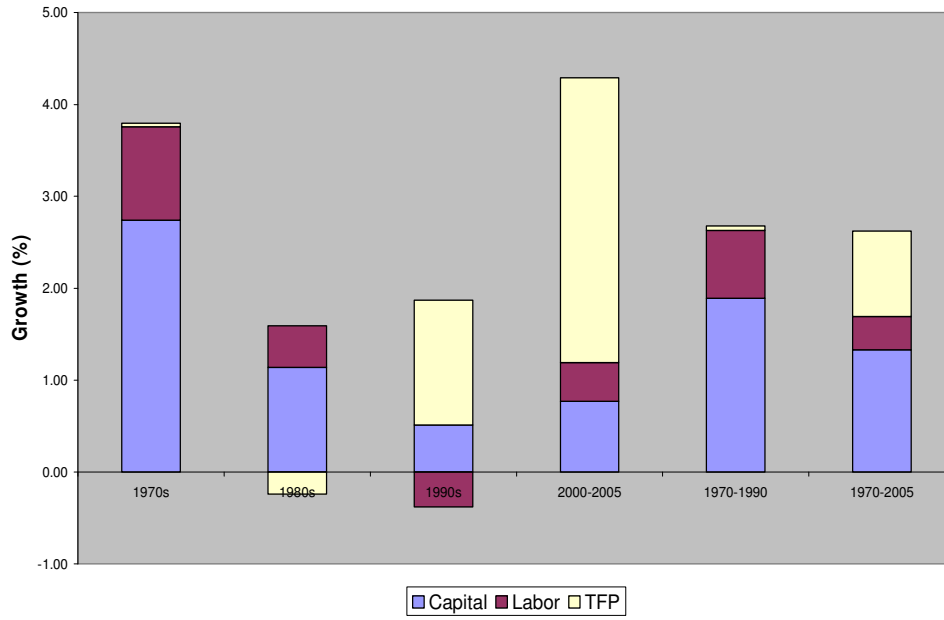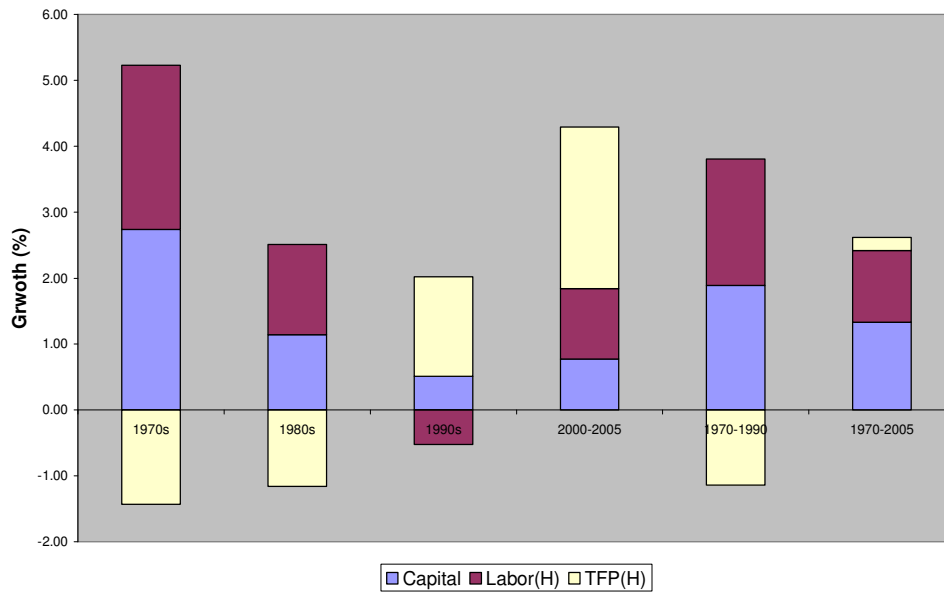
Figure 4.1 Sources of Growth (ρ=0.48): labor not adjusted

Figure 4.2 Sources of Growth (ρ=0.48): labor adjusted

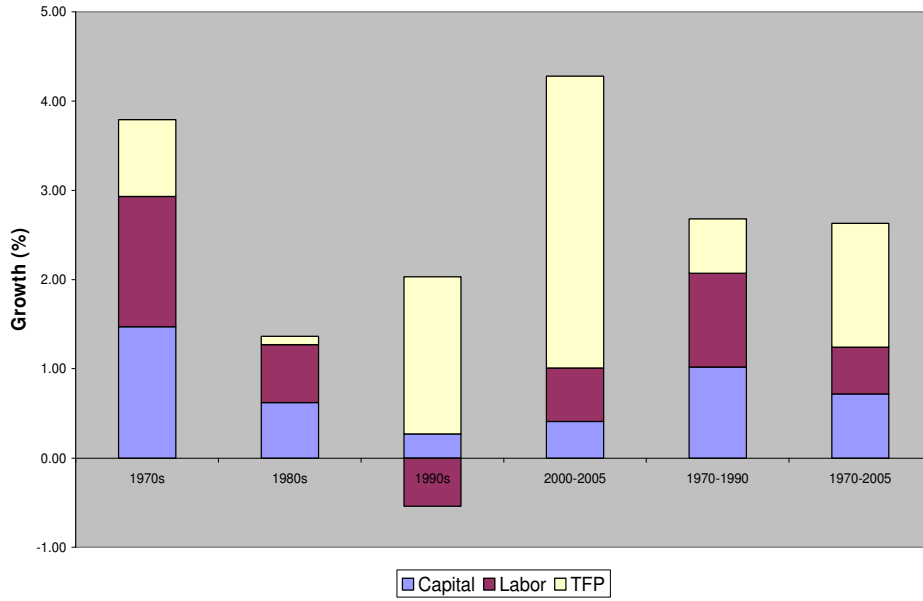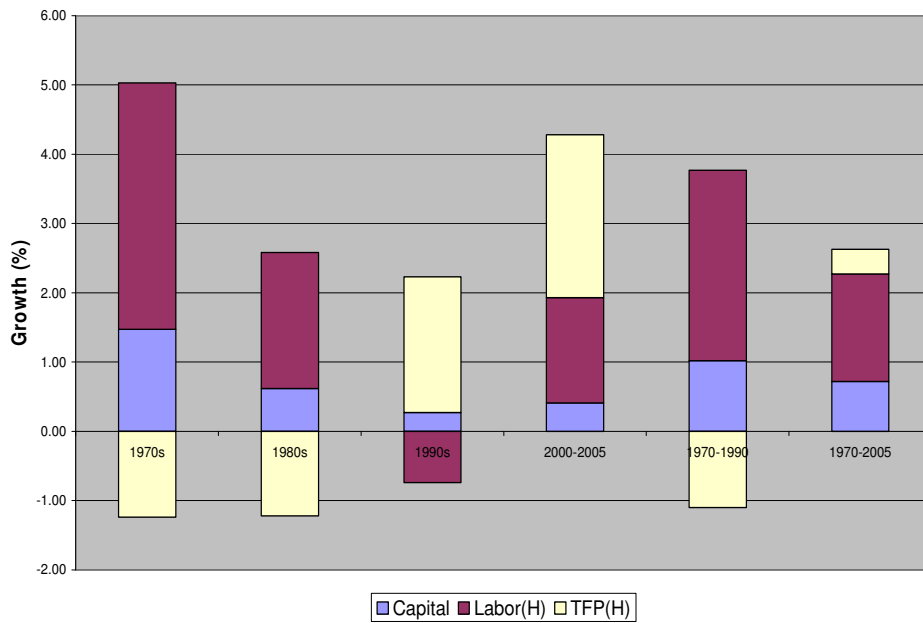Figure 4.3 Sources of Growth (ρ=0.26): labor not adjusted

Figure 4.4 Sources of Growth (ρ=0.26): labor adjusted

and 2000-2005 are reversed. The contribution of TFP is -0.24 percent in the 1980s, while it turns to 1.36 percent in the 1990s[22]. Indeed, the accumulation in TFP is the single strongest contributor to the output growth (1.49 percent) in the 1990s. This situation continues to 2000-2005, where the accumulation in TFP is 3.10 percent and output growth is 4.29 percent. In terms of the whole study period, both capital accumulation and TFP growth have made important contributions to growth.

4.2 Human Capital

Besides the finding that the source of growth has significantly shifted from capital accumulation to the TFP growth over time, the growth accounting exercise also shows that the decomposition is sensitive to underlying assumptions of the production factors[23]. Labor adjusted for changes in human capital affects the result of the decomposition of growth. The contribution of labor increases significantly after adjusted for human capital in 1970s and 1980s, which in turn results that output growth is explained by both capital and labor. The labor adjustment effect is minimal in the 1990s. In terms of the whole study period, capital and labor are the main sources of growth, and there is little role for TFP. But, in 1990s and 2000-2005, TFP still contributes the most to growth. Moreover, there is a significant increase in TFP accumulation in 2000-2005, which indicates the same finding in the case of labor unadjusted for changes in human capital.

Increases in education could affect economic growth through two different channels. First, microeconomic studies suggest more education may improve the productivity of the workers. Second, Mankiw et al (1992) introduce human capital (education) as an independent factor in growth process. The authors argue that as machines and capital increasingly substitute for the raw force of labor, human capital is the most important production factor nowadays. An educated worker is more capable to implement new technologies and improve efficiency than an

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[22] For the capital output share of 0.48 and unadjusted labor.
[23] See Figure 4.1 and 4.2.

uneducated worker. Thus, both approaches assume a positive correlation between gains in education and growth. However, recent macroeconomic studies (Barro and Lee, 2000; Bils and klenow, 2000; Easterly and Levine, 2001) fail to find a significant positive correlation between gains in education and growth. The failure to replicate the microeconomic results at the aggregate level might due to: (1) the private return to education that underlines the micro-analysis is much greater than the social return reflected in the aggregate data; (2) the variations in the quality of education across countries (Bosworth and Collins, 2003).

The use of years of schooling as the measure of education attainment does not incorporate any adjustment for variations in quality. In the international context, the quality of education varies substantially across countries although it is difficult to measure directly. In the South African context, there is a significant racial difference in the quality of education[24]. It is widely believed that the African education system provides inferior education in South Africa, due to "historically" a combination of extremely high pupil-teacher ratios, poorly qualified teachers and low financing levels (Moll, 1996). Racial differences in education have decreased steadily over time since 1994. Nonetheless, as Fedderke (2001) points out now South Africa spends far more than comparable developing countries as a percentage of GDP on education, the problem is with little concern for the deepening of the quality of education. School quality has been shown to have a positive and significant effect on years of completed education. Investing in human capital is a key means of improving the economic growth in the long run. Moreover, the external effect of human capital is at the heart of the endogenous growth literature (Case and Deaton, 1999).

4.3 Input Factor Elasticity

In the standard growth accounting exercise, the capital output shares are obtained through two different approaches as explained above. Do the obtained

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[24] See Fedderke et al (2000) and Anderson et al (2001) for a discussion of historical differences in school quality across racial groups.

two different values of capital output shares (0.48 vs. 0.26) matter? Comparing Figure 4.1 to 4.3 (labor not adjusted for education) as well as Figure 4.2 to 4.4 (labor adjusted for education), the differences in terms of the contributions to growth are minimal especially for the later case. The only relatively significant effect appears in the 1970s and 1980s for the case of labor not adjusted for education. There is a significant increase in TFP and decrease in labor contribution to growth in the 1970s, while an inverse contribution of TFP in the 1980s although the absolute value is minor.

From the real business cycle perspective, both TFPs obtained from different approaches do an equally good job. Figure 4.5 shows percentage deviations from trend in TFPs for the years 1970-2005, along with percentage deviations from trend in real GNP. The fluctuations in Both TFPs about the trends are highly positively correlated with the fluctuations in GNP about the trend. It is clear that TFPs move closely with GNP, so that fluctuations in TFPs can be an important explanation for why GNP fluctuates.

Figure 4.5 TFPs (Solow Rediduals) and GNP, 1970-2005.

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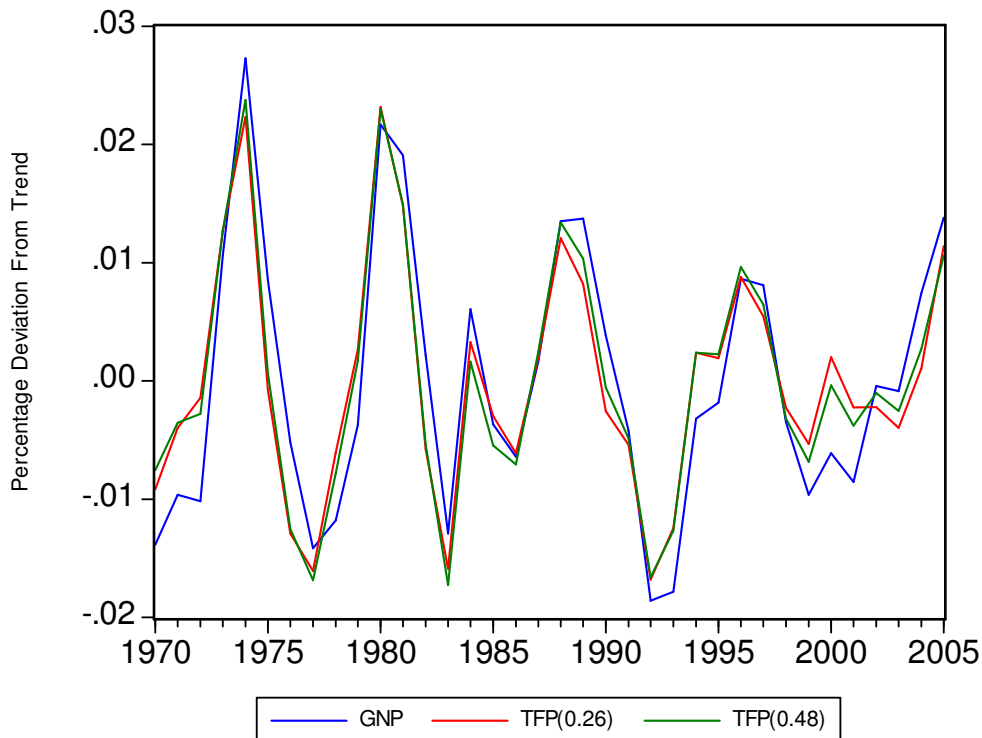
5. CONCLUSION

Macroeconomists have responded with a rich literature on growth theory to the vast differences in living standard over time and across countries. The traditional Neoclassical growth theory does a nice job in explaining the "growth miracles", that is, the Eastern Asia's rapid growth is mainly explained by the high growth rate in the capital stock. However, the traditional Neoclassical growth models are exogenous. The model itself can neither explain the mechanisms that generate long run growth, nor explain the "conditional convergence". Alternatively, new growth theory models explain the failure of "conditional convergence" by proposing the externalities and spillover effects of human capital and knowledge.

Growth accounting exercise shows that South Africa experiences a capital-accumulated growth in the 1970s and 80s, while sharply shifts to technology-accumulated growth in the 1990s and early 2000s. The standard growth accounting approach applied in this essay is based on the assumption of constant returns to scale. Since new growth (endogenous) theory is challenging against this assumption, further study should be done in this regard.

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