Ghana's Economic Growth in perspective: A time series approach to Convergence and Growth Determinants

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GHANA'S ECONOMIC GROWTH IN PERSPECTIVE:

A TIME SERIES APPROACH TO CONVERGENCE AND GROWTH DETERMINANTS

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Abstract

Economic growth around the world has not been equal for a long time. Some economics grow faster while others grow slower. But economists have predicted that the slower growing economics will eventually converge with the faster growing economy as some point in the future. This is known as the convergence hypothesis. In this study, we test this hypothesis for Ghana and the Western Europeans countries with UK been a proxy for these countries, using time series data to determine whether or not it holds. We determine how fast or slow this convergence process is by using the returns to scale concept on Ghana's economy and latter account for factor that determines economic growth in sectors. The study supported the null hypothesis of convergence i.e. Ghana is catching up with the Western European countries. The study also shown that Ghana growth accounting exhibit decreasing returns meaning convergence is relatively slow and also signifies that Ghana is not on a balanced growth path (this refers to the simultaneous, coordinated expansion of several sectors of the economy). The study showed a negative relationship between GDP and labour both in the long run and short run relationship. Again the study showed a positive relationship between GDP and capital, Agric and Industrial sector. Lastly, the study showed a negative relationship between GDP and AID and Service in the long run and positive relationship in the short run.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The surge in economic growth over the past two centuries brought the greatest and most rapid improvement in human welfare the world has ever experienced. In nearly all countries, we live more comfortably than ever before because economic growth provides us with the means to better control our lives and the environment within which we live. We live longer and with less physical suffering because economic growth provides us with the means to find solutions to health problems and disabilities. We enjoy more leisure because economic growth permits us to satisfy our material wants with less effort. We have more choices, both in consumption and work, because economic growth has expanded the variety of economic activities we can pursue and the goods and services we can consume. But is economic growth at the same rate everywhere? The answer is a definite no.

Successive governments all over the world have aimed at reducing the level of poverty and attainting high economic growth. It is important to note that, a requirement to better policies is a better understanding of economic growth. Standards of living differ among the parts of the world by amounts that almost challenge understanding (Romer, 1996). Among the worst performance in terms of economic growth in the mid 1980s and 1990s were the African countries of Cameroon (-6.9 percent per year), Rwanda (-6.6 percent), and Cote d'Ivoire (-4.6 percent). But there were economic disasters elsewhere in the world as well. In the Central American country of Nicaragua, citizen's average income fell by 6.1 percent per year over the same period. While the causes of economic disaster vary from one country to another, it is clear that not everyone enjoyed rapid improvements in his or her standard of living in recent years.[1]

Economic growth always take the center stage in most economic policies and is necessary associated with economic development as there can be no development without growth. However, growth does not necessarily imply development. Simply put

[1] Based on data from World Bank(1996), *World Development Report 1996*, Washington, D.C.: World Bank,

growth merely refers to the growth of output, while development refers to all the changes in the economy including the social, political and institutional changes that accompany changes in output.[2] Robert Lucas writes that growth and development are different fields of study 'with growth the theory defined as those aspects of economic growth we have some understanding of, and development defined as those we don't'.[3] Because of the role that economic growth plays in the development process in the Ghanaian economy as well, it is imperative to comprehend the nature and determinants of economic growth and to establish whether or not Ghana's growth is catching up (converging) with the developed countries. It is through this that one can begin to appreciate the progress or otherwise of Ghana's development agenda. This study focuses on whether Ghana's economic growth is converging with the Western European countries that is the **UK** used as a proxy for Western European countries, how fast or slow Ghana is converging with the UK if there is actually coverngence and the key determinants of growth in sectors in Ghana. Because the study of convergence dwells on UK and Ghana mostly, we give a brief overview of the two economics.

1.2 An Overview of Ghana's Economy

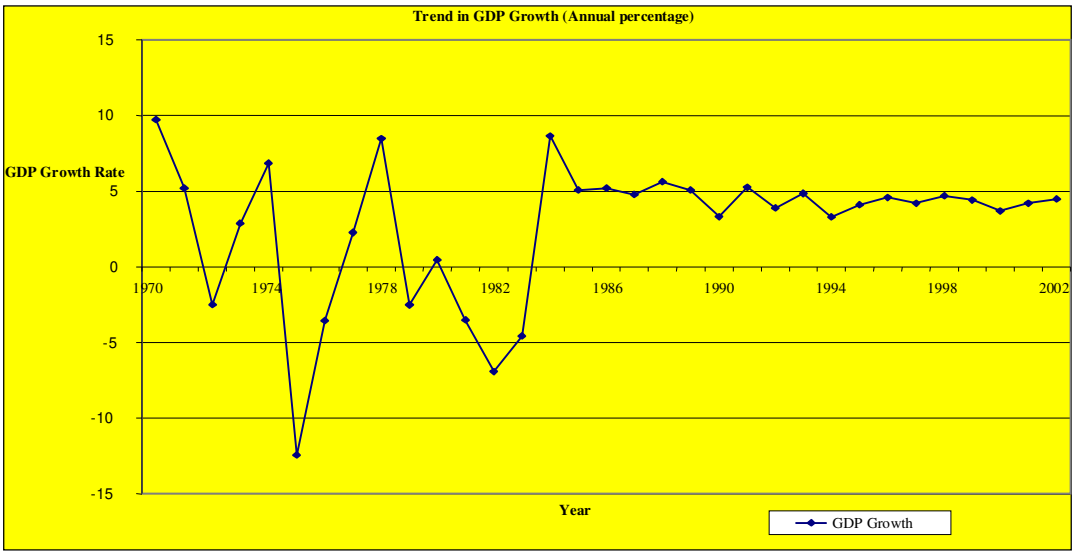
Since independence in 1957, Ghana has tried a number of approaches to achieving acceptable rates of growth and development. When Ghana gained her independence she was the world's leading producer of cocoa and this supported a well-developed infrastructure to service trade, and enjoyed a relatively advanced educational system. The government sought to use the apparent stability of the Ghanaian economy as a springboard for economic diversification and expansion and began the process of moving Ghana from a primarily agricultural economy to a mixed agricultural-industrial one (Aryeetey and Fosu). But unfortunately, the price of cocoa collapsed in the mid-1960s, destroying the fundamental stability of the economy. Since then, Ghana has been caught in a cycle of debt, weak commodity demand, and currency overvaluation, which has resulted in the decay of unproductive capacities and a crippling growth rate.

The growth rate record of Ghana has been one of unstableness when the post-reformed period is compared to the earlier period. With logically high GDP growth in the 1950s and early 1960s, the economy began to experience a reduction in GDP growth in 1964.

[2] Berg Hendrick V.D., *Economic Growth and Development, International Edition*, McGraw-Hill Company, 2001, p.11
[3] *Ibid*, p.11

According to Aryeetey and Fosu (2005), 'growth was turbulent during much of the period after mid-1960s and only began to stabilize after 1984. In 1966, 1972, 1975-1976, 1979 and 1983, the growth rate of real GDP was negative for Ghana'.[4] The GDP growth has been negative for a number of years. This is mainly due to political instability between these years, even though some years recorded some positive growth in 1974, 1977 and 1978. From 1984 to 2006, the GDP growth has averaged about 3.9 to 4.5 percent.

Figure 1.1 A cursory sketch of Ghana Economics growth Performance



Source: Aryeetey and Fosu, Economic Growth in Ghana

1.3 An Overview of the UK's Economy

The United Kingdom is a major developed capitalist economy. It is currently the world's sixth largest by nominal GDP and the sixth largest by purchasing power parity[5]. It is the third largest economy in Europe after Germany's and France's in nominal terms, and the second largest after Germany's in terms of purchasing power parity.

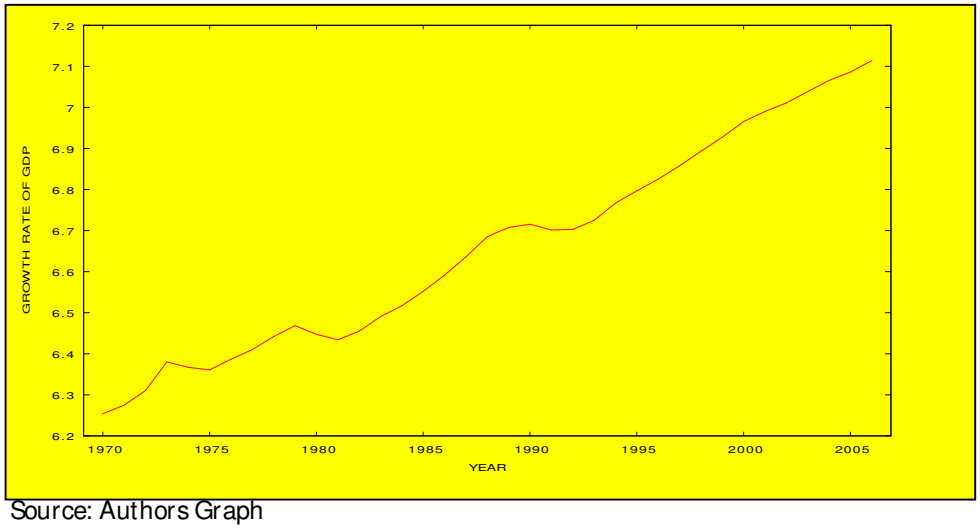
The UK was the first country in the world to industrialize in the 18th and 19th centuries, and for much of the 19th century had a major role in the global economy. However, by the late 19th century, the Second Industrial Revolution in the United States and the German Empire meant that they had begun to challenge Britain's role as the leader of the global economy. The extensive war efforts of World Wars 1 and 2 in

[4] Aryeetey, E. and A.K. Fosu, *Economic Growth in Ghana: 1960-2000*, Draft Chapter for AERC Growth Project Workshop, Cambridge 2002.
[5] Gross domestic product, 2008". World Bank. http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP.pdf.

the 20th century and the dismantling of the British Empire also weakened the UK economy in global terms, and by that time Britain had been overtaken by the United States as the chief player in the global economy. At the start of the 21st century however, the UK still maintains an important role in the global economy.

The British economy is substantially boosted by North Sea oil and gas reserves, worth an estimated £246.2 Billion in 2007. The British economy is made up of the economies of England, Scotland, Wales and Northern Ireland. The UK entered its worst recession since World War 2 in 2008, but has since climbed its way back into growth.

Figure 1.2 A cursory sketch of UK's growth Performance



Source: Authors Graph

From figure 1.2 the growth rate of GDP has been continually increasing from the 1970s. Even though decreases can be seen in between 1975 and 1980s and also between 1990 and 1995, average growth of GDP has been relatively high.

1.4 Objectives of the Study

The study will primarily aim at seeking answers to the following questions:

- Does the convergence hypothesis hold for Ghana? That is comparing Ghana with the Western European countries with UK as a proxy.
- How fast or slow Ghana is converging with the UK? This is done my investigating the returns to scale of Ghana's economy. We also ask further question; Is Ghana on a balanced growth path or not?
- What are the determinants of economic growth in Sectors (sectoral growth accounting)?

1.5 METHODOLOGY

1.5.1 Data Collection

Date used for this report are generally secondary data and were collected from sources such as the Institute of statistical Social and Economic Research (ISSER), Ghana Statistical Service, Ministry of Finance and economic planning, the International Monetary Fund (IMF), the Bank of Ghana, and others such as journals, articles, reports and other unpublished materials.

1.5.2 Stochastic Processes

The stationarity or otherwise of the data was tested for using the Augmented Dickey-Fuller (ADF) for unit root. This is because if a time series is nonstationarity, we can study its behavoiur only for the time period under consideration. Each set of time series data will therefore be for a particular episode. As a consequence, it is not possible to generalize it to other time periods. Therefore, for the purpose of forecasting, such (nonstationarity) series may be of little practical value. In order to discover the long-run relationships between the appropriate variables, a test for cointegration was conducted using Engle-Granger (EG) test and the number of cointegration vector was tested using Johansen test. The results of the data analyses and model diagnostic tests were done using SPSS, Gretl and Microsoft Excel.

1.5.3 Hypothesis Testing

The following hypotheses will be tested:

1. **H_0:** The convergence hypothesis holds for Ghana.
   H_1: The convergence hypothesis does not hold for Ghana

2. **H_0**: The growth model for Ghana exhibit constant return to scale
   (A balanced growth)
   H_1: The growth model for Ghana does not exhibit constant return to scale
   (An unbalanced growth)

3. **H_o**: A cointegration relationship in the growth model leading to Error Correction Model
   H_1: No cointegration relationship in the growth model

To test the hypothesis above, two functions are estimated. One for the convergence hypotheses and the other function focused on the possible factors that determine in sectors, the rate of growth of real GDP. In this case the factors were the Agriculture sector, the Service sector and the Industrial sector and AID. Using the aggregate production function model approach, growth equation was specified and estimated using ordinary least squares (OLS). The subsequent analytical tools are used: verbal explanation, regression models, tables, and graphs where suitable.

1.6 ORGANIZATION OF THE STUDY

The report is organized into six chapters.

Chapter one gives a general introduction and background to the study. In this chapter, the background to the study, research problem and the objectives and methodology of the report are discussed.

Chapter two presents a review of the relevant literature about the study. It will contain theoretical literature on growth and convergence and some empirical literature. The last section of chapter two reviews the various empirical studies on growth.

Chapter three is divided into two parts. The first part consists of the test of the convergence hypothesis and the second part presents it empirical results and analysis of the test.

Chapter four contains the results of the returns to scale. Whether or not the economy is exhibiting increasing, decreasing or constant returns to scale and what it means for the convergence hypothesis.

Chapter five also consists of two parts. The first part shows the long-run equilibrium relationship and its result and analysis and the second part shows the short run error correction model and its results and analysis

Chapter six is made up of the summary of finding, policy implications, recommendation, limitations and conclusions of the study.

CHAPTER TWO
LITERATURE REVIEW

The chapter is divided into two broad sections. The first section deals with the theoretical literature on growth and convergence. The second section deals with the empirical studies.

2.1 Theories of Economic Growth

Economic growth is defined as the growth in individual human welfare; on a practical level, a sustained increase in per capita or per worker product. We often use real per capita GDP as a proxy, not just total GDP, for measuring the rate of economic growth. Alternative measures include life expectancy, average levels of education, infant mortality and nutrition, all of which are related to individual welfare.[6] DeLorme et al (1983) defined economic growth as an increase in the full productive capacity of an economy to produce real output.[7] From this definition, economic growth would involve the process of increasing and humanizing the determinants of these productive capacities. According to Wallace (1988), the productive capacities are remarkably vital, but actual growth depends not on that, but also on the degree to which those capacities are utilized. Therefore, economic growth involves an increase over time in actual output of goods and services as well as an increase in the economy's capacity to produce goods and services.

Economist grasped the importance of economic growth centuries ago. The rate of economic growth was beginning to pick up speed 200 years ago, and the early economists were quit interested in how nations could become more wealthy and how standard of living could be raised. Various macroeconomist have contributed their quote towards the development of the study of economic growth. Notable among them are Adam Smith, Paul Romer, Robert Lucas, Robert Solow, Nicholas kaldor, Roy Harrod and Evsey Domar and many more. Some made theoretical contributions while other made empirical ones.

[6] Berg Hendrick V.D., Economic Growth and Development, International Edition, McGraw-Hill Company, 2001, p. 10-11
[7] Delorme C. D. Jr and Ekelund, R. B. Jr (998), *Macroeconomics*, Business Publications, INC, Texas

The main key points of Adam Smith growth theory made in his book the *Wealth of Nations* are that; specialization and exchange must increase if the economy is to grow; that markets where transactions are voluntary result in individuals and firms making decisions that are compatible with the 'general welfare'; that there is a close association between specialization and the generation of new technology and that the bottom line in judging the performance of an economy is human welfare throughout the entire population.[8] Adam smith also made note of institutions. By that he meant laws, norms, rules of just conduct etc.

Thomas Multhus also came through with his model. Multhus hypothesized that output is a function of labour and land, where the amount of land is fixed in quantity but labour can grow or contract depending on birth and death rates. He stated the production function Y= *f* (L, N), where Y is real output, L is labour and N is fixed arable land. Because labour is combined with a fixed stock of land, production is subject to diminishing returns[9]. This model of course has been widely criticized.

Joseph Schumpeter also came in with the idea of creative destruction[10] and competition as important factors to economic growth. Schumpeter's creative destruction generally assumed perfect competition and a fixed level of technology in order to focus on resource allocation. Again his idea of competition was that of ferocious competition among firms in the realm of technological competition and not price competition. The idea of creative destruction captures the concept of structural change which implies the substitution of new products for old ones, new jobs for old ones and new productions methods for what most people had come to view as the normal ways of doing things.

One growth model that was popular with economic planners just after the World War II was the Harrod-Domar model. The model makes two assumptions; that there is an unlimited amount of unemployed labour available; hence output can be increased without triggering price increases and that productive investment is always equal to

[8] Berg Hendrick V.D. op. Cit. p. 95
[9] As additional workers are employed, output increases by smaller and smaller amounts because each additional worker has less and less land to on.
[10] The processes in firms continually seek profits by means of gaining an advantage in the market place through innovation. As a result of creative activity, a firm destroys the monopoly power that its competitors had gained as a result of earlier innovations

saving. The model was formally presented in mathematical form[11] and concludes that, if we assumes a constant capital-output ratio so that we know how much capital we need for a given level of output, and if we save a constant proportion of the income generated by our production of output, then we can figure out exactly how fast we can increase our output. While this may be an interesting insight, the model is obviously unrealistic.

Romer (1989) suggests five stylized facts that growth theorists should be able to explain.

- In cross-section, the mean growth rate shows no variation with the level of per capita income.
- The rate of growth of factor inputs is not large enough to explain the rate of growth of output; that is, growth accounting always finds a residual.
- Growth in the volume of trade is positively correlated with growth in output.
- Population growth rates are negatively correlated with the level of income.
- Both skilled and unskilled workers tend to migrate towards high-income countries.[12]

As seen from the previous paragraphs, many have contributed to the economic growth theories throughout the years. But the model that has gained the widespread fame and has been the corner stone of most economic growth analysis is the Solow Model. Many economists felt that a much more sophisticated model was needed to accurately depict the complex process of economic growth. Yet almost half a century later, Solow's simple neoclassical model still dominates the economic growth literatures. The next section takes a closer look at the Solow Model and links it to the convergence hypothesis. The Solow's model has many aspects; however we shall concentrate on parts of the model that are relevant to our study.

2.2 Economic Growth and Convergence

Because Robert Solow used the 'marginalist' thinking of the 19th century neoclassical economist, his model is usually referred to as neoclassical growth model. The basic structure of the Solow model is quite simple. To differentiate his model from the

[11] $\Delta Y / Y = g_y = \sigma / \gamma$ where Y is output, g_y is growth of Y. This means that the rate at which the economy can grow is a constant, determined by the economy's rate of savings, σ, and the technical capital-output ratio, γ

[12] *Ibid*, p 405

Harrod-Domar model and its fixed capital-output ratio, Solow defined a production function that permits factors to be continuously substituted for each other. Such continuous substitution means that the marginal product of each factor are variable, depending on how much of the factor is already used in production and how many other factors it is combined with. This continuous substitutability of the factors of production is what makes Solow's model neoclassical in nature (*Hendrick Van den Berg, 2001*).

Solow furthermore assumed that each factor of production is subject to diminishing returns. That is, as equal increments of one factor are added to a fixed amount of the other factors of production, output increases, but it increases by ever-smaller amounts. This is not a radical assumption: Recall that 150 years earlier, Thomas Malthus had assumed that labour was subject to diminishing returns when it was combined with a fixed stock of agricultural land. Solow's aim was to show that the Harrod-Domar model was wrong in concluding that a constant rate of saving and investment could bring everlasting economic growth. Solow showed that, with diminishing returns, continuous investment could not, by itself, generate permanent economic growth because diminishing returns would eventually cause the gains in output from investment to approach zero. Solow's model thus clashed with what many development economist were advising policy makers to do in order to increase economic growth, which was to increase saving and investment any way possible. (*Hendrick Van den Berg, 2001*).

But if investment is not the determinants of an economy's long-run rate of growth, what is? Solow's identified that; long-run growth must come from another source: technological progress. Only if an economy keeps increasing the amount of output that it can produce from a given amount of input can it avoid diminishing returns and keep it per capita output growing forever. (*Hendrick Van den Berg, 2001*).

Solow begins with a production function in which, *Y*, is a function of quantity of capital, *K* and labour *L*:

$Y = f(K, L)$ ..... (2.1)

Solow assumed that this production function exhibits constant returns to scale, which means that if all inputs are increased by a certain multiple, output will increase by

exactly that same multiple. Specifically, if equation 2.1 represents a constant-returns-to scale production function, then for any positive constant *c* the following must also hold:

$cY = F(cK, cL)$……(2.2)

We now take advantage of this characteristics of constant-returns-to scale production functions and let $c = 1/L$, which give us

$Y/L = F(K/L, 1)$……(2.3)

Equation 2.3 can be conveniently rewritten as

$y=f(k)$……(2.4)

If we define Y/L and K/L as y and k, respectively, and let the function $f(k)$ represent $F(k, 1)$. Equation 2.4 describes output per worker as a function of capital per worker. This representation of the production function in per-worker terms is quite appropriate given that we define economic growth as the change in per capita output. In judging whether welfare in society increases, output per person must increase. In terms of the variables defined above, economic growth requires an increase in y, not just Y.

In addition to assuming constant returns to scale, Solow further assumed positive but diminishing marginal returns to any single inputs. That is the slope of output continuously decreases because each additional increase in K relative to L causes smaller and smaller output (see *Hendrick Van den Berg, 2001*). This is the inherent characteristics of the Solow model that brings convergence to light.

We have so far specified a neoclassical production function with the general form $Y=f(K, L)$, in which f represent the functional relationship between output and the inputs. But such a general form has its limitations. We can reach many useful qualitative conclusions, but specific quantitative solutions are not possible. To reach more specific quantitative conclusion, Solow applied the Cobb-Douglas production to his model. The Solow model also identified total factor productivity (TFP) as the key determinant of growth in the long run, but did not provide any explanation of what determines it. In the technical language used by macroeconomists, long-run growth in the Solow framework is determined by some other factors apart from capital and labour that is exogenous to the model. We shall explore this theoretically in the next section.

One major importance of the Solow's model is that, some economists have claimed it could predict the convergence of per capita income in the world. Generally,

convergence means that low-incomes economics should grow faster than high-income economics or that a process by which relatively poor countries or region grows faster than their rich counterparts (Mathur et al, 2005). The reason for the claim is that the lesser the capital the greater is the slope of the production function and the marginal productivity of capital and the more the capital the lesser is the slope of the production function and the marginal productivity of capital. Thus while lower income economics have lesser capital, marginal productivity of capital is high and that growth tends to be higher than higher income economics with more capital with lesser marginal productivity of capital.

Economists wonder if real economy convergence can actually be achieved only in a competitive market according to the neoclassical model. In this respect, extensive studies and models have been conducted. Considering the way the determinants and trends of real convergence are approached, the studies and models may be divided into three categories:

- The first one views real convergence as a natural process, based exclusively on the market forces, in accordance with which the convergence process is surer and faster as the market is larger, more functional, less distorted.
- The second one denies that, in the present competitive market, there is an actual real convergence between the poor and the rich countries, but accepts the existence of the tendency of polarization or deepening of the divergences and inequalities between the centre and the periphery.
- The third one considers that real convergence is necessary and possible in a competitive market, provided that economic policies are implemented to compensate for the negative effects of the inequalities or divergences, until the economic systems reach maturity or the so-called critical mass to support the self-sufficiency of the real convergence process.[13]

Convergence can be conditional (conditional beta convergence) or unconditional (unconditional beta convergence). Conditional convergence implies that a country or a region is converging to its own steady state while absolute convergence implies that all countries or regions are converging to a common steady state. A test for the absolute

[13] Aurel Lancu, *Real Convergence and Integration,* National institute for Economic Research, Romania, 2001 p.1

and conditional convergence mainly uses cross sectional data for a number of countries.

For the purpose of this study, we shall divert from the traditional cross-sectional approach and consider the time series approach between two countries (Ghana and UK). The time series approach also disintegrates convergence into two: catching up and long-run convergence. Further explanations to these two concepts are given in the next chapter. But the general idea is that, for there to be convergence between two countries, there must be no permanent shock between their levels of real GDP per capita. That is the difference of the real GDP per capita between these two countries should be stationary. See the next chapter for further explanation and references.

When convergence is established between these two economics, we can determine how fast or slow (rate of convergence) these economics converge. Even though with cross-sectional data, the rate of convergence can be easily computed (see Muthur K. Somesh, 2005), for time series the rate is not easily computed. We cannot put a numerical value as can be easily done with cross-sectional data.[14] But Jonathan Temple (1999) and Vasco M. Carvalho and Andrew C. Harvey (2005), stated that when the relatively poorer country is experiencing increasing or constant returns to scale, the rate of convergence is fast and when the poorer country is experiencing decreasing returns to scale the rate is slow.

Thus the Solow model has helped us to establish the foundations for testing the convergence hypothesis not only by using cross sectional data, but with time series data as well.

2.3 Growth Accounting Methodology

2.3.1 Theoretical literature on determinants of economic growth

We have noticed from the previous section that, the neo-classical Solow model explains economic growth as resulting from the combination of two elements, namely Capital and Labour. Now the question arises as to how much of the output growth can be attributed to other factors apart from capital and labour. To answer this question, Solow decomposes the growth in output into three components, each identifiable as

[14] The author intends to develop a formular in his further studies.

contribution of one factor of production, that is labour, capital and total factor productivity. This type of measurement of total factor productivity is still often referred to as the Solow residual. The term residual is appropriate because the estimate present the part of measured GDP growth that is not accounted for by the weighted-average measured growth of the factors of production (capital and labour). To account for this, Solow used the Cobb-Douglas production function and started from his simple growth equation. For simplicity, we repeat the equation as

$Y = f(A, L, K)$ ..... (2.5)

Where A = total factor productivity

L = labour

K = capital

Using Cobb-Douglas production function, Solow stated the following equation

$Y = AK^{\alpha}L^{1-\alpha}$ ..... (2.6)

From this, Solow defined his other factor (total factor productivity) to be technology as noted earlier. Solow acknowledged the convenience of the Cobb-Douglas production function because it exhibits constant returns to scale which is consistent with his model. We should note that the variable *A* is not constant but varies with different production functions based on the factors studied. Different authors have used different factors to account for the total factor productivity. In the following paragraph we review a few of these authors.

In accounting for the determinants of Morocco's economic growth, Mansouri (2005), used the aggregate production function model. He used the aggregate production of the following general form:

$Y = f(A, L, K)$ ..... (2.7)

where *Y* is real GDP, *A* is total factor productivity, and *L* and *K* stand for labour and capital inputs respectively. Mansouri (2005) argued that *A* is determined by economic factors. He argued that in the case of Morocco, *FDI and FDI interacted with trade openness (TR)* are the vehicle through which technology travels. Therefore, he wrote:

$A = g(FDI, FDI * TR)$ ..... (2.6)

Substituting (2.6) into (2.7), gives:

$Y_t = f(FDI_t, FDI_t * TR_t, L_t, K_t)$ ..... (2.7)

To account for the isolated impact of trade openness on economic growth, Mansouri (2005) introduced *TR* as an explanatory variable. To take into account of specificities of

the Moroccan economy, Mansouri accounted for the impact of drought cycles on economic growth in the particular case of Morocco. Mansouri finally added a proxy for drought (DR) to equation (2.7), to yield:

$$Y = G(FDI_t, TR_t, FDI_t * TR_t, L_t, K_t, DR_t) \quad \text{.....(2.8)}$$

where *DR* is a proxy for drought, is the inverse of the cereal yield per hectare. The operational model that was finally selected by Mansouri (2005) to explain Moroccan growth is:

$$\ln Y = \beta_0 + \beta_1 \ln FDI_t + \beta_2 \ln TR_t + \beta_3 \ln FDI_t * TR_t + \beta_4 \ln L + \beta_5 \ln K + \beta_6 \ln DR_t + \varepsilon_t \quad \text{.....(2.9)}$$

In accounting for the growth rate in Nepal, Khatiwada and Sharma use the growth accounting exercise which is normally conducted in terms of labour share and capital share in the output and the growth rates of other factors of the production function. The output growth not explained by these variables is treated as the contribution of TFP. They therefore started from the Cobb- Douglas production function

$$Y = AK^{\alpha} L^{(1-\alpha)} \quad \text{.....(2.10)}$$

For the empirical purpose and specificity to their model, they estimated the Cobb-Douglas production function in the following type

$$Y = e^{\delta} K^{\alpha} L^{(1-\alpha)} U \quad \text{.....(2.11)}$$

Where, Y = real GDP, δ = constant term (shift factor), L = labour force, K = real capital, U = random error term, and δ and α are the parameters to be estimated.

This equation assumes constant returns to scale as most empirical growth accounting studies have undertaken. A logarithmic transformation of the above equation would be:

$$\log Y = \delta + \alpha \log K + (1-\alpha) \log L + U \quad \text{.....(2.12)}$$

Subtracting log L from both sides, we get:

$$\log Y - \log L = \delta + \alpha \log K + (1-\alpha) \log L - \log L + U \quad \text{.....(2.13)}$$

$$\text{Or, } \log Y - \log L = \delta + \alpha \log K + \log L - \alpha \log L - \log L + U \quad \text{.....(2.14)}$$

Rearranging the equation, we get:

$$\log Y - \log L = \delta + \alpha (\log K - \log L) + U \quad \text{.....(2.15)}$$

$$\text{Or, } \log (Y/L) = \delta + \alpha \log (K/L) + U$$

The above equation is the estimating regression equation in log-level form. The estimating equation in growth rate form would be the following:

d log (Y/ L) = δ + α d log (K/ L) +U ……(2.16)

However, the output growth not explained by these two factors would be attributed to total factor productivity growth. Therefore,

$$_gTFP = {}_gY - \hat{\alpha} \times {}_gK - (1-\hat{\alpha}) \times {}_gL \quad \ldots\ldots(2.17)$$

where, $_gY$ = dlog(Y), $_gK$ =dlog (K) and $_gL$ = dlog (L), $\hat{\alpha}$ and 1-$\hat{\alpha}$ are the estimated values of capital and labour share in output (GDP) from the above Cobb-Douglas production function.

After estimating the TFP growth from the regression method, the study attempts to examine the determinants of the growth rate of TFP in Nepal during 1981-2000. The dependent variable is TFP growth and the explanatory variables are: rate of inflation, growth in public consumption, real exchange rate change, change in foreign exchange regime and a dummy variable to capture weather effects. Consequently, to estimate the determinants of TFP, the following regression equation was estimated:

$$dTFP = a_0 + a_1 P + a_2 dPC + a_3 dRER + a_4 dOP + a_5 Dummy + U \quad \ldots\ldots (2.18)$$

where *dTFP*= change in total factor productivity (derived from the equation estimated above), *dP* = change in price (rate of inflation), PC/ Y = public consumption as a ratio of GDP, dRER = change in real exchange rate (increase in the RER implies appreciation of the real exchange rate), and OP/ Y = trade openness as a ratio of GDP. Dummy is a dummy variable to capture the weather condition to reflect the weather dependency of agriculture. For bad monsoon years, the dummy value takes the value one and otherwise zero.

In accounting for the growth model of India changing economy in sector, Rubina et al, 2006, focuses on building a quantitative model which can replicate certain features specific to an economy undergoing economic growth and structural transformation. Rubine et al provided results using two different calibrations which use different shares of capital income in the economy and the three sectors – Agric, Service and Industry. The first simulation uses sectoral capital shares calibrated from the Indian Social Accounting Matrix (SAM) while the second simulation uses those provided by Brahmananda (1982). Under both simulations, Rubine et al found that the model fairs well in capturing the correct direction of change as the economy transforms from a situated Agric dominance of GDP to service dominance of GDP

Rubine et al estimated the following growth accounting equation starting from the Cobb-Douglas production function for aggregate output and output in the agric, industrial and service sectors as follows.

$$Y_{it} = A_{it} K_{it}^{\alpha_i} N_{it}^{1-\alpha_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.19)$$

Where A_{it} = (agriculture, industry, service) and Y_i is output, K_i is capital, N_i is labour and A_i is total factor productivity.

These and many more literatures follow Solow's application of Cobb-Douglas production function to determine the growth accounting model of various economics. This study thus follow similar methodology especially as one adopted by Mansouri 2005 and in furtherance to this, Rubine 2006, has showed that the various sectors of the economy can enter into the growth accounting model specification. We shall estimate the growth model for Ghana in the next two chapters.

2.4 Empirical Literature

2.4.1 Empirical Literature: Convergence

In the last decade, a vast literature has gone into investigating the convergence hypothesis (Barro and Sala-i-Martin, 1992; Mankiw, Romer and Weil, 1992).

The results from the convergence literature are interesting for a variety of reasons. Most importantly, the literature finds that conditional convergence is a strong empirical regularity, indicating that the data is consistent with the neoclassical theory based on diminishing returns. This was the initial and most widespread interpretation. These empirical results also mean that the simple closed-economy, one-sector model of endogenous growth is easily rejected by the data. However, more sophisticated models of endogenous growth that display transitional dynamics are also consistent with the convergence hypothesis (Sala-i-Martin, 2002).

It is common to read that the rate of convergence between countries and region is about 2% a year[15]. But according to Temple, 1999, this value is mostly gained from cross-sectional data regression and the associated data problems cannot be ignored completely.

[15]Temple, J. (1999), The New Growth Evidence, Journal of Economic Literature, Vol. 37, No. 1., pp. 134

The consensus now emerging is one of uncertainty. It is just not very easy to disentangle the convergence results from other aspects of growth. Arguably, this is not surprising since conditional convergence implies mean reversion and so there is a close link between investigating convergence and testing for unit roots.[16]

Walliam Baumol (1986) argues that convergence has shown itself strongly in the growth of industrial nations since 1870. According to Baumol, those nations positioned to industrialized are much closer together in productivity now than a century ago. He bases this conclusion on a regression of growth since 1870 on 1870 productivity for sixteen industrialized countries and found the ß value to be -0.995 suggesting an almost complete convergence for these groups of countries.

De-Long (1988) however showed that Baumol's finding is largely spurious. De-Long, identified two problems with Baumol's model. The first problem he identified is sample selection and the second is measurement error. In the first place countries that were not rich a hundred years ago are typically in the sample only if they grew rapidly over the next hundred years. Countries that were rich hundred years ago in contrast, are generally included even if their subsequent growth was only moderate. Because of this, we are likely to see poorer countries growing faster than richer ones in the sample of countries he considered. Secondly De-Long states the problem of measurement error but does not give a clear example of where the error might result. He only sates that estimates of real GDP per capita in the 1870 were not correct as statistical tools had not been developed widely at that time. Thus When 1870 income is overstated, growth over the period is understated by an equal amount; when 1870 income is understated, the reverse occurs.

Barro (1991) in his first empirical work on growth showed that if differences in the initial levels of human capital (along with some other pertinent variables) are controlled for, then the correlation between the initial level of income and subsequent growth rate turn out to be negative even in a wider sample of countries. An early hypothesis proposed by economic historians such as Aleksandra Gershenkron (1952) and Moses Abramowitz (1986) was that at least under certain conditions, '' backward''

[16] Ibid, pp. 134

country would tend to grow faster than the rich ones, in order to close the gap between the two groups.[17]

Polanec (2004) using data on twenty-five transition economics from 1990 to 1994 found evidence against the absolute convergence hypothesis. Polanec found that real GDP growth is positively related to the initial GDP at 10% significance level. However, using data from 1994 to 1998, he found a negative relationship and using data from 1998 to 2002 he again found a negative relationship between initial level of GDP and productivity growth and statistically significance at 5% significance level.

In testing for conditional convergence hypothesis among the EU, EA and South Asia (SA) region, Mathus found that the coefficient of initial level of log GDP (α_1) to be negative and significant across almost all regression equations. Such results suggest evidence in favour of conditional convergence among EU, EA and South Asia (SA) regions together. Mathus calculated the speed of conditional convergence to range from 0.26% to 1.82% annually.

Working on time series convergence, Les Oxley, 1995, rejected the hypothesis of convergence in the cross-country difference between Canada and Australia using data set from 1870-1992. But Oxley acknowledge the likelihood of structural discontinuities in the Canadian and Australian growth records. Interestingly, the British and Australian economics appear to have convergence during the century following the discontinuity associated with the 1891 Australian crash. Oxley stated that, whether or not the failure of time series approach to typically identify convergence stems more widely from discontinuities in the process and that can be assessed by applying Zivot and Andrew's search procedure to the comparative series.

Manuel G. and Daniel Ventosa S., (2007) found convergence among Mexican regions from 1940 – 2003. Even though different regions were considered, Manuel and Daniel used time series approach and thus used the difference approached for two regions at a time. In all, Manuel and Daniel worked on 30 regions with special interest given to the post liberalization period. They found evidence that supports the hypothesis that trade reforms reversed the convergence process of some regions, especially those less

[17] Adu George, *Economic growth in Ghana: Convergence and Determinants*, 2006. pp. 34

developed. Results further suggest that trade liberalization did not contribute to per capita income convergence between the U.S. and Mexico border regions.

2.4.2 Empirical Literature on the Determinants of Economic Growth

Capolupo and Celi (2005) present evidence of the relationship between trade-openness and growth in the sample of former communist countries before and after the transition from a central planned economy (CPE) to a market economy by applying standard OLS and panel estimation techniques. The main finding is that during the transition the importance of openness on growth per capita has increased sharply by changing the coefficient from a negative sign to a positive and significant one. The result seems to be robust to (i) estimation methods, (ii) different measures of openness adopted and (iii) consistent with the integration view, which states that a higher degree of trade openness spurred by market incentives and comparative advantages enhances the per capita growth rate of economies. Capolupo and Celi identify GDP per capita, the share of total gross investment in GDP and government expenditures. Capolupo and Celi found the estimated coefficient of the log of real investment to GDP to be positive, the openness variable has a negative coefficient, the coefficient of government consumption to GDP was also found to be negative and the relationship between population growth and real GDP growth was also found to be negative.

Obwona finds all the coefficients to have the right sign in estimating the growth model for Uganda. The coefficient of FDI and savings, trade accounts balance, inflation rate, government expenditure, rate of growth of real export all had the right sign and statistically significant at 5% level of significance.

Accounting for Ghana's growth, Aryeetey and Fosu (2005), used the aggregate production function model of growth accounting. They used Cobb-Douglas production function in formulating their model. The results of their estimation indicate that most of GDP growth seems to be accounted for by factors outside the model. Their results show that the only significant variable is the economic liberalization dummy variable which has a positive coefficient. Labour has negative coefficient, though not statistically different from zero. The capital variable has a positive coefficient though it's not statistically significant. The results suggest that total factor productivity may have played a more important role in the observed pattern of GDP growth, and that total

factor productivity is affected by political regimes. In particular, liberal regimes apparently positively contribute to total factor productivity and to growth in Ghana.

This study follows Oxley Les (1995) approach to the study of convergence hypothesis. However, in accounting for Ghana's economic growth the study uses the aggregate production function approach as has been used by Mansouri's (2005) and Rubina Verma (2006) approach, taking the Ghanaian specificities into account.

2.5 Literature on Statistical Methods

Different authors use similar methodology for testing convergence using cross sectional data. The commonest methodology is regressing the Log of per capita GDP on real GDP per capita. For conditional convergence, different variable are defined based on the group of countries chosen.

Even though the methodology for cross sectional data is somewhat different, authors testing convergence using time series uses almost the same method regardless of the countries in study. The basic statisitical methodology employed is that of Augmented Dickey Fuller (ADF) type tests. With these tests, we analyze the stationarity properties of the logarithm differences of real per capita income between two given economies; see for example, Li and Papell (1999), Lee, Lim, and Azali (2005), Oxley and Greasley (1995), Barossi-Filho and M. Carlos R. A., Manuel G. and Ventosa-Santaul`aria D. amongst others.

Testing for unit-roots can be difficult for three reasons. First, it is difficult to distinguish a unit-root process from a near unit-root process. Second, the presence of deterministic variables affects the test results. Third, the presence of structural breaks can bias the test results toward a non–rejection of the unit roots (Richard Kane 2001). The Dickey-Fuller test assumes that the errors are statistically independent and with constant variance. Although the Augmented Dickey-Fuller test can deal with correlated errors, the Phillips-Perron test has greater power so long as the true data-generating process is one of positive moving-average terms (Enders 1995), which is not always the case. Thus many author stick to the ADF test for unit root. We also stick to the ADF test and do not consider discontinuity of the data as it is beyond the scope of this study.

In accounting for agriculture export modeling in Nigeria, Nkange, Abang, Akpan and Offem used a cointegration and error correction mechanism method to ascertain the long and short run relationship in the face of the trending down of the growth of cocoa output over time. The results reveal that the error correction mechanism (ECM) shows any disequibria away from the long-run steady state equilibrium of cocoa exports is corrected within one year. Specifically, the speed at which cocoa export supply adjusts to changes in real producer price, trading partners' income and lagged cocoa export supply in an effort to achieve long-run static equilibrium is 78.75%. In the short-run, real cocoa producer price has significant but negative effect on cocoa export supply. However, in the long-run, the effect of real producer price on cocoa export supply is significant, positive and inelastic.

Sushil et al employed Johansen's cointegration and error correction model when writing on the economic growth in India. He found that human capital investment plays a crucial role both in the long run as well as in the short run. The export-led growth hypothesis is partially valid whereas the physical capital investment-led growth appears to be insignificant in our findings. Sushil assumed one cointegrating vector from the Johansen's test conducted and used the AIC and SIC method to determine the lag length. This study again follows the methodology of the above literature.

CHAPTER THREE
CONVERGENCE HYPOTHESIS

3.1 A test for the Convergence hypothesis

Most test of the convergence hypothesis utilizes cross-sectional data and report convergence for the industrial economies (normally defined to include Australia, Canada, the UK and USA). See Les Oxley (1995). Outside the industrial world convergence countries, there appear fewer tendencies for per capita income difference to narrow. Although diminishing returns provide a simple economic underpinning for the convergence hypothesis, Barro and Sala i Martin (1992) and Mankiw, Romer and Weil (1992) argue investment in human capital might reduce the tendency for returns to diminish. Their perspective suggests convergence may be prolonged, which might help macroeconomics experience. Alternately doubts have grown around the ability of cross-sectional test to distinguish convergence. In particular, Bernard and Durlauf (1994), identify inconsistencies between cross-sectional and time series tests, favoring time series methods for pure tests of convergence hypothesis. Suing such test, Bernard (1992) and Bernard and Durlauf (1993) reject convergence, even among industrial economics.[18]

Les Oxley et al (1995) deployed time series unit root test to consider the convergence in GDP per capita between Australia, Canada, the UK and USA during the period 1970-1992, and pays particular attention to the experiences of the two British dominions. While both Canada and Australia had close and complimentary links with the UK, shaped by trade, investment and migration during the century after 1870, Canada's economics links to the USA were also strong.

The economic underpinnings of the convergence hypothesis arise naturally within the standard Solow neoclassical diminishing returns growth model as noted earlier on in the previous chapter. Differences in initial endowments are seen to have no long term effects on growth with deficient countries able to catch-up to the leaders who suffer from diminishing returns. As such, not only are tests of convergence interesting in their own right, but they emerge as one natural testable implication of alternative models of growth. However, convergence is but one implication of such models and does not in

[18] In Zerger, A. Argent, R.M. (eds) MODSIM 2005 International Congress on Modelling and Simulation. Modelling and Simulation Society and New Zealand, December 2005, pp 77

itself represent a full test of the competing approaches. In order to test for convergence some form of clear definition and some appropriate form of time series data are required.

The time series approach developed by Bernard and Durlauf (1994) gives rise to two definitions of the convergence hypothesis, one associated with long run convergence and the other with Catching up.

3.1.0 Catching Up

Consider two countries *a* and *b*, and denotes their log per capita real output as Y_a and Y_b. Catching-up implies the absence of a unit root in their difference $Y_a - Y_b$. This concept of convergence relates to economics out of long run equilibrium over a fixed interval of time, but assumes that they are sufficiently similar to make a test of the hypothesis important. In this case catching-up relates to the tendency for the difference in per capita output to narrow over time. Hence non-stationarity in $Y_a - Y_b$ must violate the preposition although the occurrence of a non-zero time trend in the deterministic process in itself would not.

3.1.1 Long-run Convergence

Consider two countries *a* and *b,* and denotes their log per capita real output as Y_a and Y_b. Long-run convergence implies the absence of unit in their difference $Y_a - Y_b$ and the absence of a time trend in the deterministic process. The existence of a time trend in the stationary $Y_a - Y_b$ series would imply a narrowing of the (log per capita output) gap or simply that the countries though catching-up had not yet converged. This catching-up could be oscillatory, but must imply non divergence of output differences. Conversely, the absence of time trend in the stationary series implies that catching-up has been completed (Les Oxley 1995).

Clearly long run convergence and catching up are related in that both imply stationarity $Y_a - Y_b$. In either case, output shocks in one country have only transitory effects and are transmitted to the other such that outputs disparities do not persist i.e. are stationary. This is because there is the general idea that in the 'leading country', one may suppose that the capital embodied in each vintage of its stock was at its highest point in terms of productivity at the time of investment. The capital age of the stock is, so to speak, the

same as its chronological age. On the contrary, in the backward country where productivity level is lower, the capital age of the stock is high relative to its chronological age. Therefore when the leader discards old stock and replace it, the accompanying productivity increase is governed and limited by the advanced of knowledge between the time when the old capital was installed and the time it is replaced. The marginal productivity of capital thus falls. Those who are behind, however have the potential to make a larger leap, because capital transferred to these economics have higher marginal productivity. As no permanent shock is present between the two economics and capital continue to be transferred, output difference may not occur or even if it occurs, it does so on a very small scale. Followers tend to catch up faster (Moses Abramovitz, 1968).

To test the convergence hypothesis the classical convergence approach consists of fitting cross-country regressions as noted earlier, relating the average growth rate of per capita income over some time period to initial per capita income and country characteristics (Barro and Sala-i- Martin (1992). Then, convergence is said to hold if a negative correlation is found between the average growth rate and the initial income. Friedman (1992) and Quah (1993) criticize cross-country growth regression on the basis of Galton's fallacy and Quah (1996) shows that the cross-sectional result of speed of convergence is a statistical illusion. An alternative approach for testing convergence hypothesis is using time series econometric methods and focusing on direct evaluation of the persistence of transitivity of per capita income differences between economies (see Bernard and Durlauf (1995, 1996), Carlino and Mills (1993), Evans (1996), Evans and Karras (1996), Li and Papel (1999) for different applications of this approach).

According this method, tests for convergence require cross-country per capita output differences to be stationary and non stationary difference is symptom of divergence. In the case of two economies, this definition of convergence is relatively unambiguous, but in the case of more than two economies, this is not so clear. In a multi-country situation, some researchers have taken deviations from a reference economy as the measure of convergence (In most case, the richer or the more developed country of the group is chosen as reference country (Oxley and Greasley (1999)). Other researchers have taken deviations from the sample average (Carlino and mills (1993, Ben David (1996)). To test the stationarity or otherwise of a set of data to establish convergence

hypothesis, the method of unit root test is utilized. However, given the time span and the limit of the available data, there is much evidence that method of testing the unit root hypothesis, such as the Augmented Dickey Fuller (ADF) test, though using for time series convergence test, have serious power problems. One of the solutions for this problem is "increasing the sample size". Since the power of any test depends on the available information (sample size) and as Evans 1996) suggests, "exploiting both the time series and the cross section information included in the data of the per capita income is necessary to evaluate the convergence hypothesis", extra information for improving the performance of the unit root tests, can be gained by using panel data, i.e. by combining time series and cross sectional observations (Ranjpour Reza and Karimi Takanlou Zahra, 2008). Because of the usefulness of the ADF test to time series test of convergence and to this study, we give a brief description of it in the next section and build on it.

3.2 A Brief Overview of Unit Root Tests

In conducting a Dickey-Fuller test for stationarity, it is assumed that the error terms are uncorrelated.[19] But in case the error terms are correlated, Dickey and Fuller have developed another test, known as the Augmented Dickey-Fuller (ADF) test. This test is conducted by 'augmenting' the three equation of the Dickey-Fuller test (that is random walk equation, random walk with drift equation and random walk with drift and around a deterministic trend equation) by adding the lagged values of the dependent variable. To be specific, supposed we have

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \mu_t \quad \text{..... (3.1)}$$

The ADF test here consists of estimating the following regression.

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + \varepsilon_t \quad \text{..... (3.2)}$$

Where ε_t is pure white noise error term and where $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc. The number of lagged difference terms to include is often determined empirically, the idea being to include enough term so that the error term in Equation 3.2 is serially uncorrelated, so that we can obtain an unbiased estimate of δ, the coefficient of lagged

[19] Gujarati N.D and Porter D.C, *Basic Econometrics Fifth Edition*, McGraw-Hill Companies, United States, pp.757

$Y_{t-1.}$ In ADF test we still test whether δ = o and the ADF test follows the same asymptotic distribution as the DF statistics, so the same critical values can be used.[20]

3.3 Methodology for testing

The basic methodology employed is that of Augmented Dickey-Fuller (ADF) type test. With this test, we analyze the stationarity properties of the logarithm differences of real per capita output between two given economies; see for example, Manuel G´omez and Daniel Ventosa-Santaul`aria (2007), Oxley and Greasley (1995), and Ranjpour Reza and Karimi Takanlou Zahra (2008), amongst others. The convergence hypothesis can be studied using this approach by estimating the following basic model:

$$\Delta\left(y_{it}-y_{jt}\right)=\mu+\alpha\left(y_{i,t-1}-y_{j,t-1}\right)+\beta t+\sum_{k=1}^{n}\delta_t\Delta\left(y_{i,t-k}-y_{j,t-k}\right)+\varepsilon_t \quad \text{(3.3)}$$

Where the variable $(y_{i,t} - y_{j,t})$ is the logarithmic difference in per capita output between economies *i* and *j* in period t, and t is a deterministic trend. If the difference between the output series contain a unit root, $\alpha=1$, output per capita in the two economics will not converge. Because, for $y_{i,t}$ *converge to* $y_{j,t}$, it must be that $(y_{i,t} - y_{j,t})$ contains only nonpermanent shocks. This implies that the deviations of $y_{i,t}$ *and* $y_{j,t}$ will vanish in the long-run and the simplest case of non-persistence of shocks consists of $(y_{i,t} - y_{j,t})$ being an I(0) series. The absence of a unit root, $\alpha< 1$ indicates either catching-up, if $\beta \neq 0$ or long run convergence if $\beta = 0$. However it must be noted that there are some reservation surrounding the robustness of unit root test in general and therefore their application to test of convergence in particular.

3.4 Definition of Variables used in the test of Convergence in the operational Model for Ghana and UK

The convergence hypothesis seeks to test the convergence of Ghana's economic growth rate and that of Western European countries economics growth rate. Since data is not available for all countries, the report takes the UK as a proxy for all Western European countries. The variables used in the convergence hypothesis and growth model are explained below:

Gross Domestic Product per capita is the value of all final goods and services produced within a nation in a given year divided by the average (or mid-year) population for the

[20] *Ibid*, pp 757

same year or an approximation of the value of goods produced per person in the country, equal to the country's GDP divided by the total number of people in the country. Both the GDP per capita of Ghana and UK are measured in US dollars.

3.5 Model Specification

Model I: Convergence Hypothesis for Ghana and UK

To test the convergence hypothesis for Ghana and UK using time series data, we follow, Manuel G´omez and Daniel Ventosa-Santaul`aria (2007), Ranjpour Reza and Karimi Takanlou Zahra (2008) and Oxley and Greasley (1995) methodology of testing the unit root with time trend in the following equation with two countries specified as Ghana and the UK. The natural route for such tests involves Augmented Dickey Fuller type test based on the difference in log per capita output between pairs of countries United Kingdom (UK) and Ghana (GH), i.e.

The equation is specified below,

$$\Delta(GDP_{UK,t} - GDP_{GH,t}) = \mu + \alpha(GDP_{UK,t-1} - GDP_{GH,t-1}) + \beta t + \sum_{K=1}^{n} \delta_K \Delta(GDP_{UK,t-K} - GDP_{GH,t-K}) + \varepsilon_t \text{.....(3.4)}$$

Where $GDP_{UK,t}$ = the log of per capita output for UK

$GDP_{GH,t}$ = the log of per capita output for Ghana

μ = the constant term which has no real significance in this test as suggested by other authors.

As noted above, testing convergence hypothesis comes to testing whether the series $(GDP_{UK,t} - GDP_{GH,t})$, for two countries exhibit or not a unit root (Evans and Karras (1996)). For convergence hypothesis to hold for both economics, the difference between the log of GDP for UK and Ghana must not contain unit root, that is $\alpha<1$. If the difference contain unit root, that is $\alpha=1$ the two economics diverge. The absence of unit root indicates either catching up, if $\beta \neq 0$, or long-run convergence if $\beta=0$.

We use the Akaike Information Criterion and Schwarz Information criterion to determinate the lag length *n* for $\sum_{K=1}^{n} \Delta(GDP_{UK,t-K} - GDP_{GH,t-K})$. By doing this, we chose a maximum lag length of ten (10) and run different regressions. We will then choose the lag length with the lowest AIC and SIC values.

3.6 EMPIRICAL RESULTS AND ANALYSIS

This section presents and discusses the results of the study.

3.6.0 The result of the Convergence model

To test this hypothesis, the stationarity or otherwise of the difference of the log of GDP per capita for both countries (Ghana and UK) is tested. But before the test, the lag lengths need to be determined. We use AIC and SIC methods for determining the lag length and the result is displayed below

Table 3.0 Result of the AIC and SIC values

Lag Length	AIC Value	SIC Value
1	85.1086	92.3353
2	84.94605	92.0973
3	83.1602	90.205
4	81.3287	88.2794
5	80.7657	87.6200
6	79.3336	86.0891
7	78.6472	85.3015
8	77.4980	84.0484
9	76.2520***	82.6957***
10	76.386	82.7957

*** indicate lowest AIC and SIC value

The rule of thumb for choosing the lag length is that the lag with the smallest AIC and SIC value should be chosen. From the table, the lag with the smallest AIC and SIC value is 9, that is has the AIC value of 76.2520 and SIC value of 82.6957. We therefore use 9 lag lengths in the test of the convergence hypothesis. We go on to test the stationarity or otherwise of the data using the Augmented-Dickey Fuller (ADF) test. The result of the ADF test is shown below

Table 3.1 The Result ADF Unit root test (Ho: Unit root)

Countries	Year	Time Trend
UK-Ghana	1960-2006	-5.3822***

***(***) denotes significance at 5% level of significance

This section reports the pairwise test for long run convergence and catching-up. The result of the ADF test shows that the difference of log of GDP per capita for both Ghana and UK is stationary as their reported tau values are more negative. The critical values given in the appendix - Table 1 - at 5% level of significance, is -3.19. The ADF test states that if the computed tau value is more negative, we reject the null of unit root and accept the null no unit root. Before the implication of this result is given, we confirm our results by using the Dickey-Fuller regression for testing unit root and time trend.

Table 3.2 The result of Dickey Fuller regression with time trend

Null hypothesis H_o : there is unit root $\delta = 1$

H_1 : there is no unit root $\delta < 1$

Dependent Variable = ΔGAP_t

Variables	Co-efficient	Std Error	t-stat
Constant	0.5074	0.3172	1.600
GAP_{t-1}	-0.0403	0.1734	-5.998***
Bt	-2.0120	0.0010	-2.191***
GAP_{t-9}	0.9685	0.1162	0.589

***(***) denotes statistically significant at 5% level of significance

On the basis of the results in table 4.2.1 on equation 3.4, for the periods 1970-2006, both version of the convergence hypothesis receives support, since a unit root can be rejected in the cross-country difference in GDP per capita. The tau value of the lagged coefficient is 8.3348 which is greater than the critical value of 3.61 suggesting that the log of the difference between both countries are stationary.

The pairwise results reject the existence of a unit root in some variant of the model and are supportive of the convergence hypothesis. The absence of the unit root point to the concept of catching up. This concept of convergence relates to economics out of long

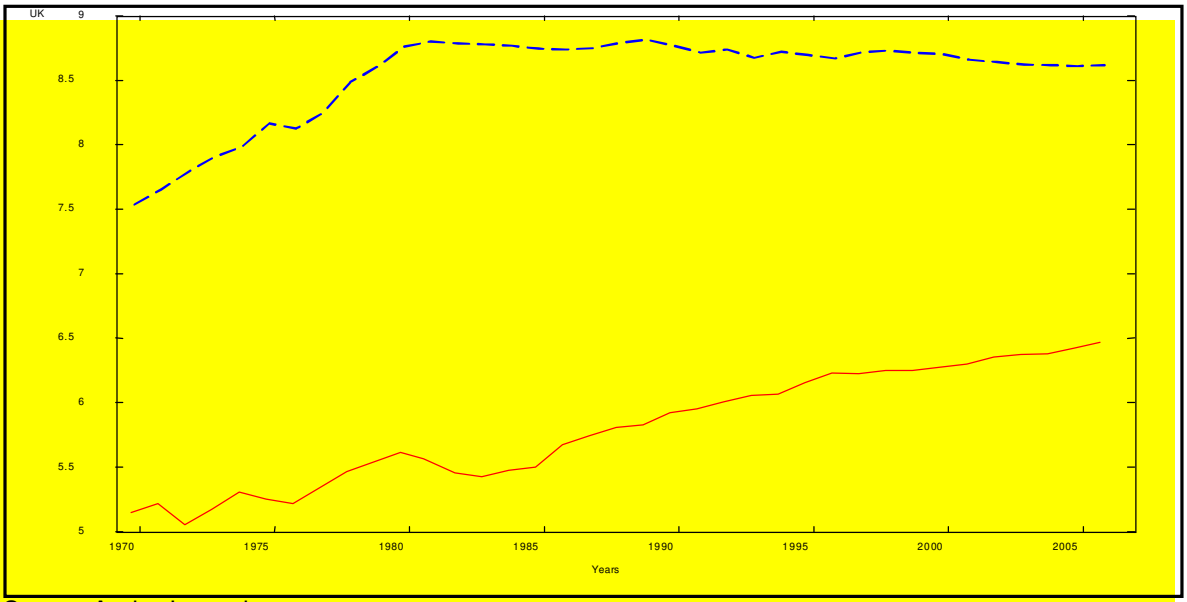
run equilibrium over a fixed interval of time. In this case, the result indicates that the difference in per capita output between UK and Ghana narrows over times.

Again from the table, the deterministic time trend value of -2.0120 is statistically significant at 5% level of significance. This indicates that the deterministic time trend is statistically different from zero. This therefore does not accept the concept of long-run convergence. That is the existence of time trend in the stationary series imply a narrowing of the log of per capita output gap or simply that though Ghana is catching-up with the UK in term of growth in GDP per capita, both had not yet converged and this convergence is oscillatory.

In either case, output shocks in the UK have only transitory effects and are transmitted to Ghana such that output disparities do not persist - are stationary. However long run convergence relate to similar economics in the long-run equilibrium. It is therefore not surprising that the results did not support the concept because of the non-similar nature of the UK and Ghanaian economics.

The above results can be verified by plotting a graph of log of Real GDP per capita for both the Ghanaian and the UK economy. Figure 3.1 shows such graph.

Figure 3.1 A cursory sketch of UK's and Ghana's Real GDP percapita from 1970 to 2006



Source: Author's graph

From figure 3.1, we notice convergence between the two economics especially from the 1980s. While UK's real GDP per capita value decreased continuously but marginally, from 1980s to 2006, Ghana's real GDP per capita increased continuously during the same period. The gap between the two economics seems to narrow even though it is relatively larger. This supports the view of catching up, thus Ghana is catching up with the UK. However, long run convergence has not been reach as suggested by the analyses made before.

Because of the movement of capital/technology across countries generally, we lay emphasizes on marginal productivity of capital between these countries as accounting for the convergence as noted earlier on. However we do so with much pessimism as other factors come in play. First, technological backwardness is not usually a mere accident. Tenacious societal characteristics normally account for a portion, perhaps a substantial portion, of a country's past failure to achieve as high a level of productivity as economically more advanced countries. The same deficiencies, perhaps in attenuated form, normally remain to keep a backward country from making the full technological leap envisaged by the simple hypothesis. Moses Abramotizv has a name for these characteristics. He calls them "social capability." One can summarize the matter in this way. Having regard to technological backwardness alone leads to the simple hypothesis about catch-up and convergence already advanced. Having regard to social capability, however, we expect that the developments anticipated by that hypothesis will be clearly displayed in cross-country. One should say, therefore, that a country's potential for rapid growth is strong not when it is backward without qualification, but rather when it is technologically backward but socially advanced (Moses Abramotivz 1986).

This to some extent can explain Ghana's rise from the 1980s (refer to figure 3.1) and the accelerated catch up experience between 1980 -2006. This is because; Ghana has increased her social capacity in so many ways. Ensuring political stability, improving levels of literacy, ensuring democracy, fighting corruption, improving on her legal system, improvements on institutional arrangements and many more are examples of the social capacity Ghana has improved on even though there is still much more needed to be done.

Other definition of catch up includes loose catch up i.e. two economics are catching up rapidly. We can investigate how rapid Ghana is catching up with the UK. This can be done by investigating the return to scale of Ghana's production function or growth model. Recall we stated earlier on in the previous chapter that, if the growth exhibit an increasing returns to scale or constant return to scale, then there is a possibility of loose catching up (faster catch up) . On the other hand if the growth model exhibit decreasing returns to scale, there is still catching up but at a relatively slower pace. Knowing this will help the government of ascertain the growth situation of the economy (balanced growth or unbalanced growth) and help put together an effective economic policy that will affect the various components in an effective way to ensure quick long run convergence.

CHAPTER FOUR

4.1 THE GROWTH MODEL SPECIFICATION (CONSTANT, INCREASING OR DECREASING RETUNRS TO SCALE)

In this chapter, we test the return to scale of Ghana's growth model to ascertain how fast or slow Ghana is converging with the UK. We also explore the same option to check whether or not the Ghanaian economy is on the balanced growth path.

This study makes use of the macroeconomics and development economist definition of balanced growth. In macroeconomics, balanced growth occurs when output and the capital stock grow at the same rate. In development economics, balanced growth refers to the simultaneous, coordinated expansion of several sectors of the economy (Temple J. 2005). The usual arguments for this development strategy rely on scale economies, so that the productivity and profitability of individual firms may depend on market size. The existence of a balanced growth path requires strong assumptions. The usual derivation assumes that aggregate output can be written as a function of the total inputs of capital and labour, with diminishing returns to each input and constant returns to scale overall. In addition to the conditions needed for aggregation, either the production function should be Cobb-Douglas, or technical progress should be restricted to the labour-augmenting type. In other words, when technology advances, it should be "as if" the economy had more labour than before, and not "as if" it had more capital.[21]

4.2 Growth Accounting for Ghana

As noted earlier in chapter two, growth accounting provides a framework for allocating changes in a country's observed output into the contributions from changes in its factor inputs—capital and labour—and a residual(s), typically called total factor productivity.

This approach is based on a production function in which output is a function of capital, labour, and a term for total factor productivity. As discussed in more detail in chapter two, we essentially assume a Cobb-Douglas production function with fixed factor shares: $Y = AK^{\alpha}L^{1-\alpha}$, where *Y, A, K,* and *L* are measures of output, total factor productivity, physical capital services and Labour's share of income respectively.

[21] Jonathan Temple, *Balanced Growth*, Department of Economics, University of Bristol, 2005,p.2

Various authors have included various variables to make up for the total factor productivity. In this study, we use the Agriculture, Industrial and Service sectors and AID to constitute total factor productivity. This is because; we have observed recently that there has been an increase in the service sector growth to national output more than the industrial sector. Smooth structural change should have been an increase in the industrial sector, followed by the service sector, but this has not happened. We shall therefore investigate the long run and short run effects of such increase on GDP. This will do in the next chapter. But in the meantime, we shall use the same variable set to identify the returns to scale position of the Ghanaian economy. The study will include one more variable – AID- to ascertain the long and short run effect on GDP.

Growth accounting in sectoral terms' is not a new idea. Earlier on in chapter two, we found that Rubina Verma (2006) followed the same sectoral growth accounting methodology. Barry Bosworth and Susan M. Collins (2008) used such variable (Agric, Service and Industry) when accounting and comparing the growth of China and India. Nicholas Oulton (1999) used the estimate of TFP growth derived by O'Mahany (1999) for ten sectors covering the whole UK economy for the period 1973-95 when writing on the structural change for the UK growth for the same period. Others include Bart Van Ark (1995), (1999) and Robert Dekle and Guillaume Vandenbroucke (2006).

In line with this study, we also follow the sectoral growth accounting methodology in accounting for Ghana's growth model. Having justified the usage of these variables, we add one more variable – AID- and define these variables in the next section.

4.3 Definition of Variables for Ghana's Growth Model

This variables used in Ghana's growth model are defined below;

Labourforce (L) comprises people who are economically active according to the ILO[22]. That is people who supply labour for the production of goods and services during a specified period. It includes both the employed and the unemployed. Normally, the labourforce of a country consists of everyone of working age who are participating workers, that is people actively employed or seeking employment. Data for labour is provided by the Ghana statistical service.

[22] The ILO was founded in 1919, in the wake of a destructive war, to pursue a vision based on the premise that universal, lasting peace can be established only if it is based upon decent treatment of working people. The ILO became the first specialized agency of the UN in 1946.

Gross fixed capital formation (K) is defined as the total value of additions to fixed assets by resident producer enterprises, *less disposals* of fixed assets during the year, *plus* additions to the value of non-produced assets such as discoveries of mineral deposits, or land improvements, plant, machinery, and equipment purchases; and the construction of infrastructure and commercial and industrial buildings. This variable is used as a proxy for the capital stock. The data is provided in dollar terms.

Agric (AGR), measured as the share of the Agric sector to real GDP. The agricultural sector dominates the economy with the largest share in the country's GDP. The sector also employs the largest proportion of Ghana's economically active population. Key activities in the sector are food cropping and livestock, cocoa production and marketing; forestry and logging; and fishing.

Industry (IND), measured as the share of the industrial sector to GDP. Industry here conforms to the classification given by the ISIC[23] which is Rev.4 from B05-F43[24]. It comprises value added in mining, manufacturing and constructions. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs.

Service (SER) measures as the share of the Service sector to GDP. This is the fastest growing sector and contributes about 24.3%. It is the most diversified, made up of wholesale & retail trade; restaurants & hotels; infrastructure services; financial services; community, social & personal services, as well as private non-profit services. But wholesale and retail trade dominates this sector.

Aid includes both official development assistance (ODA) and official aid. Ratios are computed using values in U.S. dollars converted at official exchange rates.

[23] ISIC stands for International Standard Industry Classification and the main function of the division is to regularly publishes data updates, including the Statistical Yearbook and World Statistics Pocketbook, and books and reports on statistics and statistical methods

[24] http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27&Lg=1

4.4 Model Specification

The starting point of an empirical study of growth determinants in any given country is the Solow's growth model based on aggregate production function: (Please see chapter two for more details)

$$Y_t = f(A, L, K) \quad \text{..... (4.1)}$$

where *Y* = Real GDP, *A*= total factor productivity and *L* and *K* are the straight inputs of labour and capital respectively. As usual '*A*' measures the total factor productivity (TFP) of growth in output not accounted for by increase in labour and capital.

Thus, we have,

$$A = f(AGR, SER, IND, AID) \text{ .....(4.2)}$$

Where AGR = Agric Sector

SER = Service Sector

IND = Industry Sector

AID = AID

By substituting (4.2) into (4.1), we obtain:

$$GDP_t = F(K_t, L_t, AGR, SER, IND, AID) \text{ ..... (4.3)}$$

Using Cobb-Douglas method, we rewrite equation (4.3) as

$$GDP = \alpha K^{\beta_1} L^{\beta_2} AGR^{\beta_3} SER^{\beta_4} IND^{\beta_5} AID^{\beta_6} \cdot 1/S_t \text{ .....(4.4)}$$

the logarithm form of equation 4.4 is written as

$$\ln GDP_t = \beta_0 + \beta_1 \ln K_t + \beta_2 \ln L_t + \beta_3 \ln AGR_t + \beta_4 \ln SER_t + \beta_5 \ln IND_t + \beta_6 \ln AID_t + \varepsilon_t \text{ ..... (4.5)}$$

where $\beta_0 = \ln \alpha \quad and \quad \varepsilon_t = \ln 1/S_t$ and ε_t is the disturbance.

Even though GDP is stationary, we can not say the same for the log of GDP at all times. Because of this, we perform a standard test for the presence of unit root based on the

Augmented Dickey-Fuller since equation 4.5 is expressed in a log form. This is to help us check the stationarity or otherwise of the data.

If we find a presence of nonstationarity in the data, we deal with the problem by taking the first difference of the variables in the model as their first difference will be stationary and is given as follows

$$\Delta \ln GDP_t = \beta_1 \Delta \ln K_t + \beta_2 \Delta \ln L_t + \beta_3 \ln \Delta AGR_t + \beta_4 \Delta \ln SER + \beta_5 \Delta \ln IND + \beta_6 \Delta AID + \varepsilon_t \quad \text{.....(4.6)}$$

Equation (4.6) gives the unrestricted model. We again specify another model known as the restricted model. Where $\beta_1 \Delta \ln K_t$ is used as the restriction. The following model is specified

$$\Delta \ln GDP_t^* = \beta_2 \Delta \ln L_t^* + \beta_3 \Delta \ln AGR_t^* + \beta_4 \Delta \ln SER_t^* + \beta_5 \Delta IND_t^* + \beta_6 \Delta \ln AID_t^* \text{ .....(4.7)}$$

Where $\Delta \ln GDP_t^* = \dfrac{\Delta \ln GDP_t}{\beta_1 \Delta \ln K_t}$, $\beta_2 \Delta \ln L_t^* = \dfrac{\beta_2 \Delta \ln L_t}{\beta_1 \Delta \ln K_t}$, $\beta_3 \Delta \ln AGR_t^* = \dfrac{\beta_3 \Delta \ln AGR_t}{\beta_1 \Delta \ln K_t}$

$$\beta_4 \Delta \ln SER_t^* = \frac{\beta_4 \Delta \ln SER_t}{\beta_1 \Delta \ln K_t} \quad , \quad \beta_5 \Delta \ln IND_t^* = \frac{\beta_5 \Delta \ln IND_t}{\beta_1 \Delta \ln K_t} \quad , \quad \beta_6 \Delta \ln AID_t^* = \frac{\beta_6 \Delta \ln AID_t}{\beta_1 \Delta \ln K_t}$$

The results of the unrestricted equation and the restricted equation are used to calculate the F-statistics which is later used to evaluate equation 4.8, 4.9 and 4.10.
The check whether the production function is constant return to scale (balanced growth path or not), the Restricted Least Square method is used. The null that the entire coefficients add up to one is tested against the null that the entire coefficients do not add up to one.

To test whether the economy has constant returns to scale or not, the following equation is specified

$$\beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 = 1 \text{.....(4.8)}$$

If this is not equal to one, it means the economy is not on a balanced growth path. If the above condition in equation 4.8 is not fulfilled, it means the economy has either increasing returns to scale[25] or decreasing returns to scale. We test either of the two cases by specifying the following,

$$\beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 > 1 \quad (4.9)$$

$$\beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 < 1 \quad (4.10)$$

Equation 4.9 signifies increasing returns and equation 4.10 signifies decreasing returns.

4.5 THE EMPIRICAL RESULTS AND ANALYSIS

This section presents the results of the study. This section is divided into two parts; the first part deals with the results of the unit root test and the second part deal with the results of the return to scale.

4.5.0 The Results of the Unit Root Tests (Stationarity)

To examine the determinants of economic growth in Ghana, the stationarity or otherwise of the variables that is used in the growth equation are determined. The stationarity test is based on the ADF. The results of the Unit root tests are presented in table 2 in the appendix. The test is conducted using the log levels and the first differences of the variables.

The ADF test involve testing the null hypothesis of non-stationarity of the variables against the alternative hypothesis of stationarity, As seen from tables 2 the null hypothesis of nonstationarity (with and without trend) by the ADF cannot be rejected for all the variables in the log levels. However, all the variables become stationary after first differences are taken. Thus the first differences of the variables are integrated of order zero, *I(0).* The results from the test suggest that all the variables are I(1) in log levels but I(0) in first difference, indicating the presence of unit root. The suitable method is to use the first difference of the variables for estimation and analysis.

[25] Increase in output that is proportionally greater than a simultaneous and equal percentage change in the use of all inputs

4.5.1 A Constant Return to Scale Test (Balanced Growth)

The results of the restricted least square method are presented in table 3. From the result, the null that all the coefficients add up to one is rejected at 5% level of significance. This signifies that, the Ghanaian economy does not exhibit a constant return to scale in other words, is not on a balanced growth path.

We thus go on to test whether the economy exhibit increasing returns to scale or decreasing returns to scale. We test the null that there is increasing returns against the null that there is decreasing returns. From the results, the null that the economy exhibit increasing is rejected, thus the Ghanaian economy exhibit a decreasing returns to scale. This means GDP increases by less than the proportional changes in capital, labour, Agric, Service and Industrial sector and AID.

In general, decreasing returns to scale is hard to justify. But the only way one might obtain decreasing returns to scale in the circumstance is, if there are externalities of some sort. In this case, we define source of externalities as been unfavorable terms of trade (high export tariffs), importation of consumable goods rather than capital goods, import substitute goods and high interest payment in the long term on loans acquired. These are factors that might have contributed to the decreasing returns to scale.

The results further reveal that even though Ghana is converging with the UK, the rate at which convergence (catching up) is taken place is slow. For Ghana to ensure fast convergence, targets should be directed at turning the returns to scale from decreasing to constant or increasing returns.

We have identified some external factors that cause a decreasing return to scale with respect to the Ghanaian economy. Let's move a step further to identify some possible factors internally that might result in this. Investigating the various components behavoiur both in the long run and short relations will give us a fair idea of what might be the cause of such decreasing return. The roles of these variables are so crucial that having knowledge of them will help policy makers plan well in all aspect of economics growth.

CHAPTER FIVE

5.1 The Growth Equation Specification (LONG RUN AND SHORT RUN RELATIONS)

Apart from labour and capital as the major explanatory factors of growth[26], there are other factors that affect growth. In Chapter four, we justified the usage of the sectoral variables that enters the model. We thus go straight to estimate the long run and short run growth model and present the results of our empirical study.

From (4.5), the specific operational model for real GDP growth for Ghana in log-linear form is:

$$\ln GDP_t = \beta_0 + \beta_1 \ln K_t + \beta_2 \ln L_t + \beta_3 \ln AGR_t + \beta_4 \ln SER_t + \beta_5 \ln IND_t + \beta_6 \ln AID_t + \varepsilon_t \quad \text{..... (5.1)}$$

Equation (5.1) shows the long-run equilibrium relationship. It is expected that capital (K) be positively correlated with growth of real GDP and thus, $\beta_1 > 0$. All things been equal the higher the rate of investment, the higher the real GDP growth. Increase in labour input (L) is expected to lead to an increase in real GDP all things being equal. Therefore, the coefficient of labour β_2 must be positive and significant. An increase in the growth rate of Agriculture is expected to cause in increase in real GDP growth. We therefore expect β_3 to be positive. An increase in the growth rate of Service is expected to cause in increase in real GDP growth. We therefore expect β_4 to be positive. An increase in the growth rate of Industry is expected to cause in increase in real GDP growth. We therefore expect β_5 to be positive. Foreign aid is considered as an inflow. It is therefore expected that an increase in the inflow of AID lead to an increase in aggregate output and hence its rate of growth. We expect β_6 to be also positive.

From the previous chapter, we noticed the presence of nonstationarity in the variable set. The best way is to make the variable stationary by taking the first difference; however, valuable long–run relationships among the variables would be lost after differencing. In the presence of cointegration, the valuable long-run relationship can be

[26] this is in accordance with the neoclassical growth model which considers labour and capital as the most important factors that affect growth in an economy.

preserved since estimation will not be spurious, so long as the variables are integrated by the same order and are cointegrated.

The study tests for the existence of a long run relationship among the variables from equation (5.1). By doing this, the study undertake the following; by verifying the order of integration of the variables since the various cointegration tests are valid only if the variables are integrated of the same order.

After the cointergration relationship has been established among the variables, an Error-Correction Model (ECM) is estimated to determine the dynamic behaviour of the growth equation. The report estimate the short run ECM (equation 5.3) based on the following specifications derived from a general-to-specific modelling: The general modelling based on the i th adjustment to equilibrium Period is

$$\Delta \ln GDP_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta \ln GDP_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta \ln K_i + \sum_{i=0}^{n} \beta_{3i} \Delta \ln L_i + \sum_{i=0}^{n} \beta_{4i} \Delta \ln AGR_i$$
$$+ \sum_{i=0}^{n} \beta_{5i} \Delta \ln SER_i + \sum_{i=0}^{n} \beta_{6i} \Delta \ln IND_i + \sum_{i=0}^{n} \beta_{7i} \Delta \ln AID_i + \lambda ECF_{t-1} + \varepsilon_{t-i} \quad \ldots(5.2)$$

The specific modelling based on i=1 adjustment-to-equilibrium period is:

$$\Lambda \ln GDP_T = \beta_1 \Lambda \ln GDP_{t-1} + \beta_2 \Delta \ln K_1 + \beta_3 \Delta \ln L_1 + \beta_4 \Delta \ln AGR_1 + \beta_5 \Delta \ln SER_1$$
$$+ \beta_6 \Delta \ln IND_1 + \beta_7 \Delta \ln AID_1 + \lambda ECF_{t-1} + \varepsilon_{t-1} \quad \ldots\ldots\ldots (5.3)$$

where all the variables are as previously defined except Δ which represents first difference of the variable and ECF_{t-1} is the error correction factor. The coefficient of the error correction factor, λ measures the speed of adjustment to obtain equilibrium in the event of shocks to the system. The error correction model captures the short run dynamics of the equation. In other words, the short run dynamics is tested for by using the error correction model.

The report thus makes use of the error correction model (ECM). The report invoke the Engle-Granger theorem (1987) which states that in the presence of cointegration, there always exists a corresponding error correction representation which implies that

changes in the dependent variable are a function of the level of disequilibrium in the cointegrating relationship, captured to be the error-correction factor (ECF), as well as changes in other explanatory variables to capture all short run relationships among the variables.

Mention should be made of the fact that, the above methodology of cointergration and Error correction mechanism has been used by a number of writers including Sushil Kumas when he wrote on the 'Economic growth in India Revisited – An application of cointergration and Error correction mechanism' and Nkang, Abang, Akpam and Offem when are wrote on 'cointergration and error-correction modeling of Agricultural export trade in Nigeria.'

5.2 EMPIRICAL RESULTS AND ANALYSIS

The section is divided into two parts. The first part deals with the results of the long-run relation and the second part deals with the results of the short run relation.

5.2.0 Results of the Co integration Test

Table 5.0 presents the Engle-Granger test of cointegration. The cointegration test statistics for the variables, lnGDP, lnK, lnL, lnAGR, lnSER, lnIND and lnAID, indicate the presence of cointegration and also the presence of one cointegration vector as the variables are integrated of order one. The null hypothesis that there is no cointegrating vector in the system is rejected, but the null that there exists at most one cointegrating vector of order one is not rejected at 5% level of significance. These findings establish the existence of an underlying long-run equilibrium relationship between the dependent variable, real GDP and the independent variables.

Table 5.0 Result of Engle-Granger test of Cointegration

Dependent Variable: First Difference of the residual

Variables	Coefficients	SE	t
LAG(RES_1)	-0.817	0.201	-1.430*
R-squared	=0.157		
Adjusted R-Squared	= 0.080		
F	= 2.046		
DW	= 1.685		
τ	= -4.065***		

(*)* significant at 10% level of significance

(***)*** value is more negative, hence accept the hypothesis of cointegration

5.2.1 The Results of Johansen's Test For Co integration Vectors

The Johansen's maximum eigenvalue is presented in table 4 of the appendix and determine the number of cointegrating vector. The cointegration test statistics for the variables indicate the presence of one cointegration vector. The null that there is no cointegrating vector: H_0: r =0 is rejected, but the null that there exist at most one cointegrating vector (H_0: r =1) is not. From the maximum eigenvalue test results, for Ho: r = 0, the reported trace statistic is 180.50 which is greater than the critical value of 178.33, thus suggesting that the null hypothesis is rejected. But for Ho: r = 1, the reported trace statistic is 123.11 which is less than the critical value of 165.06. Thus, the null hypothesis that Ho: r = 1 cannot be rejected at 5% level of significance. The results therefore confirm the existence of only one cointegrating vector. These findings establish the existence of an underlying long-run equilibrium relationship between the dependent variable and the independent variable.

Sushil Kumar used this methodology in determining the cointegration and Error correction Mechanism and used a cointegration vector of one to establish his long run relationship. This study thus follows Sushil methodology.

5.2.2 Result of the Long-run Growth Model

TABLE 5.1 The Results of the Long-run Growth Equation

Dependent variable: $LnGDP_t$

Variables	Coefficient	SE	t-Statistics
Constant	1.4715	0.4537	0.893
LnK_t	0.702	0.5460	1.931***
LnL_t	-1.239	0.5055	-1.976***
$LnAGR_t$	0.714	0.0892	2.456***
$LnSER_t$	-0.663	0.1499	-1.883***
$LnIND_t$	0.218	0.1118	2.149***
$LnAID_t$	-0.198	0.0892	-0.157
Unadjusted R-squared	= 0,981		
Adjusted R-squared	= 0,864		
Durbin-Watson statistic	= 1, 7954		
F	= 3.5921***		
N	= 30		

***(***) significant at 5% level of significance

From the above regression, all the coefficients are statistically significant at 5% level of significance with the exception of the coefficient of the constant term and LnAID. The whole regression is also statistically significant and the R-squared is much higher. The Jarqie-Bera test of Normality accepted the null of normality in the residuals. The Durbin-Watson value is also fairly around two suggestions no autocorrelation, positive or negative. The whole regression is also statistically significant. The result is thus good for interpretation, analysis and conclusion.

The coefficient of capital of 0.702 shows that a 1% change in capital input results in a 0.702 percentage change in real GDP, holding all other factors constant. Thus, the capital coefficient is the elasticity of output with respect to capital. This is true for all log-log models. The sign on the capital variable support the theoretical conclusion that capital contributes positively to growth of GDP since the coefficient of capital in this long-run growth equation is positive and significant at 5% level of significance. The result is consistent with Ayeerty and Fosu work on the similar growth model for Ghana.

With the exception of LnL variable and the constant term, the other measures of elasticity are inelastic. The most theoretically surprising result from the estimated long-run relationship between GDP and the explanatory variables is the coefficient of labour (L) which is negative and significant at 5%. It is expected that additional labour adds to output and not to reduce it. However, our results indicated the contrary. A careful study reveals that this is not all that odd. Some explanations can be offered for this. Firstly, a potential source of negative role of labour in Ghana may be due to data problems. This is because of inadequate statistics on employment and unemployment in Ghana. Secondly, this can also be attributed to the growing unemployment problem in the country because the Ghanaian economy is based on land intensive agriculture which has the largest share of GDP and capital intensive mining and construction both of which have limited employment benefits for the country. Lastly, a careful search reveals that, the coefficients of labour in most growth regressions in developing countries are negative in most cases.[27] Probably, the negative contribution of labour in our model and other developing countries is due to the fact that labour is proportionately too larger than capital such that the marginal productivity of labour is negative, as our results indicate. This is consistent with George work on growth model in Ghana and Aryeetey and Fosu study of growth from 1960 – 2000. Taking into account low quality of the labour force in terms of nutrition, health and education and mass unemployment and underemployment that are widespread in the country implies that large proportion of the workforce are not working. Thus, additional labour does not add anything to output, they rather reduce it.

The coefficient of LnAGR is positive and significant at 5% level of significance. The results suggest that in the long-run, growth in the Agric sector tends be have a positive effects on GDP growth. That is, a 1% growth in the Agric sector will result in a 0.714 percentage growth in GDP holding all other factors constant. This is consistent with theoretical expectation of growth in GDP that growth in the Agric sector propels forward linkages[28].

[27] Senthsho Joel, Export Revenue as Determinant of Economic growth: Evidence from Botswana, University of Botswana, Department of Economics, 2000. p.7

[28] Forward linkages occurs when the products of one industry is used as the raw materials of another industry. It can involve an industry in primary production linking with an industry in secondary production. A forward linkage is when one industry is producing the raw materials for another industry.

The coefficient of LnIND, also have the theoretically correct sign and is significant at 5% level of significance. In other words, a 1% growth in industry will result in a 0.218 percentage change in GDP. Thus the industrial sector affects GDP growth in the long run. This implies that a critical level of economic development required for industrial production to have a positive and significant impact on Ghana's economic growth is achieved but effort should be channeled into causing the impact to increase.

The coefficient of service is negative and significant at 5% level of significance. This is quite unlikely, as it is expected that the service sector should enhance growth in the long run. The Ghanaian data however supports the reverse of this theoretical assertion. The negative contribution of service to growth in the long run may be due to the fact that, the service sector is basically made up of wholesale and retail activities (buying and selling) of imported goods. A careful consideration of the Ghanaian economy over the years has shown that, the service sectors is gradually, having a greater share of GDP growth than the industrial sectors. This would have been good if Ghana had transcend smoothly from the Agric sector to the industrial sector and then to the service sector. But this has not happened. Ghana share component of GDP by sectors has seen a move from the Agric sector directly to the service sector. Thus many of the goods sold are imported. Even though this might have an effect on GDP growth in the short run, the adverse effects in the long run as a result of balance of trade deficit will be felt very much. In addition, Ghana's imports are mainly consumables rather than investment goods with no growth potentials. Thus, the negative coefficient of service should not be a surprise in the Ghanaian context.

The coefficient of LnAID variable is not statistically different from zero at 5% level of significance, not even at 10% significance level. The negative sign of aid in the long-run growth model is quite surprising. Foreign aid is considered as an inflow of additional capital to compliment domestic resources so as to speed the growth process of the economy. However, the growth effect of foreign aid has been found to be neutral if not negative as the coefficient of aid is negative, though not statistically different from zero. The poor performance of aid in the long-run may be due to the fact that, aid that comes in the form of loans becomes liability in the long-run as the debt must be serviced. Sometimes donor conditionality affects efficient allocation of the loans and thus leads to poor impact of aid on growth. The poor contribution of aid to growth raises a big

issue as to whether or not we should continue to rely on AID as an important factor in the growth and development agenda of the nation. From our results, AID at its best is neutral to growth in the long-run and at worse impedes growth.

5.2.3 The Results of the Short-Run Error Correction Equation

The results presented in table 4.5 are based on the assumption of one year adjustment-to-equilibrium period instead of an instantaneous adjustment to equilibrium.

Table 5.2: The Results of the Short-Run Error Correction Growth Equation

Dependent variable: $\Delta LnGDP_t$ (First difference of the log of real GDP)

Regressors	Coefficient	SE	t
Constant	0.128	0.108	1.183
$\Delta LnGDP_{t-1}$	0.054	0.431	0.126
ΔLnK_t	0.611	0.445	1.820***
ΔLnL_t	-1.943	1.002	-1.919***
$\Delta LnAGR_t$	0.899	0.789	1.998***
$\Delta LnSER_t$	0.539	0.369	2.744***
$\Delta LnIND_t$	0.038	0.161	1.335
$\Delta LnAID_t$	0.199	0.168	1.684***
ECF_{t-1}	-0.614	0.022	-2.710***

Unadjusted R-squared	= 0,842
Adjusted R-squared	= 0,621
Durbin-Watson statistic	= 1,666
F	= 4.252***
N	= 33

***(***) Significant at 10% level of significance.

From the regression, all the coefficients are statistically significant at 10% level of significance with the exception of the coefficient of Industry and the constant term. The R-squared value is relatively high and the Durbin-Watson value indicates the absence of no autocorrelation, positive or negative. The whole equation is also statistically significant as indicated by the F value. The model is thus said to have the right functional form. The JB test shown that the residuals are normally distributed and the

Reset test shown no specification error. The above regression can therefore be used for analysis.

In the short run dynamic growth equation, presented in Table 4.5, the coefficients maintain their signs as in the long run equation except the coefficients of Services and AID which change from negative to positive. The coefficients are also short run elasticities.

The coefficient of the capital variable in the dynamic growth equation is positive and significant at 5% level of significance. This is consistent with the result of the long-run growth equation. This indicates the crucial role that capital play in Ghana's growth process as its coefficient is positive in both the long-run and short run.

The coefficient of labour in the short run growth equation maintains its negative coefficient just as in the long run growth equation. This is a signal of the severity of the unemployment and under-employment problem in Ghana. The problem is extra aggravated by the poor quality in terms of education, health and nutrition and poor human development of the labour force.

The coefficient of Agric also maintains it right as just as in the long run growth equation. This emphasizes the Agric sector dominance of the Ghanaian economy.

The coefficient of industry also maintains its right sign though it's statistically insignificant at 5% level, not even at 10% level, but is quit relatively lower than the impact it has of the economy in the long run. This also implies that to ensure a long run growth in the Ghanaian economy, attention should be given to the development of the Industrial sector. Even though the impact will not be readily felt in the short run, growth will be assured in the long run all things been equal.

The most interesting result in the short-run growth equation is the coefficient of the service and AID which has a positive sign, and is significant at 5% level of significance. As already mentioned the service sector is made up of wholesale and retail activities (buying and selling) of imported goods. As these goods are imported into the country and the number of transactions activities increases, it will tend to affect GDP growth

measured in monetary terms by swelling up the consumption component of the identity equation. But over time when importers will have to pay for the goods imported in foreign currencies, GDP measured in monetary terms shrinks. Again, import of good for sales and resale, tends to be deceptive as one may not see how unproductive the economy has becomes.

In the dynamic growth equation, the coefficients of AID is negative as in the long run equation but later becomes positive in the short run. This implies that in the short run the impact of increase in AID enhances growth but becomes a liability to growth in the long run

The estimated coefficient of the error correction term is statistically significant at the 5% level of significance and with the appropriate negative sign. This is an indication of joint significance of the long run coefficients. This suggests the validity of a long run equilibrium relationship among the variables in the long run growth equation. The estimated coefficient of the error correction term (ECT_{t-1}) is less than one (-0.614) in absolute terms. Statistically, the equilibrium error term is non-zero, suggesting that GDP growth adjusts to changes in Capital, Labour, Agric, Service and Industrial sectors and AID in the same period and also indicates that the system corrects its previous period's disequilibrium in less than one year to its equilibrium level following a shock. The ECF_{t-1} coefficient of -0.620, indicates that the speed of adjustment of GDP to its steady state level following a shock is high. Thus, the possibility of sluggish adjustment from disequilibrium to the steady state level is ruled out.

The above analysis brings out two variables that might be the possible factor for the decreasing returns to scale problem exhibited in chapter four. These two factors are labour, the service sector and AID. Therefore for policy makers to curve the problem of decreasing returns to ensure loose convergence, special attention should be given to the labourforce, the sector and AID. The following chapter summaries the results and gives recommendation as to what should be done to the variables.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Findings

The main findings of the study are summarized below:

The convergence hypothesis is accepted using the Ghanaian and UK data. It means Ghana's growth rate is converging to that of UK growth rate. That is Ghana is catching up with the UK in terms of growth. The result also shows that even though the catch up is on, long-run convergence has not been achieved

The result of the constant returns to scale suggests that the economy is not on the balanced growth path as all the coefficients did not add up to one. A further test for increasing returns or decreasing returns suggests that the economy is exhibiting decreasing returns to scale. Even though some components shows positive returns, the negative returns are so high that it offset the positive returns causing decreasing returns to scale. This indicates that even though there is convergence, the speed is slow.

An Engle-Granger test for cointegration showed that there exist a long run relationship between the dependent variable on one hand and the independent variable on the other hand. The cointegration among the variable rules out the possibility of a spurious regression.

The long-run relation results show that, there is a positive relationship between real GDP growth and capital, proxied by Gross domestic fixed capital formation. The results indicate that a percentage change in capital stock lead to a 0.702 percentage change in real GDP growth. This is significant at 5% level of significance.

The long run relations results show a negative relation between GDP and labour proxied by labourforce. The results indicate that, real GDP growth falls by -1.239 percentage as labourforce increases by one unit.

The result also shows a positive relationship between real GDP growth and growth rate in the Agric sector. Thus a one percentage change in Agric sector growth rate will result in a 0.714 percentage change in real GDP.

The result shows a negative relationship between real GDP growth and the growth rate in the Service sector. Thus a one percentage change in the service sector will result in a -0.663 percentage change in real GDP growth. This is theoretically incorrect but reason is that the Service sector of the Ghanaian economy is largely made up of (whole and retail of imported goods) buying and selling of imported consumable goods which only swells up the consumption component of the income identity.

The result also found a positive relationship between Industrial growth rate and real GDP growth. A one percent change in the industrial sector will cause real GDP rate to grow by 0.218 percent. This is theoretically also correct as industrial growth rate increase real GDP growth.

Lastly the long run relationship showed a negative relation between real GDP growth and AID. This is because in the long run, these AID's become liability to the nation as higher interest rates are paid on them.

The study also finds that, there were negative long run relations among real GDP growth and the Service sector growth and AID variable, but these variables had positive relations when the short run relationship was estimated.

The short run dynamic error correction model indicates that the estimated coefficient of the error correction term is statistically significant at the 5% level and with the appropriate negative sign. This suggests the validity of the long run relationship among the variables in the long run growth equation. The speed of adjustment to equilibrium is quit high, but less than one with the implication that the model is dynamically stable.

6.2 Policy Inference

This report accepted the null of convergence i.e. catching up. What it means is that under good macroeconomic environment, Ghana's economy has the ability of catching up with the rest of the developed countries: the UK in our case. There is therefore the need for a great deal research into the issues concerning convergence in the Ghanaian economy. More significantly, effort should be on influencing the factors that can greatly affect the speed of convergence such as population. The result also shows that long run

convergence has not been attained. Further investigation was conducted to try to know the cause of this by means to returns to scale.

The result of the returns to scale suggests that the Ghanaian economy exhibit decreasing returns to scale. This is basically due to externalities as already defined. Governments and policy makes should thus consider ways of mitigating against such externalities and that even if it impacts on the economy, the impact will not be felt so much. For example, government should consider ways to increasing internally generated revenue instead of relying on AID's and should encourage capital goods importation instead of consumable goods.

The growth equation indicates a positive relationship connecting the capital stock and real GDP. By this Ghana can increase its savings and investment rates which will cause capital to increase and thus increase growth. But because of poverty, saving rates cannot easily increase. Policy makers should create the needed environment for foreign business community to invest in Ghana. This will help make up for the low savings to investment ratio and will propel the economy towards growth. But for this to become a reality, policy makers should really get serious. A ranking relied by the International Finance cooperation on *'Doing Business report'* showed that Ghana dropped twelve place down from 80 to 92 between 2008 and 2009.[29] This definitely does not order well for the Ghanaian economy if convergence and growth is to be realized. If the right investment environment is created and investment is attracted, employment opportunities will abound and as people get employed, saving might increase and growth starts increasing. Again, a larger proportion of the country's budget should be targeted towards industrialization.

The growth equation also showed a negative relationship between real GDP growth and labourforce. This shows the poor quality of labour in term of health and nutrition, education and training, as well as inherent cultural attitudes of apathy and attitudes to

[29] Economies are ranked on their ease of doing business, from 1– 183, with first place being the best. A high ranking on the ease of doing business index means the regulatory environment is conducive to the operation of business. This index averages the country's percentile rankings on 10 topics, made up of a variety of indicators, giving equal weight to each topic. The rankings are from the *Doing Business 2010* report, covering the period June 2008 through May 2009
http://www.doingbusiness.org/economyrankings/

work. A quick reference to the Human Development Index (HDI)[30] has shown that Ghana has increased her index value from 0.4950 to 0.533 between 2000 to 2009.[31] Besides this achievement, there is still a lot to be done. The negative relation also brings out the issue of high unemployment. Policy makers should consider policies that will ensure high enrollment of people in educational institution from primary to the tertiary level. Adult education should also be given a significant amount of consideration. As efforts are spent on training the minds and skills of the people, they will become more innovative and their productivity will increase very much.

Also civic programs should be introduced to deal with the culture of apathy and attitude of people towards work. This is important because of the crucial role culture plays in shaping our mental models, our moral standards, our aesthetic sensibilities and in general the context that give meaning to our lives. Culture is a society's collection of meanings which emerges through social interaction and which allows the individual to interpret (relating to the mind) her own circumstance. The interpretive processes result in patterns of behaviour across individuals. Individual does not wholly choose his culture. The individual inherits a language community, values and ethics. While the individual does not choose that cultural influences which shape her thinking/perspective she/he has it within her grasp to challenge inherited cultural norms. Learning how to 'read' any particular cultural context is the process which makes use of tacit or inarticulate knowledge (Lavoie and Chamlee-Wright). Hayek made this point about knowledge. He point out that individual also make use of inarticulate knowledge, perhaps derived from the experience or map of many years within a particular environment, which enable him to make sense of all the many bits of information available to them. The different experience or map which will thus be formed in different brains will be determined by factors (culture) to each other, but will not be identical.

How knowledge or messages or experience play into the Ghanaian individual's everyday reasoning and/or lives – their choices, attitudes, judgments and perceptions

[30] The HDI—human development index—is a summary composite index that measures a country's average achievements in three basic aspects of human development: longevity, knowledge, and a decent standard of living. Longevity is measured by life expectancy at birth; knowledge is measured by a combination of the adult literacy rate and the combined primary, secondary, and tertiary gross enrolment ratio; and standard of living by GDP per capita (PPP US$)

[31] United Nations Development Program (UNDP)

is very important. This is because of the multiplicity of meaning that a message might take on because of the different functioning of the brains of individual Ghanaian and/or of groups in similar cultural setting. In the process of experience this does not begin with perceptions, but necessarily precedes them: it operates on physiological events and arranges them into a structure or order which becomes the basis of their 'mental' significance; and the distinction between the sensory qualities, in terms of which world, is the result of such pre-sensory experiences. We may express this also by stating that experience is not a function of mind or consciousness, but that mind and consciousness are rather products of experience (Hayek 1952).

Culture is a whole orientation to a society, a way of living that necessarily involves ethical choices. Images and symbolic message we receive and send through culture profoundly shape the way we think. These ways of thinking, by setting the framework within which all interaction will take place can be viewed as crucial elements underlying the quality of our lives in the larger social existence. Suppose we are to relate the way of life to the structure of domestic unit in Ghana. We would understand that well if we understand the thought of the people about the basic household group formed on a complex set of traditional and con forces. This indicates that, the average Ghanaian will have to be forced to do the right thing and this expalins why under colonialism the Ghanaian economy did much more better. But with intensive and continous civic education, the averge Ghanaian mental processes will be tilted towards the right attitude to work and this can go a long way to affect the productivity of labour.

The short run dynamic growth equation shows that the service sector increases growth of real GDP because it swells the consumption component of the income identity. However, this is detrimental to the economy in the long run. Therefore, the service sector needs major sake up. Policy makers should look at ways of encouraging people to import capital goods instead of consumption goods. This can be achieved by allowing for a duty free importation of capital goods and imposing heavy taxes on the importation of consumption goods. This will affect the industrial sector which will intend affect the service sector.

Foreign aid cannot be relied on in achieving long run economic growth in Ghana. The study finds that the contribution of AID to real GDP and growth in the long run is

negative while it is positive in the short run. The implication is that the economy can do better by reducing its external borrowings, as far as real GDP growth is concerned.

6.3 Recommendations

Based on the results of the present study, the following recommendations are made:

1. More resources should be dedicated to the empirical studies of growth determents especially sectoral growth and issues of convergence to establish the results of this study. There has not been much research in the areas of convergence and growth determinants based on time series analysis for Ghana.
2. As the economy strives to achieve middle income status, savings and investment rates should be increased. This will lead to an increase in the capital stock and thus shift the rate of growth of real GDP from its current average of 4.5% to about 9% or higher. The study finds a significant positive relationship between real GDP and the level of the capital stock in both the short-run dynamic and the long-run static models.
3. The service sector of the economy needs a major restructuring. There should be reduction in the importation of consumable goods by imposing heavy taxes and allowing an almost tax free importation of capital goods.
4. Human development should be a core aim of every government as this will improve the quality of labourforce to ensure that additional labourforce contributes positively to GDP.
5. More Jobs should be created through private sector initiatives to reduce the level of unemployment as government cannot create enough employment avenues towards its natural rate and increase real GDP.
6. More resources should be channeled to the industrial sector as this will propel the economy to faster growth rate.

6.4 Limitations of the Study

There were many constraints that hindered the quality of this study. Among them is the most pressing one on materials on time series convergence especially on Ghana. The only material on convergence in Ghana was an unpublished by one George Adu who even used a cross-sectional approach instead of a time series approach. Another problem encountered was time as other aspect of catching up was not investigated into.

6.5 Concluding Note

The objective of the study has been finding verification in favour or against the convergence hypothesis, to determine whether or not this convergence has been fast or slow, to know whether or not Ghana is on a balanced growth path and to examine the major factors behind the poor rate of growth of real GDP in Ghana through sectoral contributions. These were accomplished by employing modern time series analysis of unit root, cointegration and the associated error correction model to a set of annual data from 1960 -2006. The empirical results suggest the hypothesis of convergence that Ghana is converging with Western Europe in its growth rate taken the UK as a proxy for Western Europe thus accepting the null of the convergence hypothesis.

The balanced growth equation showed that Ghana is not on the balanced growth path and a further investigation reveals that Ghana's growth is experiencing a decreasing return to scale. Both the long run and short run dynamic error correction model show that growth of real GDP in Ghana is greatly influenced by factors such as stock of capital, the labourforce, the Agric, service and Industrial sectors of the economy and AID. In both functions the coefficient of capital was positive while that of labour was negative. The coefficients of service sector and AID were negative in the long run model, but positive in the short run dynamic growth equation.

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APPENDIX

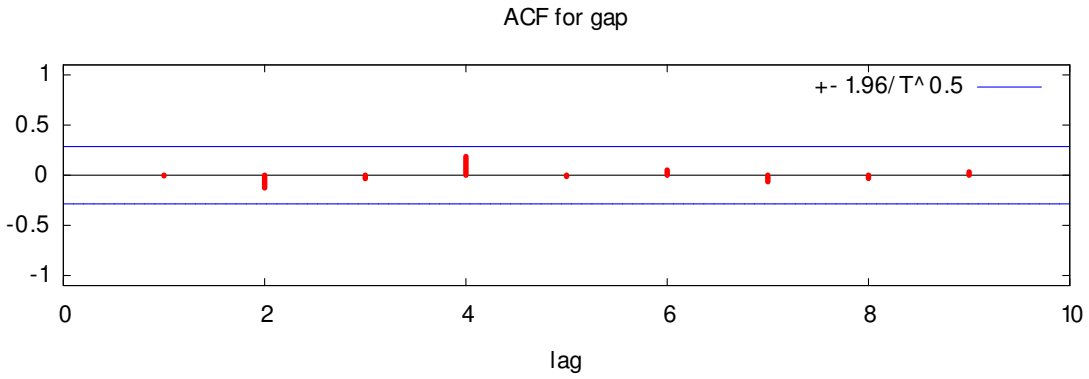
Table 1

```
Augmented Dickey-Fuller tests, order 1, for gap
sample size 45
unit-root null hypothesis: a = 1

   test with constant
   model: (1 - L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.008
   estimated value of (a - 1): -1.13856
   test statistic: tau_c(1) = -5.2559
   asymptotic p-value 5.939e-006

Augmented Dickey-Fuller regression
OLS estimates using the 45 observations 1962-2006
Dependent variable: d_gap

      VARIABLE       COEFFICIENT        STDERROR      T STAT   P-VALUE

  const                 0.928063         0.198239      4.682
  gap_1                -1.13856          0.216625     -5.256  <0.00001 ***
  d_gap_1               0.129061         0.152882      0.844

   with constant and trend
   model: (1 - L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.022
   estimated value of (a - 1): -1.17136
   test statistic: tau_ct(1) = -5.38212
   asymptotic p-value 3.005e-005

Augmented Dickey-Fuller regression
OLS estimates using the 45 observations 1962-2006
Dependent variable: d_gap

      VARIABLE       COEFFICIENT        STDERROR      T STAT   P-VALUE

  const                 0.755421         0.247738      3.049
  gap_1                -1.17136          0.217640     -5.382   0.00003 ***
  d_gap_1               0.145427         0.152941      0.951
  time                  0.00797746       0.00691321    1.154


Augmented Dickey-Fuller tests, order 1, for gap
sample size 45
unit-root null hypothesis: a = 1

   with constant and trend (GLS)
   model: (1 - L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: -0.012
   estimated value of (a - 1): -1.15174
   test statistic: tau = -5.41299
```

```
                      10%     5%      2.5%     1%
Critical values: -2.89   -3.19   -3.46   -3.77
```

Autocorrelation function for gap

LAG	ACF	PACF	Q-stat.	[p-value]
1	-0.0061	-0.0061	0.0019	[0.966]
2	-0.1265	-0.1266	0.8211	[0.663]
3	-0.0339	-0.0361	0.8812	[0.830]
4	0.1867	0.1730	2.7476	[0.601]
5	-0.0128	-0.0195	2.7565	[0.737]
6	0.0520	0.0968	2.9087	[0.820]
7	-0.0648	-0.0592	3.1502	[0.871]
8	-0.0319	-0.0513	3.2104	[0.920]
9	0.0324	0.0308	3.2739	[0.952]



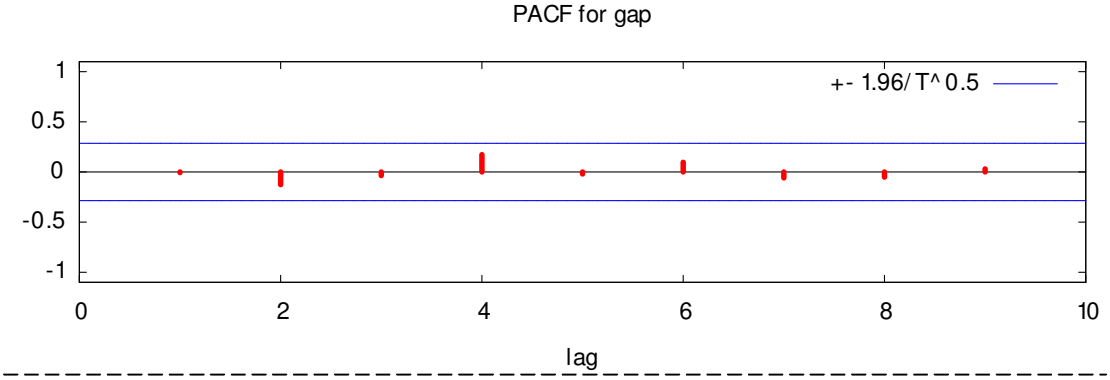


Table 2

THE RESULT OF ADF TEST FOR UNIT ROOT (H_0: Unit roots)

	Log-level		First Difference level	
Variable	No trend	Trend	No Trend	Trend
GDP	-0.7997	-1.066	-5.8764***	-7.2109***
GDFC	-1.7938	-1.8032	-4.325***	-4.826***
Labour	-0.1649	-0.1666	-5.969***	-4.623***
Agric	-0.9319	-1.0507	-4.799***	-4.697***
Service	-1.0054	-1.2021	-4.1416***	-5.5672***
Industry	-0.6412	-0.7197	-6.3926***	-6.2633***
Aid	-0.4299	-0.5681	-4.4866***	-4.426***

Table 3

Unrestricted Regression

Dependent Variable = $\Delta LnGDP_t$

Regressors	**Co-efficient**	**SE**	**t**
ΔLnK_t	0.016	0.030	0.542
ΔLnL_t	-9.016	0.035	-1.494
$\Delta LnAGR_t$	0.252	0.216	1.166
$\Delta LnSER_t$	-2.384	1.041	-2.290
$\Delta LnIND_t$	0.124	0.439	0.282
$\Delta LnAID_t$	-0.236	0.538	-0.468

R square = 0.510
Adjusted R square = 0.216
F = 1.734

Restricted Regression

Dependent Variable = $\Delta LnGDP_t$

Regressors*	**Co-efficient**	**SE**	**t**
ΔLnL_t*	2.822	2.681	1.053
$\Delta LnAGR_t$*	-0.545	0.415	-3.751
$\Delta LnSER_t$*	-0.162	0.266	-0.609
$\Delta LnIND_t$*	0.290	0.979	0.296
$\Delta LnAID_t$*	-1.430	0.203	-7.031

R square = 0.968
Adjusted R square = 0.953
F = 6.732

Regressors* = Regressors/ΔLnK_t

```
Run MATRIX procedure:

The RSS without restriction
    11,9634

The RSS with restriction
      ,1761

F-Value
    29,5585

Sig. level of F-test (H0 = The restrictions hold/CRS in the present example)
 1,000

------ END MATRIX -----
```

Table 4

```
Johansen test:
Number of equations = 7
Lag order = 1
Estimation period: 1971 - 2006 (T = 36)

Case 3: Unrestricted constant
Rank Eigenvalue     Trace test p-value   Lmax test p-value
   0    0.79733     180.57 [0.0000]     59.762 [0.0011]
   1    0.67933     123.11 [0.0001]     40.945 [0.0356]
   2    0.54461     82.166 [0.0031]     28.318 [0.2047]
   3    0.51223     53.849 [0.0111]     25.845 [0.0806]
   4    0.42699     28.004 [0.0807]     20.047 [0.0699]
   5    0.18859     7.9570 [0.0773]     7.5234 [0.0380]
   6   0.011973    0.43365 [0.0102]    0.43365 [0.0102]


eigenvalue 0.79733  0.67933 0.54461  0.51223   0.42699    0.18859  0.011973

beta (cointegrating vectors)
LnGDP    -0.87486   -1.443  0.31105  0.79623  0.10469  -0.029053   0.20651
LnK       0.067318  -0.222  0.39435 -0.22622 -0.28599   0.017764  -0.046473
lnl      -1.8784    -0.522  1.6116  -1.5249   0.81479  -0.99782   -5.9710
LnAgr     0.098785  -0.722 -0.50619 -0.48492  0.14611  -0.10955   -0.20836
LnSer     0.46574    0.354 -1.1209   0.25127 -1.0320    0.085629  -0.48331
LnInd     1.1724    -0.200 -0.13853  0.14342  0.062995 -0.033123  -0.19718
lnAID     0.14379    0.153  0.13790  0.11321  0.094129 -0.84362   -0.31609

alpha (adjustment vectors)
LnGDP     0.021106   0.413    -0.065356 -0.37886 0.21224  -0.020919 -0.025664
LnK      -0.56351    0.302    -0.89585   0.97341 0.68894   0.35632   0.0067614
lnl      -0.01408    0.012123  0.029737 -0.03105 0.008102  0.019959  0.013491
LnAgr     0.18641    0.54977   0.57310   0.7828 -0.013594 -0.018079  0.021247
LnSer     0.067995  -0.13839   0.32401  -0.06559 0.41853   0.12511  -0.0098879
Lnind    -1.2364     0.026300 -0.040798 -0.3305 -0.092106 -0.15620   0.022851
lnAID    -0.0036946  0.059658  0.036050 -0.0129 -0.13275   0.31205  -0.035036

renormalized beta
LnGDP     1.0000     6.4889    0.19300  -1.6420 -0.10144   0.87713  -0.65333
LnK      -0.076948   1.0000    0.24469   0.46651 0.27712  -0.53630   0.14703
lnl       2.1471     2.3468    1.0000    3.1447 -0.78951   30.125    18.890
LnAgr    -0.11292    3.2448   -0.31409   1.0000 -0.14158   3.3075    0.65919
```

```
LnSer    -0.53237   -1.5934   -0.69553  -0.51817 1.0000   -2.5852    1.5290
Lnind    -1.3401     0.90251  -0.085960 -0.2957 -0.061041  1.0000    0.62382
lnAID    -0.16435   -0.69065   0.085565 -0.2334 -0.091209  25.470    1.0000

renormalized alpha
LnGDP    -0.018464  -0.092023 -0.10533   0.1837 -0.21903   0.00069   0.0081121
LnK    0.49299   -0.067335 -1.4438   -0.4720 -0.71100  -0.011802 -0.0021372
lnl       0.012324  -0.002697  0.047924  0.0150 -0.008362 -0.000661 -0.0042644
LnAgr    -0.16308   -0.12233   0.92362  -0.37961 0.014029  0.000598 -0.0067158
LnSer    -0.059486   0.030793  0.52217   0.0318 -0.43193  -0.004143  0.0031254
Lnind     1.0817    -0.005852 -0.065751  0.16030 0.095056  0.005173 -0.0072230
lnAID     0.0032323 -0.013275  0.058099  0.00628 0.13700  -0.010336  0.011074

long-run matrix (alpha * beta')
              LnGDP    LnGDFC   lnl    LnAgr    LnSer   Lnindustry     lnFDI
LnGDP       -0.92005  -0.090546 0.5638 -0.04106 -0.0738 -0.084466     0.060427
LnK          0.61564  -0.86977 -1.8622 -0.23249  0.4098 -0.42743     -0.28574
Lnl         -0.017599  0.012515 0.0215 -0.01395 -0.0565 -0.030333    -0.019916
LnAgr       -0.15182  -0.05829 -1.0273 -1.0527  -0.16176 0.13657      0.28620
LnSer        0.22701   0.060968 0.84197 0.02394 -0.81351 0.077383    -0.037258
Lnind        0.76740  -0.007885 2.6915  0.03871 -0.5332 -1.5017      -0.10090
lnAID       -0.11222  0.048764 -0.15668  -0.10168 0.15642 -0.034956     -0.25254
```

The Results of Johansen's Test For Co integration Vectors

Rank H_0	H_1	Eignevalue	Trace test	5% Critical Value	Lmax	5% Critical Value
r=0***	r=1	0.79733	180.57	178.33	59.762	59.65
r≤1	r≥1	0.67933	123.11	165.06	40.945	56.55
r≤2	r≥2	0.54461	82.166	151.72	28.318	53.40
r≤3	r≥3	0.51223	53.849	138.30	25.845	50.20
r≤4	r≥4	0.42699	28.004	124.77	20.047	46.94
r≤5	r≥5	0.18859	7.9570	111.11	7.5234	43.61
r≤6	r≥6	0.011973	0.43365	97.26	0.43365	40.19

***(***) denotes rejection of the null hypothesis at 5% significance level.