Is Ghana Catching up with Her Colonial Master? A Time Series Analysis into Speed of Convergence Between Ghana and UK

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Abstract
This work set out to undertake a study into time series speed of convergence between two 'worlds'. That is the developing and the developed 'world'. The study used data on Ghana to represent developing countries and the United Kingdom data to represent developed countries. The study also calculated the number of years Ghana would need to catch-up with UK in terms of growth. The period used in the study was from 1958-2011. The work found evidence in favour of convergence between the two countries using time series technique. However, when the study tested the series from 1958 to 1970 (where this period also included a policy of import-substitution industrialization) there was evidence of convergence. In calculating the speed of convergence that is the number of years both countries would converge, then Ghana would catch-up in 183 years. However, a growth catch up simulation suggests that Ghana will converge with the UK in 22 years with a growth rate of 11%, and with a rate of 5% Ghana would catch up in 72 years and UK growing at a rate of 2.4%. The study therefore recommends industrialization as the main driving force for faster catch-up.
Keywords: Convergence, Speed of Convergence, Economic Growth, Time Series Analysis

1. Introduction

An analysis of world income distribution has brought about the significance of economic growth. Economic growth has ensured that the average person on the planet has been getting richer over time. Specifically, the total number of people with income below the one dollar per day threshold declined by more than 300 million. A clear conclusion is that economic growth has led to substantial reduction in the world's poverty rates and head counts (Sala-i-Martin and Barro ,2004). Sala-i-Martin (2004) noted that poverty eradication has been most pronounced in the regions where growth has been the largest. For example in 1970, East Asia and South Asia have experienced substantial reductions in poverty rates.

An acknowledgement of our comfort, lifelong living, and living with less physical suffering in terms of health will help us appreciate the issue of economic growth more closely. We enjoy more leisure and more options in terms of consumption and work. Growth has ultimately given humankind ways to control the environment and improve lives, helped humankind to find answer to challenging health issues and general disabilities, and has provided us with a means to achieve s;atisfaction from all material wants with less effort and expanded the variety of economic activities.

Consecutive governments all over the world especially in developing countries (with Sub-Saharan Africa (SSA) as the locus) have aimed at reducing the level of poverty and attainting high economic growth and development. Various economic policies have been pursued over the years. Some of these policies have worked to some extent while others are complete failures. It is important to note that, a requirement to better policies is a better understanding of growth. Kaldor (1963), listed a number of stylized facts that he thought typified the process of growth. These include (1) per capita output increases over time and its growth rate does not tend to diminish (2) physical capital per worker increases over time (3) the rate of return to capital is nearly constant (4) the ratio of physical capital to output is nearly constant (5) the percentage of la;bour and physical capital in national income are nearly constant (6) the growth rate of output per worker differs substantially across countries. If we explore these facts, we could come to an interesting conclusion between the growth of developing and developed countries. One pattern that was noticed in a cross-country dataset by Barro and Sala-i-Martin (2004) is that growth rate of per capita GDP for developing and developed countries from 1960 to 2000 is essentially uncorrelated with the level of per capita GDP in 1960. That is, poor countries grew relatively faster than rich countries. In a simple terminology, the study refers to such a tendency for the poor to grow faster than the rich as beta convergence. In the 1950s, proportional growth of income per head was roughly the same between developed and developing countries, each taken as a group (UN Yearbook of National Accounts Statistics, 2012). Again, the poorest developing countries gained on the richest countries with the ratio of incomes per head falling from 15:1 to 13:1. This indicates an overall catching up of developing countries (Clunies-Ross et al, 2009).

A close analysis of convergence would offer suggestions as to how the gap that exist between the developing countries and developed countries could be narrowed if not completely closed. Such an investigation of the growth progress made by developing countries by examining how fast they are catching up with developed ones would be very good. However, analyzing all developing and developed countries in a single study will be a huge task especially when using time series methodology. Thus, the study would use data on Ghana to represent developing countries and data on United Kingdom to represent developed countries. The main objective of this chapter is to test whether or not the convergence hypothesis holds for developing countries and developed countries. The focus here would be on two countries because using multiple countries makes the policy implication difficult to arrive at as literature has shown. The specific objectives are (a) to test whether Ghana is catching up with UK in terms of economic growth (b) to examine the factors that have helped cause such growth catch-up if it exist (c) the calculate the duration of catch up using time series technique. Reasons why Ghana and UK are used are outlined below

Firstly, Ghana before 1957 was a colony of United Kingdom. Throughout this period, Ghana inherited institutional and economic policy style from her colonial masters. Trying to compare Ghana with some other country apart from UK will call for a lot of consideration including style of governance, arbitration system, rule of law etc. Secondly, GDP growth rate of Ghana was twice as fast as that of UK from 1950 to 1956. Available data indicate that from 1950 to 1956, GDP growth rate for Ghana averaged at 4.69% and that for UK averaged about 2.62% (conference-board, 2012). This on the surface depicts convergence in growth. Because Ghana was growing faster than UK and when maintain, catch-up would occur. Generally, the expectation is that, there is a continuous upward movement in GDP growth for Ghana as against that of UK. But what is the prevailing situation after independence? Is the catch-up on, or has halted? Is there divergence in growth? The work thus concentrates on years after independence (1958).

Another reason for using Ghana and UK is that both countries have economic performances that are very similar to their respective groups in their sub-regions. Economic, social, and climatic characteristics of SSA countries could be observed also in Ghana. Ghana's economic performance is very similar to the rest of other SSA. The table shows the performance of Ghana in terms of growth in relation to other countries

Table 1: Comparison between Ghana's growth rate and other West African Countries' growth

Year	Average GDP Growth Rate		Average GDP per capita Growth Rate	
	Ghana	Other SSA countries	Ghana	Other SSA countries
1960-2011	3.418	3.531	0.7998	0.8383

Sources: African Development Data, 2012. Note: Averages were computed by author.

Table 1 indicates that from 1960–2011, average GDP growth rate for Ghana, does not vary altogether differently from other West African countries. A similar analysis could be made for the UK. Below is a table that shows the economic performance of UK as compared to other Western European countries.

Table 2: Comparison between UK's growth rate and other Western European Countries' growth rate

Year	Average GDP Growth Rate		Average GDP per capita Growth Rate	
	UK	Other Western European countries	UK	Other Western European countries
1960-2011	2.409	2.777	2.052	2.337

Source: World Development Data, 2012. Note: Averages were computed by the author.

Table 2 indicates the average GDP growth from 1960-2011. UK's average GDP growth was 2.4% while that of other Western European countries was 2.7%. There is no wide variation in those two averages. The study could thus use UK as correct placeholder for other Western European countries.

Lastly, previous literatures have shown that policy recommendation for time series data when more than two countries are involved is always difficult. Examples could be seen in the following studies: Ramlogan-Dobson and King (2011), Cunado and Gracia (2006) and Kim and Evans (2011). Even though these works used very good econometrics approach in the test of convergence, policy recommendation was missing. This is because different countries pursue different economic policies at different times. Therefore, finding a single policy to work for all countries used in a study will be very difficult if not impossible. For instance, if this current study used an average growth rate for all SSA countries, then recommending a single growth policy will be merely impossible. To prescribe a policy, each country should be considered individually. That is the reason why Ghana and UK are used to give a fair idea of catch-up for SSA countries and prescribe appropriate policies for both countries.

Literatures that exist on time for catch-up are mostly in the area of cross-sectional and panel data methodology. The reason for this is not farfetched. The duration of catch-up approach was initially culled out from a cross sectional data set in the Solow's convergence model. Later, researchers began to use panel dataset when they realized the problems associated with cross-sectional methodology. Time series technique for catch-up and its duration mostly existed for developed countries data. Ones that exist on developing countries do not mostly prescribe direct policy recommendation because of using more than two countries. The advantage of time series methodology over cross sectional and panel data methodology in calculating the time of catch is that it allows for easy comparison between two series. This works very well for only two series of data. This work attempts to ascertain whether the issue of convergence really holds for Ghana and UK and seeks to calculate the period of years Ghana will need to catch-up with UK using time series methodology.

This work is divided into five sections. Section one considers the introduction and motivation of the study. Section two discusses the literature review of time series convergence both theoretical and empirical aspect.

Section three discusses the methodology and presents the results of convergence hypothesis. Section four entails the calculation of time series speed of convergence. Section five considers the recommendation and policy inference.

2. Literature Review

2.1 Theoretical Literature on Convergence Hypothesis

To understand the issue of convergence, it would be worthwhile to consider Gerschenkron (1962) theory of advantage backwardness. The theory could be summarized in four major point. Firstly, a backward economy is saddled with these characteristics: stressing upon the need to increase domestic production goods needed for production instead of goods needed for consumption; an emphasis on capital-intensive method of production instead of labour intensive method; increasing large-scale production units of firms within the country; reliance on borrowed technology instead of local indigenous ones. Secondly, a backward economy is likely to have an agricultural sector that may not be able to provide market for a growing industrial sector productivity. Thirdly, a backward economy is likely to have more intervention in the market economy. Such interventions are mostly in the area of channeling capital and entrepreneurial leadership to promising industries. Lastly, relative backwardness creates a tension between the promise of economic growth, as attained somewhere, and the permanence of stagnation. Such a tension assumes political form and encourages institutional innovation, whose product becomes suitable replacement for the missing preconditions for growth. Using the theory of advantage backward backwardness, Gershenkeron (1962), noted the German's industrial revolution of able take advantage of its backwardness in relation of UK, through the adoption of some UK technologies and methods of production that augmented growth. At the same time, German avoided the errors committed by those countries that have industrialized before them. The authors also noted how those countries that were late in industrialization such as German built new and innovative institutions to enable them manage the problems associated with backwardness. This actually meant that the experience of those countries that industrialized late was institutionally more developed than those who industrialized earlier. Following from this, if developing countries (e.g. Ghana) take advantage of these situations, then they should converge with developed countries (UK).

Convergence is an idea that has gained reputation among economists, not only because of the importance of the issue about poor countries catching up with rich ones, but also because this analysis can serve as a way to prove the soundness of different growth models. Convergence hypothesis of the Solow-Swan model is of two major types. These are Absolute and Conditional convergence hypothesis. The Absolute Convergence hypothesis states that in the long run, *all* countries or regions should converge to the same steady-state growth rate and per capita income. Conditional convergence implies that a country or a region is converging to its own steady state. These hypotheses are mostly tested using cross-sectional data.

Cross sectional technique to convergence analysis has been widely used. The most frequently cited study of absolute (unconditional) convergence was performed by Baumol, who based it on sample data of 16 OECD members (Baumol, 1986). The fascinating conclusion about his work is the reliance of the absolute convergence hypothesis on the sample used. From the original OECD sample, Baumol obtained a significant negative coefficient of the initial income variable used in the estimation. Hence, the result supported absolute convergence (Urmas et al and Priit et al 2005). However, Baumol (1994) found a nonexistence of convergence when he sampled about 70 countries. Actually, the results of these two empirical studies supported the idea of the existence of club convergence. Later, a World Bank economist discovered that a sample of over 80 countries for the period 1965–89 provided no evidence of unconditional convergence. Please see also Barro and Sala-I-Martin (1991, 1992, 1995), Dowrick and Nguyen (1989), Barro (1991), Mankiw *et al.* (1992), Bernard (1992), Quah (1993), David (1993, 1996), and Sachs and Warner (1995), Ben-David and Kimhi (2000), Romer and Weil (1992) many researchers.

Because of the problems associated with cross-sectional analysis, Bernard and Durlauf (1989) and Durlauf (1995) utilized the Dickey-Fuller unit root testing procedure as a time series based test of convergence. Many researchers have used this methodology in time series analysis. These include Durlauf and Johnson (1995), Gomez and Santaularia (2007), Levin and Lin (1993) and Lin and Chu (2002), Bernard (1992) and Durlauf (1989), Greasley and Oxley (1997).

Theoretically, tests for convergence require cross-country per capita output difference to be stationary and non-stationary difference depicts divergence. In the case of two economies, this definition of convergence is relatively clear. In a multi-country situation, some researchers have taken deviation 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 (see Carlino and Mills 1993). 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 useful for time series convergence test, have serious power problems. One of the solutions to

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this problem is increasing the sample size.

With the ADF test, the study analyzes the stationarity properties of the logarithm differences of real per capita income between two given economies. The convergence hypothesis can be studied using this approach by estimating the following basic model:

$$y_{i,t} - y_{j,t} = \vartheta + \partial T + \alpha(y_{i,t-1} - y_{j,t-1}) + \varphi_k(y_{i,t-k} - y_{j,t-k}) + \epsilon_t \quad (1)$$

Where:

- $(y_{i,t} - y_{j,t})$ is the logarithmic difference in per capita income in two economics, say *i* and *j* in time period *t*.
- T is a deterministic trend.

Using the above equation in estimating procedures, there are four (4) results that can be obtained. These are as follows,

I. If $\partial < 0$ and $\alpha < 0$, the series $(y_{i,t} - y_{j,t})$ is said to be stationary around a negative deterministic trend. In other words, there is a tendency for the difference in per capita income to narrow over time. This postulates catching-up or stochastic convergence.

II. If $\partial = 0$ and $\alpha < 0$, the series y_i and y_j are cointegrated. In other words, the reductions in per capita income difference have ended and remain stable over time. This postulates Long-run convergence or deterministic convergence.

III. If $\partial = 0$ and $\alpha = 0$, income difference follows a random walk or is nonstationary. In other words, per capita income difference is unpredictable. This postulates divergence hypothesis.

IV. If $\partial < 0$ and $\alpha = 0$, the income difference is decreasing but in an inconsistent way. This also postulates loose catching-up. According to Gomez (2007), loose catching-up suggests that economy *i* is erratically, but also inevitably, catching up with economy *j*.

2.1.0 ADF test with Structural Break

Time series methodology however has some difficulties. 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. Kane (2001) writes 'testing for unit-roots can be difficult for three (3) main 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 root'. Phillip and Perron (1989) have shown that the effectiveness of the unit root tests decreases significantly in the presence of structural breaks by biasing the results towards the non-rejection of the null hypothesis. If the structural break in the trend function is not catered for, it allows for a bias by decreasing the power of the test.

There are other ways to deal with structural break but this work shall consider only two. Applying Perron's unit root testing strategy requires the prior specification of break point years. In other procedures, Chow test for structural break or introducing a trend dummy variable in the functional equations could be used. By using the trend dummy variable where a major break is known, the following functional equation is fitted to allow for the issue of break points:

$$(y_{i,t} - y_{j,t}) = \vartheta + \partial T + \alpha(y_{i,t-1} - y_{j,t-1}) + \emptyset DT_t + \varphi_k(y_{i,t-k} - y_{j,t-k}) + \epsilon_t \quad (2)$$

Where DT_t represents the trend dummy varibles

$DT_t = t - T_B$ if $t > t^*$ $(break\ date)$ and 0 in any other case.

If the income gap is increasing after the break date (t^*), the estimation result for $\emptyset$ value could be greater than zero.

There are various methods of testing for multiply structural break. Some of these methods include Lagrenge-Multiplier unit root with two structural breaks, Andrews and Ploberger (1994) test, Lumsdaine and Papell (1997) unit root test, Zivot and Andrew (1992) test and Bai-Perron Unit root test. Of all these test, the one that has the ability to test up to five breaks point with date is the Bai-Perron (1998) test. The starting point of this model is that the dates and breaks are unknown variables to be estimated. The test procedure is as follows. Consider the following regression with *n* breaks *(n+1 regimes)*

$$y_t = x_t' \propto + Z_t' \partial_j + \varepsilon_i \quad (3)$$

For $j = 1, \ldots\ldots, n+1$ and a rule is used for T such that $T_o = 0$ and $T_{n+1} = T$, where for the above equation y_t = independent variable, X_t *(px1)* and Z_t *(qx1)* are vectors of covariates, $\propto$ *and* $\partial_j (j = 1 \ldots . m+1)$ = the corresponding vectors of coefficient ε_i = disturbance term. The break points are treated as unknown. The aim of this equation is to estimate the unknown regression coefficient together with the breakpoint when the time observation for y_t, x_t, *and* z_t are given. In this, we do not subject $\propto$ to any shift. If we denote the true value of the parameter with superscript 0, then equation 3 becomes

$$y = x \propto^0 + \bar{Z}^0 \partial^0 + u \quad (4)$$

We then have to run the regression and estimate the unknown coefficient($\propto^0, \partial_1^0, \ldots, \partial_{m+1}^0, T_1^0, \ldots, T_m^0$), and assuming that $\partial_i^0 \neq \partial_{i+1}^0$ $(1 \leq k \leq m)$. We do not impose the restriction that the regression function is continous at the turning points. In general terms, the number of breaks n are unknown variables as already stated with n^o. For each n-partition (T_1.........,T_m), denoted {T_j}, the associated estimates are obtained by minimizing the sum of squares residuals $\sum_{i=1}^{n+1}\sum_{t=T_{i-1+1}}^{T_i}[y_t - x_t' \propto -Z_t'\partial_i]^2$. Let $\hat{\propto}$ ({T_j}) and $\hat{\partial}(\{T_i\})$ denotes the resulting estimate. Substituting them in the objective function and indicating the resulting sum of squares residuals as $S_T(T_{i,\ldots\ldots,}T_m)$ the estimated break point $(\hat{T}_i, \ldots, \hat{T}_m)$ are such that

$$(\hat{T}_i, \ldots, \hat{T}_m) = argmin_{T_1\ldots\ldots T_m}\, S_T(T_1 \ldots\ldots T_m) \qquad (5)$$

Where $T_i - T_{i-1} \geq q$. Therefore, the break-point estimator are global minimizes of the objective function. Meaning it is feasible, and its value is not larger than the value of any other feasible point. This regression is carried out with some set of assumptions.

Assumption 1: Let $q_t = (x_t', z_t')$, $Q = (w_1 \ldots\ldots w_T)'$ and $\bar{Q}^0$ be the diagonal partition of Q at $(T_i^0 \ldots\ldots\ldots T_m^0)$ such that $\bar{Q}^0 = diag\,(Q_1^0, \ldots.. Q_{n+1}^0)$. We assume for each i=1,…..n+1, with $T_0^0 = 1$ and $T_{n+1}^0 = T$, that $Q_i^{0'} Q_i^0/(T_0^0 - T_{i-1}^0)$ converges in probality to some nonrandom positive definite matrix not necessarily the same for all *i*.

Assumption 2: There exist an $\ell_0 > 0$ such that all $\ell > \ell_0$, the minimum eigenvalues of $D_{i\ell} = (1/\ell)\sum_{T_{i+1}^0}^{T_{i+1}^0} q_t q_t'$ and of $D_{i\ell}^* = (1/\ell)\sum_{T_{i-1}^0}^{T_i^0} q_t q_t'$ are bounded aways from zero (i=1,…. n+1).

Assumption 3: The matrix $D_{k\ell} = \sum_K^\ell z_t z_t'$ is invertiable for $\ell - k \geq p$, the dimentsion of z_t.

The error term satisfies any one of the following sets of condition

Assumption 4: The disturbance is independent of the regressors for all t

Assumption 5: The disturbance is a martingale difference sequence. That is its expectation with respect to the past is zero.

Based on these set of assumptions, Bai-Perron gave two statistical properties of the estimators. These are consistency and asymptotically distributed (limiting distribution). An asymptotic distribution provides approximations to the cumulative distribution functions of an estimator. By consistency, we mean that as the sample size gets larger and larger, the estimate gets closer and closer to the true value of the parameter. To undertake the multiple break tests, Bai and Perron specified some set of hypothesis. The first set of hypothesis is a test of no break versus some fixed number of breaks. The second set is the test of no structural break against an unknown number of breaks given some upper bound *n*. The third set of hypothesis is a test of the null hypothesis of ℓ breaks against the alternative that additional breaks exist $(\ell + 1)$. The issue of sequential estimation of the breaks point was also addressed. This is mostly used to estimate models with an unknown break.

2.1.1 Lag length

Another issue of time series is the selection of lag length. The problem is further deepened by the un-identical lag length for all the separate individual economies. On this issue of lag length, Perron (1991) states 'in the case of time series, the choice of the number of lags is crucial, because it affects both the level and the power of stationarity tests'. This problem associated with the selection of lag length could be handled by using two different procedures even though there are other procedures used by different authors. First is the use of Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). Another way is to use the Hanna-Quin's criterion (1976). According to this, the lag length could be derived from

$$\log(\hat{\sigma}^2) + 2(p+q)\, log\, \frac{[\log(T)]}{T} \qquad (6)$$

Where $\hat{\sigma}^2$ is the residual variance, p is the number of variables considered in the model, q is the lag's order and T is the sample size. These two procedures give similar results.

2.2 Empirical literature on time series convergence

These theoretical underpinnings have brought about different types of time series convergence.

2.2.0 Catching Up Convergence Approach

Catching up refers to an absence of unit root in the difference in per capita output between two countries. Suppose two countries *a* and *b*, and represent the respective log per capita real output as Y_a and Y_b. There is Catching-up if unit root is absent from the series $Y_a - Y_b$. This largely indicates that the economies are out of long run equilibrium. By this, catching up refers to the situation where the difference in per capita output is narrowed over time.

2.2.1 Long-run Convergence

Long-run convergence refers to the situation where there is absence unit root and the absence of a time trend in the deterministic process. Suppose two economies *a* and *b,* and represent their logarithm of output per capita as

Y_a and Y_b. Long-run convergence indicates that unit root is absent and time trend in the deterministic process is absent. If time trend exist, it only indicates that the gap between the two countries is narrowing but convergence has not yet been achieved. But if time trend is absent, catching up has completed (Les Oxley 1995).

2.2.2 Deterministic Convergence and Stochastic Convergence

According to Islam et al (2003) the convergence debate has turned into different interpretation. Several researchers, such as Bernard and Durlauf (1996), Carlino and Mills (1993), Evans (1996), and Evans and Karras (1996a), Qing and Papell (1999), and others have investigated convergence using time series econometric methods. These researchers have invariably defined 'within convergence' as actually a time series concept. Within Convergence states that, no matter whether the economy starts from a per capita capital stock that is lower or higher than the equilibrium capital level the substitution possibility or diminishing returns force the economy to converge to the equilibrium. However, researchers have used time series analysis to examine 'across convergence' too (convergence across a section of countries). From this point of view, two economies, i and j, are said to converge if their per capita outputs, $y_{i,t}$ *and* $y_{j,t}$ satisfy the following condition:

$$\lim_{k\to\infty} E\left(y_{i,t+k} - a.y_{j,t+k} \middle| I_t\right) = 0 \quad (7)$$

Where I_t denotes the information set at time t.

This definition of convergence is relatively clear for a two-economy situation. This is not so when convergence is considered in a sample of more than two economies. Researchers differ on defining convergence in such multi-country situations. Some have taken deviations from a reference economy as the measure of convergence. In this situation, y_{it} in the above equation is replaced by y_{1t}, where *1* is the index for the reference country. Others have based their analysis of convergence on deviations from the sample average. In this treatment, y_{it} is replaced with $\overline{y}_t$, the average for time t. This difference is not safe, as proposed by Islam. (Islam et al 2003).

Oxley and Greasley (1995), utilize time series data on Australia, Canada, UK, and USA for the period 1870-1993 and time series tests based upon the Augmented Dickey-Fuller approach to consider both catching-up and long-run convergence with particular focus on Australia and Canada. The paper found evidence in favour of long run convergence in per capita income levels for the UK and Australia catching-up in all other bi-variate comparisons. The authors used Zivot and Andrew (1992) method to take care of structural break. But Lee and Strazicich (1999) found some problems with this method. However, Kane (2001) used time series analysis to investigate convergence in US region and found evidence that the U.S. regions have conditionally converged in per capita earnings. The author however did not consider the issue of multiple structural break which can affect the test results.

Barossi-Filho and Azzoni (2003) dealt with regional income convergence in Brazil. In order to test for the existence of evidences on income convergence endogenously determined break points were introduced in the analysis. The results indicated that there were signs of stochastic convergence of income at the macro regional level, with the exception of the North region. Stochastic convergence requires that relative regional earnings be stationary. Shocks to a stationary time series are temporary in that their effects will dissipate and the series will revert back to its long-run mean or trend. If relative earnings are non-stationary for a particular region, then shocks affecting that region's relative earnings have permanent effects and convergence will not occur. In order to determine whether a series is stationary, we must test for unit roots in the auto-regressive terms. If a unit root is present, the series is non -stationary. Data used for this work spanned from 1947 to 1998 which is old in contemporary literatures in convergence. Again, with this time span, there could be the possibility of more than two structural breaks but the method adopted for testing multiple break (Lee and Strazicich, 1999) could test only up to two breaks. Brown et al (1990), Loewy and Papell (1996) and Carlino and Mills (1993) used this same technique of break point in their convergence analysis. Not only did they use this technique, they further strengthened it by working with endogenously determined break points rather than the normal exogenous break point.

Using historical time-series data set, Giles (2001) tested for convergence and common trends in real per capita output for New Zealand and her four major trading partners (Japan, Australia, UK and USA). The results of this study are quite similar to most other related studies. The unit root/cointegration analysis propose a general absence of stochastic convergence (except in a few bilateral cases), but it also suggests the existence of three common trends in the five output series. Even though the use of Fuzzy Clustering was innovative, structural break with is an important component of time series methodology was missing.

Asteriou et al (2011), also examine income convergence across the regions of Greece. The findings of the study are not in accordance with the neoclassical model and gave evidence to the popular view prevailing in Greece, about the existence of economic dualism across the Southern and Northern regions of the country. Economic dualism is a way of conceptualizing the existence of two or more separate but symbiotic sets of economic processes within the same political and national social framework. A typical example is the coexistence of peasant farming and cash production of basic commodities within the same social framework. Even though this work applied a multivariate methodology in testing convergence using time series data, issues of single or multiple structural breaks was missing.

Cunado and Gracia (2006) examined the real convergence hypothesis in 43 African countries using time series techniques. The catch-up rates for these countries were compared with US. The authors applied unit root test allowing for multiple structural breaks using the LM unit root test and found evidence of conditional convergence for the case of Seychelles. With the catch-up hypothesis, the study found evidence of convergence both towards the Africa average for these countries: Benin, Cameroon, Cape Verde, Djibouti, Egypt, Ghana, Kenya, Mali, Uganda and Zimbabwe and towards the US for these country: Cape Verde, Egypt, Mauritius, Seychelles and Tunisia. This work has two main critics: firstly, data used was from 1950 to 1999, which is quit old relative to contemporary work, secondly, because the work tried to compare the US growth with 43 African countries, specific recommendation in terms of policy was missing. This is understandable because there have been different policies for different countries therefore if we need to access the impact of a single policy, we then have to focus on each individual country. This is the disadvantages sometimes when working with time series data for more than two countries. The same criticism could also be advance for the work by Kim and Evans (2011). This study also sought to find out whether 13 Asian countries could converge stochastically with US using Carrion-i-Silvestre et al (2005) unit root test. The study found that there was evidence of catch-up rates. But the study was not able to provide meaningful policy implication for these Asian countries.

Working on Southern Africa, Kumo (2011) sought to inquire about the two aspects of intra- regional convergence among countries that belonged to the Southern Africa Development community (SADC) from 1992 to 2009. The first aspect had to do with convergence to the regional average per capita income and the second had to do with investigation of macroeconomic convergence needed to aid deeper economic integration. Results of the study showed that there was no evidence of absolute beta and sigma convergence in real per capita GDP. But on an individual level, ADF unit root test indicated that Botswana and South Africa's real per capita GDP converged to a common stochastic trend while the rest shoed a boundless drift.

The above studies used a linear time series technique in testing convergence. Chong et al (2008) discovered nonlinear time series technique by applying ADF test and added a smooth transition autoregressive processes to data on for 15 OECD countries as against that of US. The work found evidence of convergence for four countries when time trend is included in the test equation. But this study did not take in consideration multiply structural breaks. Ramlogan-Dobson and King (2011) extended this work and investigated whether such an omission affected the outcome. By allowing for multiple breaks, the work found greater evidence for convergence. but again, no real policy implication was put forward. This study seeks to divert from such literature by considering only two countries to help in policy recommendation.

Iancu (2007) deals with the economic convergence of European countries, and especially the convergence of the CEE countries, including Romania. Iancu (2007) used models to assess the economic growth, approximate the period of real convergence of Romania to the EU, as well as to estimate the σ-and β-convergence. In calculating the approximate period when convergence of Romania's GDP growth might occur with the EU, Iancu (2007) started with the simple relations concerning the GDP per capita growth of the two entities (Romania and EU) with different initial levels and annual average growth rates. The author concluded that when Romania grows by 4%, 5%, 6%, 7% and 8%, it will take 57 years, 39 years, 30 years, 24 years and 20 years respectively to catch up with EU 15 and the two EU leaders of France and Germany.

2.3 Time Series duration of Catch-up

The issue of the speed of convergence in relation to cross-sectional methodology has been broadly discussed and analyzed by various researchers. Time series speed of convergence, however, has not enjoyed such broad spectrum discussion. Relatively fewer researches have actually been carried out in this area. Key among those is Iancu (2007).

The most frequent question concerning the economic growth convergence (time series and cross-sectional) refers to the length of the process. In an analyzes the convergence of the real economies of two countries or two proxy countries, the first thing to spell out is the length of the period (time) necessary to achieve the future balance between these two countries' annual average per capita income. Take note that, the initial level of GDP per capita of the two economies is usually characterized by a significant difference especially if one economy is in the developing world and the other economy is in the developed world. A faster closure of the length of process (time gap) could be achieved within a reasonable period of time, only if the lagging economy is able to attain an annual average growth rates per capita much higher than the leading country.

3. Methodology and Empirical Analysis

3.1 Data

Data used for the study was obtained from Penn World Table version 8.0 (PWT 8.0). Penn World Table provides Purchasing Power Parity and National Income accounts converted to international prices for 189 countries for some or all of the years 1958-2011. One major characteristics of the Penn World data set has been the measurement of GDP in two main ways. The first measurement is GDP in national currency and the second measurement is GDP in purchasing power parities (PPP) to correct for difference in prices across countries.

Table 3: Summary of the Key Variables for United Kingdom and Ghana

Descriptive	UK	Ghana
Mean	20331.97	1710.50
Standard Error	944.55	41.045
Median	18011.97	1741.11
Standard Deviation	6941.014	301.62
Sample Variance	48177682.83	90976.97
Kurtosis	-1.17	-1.15
Skewness	0.47	0.08
Range	21237.20	1111.57
Minimum	10831.66	1168.43
Maximum	32068.87	2280.01
Count	54	54

Source: Author, 2017

Table 3 presents a summary statistics of the key variable used in the study from 1958 to 2011. That is GDP per capita for both countries. The mean per capita for UK is 20,331 while that for Ghana is 1710. For UK the skewness of the distribution is a little bit tilted towards the left. This indicates that income has varied widely over the years under consideration. The UK started on a per capita income of 10,831 and has grown to attain an income of 32,068. In the case for Ghana, per capita income has not varied much indicating the slow pace in term of growth. The lowest per capita income is 1168 and the highest is 2280. This explains why the skweness is 0.08 approximately getting closer to zero. The range also gives an indication of f the levels of growth for both countries. While the range is very large for UK, that of Ghana is relatively small.

3.2 Model Specification

3.2.0 Model I: Time Series Convergence Hypothesis for Ghana and UK

To test the convergence hypothesis for Ghana and UK, the study followed, Gomez and Ventosa-Santaularia (2007), Ranjpour and Zahra (2008) and Oxley and Greasley (1995) methodology of testing the unit root with time trend in the following equation. 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),

The specification of the equation is given below,

$$GDP_{UK,t} - GDP_{GH,t} = \Psi + \omega\left(GDP_{UK,t-1} - GDP_{GH,t-1}\right) + \beta t + \varphi_k\left(GDP_{UK,t-k} - GDP_{GH.t-k}\right) + \epsilon_t$$

(8)

Where $GDP_{UK,t}$ is the logarithm of real GDP per capita for United Kingdom from 1958 to 2011.

$GDP_{GH,t}$ is the logarithm of real GDP per capita for Ghana from 1958 to 2011

Ψ = constant term

β = coefficient of deterministic trend

Equation 8 could be simplified as follows

$$\Delta_{GAP} = \Psi + \omega GAP\_1 + \beta t + \Delta GAP_{t-k} + \epsilon_t \quad (9)$$

Where $\Delta\_GAP = \left(GDP_{UK,t} - GDP_{GH,t}\right)$

$GAP\_1 = \left(GDP_{UK,t-1} - GDP_{GH,t-1}\right)$

$GAP_{t-k} = \left(GDP_{UK,t-k} - GDP_{GH.t-k}\right)$

Testing time series convergence hypothesis for two economies comes down to testing whether the series $GDP_{UK,t} - GDP_{GH,t}$, has a unit root or otherwise (Evans and Karras, 1996). The convergence hypothesis hold for both economies if;

- the difference between the log of GDP for UK and Ghana must not contain a unit root, thus $\omega < 0$. If β ≠ 0 (i.e. the existence of a deterministic trend) the series described indicate catching up.
- If the difference in the series does not contain a unit root, thus $\omega < 0$ and an absence of a time trend in the deterministic process thus β = 0 than it indicate long run convergence.
- If the difference in the series contain unit root, thus $\omega = 0$ the two economies diverge.
- If the difference in the series contain a unit root, thus $\omega = 0$, but there still exist a deterministic trend in the series thus β ≠ 0, there is loose catching up.

The study used Akaike Information Criterion to determine the lag length n for $\sum_{k=1}^{n}\left(GDP_{UK,t-k} -\right.$

$GDP_{GH.t-k}$). As the rule of thumb rightly point out, use the length with the smallest AIC. Reasons for using AIC over other information criteria are that Bozdogan (1987) found that AIC are asymptotically consistent and penalize over parameterization more stringently to pick only the simplest of the "true" models. These criteria are called Consistent Akaike Information Criterion (CAIC) and Consistence Akaike Information Criterion with Fisher Information (CAICF). Burnham and Anderson (2004) showed that AIC can be derived in the same Bayesian framework as BIC simply by using different prior. The theoretical advantage of AIC over the other information criteria lies in the derivation of AIC from principles of information. Again Yang (2005) showed that AIC is asymptotically optimal in selecting the model with the least mean square error. BIC is not asymptotically optimal under this set of assumption and that the rate at which AIC converges to the optimum is the best as compared to others.

3.3 Results

3.3.0 The result of the convergence model

Before the convergence test could be carried out, the first step is to determine the lag length. Table I at the appendix shows the results of the lag length. The rule of thumb for choosing the lag length is that the lag with the smallest AIC is chosen. From the table, the lag with the smallest AIC value is 3. That is, lag length 3 has AIC value of -7.038311. The study therefore uses three (3) lag lengths in the test of the convergence hypothesis. A test for the stationarity or otherwise of the series using 3 lag length with the Augmented-Dickey Fuller (ADF) test followed. The result of the ADF test is shown below

Table 3: The results of Augmented-Dickey Fuller test

Dependent Variable = Δ_GAP_t

Variable	Co-efficient	Stderror	t-stat
Constant	-0.0425	0.1233	-0.345
GAP_1	0.0681	0.0784	0.869
T	-0.0035	0.0019	-1.842***
GAP_{t-3}	0.2651	0.1536	1.726***

***(***) statistically significant at 10% level of significance

Source: Author's Estimate, 2017

The result of equation 8 has been presented in table 4. The results accept the existence of unit root and thus reject the convergence hypothesis. This is because the computed tau value for the co-efficient of GAP_1 must be negative and statistically significant. On the absolute form, the critical value for the sample size is 3.50. The computered value is thus lesser than the critical value, which leads to an acceptance of the null hypothesis of the existence of unit root. Another important aspect of this result is the existence of a time trend. This is evidenced from the fact that the co-efficient of T is statistically different from zero. That is, $\beta \neq 0$. The difference in the series contains a unit root $\omega = 0$, but there still exist a deterministic trend in the series $\beta \neq 0$. There is loose catching up. In other words, Ghana is erratically, but certainly catching up with the UK. The existence of deterministic trend in the series also indicates that predictions about convergence between the two countries could be made but not with sure certainty. Cunado and Garcia (2006) found similar evidence for some African countries: Cape Verde and Seychelles and the US economy.

3.4 ADF test with structural break

3.4.0 Model Specification

The above empirical analysis is done with the assumption of no structural break in terms of major economic and/or social policy that affects the per capita incomes of countries. The effectiveness of the unit root tests decreases significantly in the presence of structural breaks by biasing the results towards the non-rejection of the null hypothesis. Ghana has had several economic policy reforms. Some of these may include trade policy reforms to achieve greater openness, support for industrial sector development, support for agricultural sector development, rapid industrialization in the 1960s. Other reforms included the Economic Recovery Programme (ERP) in 1983. This was necessitated by Ghana's economic crisis in early 1980s. The program stabilized the economy and set it on a growth path. After this achievement, a Structural Adjustment Programme (SAP) was implemented from 1986 to bring about sustained growth and development of the economy. Not only is the study considering policy changes in the Ghanaian economy that of UK economy was also considered. The UK Economy has also had years in which policy change was much significant. Our goal here is to consider whether the results of convergence achieved is the actual or that the result was biased by structural breaks. The study considers one and two structural breaks using the Bai-Perron test. Before this is done, let us present a simple structural break test using dummy variables technique.

3.4.1 Model Specification (Model II)

By using a trend dummy variable where a major break is known, the following functional equation is fitted

$$GDP_{UK,t} - GDP_{GH,t} = \forall + \beta t + \pi\big(GDP_{UK,t-1} - GDP_{GH,t-1}\big) + \wp BT_t + \gamma_k\big(GDP_{UK,t-K} - GDP_{GH,t-K}\big) + \epsilon_t \quad (10)$$

Where

- BT_t represents the trend dummy variables
  $BT_t = t - T_B \ if \ t > t^* \ (break \ date)$ and 0 in any other case. The break date is 1975 (date the Structural Adjustment Programme started).

Equation 2 could be simplified as follows

$$\Delta_{GAP} = \forall + \beta t + \pi GAP\_1 + \wp BT_t + \gamma_k GAP_{t-k} + \epsilon_t \quad (11)$$

Where $\Delta\_GAP = \big(GDP_{UK,t} - GDP_{GH,t}\big)$

$GAP\_1 = \big(GDP_{UK,t-1} - GDP_{GH,t-1}\big)$

$HGAP_{t-k} = \big(GDP_{UK,t-k} - GDP_{GH.t-k}\big)$

If the income gap is increasing after the break date (t^*), then expect the estimation to result in a $\wp$ value statistically greater than zero. This means that the income gap between the two countries was increasing after the structural adjustment program. This may not necessarily mean divergence, but a mere widening of the income gap. It could mean the reforms had negative impact during its implementation stage but once it took off the positive impact far outweighs the negative. If $\wp = 0$ it means income gap was decreasing or remains the same between the two countries.

3.4.2 Results

Table 4: The result of Augmented-Dickey Fuller test with structural break.

Dependent Variable = Δ_GAP_t

Variable	Co-efficient	Stderror	t-stat
Constant	0.0784	0.1481	0.5299
GAP_1	0.7300	0.0974	7.4881***
T	-0.0045	0.0021	-2.1311**
BT_t	0.0932	0.0404	2.3070**
GAP_{t-3}	0.2771	0.1066	2.5991**

***(***) statistically significant at 1% level of significance **(**) statistically significant at 5% level of significance

Source: Author's Estimate, 2017

The results in table 5 reject the null hypothesis that $\wp = 0$, thus accept $\wp > 0$. This is because the coefficient of BT_t which is $\wp$ is statistically different from zero. The implication is that after the reforms (Economic Recovery Programme later the Structural Adjustment Programme), the gap of GDP per capita between the two countries was still increasing. This may not necessarily mean divergence, but a mere widening of the income gap.

3.4.3 Test for Convergence from 1958-1970

The study has already stated that Ghana has had major economic policy reforms. After independence, the then government embarked on a policy of import-substituting industrialization (ISI). The policy was a 7 year development plan: 1963/4-1969-70 aimed at modernizing the economy. The physical capital accumulation was the most contributor to output growth during this period. This policy improved the macroeconomic variables. During this period, real GDP growth stood at 6.78 percent and 5.56 percent in 1970 and 1971 respectively. At the same time, gross fixed capital formation as a percentage of GDP also stood at 12.0 percent and 12.4 percent in 1970 and 1971. Our interest here is to test the convergence hypothesis from 1958 to 1970 to assess the effects of this industrialization drive on the convergence process.

3.4.4 Results

Table 5: The result of Augmented-Dickey Fuller test from 1958-1970

Dependent Variable = Δ_GAP_t

Variable	Co-efficient	Stderror	t-stat
Constant	2.0569	0.2579	7.979***
GAP_1	-1.1931	0.1507	-7.916***
GAP_{t-1}	0.6321	0.0849	7.443***

***(***) statistically significant at 1% level of significance

Source: Author's Estimate, 2017

The results reject the null of unit root and thus accept the alternative of no unit root. This is because the coefficient of *GAP_1* is statistically significant even at 1 percent level of significance and negative. In other words, there was convergence in the two economies up to the period of import-substitution industrialization. From this result, it could be noticed that for Ghana to catch-up with UK in terms of growth, Ghana should embark on rapid-industrialization policy.

Before the study conduct a test for multiple structural break, a graphical representation for the concept of loose catch-up is presented in figure 3.1 below. The figure shows the GDP per capita growth rate for both countries. The left axis of the figure measures GDP per capita growth rate for Ghana while the right axis measures the GDP per capita growth rate for UK. From the figure, it could be noticed that while UK grows consistently showing intermittent fall in growth, that of Ghana has been very oscillatory. Ghana seemed to be catching up around 1968 but fell sharply. Such periods of catch-up and falling behind could be seen throughout the figure. Beyond 2010, we could observe a closure of the growth gap.

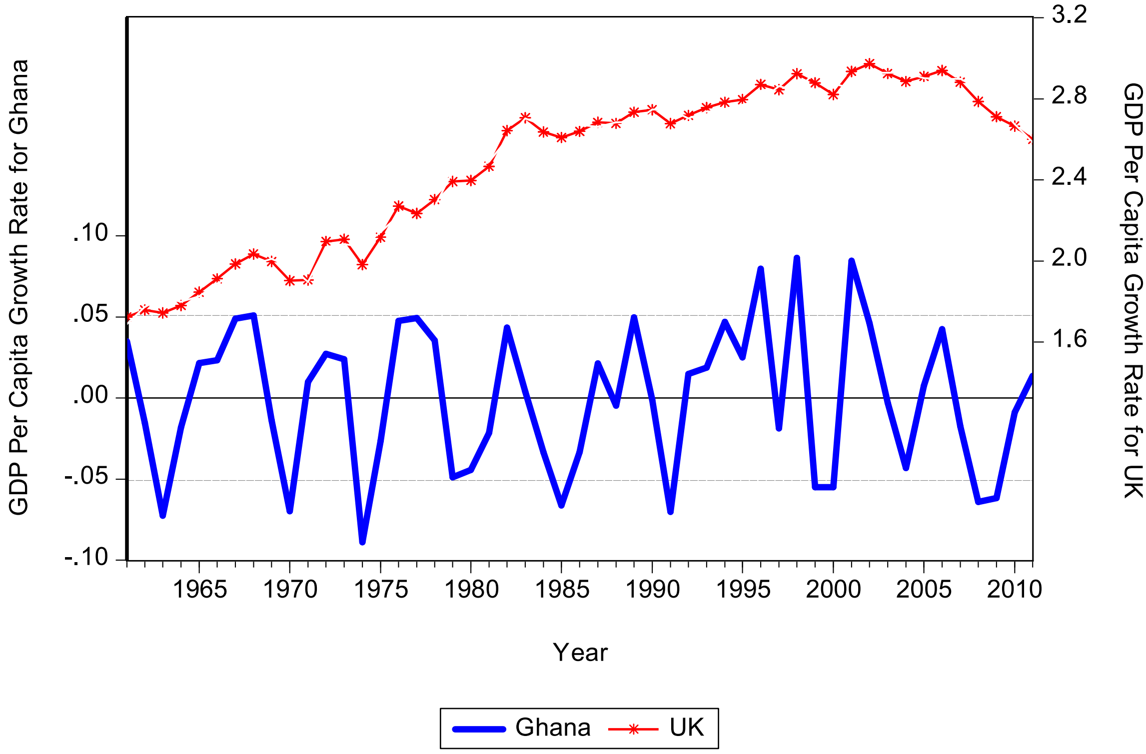

Figure 1: A plot of Ghana's and UK's GDP per capita Growth Rate over the period

3.5 Bai-Perron Multiple Structural Break test

To test for the multiplicity of the structural break we follow Bai-Perron and estimate equation 8 together with the breaks. The results for the test are displayed below.

Table 3.6: Results of Estimation using Bai-Perron Structural Break test

Dependent Variable = Δ_GAP_t

Variable	Co-efficient	Stderror	t-stat	Prob
Constant	-0.131103	0.126128	-1.039440	0.3039
GAP_1	0.837355	0.089545	9.351207	0.0000***
GAP_{t-3}	0.290597	0.111250	2.612101	0.0120**
T	-0.005508	0.002216	-2.485970	0.0165**

***(***) statistically significant at 1% level of significance **(**) statistically significant at 5% level of significance

Source: Authors Estimation, 2017

The above results indicate a test of stationarity having allowed for structural break according to Bai and Perron. As indicated earlier, if the difference in the series are stationary (i.e. the coefficient of GAP_1 is negative and statistically significant), then there is convergence between the two series. The above results showed that the coefficient of GAP_1 after taking care of possible breaks is positive and statistically significant and the coefficient of T (deterministic trend) is also statically significant. This means that even though the series is not stationary, there exists a deterministic trend. This points to the conclusion of loose catching-up as noted earlier.

Breakpoint specification

Before proceeding, a test for the existence of one or two structural break was conducted to confirm the breaks and estimate the break date. The results are displayed in table 8

Table 7: Results of a test for one or two structural break

Breaks	F-Statistics	Critical Value
1**	6.6788	16.37*
2**	14.3572	17.83*
Estimated Break Dates 1. 1972 2. 1972, 1984		

**Statistically Significant at 0.05 *Bai-Perron Critical Values

Source: Authors Estimation, 2017

The test result was conducted on two hypotheses: the null hypothesis that there exists one break point and the alternative hypothesis that no break point is present; the null hypothesis that there exist two break points and the alternative hypothesis that no break point exist. The test results showed an acceptance of the null of one and two breaks. This is because the F-value of the break is lesser that the critical value provided by Bai and Perron at 0.05 level of significance. Therefore, there exist two break points in the series. The estimated break date for one break is 1972 and that for two breaks are 1972 and 1984

Results of Bai-Perron Determined Breaks

Table 8: Results of the period before First Break Point: 1958 – 1971

Dependent Variable = Δ_GAP_t

Variable	Co-efficient	Stderror	t-stat	Prob
Constant	0.903196	0.639245	1.412911	0.1656
GAP_1	-0.753571	0.193335	-3.897748	0.0004*
GAP_{t-3}	-0.275606	0.279015	-0.987783	0.3293
T	0.009250	0.010540	0.877613	0.3855

Source: Author's Estimate, 2017 * Statistically significant at 1 percent level of significance

A test of stationarity of the period before the first break point was conducted. The test result is shown in table 9. The result shows that before the first break point, the difference in the series was stationary indicating a general catching up. Thus, the period from 1958 to 1971 was a period of convergence. This is understandable because the UK economy performed badly from 1960 to early 1970s according to Medhurst et al (2014). Around the same time, Ghana had introduced import substitution industrialization policy and that increased the economic growth. These two contracting events was the cause of convergence for the period.

Table 9: Results of the period before Second Break Point: 1972 – 1983

Dependent Variable = Δ_GAP_t

Variable	Co-efficient	Stderror	t-stat	Prob
Constant	-0.850237	0.624820	-1.360772	0.1814
GAP_1	0.689033	0.161097	4.277135	0.0001*
GAP_{t-3}	0.970408	0.328590	2.953244	0.0053**
T	-0.023804	0.022956	-1.036926	0.3062

Source: Author's Estimate, 2017 *statistically significant at 1% level of Significance
** Statistically significant at 5% level of Significance

The next period after the first break, date was from 1972-1983. The coefficient of GAP_1 for this regression is positive and statistically significant. This means that over this period the difference was not stationary. There was no catching up. This is also understandable because the UK economy began to improve from 1974 because of economic policies including and not limited to privatization and deregulation, reform of industrial relations, and tax changes introduced by Margaret Thatcher. This improvement coupled with Ghana's economic problems during this period was the cause of this economic growth divergence.

Table 10: Results of the period after Second Break Point: 1984 – 2011

Dependent Variable = Δ_GAP_t

Variable	Co-efficient	Stderror	t-stat	Prob
Constant	-0.614754	0.331829	-1.852624	0.0715
GAP_1	0.888262	0.097419	9.117942	0.0000*
GAP_{t-3}	0.428850	0.163527	2.622504	0.0124***
T	-0.006826	0.001999	-3.414774	0.0015**

Source: Author's Estimate, 2017 *statistically significant at 1 percent level of significance
**statistically significant at 5 percent level of significance
***statistically significant at 10 percent level of significance

The last period after the second break is a period from 1984 to 2011. The results are shown in table 11. The results show that the coefficient of GAP_1 is positive and statistically significant while there exist a deterministic trend in the series. This also points to the result of loose catching up. Over this period, both economies have had their fair share of upturns and downturns. A quick reference to figure 1 above offers a pictorial image to the concept of loose catching up. From the figure, it could be noted that there was convergence from 1958 up to the period of about 1970. After this period starting from about 1972, the growth gap began to widen as the economy of UK improved. But, the period after that has seen a close and open of the gap. In conclusion, all these support the initial results of loose catching up.

4. Time series Catch-up Period

4.1 Model Specification (Model III)

One of the most regular questions concerning the economic growth convergence relates to the duration with which the lagging country would catch up with the leading country. Specifically, when convergence of Ghana and UK is analyzed, the first thing to be clarified is the length of period necessary to achieve the future balance between the two economies. This section seeks to calculate such duration and also offer prediction of duration if growth rate of the lagging country increases over time. To calculate such duration, write the following equation

$$Y_{tGH} = Y_{GH}(1 + R_{GH})^{t} \quad (12)$$

$$Y_{tUK} = Y_{UK}(1 + R_{UK})^{t} \quad (13)$$

Where:

Y_{UK} is the initial level of GDP per capita for United Kingdom, R_{UK} is the average annual growth rate per capita for UK, Y_{GH} is the initial level of GDP per capita for Ghana, R_{GH} is the average annual growth rate per capita for Ghana. Convergence may be achieved when the values of the two relations are equal as shown in the following equation

$$Y_{tGH} = Y_{tUK} \quad (14)$$

$$Y_{GH}(1 + R_{GH})^{t} = Y_{UK}(1 + R_{UK})^{t} \quad (15)$$

By logarithmating and rearranging equation 3.15

$$t = \frac{logY_{UK} - logY_{GH}}{log(1+R_{GH}) - log(1+R_{UK})} \quad (16)$$

Using equation 16, the study calculate the time period which is presented in the table below

Table 11: The number of years to achieve convergence between Ghana and UK

Initial GDP per capita (1958) in PPP		Annual average growth rate of GDP from 1958 to 2011		Number of years (t) to achieve the convergence at current growth rates
Ghana	UK	Ghana	UK	**183**
1800	10831	3.4184	2.4094	

Source: Author's Calculation, 2017

The table includes the data used in the calculation formula (initial GDP per capita and the annual average growth rates) and the results representing the number of years required to achieve convergence with UK. According to the table, at an annual average growth rate of GDP per capita of 3.4184, Ghana would need 183 years to reach UK's level of growth and development. This is not to far from reality as Urmas and Priit (2005) found that at a growth rate of 3.2 for Estonia and 2.4 for EU 15 the duration of 100 percent catch-up would be 133 years.

4.2: Forecasting the number of years to achieve convergence between Ghana and UK using different growth rate of GDP for Ghana

Table 12: Table of Forecast

Initial GDP per capita (1958) in PPP		Annual average growth rate of GDP per capita for UK	Number of years (t) to achieve the convergence of alternative annual average growth rate in Ghana.					
Ghana	UK	2.4094	5%	6%	7%	8%	9%	11%
1800	10831		72	52	41	33	29	22

Source: Author's Calculation, 2017

According to the table, at an annual average growth rate of 5%, Ghana would need 72 years to catch-up with the level of UK, at a growth of 6% Ghana would need 52 years to catch up, at a growth of 7% Ghana would need 41 years to catch-up with UK, at the rate of 8% Ghana would need 33 years to catch-up with UK, at a rate of 9% Ghana would need 29 years to catch-up with UK and at a rate of 11% Ghana would need 22 years to catch-up. Making a claim that Ghana would catch-up in 22 years is not out of place as Iancu (2007) also found that Romania would catch up with the rest of EU 15 in 20 years if Romania grew at 8 percent. At a growth rate of 7 percent, Romania would catch-up in 24 years. The above result is not thus far from reality. The next issue is whether Ghana could grow at 11 percent. Available data from International Monetary Fund, World Economic Outlook Database (2015) showed that in 2011, Ghana's GDP grew as high as 13.6 percent. This was primarily a result of oil exploitation that ensured massive capital inflows. Thus, policies that would ensure capital inflows to help propel the industrial sector should be a major priority.

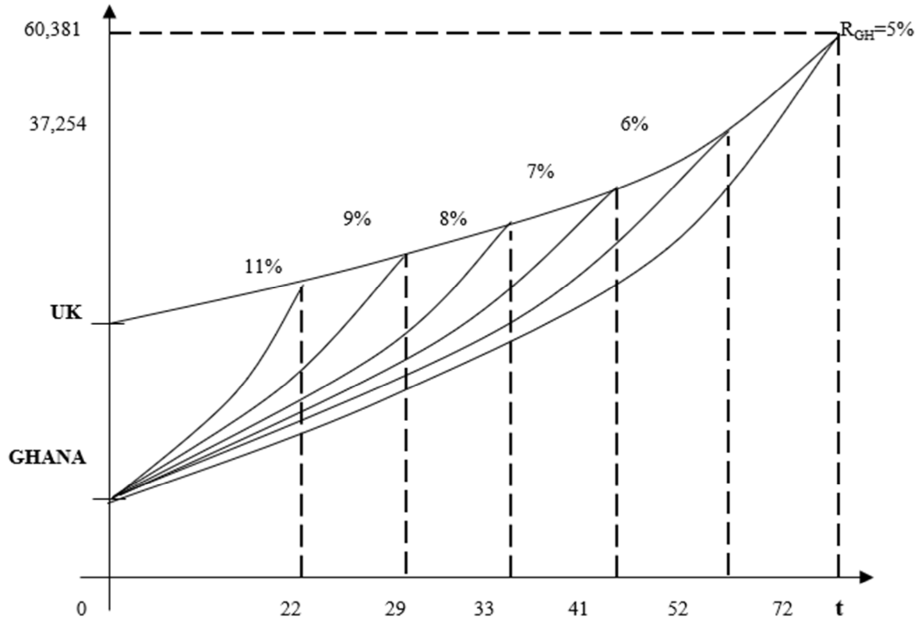

Figure 2: The dynamics of convergence between Ghana and UK, in relation to the GDP per capita by size of the annual average growth rates in Ghana

At a 5 percent growth rate of Ghana's economy and a 2.05 percent for UK, the convergence point (curve intersection) of the two countries will be achieved at a GDP per capita of about US$60,381. This per capita figure will be achieve in 72 years and a rate of 6% for the Ghanaian economy and 2.05 percent for the UK, the convergence of the two countries will be achieved at a GDP per capita of about US$37,254 that is in 52 years.

5. Conclusion

This study set to find whether Ghana and UK are catching up in terms of growth. Using time series data, the convergence hypothesis is weakly accepted. The hypothesis further indicates convergence in the form of loose-catching up. There was no evidence of long-run convergence. This was based on the existence of time trend. This implies a mere narrowing of the income gap between the two countries over time. The income gap narrowed when UK's growth rate began to fall. Ghana's growth rate has only seen a marginal increase over the years. This has resulted in the process of catching up in one period and falling behind in another period. However, the results using the data from 1958-1970 indicate otherwise. This is because the policy of import substitution industrialization was pursued. The policy caused the growth rate of Ghana's economy to increase narrowing the income gap.

Evidence of structural break was of paramount importance. Test of convergence with one and two structural break(s) rejected the hypothesis of stationarity in the series. However, if trend shift is included, the test showed support for loose catching-up. The break date in the series was given as 1972 and 1984. To better appreciate the concept of loose catch-up, three test was conducted on the period before the first break date (1958-1971), the period after the first break date (1972-1983) and the period after the second break date (1984-2011). The period from 1958 to 1971 showed convergence, the period from 1972 to 1983 showed no convergence and the period from 1984 to 2011 showed loose catching up. Again, the period that showed convergence had a policy aimed towards industrialization. The results of the speed of convergence showed that based on the annual average growth rate of GDP from 1958 to 2011 of 3.42 percent for Ghana and 2.41 percent for UK, Ghana will need 183 years to catch up with the UK. Further forecasting shows that if Ghana grows at 5 percent, the number of years would be 71, at 6 percent, the number of years would be 52, at 7 percent the number of years would be 41, at 8 percent the number of years would be 29, at 9 percent, the number of years would be 29 and at 11 percent the number of years would be 22.

5.1 Recommendations

Based on the results, the study recommends a policy of industrialization as one of the main driving force for narrowing income gap. This is because of convergence that was achieved from 1958 to 1971. Even though other minor factors might have caused such process, the one main policy that could account for this is the Import

Substitution Industrialization (ISI) policy. The major reason for industrial development is that it has been observed from history that anytime Ghana embarks on major industrial drive, growth seems to be faster. The recommendation for Ghana's industrial drive is in two parts. Firstly, Ghana could identify one industrial sector that has the potential of creating forward and backward linkages. Just as Western Europe industrialization mainly concentrated on new methods of manufacturing pig iron which propelled the electrical and chemical industries, Ghana could also concentrate on mainly one industry with such potential. At the moment, the oil industry has such a potential. This suggestion is not out of place, because examples could be seen in other parts of the world. Aruba, found in Latin America & Caribbean region have developed a whole industrial sector around oil refinery. Aruba is ranked among the high-income group in the world. Such policies are called growth pole. Perroux (1950) defined a growth pole as 'a regional and industrial planning model for a set of expanding industries located in an urban area and inducing further development of economic activity throughout its zone of influence. It is the product of agglomeration economies in a leading, dynamic industry or sector that serves as an "engine" for growth….' This theory places emphases on the role of propulsive branches and their impact on the development of their surroundings. Features a location should have in other to be considered a growth pole include, an existence of a propulsive firm or industry, the command of an assemblage of linked industries whose growth is induced by the propulsive firm (industry), the potential for technical and administrative innovations, the ability to achieve self-sustaining growth, and the capacity for growth impulses to be diffused over the pole's environment or periphery (Parr 1973, 175–176).

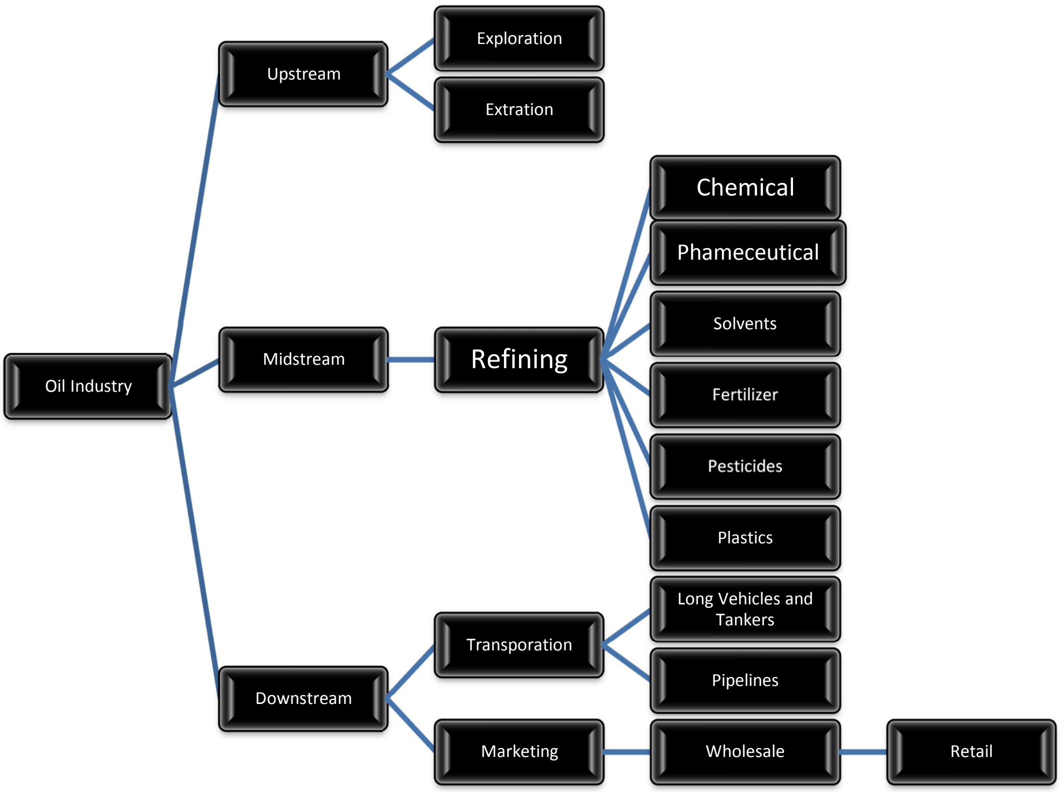

Figure 3: A Diagram showing potential manufacturing firms if the Oil industry would be used as a growth pole

Figure 3 above shows that using the oil industry as a growth pole, many other firms could be derived thus forming a complex structure with forward and backward linkages. The above figure is a simplification of what the oil industry can render for any economy. Each of the three streams has the potential to increasing growth as was experienced in 2011.

The second option towards industrialization is a simultaneous establishment of industries in all 230 districts capital in Ghana. This would be a radical approach towards a complete industrial revolution. With this approach, the various raw materials abundant in the district capital could be identified and an appropriate industry to make use of such raw material would be established. The positive side of the recommendation is that, there would be 230 industries been set up at the same time. This would help solve most of the micro and macroeconomic problems.

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APPENDIX

Table I: Result of AIC values

Lags	AIC
1	-6.756878
2	-6.854632
3	-7.038311**
4	-6.948310

** indicate lowest AIC. VAR system, maximum lag order 4
The asterisks below indicate the best (that is, minimized) values
of the respective information criteria, AIC = Akaike criterion,
BIC = Schwartz Bayesian criterion and HQC = Hannan-Quinn criterion.

lags	loglik	p(LR)	AIC	BIC	HQC
1	176.92195		-6.756878	-6.450955*	-6.640381
2	183.36579	0.01184	-6.854632	-6.395746	-6.679885
3	191.95776	0.00178	-7.038311*	-6.426463	-6.805316*
4	193.70775	0.47788	-6.948310	-6.183501	-6.657066

Table II: Results of test of Break Points
Breakpoint Specification
Description of the breakpoint specification used in estimation
Equation: UNTITLED
Date: 11/13/16 Time: 17:17

Summary

Estimated number of breaks: 2
Method: Bai-Perron tests of 1 to M globally determined breaks
Maximum number of breaks: 2
Breaks: 1972, 1984

Current breakpoint calculations:

Multiple breakpoint tests
Bai-Perron tests of 1 to M globally determined breaks
Date: 11/13/16 Time: 17:17
Sample: 1961 2011
Included observations: 51
Breaking variables: C D1 D3 @TREND
Break test options: Trimming 0.15, Max. breaks 2, Sig. level 0.05
Test statistics employ HAC covariances (Quadratic-Spectral kernel, Andrews bandwidth)
Allow heterogeneous error distributions across breaks

Sequential F-statistic determined breaks:	2
Significant F-statistic largest breaks:	2
UDmax determined breaks:	2
WDmax determined breaks:	2

Breaks	F-statistic	Scaled F-statistic	Weighted F-statistic	Critical Value
1 *	6.678833	26.71533	26.71533	16.19
2 *	14.35729	57.42914	67.52199	13.77

UDMax statistic*	57.42914	UDMax critical value**	16.37
WDMax statistic*	67.52199	WDMax critical value**	17.83

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Estimated break dates:
1: 1972
2: 1972, 1984