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Openness, Threshold Effects and Growth-Convergence Nexus in Sub-Saharan Africa, 1975-2002

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Abstract

The study analyzed the forms and patterns of convergence among sub Saharan African countries, established the existence of openness threshold point and analyzed the growth impact of openness under threshold effects. This was with a view to shedding more light on the proposition that more open economies grow faster than less open economies.

The study employed secondary data sourced from World Development Indicators and Penn World Table (6.0). It focused on a cross-section of thirty sub-Saharan African countries for the period 1975-2002. The two-stage-least-square (TSLS) regression method and the data-splitting technique of Hansen were employed to analyze the data.

The study found out that for sub-Saharan Africa as a whole, openness was negatively associated with growth but not statistically significant, the elasticity coefficient being -0.002 ($t=-0.40$, $p>0.05$). It was also found out that the threshold point was 68.3 times the real national income with 10.38 as the corresponding minimum sum of squared residual. The 5% bootstrapped confidence values for this threshold estimate were 65.5 and 71.2 respectively.These confidence values correspond to the 2.5 and 97.5 percentiles respectively of 1000 draws sampling from the residuals.

The rate at which the poor countries caught up with the rich was found to be faster among the less open economies than among the more open economies. The convergence speeds were 1.97% and 1.04% annually for less open and more open economies respectively. The growth elasticity coefficient of openness below the threshold point

was 0.02 ($t=2.44$, $p<0.05$) and reduced by 0.014 ($t=-2.42$, $p<0.05$) once the threshold point was breached. This means that the growth elasticity coefficients of openness for less open and more open economies were 0.02 and 0.006 respectively. These results showed that sub-Saharan Africa was not homogenous with respect to the extent of openness and that countries obeyed different statistical rules depending on whether they were below or above the threshold point.

The study concluded that less open economies in sub-Saharan Africa experienced higher growth rates and converged faster than more open economies during the period under reviews.

Chapter 1

Introduction

1.1 Background to the Study

The economic fortune of the people of sub-Saharan Africa presents a major challenge to the policymakers. The major concern is how to at least halve the number of the people living below the poverty line defined as US$1 per head daily (United Nations, 2006). Understanding the basic features of the economies of sub-Saharan African countries thus becomes important. One of such features is that sub-Saharan Africa is still relatively a closed economy compared to the rest of the world (Masanjala and Papageorgiou, 2003). Thus the policy recommendation stemming from this feature is that sub-Saharan African countries should be made more integrated with the rest of the world (Sachs and Warner, 1997).

At least two lines of influence could be adduced to this policy recommendation. First, the growth empirics have presented a good deal of evidence that open economies grow faster than closed ones and the more open an economy is the faster its growth rate

(World Bank, 2001). Second, the theoretical advances in growth theory are now more elaborate. For instance, the endogenous growth models such as Lucas' (1988) have left on the policymakers the impression that openness enhances growth process. Trade liberalization thus becomes a basic policy tool and a norm.

The linear relation presumed in most of the policy recommendations however shirks when confronted with the data available on sub-Saharan Africa. Against this backdrop, Rodrik (1999) as discussed in Hoeffler (2002) points out that the direct links between openness and growth are weak.

In view of the above, the proposition that more openness in sub-Saharan Africa will enhance its growth process and/or reduce its poverty level will be exposed to a more scrutinizing technique so as to assess its validity. The remaining of this study will focus on this issue.

1.2 Concepts of Convergence and Threshold Effects

1.2.1 Convergence Hypothesis

To properly understand the discussion that follows it is important to have an idea of convergence hypothesis. It is one of the basic fallouts of the neoclassical growth model. It is a proposition that in the absence of technological progress, the initially poor economies (by which is meant economies with low levels of capital per head) will grow faster than the initially rich economies (by which is meant economies with high levels of capital per head) because the returns to capital (that is, marginal product of capital) are expectedly high in the former than in the latter. This is because with high returns the initially poor economies are better able to attract investment.

More recently, the convergence theory has been studied by the growth theorists and empiricists although the convergence problem had been present in the growth literature since Solow's (1956) seminal paper. For a long time, data quality and availability had prevented serious research efforts in this area. Among the earlier attempts to test empirically for convergence were Baumol (1988) using Maddison's dataset, and DeLong (1988), who questioned the empirical validity of Baumol based on the marked selection bias charactering the data for the latter's study. Romer (1986, 1990), Lucas (1988), the availability of the Summer-Heston dataset as well as advances in econometrics have made convergence become a much frequently researched area in growth empirics.

But why should the growth process among a cross-section of countries motivate such a phenomenal research interest? There are at least two reasons. First to the optimists: if the existence of convergence (which is the term used to describe such a growth process) can be established among a cross-section of states or regions of a particular country or among a cross-section of countries then hopefully in the long run one can observe that they will be converging to either a common per capita income level or growth rate or both. This implies that the income inequality among them will tend to disappear either absolutely or conditionally over time. By absolute convergence is meant the inverse relationship between the initial income level of a country and the growth rate of that country. If this relationship cannot be established without further incorporating other control variables describing the steady state, then conditional convergence is an issue.

The second reason is that convergence informs on the test of a proposition of the Solow growth model that absent technological progress, an economy will be led transitionally from its initial income level to its steady-state level of per capita income, which is consistent with the balanced growth path (BPG) with no growth in key economic variables. In other words, the model predicts an inverse relationship between the growth rate of income and the initial level of income because the further away an economy is from its steady state the faster it is expected to grow. Thus, by testing for growth process among countries one fortuitously tests for the validity of the Solow growth model for the group of countries.

Questions that have been raised in the growth literature concern the nature and forms of convergence. Specifically, the literature is clear about whether one observes beta-convergence, meaning the tendency for the expected values of the income distribution for a group of countries to converge, or sigma-convergence, meaning the tendency for variability of the income distribution for a cross-section of countries to diminish (this is often interpreted as the catching-up in the income distribution); what the speed of convergence is like; how many years it would take a cross-section of countries to halve the gap between their initial income and the steady-state or the long-run income.

These questions will be addressed for sub-Saharan Africa.

1.2.2 Threshold Effects and Non-linear Relationship

That more openness will reduce the poverty level and enhance the growth rate will demand knowledge of the critical point that severs the small open economies from the highly open economies. Interestingly, this reechoes the argument in the new body of literature that there is non-linearity in the relationship between the level of openness and economic growth. The literature is already replete with mixed findings with respect to these variables. Many growth models demonstrate that low-income countries can benefit from openness by emphasizing the dynamic benefits that accompany it (Baldwin, 1989; Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991; and Aghion and Howitt, 1998). Surprisingly, within the same class of models, the growth-retarding effects of more openness have been emphasized by some studies (Young, 1991; Feenstra, 1996; van de Klundert and Smulders, 1996; Diao et al., 1999; Rodriguez and Rodrik, 1999; and Redding, 1999). They claim that it depends on where the low-income countries specialize after they had been open to trade.

Empirically, there is no clear and robust relationship between openness and economic growth. Edwards (1993) concludes that the benefits imputed to more openness have been broadly based on the studies that focus mainly on one country rather than cross-sectional analysis. Levine and Renelt's (1992) study on growth variables reports no robust relationship between economic growth and various measures of openness. Even with the recent Sachs-Warner (1995) measure of openness the robustness issue cannot be swept away as Harrison and Hanson (1999) and Rodriguez and Rodrik (1999) have shown the conceptual inadequacy in that measure. Pritchett (1996) reaches the same conclusion.

However, recent development has emphasized a non-linear relationship between openness and economic growth and that openness may generate a negative effect after it breaches a critical point (see for example Girma et al., 2003). When this happens the stifling effects of openness might more than dominate its enhancing effects, and whether or not openness is beneficial becomes moot. In other words, the kernel of controversy should shift away from whether there is or there is no growth effect to establishing the existence of this critical point. This will serve as the first approximation to assessing the growth effects of openness. It is not so useful to the policymakers to find whether openness is associated with high or low economic growth rate.

1.3 Statement of Research Problems

Should sub-Saharan Africa liberalize its economy so as to reduce the high and rising poverty level in the region and to enhance its growth rate? World Bank (2001) recommended that it should. This recommendation was predicated on the finding that in developing countries that have integrated into the world economy, globalisation has helped reduce poverty, while in those that have failed to do so, poverty has increased.

The report specifically highlighted sub-Saharan Africa as a region that is less integrated into the world economy and thus has experienced rising and persistent poverty. It then recommended that the sub-region should be made more integrated. While the correctness of this report cannot be questioned, the recommendation inferred, by most standards, does not necessarily follow. In particular, there is no evidence that sub-Saharan Africa could not remain poor even if its economy is left wide open. This is because persistent poverty may be consistent with both the high-openness regime and the low-openness regime just because some essential underlying parameters are missing or not being got right.

The view in the present study is that for that policy recommendation to be valid and capable of bringing down the poverty level in the region, it must be true that the more open economies among the sub-Saharan African countries should experience a lower poverty level and higher growth rates than the less open economies. Put differently, the initially poor economies among the more open economies in sub-Saharan Africa should grow faster than the initially poor among the less open economies. Also the divergence in per capita incomes among the more open economies should reduce faster over time than that among the less open economies. If this is not the case a serious doubt is then cast on the recommendation. Given that the relationship between openness and growth may be non-linear (sub-section 1.1.2 above), this doubt may be substantive.

The following question is therefore a natural one: At what level of openness will the relationship between economic growth and openness become critical? Important as this question is, it does not seem to have received any systematic treatment in the growth literature and this is not surprising since advances in the threshold econometrics have only recently been available (Hansen, 1999 and 2000; Khan and Senhadji, 2001; Rousseau and Wachtel, 2002; and Funke and Neibhur, 2005). Exceptions however are Baldwin and Sbergami (2000), Serranito (2003), Girma et al. (2003) and El Khoury and Savvides (2006). To the best of our knowledge no known study has been carried out on sub-Saharan Africa that integrates heterogeneity arising from openness threshold effects. Indeed, finding threshold point(s) presupposes heterogeneity, which in the context of a cross-section of countries implies that the growth process in each regime obeys a different statistical rule. Pooling together such heterogeneous countries in a regression equation will conceal information about them that will otherwise be available if cognizance is taken of that peculiarity. This is the gap that the present study intends to bridge in the literature.

1.4 Research Questions

The following research questions are posed: What are the implications of openness thresholds for the growth among sub-Saharan African countries? That is, do the countries' heterogeneities in openness threshold explain the differences in their catch-up rates? What is the half-life like? Is there incidence of multiple regimes (i.e. strata of countries obeying different statistical rules) in sub-Saharan Africa? Does openness to trade help explain such incidence of multiple regimes? Or put differently, is openness a threshold variable in sub-Saharan Africa? Would the proposition that poverty level in the region correlates with the extent of openness be true? Under the circumstance of multiple regimes, are the catch-up rates and half-lives different for each regime?

1.5 Objectives of the Study

The broad objective of the study is to investigate the implications of openness threshold effects for convergence and economic growth in sub-Saharan Africa for the 1975-2002 period. The specific objectives are to

i analyze the forms and patterns of convergence among sub-Saharan African countries;

ii establish the existence of openness threshold point during the period under review; and

iii analyze the impact of openness threshold effects on economic growth in sub-Saharan Africa.

1.6 Justification

The new Millennium Development Goals requires that the number of people living on US$1 per day be halved by 2015. This has placed the world community on a mutual timetable. According to the WDI (2004) statistics shows that

"...in sub-Saharan Africa ... GDP per capita shrank 14 percent, poverty rose from 41 percent in 1981 to 46 percent in 2001, and an additional 140 million people were living in extreme poverty."

This calls for research on the differential pattern of convergence among the countries in the sub-Saharan African region as being on the same timetable may not be optimal for sub-Saharan Africa. Indeed, it would not be if income distribution were stratified and highly persistent with high half-life for convergence.

Openness to trade has been observed as one of the ways available to sub-Saharan Africa to grow faster (Sachs and Warner, 1997). But such a benign observation may mask the question of multiple equilibria that threshold effects raise as an economy may find itself permanently on a sub-optimal trajectory. One of the fortuitous outcomes of this study therefore is that it will deliver to the policymakers useful estimates to assess how the region will fare under trade liberalization when it is subject to threshold (or non-linearity) effects in openness. Azariadis (1993, 1996) raised doubts about the mainstream macroeconomics that looks at the economic relationship absent the threshold effects. As Shone (1997: pp 11-12) puts it, "...non-linearity is the norm. But in both physical sciences and economics linearity has been the dominant mode of study for over 300 years." Hence investigating the existence of threshold effects in openness is the first approximation to understanding how sub-Saharan Africa will really fare in the event of liberalization in trade.

An understanding of convergence in sub-Saharan Africa will give the policymakers the idea of income inequality reduction in the region. Indeed, the estimated half-life after having considered threshold effects will be more useful than that without cognizance of those effects in assessing the timeframe for major policy changes. This will put in perspective not only whether it is optimal for sub-Saharan Africa to be on the same timetable with the rest of the world community but also whether sub-Saharan Africa should be viewed as homogenous. After all, some sub-Saharan African countries are more likely to be forming a convergence club at high or low per capita income and it will be more hopeless to have a unified policy package for the countries that have not so much in common other than colonial history and geographical boundaries.

1.7 Scope of the Study

This study focuses on sub-Saharan Africa for the period of 28 years, that is, from 1975 to 2002. On the basis of data quality and availability, thirty-three out of forty-eight countries within the sub-region are included in the study: Angola Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Dem. Rep. Congo, Rep. Congo, Cote d'Ivoire, Equatorial Guinea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Swaziland, Togo, Uganda, Zambia and Zimbabwe.

Chapter 2

Literature review

2.1 Introduction

The objective in this chapter is to review the papers that share the same thematic focus in the area under study. Section 2.1 deals with the review of theoretical studies. In section 2.2 we review empirical studies. Section 2.3 summarizes by collecting together the gaps in the literature.

2.2 Review of Theoretical Literature

The departing point in most of the theoretical debates on the growth, convergence, lagging behind and catching up is the Solow-Swan growth model (Solow, 1956 and Swan, 1956). The model is an improvement on the Harrod-Domar model by removing the stricture of knife-edge proposition. By assuming that the production function is subject to diminishing returns and the constant savings rate, the central conclusion of the model is that absent technical progress the economy stagnates. Thus, in the Solow-Swan model the engine of growth is the exogenously given rate of technical progress (and rate of population growth). As it is, at least two aspects of this model need repair. One the constant savings rate has to be endogenised so that economic agents make economic decisions about their pattern of savings (and consumption). Cass (1965) and Koopmans (1965) fill this gap. Their model like its ancestor is also recognized as neoclassical perhaps because of the law of diminishing returns they continue to maintain. Even with this fix the fundamental predictions of the Solow-Swan model still hold good.

However a radical revolt comes from the 'new' (endogenous) growth theorists who find the idea of diminishing returns not so convincing. The basis for this is that even though the Solow-Swan growth model is able to explain the Kaldor (1961) stylized facts about growth for which Solow took Nobel Prize in Economics the model severely shirks when confronted with the Summer-Heston development facts. In particular, the differences in cross-country income cannot easily be reconciled with the data. Hence, the second repair. The canonical endogenous growth model is the AK model so-called because of its form. This model does not predict convergence at all. It predicts that various countries grow at different rates. However if all countries share the same growth rate and if they differ with respect to the initial income then the model predicts that the initial differences will persist forever. Indeed, under some regularity conditions, most of the sophisticated endogenous growth models can be conveniently transformed to this canonical form. Jones and Manuelli (1990) consider a more general convex technology. Among the pioneering theoretical studies here are Romer (1986) and Lucas (1988). Romer (1986) for instance emphasizes the externalities generated by a high economy-wide stock of knowledge and Lucas (1988) the externalities generated by human capital. With this augmentation of the technology they model a non-diminishing-return technology that postpones convergence among different economies. What the mainstream endogenous growth theorists emphasize is that incentives count since it is the profit-maximizing firms that innovate, the view that underlies Romer's (1990) model. It turns out that incentives depend on the property right and condition of competition.

The upshot of these models is that countries are allowed to grow at different rates and the initially poor country may not necessarily grow faster than the initially rich country since each will probably not have entirely similar institutions to foster innovation. This makes a good deal of sense in the sense that the prediction matches the data better. Thus the endogenous growth models do not predict convergence. Ethiopia is a poor country but that does not make it grow faster than the US; indeed, it has not grown faster.

2.3 Review of Empirical Literature

Both the neoclassical and endogenous growth models have testable implications that have been examined by and a number of studies including Barro and Sala-i-Martin (1992), Broadberry (1993), Dollar and Wolff (1988), Wang (2004), Mankiw, *et al*

(1992), Caselli, *et al* (1996) and Jian, *et al* (1996) have studied the convergence within the countries and across the countries.

Mankiw, *et al* (1992), running OLS regression in a cross-section setting, examine the Solow growth model. They find that holding population growth and capital accumulation constant countries conditionally converge at about the rate predicted by the Solow model. However, using the same dataset, Caselli, *et al* (1996) obtain very different results by applying the GMM estimating technique thereby rejecting the Solow model.

2.3.1 Studies on Developed Countries

Barro and Sala-i-Martin (1992) document convergence across the U.S. states in terms of income per capita and gross state product per capita. They find that convergence holds in aggregate across U.S. states using cross-section techniques with speeds of convergence to steady state around 2 percent per year. Considering productivity growth by sector from 1963-1989, they conclude that convergence was occurring in all sectors, although more rapidly in manufacturing than in other sectors. They also conclude that a lack of aggregate convergence after the early 1970s was due primarily to relative price movements in oil-related industries.

Broadberry (1993) compares manufacturing data to GDP data and finds the time-series and cross-sectional results to be very different for Britain, Germany and the

United States. Although his time series evidence suggests persistent labor productivity gaps between countries in the manufacturing sector, he also indicates that during periods in which one country alters its comparative labor productivity position there are periods of catching-up that restores the long-run comparative position.

Dollar and Wolff (1988) find convergence in virtually all manufacturing-industries and conclude that this is the proximate source of aggregate convergence. Bernard and Jones (1996) also find manufacturing to have performed differently compared to GDP and other sectors for 14 OECD countries. They conclude that there is no evidence of convergence for manufacturing in terms of labor productivity, and even less when looking at broader productivity measures. Both of these papers indicate that convergence of GDP per worker must have occurred through trends in other sectors than manufacturing or through compositional effects. Using a Kalman filter approach, St. Aubyn (1999) finds convergence, after World War 2, between the U.S.A. and every G-7 country except Canada while Nahar and Inder (2002) criticizing the definition of convergence used by Bernard and Durlauf (1995), propose an alternative approach that yields evidence of convergence between 16 out of 21 OECD countries, relative to the U.S.A.

2.3.2 Studies on Developing Countries

Jian, *et al* (1996) also examined the China's growth trend during 1952-1993. They find that the regions in China display strong absolute sigma convergence only from

1978 to 1990. They observe that there is weak sigma convergence from 1952 to 1965. Between 1965 and 1978, however, evidence of strong sigma divergence is found.

Wang (2004) finds that the regions in China conditionally converge to their steady state. Using the system Generalized Method of Moment on Chinese data between 1991 and 1999 he finds that the convergence rate is about 8% per annum, estimating the half-life to be around 8 years.

Giles and Stroomer (2005) calculate the convergence speeds for various countries, in terms of half-lives, using a time-series dataset for 88 countries between 1965 and 1990. They develop a novel technique called 'fuzzy' regression along with the nonparametric kernel regression, and compare the results with more restrictive estimates based on the assumption of linear convergence. The calculated half-lives are regressed, again in various flexible ways, on cross-section data for the degree of openness to trade. They find evidence that favours the hypothesis that increased trade openness is associated with a faster rate of convergence in output between countries.

2.3.3 Studies on Sub-Saharan Africa

Ghura and Hadjimichael (1996) investigate long run growth in Sub-Saharan Africa over the period 1981-1992. Using feasible generalised least squares techniques on a panel of 29 Sub-Saharan African countries, the authors found support for conditional convergence, even though absolute convergence was rejected. On the control variables, the authors found that both private and public investment had a positive and significant effect on growth.

Sachs and Warner (1997) present one of the most comprehensive analyses of the sources of slow growth in developing countries with a particular emphasis on Sub-Saharan Africa over the period 1965 - 1990. The authors included a wide range of explanatory variables such as openness, geography, climate, natural resources, institutional quality, inflation, life expectancy, neighbourhood effects, ethnic fractionalisation, and population growth. They find that both natural factors and inappropriate economic policies were responsible for the slow growth in developing countries including Sub-Saharan Africa. The authors find no support for factors such as neighbourhood effects, ethnic diversity, and the so-called Sub-Saharan African "dummy".

Easterly and Levine (1997) examine the growth tragedy in Sub-Saharan Africa. Their paper investigates both the direct and indirect effect of ethnic diversity on growth using the seemingly unrelated regressions. The paper makes some interesting observations. First, it is reported that ethnicity has a significant negative direct effect on growth. Second, it is found that high levels of ethnic diversity were strongly linked to high black market premiums, political instability, poor financial development, low provision of infrastructure, and low levels of education. Since these variables were also found to have a negative effect on growth, this means that ethnic diversity has both a direct and an indirect effect on growth. The paper also finds evidence of non-linear convergence in growth rates. The Sub-Saharan African "dumm" in their regression is found to be significant and negative.

Temple (1998) seeks to extend the analyses in Easterly and Levine (1997) and Sachs and Warner (1997) by explicitly exploring the effect of initial conditions and social arrangements on growth in Africa. Using a novel estimation technique of "re-weighted least square", his paper finds that more than half of the variation in growth rates could be explained by observable variables capturing initial conditions. Further, it is found that social capital matters for growth in the sense that countries that have relatively low social capital are more likely to have dismal policy outcomes, low investment and slow growth.

Savvides (1995) investigates the determinants of per capita growth rates across Africa for the period 1960-1987. Using a fixed effects panel model based on endogenous growth theory, the paper finds support for both absolute and conditional convergence. It is further reported that both economic and political variables influence growth in Africa. The economic variables include initial conditions, investment, population growth, trade orientation, inflation, financial development, and government expenditure. The study makes additional observation that growth in CFA countries is worse than in non-CFA countries over the period.

Ojo and Oshikoya (1995) also examine the determinants of long-term growth in a cross-section of African countries over the period 1970-1991. The authors include variables such as initial per capita income, investment, population growth, macroeconomic policy (inflation and exchange rates), external factors (export growth, external debt, and terms of trade), political environment, and human capital development. The paper finds that, on average the most significant variables influencing long-term growth in the sample of African countries over the study period were investment, external debt, population growth, and the macroeconomic environment.

2.3.4 Review of Literature on Openness and Trade

Dollar (1992) studies the effect of outward orientation. He investigates sources of growth in 95 developing nations over the period 1976-85 and reports that, while per capita income for this period grew at an annual average of 3 per cent for 16 Asian countries, it fell at a rate of 0.4 per cent in Africa and 0.3 per cent in Latin America. Dollar's conclusions emphasize that Asian developing economies were more outward oriented than African and Latin American countries.

Florax *et al* (2002) use meta-analysis and response-surface analysis to assess the robustness of the estimates in the empirical growth literature. The authors analyze the significance and magnitude of the estimated coefficients, and the sign variability in the empirical growth regressions. They report that of the 61 variables used in the regressions, only three variables—years of openness, equipment and non-equipment investment, and human capital—are robust.

Harrison (1996) looks at a number of openness indicators that turn out to have a positive 'association' with economic growth while they have weak correlation with each other. Furthermore, a VAR specification in Harrison's paper produces evidence in support of bi-directional causality between openness and economic growth. The role of human capital has been emphasized in many studies. Growth promoting outward orientation may require high levels of human capital.

Using a large number of openness measures for a cross section of countries over the last three decades, Yanikkaya (2003) shows that trade liberalization does not have a simple and straightforward relationship with growth. However, contrary to the conventional view on the growth effects of trade barriers, the study shows that trade barriers are positively and, in most specifications, significantly associated with growth, especially for developing countries.

2.3.5 Reviews of Literature on Openness and Threshold Effects

Serranito (2003) investigates the trade-and-growth link by applying a new threshold econometric methodology developed by Hansen (2000) to standard growth regressions in order to capture a non-linear effect of trade on growth. Amongst all the threshold variables tested, trade policy indexes are the variables that best sort out the sample. The threshold test splits up the sample into two regimes of the 'open' countries and the 'closed' ones. For the 'open' club, he finds that trade coefficients are rightly signed but are non-significant. By contrast, as far as the 'closed' club is concerned, he finds a significant relationship but the coefficients have the opposite sign. He interprets this to mean that for countries with already low barriers to trade, an increase in openness degree is not growth increasing, whereas for high level trade barriers countries this is growth reducing.

Girma, Henry, Kneller and Milner (2003) explore whether the productivity payoffs from openness or trade liberalization are conditioned by the quality of a country's institutions and the extent of natural barriers. Their paper endogenously searches for the variable that might be used to capture the heterogeneity and with what level of certainty can we attach to it. They find that there is a threshold in the effect of openness on growth that depends on the level of natural barriers but not institutions.

Papageogious (2001) employs the data-sorting method developed by Hansen (2000), which allows the data to endogenously select regimes using different variables. It is shown that openness, as measured by the trade share to GDP, is a threshold variable that can cluster middle-income countries into two distinct regimes that obey different statistical models. He finds that openness may not be as crucial in the growth process of low and high-income countries but it is instrumental in identifying middle-income countries into high and low-growth groups.

El Khoury and Savvides (2006) examine the relationship between openness in services trade and economic growth. They estimate a threshold regression model to test whether openness in services trade has a different impact on low- and high-income countries. They consider openness in both telecommunication and financial services. The results of their study confirm the existence of a two-regime split (threshold effect) with low-income economies benefiting from greater openness in telecommunication services and high-income economies from financial services openness.

2.4 Summary of Major Gaps

The finding that sub-Saharan Africa is not an example of convergence club is an intriguing one. However, that finding was of limited use considering the fact that the reason for this tendency was not explored. The guess is that openness may be a key variable for this outcome. This will help put in perspective whether openness is a factor to reckon with when formulating policy for sub-Saharan Africa.

The common practice of treating (sub-Saharan) Africa as "African dummy" in regression seriously trivializes the earnestness of optimal policy formulation for Africa. For one thing, detailed rather than holistic views of "Africa's economics" need to be neatly worked out. "African dummy" is a summary value for a whole lot of debilitating factors that prevent Africa from reaching its targets less painfully. Any study on (sub-Saharan) Africa that is worth its salt must take these debilitating factors into account rather than their summary value.

Lastly, the present study is distinguished by recognizing the threshold effects in openness. These effects have been relegated to the background in the literature and not so much of these effects have been studied in the specific case of sub-Saharan Africa. Also, most studies simply argue in favour or against. Given that openness is not all virtues nor all vices it is reasonable to steer a middle course, which is the focus of the present study.

Chapter 3

Theoretical Framework and Model Specification

3.1 Introduction

In the previous chapters the questions of what and why were squarely addressed. In the present the how question is undertaken. Section 3.2 provides the discussion of the theoretical framework for the study. In section 3.3 the model is specified while in section 3.4 data measurement and variable definitions are undertaken. Section 3.5 details the methods of data analysis.

3.2 Theoretical Framework

The law of diminishing returns driving the economy to a steady state is old and standard in economics. It has been used by the classical pessimists like David Ricardo to show that "capitalist economies would end up in a stationary state" (Thirlwall, 2003: p 132), and Thomas Malthus to prove his law of demographic growth.

The classical theory was not developed into a growth theory but the underlying consistency is such that one may conclude that the classical were also interested in the state of the economy of their time. One logical extension of the Classical ideas is the neoclassical growth model. An alternative theoretical perspective on growth process is the well-known Harrod-Domar growth model, which is more grounded in Keynesian thought. Although the Harrod-Domar growth model is dynamic, it leads nowhere as it is silent on the concept of convergence that is of interest in this study. Thus, the neoclassical growth model is adopted for this research study.

3.2.1 Ramsey-Cass-Koopmans Neoclassical Growth Model

Of particular interest is the Ramsey-Cass-Koopmans model that provides the microfoundation for the Solow model. The conclusions of the two models are similar. The Ramsey-Cass-Koopmans model assumes that the economic agents can optimally choose their consumption bundles. Thus, the representative consumer's intertemporal preference under the constant relative risk aversion (CRRA) is:

$$\sum_{t=0}^{\infty} N_t \rho^t \frac{C_t^\theta}{\theta}$$

or in per effective terms:[1]

$$\sum_{t=0}^{\infty} \left[\rho\left(1+n\right)\left(1+a\right)^{\theta}\right]^{t} \left(\frac{x_t^\theta}{\theta}\right) \tag{3.1}$$

[1] $\sum_{t=0}^{\infty} N_t \frac{c_t^\theta}{\theta}$. Using $A_t = (1+a)^t$ and $N_t = (1+n)^t$ we have Eq.(3.1)

where ρ is the discount factor, θ is a measure of curvature of utility, c_t is consumption per head, $x_t = \frac{c_t}{A_t}$ is the per effective capita consumption, and $N_t = (1+n)^t$ is the population with n as its growth rate and N_0 normalized to unity. Also $A_t = (1+a)^t$ is the technology factor with a as its growth rate and normalized to unity.

The representative firm employs the Cobb-Douglas technology, which in per effective capita terms is:[2]

$$y_t = f(k) = k_t^\alpha \tag{3.2}$$

where y_t is the output per effective labour and k_t is the physical capital per effective labour. α is the share of the physical capital per effective labour.

The law of motion for capital accumulation for net physical capital is given thus:

$$K_{t+1} - K_t = sY_t - \delta K_t \tag{3.3}$$

where K_t is the physical capital, δ is the discount rate for physical capital and s is the savings rate in the economy. It is assumed with the formulation in Eq.(3.2) that the technological progress is labour-augmenting or Harrod-neutral.

The Solow model is a closed economy model where in addition there is no government. Thus, the resource constraint of the economy is given as:

$$N_t c_t + K_{t+1} - (1-\delta) K_t = Y_t$$

[2]Given the Harrod-neutral technological progress, $Y_t = K_t^\alpha (A_t N_t)^{1-\alpha}$. Dividing both sides of this equation by $A_t N_t$ and noting the following $k_t = \frac{K_t}{A_t N_t}$ we have Eq.(3.2). Other specifications of technological progress in the growth literature are the capital-augmenting or Solow-neutral technological progress and the output-augmenting or Hicks-neutral technological progress.

or in per effective capita terms:

$$x_t + (1+n)\,k_{t+1} - (1-\delta)\,k_t = k_t^{\alpha} \tag{3.4}$$

where $C_t = N_t c_t$ is the aggregate consumption. Eq.(3.1) is maximized subject to Eq.(3.4) using the Bellman equation of the dynamic program.

$$v(k_t) = \max_{\{x_t, k_{t+1}\}} \left[\frac{x_t^{\theta}}{\theta} + \rho\,(1+n)\,(1+a)^{\theta}\,v(k_{t+1}) \right] \tag{3.5}$$

where $v(k_t)$ is the value function for the Bellman equation. The first order condition is given as

$$(1+n)(1+a)x_t^{\theta-1} - \rho(1+n)(1+a)^{\theta}v'(k_{t+1}) = 0$$

and the envelope condition is

$$v'(k_t) = (\alpha k_t^{\alpha-1} + (1-\delta))x_t^{\theta-1}$$

3.2.2 Steady-State Evaluation of the Model

Utilizing the above equations we have the following Euler equations:

$$\frac{x_{t+1}}{x_t} = (1+a)^{-1}[\rho(\alpha k_{t+1}^{\alpha-1} + (1-\delta))]^{\theta-1}$$

The steady state values of capital per effective labour, savings rate and income per capita are given in Eqs(3.6)-(3.8) respectively:

$$k^* = \left[\frac{(1+a)^{1-\theta} - \rho(1-\delta)}{\rho\alpha} \right]^{\frac{1}{\alpha-1}} \tag{3.6}$$

$$s^* = \left[\frac{\rho\alpha[(1+a)(1+n) - (1-\delta)]}{(1+a)^{1-\theta} - \rho(1-\delta)} \right] \tag{3.7}$$

$$y^* = \left[\frac{(1+a)^{1-\theta} - \rho(1-\delta)}{\rho\alpha} \right]^{\frac{\alpha}{\alpha-1}} \tag{3.8}$$

3.2.3 Theoretical Background to Convergence

The deviation of the economy from the steady state can be explored to assess the transitional dynamics. The fundamental equation of the Solow model derived from Eq.(3.3) is useful here:[3]

$$k_{t+1} - k_t = sf(k_t) - (n + a + \delta)k_t \tag{3.9}$$

This equation can be used to explore the proposition that growth rate in any any economy is faster the further away it is from its steady state. From the fundamental equation in Eq. (3.9) the basic growth equation is defined as:

$$\frac{k_{t+1} - k_t}{k_t} = \gamma(k_t) \equiv s\phi(k_t) - (n + a + \delta) = \gamma_t \tag{3.10}$$

where $\phi(k_t) = \frac{f(k_t)}{k_t}$. Eq.(3.10) can be log-linearized to quantify the deviation of the economy around the steady state. Durlauf and Quah (1998) showed that the speed of convergence is $\lambda = -(1-\alpha)(\delta + n + a)$ and, allowing for the monotonic relationship between effective capital per head and effective output per head, the output grows thus:

$$\frac{\dot{y}}{y} = -(1-\alpha)(\delta + n + a)\log(\frac{y}{y^*}) \tag{3.11}$$

The above shows that as $\alpha \to 1, \lambda \to 0$, the convergence becomes slower as the income share of capital approaches unity.

[3]See Appendix D and the derivation therein.

3.2.4 Implications of the Theory

The steady state and convergence implications of the neoclassical growth model are as follows:

1. Since the values of per effective quantities are constant along the balanced growth path (BGP), the aggregate consumption, the aggregate capital stock and the aggregate output all grow at the common rate $n + a$. However, per capita consumption, per capita capital and per capita output grow at the rate a. This implies that aggregate quantities are exogenously determined in the long run by the growth rates in the population or labour force and in the technical change, whereas per capita quantities are exogenously determined in the long run by the growth rate in the technical change alone.

2. Changes in the share of physical capital in income (α) discount rate (δ) time preference coefficient (ρ) and the extent of risk aversion (θ) have no growth effects since they could not affect the exogenous growth rates of technology and population. They however have level effects since they affect steady state quantities (see Eq.(3.8) above). Thus, the share of physical capital in income, time preference coefficient, discount rate and the extent of risk aversion may not cause differences in growth but do cause differences in per capita income levels across countries. Since savings rate depends on these parameters a country that saves more does not necessarily grow faster although it may have a higher level of income. Indeed, the dependence of the savings rate on the exogenous rates (a) and (n) implies that savings rate is exogenously determined and could be part of the reasons for income inequality in the world.

3. If all countries were closed and had access to the same technology they would converge to a common balanced growth path. Differences in income per effective labour are entirely explained by differences in α, β, δ, ρ and θ . Moreover, if all countries had access to the same technology then α, β and δ would not change much across the countries so that preference parameters ρ and θ remain as the only factors that determine the differences in income. In this study we seek part of the explanations for these differences in the way that openness may cluster the economies into regimes of high-income and low-income countries

4. We observe that the convergence rate does not depend on A. This implies that economies that differ in every other respect, differences in technology in this case, may well have very similar convergence rates, suggesting that in the context of sub-Saharan Africa a country such as South Africa that has all-time high income per capita may have the same convergence rate as Niger or even Ethiopia for that matter. This allows for common convergence coefficient in the regression model (Barro and Sala-i-Martin, 1992). If however differences in technology are allowed for as the basis for openness (as will be demonstrated shortly), this implication will no longer hold. Put differently, the introduction of technological differences brings into focus the heterogeneity issue in convergence. That is, differences in technology will matter.

5. Later in this study we will show that the convergence coefficient is $1 - e^{-\lambda t}$. One property of this is that over time an economy converges asymptotically and monotonically to its steady state, meaning that there is no overshooting in the Dornbusch (1976) sense. This implies that there is no incidence of multiple

equilibria, which the present research work finds not so interesting and realistic.

3.2.5 Graphical Illustration

The predictions of the neoclassical growth model can also be illustrated geometrically. Fig 3.1 below depicts these predictions. The slopes of the heavy arrows refer to the growth rates in the low and high-income countries respectively. Since they are homothetic the growth rates are the same in both economies. The paths, LIC and HIC, refer to the steady-state levels of logarithm of the per capita income. They depict the low and high income for the poor and rich countries respectively. The major concern of the policymakers is how to lever an economy on LIC-path onto HIC-path. In the context of this study, we are interested in whether openness to international trade as a policy tool can be used to achieve this or it is merely a threshold variable. Fig 3.1 below shows that for a perfectly open economy there will be an instantaneous adjustment which will lead to the movement of the economy along the line from LIC-path to HIC-path. A not-so perfectly open economy will take some time to converge on HIC-path as it moves transitionally along the heavy dotted line in Fig 3.1. In either case, openness to trade will have had level effects in the long run. For openness to have growth effects in the long run, it must be capable of tilting the heavyarrows. The proposition that the further away an economy is from its steady state the faster it grows can be seen in Fig 3.1 as the slope of the heavy dotted line (i.e the three light-dotted lines, representing the tangents to the heavy dotted line at three different points in time), which levels off as the economy approaches its steady state. Tangent *(A)* has the highest slope while tangent *(C)* has the lowest slope. Tangent *(B)* falls

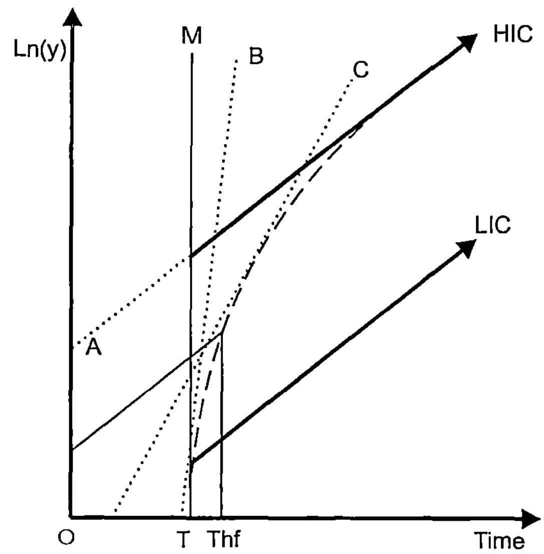

Figure 3.1: Neoclassical Predictions on Convergence

somewhere in between. This means that an economy can display growth effects even in the short run. Such effects will however fade out as the economy approaches its steady state. It is assumed that the extent openness can interact with the rate at which the economy approaches this steady state. Of course, as will soon be made explicit, we will focus on the threshold effect in this study.

3.2.6 Openness and Technology Transfer

The third prediction above depends seriously on the assumption that all the countries have access to the same technology. We can however allow for differences in the technology growth rates in order to introduce technology transfer across borders. In the growth literature, openness has been modelled by assessing the role that this transfer plays in transmitting knowledge among countries. Therefore, if the domestic technology A grows at a constant rate a while the foreign and more advanced technology is

A^* then the growth rate of domestic technology in the presence of technology transfer is given as

$$\frac{\dot{A}}{A} = a + \varpi \log(\frac{\kappa A^*}{A}) \qquad a, \varpi > 0 \quad \text{and} \quad 0 \leq \kappa \leq 1 \tag{3.12}$$

where ϖ is the transfer rate and is the transferable ratio (Quah 1997). The domestic growth rate of income per head will be affected depending on whether the domestic economy fully harnesses the technology transfer that trade openness presents. Note that Eq.(3.12) can be written in raw per capita income as $\tilde{y}_t = Ak_t^{\alpha}$.[4] In per capita growth rate this output per capita gives

$$\frac{\dot{\tilde{y}}_t}{\tilde{y}_t} = \frac{\dot{A}}{A} + \alpha\frac{\dot{k}}{k}$$

When the preceding is combined with Eq.(3.12), we have the following per capita growth rate in an open economy:

$$\frac{\dot{\tilde{y}}_t}{\tilde{y}_t} = a + \varpi \log\frac{kA^*}{A} + \alpha\frac{\dot{k}}{k} \tag{3.13}$$

This equation may coincide with that of a closed economy if $\varpi \log \frac{kA^*}{A}$ is zero. This will be the case if $A = \kappa A^*$. Other two possible cases are when the growth rate in an open economy is greater than that of a closed economy which occurs when $A < \kappa A^*$; and when the growth rate in an open economy is less than that of a closed economy which occurs when $A > \kappa A^*$. This shows that where there are threshold effects the economy cannot be expected *a priori* to follow a given growth path. That is only an empirical issue. It also shows that there is possibility of multiple equilibria in an open economy.

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[4]Note that $\tilde{y}_t = \frac{Y_t}{N_t} = A_t y_t$. That is, $\tilde{y}_t$ is income per raw labour.

3.2.7 Theoretical Implications of Openness Threshold Effect for Convergence

It will be interesting to see the channels through which the threshold effects arising from openness impact on the convergence speed and thus on growth. The knowledge of such channels will give the policymakers a spectrum of choices to make in order to mould how the economy will respond to a series of shocks in the context of threshold effects. To do this, we substitute Eq.(3.12) into Eq.(3.11). Recall that Eq.(3.11) describes the growth process in an autarchic economy. In that case, $\frac{\dot{A}}{A} = a$. In an open economy, however, the term capturing technology transfer is added so that $\frac{\dot{A}}{A} = a + \varpi \log(\frac{\kappa A^*}{A})$, that is, Eq.(3.12). Considering this extension, we can modify Eq.(3.11) as follows:

$$\frac{\dot{y}}{y} = -(1-\alpha)(\delta + n + a + \varpi \log(\frac{\kappa A^*}{A})) \log(\frac{y}{y^*}) \tag{3.14}$$

the solution of which is

$$\log y_t - \log y^* = \Psi \exp[-(1-\alpha)(\delta + n + a + \varpi \log(\frac{\kappa A^*}{A}))] \times t$$

or,

$$\log y_t = \Psi \exp[-(1-\alpha)(\delta + n + a + \varpi \log(\frac{\kappa A^*}{A}))] \times t + \log y^* \tag{3.15}$$

where $\Psi \equiv \log y_0 - \log y^*$. Taking the limit of both sides would make the right hand side term go to zero if $\delta + n + a + \varpi \log(\frac{\kappa A^*}{A}) > 0$ since $1 - \alpha > 0$. This condition implies that the transferable technology must be at least $A \exp(-\frac{\delta+n+a}{\varpi})$ or:

$$\kappa A > A \exp(-\frac{\delta + n + a}{\varpi}) \tag{3.16}$$

Recall from sub-section 3.1.6 that the threshold is defined as $A = \kappa A^*$, that is, the level of technology that sets both the domestic and the transferable foreign technology equal such that the per capita income growth for the domestic economy is always equal to that of the autarchic economy. If that is the case,

$$1 > \exp(-\frac{\delta + n + a}{\varpi}) \Rightarrow \delta + n + a > 0$$

Now consider a small positive deviation ($0 < \Delta < 1$) of foreign technology away from the level consistent with the threshold point, that is

$$1 + \Delta > \exp(-\frac{\delta + n + a}{\varpi})$$

or

$$\ln(1 + \Delta) > -\frac{\delta + n + a}{\varpi}$$

This relation will imply that[5]

$$\varpi\Delta > -(\delta + n + a) \qquad (3.17)$$

Eqs.(3.16) and (3.17) imply the following policy issues:

1. Eq.(3.17) provides the lower bound for the total transfer rate in the event that there is a small positive deviation from the level consistent with the threshold point. Thus, in an open economy where the relation fails to hold for every gap created due to technological advancement between the domestic and the foreign technology, per capita income may fail to converge to its steady state value. In other words, an economy that opens up to the rest of the world should encourage learning and R&D so as to internalize the effects of technological progress in

[5]Note that $\ln(1 + \Delta) \approx \Delta$.

the technologically more advanced trading country if it is to avert per capita income divergence.

If the domestic technology is as good as the foreign technology no reasonable number of people will be motivated to learn foreign technology. In that event the transfer rate will tend to zero and there is no hassle of always ensuring that the lower bound is not violated as long as $(\delta + n + a)$. This condition is the same as will obtain in an autarchic economy.

Also common convergence is not possible because the lower bound in the relation is defined by the parameters that are not likely to be the same within a cross-section of countries and over time. This is suggestive of asymmetry in the convergence rate in a cross-section of countries racing to the steady state. This provides a rebuff to the implication (5) noted earlier, showing that in an open economic system, the assumption of common convergence speed for a cross-section of countries is not tenable.

2. The left hand side of Eq.(3.16) reveals that reducing the transferable ratio (κ) will reduce the minimum threshold point and thus slow the rate at which the economy approaches the steady state. This implies that the extent of institutions such as copyrights and property rights in the more advanced trading countries matter for the growth path that the domestic economy follows. A high value of κ will mean a high level of transferable technology will be available and this will serve to postpone the threshold point. Thus, the speed of convergence to the steady state will be higher.

3.3 Model Specification

3.3.1 Empirical Model and Threshold Specification

This section discusses how the estimating model for this study will be obtained. To do this we solve Eq.(3.11) to obtain the following regression-like equation:[6]

$$\ln y_t = (1 - e^{-\lambda t}) \ln k^{*\alpha} + e^{-\lambda t} \ln y_0 \tag{3.18}$$

We note that at the steady-state capital per effective labour is:

$$k^* = \left(\frac{s}{n + a + \delta}\right)^{\frac{1}{1-\alpha}}$$

The process of substituting the values of k^* in Eq.(3.18) yields the empirical model:[7]

$$\ln y_t = \varphi_1 \ln y_0 + \varphi_2 \ln s + \varphi_3 \ln (n + a + \delta) + \epsilon$$

where s is the saving rate, n is the population growth rate, a is the growth rate of domestic capital, δ is the rate of depreciation and $n+a+\delta$ is the effective growth rate. Following Islam (1995), the preceding can be written in a dynamic panel structure as follows:

$$\ln y_{i,t} = \varphi_0 + \varphi_1 \ln y_{i,t-1} + \varphi_2 \ln s_{i,t} + \varphi_3 \ln (n_{i,t} + a + \delta) + \mathbf{X}'_{\mathrm{i,t}}\mathbf{\Pi} + \epsilon_{i,t} \tag{3.19}$$

where $\mathbf{X}_{\mathrm{i,t}}$ is a vector of control variables including openness. Eq.(3.19) is our estimating model. In view of the threshold effects discussed in Section 3.1 our auxiliary

[6] See Appendices A and B.

[7] See Eqs.(D-09) and (D-10) in Appendix D.

estimating model is thus:

$$\begin{aligned}\ln y_{i,t} &= \varphi_0 + \varphi_1 \ln y_{i,t-1} + \varphi_2 \ln s_{i,t} + \varphi_3 \ln(n_{i,t} + a + \delta) + \\ &+ \varphi_4(1 - \partial^O_{i,t})(\ln(Op)_{i,t} - \ln(Op^*)) + \varphi_5 \partial^O_{i,t}(\ln(Op)_{i,t} - \ln(Op^*)) \\ &+ \chi'_{\mathrm{i,t}}\mathbf{\Lambda} + \epsilon_{i,t} \end{aligned} \tag{3.20}$$

where $\epsilon_{i,t}$ is the idiosyncratic error term. $\chi_{i,t}$ is the vector of the control variables excluding openness; and $\partial^O_{i,t}$ is the dummy capturing the threshold effects and is defined as:

$$\partial^O_{i,t} = \begin{cases} 1 & \text{if } Op > Op^* \\ 0 & \text{if } Op \leq Op^* \end{cases} \tag{3.21}$$

$Op_{i,t}$ measures openness. φ_4 and $\varphi_4 + \varphi_5$ are trade openness effects for the less open and the more open economies respectively and

$$Op^* = \arg \min_{Op_{i,t} \in \Gamma} \{S_0(Op_{i,t})\}$$

is the critical value of openness that is being searched for. As defined, it is the value of openness that minimizes the sums of squared error (i.e. S_0). The precise way to compute this value is as follows.

Regressing the threshold equation could be much easier if the threshold point is already known. Under that circumstance, we would simply set the threshold point in the estimating equation equal to that value. Suppose for instance we know the threshold point for a threshold variable to be zero. All that will be required is to set the threshold point equal to zero. This will be the case if we know that the negative values of our threshold variable behave differently than its positive values.

But in most problems as in the present case, the threshold point is not known. Thus, the bulk of the threshold equation regression lies squarely in grid searching. In other words, all the potential threshold points will be examined on the basis of the criterion set out above. This is done by first ordering the observations on threshold variable (i.e. openness in this case) from the smallest to the highest value (Chan, 1993), and each of such values is considered as a possible threshold point. Depending on how much smoothness is desired and on the number of the observations on the threshold variable, the number of regressions needed to identify the threshold point may run from few regression equations to several hundreds of regression equations.

By the definition of the threshold point the existence of this point implies the existence of regimes in the data. If many of such points are identified, they will imply the occurrence of multiple regimes. Of course, it may be possible to find a global threshold point and a sequence of local threshold points. This will be interpreted to mean that within each regime there are sub-regimes, thereby emphasizing "stratification" or heterogeneity.

As mentioned above the major problem is how to find the threshold point when it is not known and this is potentially time-consuming. Fortunately, a simple algorithm could be followed to minimize the computation time and to enhance the speed and accuracy. Specifically, Eviews codes would be used to handle these replications.

3.4 Data Measurement

3.4.1 Data Sources

Analysis of this study will be conducted using the panel data for Sub-Saharan Africa over the period 1975 to 2002 making 28 years in all. A total of 30 countries are included in the study. The data will be obtained mainly from the World Development Indicators (WDI) (WDI Data CD-ROM, 2005) and their quality and quantity be augmented from other sources like the Penn World Table.

3.4.2 Definitions of Variables

GDP is conventionally measured as income denominated in terms of the currency of that particular country. In the present study GDP measured in this way is inadequate. We seek a measure that will allow us to compare countries. To do this, GDP adjusted for Purchasing Power Parity (PPP) based exchange rate is used. Such measure is available in the WDI Data CD-ROM (2005). Thus we measure the variables for this study as follows:

1. GDP:real Purchasing Power Parity (PPP)-adjusted GDP based on the foreign exchange. (WDI, 2005; and Penn World Table (6.0));

2. $\ln(s_k)$:logarithm of real investment as ratio to GDP plus foreign direct investment. (WDI, 2005; and Penn World Table (6.0));

3. $\ln(n + a + \delta)$: logarithm of population annual growth rate plus 0.05. (WDI, 2005; and Penn World Table (6.0))

4. $\ln(GOV)$:logarithm of real government consumption as ratio to GDP (WDI, 2005; and Penn World Table (6.0));

5. $\ln(Op)$(Openness): logarithm of the ratio of exports plus imports to GDP(WDI, 2005; and Penn World Table (6.0)); and

6. $\ln(M2)$:(Financial Deepening): Ratio of M2 to GDP (WDI, 2005; and Penn World Table (6.0)).

3.5 Operational Definitions of Convergence

Suppose we have a cross-section of countries that have beta-convergence in their annual per capita incomes. This can be understood in terms of the following equation:

$$\ln y_t - \ln y_{t-1} = \beta_0 + \beta_1 \ln y_{t-1} + e_t \qquad (3.22)$$

It follows that we can approximate their income per capita thus:

$$\ln y_t = \beta_0 + (1 + \beta_1) \ln y_{t-1} + e_t \qquad (3.23)$$

The existence of beta-convergence will imply that β_1 is negative. Otherwise, there will be beta-*divergence*, to be interpreted as the initially rich economies growing faster than the initially poor economies. Using Eq.(3.23) we find that:

$$\sigma_t^2 \cong (1 + \beta_1)^2 \sigma_{t-1}^2 + \sigma_e^2 \qquad (3.24)$$

where σ_t is the standard deviation of income per head defined as:

$$\sigma_t = \sqrt{\frac{\sum_i (\ln y_i - \mu)^2}{n}} \qquad (3.25)$$

σ^2 is the variance of error term that is believed to stand in for all other variables omitted in the growth regression. As argued by Sala-i-Martin (1996), and can be proved from Eq.(3.24), the existence of sigma-convergence is a sufficient but not a necessary condition to find unconditional beta-convergence in the data. This is because even when β_1 is not changing σ_e can still change. Therefore, it is not paradoxical to find beta-convergence on the one hand and sigma-divergence on the other.

Also to conform to the standard in the convergence literature, however, it is necessary to transform those models to take the following form:

$$\ln y_t - \ln y_{t-1} = \varphi_0 + \Phi \ln y_{t-1} + \mathbf{G}'\mathbf{\Theta} + u_t \tag{3.26}$$

where $\mathbf{G}$ is a set of other variables defined in Eq.(3.19) above, $\Phi = -(1-\varphi_1)$ and $0 < \varphi_1 \leq 1$. Two conceptually related formulae that will prove useful in the presentation of results and discussion in Chapters Four and Five can be derived for the convergence speed and the half-life respectively as follows:

$$e^{-\lambda t} = \varphi_1 = \ln(\varphi_1/t) \tag{3.27}$$

$$1 - e^{-\lambda t} \Rightarrow \quad t = \ln 2/\lambda \tag{3.28}$$

3.5.1 Methods of Data Analysis

Endogeneity Problem and the Choice of Technique

The presence of lagged dependent variable in Eqs.(3.19) and (3.20) complicates the "static" panel data estimators – the fixed and random effects estimators. The complication arises from the fact that $\ln y_{i,t-1}$ is correlated with the error term. Under the fixed effects estimator, $\Delta y_{i,t-1}$ is correlated with $\bar{\epsilon_i}$ (i.e. mean of the error term) while under the random effects estimator, $\ln y_{i,t-1}$ is correlated with τ_i (i.e. unobserved heterogeneity or omitted variables). Thus, both the fixed and random effects estimators are not applicable. Under this circumstance, the instrumental variable estimators have to be used.

The Two-Stage-Least-Square (TSLS) and the Generalized Method of Moment (GMM) are the two most commonly used IV estimators. Funke and Neibhur (2005), however, remark that the GMM has not been extended to the threshold effects econometrics. The TSLS is therefore adopted for this study. To use an IV estimator we would need to construct a set of instruments with the assumption that that set of instruments is not correlated with the error term while it is correlated with the rest of the regressors. The practice in the literature is to use the lags of the regressors as the instruments. Also, some variables may stand in as their own instruments.

Method of Instrumental Variables/ Two Stage Least Square

As the name suggests, working with the IV/TSLS technique involves running the OLS regression twice. At the first stage, each of the exogenous and/or the predetermined endogenous variables is OLS-wise projected on the set of all the instruments and exogenous variables believed to be independent of the random term and their resulting fitted values saved for the next stage of regression. The second stage entails an OLS regression of the endogenous variable on the set of the fitted values of the exogenous variables obtained in the first stage. Put differently, the series are first purged of the influence of the error terms so that their values are free of endogeneity problem between the regressors and the residuals. To see what is involved here suppose we have the following structural regression equation, which is troubling because of the presence of endogenous variable that is correlated with the error term such as the lag of endogenous variable in Eq.(3.18) or (3.19):

$$y_t = \delta x_t + \mathbf{\Gamma}(\cdot) + u_t \tag{3.29}$$

where x_t is an endogenous dependent variable and $\mathbf{\Gamma}(\cdot)$ is a vector of other truly exogenous variables. As it is the OLS is not applicable in this case. This is because x_t is potentially correlated with the error term, that is, with u_t. Now suppose we have a set of instruments $Z_i \{i\}_1^n$ that can shift x_t without shifting u_t, that is, Z_i is correlated with x_t but not with u_t. With this set of instruments, we can construct auxiliary regression such that

$$x_t = \varrho_0 + \varrho_1 Z_1 + \cdots + \varrho_n Z_n + v_t \tag{3.30}$$

and then use the estimated or fitted value of x_t, i.e. $\hat{x}_t$, to substitute out x_t in the structural equation. Thus, instead of the previous structural equation, the following model will be used:

$$y_t = \theta \hat{x}_t + \Gamma(\cdot) + u_t \tag{3.31}$$

With this construction, $\hat{x}_t$ is purged of $Z_i \{i\}_1^n$ and is therefore uncorrelated with u_t. Thus, we are free of the endogeneity problem.

Chapter 4

Patterns and Forms of Convergence in Sub-Saharan Africa: Catching Up and Lagging Behind

4.1 Introduction

The question we shall be addressing in this section concerns whether the poor economies in sub-Saharan Africa were catching up with the rich economies in the region or were simply lagging behind. Two interrelated concepts used in the growth literature to describe this phenomenon are unconditional/absolute beta-convergence and sigma-convergence. In section 3.3.3 we saw how we could operationally think about these concepts. In this chapter we put those concepts to service. We analyze the data for

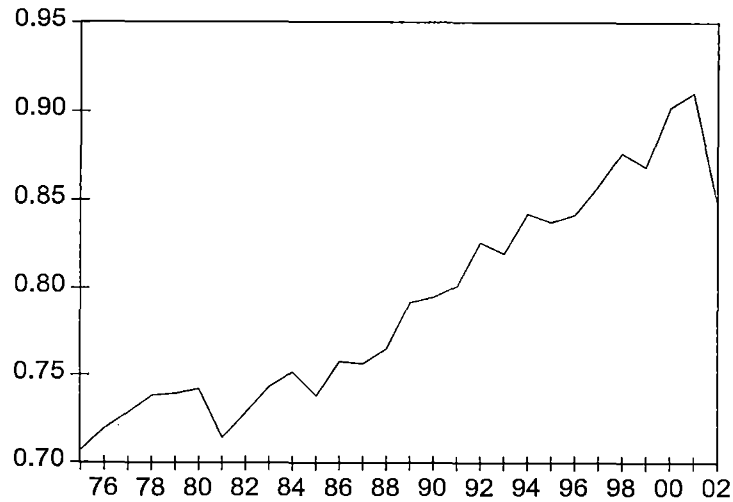

Figure 4.1: Sigma-Convergence among the SSA Economies

the entire sample size without paying attention to whether the threshold effects exist or not. The results are presented in sections 4.1 through 4.3.

4.2 Analysis of Unconditional Beta-Convergence

Fig 4.1 presents beta-convergence for the period 1975-2002. It is observed that during this period the initially poor countries grew faster than the initially rich countries. This result follows from the negatively sloping nature of the fitted regression line in that figure. But when this result is interpreted along with the sigma-convergence (Fig 4.2 below), we are led to conclude that although the initially poor countries were growing faster than the initially rich countries, they were converging to different steady-state levels of income per capita. This further suggests that income inequality had been sustained in sub-Saharan Africa. This is because of the upward trend of the standard deviation of income per capita in Fig 4.2 above. This upward trend is suggestive of the possibility of sigma-*divergence.* As noted above these results are not at all antithetical. They simply point to the fact that other than the initial per capita income, there are other controlling steady-state variables that are important to account for the observed disparity in per capita income levels but which were not yet included. They also suggest that the deep parameters noted in implication (2) sub-section 3.1.4 that determine the steady-state level of per capita income were not the same for all the countries and were probably changing over the sample period. In particular, the share of capital in national income, the discount rate, the time preference and the extent of risk aversion were not homogenous in all these countries. Over the sample period, the systemic economic activity of sub-Saharan Africa went through a series of upheavals (e.g. the 1973/74 and 1979/80 oil shocks, the structural adjustment programmes, the declining commodity prices in the world market) some of which could have fundamentally altered the household consumption smoothing because of their implications for wealth effects and the production pattern among the firms. In sum, it could be true that the initially poor countries actually grew faster than the initially rich countries but that the initially poor countries did so towards lower levels of per capita income, which was not necessarily the same for the initially rich countries. The results above prompt the need to take a closer look at the data by assessing them *recursively.* Fig 4.3 above shows that between 1975 and 1980, the initially poor economies in sub-Saharan African were growing as fast as the initially rich economies, so that the initial income level was maintained (although the average growth rate over this period was for all intents and purposes nil). Looking at Fig 4.2 for the same period, it is observed that the divergence in income per capita was

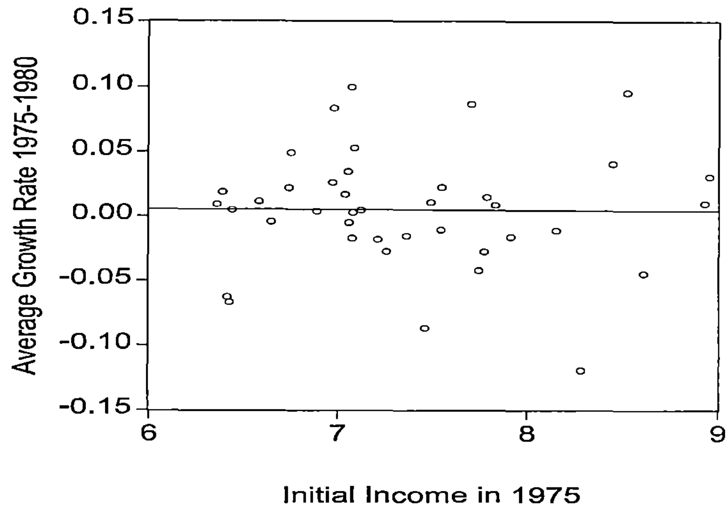

Figure 4.2: Unconditional Beta-Convergence (1975-1980)

minimal. This suggests that in terms of income level the initially poor could hardly be distinguished from the initially rich converging approximately to the same income level and maintaining the same (nil-)growth rate. That is, there was a low and stable deviation among sub-Saharan Africa countries in terms of income per capita between 1975 and 1980. Thus the income inequality observed today could not have been in the late 1970s despite the 1973/74 oil shock. Fig 4.4 above gives information on what happened between 1975 and 1985. That is, over the next five years since 1980, we notice that the initially poor economies showed the sign of growing faster but the rate at which they did so also negligible. Looking at Fig 4.2, we find that over this period income inequality has started to set in. This could be as a result of the changes in the fundamentals (i.e. the deep parameters) noted above. (Why these parameters obey different evolution patterns across countries is currently eliciting lively research efforts.) The fact that the initially poor economies were growing faster than the initially rich economies but were unable to attain the same income per capita (as a

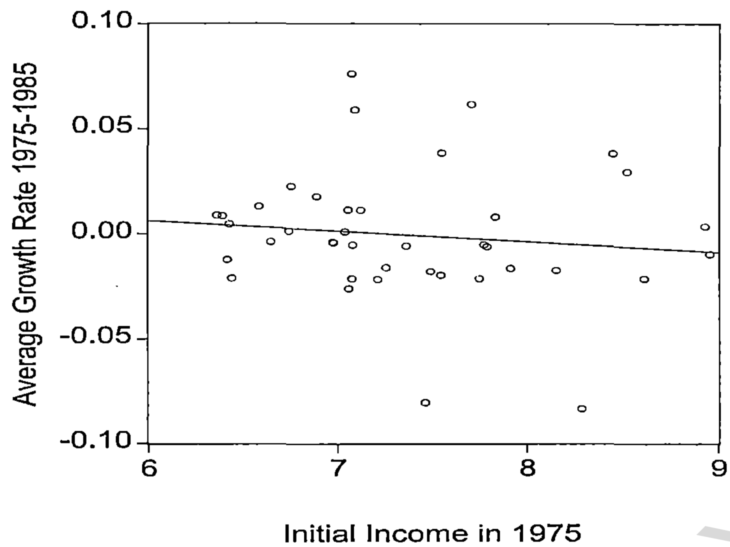

Figure 4.3: Unconditional Beta-Convergence (1975-1985)

result of widened deviation) can only be correct if they were converging at a lower per capita income. It seemed that the effect of the first oil shock of 1973/74 was persistent, lasting until the second oil shock of 1979/80 even though it was contained within a limited range. Thus, the income inequality widened marginally this time.

Figs 4.5 shows that in the 1980s the region reverted to the zero average growth rate, althogh this time around the income inequality had started to widen. In other words, the initially poor economies were doing well, maintaining the same growth rate and sustaining the initial income differences. However, Fig 4.6 reveals that over the next five years, the initially poor grew faster. We observe also that the income inequality among the countries had enlarged phenomenally and was on the upward trend. This is suggestive that most of the policy packages implemented during this period had both growth effects and level effects. that the rate at which the initially poor were growing became faster in the early 1990s. Of particular interest to us

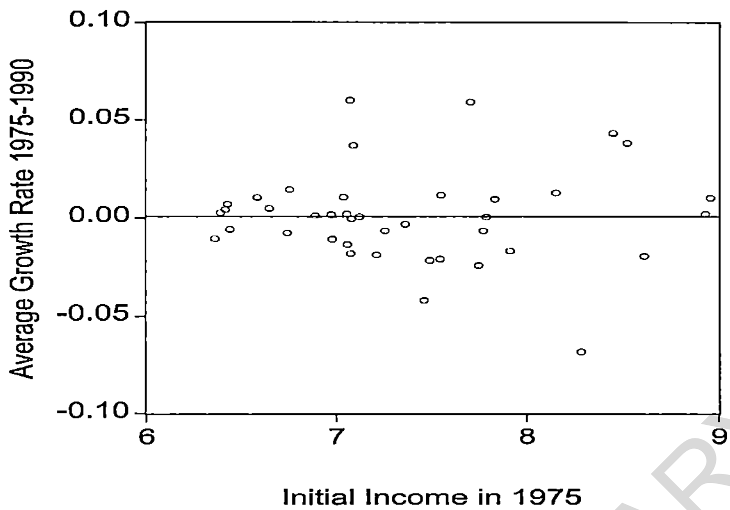

Figure 4.4: Unconditional Beta-Convergence (1975-1990)

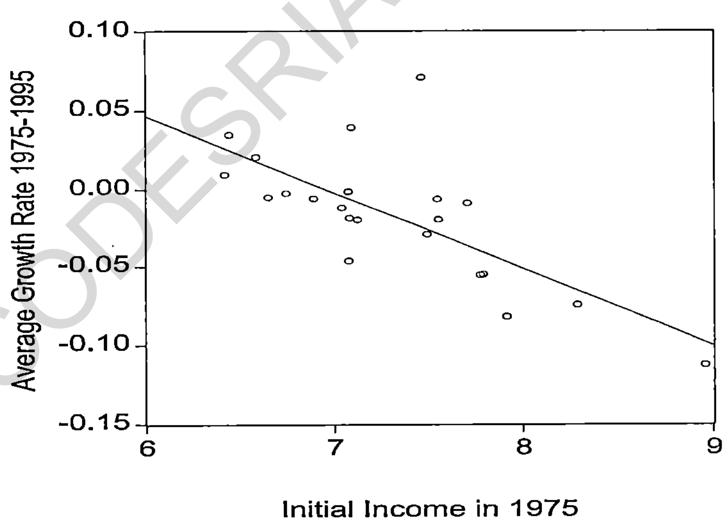

Figure 4.5: Unconditional Beta-Convergence (1975-1995)

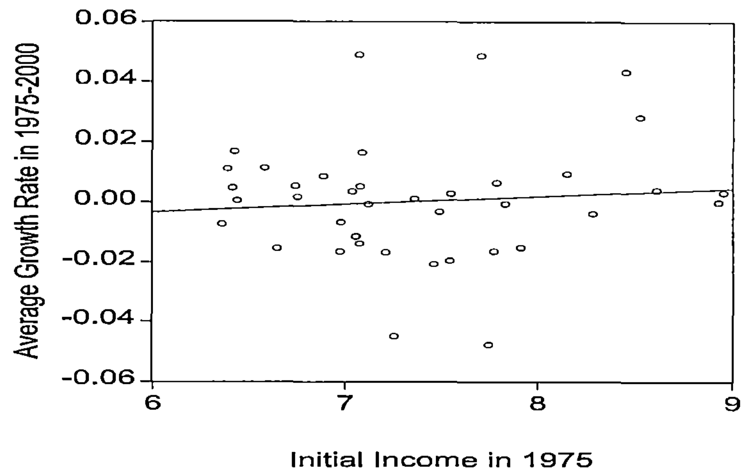

Figure 4.6: Unconditional Beta-Convergence (1975-2000)

is what transpired during the era of structural adjustment programmes. During this period, the income inequality among sub-Saharan African countries increased. This finding then casts doubts on the efficacy of the World Bank/IMF conditionality policy. We also notice that the region was apparently locked in zero-bound growth. (In Chapter Five, we will see the asymmetric implications of this policy on the more and the less open economies). A word of caution is in order here. It is possible that there is transition of an initially poor country from its position at the beginning of a period to a much better position at the end of that period. This possibility can be studied more formally using the transition matrix model in the tradition of Quah (1996) and a quantitative estimate can be provided. Since it is not of immediate interest to this study to examine the evolution of income distribution in sub-Saharan Africa, we leave this as an agenda for later study.

4.3 Analysis of Conditional Convergence

Having looked at the unconditional beta-convergence and sigma-convergence, and having discovered that on average the data on Sub-Saharan Africa are described by beta-convergence on the one hand and by sigma-divergence on the other, we now turn to the conditional beta-convergence. The objective in this section is to discover the variables that determine the steady-state levels of income per capita in Sub-Saharan Africa, that is, those variables apart from the initial level of income that are significant as explanatory variables of the divergent levels of income per capita to which the countries converge. We will also characterize the speed of convergence and the half-life for various sample periods.

4.3.1 Model Evaluation

Table 4.1 above gives the summary of TSLS estimation of our conditional convergence for the period 1975-2002. Before we analyze our model, it is necessary to evaluate it based on its general summary statistics. Both the adjusted and the unadjusted R-squared are quite substantial as they account for almost all the variation in the dependent variable. This is however expected given the dynamic structure of the model. The F-statistic shows that the joint significance of all the regressors is commendable and the associated p-value confirms this. The residual variation of 0.9993% (i.e the standard error of the regression [=0.072838] is about 1 per cent of the mean of the dependent variable [=7.334370]) is respectable. Although the Durbin-Watson statistic almost hits the benchmark of 2, we observe that within the context of dynamic

Table 4.1: Summary Statistics

R-squared	0.990859	Mean dependent var	7.33437
Adjusted R-squared	0.990826	S.D. dependent var	0.760479
S.E. of regression	0.072838	Sum squared resid	10.41973
F-statistic	30413.01	Durbin-Watson stat	1.9859
Prob(F-statistic)	0.000000		

model this statistic is not dependable. Thus, we calculate the Durbin-h statistic[1], which is 0.315535. Because this value is less than 1.645 under the null of no autocorrelation, we accept the null hypothesis of no autocorrelation. Also, we cannot be sure of being free of the heteroscedasticity problem. We therefore make use of the White heteroscedasticity-consistent standard errors and covariance (HCSEC).

4.3.2 Analysis of Conditional Convergence for the 1975-2002 Period

We start with the quantitative analysis of this concept for the sample period between 1975 and 2002. Subsequently, we will examine the data *recursively* to have a deeper understanding of growth evolution in Sub-Saharan Africa. Notice that in our estimating models [Eqs.(3.19) and (3.20)] both the dependent and the independent variables are in log-linear form so that the coefficients in those models carry

[1]Durbin-h statistic is given as $h = (1 - \frac{d}{2})\sqrt{\frac{n}{1-n(\eta_1)}} \sim N(0,1)$. n is the number of observation. In this regression, n=1972

Table 4.2: TSLS Estimate of the Conditional Convergence Regression

Dependent Variable $\ln(GDP)_{i,t}$	Coefficients	p-values
$\ln(GDP)_{i,t-1}$	0.989	0.0000
$\ln(S_k)_{i,t}$	0.028	0.0000
$\ln(n_{i,t} + a + \delta)$	-0.042	0.0188
$\ln(Op)_{i,t}$	-0.002	0.6905
$\ln(M2)_{i,t}$	0.002	0.5793
$\ln(GOV)_{i,t}$	-0.006	0.1144
$\ln(POP)_{i,t}$	-0.003	0.0176
$\lambda = -\ln \varphi_1 / t$	1.05% annually	
$t = \ln 2/\lambda$	66years	

the elasticity interpretation. From the Table 4.2 above, $\varphi_1 = 0.989$, which implies from Eq.(3.27) that $\Phi = -0.011$. Also by substituting this value into Eqs (3.28) and (3.29) we have that the convergence speed and the half-life in sub-Saharan Africa for the period were respectively around 1.1% annually and 66 years. This implies that it would take about 66 years on average for any sub-Saharan African country to get halfway to its steady-state level of income given that it was growing at an annual rate of 1.1%. All steady-state variables but the measures of financial deepening, openness and government spending are significant given their low p-values as can be found in Table 4.2 above. Thus, the rate of investment, population and its growth rate, and government spending are important steady-state variables that determine the long-run equilibrium per capita income to which a typical country converged during the sample period for this study. Considering our argument and findings in the previous section, all these variables are chief reasons why we observe sigma-divergence. In other words, the heterogeneities arising from the rate of investment, population and its growth rate and government spending matter for divergence in per capita income level in sub-Saharan Africa. Openness measure, however, is not so much of a determining factor of the steady-state level of per capita income and thus of sigma-divergence among them during the period under review. This result puts in doubt the role of openness as a growth variable. In Chapter Five, we will examine the role that openness may well have played in sub-Saharan Africa – that of a threshold variable.

As expected the investment rate is a growth variable and is rightly signed. The coefficient on the log of this variable reveals that the investment elasticity of income per capita is 0.028, meaning that $1 increment in investment is expected to generate about $0.028 in per capita income. This implies that investment rate contributes positively to income per head in sub-Saharan Africa and is a key steady-state variable. As for the role of the rate of investment in promoting sigma-divergence, we notice that differences in this factor matters for the observed divergence in per capita income levels, as it is a significant variable determining the steady-state per capita income.

Population and its growth rate are significant growth variables and negatively signed. The elasticity coefficients on them are about -0.003 and -0.042. Although these coefficients are inelastic, they imply trade-offs between "baby boom" and income per head. Specifically, one more baby born between 1975 and 2002 in Sub-Saharan Africa inelastically reduces income per head by $0.0034. This result brings to the foreground the need to consciously control the population in the region. The population growth rate, however, seems to have a more depressing effect on income per head in the region than the population itself as the effect of the population growth rate is about twelve times more than that of population. This finding emphasizes the need to consider population in conjunction with its growth rate. In other words, population is not much of problem as the population growth rate. We also observe that both of these variables are important determinants of the steady-state level of per capita income to which a country in sub-Saharan Africa converges. In other words, population and its growth rate are sources of sigma-divergence – or in short, divergence – in per capita income among sub-Saharan African countries.

The measure of financial depth contributes positively to income per capita. The elasticity coefficient is about 0.0024, suggesting that as financial depth takes root income per head responds inelastically but positively. More lucidly, the more monetized an economy becomes, moving away from a barter-type economy, the greater the resources that will be available for development purpose and the higher the per capita income. This is because "... in a growing economy, monetary expansion... allow[s] an increased volume of transactions to take place... [and] saves resources by replacing barter objects... with money which is costless to produce." (Thirlwall, 2003: p 500). It is not surprising therefore that the elasticity coefficient on financial depth turns out to be positive. However, differences in the quality and extent of financial system among sub-Saharan African countries may not be an important reason for the divergence among them in terms of income per head. This is because of the ostensibly high corresponding p-value.

Lastly, we observe that government spending impacts negatively on income per head, with the elasticity coefficient being -0.0056. This may be adduced to the fiscal dominance feature of most economies in Sub-Saharan Africa, where monetary authorities passively adjust their balance sheets to accommodate fiscal excesses by way of seigniorage, and to the crowding-out effect that government spending may have on the private investment particularly when it is directed to non-core areas, where the substitution effect between the private investment and government spending is high. Thus, the extent of government involvement in terms of its fiscal spending is statistically one of the reasons there is per capita income divergence in sub-Saharan Africa. This result may also be closely associated with the fact that on average following the collapse in the world commodity markets the revenues of the governments started to decline whereas the spending hardly declined thereby putting more pressure on the governments to contest for the available resources in their domestic financial markets and denying the private sectors the resources to expand.

In order to further deepen our understanding of the growth evolution in sub-Saharan Africa, it is necessary to analyze the data recursively by which is meant layering the data with the freshly available ones. We will move at a 5-year increment. By so doing we will be able to track the changes in the parameters of interest over time.

4.4 Recursive Analysis of Conditional Convergence

The results for the recursive analysis are presented in Table 4.3 below. The table shows that between 1975 and 1980 there was convergence speed of 1.64% annually, which implies the half-life of about 42 years. Thus, the convergence speed for this period is faster than for the whole period put together and the period's half-life is shorter. This means that during the late 1970s, a typical sub-Saharan African economy grew at an annual rate of 1.64%, and was hopeful of halving the deviation of its initial income per head from its steady-state income per head in about 42 years.

However, between 1975 and 1985, the convergence speed reduced to 1.39% annu-

Table 4.3: TSLS Estimates of Conditional Convergence Regression

Dependent variable $\ln(GDP)_{i,t}$	1975-1980	1975-1985	1975-1990	1975-1995	1975-2000
$\ln(GDP)_{i,t-1}$	0.984*	0.986*	0.983*	0.988*	0.988*
$\ln(S_k)_{i,t}$	0.020*	0.029*	0.028*	0.027*	0.031*
$\ln(n_{i,t}+a+\delta)$	0.150**	0.051	0.012	-0.023	-0.033
$\ln(Op)_{i,t}$	-0.007	-0.007	-0.004	-0.003	-0.003
$\ln(M2)_{i,t}$	0.008	0.003	0.003	0.003	0.001
$\ln(GOV)_{i,t}$	0.001	-5.3E(-5)	-0.003	-0.004	-0.005
$\ln(POP)_{i,t}$	0.001	-0.008**	-0.007**	-0.005*	-0.005*
$\lambda = -\ln\varphi_1/t$	1.64%ann.	1.39%ann.	1.71%ann.	1.22%ann.	1.18%ann.
$t = \ln 2/\lambda$	42 years	50 years	41 years	57 years	59 years

*significant at 1%, **significant at 5% and ***significant at 10%.

White heteroscedasticity consistent standard errors and covariance estimator has been used.

ally. This implies that during the early 1980s, the half-life was further elongated to about 50 years and it became much more difficult to halve any deviation of income per head from the steady-state value. It should be noted that during the 1970s, the world economy underwent a drastic upheaval in the world energy market. Specifically, the oil shocks of 1973/74 and 1979/80 must have left Africa in general and sub-Saharan Africa in particular worse off. This was also coupled with the decline in the prices of primary commodities in the world market following the recessions in the industrial countries. Thus in the aftermath, sub-Saharan Africa was at dire mercy of the Euromarket into which most of the surplus revenues from oil-exporting countries went. Amidst of these developments in the world economy, it is hardly deniable that sub-Saharan Africa could not but plumb the depths of slow growth over the period.

Between 1975 and 1990, the convergence speed was 1.71% annually, implying that the half-life was 41 years. Thus, in the next five years since the close of 1985, the fortune of sub-Saharan Africa seemed to have improved. Interestingly, the world oil price had started to fall by this time even though the prices of primary commodities continued to fall. This means that much of economic angst that came the way of sub-Saharan Africa in the 1970s was more as a result of the increase in the price in the world oil market than as a result of the decline in the revenue following the decreasing prices of primary commodities.

The intra-SAP period – that is 1985-1990, when most African countries embraced the adjustment programmes – marked a period of significant growth. In particular, the convergence speed rose from 1.39% annually to 1.71% annually, a increase of about 23% over the previous period. It is therefore not in doubt that the adjustment programmes did benefit sub-Saharan Africa as a region although it seems there were no long-lasting effects of those programmes as the convergence speed fell to 1.22% annually over the next five years thereby pointing to the fact that it now took a long time period (i.e now 57 years as against 41 years) before any deviation from the steady-state could be halved.

By 2000, the slow growth trend was simply being perpetuated. In fact the convergence speed declined somewhat to 1.18% annually and the half-life increased slightly to 59 years. This may well be due to the compounding debt profile complicated by the appearance of multilateral finance and policy conditionality. This period was characterized by "the growth of multinational debt, especially that owed to the World Bank and African Development Bank and to a lesser degree the IMF." (Alemayehu, 2001:p 22). Thus growth rate sub-Saharan Africa had been slowed down perceptibly post-SAP era.

Looking ahead, in Chapter Five we shall explore whether these developments had *symmetric* repercussions on sub-Saharan African economies. In particular, we shall try to examine the implications for the growth rates in the more open and the less open economies. We now turn to the steady-state variables.

Throughout the period investment rate was significant at 1% and impacted on income per head positively although inelastically. The impact on income per capita varied from one period to the other. Thus the coefficient of elasticity between 1975 and 1980 was 0.02 suggesting that a $1 percent increment in investment rate would have contributed about $0.02 to income per capita. Between 1975 and 1985 this coefficient increased to 0.029. This means that over the next five years since 1980 investment rate contributed more to income per capita. In particular, a $1 percent increment in investment rate between 1980 and 1985 contributed about $0.009 percent increment. In the late 1980s, however, a $1 percent increment in investment rate reduced income per capita by $0.001 percent. Thus, by the SAP period investment did not seem to contribute much to per capita income growth. The next five years, from 1995 to 2000, recorded a substantial percentage increment of $0.004 however.

Population and its growth rate reversed in importance. While population growth rate was significant at 5% between 1975 and 1980, losing its significance subsequently, population size was not significant at all in the 1975-1980 period. However, between 1980 and 2000, population size turned out to be an important variable and was improving in significance from 5% between 1980 and 1985 to 1% between 1990 and 2000. This suggests that in recent time population size rather than population growth (which draws a line between stock and flow variables) is more important. We also note that over the time population size was consistently negatively signed while its growth becomes negative only recently. The policy implication is therefore that the policymakers should worry more about the quality of the existing population than on its growth rate. Policies that tend to reduce the growth rate of population may not be as effective as the policies that tend to equip the existing population with skills and expertise. It may be true that population growth in Africa is alarming, but the result here is in complete deviance of the efficacy of policy that is intended to raise income per capita in sub-Saharan Africa by controlling population growth rate. If such a policy should be on for some time, sub-Saharan Africa would risk the danger of ageing population!

Our recursive exercise shows that openness had weakly impacted on income per capita doing so consistently over the period. In addition, over the sample period, it remained negatively signed. This finding puts in complete doubt how the liberation of the external sector could have contributed to the growth rate of per capita income. Therefore, openness may be important but perhaps not as a growth variable for sub-Saharan Africa.

Over time, financial depth and government spending turned out to be insignificant although financial depth was positively signed all the time and government spending negatively signed in all but the 1975-80 period. This explains that a large proportion of transactions in sub-Saharan Africa were carried out outside the formal financial sector, and so the extent of monetization of the economy (i.e, the movement away from the barter-type economy) was not yet a significant explanatory variable. Thus, financial liberalization of sub-Saharan Africa economy would go a long way in contributing to the growth process of the region. The insignificance of government spending could be anchored on the fact that much of government spending was not on productive process. While government spending may well have increased over the years, it is also possible that much of it was spent to finance white-elephant projects that only negligibly affected the productive process, that is, there were lots of sunspots. Thus government spending in sub-Saharan Africa was not only insignificant but also negatively signed.

The implication of these results is that sub-Saharan Africa conditionally converged to a steady state, meaning that when the differences among sub-Saharan African economies were taken into account the poor no doubt were able to catch up. It was also revealed that the investment rate played an important role in this convergence process. The convergence speed however was subject to a lot of variations over the period. The income inequality also grew over the period as indicated by the rising sigma-convergence. Noteworthy is the observation that openness was not so much a growth variable as could have been expected. This reinforces the need to examine the variable under the assumption that it is subject to threshold effects. That is our next line of analysis.

Chapter 5

Openness Thresholds Effects, Convergence and Economic Growth

5.1 Introduction

In the last chapter we carried out our analysis without due consideration of the linearity issue. In particular, we studied our growth equation thinking that all the countries in our study should behave statistically alike. That of course was the basis for running a single growth equation. But there are legitimate reasons to doubt this presumed homogeneity assumption. For instance, lately, a growing literature has come to the conclusion that openness though may not be a growth variable, its role in clustering economies into high and low growth rate regimes cannot be fully discounted. In this chapter we are going to look very closely at this issue. We will first examine the data for non-linearity. More precisely, we will investigate the existence of threshold point. We will then examine the effects the openness threshold point on income per capita of the less open and more open economies. To say more on the impact of threshold point on the growth in sub-Saharan Africa, we will have to split the data into regimes of the less open and more open economies.

5.2 Examining the Data for Threshold Point

In the threshold econometrics, it is not a good practice to search for the optimal threshold point at the tails of the distribution. Therefore, we were constrained to grid-search over the interval [15 200] at the increment rate of 0.1. Thus, in order to estimate whether the value of the threshold variable binds on the growth process, we run 1,750 regressions for Eq.(3.19). The corresponding set of sums of squared residuals that is grid-searched to find the critical point also known as threshold point is graphed in Fig5.1 above. Openness level that minimizes the sums-of-squared-residuals was 68.3 times the real national income and the corresponding sum of squared residual was 10.37732. The 5% bootstrapped values of confidence interval for this threshold estimate were 65.5 and 71.2. This shows there is not much dispersion around the threshold estimate, so that our confidence in the estimate becomes much robust. These confidence values correspond to the 2.5 and 97.5 percentiles respectively of 1000 draws sampling from the residuals. To quantitatively see the effects of data-splitting, we re-estimate our regression model while plugging in the estimated value of the threshold point. By so doing, we have the results presented in Table 5.1 below.

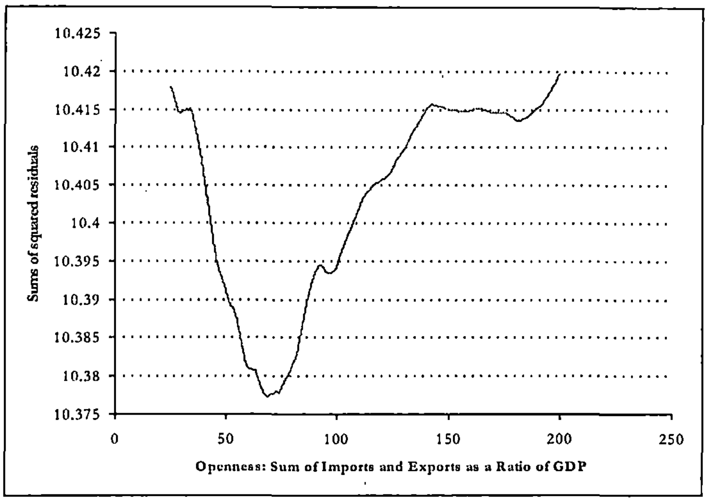

Figure 5.1: Openness Threshold in Sub-Saharan Africa

We found out that below the threshold point openness enhanced growth given that the coefficient on $\partial_{i,t}^{O}(\ln(Op)_{i,t} - \ln(68.3))$ was positively signed. This was strongly so considering the low p-value for this variable. The result suggested sub-Saharan African economies that had not breached the threshold point during the time under review had the elasticity of 0.0194. Of greater importance to us however was the coefficient on $(1 - \partial_{i,t})^{O}(\ln(Op)_{i,t} - \ln(68.3))$. Like in the previous case this coefficient was statistically different from zero given its low p-value. When considered in conjunction with the coefficient on $\partial_{i,t}^{O}(\ln(Op)_{i,t} - \ln(68.3))$, that is, $\varphi_1 = 0.0194$, which was the growth effect of openness on the growth rate in small open economies, openness seemed to have a dampening effect on the growth once the threshold point was breached. Therefore, for the more open economies that had overshot the threshold point, the growth effect of openness on the growth rate was $\varphi(= \varphi_5 + \varphi_6) = 0.00587$. Thus, for high-open economies the growth-retarding effect of openness is twice the same effect among small-open economies.

Table 5.1: Estimated Threshold Model

Independent variables	**Coefficients**	**p-values**
$\ln(GDP)_{i,t-1}$	0.9891	0.0000
$\ln(S_k)_{i,t}$	0.0284	0.0000
$\ln(n_{i,t} + a + \delta)$	-0.0453	0.0114
$\partial_{i,t}^{O}(\ln(Op)_{i,t} - \ln(68.3))$	0.0194	0.0147
$(1 - \partial_{i,t})^{O}(\ln(Op)_{i,t} - \ln(68.3))$	-0.0135	0.0156
$\ln(M2)_{i,t}$	0.0025	0.5524
$\ln(GOV)_{i,t}$	-0.0071	0.0459
$\ln(POP)_{i,t}$	-0.0028	0.0612

5.3 Bi-Modality in sub-Saharan Africa: the Less and the More Open Economy Regimes

In the previous section our data revealed the existence of threshold point. In this section we go a step further classifying our data into these two regimes. It is typical in threshold analysis to find in addition to the global threshold point some local threshold points that usually reveal the existence of multiple regimes. However as Figure 5.1 above shows, it is safe to say that sub-Saharan Africa was fragmented only into two regimes of the less and the more open economies respectively. In other words, we had that sub-Saharan African economy as whole was bi-modal and not entirely homogenous as we were routinely led to believe. In fact in the previous section, we found that openness clustered these economies into high-growth small-open economies on the one hand and low-growth high-open economies on the other. We also found that the region was not severely heterogeneous. Failure over the years to properly delineate this fact about sub-Saharan Africa has probably led to the view that sub-Saharan African countries are homogenous – the view that is often reflected in policy recommendations and the establishment of institutions (e.g., the proposal for common currency in West Africa). This result corroborates earlier findings by Asiama and Kugler (2003). More importantly, we have that openness to trade turns out to be a threshold variable.

As noted in Chapter One, openness had a mixed reputation as a growth driver. Here we had additional information that openness was a threshold variable. One direct implication of this finding is that it would be statistically wrong to attempt to regress all the countries together, under the assumption that they obeyed the same statistical rule. It would be interesting therefore to split the data for the study into regimes informed by the threshold point namely small open[1] and highly open[2] economies[3] On the basis of taxonomy of countries into regimes, most of our discussions in Chapter

[1]Angola, Burundi, Burkina Faso, Central African Republic, Cameroon, Chad, Comoros, Cape Verde, Ethiopia, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Madagascar, Malawi, Mali, Mozambique, Niger, Sao Tome and Principe, Sierra Leone, South Africa, Uganda and Zimbabwe.

[2]Benin, Botswana, Dem. Rep. Congo, Rep. Congo, Cote d'Ivoire, Equatorial Guinea, The Gambia, Mauritania, Mauritius, Namibia, Nigeria, Senegal, Seychelles, Swaziland, Togo and Zambia.

[3]The classification of these countries into regimes of small and highly open economies is based on the average values of openness variable over the sample period.

Four will be revisited.

5.4 Analysis of Unconditional Beta-Convergence for the More Open Economies in sub-Saharan Africa

Fig5.2 below presents the graphical representation for the unconditional beta-convergence for the more open economies between 1975 and 2002. We intend to dissect whether the initially poor among the more open economies grew faster than the initially rich among them during this period. The regression-line fitted scatter plot in Fig5.2 indicates that over the period under consideration the initially poor among the more open economies did grow faster than the initially rich among them; rather there was noticeable divergence as the initially rich more open economies continued to grow much faster than the initially poor more open economies. Compared with the scatter plot for the whole dataset for the same period we find that the rate of growth divergence became more pronounced among the more open economies. Thus, the *extent* of openness influences the catch-up rate of the initially poor economies with the initially rich economies but more than that openness seems to be an important threshold variable in that the *divergence* rate among the more open economies was higher than for sub-Saharan Africa as a whole. This result simply reinforces the earlier conclusion that the openness may well not be a growth variable even though it has a great potential to be a threshold variable clustering the economies into the more and the less

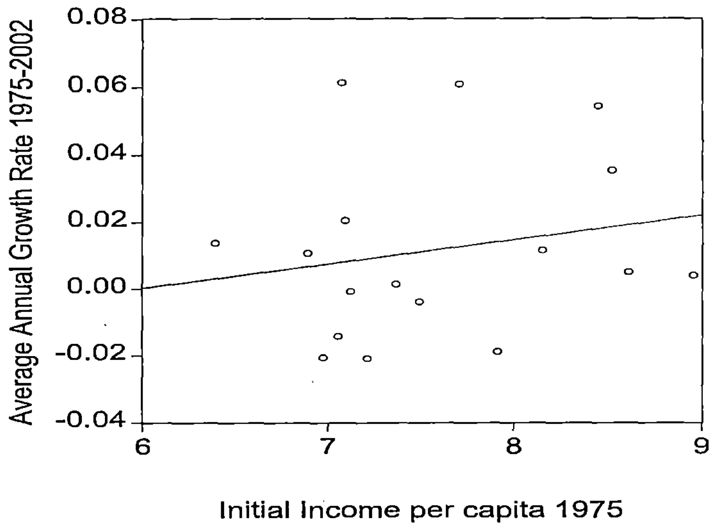

Figure 5.2: Unconditional Beta-Convergence among the More Open Economies (1975-2002)

open economies. Note that the conclusion reached here is predicated on the data for the more open economies. As discussed in the last chapter, there is another angle to convergence. This has to do with the subject-matter of sigma-convergence, which reflects the income inequality. We will shortly study this in a subsequent section.

Considering the unconditional beta-convergence recursively (that is, by each time layering the data with the newly available data) we have that the initially poor among the more open economies were not actually monotonically lagging behind all the time as one might be tempted to conclude using the whole sample period. Rather there have been times when the convergence rate slowed and even led to divergence. For instance between 1975 and 1980 (Fig5.3 above) both the initially poor and the initially rich economies were growing almost at the same rate, thus subscribing to one of the implications of the AK-growth model–a variant of the endogenous growth model. Given this result, it follows that the initial income inequality would persist

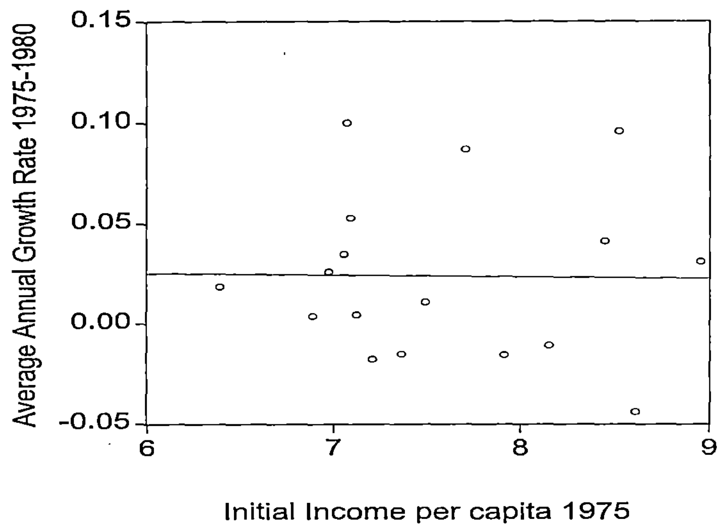

Figure 5.3: Unconditional Beta-Convergence among the More Open Economies (1975-1980)

and be irreversible. Thus, one unfortunate outcome of the 1973/74 oil shock was probably to perpetuate the initial income inequality between the initially poor and the initially rich economies among the more open economies. Between 1975 and 1985 (Fig5.4 below), it is observed that the initially poor among these more open economies were somewhat growing faster than the initially rich. This follows from the inverse relationship between the initial level of per capita income and the average annual growth rate in this period. However, by the late 1980s the initially poor economies had started to lag behind. This is depicted in Fig5.5. Interestingly, most of African economies embraced structural adjustment programmes during this period. Thus, intra-SAP, it is plausible to conjecture that contrary to the implications of the neo-classical growth theory, the initially rich more open economies were able to attract more investment than the initially poor more open economies, thereby increasing the disparity in growth rate observed in the early 1980s. It seemed that the investors were more risk-averse and thus were prepared to put their capitals in the less volatile

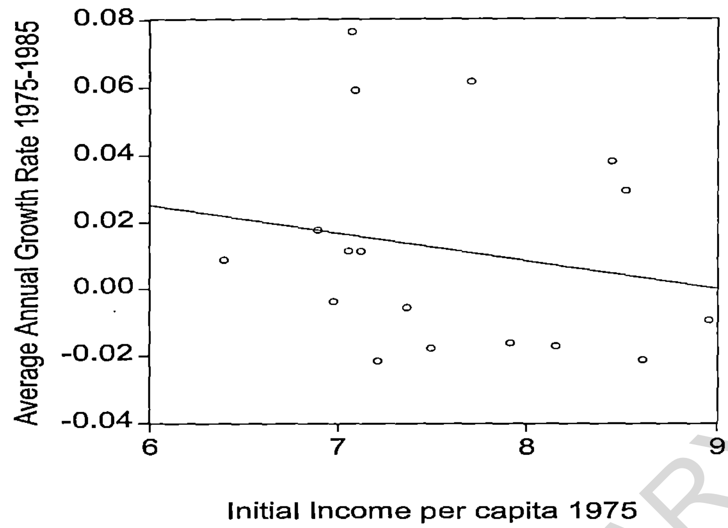

Figure 5.4: Unconditional Beta-Convergence among the More Open Economies (1975-1985)

Figure 5.5: Unconditional Beta-Convergence among the More Open Economies (1975-1990)

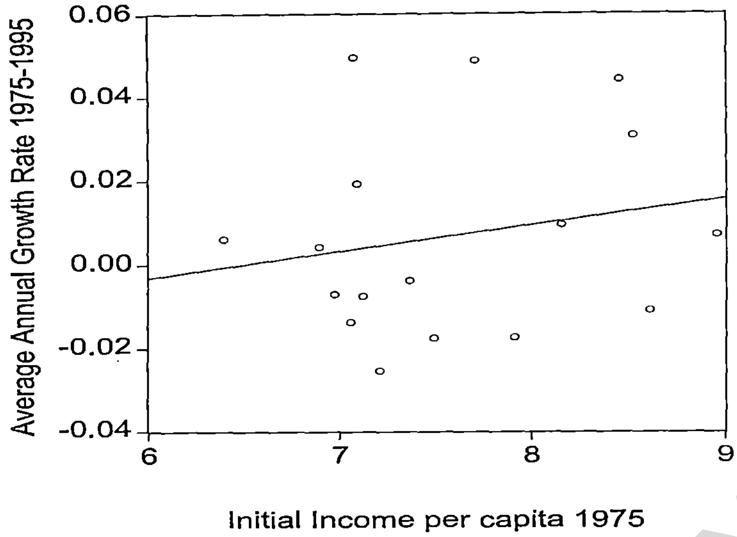

Figure 5.6: Unconditional Beta-Convergence among the More Open Economies (1975-1995)

countries and not following the theory to invest in the initially poor economies where ex-hypothesi there should be higher returns. At the same time, the invasion of Kuwait by Iraq might have caused more ripples in the more open economies. Thus, the structural adjustment programmes were more favourable to the initially rich more open economies. The post-SAP era was characterized by the tendency for the growth rates to widen within the regime of the more open economies. As Fig 5.6 below shows in the early 1990s the initially poor more open economies were lagging behind the initially rich more open economies in terms of growth rate.

This may well have been as a result of the debt burden. As Alemayehu (2001) puts it "...African countries are on a net basis transferring resources to the developed countries since 1985." The analysis above implies that the initially poor among the more open economies must have probably experienced a greater rate of transfer. This is because otherwise the theory predicts that they should grow faster. The scenario in the late 1990s was not in any meaningful way different than it was in the early 1990s. The initially poor more open economies simply continued to plumb the depths of slow growth rate.

The morale of this analysis is that the more open economies had not fared nicely all the time. In particular, the initially poor among them had experienced slower growth rate sometimes. But the unconditional beta-convergence analyzed for the whole sample period actually concealed this stylized fact. Again this shows the danger of looking at sub-Saharan Africa as totally homogenous. In the following section we will analyze the unconditional beta-convergence for the less open economies.

5.5 Analysis of Unconditional Beta-Convergence for the Less Open Economies in Sub-Saharan Africa

As in the immediate section, the objective here is to investigate whether the less open but initially poor countries were growing faster than the less open but initially rich countries. Fig5.7 below shows that over the period under review the initially poor among the less open economies were growing faster than the initially rich. This result is directly at variance with what we obtained for the more open economies (Fig5.2 above) and with what we obtained for the whole data absent the threshold effects. It follows therefore that the extent of openness not only classifies sub-Saharan Africa

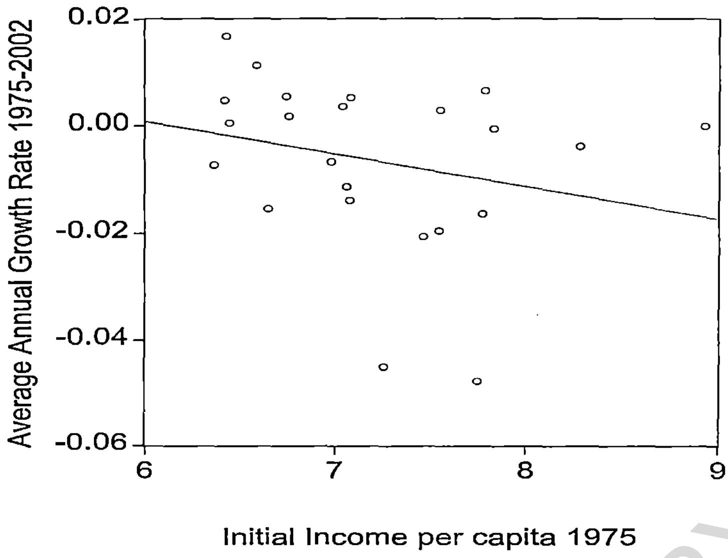

Figure 5.7: Unconditional Beta-Convergence among the Less Open Economies (1975-2002)

into economies of high and low growth rate (the threshold effect in section 5.2) but also indicates that the catch-up rate within each regime could be different. To reiterate, among the more open economies the initially poor economies could not catch-up with the initially rich (Fig 5.2) while among the less open economies the initially poor economies were simply converging faster than the initially rich. This is one result that was concealed when we analyzed the data for the whole sample period without taking cognizance of the threshold effects.

In order to have a deep understanding of the growth evolution over time, we shall explore the data recursively as done above for the more open economies. Between 1975 and 1980, the unconditional beta-convergence shown in Fig 5.8 below reveals that among the less open economies the initially poor economies were growing faster than the initially rich economies. Compared to the same period for the more open economies when the initially poor and the initially rich economies displayed almost

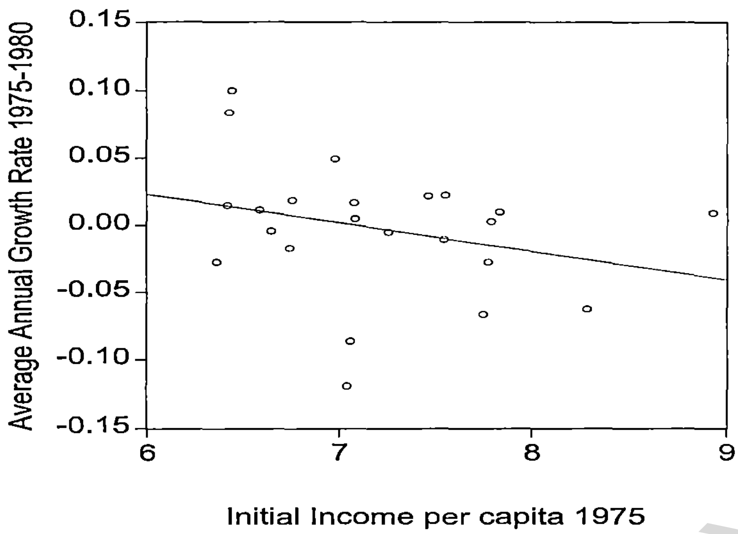

Figure 5.8: Unconditional Beta-Convergence among the Less Open Economies (1975-1980)

the same growth rates, the probable effect of the oil shock of 1973/74 was the creation of growth convergence among the less open economies. In other words, the initially rich among the less open economies were affected the more by the shock to their growth rates. Over the next five years (Fig 5.9) the initially poor economies continued to grow faster than the initially rich economies. From 1980 through 1995 (see Figs 5.10 to 5.11 below), the initially poor economies among the less open economies maintained its growth rate over the initially rich economies among them. Again this turned out to be different from the analysis over the same period for the more open economies, when the initially poor but more open economies lagged behind. Here the initially poor but less open economies converged faster than the rich among them. It follows that the second oil shock of 1979/80 had asymmetric effects on the growth structure of sub-Saharan African economies depending on their positions relative to the threshold point and on their initial conditions. In the next section, we shall dwell on the nature of sigma-convergence among the less open economies on the one

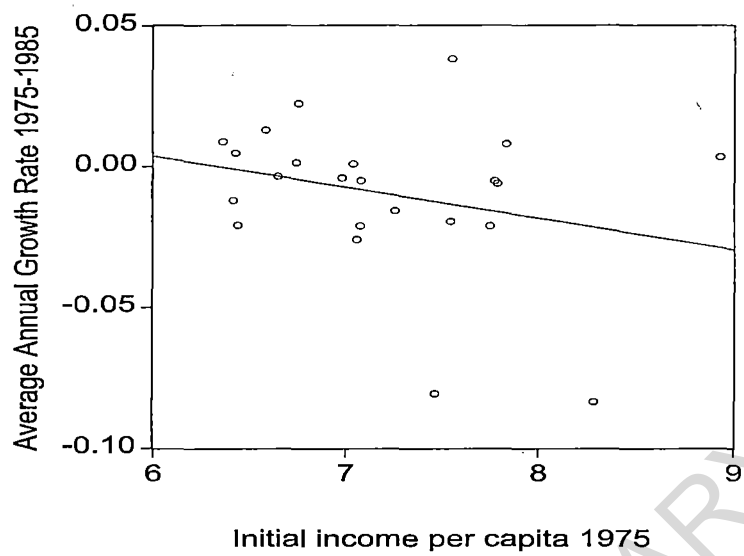

Figure 5.9: Unconditional Beta-Convergence among the Less Open Economies (1975-1985)

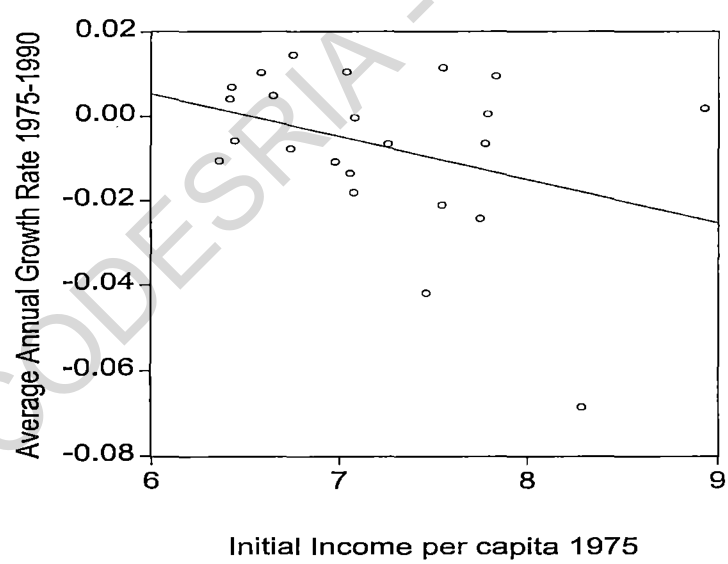

Figure 5.10: Unconditional Beta-Convergence among the Less Open Economies (1975-1990)

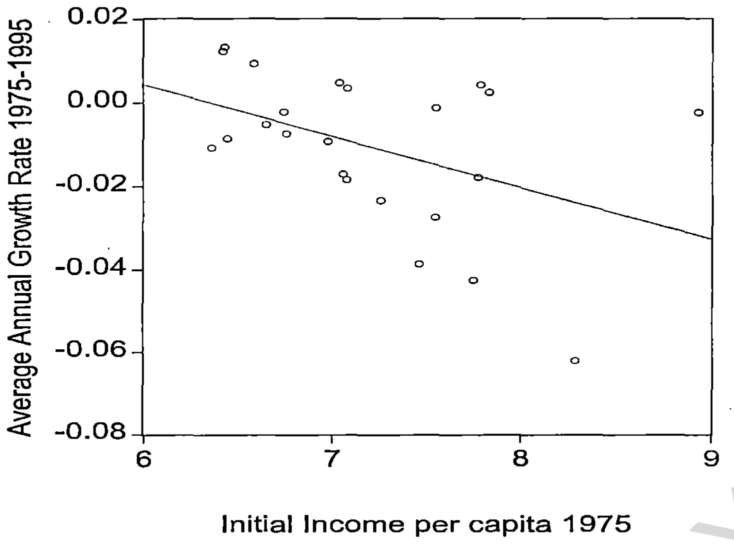

Figure 5.11: Unconditional Beta-Convergence among the Less Open Economies (1975-1995)

hand and the more open economies on the other. This will give us the idea of income inequality among them.

5.6 Analysis of Sigma-Convergence among the Less Open and the More Open Economies

In this section we study the pattern of sigma-convergence among the more open economies and the less open economies. From Fig 5.12 below we see that the more open economies displayed sigma-divergence indicating that among these countries the income inequality widened over time. We notice that this widening deviation from the mean of per capita income first showed up in the late 1970s although reverted very quickly before the close of that decade. Correspondingly during this period,

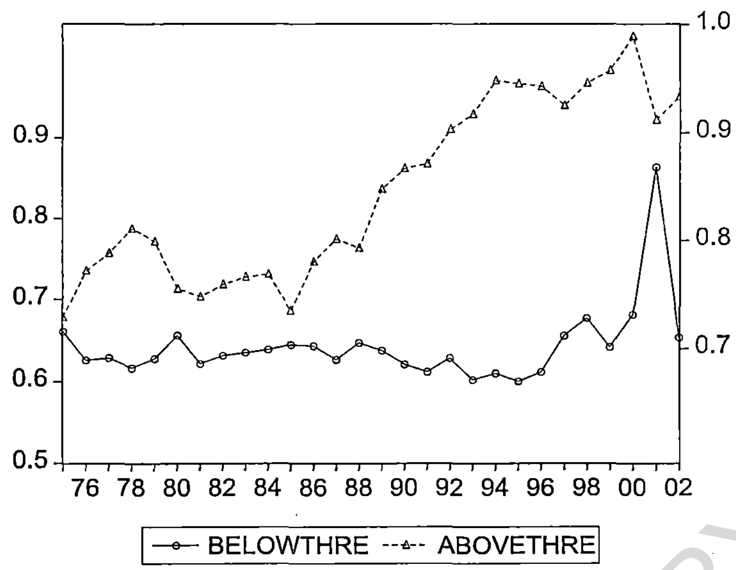

Figure 5.12: Sigma-Convergence within Regimes in sub-Sahara Africa

the less open economies seemed to be experiencing sigma-convergence. This implies that the income inequality among the less open economies did reduce temporarily and started to increase somewhat before the close of the decade too. Generally, however, the income inequality was more stable among the less open economies than among the more open economies. Between 1985 and 1994, the more open economies experienced a growing standard deviation, which confirmed sigma-divergence among these countries. Put differently, income inequality grew and was on the upward trend for the better part of the late 1980s and the early 1990s among the more open economies. It is also observed that within this period income inequality among the less open economies was somewhat on the decline, which affirmed sigma-convergence. This brings to the foreground the influences that the variances in the quality of the technologies transferred courtesy of the extent of openness, their relevance and the rate of internalizing the growth effect of those technologies could have on income

Table 5.2: Summary Statistics for the More Open Economies

R-squared	0.994382	Mean dependent var	7.626629
Adjusted R-squared	0.994336	S.D. dependent var	0.829072
S.E. of regression	0.062394	Sum squared resid	3.324595
F-statistic	21595.46	Durbin-Watson stat	2.167978
Prob(F-statistic)	0.00000		

per capita. We can therefore conveniently say that most of the inequality that we observed in Fig 4.2 in Chapter Four can be adduced to the income inequality among the more open economies. In other words, income inequality occurred and trended up among these more open economies.

5.7 Analysis of Conditional Convergence under the Threshold Effects

5.7.1 Model Evaluation

Tables 5.2 and 5.3 below give the summary of TSLS estimation of our conditional convergence for the period 1975-2002 for the more and the less open economies respectively. Before analyzing our model, we evaluate it based

on its general summary statistics. Both the adjusted and the unadjusted R-squared are quite substantial as they account for almost all the variation in the dependent variable. This is however expected given the dynamic structure of the model. The F-statistic shows that the joint significance of all the regressors is com-

Table 5.3: Summary Statistics for the More Open Economies

R-squared	0.983434	Mean dependent var	7.107409
Adjusted R-squared	0.983329	S.D. dependent var	0.613392
S.E. of regression	0.079199	Sum squared resid	6.912296
F-statistic	9345.745	Durbin-Watson stat	1.930297
Prob(F-statistic)	0.00000		

mendable and the associated p-value confirms this. The residual variation of 0.8181% for the more open economies (i.e the standard error of the regression [=0.062394] is about 1 per cent of the mean of the dependent variable [=7.626629]) is respectable. The same residual variation for the less open economies is 1.114% (i.e the standard error of the regression [=0.079199] is a little more than 1 per cent of the mean of the dependent variable [=7.107409]). This is also commendable. Although the Durbin-Watson statistic almost hits the benchmark of 2, we observe that within the context of dynamic model this statistic is not dependable. Thus, we calculate the Durbin-h statistic[4], which is -2.4824 for the more open economies and 1.1709 for the less open economies. Because these values are less than -1.645 and 1.65 respectively under the null of no autocorrelation, we accept the null hypothesis of no autocorrelation for both regimes. Since we cannot be sure of being free of the heteroscedasticity problem, the White heteroscedasticity-consistent standard errors and covariance (HCSEC) is used.

[4]Durbin-h statistic is given as $h = (1 - \frac{d}{2})\sqrt{\frac{n}{1-n(\eta_1)}} \sim N(0,1)$. n is the number of observation. In this regression, n=862 for the more open and n=1110 for the less open economies.

5.7.2 Analysis of Conditional Convergence for the 1975-2002 Period for Both Regimes

The regression results for the sample period 1975-2002 are reported in Tables 5.4 and 5.5 below for the more open and less open economies respectively. The convergence speed was about 1.97% annually for the economies that were below the threshold point while it was about 1.04% annually for the economies that breached the threshold point on average. The implied half-life was 35 years and 67 years respectively. That is, it would take around 35 years for a typical less open economy to converge halfway between its initial income and the steady state, whereas a typical more open economy would take almost twice that number of years to converge halfway. Thus, the growth rate was faster among the less open economies than among the more open economies in sub-Saharan African countries between 1975 and 2002. When these countries were regressed together, the convergence speed was 1.06% annually, suggesting the half-life of 66 years.(This is one of our results in the last chapter) It is obvious therefore that policy based on the joint regression, which does not take into account the threshold effects, would have underestimated the growth rate for small open economies while exaggerating the growth rate for the more open economies. Thus, openness in itself might not be a growth variable but it could serve to classify economies into regimes of high-open low-growth economies and small-open high-growth economies.

At the steady state, openness seemed to be an important variable that determined the long-run equilibrium position to which the more open economies converged during the period 1975-2002. This followed from its low p-value of 0.0671. We also

Table 5.4: TSLS Estimate of the Conditional Convergence Regression for the More Open Economies

Dependent Variable $\ln(GDP)_{i,t}$	**Coefficients**	**p-values**
$\ln(GDP)_{i,t-1}$	0.987	0.0000
$\ln(S_k)_{i,t}$	0.033	0.0000
$\ln(n_{i,t} + a + \delta)$	-0.038	0.1741
$\ln(Op)_{i,t}$	0.014	0.0671
$\ln(M2)_{i,t}$	0.001	0.8260
$\ln(GOV)_{i,t}$	-0.017	0.0004
$\ln(POP)_{i,t}$	-0.008	0.0002
$\lambda = -\ln \varphi_1/t$	1.04% annually	
$t = \ln 2/\lambda$	67years	

Table 5.5: TSLS Estimate of the Conditional Convergence Regression for the Less Open Economies

Dependent Variable $\ln(GDP)_{i,t}$	**Coefficients**	**p-values**
$\ln(GDP)_{i,t-1}$	0.980	0.0000
$\ln(S_k)_{i,t}$	0.026	0.0000
$\ln(n_{i,t}+a+\delta)$	-0.038	0.1149
$\ln(Op)_{i,t}$	-0.004	0.5653
$\ln(M2)_{i,t}$	0.002	0.7276
$\ln(GOV)_{i,t}$	-0.002	0.6921
$\ln(POP)_{i,t}$	0.004	0.1832
$\lambda = -\ln\varphi_1/t$	1.97% annually	
$t = \ln 2/\lambda$	35years	

observe that openness was positively signed for the more open economies and negatively signed for the less open economies. During the same period however openness was not an important variable determining the long-run position to which the small open economies converged. By all statistical standards, the corresponding p-value of 0.5653 is too high to be acceptable, suggesting the insignificance of openness during the period 1975-2002 for the small open economies.

For both regimes, investment, population size and its growth rate appear to be key determinants of the long-run per capita income to which they converged. However, unlike investment that was positively signed and the population growth rate that was negatively signed for both regimes, population size was negatively signed for the more open economies and positively signed for the less open economies. In all these cases, we found that all the steady state variables were inelastically related to income per capita. While financial depth was not significant for both regimes, the government spending seemed to reverse its significance between these two regimes. The financial depth turned out to be insignificant given its p-values of 0.8260 and 0.7276 respectively for the more open economies and the less open economies. Government spending was superbly significant for the more open economies, its p-value being 0.0004. On the other hand, in small open economies, the government spending was insignificant considering its p-value of 0.6921. However, the joint regression reported in Chapter Four had financial depth and government spending significant, their p-values being 0.0718 and 0.0000. This again points to the inimical outcome of joint regression for the otherwise cross-section of heterogeneous countries.

5.7.3 Recursive Analysis of Conditional Convergence under the Threshold Effects

To dissect this analysis further, we consider recursively our analysis in the same manner that we did for the whole sample period in Chapter Four. The results of our analysis for the less and the more open economies are presented in Tables 5.6 and 5.7 below. For the less open economies the convergence speed was 3.39% annually implying the half-life of 21 years between 1975 and 1980. Within this period the corresponding convergence speed for the more open economies was 2.11% annually with the half-life of 33 years. Over the next five years, while the convergence speed for the less open economies increased to 3.45% annually suggesting the half-life of 20 years, that of the more open economies declined to 1.34% annually suggesting the half-life of 52 years. It therefore seemed that the more open economies were more affected by the oil shocks of 1973/74 and 1979/80. This must be expected since the pass-through effects of the shocks should be greater among the more open economies than among the less open economies. During the SAP era, the convergence speeds for both regimes declined. This raises the question of whether or not the structural adjustment programmes had meaningful effects on the growth rate in sub-Saharan African countries.

Table 5.6: TSLS Estimates of Conditional Convergence Regression:More Open Economies Case

Dependent variable $\ln(GDP)_{i,t}$	**1975-1980**	**1975-1985**	**1975-1990**	**1975-1995**	**1975-2000**
$\ln(GDP)_{i,t-1}$	0.979*	0.987*	0.977*	0.988*	0.989*
$\ln(S_k)_{i,t}$	0.019**	0.028*	0.030*	0.029*	0.033*
$\ln(n_{i,t} + a + \delta)$	0.121	0.048	0.037	-0.016	-0.029
$\ln(Op)_{i,t}$	0.022	0.007	0.006	0.014	0.0019**
$\ln(M2)_{i,t}$	0.004	-0.011	0.001	0.006	0.004
$\ln(GOV)_{i,t}$	-0.023	-0.007	-0.014***	-0.018*	-0.018*
$\ln(POP)_{i,t}$	-0.014*	-0.015*	-0.015*	-0.010*	-0.009*
$\lambda = -\ln\varphi_1/t$	2.11%ann.	1.34%ann.	2.31%ann.	1.25%ann.	1.08%ann.
$t = \ln 2/\lambda$	33 years	52 years	30 years	56 years	65 years

*significant at 1%, **significant at 5% and ***significant at 10%.

White heteroscedasticity consistent standard errors and covariance estimator has been used.

Table 5.7: TSLS Estimates of Conditional Convergence Regression:Less Open Economies Case

Dependent variable $\ln(GDP)_{i,t}$	**1975-1980**	**1975-1985**	**1975-1990**	**1975-1995**	**1975-2000**
$\ln(GDP)_{i,t-1}$	0.967*	0.966*	0.974*	0.976*	0.978*
$\ln(S_k)_{i,t}$	0.011*	0.029*	0.023*	0.023*	0.030*
$\ln(n_{i,t} + a + \delta)$	0.052	0.026	-0.023	-0.011	-0.027
$\ln(Op)_{i,t}$	0.009	0.004	0.004	0.002	-0.005
$\ln(M2)_{i,t}$	-0.002	0.010	0.008	0.011	0.002
$\ln(GOV)_{i,t}$	0.010	0.009	0.004	0.004	-0.001
$\ln(POP)_{i,t}$	0.050	0.014	0.008	0.004	0.002
$\lambda = -\ln \varphi_1/t$	3.39%ann.	3.45%ann.	2.58%ann.	2.44%ann.	2.22%ann.
$t = \ln 2/\lambda$	21 years	20 years	27 years	29 years	31 years

*significant at 1%, **significant at 5% and ***significant at 10%.

White heteroscedasticity consistent standard errors and covariance estimator has been used.

Chapter 6

Summary, Conclusions and Recommendation

6.1 Summary and Conclusions

6.1.1 Summary of Problem, Objectives and Methodology

The objectives of this study were to analyze the pattern of convergence among sub-Saharan African countries, determine the openness threshold point and analyze the impact of openness threshold effects on economic growth. The study took more seriously the proposition that more openness would lead developing countries to grow faster and consequently reduce their poverty level. In particular it investigated the validity of the proposition for sub-Saharan Africa, the region often cited as the least open economy where low openness co-exists with low growth and high poverty level. While the co-existence may well be true, the study viewed the policy recommendation that sub-Saharan Africa should be made more integrated into the world economy as far-fetched in tackling the twin problem of low growth and persistent poverty.

The present study then expressed the view that if that policy recommendation were to be valid, and do the job of reducing the poverty level in the region, not only must the highly open economies in the world grow faster than the small open economies, it must also be the case that within sub-Saharan Africa the initially poor economies among the highly open economies must be better able to catch up with the initially rich economies among them than the initially poor among the small open economies are able to catch up with the initially rich economies among them. In order to test whether this was the case, the study combined the convergence theory with the threshold econometrics - the two workhorses that formed the bedrocks of this study.

The study leaned seriously on the neoclassical growth model, which predicts that the initially poor economy should grow faster than the initially rich economy. The intuition is that in the poor economy the returns to factors are higher than in the rich economy, which implies that the poor economy will be better able to attract investment. This proposition has been described as beta-convergence in the literature.

Because our estimating model is dynamic the OLS estimator could not be applied straightforwardly. We instead adopted the Two-Stage-Least-Square estimator, which is capable of overcoming the attenuation bias that could be introduced using the OLS estimator. Using Eviews codes, we then grid-searched for the threshold point looking for the value of openness that minimized the sum of squared residual. In line with conditional convergence, we controlled for the differences in the steady state by including such variables as financial deepening, government spending, openness, population and its growth rate as well as investment ratio.

The findings of this study are in three parts:

1. For the whole sample we found that: 1) there are mixed findings with respect to whether the initially poor were catching up with the initially rich. This is becuase the periods of convergence seem to alternate with the periods of divergence; 2) the catch-up rate was greatest between 1975 and 1995; 3) the income inequality worsened for sub-Saharan African countries as the plotted standard deviation of their per capita incomes had been trending upward; 4) for the whole sample period the conditional convergence speed was 1.05% annually and that the half-life for the same period was 66 years; 5) log of openness was not significant and was negatively signed, suggesting that openness in itself did not cause much differences in per capita income; 6) the convergence speed fluctuated over the sample period and that half-life correspondingly fluctuated; 7) in no period was openness a significant variable thereby reinforcing the fact that openness in itself does not matter for the differences observed in per capita income; and 8) the intra-SAP era witnessed a declining convergence speed from 1.71% annually to 1.22% annually and then to 1.88% annually for the period 1975-1990, 1975-1995 and 1975-2000 respectively; 9) the optimal openness threshold point was 68.3 times the size of national income, its minimized sum of squared residuals being 10.37732; and 11) the growth effect of openness below the threshold point

was 0.0194 and was only 0.00587 above the threshold, showing that openness retarded growth whenever the threshold of 68.3 was breached; and 10) there was little uncertainty around this threshold estimate.

2. For the more openness regime we found that: 1) the initially poor economies could not catch up with the initially rich for the entire sample period under review; 2) during the sample periods 1975-1980 and 1975-1985, the initially poor showed the sign of convergence; 3) during the periods 1975-1990 and 1975-1995 the initially rich were actually growing at a faster rate than the initially poor; 4) the income inequality did grow among the highly open economies; 5) the speed of convergence among the highly open economies was 1.04% annually and the half-life was 67 years, approximately the same with the whole sample. This convergence speed is below the average of 2% annual rate usually reported in the literature; 6) log of openness was significant and positively signed, meaning that openness caused part of the differences in per capita income observed among the highly open economies; 7) the convergence speed fluctuated over the period along with the half-life; and 8) log of openness had just recently been significant.

3. For the low openness regime we found that: 1) the initially rich economies grew faster than the initially poor for the entire sample period under review; 2) during the periods 1975-1980, 1975-1990 and 1975-1995, the initially poor caught up with the initially rich emphatically; 3) the income inequality remained moderately stable among the small open economies as the deviation of their per capita income fluctuated mildly within a narrow band over the period; 4) the

speed of convergence was 1.97% annually and the half-life was only 35 years; 5) log of openness was insignificant by all statistical standards and was negatively signed, implying that openness did cause the differences in per capita income observed among them; 6) the convergence speed fluctuated over the period along with the respective half-life; and 7) log of openness was not significant as explanatory variable explaining differences in per capita income among the small open economies.

6.2 Recommendation

A key finding in this study was that sub-Saharan Africa is characterized by the slow-growth high-openness regime with a slow catch-up rate and the high-growth low-openness regime with a high catch-up rate. In short, sub-Saharan African countries would behave differently depending on whether they were above or below the threshold in openness. Therefore, the proposition that more openness would cure the twin problem of slow growth and persistent poverty should be carefully reconsidered in the particular case of sub-Saharan Africa. This is because it seems that the more the openness, the more the income divergence, the more sluggish the catch-up rate of the poor with the rich economies in the region and the slower the growth rate.

The investment rate could serve as an alternative way of stimulating economic growth in sub-Saharan Africa. This follows from its significance as an explanatory variable almost throughout the sample period.

Appendix A

Derivation of the Growth-Convergence Regression-like model

In the text, Eq.(3.01) was motivated theoretically. In this appendix we show how the solution to that equation can in turn be obtained to motivate an empirical verification. The following steps are involved:

$$\frac{d\ln(y(t))}{dt} = \lambda[\ln(y^*) - \ln(y(t))]$$

$$\frac{d\ln(y(t))}{dt} = -\lambda\ln(y(t)) + \ln(y^*) \tag{A.1}$$

Let

$$k = \ln(y(t)) \tag{A.2}$$

Therefore,

$$\frac{dk}{dt} = \frac{d\ln(y(t))}{dt} = 0 \tag{A.3}$$

Substituting Eqs.(A.2) and (A.3) into Eq.(A.1) we have the particular solution thus:

$$k = \ln(y^*) = y_P \tag{A.4}$$

$$\frac{d\ln y(t)}{dt} = -\lambda \ln(y(t))$$

$$\int \frac{d\ln(y(t))}{\ln(y(t))} = -\int \lambda dt$$

$$\ln(\ln(y(t))) = -\lambda t + c$$

The complementary solution is then

$$y_C = \ln(y(t)) = Ae^{-\lambda t} \tag{A.5}$$

$$\ln(y(t)) = y_C + y_P = Ae^{-\lambda t} + \ln(y^*) \tag{A.6}$$

To definitize the above we assume $t = 0$ so that

$$A = \ln y(0) - \ln y^* \tag{A.7}$$

Therefore

$$\ln y(t) = [\ln y(0) - \ln y^*]e^{-\lambda t} + \ln y^*$$

$$\ln y(t) = e^{-\lambda t} \ln y(0) + (1 - e^{-\lambda t}) \ln y^* \tag{A.8}$$

Appendix B

It was shown in Appendix A above that the solution to

$$\frac{d\ln(y(t))}{dt} = \lambda[\ln(y^*) - \ln(y(t))] \tag{B.1}$$

is

$$\ln(y(t)) = e^{-\lambda t}\ln y(0) + (1 - e^{-\lambda t}) + \ln(y^*) \tag{B.2}$$

Subtracting $\ln y(0)$ from both sides of Eq.(B.2) and noting that $y^* = k^{*\alpha}$ we have

$$\ln(y(t)) - \ln y(0) = (1 - e^{-\lambda t})\ln k^{*\alpha} - (1 - e^{-\lambda t})\ln(y(0))$$

or

$$\ln y(t) - \ln y(0) = (1 - e^{-\lambda t})\ln\left(\frac{s}{n + a + \delta}\right)^{\frac{\alpha}{1-\alpha}} - (1 - e^{-\lambda t})\ln(y(0))$$

This can be re-expressed as

$$\ln y(t) - \ln y(0) = (1 - e^{-\lambda t})\left[\frac{\alpha}{1-\alpha}\ln s - \frac{\alpha}{1-\alpha}\ln(n + a + \delta)\right] - (1 - e^{-\lambda t})\ln(y(0))$$

The preceding simplifies straightforwardly and so we have

$$\ln y(t) = \frac{\alpha(1 - e^{-\lambda t})}{1-\alpha}\ln s - \frac{\alpha(1 - e^{-\lambda t})}{1-\alpha}\ln(n + a + \delta) + e^{-\lambda t}\ln y(0)$$

$$\ln y_t = \varphi_1 \ln y_0 + \varphi_2 \ln s + \varphi_3 \ln(n + a + \delta) \tag{B.3}$$

Eq.(B.3) is the version that we want to estimate. It is the canonical equation in the growth empirics. Comparing the two preceding equations we note that

$$\varphi_1 = e^{-\lambda t} \tag{B.4}$$

$$\varphi_2 = \frac{\alpha(1 - e^{-\lambda t})}{1 - \alpha} \tag{B.5}$$

$$\varphi_3 = \frac{-\alpha(1 - e^{-\lambda t})}{1 - \alpha} \tag{B.6}$$

Appendix C

Eviews Code for Threshold Point Estimation

```
load thesisworkfinal
pool poolssa
scalar ssr=10000000
poolssa.add AGO BDI BEN BFA BWA CAF CIV CMR COG
COM CPV ETH GAB GHA GIN GMB GNB GNQ KEN MDG MLI
MOZ MRT MUS MWI NAM NER NGA RWA SEN SLE STP
SWZ SYC TCD TGO TZA UGA ZAF ZAR ZMB ZWE
matrix(2000,2) ThrMatrix
for !j=15 to 200 step 0.1
poolssa.genr unit?=1
poolssa.genr threshold1?=!j
poolssa.genr dummy1?=@recode(openhat?¿!j,1,0)
```

```
poolssa.genr thrpoint1?=dummy1?*(log(openhat?)-log(threshold1?))

poolssa.genr thrpoint2?=(unit?-dummy1?)*(log(openhat?)-log(threshold1?))

poolssa.ls(h) log(gdpp?) c log(gdpp?(-1)) log(invthat?) log(nadhat?)

thrpoint1? thrpoint2? log(m2hat?) log(govhat?) log(pplehat?)

ThrMatrix(10*!j,2)=poolssa.@ssr

ThrMatrix(10*!j,1)=!j

if poolssa.@ssr¡ssr then ssr=poolssa.@ssr

endif

next
```

Appendix D

$$\frac{K_{t+1}}{N_tA_t} - \frac{K_t}{N_tA_t} = s\frac{Y_t}{N_tA_t} - \delta\frac{K_t}{N_tA_t}$$

$$\frac{K_{t+1}}{N_{t+1}A_{t+1}}\frac{N_{t+1}A_{t+1}}{N_tA_t} - \frac{K_t}{N_tA_t} = s\frac{Y_t}{N_tA_t} - \delta\frac{K_t}{N_tA_t}$$

But

$$\frac{N_{t+1}}{N_t} = (1+n)$$

and

$$\frac{A_{t+1}}{A_t} = (1+a)$$

So,

$$k_{t+1}(1+n)(1+a) - k_t = sy_t - \delta k_t$$

$$(1+n+a+na)k_{k+1} - k_t = sy_t - \delta k_t$$

$$k_{t+1} - k_t = sy_t - (n+a+na)k_{t+1} - \delta k_t \tag{D.1}$$

It can be assumed that $na \cong 0$ since n and a are growth rates and $k_{t+1} \cong k_t$. We can therefore write the preceding equation as

$$k_{t+1} - k_t = sy_t - (n+a+\delta)k_t \tag{D.2}$$

The above is the fundamental equation used in the text. At the steady state we assume that $k_{t+1} = k_t$ so that

$$sy_t = (n + a + \delta)k_t \tag{D.3}$$

from which we derive

$$k^* = \left(\frac{s}{n + a + \delta}\right)^{\frac{1}{1-\alpha}} \tag{D.4}$$

Appendix E

In order to solve the problem set up in the text we formulate the Bellman equation. We therefore have the following dynamic program where k_t is the state variable and k_{t+1} and x_t the choice variables:

$$v(k_t) = \max_{x_t, k_{t+1}} \left[\frac{x_t^\theta}{\theta} + \rho(1+n)(1+a)^\theta v(k_{t+1}) \right] \tag{E.1}$$

By substituting out x_t from Eq.(E.1) above we have

$$v(k_t) = \max_{\{x_t, k_{t+1}\}} \left[\frac{(k_t^\alpha - (1+n)(1+a)k_{t+1} + (1-\delta)k_t)}{\theta}\theta + \rho(1+n)(1+a)^\theta v(k_{t+1}) \right]$$

The first order conditions (FOCs) for the preceding are

$$-(1+n)(1+a)x_t^{\theta-1} + \rho(1+n)(1+a)^\theta v'(k_{t+1}) = 0 \tag{E.2}$$

and the associated envelope condition is

$$v'(k_t) = (\alpha k_t^{\alpha-1} + (1-\delta))x_t^{\theta-1} \tag{E.3}$$

Utilizing Eq.(E.3) in Eq.(E.2) we have the following Euler equations

$$\frac{x_{t+1}}{x_t} = (1+a)^{-1} \left[\rho(\alpha k_{t+1}^{\alpha-1} + (1-\delta)) \right]^{\theta-1} \tag{E.4}$$

At the steady state $x_{t+1} = x_t = x^*$ so that for capital

$$k^{*\alpha-1} = \frac{(1+a)^{1-\theta} - \rho(1-\delta)}{\rho\alpha}$$

The process of substitution and simplification yields the following equations that describe the steady state values for physical capital per head

$$k^* = (1+a)^{-1}\left[\rho(\alpha k_{t+1}^{\alpha-1} + (1-\delta))\right]^{\theta-1} \tag{E.5}$$

The savings rate in this economy is defined as

$$s = \frac{I_t}{A_t Y_t} = \frac{K_{t+1} - (1-\delta)K_t}{A_t Y_t}$$

so that in the steady state

$$s^* = k^{*1-\alpha}[(1+a)(1+n) - (1-\delta)]$$

or

$$s^* = \left(\frac{\rho\alpha[(1+a)(1+n) - (1-\delta)]}{(1+a)^{1/\theta - \rho(1-\delta)}}\right) \tag{E.6}$$

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