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GROWTH REGIMES IN SUB-SAHARAN AFRICA: A MIXTURE MODEL APPROACH

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-Abstract-

This paper employs a generalized mixture model approach to empirically determine if Sub-Saharan African countries henceforth (SSA) follow a homogenous growth pattern based on the conditional distribution of their growth rates. Latent effects are employed to determine the growth experience of SSA countries and to examine the structural characteristics of the clusters if any exist. Affirmation of clusters might imply significant productivity divergence among Sub-Saharan economies, helping explaining the structural imbalances in the region. Results strongly buttress the existence of clusters and little evidence of a common growth path, implying divergence among Sub-Saharan economies and specific economic reforms are required in the identified clusters to guarantee sustainability and equality of growth in the SSA region. We also observed a positive and significant effect of investment even though the estimated long run effects of investment on economic growth are smaller than expected.

Keywords: Sub-Saharan Africa; Cluster; Mixture model; GDP growth

JEL Classification: C38; O55; R15

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1. INTRODUCTION

1.1 Background of study

This study investigates the long-run growth process in SSA, with particular emphasis on the economy, proxied as gross domestic product per capita (GDP), labour, capital formation and technological growth. It seeks to examine if a homogenous growth pattern exists in SSA economies or if we can sort SSA countries in such a manner, whereby we can draw inferences about growth patterns in Africa. Growth homogeneity among member states has long been the stated aim of the African Union (AU) to enable it achieve its stated objective of economic and political cohesion, and in addition, reduce the per capita income inequality among its members. Their conviction is based on the Barro (1991) and Mankiw et al (1992) neoclassical specification of the Solow (1956) growth model which emphasizes a common growth pattern in cross-country regression models in the long-run. However, recent studies (see Bloom et al: 2003; Paap et al, 2005; Alfo et al, 2008) have emphasized that such specifications do not take into cognizance, the heterogeneous characteristics among countries in growth patterns for the reason that parameter averages are not a true illustration of individual country characteristic, and they also tend to disclose scant information about individual countries fixed effects. Factors responsible for differences in cross-country analysis such as differences in parameters across countries, violation of the linearity assumption in the production function as well as missing or omitted variables are noted as sources of heterogeneity among countries. Empirical literature on economic growth has proceeded through different stages in line with changes in econometrical methodologies and availability of data. In an attempt to analyse growth processes in the long-run, researchers have committed a substantial deal of attention towards developing suitable econometric tools. Initial analysis on growth patterns applied cross-section least squares regression to observe growth regimes and convergence within regions. Due to inadequate data on control variables, the notable approach for modelling heterogeneity in growth process has been to include dummy variables or country fixed effects when analysing cross-sectional data, Barro & Sala-i-Martin (1991) and Armstrong

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(1995). While this method helps control for differences in average growth rates, its inability to control for differences in the marginal effect of the explanatory variables has always been a cause of concern. Alternatively, another approach is to determine countries whose growth patterns are deemed to be identical (i.e. least developed countries, developing countries, emerging countries, developed countries), and these countries are grouped together and analysed. Bloom et al (2003), using this approach on a novel based regression convergence test method, noted that models with dual growth patterns produce better results than models with single growth patterns. They also stated that geographical factors induce the likelihood of an economy designation to one of the two growth regimes. Durlauf & Johnson (1995) applied this approach using a regression tree analysis method on per capita GDP and years of schooling to determine countries with similar growth patterns. Papageorgiou (2002) enhanced the studies by Durlauf & Johnson (1995) by assessing if trade can be included as a threshold variable. However, a problem with this approach is that it hinges on the selection of a predetermined threshold level that might lead to grouping countries with contrasting growth patterns, leading to issues of outliers in regression analysis.

Instead of assuming a pre-determined number of growth patterns, we apply a data-driven approach in our analysis of economic growth pattern called a mixed mixture approach, which enables countries to be tagged into groups (regimes) based on the identical conditional distributions from the latent effects in the distribution. The growth rate of the distribution is modelled as a function of variables pinpointed as primary determinants of economic growth: human capital formation (school enrolment), Physical capital (investment & trade) and population growth rate. This methodology is similar to recent approaches by researchers who analysed cross-country differences, in growth processes by using data driven approaches, see Canova (2004); Paap et al (2005) and Alfo et al (2008)[1]. Canova (2004) took on the Bayesian approach to model regional data. His method enabled him to find an alternative process of sorting countries into groups, as well as to observe structural break points. Paap et al (2005) used a latent effect model to enable economic data decide the groupings in a cross-sectional data. Also Alfo et al (2008) applied a finite mixture approach to test for country heterogeneity in growth models and noted that the explanatory power of

[1] See Alfo et al(2008) for a review of theoretical modelling of cluster groupings

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the Solow growth model is enhanced, when mixture models are applied. They also observed that no sign of convergence to a single equilibrium exists.

Growth pattern among Sub-Saharan economies is of foremost importance in the course of achieving economic integration, and presenting a means towards attaining social and economic stability between member states. Understanding differences in economic growth pattern is very useful for poverty eradication, and having an insight into economic growth patterns, enables one to examine the factors militating against growth, Dollar & Kray (2001). The African Steering Group was established in 1991 by the African Union with the stated objective of developing blueprints, strategic framework and plans towards reducing income inequality and encouraging economic cohesion among member states.

Most empirical studies on economic growth in Africa, undertake analysis with the stated assumption that all countries in Africa have identical economic characterization or apply the growth literature model of Mankiw et al (1992) which allows for country specific intercepts using panel data methods and non-heterogeneity of the growth patterns. This study attempts to bridge the divide in the literature by observing the impact of parameter heterogeneity on a Solow growth model in a panel data framework. Similar to existing works by Alfo et al (2008), we first model growth rate distribution as a function of a number of variables identified as determinants of growth: investment of human plus physical capital and the growth rate of population, then apply Bayes probability on pooled estimates of the dynamic data models to enable intercepts to differ among countries. An added advantage of this approach is the presumption that the growth pattern or regime structure is discrete and unranked or non-hierarchical in any actual manner (the growth patterns are different, doesn't typically imply better or faster growing). This approach, while related to works by Paap et al (2005) and Alfo et al (2008), differ due to the restriction of the analysis to SSA economies, as well as the application of a different econometric framework, which derives alternative results. Lastly, it has been observed that a central feature in economic growth study is the identification of multiple equilibriums. A frequent approach is to examine initial conditions to decide the steady state level a country converges to. Analysis of models with multiple equilibriums is usually dependent on applying observable components like per capita income to categorize country into

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groups. This method is similar to our approach, but a marked difference is that our approach enables us categorize countries into groups based on an unobservable latent variable which is determined by the conditional distribution of growth variables, determined by country characteristics.

The remainder of this paper is structured as follows: in section 2 and 3, we describe the theoretical and empirical methods used to identify the growth pattern, in section 4, we discuss the empirical results and section 5 concludes.

1.2 . Determinants of Economic Growth

A large number of literatures have explored the factors fundamental to economic growth. Applying different concepts and methods, these studies have placed importance on different sets of independent variables and proffered different intuitions as their sources of economic growth (Lichtenberg, 1992; Ulku, 2004; Lensink & Morrissey, 2006). Artelaris et al (2007) argued that investment is the most central determinant of economic growth. The value linked to investment has led to a large number of empirical works analysing the relationship between investment and economic growth, Ndambiri et al (2012). Human capital has also been touted as another important source of economic growth, Barro & Sala-i-Martin (1995). Human capital is basically referred to, as workers acquisition of skill and knowledge through training and education. A large number of studies (see Barro & Sala-i-Martin, 1995; Brunetti et al, 1998; Hanushek & Kimko, 2000) have analysed human capital quality by applying proxies linked to education such as secondary school enrolment. Results from those empirical analyses suggest that education is an important determinant of economic growth. Trade has also been largely applied in growth literature as an important factor for growth, Artelaris et al (2007). Trade influences growth through different avenues such as through technology transfer, improving economies of scale and efficient utilization of comparative advantage. Trade is normally measured as the ratio of export and import to GDP. It has been observed that countries with more liberal policies towards trade and capital flows have higher per capita income and higher growth rates, Dollar & Kray (2001).

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2. THEORETICAL MODEL

2.1 Economic Growth Model

The Solow growth model insinuates that in the steady state, the level of savings and the growth rate of labour determine the output per capita in the long run. This implies that if all countries have homogenous degrees of savings and labour growth, output per capita will be expected to converge to a single equilibrium. But as differences exist between the degree of savings and labour growth rate, steady state levels differ among countries, leading to multiple equilibria, Barro & Sala-i-Marin (1992). We begin by applying the Solow growth model into a Cobb-Douglas production function:

$$f\left(Y_{it}|A_{it,}K_{it}, H_{it,}L_{it}\right) = \mathrm{K}_{\mathrm{it}}^{\alpha}\mathrm{H}_{\mathrm{it}}^{\beta}(\mathrm{A}_{\mathrm{it}}\mathrm{L}_{\mathrm{it}})^{1-\alpha-\beta} \qquad 1$$

With Y_{it} as output for country $i = 1 \ldots . n$ at time $t = 1 \ldots . . T, K_{it}$ is stock of real capital, H_{it} is stock of human capital, A_{it} is the level of technology and L_{it} is labor. L_{it} and A_{it} are assumed to grow exogenously at rates n_i and g:

$$L_{it} = L(0)e^{nt}, A_{it} = A(0)e^{nt} \qquad 2$$

If s_k is the fraction of income invested in physical capital and s_h the fraction invested in human capital, the evolution of the economy is determined by:

$$\dot{k}_{it} = s_{ki}y_{it} - (n + g + \delta)K_{it} \qquad 2a$$

$$\dot{h}_{it} = s_{hi}y_{it} - (n + g + \delta)h_{it} \qquad 2b$$

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With $y_{it} = \frac{Y_{it}}{AL_{it}}$, $k_{it} = \frac{K_{it}}{AL_{it}}$, and $h_{it} = \frac{H_{it}}{AL_{it}}$. Equation (2a) and (2b) imply convergence of the economy to a steady state. The balanced growth path of output per worker is:

$$\ln(y_{it}) = \ln A(0) + gt - {}^{\alpha+\beta}/_{1-\alpha-\beta} \ln(n+g+\delta) + {}^{\alpha}/_{1-\alpha-\beta} \ln(s_{ki}) + {}^{\beta}/_{1-\alpha-\beta} \ln(s_{hi}) \qquad 3$$

If we disaggregate s_{ki} into trade and investment, and apply school as a proxy for s_{hi} the estimated equation can be written as:

$$y_{it} = A_0 + \beta_1 \ln tr_{it} + \beta_2 \ln inv_{it} + \beta_3 \ln sch_{it} + \beta_4 \ln ng\delta_{it} + \varepsilon_{it} \qquad 4$$

With y_i as the 43-year average growth, tr_i as trade mean rate, inv_i as mean investment rate, sch_i as the mean rate of secondary school enrolment and ngd as the population growth rate for country i. ε_{it} represents the normal, independent and equal variance (homoscedasticity) of the deviations $\varepsilon_{ij,}$. $\varepsilon_{ij \sim N(0,\sigma^2)}$.

3. EMPIRICAL MODEL

3.1 Finite Mixture Model

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In this paragraph, we briefly discuss our econometric procedure. The distinct characteristic of the finite mixture model[2] is its ability to divulge heterogeneous growth composition in a sample, without enforcing provisional assumptions on the attachment of each economy to a unique regime. Its ability to enable probabilistic and endogenous distribution of countries across groups or regimes makes it more appealing than an exogenous method which can be very sensitive to selection bias. Also advantageous, is its ability to apply parameter heterogeneity to evade difficulties associated with absence of data which are important for controlling differences in steady state level by disclosing heterogeneity in the constant term. Finite mixture models[3] have been applied on studies by Tsionas (2000); Pittau et al. (2010); Battisti & Di viao (2008); Owen et al. (2009) Paap et al. (2005); Alfo et al. (2008). It should be emphasized that the finite mixture model or simply the latent class model does not directly test the club convergence hypothesis which states that the probability of an economy belonging to a regime is based on some specific variables which have a relationship with the initial conditions of the economy, Galor (1996). Rather, we assume the probability of falling into a regime as a parameter to be optimally estimated in the model. Therefore, our model can be viewed as a broad analysis of multiple regimes and tries to precisely assess specific regimes to which an economy belongs.

To estimate the model described in section 2, annual data from 1970-2013 covering 41 SSA countries from the Word Bank World Development Indicators (WDI) is used. As sizable numbers of explanatory variables can be analysed in explaining growth rates, the covariates applied are those proposed by the augmented neoclassical model used by Mankiw et al (1992). These covariates are also part of the few variables pinpointed as being robust determinants of economic growth, Levine & Renelt (1992). Average annual growth is used as the dependent variable while log of trade openness, log of annual population growth, log of secondary school enrolment and log of average savings are used as the independent variable. In selecting our regressors, we target variables that existing literature tout as central determinants in economic growth process, but it is also important to understand that these variables only assume an auxiliary part in improving our classification of economies into groups rather than defining the

[2] see Titterington, Smith and Markov (1985) on introductory study of the Finite Mixture Model

[3] The finite mixture model provides a natural representation of heterogeneity in a finite number of latent classes

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grouping. The classes or groups are determined by the conditional distribution of the growth rates. Our assumption will be based on the premise that covariates not included in the model specification are assumed to be technological growth factor and by including latent effects[4] to the linear predictor, their joint effects can be assessed, thereby relaxing the IID residual assumption. This study follows the pioneering study of Alfo et al by engaging in latent variables estimation (u_i) affecting economies growth experience as its focal point. If we begin with the assumption that conditional on a set of individual latent effects $u_{i,}$ that embody the effects of unobserved heterogeneity, the growth $\ln(y_{it})$ can be defined in a regression model as:

$$E(y_{it}|x_{it,U_i}) = A_{0i} + \beta_{0i}\ln(tr) + \beta_{0i}\ln(inv) + \beta_{0i}\ln sch + \beta_{0i}\ln ng\delta + u_i \qquad 5$$

with u_i as the latent variable, our mixture model can also be expressed as:

$$E[ln(y_{it})|x_{i,U_i}] = \gamma + x_{it,}\gamma_i + u_i \qquad 6$$

with u_i as country specific latent effects which is visible in the linear model, but this premise can be waved aside by linking the random parameters to some components of the explanatory variables. This enables us derive a random coefficient model. The model in eq. (B6) is fitted by maximum likelihood which maximizes the log-likelihood function. If the set of observations y_{it} is independent and identically distributed, the joint density or likelihood of the model can be written as:

$$f_i = f(y_i|x_i, u_i) = \prod_{t=1}^{T}\{f(y_{it}|x_{it,} u_{it})\} = \prod_{t=1}^{T} f_{it} \qquad 7$$

[4] Latent effects are assumed to be technological factor

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$$= \prod_{t=1}^{T}\{\frac{1}{2\sigma^2}\exp[-\frac{1}{2\sigma^2}((\ln(y_{it}) - \gamma_{0i} - \gamma_1 x_{it1})^2\} \qquad 8$$

Ascribing the latent parameters as unknown or nuisance parameters and integrating them out, the likelihood function can be derived as:

$$L(.) = \prod_{i=1}^{n}\{\int_{u}^{u} f_{i\ dj(u)}\} \qquad 9$$

Evaluating eq. (B6) with the likelihood function, the intercept term $\gamma_{0i} = [ln(A_0) + gt + u_i]$ is assumed to differ among economies. This is to enable us observe country-specific characteristics. While $ln(A_0) + gt$ symbolizes the fixed component of the intercept term, with the distances of each value from the mean as 0, u_i symbolizes the unobserved or hidden country effect that determine differences in technological levels among countries. If we accept the distribution function as unknown due to the fact that specifying the number of parameters can be constraining, we can estimate the number of classes using the integral in eq. (B9). If we assume the number of classes as j,

then:

$$L(.) = \prod_{i=1}^{n}\{\sum_{j=1}^{J} f(y_i|x_{i,} u_j)\pi j\} = \prod_{i=1}^{n}\{\sum_{j=1}^{J}[f i_j\, \pi_j]\} \qquad 10$$

With $f i_j$ indicating the probabilistic distribution of the response (target) variable in the j^{th} element in the mixture model. We treat u_j and π_j[5] as anonymous parameters. We use the empirical Bayes rule to calculate the J component posterior probabilities via penalized likelihood estimation. Designating δ as the parameter vector, we derive:

[5] π_j symbolizes prior probability

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$$\frac{\partial \log[(\delta)]}{\partial \delta} = \frac{\partial \log(\delta)}{\partial \delta} = \sum_{i=1}^{n} \sum_{j=1}^{J} \{\frac{\pi_j f_{ij}}{\sum_{j=1}^{J} \pi_j f_{ij}}\} \frac{\partial log f_{ij}}{\partial \delta} \quad 11$$
$$= \sum_{i=1}^{n} \sum_{j=1}^{J} w_{ij} \frac{\partial log f_{ij}}{\partial \delta}$$

With the posterior probability expressed as $w_{ij,}$ indicating that the i^{th} part is derived from the j^{th} portion of the mixture model. Mixture models or latent models have been applied on empirical studies by Quah (1996) and Alfo et al (2008), and method clusters countries which converge to a homologous steady state. This model was run using the GLLAMM[6] routine in Stata and in using this approach, the correlation between countries from the same cluster arises from their sharing specific but unobserved properties in the region.

Table 1 & 2: Summary statistics

	Count	mean	sd	min	max	sum
year	2214	1986.5	15.58931	1960	2013	4398111
growth	1933	1132.132	1686.856	50.04	13518	2188410
inv	1825	20.60199	15.34548	-2.42	227.48	37598.64
sav	1178	14.58634	11.40676	-35.81	90.79	17182.71
exp	1909	30.61904	19.28216	2.52	124.39	58451.74
imp	1909	39.24456	29.52286	2.98	424.82	74917.86
lab	943	70.26861	11.14508	46.9	90.6	66263.3
sch	1130	23.53716	18.99036	1.07	95.7	26596.99
pop	2214	11.66327	18.75765	.08	173.62	25822.49
N	2214					

	count	mean	sd	min	max	sum

[6] GLLAMM performs maximum likelihood estimation by using adaptive quadrature. See Rabe-Hesketh, 2002

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dvfit1	1006	6.039985	.3968941	4.811638	6.986665	6076.225
dvfit2	1006	6.759466	.8651377	4.220652	8.840816	6800.022
dvcombinedfit	1006	6.39193	.604473	4.669789	7.893652	6430.282
growth	1933	6.458961	.9504199	3.912823	9.511778	12485.17
N	1933					

4. FINDINGS

The regression results are presented in table 3. The table contains the estimates of the variables of the growth regression model. It corroborates findings observed by other literature- a negative and significant coefficient of population growth and a positive and significant coefficient on investment trade and schooling.

Since sensible starting values are crucial for mixture models, we initially fit a model with two points (integrating factors) and subsequently introduce further mass points to yield a higher maximized likelihood. This can be done by keeping all other parameters at their current values, and adding an extra integrating point.

Table 3: Bivariate finite mixture model: augmented model

	(1) growth	(2) growth
growth		
lsch	0.35^{***}	0.38^{***}
	(0.02)	(0.02)
lngd	-0.93^{***}	-1.00^{***}
	(0.07)	(0.06)
linv	0.26^{***}	0.07^{**}
	(0.03)	(0.02)
ltr		0.22^{***}
		(0.02)
_cons	2.06^{***}	1.64^{***}
	(0.23)	(0.18)

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lns1		
constant	-0.75***	
	(0.02)	
_cons		-1.02***
		(0.02)
z2_1_1		
constant	-0.37***	-0.69***
	(0.09)	(0.09)
p2_1		
_cons	0.88*	-0.56
	(0.34)	(0.36)
z2_1_2		
constant		1.06***
		(0.10)
p2_2		
_cons		-0.97*
		(0.42)
N	1011	1006
R^2		

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The iteration process produces a mixture component (latent class) with a mixing probability (prior probability) of countries which are divided into groups. Three distinct groups were clearly identified, according to the selection criteria

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proposed. The study consists of 41 SSA countries[7] and 7 countries each (0.17%) were clustered in both group 1 and group 2 while 27 countries (0.66%) are clustered in group 3.

Table 7 presents the results of maximizing the log-likelihood function defined in equation (B9). In examining the groups, it is important to note that these countries are grouped together because of the conditional distribution of their growth rates. The latent variable captures the effect of missing covariates which are assumed to be technological factors[8]. Although the countries are grouped by a latent characteristic, it is informative to look at the observable characteristics of these countries. The result indicates that geographical location to a SSA region does not determine the convergence to a common steady state, rather the development level of a country seem to determine its growth process. The posterior probability shows that many of the SSA economies have a large probability of being assigned to group 3 which can be termed slow economic growth economies. An interesting observation is Ghana which falls into group 3, due to relatively low per capita income over the entire period. This might be attributed to low level of investment in human capital and political instability in the first three decades of the 20th century. Unsurprisingly, South-Africa, Mauritius, Botswana and Namibia fall into group 2 with posterior probability of 0.1951. They are all southern African economies with relatively strong and transparent public institutions, clear property rights, strong judicial independence and efficient government while Nigeria, Angola and Gabon fall into same group by virtue of being SSA major oil exporting economies. This group has the most diversified and sustainable economies in Africa and also has the highest income per capita among the 3 groups. Group 3 can be termed SSA slow economic growth economies, the result of a variety of causes that may include corrupt governments that have often committed serious human rights violations, failed central planning, high levels of illiteracy, lack of access to foreign capital, and frequent tribal and military conflict (ranging from guerrilla warfare to genocide). According to the United Nations' Human Development Report in 2013, these countries ranked among the bottom 25 ranked nations (151st to 175th). Our findings are similar to results by Davis et al (2007). The Solow model based on the heterogeneous groups enable us recognize

[7] Somalia and Eritrea were omitted for non-availability of several regression variable data

[8] Technological factor is the residual, which accounts for effects in total output not caused by inputs, Solow (1956)

differences between the countries. Overall, there is a high degree of heterogeneity in the convergence behaviour. This indicates that economic integration of growth in SSA towards a steady state is not a characteristic of Sub-Saharan economies in the medium and long term. Our results can be surmised as follows: Firstly, we strongly reject hypothesis that the countries in our sample follow a common growth path in favour of a growth path in which three distinct growth paths occur. Secondly, from our analysis, classification into the growth patterns is not based on geographical distribution. For example, we observed groups of countries in East Africa and West Africa clustered in group 1. Thus mixture model is very effective in sorting for parameter heterogeneity among countries with similar income. Lastly, the regression results and growth pattern disclosed conforms to a significant degree with established theories of economic growth- see: Mankiw et al (1992) augmented neoclassical growth model; Lucas (1998) model of education driven growth; and Rebelo's (1991) model of growth derived from physical capital accumulation.

5. CONCLUSION

In this paper, we analysed the cross-country growth behaviour of SSA by applying a finite mixture model to endogenously identify potential growth patterns. Our study, follows similar literature by Alfo et al (2008) and Davis et al (2007), but differs in its analysis of only SSA countries. This analysis is of utmost importance since SSA comprises of numerous countries with different levels of productivity and economic growth. By applying finite mixture techniques, with the latent variable ascribed as technological growth, we observed that heterogeneity exist in income per capita among SSA economies. First we observe certain countries from the eastern and western region forming a cluster similar to economies with average growth rates. Next we observe a cluster of countries mostly from the southern African region and SSA major oil producers diverging from other SSA groups. Finally, we have a larger group of countries clustering within the SSA region. These countries collectively experience lower economic growth. Based on the results, SSA is a trinal economic reality with groups of economies converging to different steady states, thus having different growth patterns. This divergence in growth patterns draws attention to the

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obstacles in managing SSA economies. There is an urgent need for deep structural reform within the SSA to increase convergence levels between member countries. This is of significant relevance given the significant imbalances observed in terms of economic growth within SSA. Countries should appraise their group (cluster) position and undertake decisive structural reforms towards catch-up convergence. Extending the analysis to the entire African regions will enable us draw inferences on integration progress levels within the entire African continent. This will make for an interesting future research.

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Appendix

Table 3: Bivariate finite mixture model: augmented model

	(1) growth	(2) growth
growth		
lsch	0.35***	0.38***
	(0.02)	(0.02)
lngd	-0.93***	-1.00***
	(0.07)	(0.06)
linv	0.26***	0.07**
	(0.03)	(0.02)
ltr		0.22***
		(0.02)
_cons	2.06***	1.64***
	(0.23)	(0.18)
lns1		

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constant	-0.75***	
	(0.02)	
_cons		-1.02***
		(0.02)
z2_1_1		
constant	-0.37***	-0.69***
	(0.09)	(0.09)
p2_1		
_cons	0.88*	-0.56
	(0.34)	(0.36)
z2_1_2		
constant		1.06***
		(0.10)
p2_2		
_cons		-0.97*
		(0.42)
N	1011	1006
R^2		

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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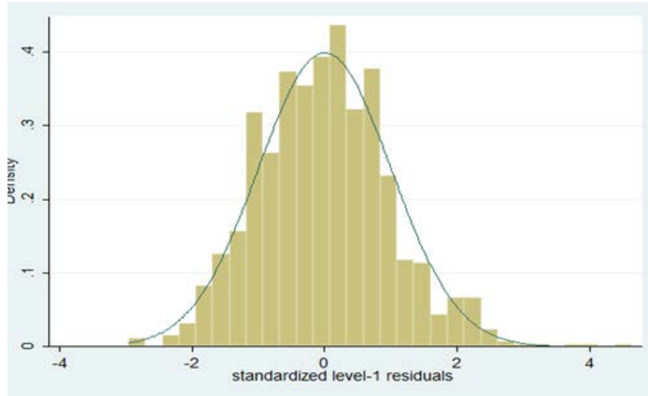

Figure 1: Mixture graph

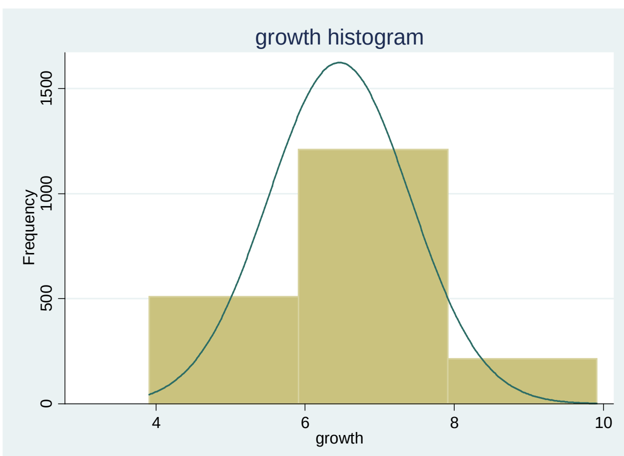

Figure 2: Standardized residuals from mixture approach

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Table 4: Bivariate posterior classification

-> k3 = 1

Summary statistics: mean

By categories of: country

country	growth	ebm1	ebs1	eb3m1	eb3s1
Burundi	5.209159	-.3670036	0	-.6867707	0
Gambia	6.052854	-.3670036	0	-.6867707	0
Guinea	5.356462	-.3670036	0	-.6867707	0
Malawi	5.356462	-.3670036	0	-.6867707	0
Sierra Leone	5.921506	-.3670036	0	-.686746	.0040956
Togo	6.056678	-.3670036	0	-.6867707	0
Uganda	5.496746	-.3670036	0	-.6867707	.0001352
Total	5.648824	-.3670036	0	-.6867694	.0002339

Table 5: Bivariate posterior classification

-> k3 = 2

Summary statistics: mean

By categories of: country

country	growth	ebm1	ebs1	eb3m1	eb3s1
Angola	7.368854	.8847508	0	1.05543	0
Botswana	7.909241	.8847508	0	1.05543	0
Gabon	8.903381	.8847508	0	1.05543	0
Mauritius	7.992534	.8847508	0	1.05543	0
Namibia	8.036209	.8847508	0	1.05543	0
Nigeria	6.518715	.8847508	0	1.05543	0
South Africa	8.510502	.8847508	0	1.05543	0
Total	7.927725	.8847508	0	1.05543	0

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Table 6: Bivariate posterior classification

-> k3 = 3

Summary statistics: mean

By categories of: country

country	growth	ebm1	ebs1	eb3m1	eb3s1
Burkina Faso	5.642636	-.3670036	0	-.009586	0
Cameroon	6.777561	.8847508	.0001069	-.009586	0
Cape Verde	7.080198	-.3670036	.0000165	-.009586	0
Chad	6.149244	-.3670036	0	-.009586	0
DR Congo	6.110472	-.3670036	2.90e-06	-.009586	2.02e-10
Djibouti	6.888033	.8847498	.0011163	-.009586	4.03e-10
Kenya	6.167245	-.3670036	0	-.009916	.0149463
Mali	5.887673	-.3670036	0	-.0101567	.0196503
R. of Congo	7.308047	.8847478	.0019444	-.009586	0
Senegal	6.616884	-.3670034	.0005532	-.009586	0
Sudan	6.264024	-.3670036	0	-.009586	0
Swaziland	7.433839	.8847508	0	-.009586	0
Zambia	6.638545	-.3668371	.0144356	-.009586	0
Benin	6.15551	-.3670036	0	-.0095878	.001113
C.A. Republic	6.048433	-.3670036	0	-.0095914	.0019221
Eq. Guinea	7.333298	-.3410927	.178221	-.009586	.000033
Ethiopia	5.02116	-.3670036	0	-.6867707	8.33e-08
G.-Bissau	6.06356	-.3670036	0	-.009586	8.16e-07
Ghana	6.091031	-.3670036	0	-.6867707	5.68e-07
Ivory Coast	7.201033	.8847508	0	1.05543	9.10e-06
Liberia	5.332653	-.3670036	.0000575	-.6867657	.0018416
Madagascar	5.859687	-.3670036	0	-.6867677	.0014351
Mauritania	6.53336	-.3670036	0	-.009586	1.07e-06

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Mozambique	5.471015	-.3670036	0	-.6867707	8.55e-06
Niger	5.745513	-.3670036	0	-.009586	7.46e-08
Tanzania	5.758276	-.3670036	.0001055	-.009586	3.54e-06
Zimbabwe	6.472895	-.3670036	0	-.009586	1.33e-06
Total	6.053718	-.2845616	.0049001	-.1704318	.0003487

Table 7

Classification Results of mean value of growth based on Mixture Results

Cluster (Groups) from 1970-2013 FMM cross-country estimates

- Group 1: Guinea, Burundi, Togo, Malawi, Gambia, Uganda, Sierra Leone
- Group 2: Angola Nigeria, Gabon, Botswana, South Africa, Namibia, Mauritius
- Group 3: B. Faso, C. Verde, Senegal, Kenya, Benin, Zambia, Ethiopia, Djibouti, Liberia, Ghana, E. Guinea, Madagascar, Mauritania, Sudan, G. Bissau, Niger, Ivory coast, Chad, Mali, R. Congo, Tanzania, C.A.R, Zimbabwe, Mozambique, Swaziland, Cameroun, DR. Congo

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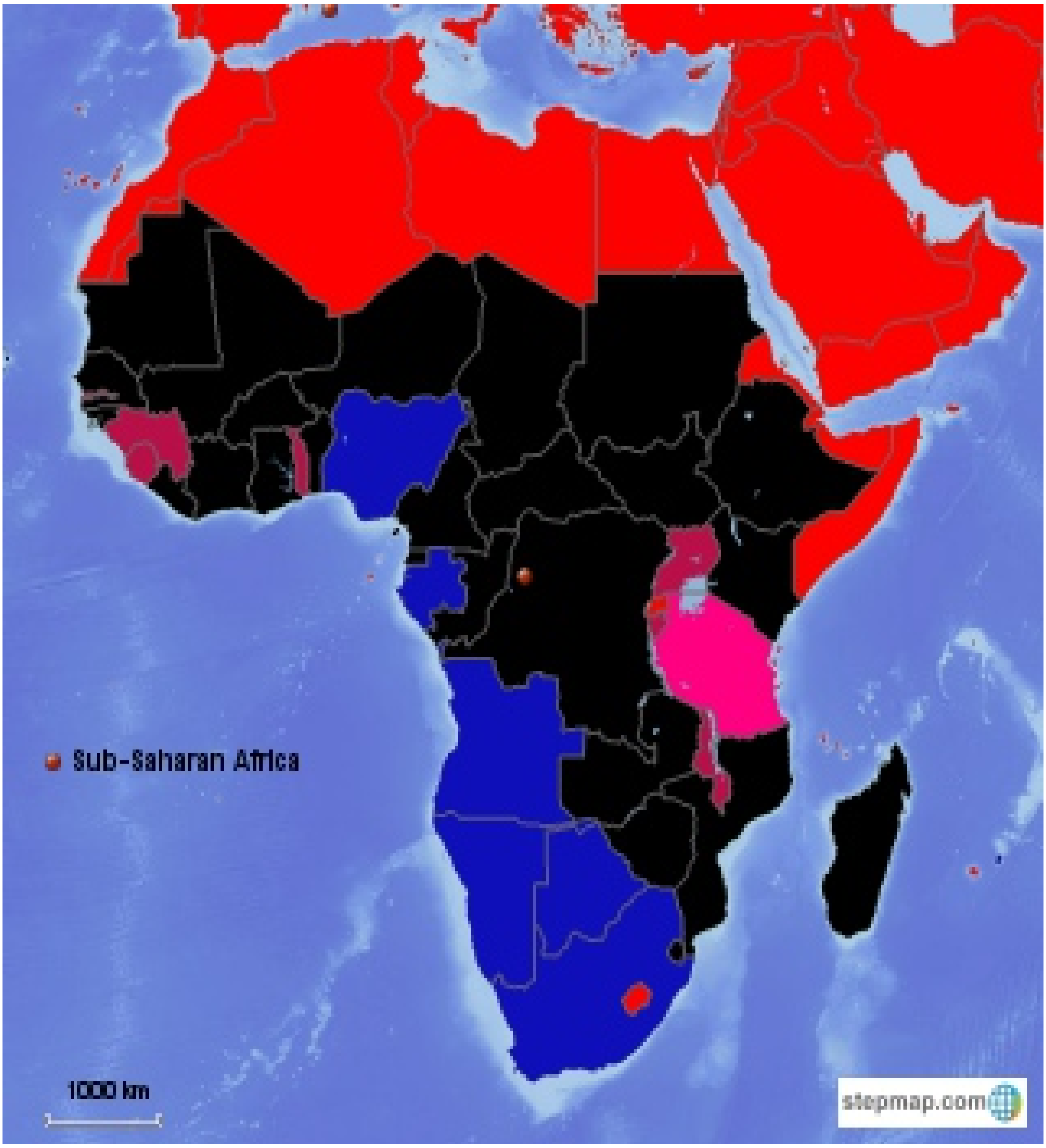

Figure 3: SSA growth classification map