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The Natural Rate of Growth and the Relevance of Aggregate Demand in Low Income Countries: the case of Sub-Saharan Africa

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Abstract

The research contributes towards understanding the relevance of aggregate demand for developing economies by applying a political economy and institutionalist approach to the post-Keynesian theory. We test the endogeneity hypothesis for the natural rate of growth, i.e. its dependence on demand, for 31 sub-Saharan African countries using time series and panel data for the 1991 to 2012 period. We find robust evidence for the endogeneity hypothesis across different estimation techniques. This is of significance for, if the natural rate of growth is endogenous to demand, then changes in demand might matter for economic growth and development in the long run as well as the short run. The paper further contributes to understanding the responsiveness of the natural rate of growth to domestic and foreign demand for developing countries by distinguishing between low income, lower middle income and upper middle income economies in the case of sub-Saharan Africa. We find that the responsiveness of the natural rate of growth to demand is L shaped for developing countries as it decreases at an increasing rate with the level of economic development.

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1. Introduction

The natural rate of growth was first introduced by Harrod (1939) alongside the geometric and the warranted rates of growth. Assuming some sort of full employment, the natural rate of growth is the maximum rate a country can grow given population growth, accumulation of capital, technological improvement and the work/leisure preference schedule (Harrod, 1939). Although Harrod (1939) originally defined the natural rate of growth as exogenous, Leon-Ledesma and Thirlwall (2002) were the first to provide evidence that the natural rate of growth is endogenous to the actual rate of growth for a selection of OECD countries.

Understanding if the natural rate of growth is endogenous or exogenous is imperative as it lies at the heart of the debate between neoclassical growth theory, which takes the natural rate of growth as exogenous to the actual rate of growth and the post-Keynesian theory, which maintains that the labour force growth and productivity growth respond to both foreign and domestic demand, therefore making the natural rate of growth endogenous to the actual rate of growth.

The endogeneity of the natural rate of growth implies a demand-led growth model. The demand for goods and services depends on relative prices as well as income. Leading development institutions, working within a neoclassical framework have focused only on policies related to price competition which reinforces the dependency of African countries on primary exports and ignores the importance of non-price competition as well as structural factors (Hussain, 2006).

Keynesian economics was argued as irrelevant for developing countries (Dasgupta, 1965). However post-Keynesian economic models argue that there are several ways in which aggregate demand is relevant for the growth process of less developed countries even in the presence of supply constraints, for example, “when constrained by capital shortages, stagnant agricultural sectors and foreign exchange availability” (Dutt, 1996).

The endogeneity hypothesis for the natural rate of growth has been applied to several middle and high income countries, all providing evidence in support for it (Libanio, 2009; Vogel, 2009; Dray and Thrilwall, 2011; Lanzafame, 2014). No studies have been carried out on low income countries or for the sub-Saharan African region.

The research aims to answer the questions related to the endogeneity of the natural rate of growth for low income countries and the sub-Saharan African region. This is done by estimating the natural rate of growth for sub-Saharan Africa and testing if it is endogenous to demand shocks.

We further contribute to the understanding of the sensitivity of the natural rate of growth, i.e. its responsiveness to demand during the boom periods for developing countries by distinguishing between low income, lower middle income and upper middle income economies. While the literature distinguishes between advanced economies and developing economies (Dray and Thirlwall, 2011), very little is known about the variability in the responsiveness of the natural rate of growth to demand changes for developing countries which are made up of a diverse range of economies.

An overview of the literature related to the endogeneity of the natural rate of growth is presented in section 2. In section 3 and 4, data for 31 sub-Saharan African countries for the 1991 to 2012 period is used to estimate the natural rate of growth as well as empirically test if it is endogenous to the actual rate of growth. This sheds light on the relevance of demand for economic growth in the region. The time period is limited due to data availability. Any results obtained from time series analysis are therefore only indicative. In order to overcome this limitation, panel data analysis determining the endogeneity of the natural rate of growth is used to complement the time series results. These are presented in section 5. Both the time series and panel data analysis provide support for the endogeneity of the natural rate of growth, i.e. the natural rate of growth responds to domestic and foreign demand.

Our results provide evidence of an L shaped relationship between the natural rate of growth and the level of economic development. Low income economies proved to be most sensitive to demand changes. The reasons for this are discussed in section 6. The results indicate that a demand-led growth model may be applicable in the region.

2. Literature Review

The endogeneity of the natural rate of growth is most commonly determined by estimating the natural rate of growth and testing if it increases during the boom periods. This is done by adding a dummy variable which represents the boom.

Several researchers have used different estimation techniques to determine the endogeneity of the natural rate of growth. Using Ordinary Least Squares (OLS), Leon-Ledesma and Thirlwall (2002) used data on 15 OECD countries for the 1960 to 1995 period and found that the dummy variable was significantly positive in all the countries used in the analysis. As a robustness test, the researchers go on to carry out Granger-causality analysis between inputs and outputs for if the natural rate of growth is endogenous, then an exogenously determined production frontier as specified in orthodox growth theory, does not exist. The production frontier instead moves with each movement of the actual rate of growth (Leon-Ledesma and Thirlwall, 2002).

Two variables are used in the analysis, the log of Gross Domestic Product (GDP) and the log of total factor inputs. Out of the 15 countries analysed, 13 showed bidirectional casualty between output and total factor productivity. The results therefore show that both inputs and outputs adapt endogenously to their long run relationship. This provides strong evidence for the endogeneity of the natural rate of growth.

Using a similar technique, Dray and Thirlwall (2011) estimated the sensitivity of the natural rate of growth to the actual rate of growth for a selection of 10 Asian countries for the 1982 to 2005 period. Results show that the natural rate raged from 2.8% for the Philippines and 10.4%

for China. When testing for the endogeneity of the natural rate of growth, they find the dummy variable and constant are statistically significant for all countries expect for the Philippines.

Vogel (2009) uses a system of Seemingly Unrelated Regressions (SUR) estimations for 11 Latin-American countries for the 1986 to 2003 period. The average natural rate of growth estimated ranged from 1.8% for Venezuela and 6.1% for Chile. After adding the dummy variable, it was found to be significant at the 99% level for all countries. Demand was therefore found to be relevant for the respective countries.

Lanzafame (2014) used panel data for 22 OECD countries for the 1960 to 2010 period. He used fixed effects to determine the natural rate of growth for each country. The average natural rate of growth was found to be 3%. Results from the endogeneity test signalled that on average, growth increased by 3.3 percentage points when the actual rate of growth was above the natural rate of growth. Lanzafame (2009) also used panel data to determine if regional growth in Italy was endogenous. For the 1977 to 2003 period, results showed that growth was endogenous in only 8 out of 20 Italian regions.

Several studies have been carried out on the endogeneity of the natural rate of growth for various countries however no studies have been carried out for low income countries or the sub-Saharan African region. Closing the gap in the literature is imperative as it would shed light on the relevance of foreign and domestic demand for the growth process in the region.

3. Data and Methodology

The endogeneity of the natural rate of growth for sub-Saharan Africa is tested in this section. We begin with an outline of the data used as well as some stylized facts. Section 3.2 outlines the two models used to estimate the natural rate of growth, i.e. the Okun (1962) specification and the Thirlwall (1969) specification. In line with the literature, both specifications are used to estimate the natural rate of growth and the results from both are compared.

3.1 Data and Stylized Facts

The unemployment rate and the percentage growth in GDP are used to estimate the natural rate of growth for 31 sub-Saharan countries for the 1991 to 2012 period. The mean, standard deviation, minimum and maximum values can be seen in Appendix A. The mean unemployment rate is shown in Figure 1 and ranged from 2.9% in Uganda to 23.9% in South Africa. It must be noted the unemployment rate does not distinguish between those employed in the formal and informal sector.

The mean growth rate for the respective countries is shown in Figure 2 ranged from -0.5% for Zimbabwe to 6.7% for Namibia. The geometric mean is also given and ranged from 2.2% for Swaziland to 7.1% for Ethiopia. In recent years, African countries have been experiencing high growth rates due to a boom in commodity prices driven by high growth rates in China and India (UNCTAD, 2013).

Figure 1; Mean Unemployment Rate

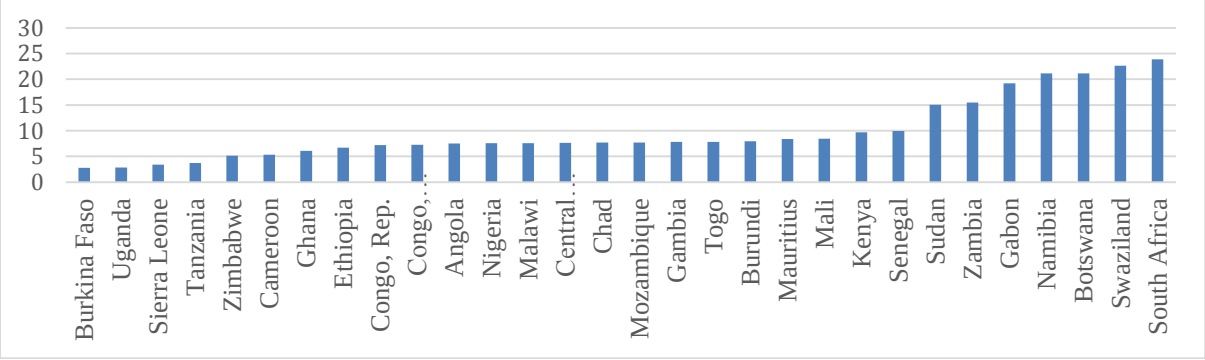
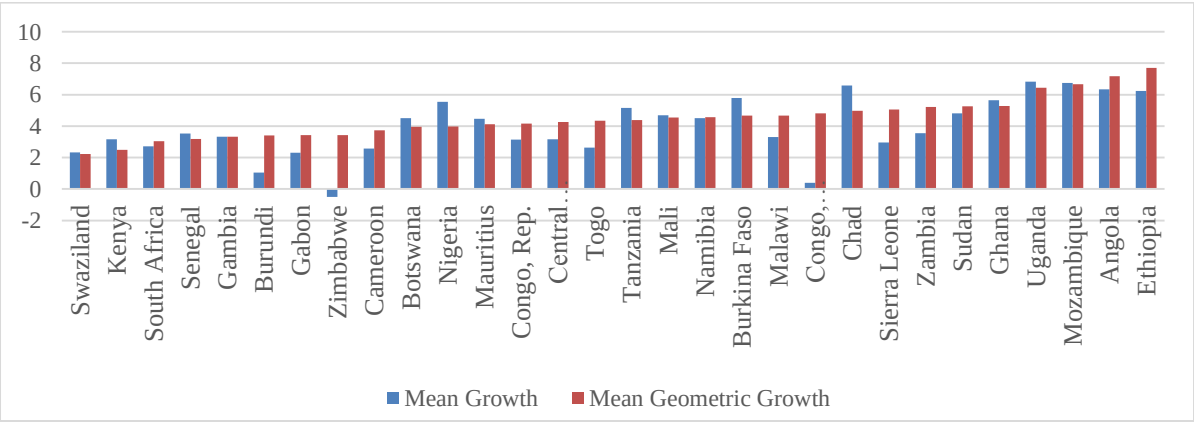


Figure 2; Mean Growth and Geometric Growth



3.2 The Model

Two different approaches will be used to estimate the natural rate of growth for each of the 31 sub-Saharan African countries using both time series and panel data analysis for the 1991 to 2012 period. The first approach derives from the specification proposed by Okun (1962) between unemployment and growth:

$$\Delta\%U = a - b(g) \qquad \text{(Equation 3.1)}$$

where $\Delta\%U$, is the change in the percentage level of unemployment and g, is the growth of output. At the natural rate of growth, unemployment is stable, i.e. $\Delta\%U = 0$; hence the natural rate of growth is defined as a/b. The estimates of a and b may be biased downward due to dropouts in the labour force and labour hoarding during recessions. In order to overcome this bias, the natural rate of growth can be directly estimated using a modified approach as suggested by Thirlwall (1969):

$$g = a_1 - b_1(\Delta\%\text{U}) \qquad \text{(Equation 3.2)}$$

where the constant term a_1, is the natural rate of growth. As $\Delta\%$U, is not exogenous, the coefficient estimates of equation 3.2 will be statistically biased although it is difficult to know a priori to what extent. The Thirlwall (1969) specification could be preferred to the Okun (1962) specification due to its simplicity in interpretation as no additional calculations are needed to determine the natural rate of growth.

Equations 3.1 and 3.2 will be estimated by Ordinary Least Squares (OLS). The results from both equations are compared to see which specification is more robust and this is done by looking at the significance of the individual variables as well as the overall significance of the model. The signs of the variables are also checked to see if they are consistent with the theoretical expectations of the natural rate of growth. We do not expect any major differences between the two specifications however in line with the literature, both equations are estimated.

Two Stage Least Squares (TSLS) using an instrumental variables approach in order to address the endogeneity of unemployment will also be applied to equations 3.2. Due to the difficulty in finding good instruments, we use the lagged values of the variables as instruments which is in line with the literature as a study by Leon-Ledesma and Thirlwall (2002) used the laggard values of both unemployment and growth as instruments.

Three different specifications will therefore be applied to estimate equation 3.2. The first uses simple OLS, second is the TSLS instrumental variable approach estimated firstly using the laggard values of both unemployment and growth and then using only the laggard values of unemployment as instruments.

Next, based on the estimation results of equation 3.2, deviations of the actual rate of growth from the estimated natural rate of growth can be calculated and a revised equation can be estimated by introducing a dummy variable, where D=1 for periods when the actual rate of growth is above the natural rate of growth and zero otherwise. The specification is as follows:

$$g = a_2 + b_2(D) - c_2(\Delta\%U) \qquad \text{(Equation 3.3)}$$

if the coefficient a_2 plus b_2 is significantly higher than the original constant a_1 in equation 3.2, then during the boom period, the actual rate of growth must have increased the natural rate of growth to keep the unemployment rate constant.

Leon-Ledesma and Thirlwall (2002) identify the mechanisms through which the natural rate of growth may be endogenous to the actual rate of growth. Firstly, growth in labour inputs increases when output growth is buoyant as hours worked increases, participation rates increase, there is reallocation of labour from low to high productivity sectors and migration may also occur. Secondly, labour productivity may be enhanced as output growth increases as apparent in the Verdoorn-Kaldor (1966) relation.

3.3 Estimation

Both time series and panel data techniques are used to estimate the natural rate of growth specified in equations 3.1 to 3.3. This is due to the limited time series of the data as annual data covering the 1991 to 2012 period is used. OLS is used to estimate the natural rate of growth using time series data. If autocorrelation is found to be present, then the method of Generalised Least Squares (GLS) is applied. If heteroscedasticity is found in the error terms, then Newey-West Heteroscedasticity and Autocorrelation Consistent (HAC) standard errors will be used.

As can be seen in section 3.1, there are large differences in the growth experience of the sub-Saharan African countries. Grouping these countries into one panel data set would be less informative as the results would give an overall average for the region. We therefore make use of Seemingly Unrelated Regressions (SUR) analysis to determine which countries share the same parameters and therefore can be grouped together. 11 different pools are created and the natural rate of growth is estimated for specification 3.1 to 3.3 using either the fixed effects or random effects estimator, based on the Hausman test. The error terms are tested for heteroscedasticity and where present, heteroscedasticity consistent standard errors are applied.

3.3.1 Time Series Estimation

The natural rate of growth and its endogeneity is estimated separately for each country using equation 3.1 to 3.3, with time series data for the 1991 to 2012 period. As the study uses time series data, autocorrelation is most likely to be present. Two tests will be used to test for autocorrelation, the Durbin-Watson d test and the Breusch-Godfrey (BG) alternatively known as the Lagrange Multiplier (LM) test. If autocorrelation is present the OLS estimators are still unbiased and consistent however they are no longer efficient. This is because in most cases the OLS standard errors will be underestimated leading to inflated t values which would indicate that a coefficient is more significant than it actually may be.

If autocorrelation is found to be present, then the method of GLS is applied. This method is preferred to the Newey-West HAC standard errors as the sample size is small. The GLS Cochrane-Orcutt iterative procedure is the method used in the literature (Dray and Thirlwall, 2002; 2010). One drawback with the procedure is that it uses the first difference and therefore loses the first observation. According to Gujarati (2008), the loss may make a substantial difference to the obtained results. Both the Newey-West standard errors and Cochran-Orcutt iterative procedure will be applied where autocorrelation is detected and if the two differ by more than 1%, then the Prais-Winsten transformation will be applied to see if the difference between the two results is due to the lost observation. If this is the case, then the Prais-Winsten transformation will be used.

The model will also be checked for heteroscedasticity, using the Breusch-Pagan (BP) test for heteroscedasticity. If heteroscedasticity and autocorrelation are found to be present in the model then the Newey-West HAC standard errors are applied. The Newey-West method estimates a kernel which is the weighted average of the number of errors. The number of errors to include is known as the bandwidth. There is a trade-off between the two as a larger bandwidth will reduce bias while increasing variance. The method used in this paper to choose the optimal bandwidth is based on the sample size;

$B=0.75N1/3$

Where, B is bandwidth and, N is the sample size, hence the larger the sample size the larger the bandwidth (Adkins and Hill, 2008)[1].

As some countries in the sub-Saharan African region have been plagued with political unrest and economic instability, dummy variables will be added where a structural break is suspected. Only significant dummy variables will be retained in the model.

[1] As the average sample size used in this paper is 21, the estimated bandwidth is 2.5 which is rounded off to 3.

3.3.2 Panel Data Estimation

Panel data estimation techniques are applied as the data is annual, covering the 1991 to 2012 period therefore making any results obtained from time series estimations only indicative due to the limited degrees of freedom. Countries with similar parameters using SUR are therefore pooled together and the natural rate of growth in equation 3.1 to 3.3 estimated using the fixed or random panel data estimation techniques. Equations 3.1 to 3.3 are also estimated using a pool with all countries in order to determine the average value of the natural rate of growth as well as test the average increase across the region during the boom. An Instrumental Variable (IV) approach is used with the entire pool of countries as the technique relies on a large sample size, in order to address the bias resulting from the endogeneity of the unemployment rate.

3.3.2.1 Pooling Countries

Due to the large variability in the growth performance in the sub-Saharan African countries, the paper makes use of a generalised least squares estimation procedure. Seemingly Unrelated Regression (SUR) estimation is used to determine which countries can be pooled together. We first jointly estimate the individual equations accounting for the different variance in the error terms and the contemporaneous correlation between the errors in the equations for individual countries (Hill et al, 2008). Using the specification in equation 3.2 proposed by Thirlwall (1969), different country combinations are estimated and the equality of the coefficients are tested. Only if the natural rate of growth and the coefficient on the change in the unemployment rate are not statistically different across the grouped countries according to the Wald test, are countries pooled.

Table 1a shows the country subgroups generated from the pooling exercise. Appendix B reports the results from the Wald test used to test for the equality of the constant and the coefficient on the percentage change in the unemployment rate. In total there are 11 groups. The advantage

of creating different subgroups instead of one single panel data set for all countries is that we are able to observe the variability in the natural rate of growth. In addition the construction of a cross-country set for the natural rate of growth, allows us to carry out future tests on the relationship between the natural rate of growth and the balance of payments constrained growth rate.

Table 1a; Pooled countries

	Countries[2]
Group 1	South Africa and Swaziland
Group 2	Zimbabwe, Zambia, Namibia and Botswana
Group 3	Angola, Mozambique and Democratic Republic of Congo
Group 4	Uganda and Ethiopia
Group 5	Chad and Central African Republic
Group 6	Cameroon and Gabon
Group 7	Nigeria and Togo
Group 8	Ghana and Burkina Faso
Group 9	Sierra Leone, Gambia and Senegal
Group 10	Cong Republic, Malawi and Kenya
Group 11	Tanzania, Ghana and Mali

Most of the countries pooled are in close geographical proximity which makes it likely that they would experience similar shocks. For instance Swaziland is completely surrounded by South Africa, one of the largest economies in sub-Saharan Africa, while Zimbabwe, Zambia, Namibia and Botswana are all part of the Southern African Development Countries (SADC) block with each sharing a common neighbour. Only for group 10 and 11 did the countries grouped together not share a common neighbour. Some countries grouped also appear to experience the same colonial legacy, for instance Angola and Mozambique, both former Portuguese colonies with strong economic ties.

[2] Equatorial Guinea is excluded from the grouping as it experienced abnormal growth rates.

3.3.2.2 Grouping Countries Based on Income Levels

In addition to the pooling exercise outlined above, countries will be separated based on their level of development. We distinguish between low income economies, lower middle income economies, upper middle income economies and high income economies based on their Gross National Income (GNI) per capita as shown in Table 1b.

Table 1b; Country groups based on income levels

Category	Description[3]	Countries
Low income	Countries which have a GNI per capita of USD1,045 or less	Burkina Faso, Burundi, Central African Republic, Chad, Democratic Republic of Congo, Ethiopia, Gambia, Kenya, Malawi, Mali, Mozambique, Sierra Leone, Tanzania, Togo, Uganda and Zimbabwe
Lower middle income	Countries which have a GNI per capita between USD1,046 and USD4,125	Cameroon, Republic of Congo, Ghana, Nigeria, Senegal, Sudan, Swaziland and Zambia
Upper middle income	Countries which have a GNI per capita between USD4,126 and USD12,745	Angola, Botswana, Gabon, Mauritius, Namibia and South Africa
High income	Countries which have a GNI per capita of USD12,746 or more	Equatorial Guinea

3.3.2.3 Estimating the Natural Rate of Growth using Panel Data

In order to estimate the natural rate of growth, two different estimation techniques are used. The first is the fixed effects estimator. As it measures deviations from individual means, the coefficient estimates depend on the variation of the explanatory and dependent variables within countries (Hill et al, 2008). Variations arising between different countries therefore do not

[3] World Bank (2013) definitions used

influence the coefficient. With this technique we assume that all the individual differences are captured by differences in the intercept parameter.

The other estimation technique used is the random effects model where individual differences between countries are captured by the intercept however the individual differences are treated as random as opposed to fixed. The random effects are analogous to random error terms and therefore follow the same assumptions in the error term as OLS of zero mean, uncorrelated across countries and the presence of constant variance.

The Hausman test is used to determine if the fixed effects or random effects model should be used to estimate the natural rate of growth. Heteroscedasticity is tested using the BP test for independence. In the presence of heteroscedasticity, we apply heteroscedasticity consistent standard errors. Time effects are included in the model and retained only when significant.

As we hypothesise that the natural rate of growth is endogenous to the actual rate of growth, an IV approach is also applied using the lags of the variables as instruments[4]. This approach is only estimated using the entire pool of countries as the method relies on a large sample size. However caution is still needed as Wooldridge (2010) shows that the estimates obtained from IV will not be efficient if the instruments are weak, even in the presence of a large sample size. Furthermore in our case where the time series dimension is rather short, even with the pooled data set, the IV results can be at best indicative.

3.3.3 Correlation Analysis with Economic Development and Institutional Indicators

We test the correlation between the increase in the natural rate of growth during the boom period and key indicators related to economic development, governance and institutions using both Pearson's correlation coefficient and Spearman's (1904) rank correlation coefficient. The

[4] 2 lags are used as determined by the F statistic from the first stage regression

latter is applied as it is less sensitive to extreme values than the former. The results are discussed in section 6.

4. Time Series Estimation Results

The results from Okun (1962) specification as defined in equation 3.1 can be seen in Table 2. The results are from the time series analysis for the 1991 to 2012 period. Although these results are only indicative due to the limited degrees of freedom, they are nevertheless informative on the country specific natural rate of growth and they will serve as a benchmark for comparison with the panel data estimations. The natural rate of growth could be estimated for 26 out of 31 countries and it ranged from 0.2 for Botswana to 19.8 for Uganda. For 12 out of the 26 countries, the natural rate of growth was significant at the 95% confidence level using the Wald test for the significance of a/b. The natural rate of growth was not significant for Botswana, Burkina Faso, the Democratic Republic of Congo, Ethiopia, Gabon, Ghana, Mali, Nigeria, South Africa, Tanzania, Togo, Uganda and Zimbabwe. The natural rate of growth using this specification could not be estimated for Cameroon, Kenya, Namibia, Sierra Leone, Sudan, Swaziland and Zambia as the constant had the wrong sign, i.e. the constant is negative when it is theoretically expected to be positive (Okun, 1962).

Table 2; Results from Okun's specification based on Equation 3.1

Country	Constant	Growth in GDP	R^2	F test	Durbin-Watson test	BG test	BP test	Natural rate of growth[N]
Angola	0.055 (0.045)	-0.009** (0.004)	0.226	5.55**	1.741	0.315	0.04	6.1**
Botswana[5]	0.008 (0.832)	-0.041 (0.147)	0.150	1.58	1.881	0.003	0.50	0.195
Burkina Faso[co]	0.277* (0.157)	-0.041 (0.026)	0.120	2.46	2.12[trans]			6.756
Burundi	0.007 (0.014)	-0.008** (0.003)	0.253	6.45**	1.477	0.848	0.17	0.875**
Cameroon[co]	-0.244 (0.339)	0.052 (0.090)	0.018	0.33	2.101[trans]			
Central African Republic	0.037 (0.024)	-0.013*** (0.004)	0.306	8.38***	2.665	2.512	0.29	2.846***
Chad[nw]	0.063*** (0.018)	-0.008 (0.003)		6.82**				7.875***
Congo, Dem. Rep.[6]	0.038 (0.039)	-0.008 (0.005)	0.103	1.03	2.159	0.237	0.01	4.75
Congo, Rep.	0.046** (0.020)	-0.0176*** (0.004)	0.487	18.03***	1.834	0.140	1.86	2.614***
Equatorial Guinea	0.161 (0.108)	-0.009** (0.004)	0.194	4.56**	1.714	0.054	0.01	17.8**
Ethiopia[co]	0.070 (0.198)	-0.0199 (0.014)	0.101	2.01	1.840 [trans]			3.518
Gabon[co]	0.205 (0.161)	-0.021 (0.021)	0.049	0.93	1.354 [trans]			9.762
Gambia	0.049* (0.026)	-0.0176*** (0.006)	0.345	9.99***	2.099	0.868	1.67	2.784**
Ghana[co]	0.023 (1.043)	-0.0197 (0.169)	0.001	0.01	2.002 [trans]			1.1675
Kenya[co]	-0.046*** (0.015)	-0.000 (0.004)	0.000	0.00	2.303 [trans]			
Malawi[7]	0.135*** (0.030)	-0.032*** (0.004)	0.765	29.31***	1.844	0.107	0.90	4.219***
Mali	0.026 (0.084)	-0.008 (0.014)	0.017	0.34	2.299	0.735	0.94	3.25
Mauritius	0.692** (0.331)	-0.171** (0.069)	0.243	6.12**	1.459	1.426	0.04	4.046**
Mozambique[nw]	0.159*** (0.020)	-0.026*** (0.004)		41.33***				6.115***
Namibia[co8]	-2.039 (1.474)	0.128 (0.128)	0.894	71.71***	2.178 [trans]			

[5] Dummy added for 2009 where there was negative growth of -7.8%
[6] Dummy added for 1991 to 2001
[7] Dummy added for 2010 negative growth of -9%
[8] Dummy added for 2008 where the unemployment rate was abnormally high at 37.6%

Nigeria[9]	0.032 (0.022)	-0.007* (0.004)	0.259	3.16*	2.245	1.136	0.34	4.571
Senegal	0.088*** (0.028)	-0.0246*** (0.007)	0.397	12.49***	1.584	0.805	0.47	3.577***
Sierra Leone	-0.003 (0.013)	0.001 (0.001)	0.041	0.81	1.946	0.008	0.22	
South Africa	0.528 (0.816)	-0.170 (0.232)	0.027	0.54	1.913	0.023		3.106
Sudan[nw]	-0.068 (0.552)	0.008 (0.011)		0.60				
Swaziland[nw]	-0.036 (0.087)	0.013 (0.039)		0.12				
Tanzania[nw]	0.365* (0.210)	-0.069 (0.052)		1.81				5.289
Togo[10]	0.0258 (0.023)	-0.007* (0.003)	0.633	15.51***	1.908	0.034	0.46	3.685
Uganda[co11]	0.0495 (0.246)	-0.0025 (0.028)	0.436	6.59***	1.453 [trans]			19.8
Zambia	-0.388 (0.359)	0.030 (0.065)	0.011	0.21	1.680	0.488	0.91	
Zimbabwe[12]	0.0335 (0.133)	-0.0037 (0.018)	0.110	1.12	1.826	0.170	0.17	9.054

Note: The natural rate of growth is estimated as a/b and the Wald test is used to test its significance. Results from the Wald test are available upon request
Standard errors are in parenthesis
*** Indicates significance at the 99% level
** Indicates significance at the 95% level
* Indicates significance at the 90% level
[co] Cochrane-Orcutt iterative procedure used to correct for autocorrelation
[pw]Prais-Winsten transformation used to correct for autocorrelation when Cochrane-Orcutt iterative procedure is not appropriate
[nw] Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors used to correct for autocorrelation and heteroscedasticity
[trans] is the transformed Durbin-Watson statistic from the Cochrane-Orcutt iterative procedure

The estimation results for the natural rate of growth using Thirlwall (1969) specification in equation 3.2 can be seen in Table 3. The natural rate of growth was statistically significant at the 95% level for all countries with the exception of Zimbabwe where it was significant at the 90% level and Burundi where it was not significant.

[9] Dummy added for 2004 where there was high growth of 33.7%
[10] Dummy added for 1994 where there was an abnormally low unemployment rate
[11] Dummy added for 2009 where there was a large increase in the unemployment rate
[12] Dummy added for 2002 to 2008 period due to the economic crash

Table 3; Results from Thirlwall's specification based on Equation 3.2

Country	Constant	%ΔU	R^2	F test	Durbin-Watson test	BG test	BP test	Natural rate of growth^N
Angola^{co}[13]	7.887*** (2.425)	-9.355 (8.816)	0.588	12.16***	1.061^{trans}			7.887***
Botswana[14]	4.947*** (0.641)	-0.104 (0.376)	0.518	9.68***	2.164	0.274	0.53	4.947***
Burkina Faso	5.674*** (0.607)	-1.496 (1.479)	0.051	1.02	1.729	0.020	1.09	5.674***
Burundi^{co}	0.772 (1.609)	-23.296 (11.517)*	0.185	4.09*	1.762^{trans}			0.772
Cameroon^{co}[15]	3.948*** (1.008)	-0.249 (0.262)	0.079	0.73	1.925^{trans}			3.948***
Central African Republic	3.222*** (0.841)	-24.341*** (8.411)	0.306	8.38***	1.446	0.778	0.08	3.222***
Chad	6.861*** (1.902)	-25.416** (11.974)	0.192	4.51**	1.332	2.730*	1.44	6.861***
Congo, Dem. Rep.^{nw}	5.856*** (0.411)	-12.182** (5.517)		26.1***				5.856***
Congo, Rep.^{co}	2.972*** (1.031)	-27.778*** (4.905)	0.641	32.07***	1.766^{trans}			2.972***
Equatorial Guinea[16]	16.084*** (3.683)	-13.561 (9.898	0.416	6.41***	1.172	3.548*	0.04	16.08***
Ethiopia	6.735*** (1.391)	-1.701 (3.632)	0.011	0.22	1.489	0.206	0.18	6.735***
Gabon[17]	2.677*** (0.680)	0.917 (1.131)	0.447	7.26***	1.731	0.074	0.73	2.677***
Gambia	3.143*** (0.605)	-19.592*** (6.199)	0.345	9.99***	1.898	0.025	2.48	3.143***
Ghana[18]	5.216*** (0.349)	0.051 (0.137)	0.678	18.96***	1.352	1.702	0.53	5.216***
Kenya^{co}	3.389*** (0.791)	-3.830 (6.727)	0.018	0.32	2.073^{trans}			3.389***
Malawi^{co}[19]	4.236*** (1.058)	-22.264*** (2.424)	0.873	58.50***	1.754^{trans}			4.236***
Mali	4.812*** (0.718)	-2.075 (3.567)	0.017	0.34	2.022	0.328	0.28	4.812***
Mauritius	4.368*** (0.349)	-1.426** (0.575)	0.243	6.12**	2.372	1.260	0.96	4.368***

[13] Dummy added for the 1991 to 1993 period where there was negative growth due to the civil war
[14]Dummy added for 2009 where there was negative growth of -7.8% due to the financial crisis
[15] Dummy added for 1996 where there was a large increase in the unemployment rate
[16] Dummy added for 1997 high growth of 71.8%
[17] Dummy added for 1999 negative growth of -8.9%
[18] Dummy added for 2011 high growth of 15%
[19] Dummy added for 2010 negative growth of -9%

Mozambique[20]	7.115*** (0.515)	-8.861** (3.891)	0.664	17.77***	1.994	0.000	0.01	7.115***
Namibia	4.616*** (0.647)	-0.062 (0.139)	0.177	1.94	2.622	2.341	0.4	4.616***
Nigeria[co21]	4.818*** (0.877)	-14.606 (9.518)	0.890	68.75***	2.214[trans]			4.818***
Senegal[co22]	3.629*** (0.637)	-17.878*** (3.369)	0.610	28.16***	1.652[trans]			3.629***
Sierra Leone	4.099** (1.729)	41.229 (38.673)	0.349	4.82**	1.747	0.123	0.43	4.099**
South Africa[co23]	3.571*** (0.429)	-0.026 (0.114)	0.575	11.51***	1.734[trans]			3.571***
Sudan[24]	5.607*** (0.742)	6.205 (3.965)	0.569	11.92***	1.479	2.263	0.58	5.607***
Swaziland[co25]	2.197*** (0.664)	-1.249 (0.982)	0.331	4.21**	1.971[trans]			2.197***
Tanzania[pw]	4.729*** (1.185)	-0.8 (0.173)			1.754[trans]			4.729***
Togo[co26]	3.837** (1.475)	-14.612** (6.503)	0.647	15.58***	1.907[trans]			3.837***
Uganda[27]	6.864*** (0.538)	-0.059 (1.688)	0.001	0.01	1.663	0.072	0.81	6.864***
Zambia	3.817*** (0.954)	0.367 (0.796)	0.011	0.21	1.475	0.871	2.30	3.817***
Zimbabwe[28]	3.264* (1.584)	-0.649 (3.108)	0.521	9.81***	1.568	0.224	0.02	3.264*

Note: the constant is measured as the natural rate of growth
Standard errors are in parenthesis
*** Indicates significance at the 99% level
** Indicates significance at the 95% level
* Indicates significance at the 90% level
[co] Cochrane-Orcutt iterative procedure used to correct for autocorrelation
[nw] Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors used to correct for autocorrelation and heteroscedasticity.
[trans] is the transformed Durbin-Watson statistic from the Cochrane-Orcutt iterative procedure and Prais-Winsten transformation

[20] Dummy added for 1992 negative growth of -5%
[21] Dummy added for 2004 high growth of 33.7%
[22] Dummy added for 1992 negative growth of -19%
[23] Dummy added for 2009 negative growth of -1.5% due to the financial crisis
[24] Dummy added for 2012 negative growth of -10%
[25] Dummy added for 2012 negative growth of -1.5%
[26] Dummy added for 1993 negative growth of -15%
[27] Dummy added for 2009 where there was a large change in the unemployment rate
[28] Dummy added for 2002 to 2008 period due to the economic crash

For four countries, the coefficient on the percentage change in the level of unemployment was positive however the coefficient was less than 1 and insignificant at the 90% level. The natural rate of growth ranges from 0.8 for Burundi to 16.0 for Equatorial Guinea.

A comparison of the results obtained from the Okun (1962) and Thirlwall (1969) specification is shown in Table 4. The natural rate of growth could be estimated for all 31 countries using Thirlwall specification while it could only be estimated for 26 countries using Okun (1962) specification. The natural rate of growth using Thirlwall specification was also statistically significant for 29 countries at the 95% level or above. For Okun (1962) specification, the natural rate of growth was significant for 12 countries. As in the literature, we find that the Thirlwall (1969) specification provides more robust results. We therefore proceed with the Thirlwall (1969) specification.

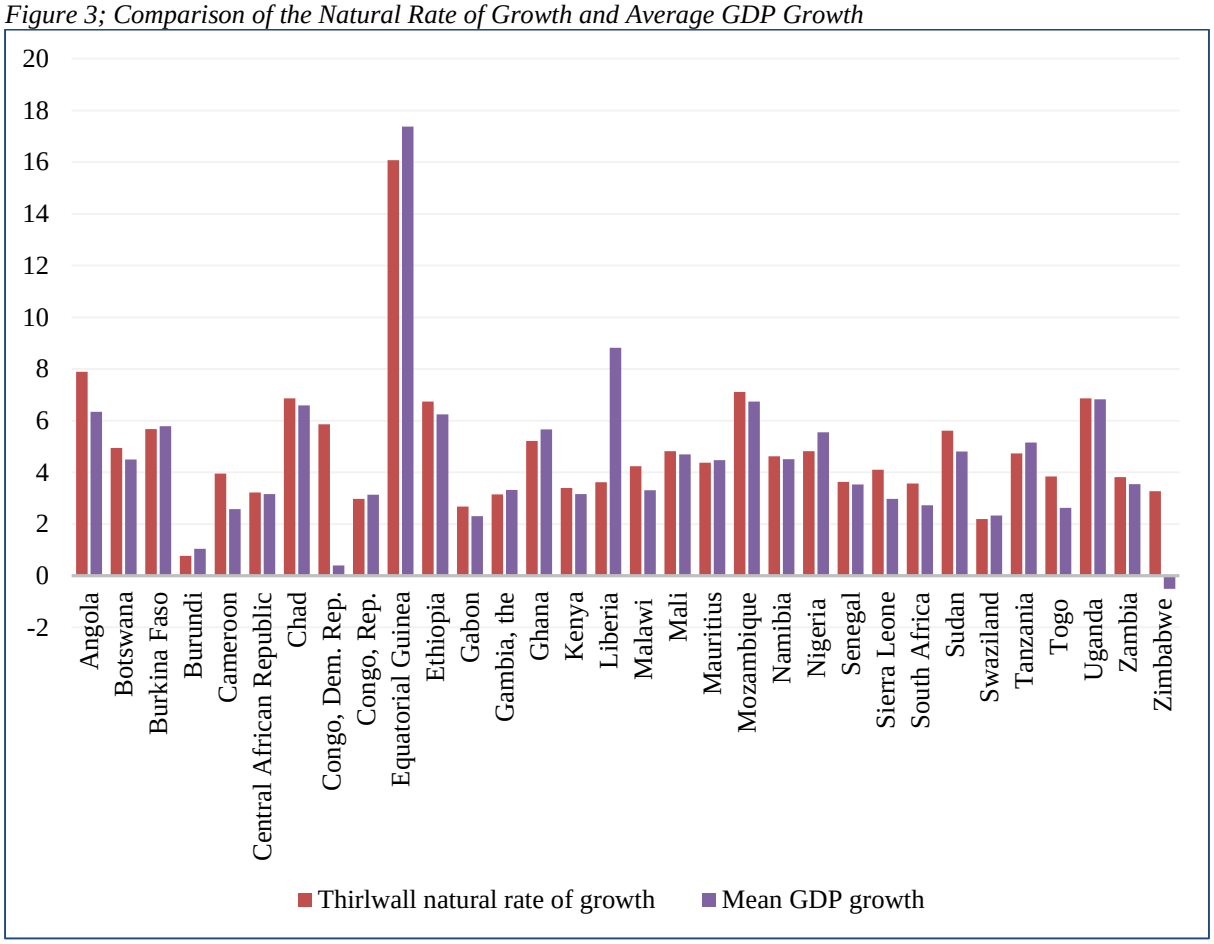
Table 4; Comparison of the natural rate of growth based on Okun's and Thirlwall's specification

Country	Okun specification	Thirlwall specification	Country	Okun specification	Thirlwall specification
Angola	6.1**	7.887***	Malawi	4.219***	4.236***
Botswana	0.195	4.947***	Mali	3.25	4.812***
Burkina Faso	6.756	5.674***	Mauritius	4.046**	4.368***
Burundi	0.875**	0.772	Mozambique	6.115***	7.115***
Cameroon	-	3.948***	Namibia	-	4.616***
Central African Republic	2.846***	3.222***	Nigeria	4.571	4.818***
Chad	7.875***	6.861***	Senegal	3.577***	3.629***
Congo, Dem. Rep.	4.75	5.856***	Sierra Leone	-	4.099***
Congo, Rep.	2.614***	2.972***	South Africa	3.106	3.571***
Equatorial Guinea	17.8**	16.084***	Sudan	-	5.607***
Ethiopia	3.518	6.735***	Swaziland	-	2.197***
Gabon	9.762	2.677***	Tanzania	5.289	4.729***
Gambia	2.784**	3.143***	Togo	3.685	3.837***
Ghana	1.1675	5.216***	Uganda	19.8	6.864***
Kenya	-	3.389***	Zambia	-	3.817***
			Zimbabwe	9.054	3.264*

Note: The natural rate of growth could be estimated for more countries using the Thirlwall specification
*** Indicates significance at the 99% level
** Indicates significance at the 95% level
* Indicates significance at the 90% level

The estimated natural rate of growth for each respective country appears to be in line with the average GDP growth rate during the 1991 to 2012 period as shown in Figure 3. There is an absolute difference of 1 percentage point or less between the estimated natural rate of growth and the average actual rate of growth for all countries besides Angola where the difference is 1.5, the Democratic Republic of Congo with a difference of 5.5 and Zimbabwe with 3.7.

Figure 3; Comparison of the Natural Rate of Growth and Average GDP Growth

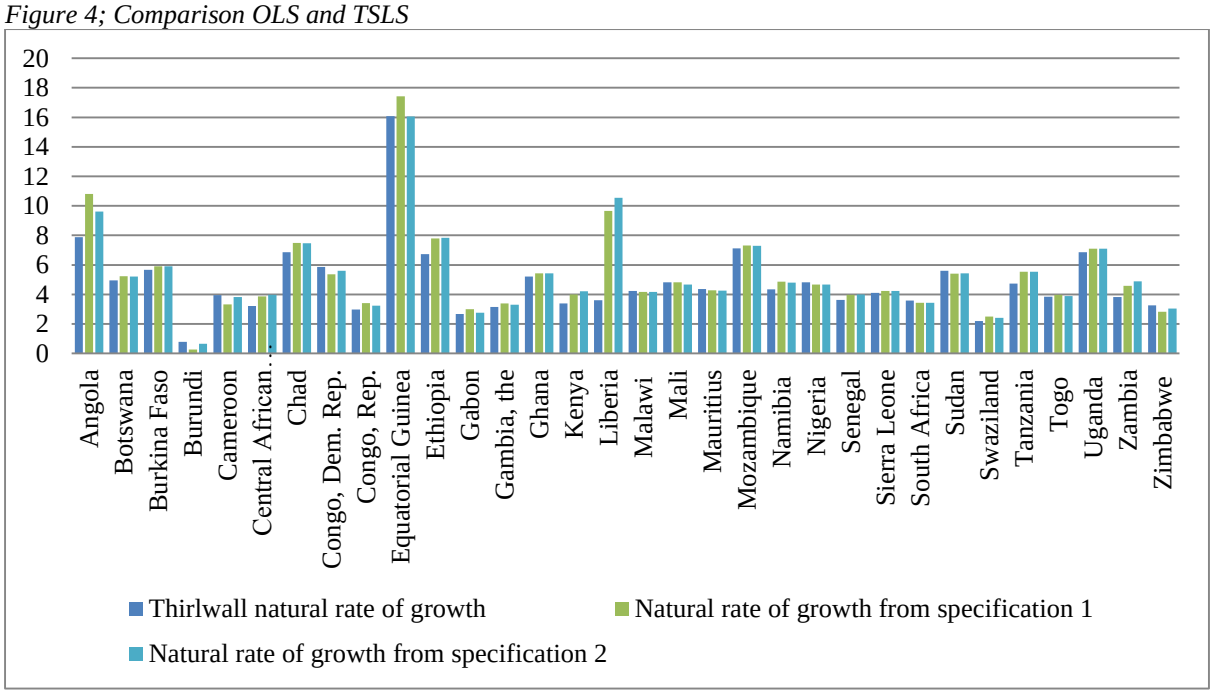


In order to address the bias resulting from the endogeneity of the unemployment rate, the robustness of the results are tested using TSLS. The results for TSLS estimations using Thirlwall's specification can be seen in Appendix D. Two different specifications are used, the first using just the lags of Δ%U and the second using both the lags of Δ%U and the lags of GDP growth. The instruments used were strong for only two countries according to the F

statistic. The instruments used for the rest of the 29 countries were weak, however they were valid according to the Sargan test in 29 out of 32 countries. For Botswana, Burundi and Tanzania the instruments were weak and invalid.

The relative difference between the natural rate of growth estimated using TSLS and OLS was less than 10% (in proportional terms) for 24 countries and less than 20% for another 6 countries. The only country where the relative difference was more than 20% was for Zambia where it was 27%. Like Leon Ledesma and Thirlwall (2002), we conclude that the bias that could arise from the endogeneity of Δ%U is unimportant. We therefore continue the analysis with the results obtained from OLS. Wooldridge (2010) shows that OLS provides better estimates than TSLS when the instruments are weak, even in large samples.

Figure 4; Comparison OLS and TSLS



4.1 Testing the Endogeneity of the Natural Rate of Growth

The endogeneity of the natural rate of growth was tested by adding a dummy variable for periods when the natural rate of growth was above the actual rate of growth as illustrated in equation 3.3. The estimation results are reported in Table 5.

Table 5; Results for the endogeneity of natural rate of growth based on Equation 3.3

Country	Constant	Dummy	%ΔU	R^2	F test	Durbin-Watson test	BG test	BP test	Natural rate of growth in boom periods[N]
Angola[co]	4.589*** (1.347)	9.11*** (1.754)	-0.729 -5.338	0.853	30.97***	1.534[trans]			13.699***
Botswana	2.845*** (0.440)	4.774*** (0.666)	0.132 (0.196)	0.880	41.65***	2.236	0.482	0.12	7.619***
Burkina Faso	2.597*** (0.558)	5.204*** (0.763)	1.620* (0.923)	0.736	25.03***	1.848	0.004	0.04	7.801***
Burundi[co]	-2.812** (1.011)	6.130*** (1.112)	-9.978 (7.919)	0.716	21.43***	1.966[trans]			3.318***
Cameroon[co]	2.962*** (0.998)	1.312 (0.912)	-0.359 (0.274)	0.181	1.18	2.262[trans]			4.274***
Central African Republic	-2.288** (0.886)	7.821*** (1.091)	-8.344* (4.936)	0.819	40.96***	1.933	0.045	0.51	5.533***
Chad	1.133 (2.097)	11.668*** (3.073)	-13.368 (9.701)	0.551	11.05***	1.209	3.316*	1.41	12.801***
Congo, Dem. Rep.[nw]	4.419*** (0.573)	2.268*** (0.584)	-12.484** (4.991)		26.25***				6.687***
Congo, Rep.[co]	-0.478 (0.97)	4.989*** (1.166)	-12.329** (5.356)	0.798	33.52***	1.768[trans]			4.511***
Equatorial Guinea	6.513** (2.602)	27.200*** (4.380)	-12.125** (5.638)	0.821	26.04***	1.722	0.535	3.25*	33.713***
Ethiopia	1.1975 (1.194)	10.145*** (1.621)	1.321 (2.149)	0.689	19.92***	1.905	0.792	6.66***	11.343***
Gabon	0.036 (0.599)	4.796*** (0.811)	0.416 (0.671)	0.819	25.66***	2.153	0.403	0.16	4.832***

Gambia	0.262 (0.662)	4.832*** (0.902)	-7.977* (4.508)	0.748	26.64***	2.329	1.485	1.01	5.094***
Ghana	4.265*** (0.210)	2.734*** (0.257)	0.092 (0.067)	0.928	72.78***	2.058	0.154	0.40	6.999***
Kenya[co]	1.725*** (0.479)	3.243*** (0.512)	-2.522 (4.066)	0.706	20.38***	2.065[trans]			4.968***
Malawi[co]	2.435** (1.109)	3.827*** (1.258)	-18.47*** (2.303)	0.923	64.27***	1.878[trans]			6.262***
Mali	2.1686*** (0.670)	5.153*** (0.957)	1.842	0.623	14.90	1.765	0.123	0.11	7.322***
Mauritius	3.3078)*** (0.296	2.615*** (0.484)	-0.583 (0.398)	0.711	22.15***	2.489	1.356	0.85	5.923***
Mozambique	5.507*** (0.633)	2.932*** (0.877)	-4.537 (3.367)	0.797	22.27***	2.203	0.310	0.01	8.439***
Namibia	2.323*** (0.601)	4.719*** (0.939)	0.166* (0.096)	0.585	12.68***	1.407	1.975	0.08	7.042***
Nigeria[co]	2.967*** (0.688)	3.859*** (0.578)	-8.449 (4.957)	0.972	188.11***	1.755[trans]			6.826***
Senegal[co]	2.539*** (0.460)	2.364*** (0.540)	-6.608* (3.536)	0.803	34.70***	1.743[trans]			4.903***
Sierra Leone	-1.699 (1.931)	10.543*** (2.634)	14.870 (29.303)	0.665	11.24***	2.387	1.421	2.02	8.844***
South Africa[co]	2.637*** (0.243)	1.948*** (0.343)	-0.191** (0.078)	0.838	27.58***	2.187[trans]			4.585***
Sudan	2.843*** (0.736)	4.896*** (0.980)	3.856 (2.640)	0.826	26.84***	1.714	1.183	0.07	7.739***
Swaziland[co]	1.325*** (0.262)	1.757*** (0.321)	-0.649 (0.812)	0.806	22.16***	2.035[trans]			3.082***

Tanzania[pw]	3.018*** (0.652)	3.283*** (0.753)	-0.062 (0.209)	0.264	3.24*	1.591[trans]			6.301***
Togo[co]	0.9375 (1.086)	6.085*** (1.544)	-8.916 (5.454)	0.789	19.98***	1.954[trans]			7.023***
Uganda	5.221*** (0.358)	4.167*** (0.580)	-1.664* (0.894)	0.752	17.20***	1.635	0.089	0.16	9.388***
Zambia	-0.344 (1.003)	6.549*** (1.247)	-0.020 (0.519)	0.609	14.05***	1.901	0.033	13.86***	6.205***
Zimbabwe	-0.769 (1.636)	9.303*** (2.526)	1.472 (2.454)	0.734	15.63***	1.863	0.066	3.52*	8.534***

Note: The natural rate of growth is measured as the constant plus the dummy variable and its significance tested using the Wald test. This is an extension of the Thirlwall (1969) specification from equation 3.2. The country specific dummy variables for structural breaks used in Table 3 are therefore also included in these estimates. The dependent variable is GDP growth.

Standard errors are in parenthesis

*** Indicates significance at the 99% level

** Indicates significance at the 95% level

* Indicates significance at the 90% level

[co] Cochrane-Orcutt iterative procedure used to correct for autocorrelation

[pw]Prais-Winsten transformation used to correct for autocorrelation when Cochrane-Orcutt iterative procedure is not appropriate

[nw] Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors used to correct for autocorrelation and heteroscedasticity

[trans] is the transformed Durbin-Watson statistic from the Cochrane-Orcutt iterative procedure

For 25 out of 31 countries, the constant and the dummy were positive and jointly significant at the 99% confidence level. This provides evidence of the endogeneity of the natural rate of growth. For 6 countries (Burundi, Central African Republic, Republic of Congo, Sierra Leone, Zambia and Zimbabwe) the intercept was negative. Caution is therefore needed when interpreting the results from these countries, however when the intercept and dummy are combined, in all cases the natural rate of growth in boom periods is above the natural rate of growth estimate based on equation 3.2.

The absolute difference between the natural rate of growth based on equation 3.2 and the natural rate of growth in boom periods can be seen in Table 6, alongside the sensitivity of the natural rate of growth to the actual rate of growth. As mentioned earlier, caution needs to be taken when interpreting the results for the 6 countries which had a negative intercept for equation 3.3. The averages are therefore given for all countries as well as the subsample of countries which does not include the 6 mentioned countries.

The average natural rate of growth in boom periods for all countries was 7.8 while that for the subsample was 8.2. The average absolute difference between the natural rate of growth estimated using equation 3.2 and the natural rate of growth in boom periods was 2.9 for all countries and 2.9 for the subsample. The increase in the natural rate of growth in boom periods to the actual rate of growth ranged from 8% for Cameroon to 330% for Burundi. The average for all countries was 64.8% while the average for the subsample was 48.7%.

As the results from the time series analysis are only indicative due to the limited time dimension, we analyse them together with the results from the panel data estimates which are given in the next section.

Table 6; The change in the natural rate of growth in boom periods

Country	Thirlwall specification	Natural rate in boom periods	Absolute difference	% difference
Angola	7.887	13.699	5.812	73.691
Botswana	4.947	7.619	2.672	54.013
Burkina Faso	5.674	7.801	2.127	37.487
Burundi	*0.772*	*3.318*	*2.546*	*329.793*
Cameroon	3.948	4.274	0.326	8.257
Central African Republic	*3.222*	*5.533*	*2.311*	*71.726*
Chad	6.861	12.801	5.94	86.576
Congo, Dem. Rep.	5.856	6.687	0.831	14.191
Congo, Rep.	*2.972*	*4.511*	*1.539*	*51.783*
Equatorial Guinea	16.084	33.713	17.629	109.606
Ethiopia	6.735	11.343	4.608	68.419
Gabon	2.677	4.832	2.155	80.501
Gambia	3.143	5.094	1.951	62.074
Ghana	5.216	6.999	1.783	34.183
Kenya	3.389	4.968	1.579	46.592
Malawi	4.236	6.262	2.026	47.828
Mali	4.812	7.322	2.51	52.161
Mauritius	4.368	5.923	1.555	35.600
Mozambique	7.115	8.439	1.324	18.609
Namibia	4.616	6.953	2.337	50.628
Nigeria	4.818	6.826	2.008	41.677
Senegal	3.629	4.903	1.274	35.106
Sierra Leone	*4.099*	*8.844*	*4.745*	*115.760*
South Africa	3.571	4.585	1.014	28.395
Sudan	5.607	7.739	2.132	38.024
Swaziland	2.197	3.082	0.885	40.282
Tanzania	4.729	6.301	1.572	33.242
Togo	3.837	7.023	3.186	83.034
Uganda	6.864	9.388	2.524	36.772
Zambia	*3.817*	*6.205*	*2.388*	*62.562*
Zimbabwe	*3.264*	*8.534*	*5.27*	*161.458*
Average	4.869	7.791	2.921	64.840
Average less 6 countries (market in italic)	5.313	8.183	2.870	48.678

5. Panel Data Estimation Results

The estimation results for equation 3.2 to 3.3 using panel data analysis are reported in Table 7. Fixed effects or random effects are used to estimate the natural rate of growth for 11 subgroups, the three country groups based on the level of economic development as well as the overall pool of countries. Estimations using the IV approach are not reported for the subgroups due to the difficulty in finding appropriate instruments as a result of poor data availability in the sub-Saharan African region. As mentioned before, IV provides inconsistent estimates, even in the presence of a large sample size when instruments are weak (Wooldridge, 2010). We therefore only apply the IV approach to the overall pool of countries, however caution is needed due to the problems arising from the use of weak instruments. The lags of the variables are used as instruments.

The results from the panel data estimates show that the natural rate of growth was endogenous for all 14 subgroups as well as the overall pool of countries. There also appears to be very little difference between the natural rate estimated using the random or fixed effects approach and that using the IV approach as the natural rate of growth was 4.9 and 5.0 respectively. The natural rate of growth for the full sample increases to 8.4 and 8.9 in the boom periods using random effects and IV estimation methods respectively. The problems arising from the endogeneity of the level of unemployment therefore does not seem to be relevant.

Table 7; Results panel data for the endogeneity of the natural rate of growth based on Equation 3.2 and 3.3

Country	Constant	Dummy	Δ%ur	R^2 overall	N	Fixed or random effects	Time effects	Time effects (P-Value)	Natural rate of growth^N
South Africa and Swaziland	2.631*** (0.265)		-0.151 (0.184)	0.016	42	Random	No	0.266	2.631***
Endogeneity test: South Africa and Swaziland	1.210*** (0.286)	2.482*** (0.380)	-0.022 (0.130)	0.529					3.693***
Zambia, Zimbabwe, Namibia and Botswana	2.927*** (0.021)		0.129 (0.106)	0.0027	84	Fixed^{robust}	No	0.893	2.927***
Endogeneity test: Zambia, Zimbabwe, Namibia and Botswana	-2.295 (1.117)	8.219** (1.771)	-0.049 (0.047)	0.557					5.925***
Angola, Mozambique Democratic Republic of Congo	6.381*** (1.147)		-22.396*** (1.968)	0.616	63	Random^{robust}	Yes	0.009***	4.547***
Endogeneity test: Angola, Mozambique Democratic Republic of Congo	-2.642*** (0.939)	9.211*** (0.769)	-26.753*** (2.011)	0.831					6.569***
Ethiopia and Uganda	6.878*** (0.060)		-0.679 (0.861)	0.003 0.560	42	Random^{robust}	No	0.485	6.878***
Endogeneity test: Ethiopia and Uganda	3.525* (1.991)	6.702** (2.833)	-1.074 (1.332)						10.227***
Chad and Central African Republic	5.037*** (0.002)		-25.109*** (0.443)	0.188	42	fixed^{robust}	No	0.568	5.0375***
Endogeneity test: Chad and Central African Republic	1.050 (1.596)	8.236 (3.351)	-11.506*** (0.235)	0.467					9.287***
Cameroon and Gabon	2.511*** (0.509)		0.294 (0.496)	0.008	42	Random	No	0.282	2.5111***

Endogeneity test: Cameroon and Gabon	-0.887* (0.533)	5.284*** (0.665)	0.259 (0.311)						4.396***
Nigeria and Togo	4.228*** (0.994)		-18.108** (8.968)	0.078	42	Fixed	No	0.395	4.228***
Endogeneity test: Nigeria and Togo	0.900 (1.143)	7.425*** (1.753)	-11.520 (7.649)	0.405					8.326***
Ghana and Burkina Faso	8.744*** (1.690)		-0.369 (0.310)	0.604	42	Random	Yes	0.061*	8.744***
Endogeneity test: Ghana and Burkina Faso	5.614*** (1.518)	6.227*** (1.590)	-0.023 (0.253)	0.781					11.840***
Senegal, Sierra Leone and Gambia	3.265*** (0.155)		-11.603 (9.184)	0.025	63	Random^{robust}	No	0.063*	3.265***
Endogeneity test: Senegal, Sierra Leone and Gambia	-0.858 (1.803)	7.530** (3.127)	7.022 (11.690)	0.412					6.672***
Tanzania and Mali	5.068*** (0.239)		-0.598*** (0.175)	0.016	42	Random^{robust}	No	0.907	5.068***
Endogeneity test: Tanzania and Mali	2.799*** (0.347)	4.343*** (0.618)	0.043 (0.183)	0.640					7.142***
Congo, Kenya, Malawi	2.895*** (0.381)		-23.196*** (2.645)	0.557	63	Random	No	0.535	2.895***
Endogeneity test: Congo, Kenya, Malawi	0.243 (0.464)	4.510*** (0.627)	-17.039*** (2.134)	0.762					4.753***
Low income economies	6.886*** (1.776)		-1.723 (1.438)	0.147	336	Fixed^{robust}	Yes	0.000	6.886***
Endogeneity test: low income economies	1.288 (0.757)	7.362*** (1.197)	-0.442 (1.322)	0.466					8.650***
Lower middle income economies	2.767 (2.261)		0.045 (0.091)	0.201	168	Random^{robust}	Yes	0.013	2.767

Lower middle income economies (excl. Congo, Dem. Rep.)	6.909*** (2.190)		-1.679 (1.460)	0.127	315	Random[robust]	Yes	0.000	6.909***
Endogeneity test: Lower middle income economies (excl. Congo, Dem. Rep.)	4.554*** (1.665)	7.737*** (1.177)	-0.330 (1.327)	0.465					12.291***
Endogeneity test: lower middle income economies	-0.892 (1.932)	4.882*** (0.872)	0.104 (0.128)	0.442					3.99***
Upper middle income economies	4.553*** (0.690)		-0.026 (0.082)	0.280	126	Randon[robust]	Yes	0.000	4.553***
Endogeneity test: upper middle income economies	1.971* (1.105)	5.367*** (1.307)	0.171** (0.086)	0.483					7.338***
Upper middle income economies (excl. Angola and Gabon)	3.726*** (1.247)		-0.022 (0.113)	0.420	84	Random	Yes	0.000	3.726***
Endogeneity test: Upper middle income economies (excl. Angola and Gabon)	2.157*** (1.012)	3.229*** (0.513)	0.040 (0.091)	0.648					5.386***
All countries	4.876*** (0.766)		-0.096 (0.152)	0.084	651	Random[robust]	Yes	0.000***	4.876***
Endogeneity test: All countries	1.213* (0.703)	7.142*** (0.902)	0.100 (0.130)	0.364					8.355***
IV	5.204*** (1.325)		2.508** (1.055)	0.012	620	Random	Yes	0.001***	5.204***
Endogeneity test: IV	1.357 (1.050)	7.637*** (0.512)	1.346* (0.776)	0.313					8.994***

Note: The constant is the natural rate of growth. The natural rate of growth in boom periods is the constant plus the dummy variable for periods when the actual rate of growth is above the natural rate of growth.
Standard errors are in parenthesis
[robust] are heteroscedasticity consistent standard errors
*** Indicates significance at the 99% level
** Indicates significance at the 95% level
* Indicates significance at the 90% level

6. Discussion of the Results

A comparison is made in Table 8 between the time series and panel data estimates. Despite the problems related to the bias arising from the endogeneity of the unemployment rate, the results are robust. The natural rate of growth using the IV approach is 5.2 and increases to 8.9 during the boom periods. The difference in the natural rate of growth in boom years versus years with growth below the natural rate is therefore 72.8% which is very close to the estimated difference using the total pool of countries (71.3%). The change in the natural rate of growth using time series techniques is slightly smaller at 64.8%. Our results therefore provide robust evidence, across different estimation techniques on the endogeneity of the natural rate of growth for the sub-Saharan African countries included in the study.

Table 8; Comparing the time series and panel data results

		Natural rate of growth		Natural rate of growth in boom periods			
Group	Country	A. Time series	B. Panel	C. Time series	D. % increase	E. Panel	F. % increase
1	South Africa	3.571	2.631	4.585	28.395	3.693	40.364
	Swaziland	2.197	2.631	3.082	40.282	3.693	40.364
2	Botswana	4.947	2.927	7.619	54.013	5.925	102.425
	Namibia	4.616	2.927	6.953	50.628	5.925	102.425
	Zambia	3.817	2.927	6.205	62.562	5.925	102.425
	Zimbabwe	3.264	2.927	8.534	161.458	5.925	102.425
3	Angola	7.887	4.547	13.699	73.691	6.569	44.468
	Congo, Dem. Rep.	5.856	4.547	6.687	14.191	6.569	44.468
	Mozambique	7.115	4.547	8.439	18.609	6.569	44.4688
4	Ethiopia	6.735	6.878	11.343	68.419	10.227	48.691
	Uganda	6.864	6.878	9.388	36.772	10.227	48.691
5	Central African Republic	3.222	5.037	5.533	71.726	9.287	84.375
	Chad	6.861	5.037	12.801	86.576	9.287	84.375
6	Cameroon	3.948	2.511	4.274	8.257	4.396	75.069
	Gabon	2.677	2.511	4.832	80.501	4.396	75.069
7	Nigeria	4.818	4.228	6.826	41.677	8.326	96.925
	Togo	3.837	4.228	7.023	83.034	8.326	96.925
8	Burkina Faso	5.674	8.744	7.801	37.487	11.84	35.407
	Ghana	5.216	8.744	6.999	34.183	11.84	35.407
9	Gambia	3.143	3.256	5.094	62.074	6.672	104.914
	Senegal	3.629	3.256	4.903	35.106	6.672	104.914
	Sierra Leone	4.099	3.256	8.844	115.76	6.672	104.914
10	Mali	4.812	5.068	7.322	52.161	7.142	40.923
	Tanzania	4.729	5.068	6.301	33.242	7.142	40.923
11	Congo, Rep.	2.972	2.895	4.511	51.783	4.753	64.179
	Kenya	3.389	2.895	4.968	46.592	4.753	64.179
	Malawi	4.236	2.895	6.262	47.828	4.753	64.176
	Low income		6.886			8.65	25.617
	Low income (excl. Congo, Dem. Rep.)		6.909			12.291	77.898
	Lower middle income		2.767			3.99	44.199
	Upper middle income		4.553			7.338	61.168
	Upper middle income (excl. Angola and Gabon)		3.726			5.386	44.551
	All countries	4.870^{A}	4.876	7.791^{A}	64.840	8.355	71.349
	All countries (IV)		5.204			8.994	72.828

Note: ^{A} is the time series average for all 31 countries

When analysing the sensitivity in the natural rate of growth using the time series results, we split the sample into countries which had a sensitivity above and below the average sensitivity for the region. The countries with a sensitivity above the average of 64.8% were Burundi (329.7%), Zimbabwe (161.5%), Sierra Leone (115.7%), Equatorial Guinea (109.6%), Chad (86.6%), Togo (83%), Gabon (80.5%), Angola (73.6%), Central African Republic (71.7%) and Ethiopia (68.4%). About 60% of these countries experienced some form of conflict or political instability. Burundi, Sierra Leone, Chad and Angola all faced a civil war while Ethiopia went to war with Somalia and Eritrea. There were several military coups in the Central African Republic following independence from France in 1960. The conflict and political instability in these countries no doubt contributed to their low level of economic growth and development. According to Collier et al (2003), there is bi-directional causality between low economic development and civil war, described in the literature as the, "conflict trap".

The negative effects of civil war and political instability on investment (Alesina et al, 1992; Serven, 1998; Collier et al, 2003) indicates that these countries may have been operating below full capacity and therefore had a stronger response to an increase in domestic and foreign demand during the boom. More stable countries may have a higher rate of capacity utilization. The remaining countries; Zimbabwe, Equatorial Guinea, Togo and Gabon all had presidents who held power for over three decades[29]. Unsurprisingly, the majority of these countries who had a sensitivity higher than the average for the region, ranked low in the Worldwide Governance Indicators (World Bank, 2015). This includes the measures for control of corruption, the rule of law and government effectiveness where the countries concerned ranked below 20 out of 100, with the exception of Gabon and Ethiopia who ranked between 25 and 40. Table 9 shows the results from the correlation analysis between the percentage increase in the natural rate of growth in the boom periods and the Worldwide Governance Indicators. All

[29] Equatorial Guinea, Gabon and Zimbabwe have faced controversy regarding election rigging.

five indicators, with the exception of control of corruption and political stability had a statistically significant negative correlation with the sensitivity of the natural rate of growth using both Pearson's correlation and Spearman's rank correlation. These results indicate that poor governance may have contributed to the low level of economic growth and development (Campos and Nugent, 1999; Kaufmann et al, 1999; Fayissa and Nsiah, 2010) and therefore the higher sensitivity in the natural rate of growth.

Table 9; Correlation Results

	Increase in the boom		Increase in the boom (excl. Angola, Gabon and Congo. Dem. Rep.)	
Indicator	Pearson	Spearman	Pearson	Spearman
GDP per capita	-0.033 (0.869)	-0.080 (0.691)	-0.196 (0.357)	-0.364* (0.080)
Human development index	-0.137 (0.496)	-0.112 (0.578)	-0.355* (0.088)	-0.373* (0.072)
Voice and accountability	-0.352* (0.071)	-0.397** (0.040)	-0.436** (0.033)	-0.539*** (0.006)
Political stability and absence of violence	-0.056 (0.779)	-0.036 (0.856)	-0.174 (0.415)	-0.232 (0.275)
Government effectiveness	-0.331* (0.091)	-0.322* (0.101)	-0.430** (0.035)	-0.389* (0.059)
Regulatory quality	-0.389** (0.047)	-0.370* (0.057)	-0.499** (0.013)	-0.476** (0.018)
Rule of law	-0.347* (-0.075)	-0.305 (0.121)	-0.472** (0.019)	-0.434** (0.033)
Control of corruption	-0.242 (0.222)	-0.186 (0.351)	-0.322 (0.124)	-0.196 (0.357)

Note: P Values are given in parenthesis
The Worldwide Governance Indicators are measured using the rank (World Bank, 2015)
Pearson refers to Pearson correlation coefficient. Spearman refers to Spearman's rank correlation coefficient
*** Indicates significance at the 99% level
** Indicates significance at the 95% level
* Indicates significance at the 90% level

70% of the countries who had a sensitivity higher than the average were categorised as low income economies (World Bank, 2015). Angola and Gabon are categorised as upper middle income countries while Equatorial Guinea is classified as a high income economy. Caution is needed when using this measure of economic development for Angola, Gabon and Equatorial Guinea as they are all oil exporting economies, with oil rents accounting for 35%, 42% and 53% of GDP respectively (World Bank, 2015). These countries have high levels of inequality with a GINI index of over 50 in Angola and 41.5 in Gabon, in addition to huge poverty rates of over 70% in Angola and Equatorial Guinea[30] and 19.5% in Gabon at the USD2 a day poverty line (World Bank, 2015). The income level of these countries is therefore not a good indicator of their economic development, so we exclude them from the upper middle income category.

Table 9 shows the correlation results obtained for the increase in the natural rate of growth during the boom period and the level of economic development measured by GDP per capita and the human development index. We find a significant negative correlation for both when we exclude the outlier countries, i.e. Angola, Gabon and the Democratic Republic of Congo.

Low levels of economic development is linked to low productivity which enables remarkable increases in productivity with relatively small increases in investment. Low income economies also have low levels of industrialisation and therefore face massive potential for growth as governed by the Verdoorn-Kaldor laws. There is a long understanding in the economic growth and development literature that there is a causal relationship between growth in the manufacturing sector and growth in GDP (Kaldor, 1966). Kaldor's (1966) three growth laws postulate firstly, that growth of GDP is positively related to growth in manufacturing output. The second law, also known as Verdoorn's Law, argues that due to static and dynamic increasing returns to scale, growth in labour productivity in manufacturing is positively related

[30] For Equatorial Guinea, the poverty headcount ratio as a percentage of the population used the national poverty line due to a lack of data on the USD2 a day poverty criteria.

to manufacturing output growth. The third law holds that due to diminishing returns in the agriculture and service sector, there is a negative relationship between growth of employment in the non-manufacturing sector and labour productivity growth in the economy.

Kaldor's (1966) three growth laws were first tested by Wells and Thirlwall (2003) for 45 African countries for the 1980 to 1996 period. They observed that the industrialisation process appeared to have 'bypassed' Africa as there had been no structural change in Africa in the two decades analysed. Their results however provided evidence in favour of Kaldor's first two laws and the authors concluded that structural change in favour of industrialisation would, 'almost certainly help to accelerate the growth of GDP and living standards in Africa' (Wells and Thirlwall, 2003, p.89).

The industries in low income countries are more labour intensive. This contributes to the high sensitivity of the natural rate of growth as there are large decreases in unemployment during boom periods. This may also help explain the negative constant when testing the endogeneity of the natural rate of growth.

As economic development, measured by GDP per capita is negatively correlated with the size of the informal sector (International Labour Organisation, 2012), we expect the natural rate of growth to be higher in low income countries as there is large participation of the labour force in the informal and subsistence economy which can easily move into the formal sector during boom periods. The informal economy represents over 80% of the labour force in sub-Saharan Africa (United Nations Economic Commission for Africa, 2015). There is poor individual country data on the size of the informal and subsistence economies for low income countries however the majority of the sub-Saharan African economies are low income. Of course, the degree of labour mobility will affect the degree of change in the natural rate of growth during the boom, for example there may be less labour mobility in South Africa due to the legacy of apartheid which legally discriminated and excluded individuals from certain social and

economic activities, and its effects persist even during the post-apartheid era (Bhorat and Oosthuizen, 2005).

The time series results for individual countries reported above are consistent with those obtained from the panel analysis for the groups corresponding to different income levels. When the countries were grouped from low income to upper middle income, we see that the group of low income countries had the highest response to domestic and foreign demand in the boom periods as the natural rate of growth increased by 77.8%.

The specification which excludes the Democratic Republic of Congo is used as the country has been plagued with war for several decades. Its inclusion may therefore lead to biased results. The low response of the natural rate of growth to the actual rate of growth in the Democratic Republic of Congo is expected due to the intensity and prolonged period of war the country has experienced resulting in reduced investment which is further exasperated by the increased rate of depreciation of the fixed capital stock, as a consequence of the destructive effect of civil war (Imai and Weinstein, 2000). It is therefore possible that the country may have lost most of its productive capacity and therefore is limited in its ability to respond to an increase in demand. This may also explain why the indicator for political stability and the absence of violence or terrorism was not significant using Pearson's correlation and Spearman's rank correlation.

The percentage increase in the natural rate of growth for lower middle income economies is 44.2% and 44.6% for upper middle income economies. The results indicate a non-linear relationship between the natural rate of growth and its response to the actual rate of growth in the boom periods. The sensitivity appears to be higher for low income countries (77.8%), it decreases for lower middle income countries (44.2%) and then levels off for upper middle income countries (44.6%). These results indicate that the responsiveness of the natural rate of growth to an increase in demand is L shaped for developing countries as it is higher the lower the level of economic development.

We do not include any high income economies in our analysis however when comparing our results with those from Leon-Ledesma and Thirlwall (2002) who only include high income economies in their analysis, we find that the sensitivity in the natural rate of growth is slightly higher for high income economies at 50.7% compared to middle income economies. The non-linear relationship on all economies for the sensitivity of the natural rate of growth and the level of economic development may therefore be U shaped. Future research looking into the differences in the sensitivity of the natural rate of growth to demand is needed.

7. Comparison with Other Studies

As no previous research on the natural rate of growth has been carried out for low income countries or the sub-Saharan African region, the results from the natural rate of growth as well as the change in the natural rate of growth in boom periods is compared to the results obtained for other developing countries as well as the OECD, i.e. Leon-Ledesma and Thirlwall (2002) for 15 OECD countries, Vogel (2007) for 11 Latin American countries, Libanio (2009) for 10 Latin American countries and Dray and Thirlwall (2011) for 10 Asian countries. The full table with the summary of results for the individual countries analysed in the above mentioned studies can be seen in Appendix C. Table 9 reports the average natural rate of growth and its change during the boom periods.

Table 9; Comparison of averages with other studies

	Region	Thirlwall specification	Natural rate of growth in boom periods	% increase
All countries – time series	Sub-Saharan	4.870	7.791	64.840
All countries – panel	Africa	4.876	8.355	71.349
Leon-Ledesma and Thirlwall (2002)	OECD	3.535	5.363	50.747
Vogel (2007)	Latin America	3.511	5.704	71.85
Libanio (2009)	Latin America	2.727	4.542	76.289
Dray and Thirlwall (2011)[N]	Asia	6.436	8.2	30.177

Note: Dray and Thirlwall (2011) found the change in the natural rate of growth in the boom to be 30% for a selection of 10 Asian countries. Included in this sample were Hong Kong, Japan, Singapore, South Korea and Taiwan which are not considered as less developed countries. The sensitivity of the natural rate of growth is therefore much lower than that estimated for developing countries.

No low income countries are included in the studies by Vogel (2009) and Libanio (2009), as categorised by the World Bank (2015), however caution is needed when making inferences about the results as many of the countries in Latin America categorised as upper middle income countries and high income countries are natural resource dependent with high levels of inequality. Per capita income may therefore not be a good economic indicator for economic development. However, the comparison is still insightful as it still provides evidence for the non-linear relationship between the natural rate of growth and its response to domestic and foreign demand.

The change of our estimated natural rate of growth during the boom periods averaged 64.8% in the time series approach and 71.3% in the panel appears reasonable when compared to the results obtained for other developing countries as the average change ranged from 71.8% to 76.3% for Latin American countries (Vogel, 2009; Libanio, 2009). This is higher than the change estimated for the OECD of 50.7%. This is additionally consistent with the literature as we expect the natural rate of growth to be higher in less developed countries due to the large size of the informal sector, low levels of development and productivity and higher degree of labour intensive industries.

8. Conclusion

The research contributes to understanding the sensitivity of the natural rate of growth to domestic and foreign demand for developing countries, by integrating a political economy and institutionalist approach to the post-Keynesian theory. It adds to our understanding of the relevance of demand for low income economies in particular, as no previous research has been done on this group of countries. The effect of demand on growth is further mediated by institutions.

We test the endogeneity hypothesis for the natural rate of growth, i.e. its dependence on demand for 31 sub-Saharan African countries using time series and panel data for the 1991 to 2012 period. Evidence in favour of the endogeneity of the natural rate of growth is found in all 31 countries using time series analysis.

As caution is needed when interpreting the time series results due to the limited degrees of freedom, we make use of Seemingly Unrelated Regressions (SUR) to pool countries which share similar parameters. Different country combinations are tested and only countries with the same parameters, tested using the Wald test, are grouped. Three additional subgroups are used based on respective country income levels, i.e. low income, lower middle income and upper middle income as defined by the World Bank (2013).

The results from the panel data estimates are consistent with the time series results, as evidence of the endogeneity of the natural rate of growth is found for all 11 subgroups, the three additional subgroups based on income levels, as well as for the overall pool of countries. The results are robust across different estimation techniques, i.e. OLS, TSLS, fixed versus random effects panel estimation and IV techniques. This is of significance as post-Keynesian economists have demonstrated that if the natural rate of growth is endogenous to demand, hence the actual rate of growth, then changes in demand might matter for economic growth and development in the long run as well as the short run (Leon-Ledesma and Thirlwall, 2002).

The results obtained are additionally in line with the literature which shows a higher natural rate of growth for less developed countries compared with developed countries (Vogel, 2009; Libanio, 2009).

We further contribute to the understanding of the relevance of demand for developing countries by distinguishing between low income, lower middle income and upper middle income economies in the case of sub-Saharan Africa. Caution is needed when using the World Bank income categories based on per capita income due to large levels of inequality and poverty which make this a poor measure for some countries such as Angola, Gabon and Equatorial Guinea. The results indicate that the sensitivity of the natural rate of growth to demand shocks for developing countries is L shaped. The sensitivity of the natural rate of growth is higher the lower the level of economic development, however it decreases at an increasing rate. This can be seen in the panel results for the sensitivity of the natural rate of growth which was 77.8% for low income countries, 44.2% for lower middle income countries and 44.6% for upper middle income countries.

There are several reasons for a higher sensitivity in the natural rate of growth for low income economies. Firstly, many of these countries have been plagued with some sort of political instability or conflict. Collier et al (2003) have provided evidence of the "conflict trap" where low economic development leads to conflict and vice versa. As conflict and political instability reduce growth partly through the negative effect on investment, it is very possible these countries had spare productive capacity which easily allowed them to respond to an increase in demand.

Other factors such as poor governance, as measured by the Worldwide Governance Indicators (World Bank, 2015), may have contributed to the low level of economic growth and development. Low income economies are characterised by low levels of industrialisation and therefore display massive potential for growth as governed by the Verdoon-Kaldor laws, which

state that there is a causal relationship between growth in the manufacturing sector and growth in GDP (Kaldor, 1966). Small increases in investment offer massive potential for improvements in productivity. Where industries do exist, they are usually labour intensive, further contributing to the responsiveness of the natural rate of growth to aggregate demand during the boom period.

Finally, we expect the natural rate of growth to be higher in low income countries due to the large participation of the labour force in the informal and subsistence economy which can easily move into the formal sector during boom periods. This is the case for low income economies as there is a negative correlation between the level of economic development and the size of the informal economy (International Labour Organisation, 2012).

These estimations give support to further estimating a demand constrained growth model for sub-Saharan Africa. In order to determine if demand matters for long term economic growth, we propose to test Thirlwall's (1979) balance of payments constrained growth model. The model synthesises aspects from the Keynesian models as well as other heterodox models, including Latin American Structuralism to explain growth rate differences between countries as well as provide policy recommendations to facilitate structural change to bring about sustainable and egalitarian growth. The model is based on the key assumption that demand is relevant for long term growth as well as structural change to overcome supply constraints.

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Appendix A

Data and Sources

Variable	Source
GDP growth in constant 2005 USD	World Bank, World Development Indicators
Total unemployment (% of total labour force)	World Bank, World Development Indicators

Descriptive statistics

	Unemployment rate				GDP growth				
Country	Mean	Standard dev	Min	Max	Mean	Geometric mean	Standard dev	min	Max
Angola	7.532	0.178	7.3	8.1	6.336	7.181	9.878	-24.7	22.593
Botswana	21.16	2.270	17.6	25	4.499	3.959	3.854	-7.841	9.667
Burkina Faso	2.782	0.402	2.3	3.3	5.781	4.667	2.804	0.233	11.015
Burundi	7.927	0.128	7.7	8.1	1.046	3.399	4.344	-8	5.385
Cameroon	5.341	1.426	3.4	8.1	2.571	3.723	2.888	-3.809	5.100
Central African Republic	7.636	0.079	7.5	7.8	3.161	4.253	4.473	-6.424	8.907
Chad	7.677	0.134	7.3	7.9	6.591	4.973	9.195	-15.71	33.629
Congo, Dem. Rep.	7.291	0.102	7.2	7.5	0.391	4.818	6.537	-13.47	7.801
Congo, Rep.	7.222	0.134	7	7.5	3.137	4.165	3.646	-5.493	8.752
Equatorial Guinea	7.105	0.473	5.8	7.7	17.37	11.718	20.293	-2.966	71.188
Ethiopia	6.682	1.154	5.4	8.2	6.244	7.704	6.653	-8.673	13.572
Gabon	19.2	0.799	17.8	20.6	2.301	3.422	3.879	-8.933	7.1
Gambia	7.832	0.078	7.7	8	3.319	3.329	3.242	-4.295	7.05
Ghana	6.086	2.678	3.2	10.4	5.656	5.287	2.540	3.3	15.007
Kenya	9.691	0.284	9.2	10.2	3.156	2.489	2.186	-0.799	6.993
Malawi	7.55	0.213	7.2	7.9	3.307	4.676	6.587	-10.24	16.729
Mali	8.441	0.219	8.1	8.9	4.695	4.542	3.223	-2.139	12.1
Mauritius	8.368	0.835	6.8	9.6	4.469	4.116	1.741	1.241	9.026
Mozambique	7.682	0.199	7.5	8.2	6.741	6.675	3.568	-5.105	11.899
Namibia	21.12	4.402	16.7	37.6	4.503	4.569	3.062	-2.008	12.272
Nigeria	7.545	0.091	7.4	7.7	5.546	3.971	6.965	-0.618	33.735
Senegal	9.959	0.059	9.9	10.1	3.533	3.184	1.945	-0.017	6.683
Sierra Leone	3.4	0.044	3.3	3.5	2.969	5.054	8.874	-19.01	26.268
South Africa	23.89	2.392	16.9	27.2	2.724	3.047	2.143	-2.137	5.603
Sudan	15.03	0.225	14.8	15.6	4.811	5.263	4.662	-10.1	11.515
Swaziland	22.62	0.333	21.7	23	2.328	2.232	1.311	-1.5	4.825
Tanzania	3.741	0.935	2	5.1	5.158	4.385	2.257	0.584	7.828
Togo	7.845	0.140	7.6	8.2	2.630	4.335	6.242	-15.09	14.982
Uganda	2.854	0.756	2	4.2	6.822	6.448	2.244	3.142	11.523
Zambia	15.48	2.312	12	19.7	3.544	5.213	4.147	-8.625	7.620
Zimbabwe	5.154	0.969	4	6.9	-0.51	3.428	8.043	-17.67	10.551

Appendix B

Results from the Wald test based on SUR estimations from Equation 3.2

Group	Country	Wald test (P Value)
1	South Africa and Swaziland	0.652
2	Zimbabwe, Zambia, Namibia and Botswana	0.870
3	Angola, Mozambique and Democratic Republic of Congo	0.1736
4	Uganda and Ethiopia	0.5886
5	Chad and Central African Republic	0.183
6	Cameroon and Gabon	0.699
7	Nigeria and Togo	0.531
8	Ghana and Burkina Faso	0.241
9	Sierra Leon, Gambia and Senegal	0.330
10	Cong Republic, Malawi and Kenya	0.089*
11	Tanzania, Ghana and Mali	0.461

Note: Wald test is used to test if the constant and the coefficient on %ΔU are not statistically different from each other.

Appendix C

Results from other studies

Leon-Ledesma and Thirlwall (2002)

Country	Thirlwall specification	Natural rate in boom periods	Absolute difference	% increase
Australia	3.999	5.713	1.714	42.861
Austria	3.136	4.956	1.82	58.036
Belgium	3.524	4.91	1.386	39.330
Canada	3.835	5.261	1.426	37.184
Denmark	2.942	4.782	1.84	62.542
France	2.827	3.934	1.107	39.158
Germany	3.505	4.709	1.204	34.351
Greece	4.509	7.671	3.162	70.126
Italy	3.344	5.91	2.566	76.734
Japan	4.567	8.719	4.152	90.913
Netherlands	3.282	5.315	2.033	61.944
Norway	3.972	5.009	1.037	26.108
Spain	4.062	6.092	2.03	49.975
UK	2.544	3.802	1.258	49.450
USA	2.991	3.664	0.673	22.501
Total	53.039	80.447	27.408	761.214
Average	3.536	5.363	1.827	50.748

Vogel (2007)

Country	Thirlwall specification	Natural rate in boom periods	Absolute difference	% increase
Argentina	3.03	7.2	4.17	137.624
Bolivia	3.03	4.42	1.39	45.875
Chile	6.12	7.91	1.79	29.248
Colombia	3.82	5.21	1.39	36.387
Costa Rica	4.77	6.81	2.04	42.767
Mexico	2.64	4.66	2.02	76.515
Nicaragua	2.64	5	2.36	89.394
Paraguay	2.64	4.54	1.9	71.970
Peru	5.13	7.96	2.83	55.166
Venezuela	1.78	4.62	2.84	159.551
Brazil	3.03	4.42	1.39	45.875
Total	38.63	62.75	24.12	790.371
Average	3.512	5.705	2.193	71.852

Libanio (2009)

Country	Thirlwall specification	Natural rate in boom periods	Absolute difference	% increase
Argentina	2.25	5.51	3.26	144.889
Chile	4.42	5.47	1.05	23.756
Colombia	3.34	4.31	0.97	29.042
Costa Rica	3.76	4.86	1.1	29.255
Mexico	2.57	4.38	1.81	70.428
Peru	2.13	4.67	2.54	119.249
Venezuela	2.36	3.11	0.75	31.780
Brazil	2.25	5.51	3.26	144.889
Ecuador	2.38	3.8	1.42	59.664
Uruguay	1.81	3.8	1.99	109.945
Total	27.27	45.42	18.15	762.896
Average	2.727	4.542	1.815	76.290

Footnotes

Dray and Thirlwall (2011)

Country	Thirlwall specification	Natural rate in boom periods	Absolute difference	% increase
China	10.36	12.04	1.68	16.216
Hong Kong	5.53	7.51	1.98	35.805
Indonesia	6.07	7.78	1.71	28.171
Japan	3.94	6.55	2.61	66.244
Singapore	7.66	9	1.34	17.493
South Korea	6.82	7.55	0.73	10.704
Sir Lanka	4.43	5.6	1.17	26.411
Taiwan	6.4	8.22	1.82	28.438
Thailand	6.72	9.55	2.83	42.113
Total	57.93	73.8	15.87	271.595
Average	6.437	8.2	1.763	30.177

Footnotes

Appendix D

Results from TSLS with the of %ΔU lags based on Equation 3.2

Country	Constant	%ΔU	R^2	F test	Natural rate of growth	lags	Durbin score[N]	Wu-Hausman[N]	F test from first stage regression[N]	Sargan score LM test[N]
Angola	10.798*** (3.292)	54.94 (53.94)		1.04	10.798***	2	5.581**	6.654**	0.883	0.095
Botswana	5.239*** (0.676)	-0.154 (1.225)	0.559	10.05***	5.239***	2			0.917	8.682***
Burkina Faso	5.897*** (0.593)	-0.061 (2.451)	0.006	0	5.897***	1	1.033	0.925	8.785***	
Burundi	0.253 (0.632)	-119.266 (74.912)		2.53	0.253	2	0.415	0.357	0.792	4.857**
Cameroon	3.318*** (0.615)	-1.212 (1.332)		0.74	3.318***	3	2.972*	2.768	0.467	0.676
Central African Republic	3.853*** (0.972)	2.759 (17.392)		0.03	3.853***	1	4.152**	4.454**	7.92**	
Chad	7.477*** (2.469)	21.096 (30.828)		0.47	7.477***	2	5.731**	6.911**	2.503	0.009
Congo, Dem. Rep.	5.355*** (0.717)	-21.652 (22.58)	0.795	32.79***	5.355***	2	0.658	0.538	0.917	1.604
Congo, Rep.	3.402** (1.313)	20.157 (44.791)		0.2	3.402**	1	5.298**	6.126**	1.679	
Equatorial Guinea	17.419*** (4.158)	-16.686 (19.782)	0.435	5.35**	17.419***	2	0	0	3.467*	0.158
Ethiopia	7.795*** (1.408)	6.215 (7.95)		0.61	7.795***	2	0.896	0.792	1.921	1.431
Gabon	2.998***	-0.515	0.503	7.96***	2.998***	2	0.116	0.092	4.812**	1.502

	(0.807)	(2.879)								
Gambia	3.384***	11.439	0.298	0.22	3.384***	1	5.258**	6.063**	3.469*	
	(0.971)	(24.62)								
Ghana	5.436***	0.421	0.583	13.77***	5.436***	2	2.231	1.995	2.786*	0.008
	(0.450)	(0.355)								
Kenya	3.986***	8.1		0.19	3.986***	2	0.892	0.787	3.135*	0.769
	(1.001)	(18.443)								
Malawi	4.174***	-15.826**	0.74	10.86***	4.174***	1	2.344	2.124	9.127***	
	(0.786)	(6.288)								
Mali	4.826***	6.352		0.08	4.826***	1	0.296	0.255	0.687	
	(1.014)	(22.18)								
Mauritius	4.279***	-0.744	0.201	0.39	4.279***	2	0.508	0.44	2.719*	0.701
	(0.389)	(1.194)								
Mozambique	7.306***	-2.576	0.101	0.14	7.306***	2	2.961*	2.953*	7.609***	1.573
	(0.578)	(6.968)								
Namibia	4.851***	-0.096	0.257	2.67*	4.851***	2	0.003	0.002	0.231	0.251
	(0.625)	(0.697)								
Nigeria	4.656***	-5.116	0.858	50.80***	4.656***	1	0.356	0.289	2.936*	
	(0.645)	(29.916)								
Senegal	3.979***	-10.145	0.436	2.04	3.979***	3	0.897	0.787	2.258	0.853
	(0.319)	(7.105)								
Sierra Leone	4.243**	49.588	0.057	0.39	4.243**	2	0.016	0.014	2.666*	2.499
	(1.821)	(79.403)								
South Africa	3.433**	-3.062		0.32	3.433***	1	3.518*	3.415*	0.125	
	(1.532)	(8.459)								
Sudan	5.406***	2.178	0.547	9.61***	5.406***	1	0.536	0.441	6.115**	
	(0.809)	(8.295)								

Swaziland	2.486***	-0.309	0.436	6.21**	2.486***	2	0.003	0.002	1.127	0.533
	(0.272)	(3.711)								
Tanzania	5.541***	1.023		0.36	5.541***	1	1.603	1.482	3.083*	
	(0.533)	(1.711)								
Togo	3.966***	-3.804	0.502	7.91***	3.966***	1	0.979	0.823	7.897**	
	(1.172)	(14.327)								
Uganda	7.093***	-3.1		0.19	7.093***	1	0.559	0.46	2.361	
	(0.588)	(5.115)								
Zambia	4.574***	0.128	0.007	0.01	4.574***	3	0.01	0.009	1.861	1.795
	(0.788)	(1.072)								
Zimbabwe	2.826	13.139	0.276	7.71***	2.826	3	7.244***	9.430***	1.899	0.585
	(2.364)	(8.207)								

Note: Durbin score and Wu-Hausman test for the endogeneity of %ΔU. Sargan score LM test for the validity of instruments used. F test from the first stage regression tests the strength of the instruments.
Standard errors are in parenthesis
*** Indicates significance at the 99% level
** Indicates significance at the 95% level
* Indicates significance at the 90% level

Results from TSLS with the lags of %ΔU AND GDPG lags based on Equation 3.2

Country	Constant	%ΔU	R^2	F test	Natural rate of growth	lags	Durbin score (endogeneity of %ΔU)	Wu-Hausman (endogeneity of %ΔU)	F test from 1st regression (weak instruments)	Sargan score LM test (validity)
Angola	9.615*** (1.775)	17.491 (13.378)		1.71	9.615***	2	10.833***	21.223***	5.374***	3.891
Botswana	5.208*** (0.691)	-0.591 (0.995)	0.536	9.71***	5.208***	2	0.216	0.172	0.683	9.020**
Burkina Faso	5.896*** (0.597)	-0.053 (2.45)	0.005	0	5.896***	1	1.044	0.936	4.158**	0.006
Burundi	0.646 (1.033)	-54.801 (33.419)	0.067	2.69	0.646	2	0.922	0.816	0.909	7.839**
Cameroon	3.814*** (0.286)	0.105 (0.472)	0.097	0.86	3.814***	1	0.033	0.026	1.333	6.029
Central African Republic	3.967*** (0.857)	-7.933 (13.036)	0.195	0.37	3.967***	3	3.204*	3.246*	2.646*	1.268
Chad	7.466*** (2.523)	23.036 (27.116)		0.72	7.466***	1	9.486***	15.952***	2.372	0.025
Congo, Dem. Rep.	5.589*** (0.697)	6.444 (9.203)	0.795	32.5	5.589***	1	10.459***	18.368***	8.973***	3.799
Congo, Rep.	3.229*** (0.94)	2.91 (16.592)		0.03	3.229***	1	12.455***	28.066***	4.57**	0.387
Equatorial Guinea	16.058***	5.579	0.309	4.03**	16.058***	1	7.642***	10.093***	7.276***	2.6117

	(4.567)	(15.982)							
Ethiopia	7.829*** (1.409)	6.712 (7.294)		0.85	7.829***	2	1.363	1.236	1.085	3.365
Gabon	2.748*** (0.826)	1.151 (2.756)	0.454	7.32***	2.748***	2	1.827	1.596	2.866*	4.315
Gambia	3.292*** (0.7)	-7.031 (11.431)	0.204	0.38	3.292***	1	3.139*	3.165*	5.521**	2.019
Ghana	5.433*** (0.447)	0.409 (0.352)	0.589	19.94***	5.433***	1	2.094	1.858	1.738	3.218
Kenya	4.219*** (0.953)	13.013 (16.987)		0.59	4.219***	1	2.444	2.363	2.852*	1.025
Malawi	4.178*** (0.806)	-14.9** (6.284)	0.727	10.16***	4.178***	1	3.243*	3.096*	4.634**	0.42
Mali	4.672*** (0.85)	0.201 (16.88)		0	4.672***	1	0.049	0.042	0.428	0.484
Mauritius	4.263*** (0.381)	-0.981 (1.155)	0.235	0.72	4.263***	1	0.219	0.187	1.752	2.773
Mozambique	7.292*** (0.568)	-3.25 (6.272)	0.123	0.27	7.292***	1	3.670**	3.830*	7.112***	1.675
Namibia	4.807*** (0.609)	0.047 (0.327)	0.221	2.55*	4.807***	2	0.169	0.134	0.54	2.573
Nigeria	4.656*** (0.641)	-5.986 (21.37)	0.859	51.38***	4.656***	1	0.727	0.603	3.196*	0.002
Senegal	3.988*** (0.328)	-8.536 (5.377)	0.396	2.52	3.988***	2	5.075**	5.890**	3.746**	1.236
Sierra Leone	4.243**	53.686	0.054	0.47	4.243**	1	0.038	0.033	1.755	2.57

	(1.824)	(78.016)								
South Africa	3.431**	-2.873		0.46	3.431**	1	7.892***	10.428***	0.15	0.001
	(1.436)	(4.983)								
Sudan	5.427***	3.168	0.558	9.91***	5.427***	1	0.335	0.273	2.907*	2.286
	(0.798)	(8.154)								
Swaziland	2.404***	3.375	0.196	5.14**	2.404***	1	4.533**	4.701**	2.601*	1.666
	(0.315)	(2.679)								
Tanzania	5.541***	-1.811		1.77	5.541***	1	1.582	1.46	2.198	11.889***
	(0.502)	(1.361)								
Togo	3.89***	-6.215	0.522	8.42***	3.89***	1	3.366*	3.237*	21.812***	0.061
	(1.098)	(9.245)								
Uganda	7.086***	-2.593		0.15	7.086***	1	0.43	0.352	1.235	0.137
	(0.573)	(4.755)								
Zambia	4.881***	1.063		1.04	4.881***	1	1.29	1.158	1.705	5.969
	(0.825)	(1.04)								
Zimbabwe	3.043	10.751	0.399	9.05***	3.043	1	6.659***	8.220**	1.87	1.295
	(2.132)									

Note: Durbin score and Wu-Hausman test for the endogeneity of %ΔU. Sargan score LM test for the validity of instruments used. F test from the first stage regression tests the strength of the instruments.
Standard errors are in parenthesis
*** Indicates significance at the 99% level
** Indicates significance at the 95% level
* Indicates significance at the 90% level