Explaining Growth in African Countries – What Matters?*

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Abstract

In this work we analyze the role of the traditional determinants of economic growth, pointed by the literature, in African countries in the period between 1950 and 2012, using growth regressions. Due to the specificity and the single nature of each one of these countries, methods that take into account observed and unobserved heterogeneity are used. Results highlight the relevance of the growth rate of the capital stock to economic growth in African countries in the short-run, which is significant in all regressions. The growth rate of the government to GDP ratio is also important in all but one of the regressions in which appears, and its growth is harmful for the growth of GDP *per capita* in the short-run. On the other hand, variables related to the public debt do not present any relationship with economic growth. Human capital has a positive relationship with economic growth in regressions that do not include public debt. The growth rate of real GDP *per capita* also depends (negatively) on its past value, i.e., the lower the real GDP *per capita* the higher will be its growth rate.

Keywords: determinants of economic growth, African countries, investment and capital stock, human capital, fiscal variables, observed and non-observed heterogeneity

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1. Introduction

Since the end of colonialism, African countries struggle for the growth of their economies and for the increase of living standards of the population. The difficulties are enormous and the results have not been the expected. Most of the African economies are amongst the poorest of the world, despite their natural resources endowment, their young and growing population and, of course, the large potential market of the whole continent. This is, in fact, a development paradox for the continent, which has been called the *"African Tragedy"*.

Nevertheless, substantial changes and considerable improvement in Africa's growth performance have begun with the new millennium. Various are the reasons for these economic changes. Most of the countries introduced deep changes in the domestic environment through the adoption and implementation of economic policy reforms and improvement of macroeconomic management such as greater fiscal discipline, privatization, investments in infrastructures and in human capital, as well as the adherence to the principles of democracy for most of the African countries which has contributed to the reduction of conflicts incidence and consequently to the increase of stability. At the same time, the growing need of capital to support the enormous investments, has led to the boom of public debt of African countries. Africa needs to find a new paradigm of growth grounded on a sustainable basis and capable to maintain or increase the rate of economic growth, creating resources to address poverty, inequality and unemployment. There is, however, a long way to go and the path differs from country to country.

The purpose of this paper is to analyze the determinants of economic growth in African countries in the period ranging between 1950 and 2012, such as public debt, the capital stock, the government ratio, the investment ratio, the human capital index, and two measures that proxy the institutional environment of countries, which are recognized by many authors as factors that contribute positively to improve the growth performance and to launch most of the African economies on the path of economic growth and social progress (Barro, 1999; Devarajan *et al.*, 1996; Calderón and Sérven, 2008). We try to shed some lights on the role of the above mentioned determinants for the economic growth of African countries, being one of the few studies that includes all these variables. Additionally, we add some originality in our econometric method, since we use recently developed methods for panel data, adapted from the time-series literature, which account for non-linearity and heterogeneity in the data (Eberhardt and Presbitero, 2015), to empirically explain: (a) the long-run relationship between some determinants of growth and the economic growth of African countries and (b) the growth heterogeneity across these countries. Moreover, our paper is entirely focused on Africa, while previous literature that also includes most economic growth determinants, usually includes countries outside the African continent.

Our work is organized as follows: Section 2 reviews the existing theoretical and empirical literature on the determinants of economic growth that we use in this work, specially focusing on the African Continent. Section 3 identifies all the data and the corresponding sources. In Section 4 we perform an evaluation of our data and identify the estimation techniques and methods. Sections 5 and 6 address the empirical results and the conclusions, respectively.

2. Literature Review

The topic of economic growth in African countries has been investigated by a wide range of studies, using different conceptual and methodological viewpoints and emphasising different sets of explanatory parameters. In this paper we make a review of the most important determinants of growth in African economies. Additionally, also in this section, we present the variables that we use as proxies for the determinants of economic growth. Details for these variables (detailed definition, time period, data source) are presented only in the next section.

There are numerous studies that bring strong evidence that a large government sector negatively affects economic growth worldwide (e.g., Barro, 1991, Engen and Skinner, 1992, Hansson and Henrekson, 1994, Gwartney *et al.*, 1998, Fölster and Henrekson, 2001). For Africa, Egbetunde and Fasanya (2013) analyse the long-run and short-run relationship between public expenditure and economic growth in Nigeria, and find that the impact of total public spending on growth to be negative. In our work we use the government ratio (gov_ratio), defined as government consumption in percentage of GDP, as a proxy for the size of the government.

Particularly on the public debt/growth nexus, e.g., Pattillo *et al.* (2002), Clemens *et al.* (2003), Reinhart and Rogoff (2010a,b), Vanlaer *et al.* (2015), and Eberhardt and Presbitero (2015) found different levels of negative correlations between them. Although the existing view, among policy makers at least, that public debt is necessary to induce economic growth, in particularly for poorer economies; in the last decade a growing discussion is being made by economists on the level of public debt above which economic growth is negatively affected (Reinhart and Rogoff 2010a, b and Panizza and Presbitero, 2013). We use public debt *per capita* (pc_pub_debt) as a proxy for public debt.

The general idea that the stock of public capital and infrastructure will boost economic growth constitutes a prominent feature of government economic programs across the world. The importance of infrastructure as an input of the capital stock and its relationship with economic growth is studied by Agénor and Moreno-Dodson (2006), who identified two main transmission channels: (1) the promotion of growth through private capital formation.; (2) crowding-out which is based on the idea that, in the short-run, an increase in public capital stocks may crowd-out private investment. Calderón and Sérven (2008) analyse the economic growth of about 100 developing countries between 1960 and 2005, using infrastructure growth and income inequality as explanatory variables. For Sub-Saharan African (SSA) countries they conclude that there is strong evidence that investment on infrastructure has a positive impact on economic growth. Calderón (2008) for a sample of 136 countries over the period 1960–2005, finds the impact on growth *per capita* caused by a faster accumulation of infrastructure stocks and a better quality of infrastructure services to be positive.

Boopen (2006) analyses the contribution of transport capital for economic growth for two different data sets: for a sample of SSA countries and for Small Island Developing States (SIDS), over the period 1980-2000, using both cross sectional and panel data analysis. The author concludes, in both cases, that economic growth in Africa has been triggered by transport capital. Cheteni (2013) examines the impact of transport infrastructure investment and transport sector productivity on South African economic growth for the period 1975-2011. The results of this paper suggest that the real domestic

gross fixed transport investment has a positive impact on economic growth and productivity.

Ghazanchyan and Stotsky (2013) used a panel data for 42 SSA countries, divided between oil exporters and non-oil exporting countries, during the period 1999-2011, to analyse the effect of some determinants of growth such as private and public investment, government consumption, and the exchange rate. Results show that the share of private investment in GDP is an important element for growth, specifically when oil-exporting African countries are comprised in the sample. The authors also found some evidence of a positive effect of public investment on growth.

We have defined two variables related with investment and accumulation of physical capital to use in our estimations – capital stock *per capita*, that is the stock of physical capital divided by the population (pc_cap_stock), and the investment ratio, which is defined as gross capital formation divided by GDP (inv_ratio).

Human capital is usually defined as the workers' acquisition of skills and know-how through education and training. Evidence from seminal empirical studies suggests that an educated population is a key determinant of economic growth (Barro and Sala-i-Martin, 1995; Brunetti *et al.*, 1998). Sacerdoti *et al.* (1998) conclude that human capital does not appear to have a significant contribution to the economic growth of West African countries, due to the inexistence of structural reforms. Kumar (2006) suggests that the negative impact of human capital investment, that the author finds, does not mean that the role of human capital in the growth process of African economies is marginal. Ndambiri *et al.* (2012) studied the determinants of economic growth in 19 SSA countries over the period 1982-2000, using the Generalized Methods of Moments (GMM) approach and concluded that human capital is important for growth. Ahmed *et al.* (2013) investigate the impact of human capital on economic growth in Sudan for the period between 1982 and 2009, by using a simultaneous equation model that links human capital (school attainment); and investment in education, and an health variable, to economic growth, total productivity, foreign direct investment, and the human development index. The authors conclude that the quality of education has a determinant positive role in economic growth. We use human capital index (hc_ind) as the proxy for human capital.

Institutional factors have also been discussed. Hall and Jones (1996) conducted empirical analysis and suggested that, in the long run, a country's economic performance is determined primarily by the institutions and government policies that make up the economic environment within which individuals and firms make investments, create and transfer ideas, and produce goods and services. Based on a cross-country regression, Sachs and Warmer (1997) analyse the sources of slow economic growth in Sub-Saharan Africa, between 1950 and 1990. According to these authors, a par from the well-known causes of slow growth of African economies, which also refers to other developing countries, namely, colonial legacy, geographical and natural, and ethnic divisions, etc., poor choices of economic policy are the main responsible for the slow growth in Africa. Indicators of economic policy such as the openness ratio, the market supporting institutions, government spending, and savings, have larger quantitative impacts. They also estimate that SSA economies could have *per capita* growth at over 4% *per* year, with appropriate policies regardless of the natural constraints. Easterly and Levine (1997) argue that Africa's poor growth and low level of *per capita* income are associated with low schooling, political instability, underdeveloped financial systems, distorted foreign exchange markets, high government deficits, and insufficient infrastructure. Tahari *et al.* (2004) examine the sources of growth in SSA countries using the

growth accounting framework. The results of the analysis show that during 1960-2002 the Total Factor Productivity (TFP) has no significant influence on the average real GDP growth. To increase the performance of those economies, it is needed a significant boost and improvement of TFP as well as on the investment/GDP ratio and the consequent diversification of the economic base. The authors also defend the need to impede the regional conflicts in order to build the path of economic growth in peaceful environment. Mathew and Adegboye (2014) apply econometric techniques such as Panel Unit Root, Least Square Dummy Variables (LSDV) and GMM for the period 1985-2012 on thirty selected Sub-Saharan African Countries to examine the influence of trade openness and institutions on economic growth. The main findings are: (1) institutions have significant positive impact on economic growth; (2) The significance of trade impact on economic growth is not relevant; (3) the process of trade liberalization through stronger institution should be a target.

In our work we will use two very distinctive variables as proxies for institutional determinants. One is a Weighted Conflict Index, a composite indicator of the number of assassinations, strikes, guerrilla, etc., i.e., a measure of conflict. The second is the ratio of the value of the exchange rate in the black market and the official exchange rate value (BMERP), i.e., a measure of the informal economy.

Our work will contribute further for the understanding of the determinants of economic growth in Africa, using a panel data set just for African countries, for the period between 1950 and 2012, using (simultaneously) the variables that we have referred above. There are only a few studies that take a wide perspective on economic growth determinants just for the African continent. Additionally, our econometric methodology takes into account the potential non-linearity and heterogeneity of the data, which is a value-added to the robustness of the results.

3. Sources and Data

Our data set comprises 52 African countries with a time span ranging from 1950 to 2012.[6] We have used several data sources in our work, which we select, based on the literature review that we have done. Below we make a description of each one of the variable used and their data source. The time period for each variable and each country can be found in Appendix A, Table A1.

- **rgdp_pc -** stands for the Real Gross Domestic Product (GDP) *per capita* and represents the measurement of the total wealth of a country divided by the total population and adjusted for inflation. The source of the data are the Conference Board Total Economy Database and also the World Economic Outlook (WEO) from the World Bank, calculated in 1990 US$ (converted at Geary Khamis Purchasing Parity Power (PPPs)).

- **pc_pub_debt** - Is the entire stock of direct government fixed term contractual obligations to others, outstanding on a particular date divided by the total population. It includes domestic and foreign liabilities, such as currency and money deposits,

[6]The African Continent has 54 countries. The two countries excluded from our sample, due to lack of data, are South Sudan and Somalia.

securities, and other shares and loans. It is the gross amount of government liabilities reduced by the amount of equity and financial derivatives held by the government divided by the total population, i.e., public debt *per capita*. The source is the WEO from the World Bank.

The following variables were taken from the Penn World Tables, version 8.0 (Feenstra *et al.*, 2015). The GDPs and the capital stocks were divided by the population to convert to *per capita* values.

- **rgdpe_pc_pwt –** stands for expenditure-side real GDP *per capita*, calculated in 2005 US$ at chained PPPs.
- **rgdp_pc_na_pwt -** stands for real GDP *per capita* at constant (2005) national prices.
- **inv_ratio -** is defined as the share of output-based real GDP that is represented by gross capital formation (investment), at current purchasing power parities (PPPs).
- **gov_ratio -** stands for the share of output-based real GDP that is represented by government consumption at current purchasing power parities (PPPs).
- **hc_ind -** represents the index of human capital, which is related to the average years of schooling and the returns to education.
- **pc_cap_stock –**Capital stock *per capita* at constant 2005 national prices (in mil. 2005US$) - is the total quantity of capital used in the production of goods and services, including factories, buildings, equipment, tools, and machinery divided by the total population.

We have also used the variables S18F2 and BMERP as proxies for the institutional environment, taken from the Databanks International database. Their definitions are presented below:

- **Weighted Conflict Index (S18F2) -** The weighted conflict index is calculated in the following manner: Multiply the value of the number of Assassinations by 24, General Strikes by 43, Guerrilla Warfare by 46, Government Crises by 48, Purges by 86, Riots by 102, Revolutions by 148, Anti-Government Demonstrations by 200. Sum the 8 weighted values and divide by 9. The result is the value (with decimal) stored as the Weighted Conflict Index.
- **BMERP (S16F7/S16F6) -** Percentage difference between the black market rate for foreign currency and the pegged official exchange rate.

The descriptive statistics (Means, Standard Deviations, Minimum, and Maximum) for the variables included in the analysis are incorporated in Table 1. The number of observations is different for each one of the variables; hence our panel is going to be unbalanced.

Table 1: Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
rgdp_pc (Y)	3,234	1,718.64	2,116.78	81.26	20,655.75
rgdpe_pc_pwt (Y)	2,556	1,896.58	1,955.43	153.15	15,067.31
rgdp_pc_na_pwt (Y)	2,556	1,963.73	2,532.41	145.51	28,425.58
pc_pub_debt (PcPD)	1,157	153.07	186.64	1.61	1,386.24
pc_cap_stock (PcCS)	2,536	5.95	7.93	0.14	62.74
inv_ratio (IR)	2,556	0.18	0.14	0.01	1.40
gov_ratio (GR)	2,556	0.21	0.14	0.01	1.44
hc_ind (HCI)	1,888	1.56	0.40	1.03	2.85
S18F2 (Inst1)	2,126	1,493.64	4,120.90	0.00	94,325.00
BMERP (Inst2)	997	1.99	6.40	0.52	125.00

Notes: Due to the higher number of observations relative to the other 2 variables that represent GDPs, we opted for rgdp_pc instead of rgdpe_pc_pwt or rgdp_pc_na_pwt, for the regression estimations.

Due to data availability issues regarding the public debt variable, that for many countries had data only after the year 2000, and also the human capital index, that presented missing data for many countries, and being these variables considered relevant to growth regressions, the group of countries that presented longer time series are much shorter than the initial database. However, in the next section we still do the statistical tests for the entire data set.

4. Estimation and Methods

This paper analyzes the behavior of economic growth in African economies, based on the traditional determinants of economic growth. The specificity and the single nature of each one of these countries brings to the analysis the question of observed and unobserved heterogeneity.

In the growth regressions literature, initiated with Barro (1991), it is usual to use both long-run determinants of economic growth, defined in the theoretical literature, such as human capital, and also short-run determinants, defined in the theoretical literature, such as physical capital (economic growth models, e.g., *à la* Solow, physical capital has just transitional dynamics) and also policy variables, such as those linked with the public budget. Our baseline specification is as follows:

$$y_{it} = \alpha_i + \beta_i PcPD_{it} + \phi_i IR_{it} + \varpi_i GR_{it} + \varphi_i PcCS_{it} + \delta_i HCI_{it} + \Omega_i Inst1_{it} + \Psi_i Inst2_{it} + \lambda'_i f_t + \varepsilon_{it} \quad (1)$$

Where y_{it} is the real GDP *per capita*, $PcPD_{it}$ is public debt *per capita*, IR is the investment ratio, GR is the government ratio, PcCS is the capital stock *per capita*, HCI represents the Human Capital Index, Inst1 represents the Weighted Conflict Index, and Inst2 represents the BMERP. All these explanatory variables were defined in the previous section. The

situational and non-observed variables that can globally affect all the African economies are considered as common factors and they are presented as f_t. α_i is the country-specific intercepts, λ'_i is the country specific factor loadings associated to the common factors, and ε_{it} is the stochastic error term.

The Common Correlated Effects (CCE) approach adopted in this work is, according to Eberhardt and Teal (2011) and Pesaran and Tosetti (2011), robust to non-stationarity in both observables and non-observables and works well in the presence of weak and/or strong cross-sectional correlated errors. To perform the estimation we used lagged/lead (3 lags) and differentiated cross-section averages to augment the CCE method, following the statement of Chudik and Pesaran (2015) that CCE-type estimators once augmented with a sufficient number of lags/leads and cross-sectional averages perform well, even in the case of dynamic models with weakly exogenous regressors. Lagged/lead and differentiated cross-section averages are computed as the average of all countries in the dataset for a specific year, i.e., they represent the cross-borders effects, i.e. the common effects affecting each country. Note that each country may be affected differently by these common effects, as the coefficients are country-specific. This model takes heterogeneity into account, since, contrary to what happens in more standard econometric models, parameters are country-specific and then 'averaged' to obtained a single coefficient. We apply an error correction-model (ECM) representation of the equation above to take into consideration the time series properties and dynamics in macro panels. The ECM allows us to distinguish between the short and the long-run.[7]Additionally, our method also takes into account the fact that the dataset is an unbalanced panel.

4.1. Cross-Section Dependence and Stationarity Tests

Interdependencies between African economies may occur after common shocks with a heterogeneous impact across countries. To this end, we apply the Pesaran (2004) to test the null hypothesis of no cross-section dependence across panel members. The results of the test are presented in Table 2 below.

Table 2: Cross-Section Dependence Test

Variable	CD-test	p-value	corr	abs(corr)
rgdp_pc	64.05***	0.000	0.218	0.505
pc_pub_debt	47.89***	0.000	0.349	0.554
inv_ratio	25.68***	0.000	0.105	0.363
gov_ratio	47.62***	0.000	0.199	0.443
hc_Ind	165.37***	0.000	0.948	0.948
pc_cap_stock	17.35***	0.000	0.072	0.545

Notes: Level of significance: *** for p-value < 0.01. Null hypothesis: There is no cross-sectional dependence between the variables.

[7] Our estimated equation is the ECM version of the specification of equation (1). The ECM version has both lagged levels and first differences variables, being the first interpreted as the long-run effects and the latter the short-run effects. Please note also that we first differenced the dependent variable, as the first difference of the log of GDP *per capita* is the growth rate of GDP *per capita*. We have just streamlined the presentation to save space, since the transformation of a levels equation as our equation (1) to its ECM version is well described in the econometric literature cited in our paper.

The Pesaran (2004) CD test assumes significant values between 17.35 and 165.37 for the capital stock *per capita* and the human capital index, respectively. There is evidence of cross-sectional dependence (CSD) between panel members. Empirically it shows that any structural shock that occurs in one of the panel members (country) will affect positive or negatively the remaining countries.

An empirical work based on time series assumes, necessarily, a long-run stationarity of the series, avoiding the non-stationarity, which invalidates the classic econometric assumptions and generates spurious relations between the series. As defended by Gujarati (2008): "a process is stationary if their means and variances are constant over time and the value of the covariance between two time periods depends only on the distance or lag between the two periods and not on the effective time period in which the covariance is calculated." The stationarity of the time series is used to test the presence of a unit root. In our study we use a second generation panel unit root test Pesaran (2007), also known as the Pesaran CIPS test, with and without trend, and considering three lags. In this test we assume as the null hypothesis that every individual time series has a unit root and is therefore non-stationary and the alternative hypothesis is that the time series is stationary. Table 3 below shows the results of this test.

Table 3: Panel Unit Root Test

Variable	Lags	1	2	3	4	5	6
		pc_rgdp	pc_pub_debt	inv_ratio	gov_ratio	pc_cap_stock	hc_ind
Pesaran (2007) Test Without Trend							
Zt - stat.	0	4.626	-0.699	0.560	-1.472	10.100	10.631
p-values		1.000	0.244	0.712	0.071(**)	1.000	1.000
Zt - stat.	1	2.553	0.243	1.485	-1.401	4.108	0.086
p-values		0.995	0.596	0.931	0.081(**)	1.000	0.534
Zt - stat.	2	3.045	4.208	3.493	-1.156	6.067	0.099
p-values		0.999	1.000	1.000	0.124	1.000	0.540
Zt - stat.	3	2.418		4.177	-0.294	5.511	-0.299
p-values		0.992		1.000	0.384	1.000	0.382
Pesaran (2007) Test With Trend							
Zt - stat.	0	5.088	0.310	-1.600	-3.075	12.020	11.584
p-values		1.000	0.622	0.055(**)	0.001(*)	1.000	1.000
Zt - stat.	1	2.435	0.689	-0.594	-3.553	6.396	3.459
p-values		0.993	0.755	0.276	0.000(*)	1.000	1.000
Zt - stat.	2	2.883	3.893	1.505	-3.472	8.008	4.042
p-values		0.998	1.000	0.934	0.000(*)	1.000	1.000
Zt - stat.	3	2.183		1.879	-3.700	6.586	4.202
p-values		0.985		0.970	0.000(*)	1.000	1.000
Number of Countries		52	52	48	48	48	35

Number of Observations	3234	1157	2156	2556	2536	1588
Avr. N. of Observations	62.73	22.25	53.82	53.82	53.43	54.42

Notes: Null hypothesis: The time series are non-stationary. (**) Stationary at 5% significance level and (*) at 10% significance level. The remaining time series are non-stationary. The CIPS test assumes that cross-section dependence is in the form of a single unobserved common factor.

Results show that in general all variables are non-stationary. The p-values for the Z_t statistics for all three lags do not reject the null hypothesis (in levels) as they are very high. The panel unit root test for public debt *per capita* is determined only for two lags, due to the insufficient number of observation required for the CIPS test with three lags. The non-stationary issue will be corrected by the ECM regressions.

4.2. Cointegration

In order to test the long-run relationship between the variables included in the estimations, we used a second generation panel co-integration test developed by Westerlund (2007) which provides four test statistics: Gτ, Gα, Pτ and Pα, described below. The co-integration test was made for the relationship between real GDP *per capita* with the following variables: public debt *per capita*, the investment ratio, the government ratio, capital stock *per capita*, and the human capital index.[8]

The four tests determine whether there is an error correction for individual panel members or for the panel as a whole. The Gα and Gτ statistics test for co-integration of at least one of the panel's countries, and the Pα and Pτ statistics perform the test for the whole panel. In other words, the Gτ and Gα test statistics, test the null hypothesis of no co-integration for all cross-sectional units against the alternative that there is co-integration for at least one cross-sectional unit (i.e. $H_0 : \rho_i = 0$ for all *i versus* $H_1: \rho_i < 0$ for at least one *i*). Rejection of the null should therefore be taken as evidence of co-integration of at least one of the cross-sectional units. The Pτ and Pα test statistics pool information over all the cross-sectional units to test the null of no co-integration for all cross-sectional units against the alternative of co-integration for all cross-sectional units (i.e. $H_0: \rho_i = 0$ *versus* $H_1: \rho_i = \rho < 0$ for all *i*). Rejection of the null should therefore be taken as evidence of co-integration for the panel as a whole.

Table 4: Westerlund (2007) Panel Cointegration Test

Statistics	**Lags**	**pc_pub_debt (a)**		**inv_rat**		**gov_rat**		**pc_cap_stock**		**hc_ind**	
		p-values		p-values		p-values		p-values		p-values	
		Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend
Test Gτ	1			0.998	1.000	1.000	1.000	0.948	1.000	0.967	0.797
	2			1.000	1.000	1.000	1.000	0.999	1.000	0.985	0.602
Test Gα	1			1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999

[8] Regarding public debt *per capita,* the test could not be done due to the insufficient number of observations.

	2			1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999
Test Pτ	1			1.000	1.000	0.169	1.000	0.993	0.062	0.008(*)	1.000
	2			1.000	1.000	0.107	1.000	1.000	0.78	0.004(*)	0.993
Test Pα	1			1.000	1.000	0.996	1.000	0.986	0.113	0.938	0.993
	2			1.000	1.000	0.997	0.999	1.000	0.809	0.989	0.978

Notes: (a) Time series is not continuous. Null hypothesis: There is no co-integration between the variables. Levels of significance: (*) for $p < 0.01$.

The results summarized in Table 4 suggest that the no co-integration hypothesis cannot be rejected both for the panel as whole (Pτ and Pα), and for the group-mean tests (Gα and Gτ). Some exception is made for human capital index with trend for which the null hypothesis can be rejected in lag 1 and 2, at 5% significance level for the whole panel.

5. Empirical Results

In this section we present our empirical estimates. We have run a set of growth regressions having as the dependent variable *D1rgdp_pc*, which is the change in real GDP *per capita,* i.e., the growth rate of real GDP *per capita*. Our best estimates are presented in Table 5.[9] All the regressions pass the Wald test for joint significance at 1%. On the other hand, in all regressions presented in Table 5, we note that the values for the Root Mean Squared Error are very low – between 0.0118 and 0.0184 -, meaning that the coefficients for predicted values are close to the observed data values, i.e., the deviation is small. In each column, we have also identified the countries used in the estimations. Please note that the public debt variable had data only after the year 2000 for many countries, and the human capital index variable presented missing data for many countries. Since the two referred variables are considered important determinants for economic growth, they had to be included in the regressions; hence, the group of countries that presented longer time series are much shorter than the initial database.

Results for the African countries specified in Table 5 highlight the relevance of the growth rate of the capital stock (D1pc_cap_stock) to economic growth, in the short-run, which is significant in all regressions. This is in line with findings by Calderón and Sérven (2008) and Calderón (2008) who noted that physical capital accumulation was a fundamental determinant of economic growth for SSA countries. The growth rate of the government ratio (D1gov_ratio) in the short-run is also important in all but one of the regressions in which appears, and its growth is harmful for economic growth. For the long-run also exhibits a negative relationship, but only for equation (5). Egbetunde and Fasanya (2013) for Nigeria also find, both in the short and the long-run, a negative relationship between the government size (consumption) and economic growth. On the other hand, variables related to the public debt do not present any relationship with economic growth. Human capital, in the long-run, has a positive relationship with economic growth in regressions that don't include public debt. Ndambiri *et al.* (2012) and Ahmed *et al.* (2013), respectively for SSA countries and for Sudan, also found a positive relationship between human capital and economic growth. The growth rate of real GDP *per capita* also depends

[9] We have tried estimations using the investment to GDP ratio and also the two proxies for institutions – S18F2 and BMERP -, but they were not significant. We selected the best estimations concerning the cross-correlations tests.

(negatively) on its past value, i.e., the lower the real GDP *per capita* the higher will be its growth rate.

The variability of effects across countries can be observed by the count of significant (positive or negative) effects by country in Table 5. While the results for real GDP *per capita* in the previous period and the growth rate of the capital stock *per capita* remain very consistent, variables like the government ratio and human capital present significant positive and negative coefficients, indicating a great irregularity between these variables and the growth rate of real GDP *per capita* between countries.

Table 5 – Growth Regressions

Dependent Variable: $D1rgdp\_pc_t$	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Constant	2.195*** (0.001)	1.826*** (0.009)	2.627*** (0.010)	1.487 (0.109)	4.598*** (0.000)
$rgdp\_pc_{t-1}$	-0.389*** (0.002)	-2.662** (0.041)	-0.442*** (0.000)	-0.154** (0.045)	-0.592*** (0.000)
$pc\_pub\_debt_{t-1}$	0.007 (0.785)	0.005 (0.785)	0.011 (0.845)	-	-
D1pc_pub_debt	0.010 (0.803)	0.001 (0.967)	0.002 (0.930)	-	-
$pc\_cap\_stock_{t-1}$	0.187 (0.231)	0.057 (0.543)	0.284 (0.106)	0.050 (0.103)	0.134 (0.142)
D1pc_cap_stock	1.506*** (0.000)	1.509*** (0.000)	1.114*** (0.000)	1.320*** (0.000)	0.949** (0.037)
gov_ratio_{t-1}	-	-0.354 (0.483)	-0.011 (0.767)	-0.016 (0.686)	-0.080* (0.067)
D1gov_ratio	-	-0.055** (0.038)	-0.065** (0.017)	-0.076** (0.025)	-0.061 (0.414)
hc_ind_{t-1}	-	-	0.329 (0.115)	-	0.259** (0.017)
D1hc_ind	-	-	0.643 (0.459)	-	2.076 (0.138)
Number of observations	328	308	221	328	308
Avg Nr. Observ. **Min-Max**	36.4 20-58	38.5 28-58	44.2 32-58	36.4 20-58	38.5 28-58
Number of countries	9 (Côte D'Ivoire, Egypt, Ghana, Kenya, Lesotho, Mauritius, Morocco, South Africa, Zimbabwe)	8 (Côte D'Ivoire, Egypt, Ghana, Kenya, Mauritius, Morocco, South Africa, Zimbabwe)	5 (Côte D'Ivoire, Egypt, Ghana, Kenya, South Africa)	9 (Côte D'Ivoire, Egypt, Ghana, Kenya, Lesotho, Mauritius, Morocco, South Africa, Zimbabwe)	8 (Côte D'Ivoire, Egypt, Ghana, Kenya, Mauritius, Morocco, South Africa, Zimbabwe)
Wald	59.34***	97.81***	402.9***	79.74***	55.47***
Root Mean Square Error	0.0184	0.0145	0.0118	0.0177	0.0134

CD-test (res)	0.12 (0.906)	2.31** (0.021)	-1.49 (0.137)	1.99** (0.047)	0.35 (0.730)
Stat-test (res)	Rejects I(1)	Rejects I(1)	Rejects I(1)	Rejects I(1)	Rejects I(1)
sig. signs/countries for *rgdp_pc$_{t-1}$*	4 (-)	4(-)	3(-)	6(-)	8(-)
sig. signs/countries for *pc_pub_debt$_{t-1}$*	1(+)/1(-)	1(+)	1(+)	-	-
sig. signs/countries for *D1pc_pub_debt*	2(+)	1(+)	-	-	-
sig. signs/countries for *pc_cap_stock$_{t-1}$*	4(+)	3(+)/1(-)	2(+)	3(+)/1(-)	3(+)/1(-)
sig. signs/ countries for *D1pc_cap_stock*	7(+)	6(+)	3(+)	7(+)	3(+)
sig. signs/ countries for *gov_ratio$_{t-1}$*	-	2(-)	1(-)	1(+)/3(-)	1(+)/2(-)
sig. signs/countries for D1*gov_ratio*	-	2(-)	-	2(-)	1(+)/2(-)
sig. signs/countries for *hc_ind$_{t-1}$*	-	-	-	-	3(+)/1(-)
sig.signs /countries for *D1hc_ind*	-	-	-	-	1(+)

Notes: Values between parentheses below coefficients are p-values from robust (clustered) standard errors. Level of significance: *** for p-value<0.01; **for p-value<0.05;* for p-value<0.1. Wald test is a joint significance test for the regressors. Regressions include three lags of lagged differences of cross-section averages.

6. Conclusions

This paper empirically assesses the determinants of economic growth, as previously uncovered by the literature, in African economies over the period 1950 to 2012, using growth regression techniques. Our work studies only the African continent, using (simultaneously) the variables that were previously defined by the literature, as the most important determinants of economic growth. Additionally, our econometric method takes into account observed and unobserved heterogeneity and the non-linear properties of the data, which increases the robustness of the results.

We found strong evidence for the African countries for which we had longer time-series, of a positive impact of the growth rate of capital stock to economic growth in the short-run, which is significant in all regressions. The growth rate of the government to GDP ratio, in the short-run, is also important in all but one of the regressions in which appears, and its growth is harmful for economic growth. Human capital has a positive relationship with economic growth, in the long-run, in regressions that do not include public debt. Our results corroborate some of the empirical literature for African countries. However, the cross-country impact of these two last variables on the growth rate of the economies (positive to some and negative to others) is not uniform, so that appropriate policies for one country may be seriously misguided in another. Concerning public debt, we found that it is not significant and therefore it has no impact on the economic growth of African countries. The growth rate of real GDP *per capita* also depends (negatively) on its past value, i.e., the lower the real GDP *per capita* the higher will be its growth rate. We have also tested two

proxies for institutions, which did not deliver significant results. The investment to GDP ratio is also not significant.

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APPENDIX A

Table A1 – Time Dimension of Variables for each African Country

TIME DIMENSION OF VARIABLES

country_name	rgdp_pc	rgdpe_pc_pwt	rgdp_pc_na_pwt	Inv_ratio	pc_Pub_Debt	Gov_ratio	HC_Ind	S18F2	BMERP	pc_Cap_Stock
Algeria	1950 - 2012	n/a	n/a	n/a	1964 - 2012	n/a	n/a	1967-2004	1962-1985	n/a
Angola	1950 - 2012	1970 - 2011	1970 - 2011	1970 - 2011	2000 - 2012	1970 - 2011	n/a	1975-2005	1975-1977 ; 1982-1985	1970-2011
Benin	1950 - 2012	1959 - 2011	1959 - 2011	1959 - 2011	2000 - 2012	1959 - 2011	1959 - 2011	1960-2005	1960-1985	1959-2011
Botswana	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1998 - 2012	1960 - 2011	1960 - 2011	1967-2005	1966-1985	1960-2011
Burkina Faso	1950 - 2012	1959 - 2011	1959 - 2011	1959 - 2011	2002 - 2012	1959 - 2011	n/a	1960-2005	1960-1985	1959-2011
Burundi	1950 - 2012	1960 -2011	1960 -2011	1960 -2011	2000 - 2012	1960 -2011	1960 -2011	1967-2005	1971-1985	1960-2011
Cameroon	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Cape Verde	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2002 - 2012	1960 - 2011	n/a	1975-2005	1979-1984	1960-2011
Central African Republic	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Chad	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1999 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Comoros Islands	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	n/a	1975-2005	1975-1985	1960-2011
Côte d'Ivoire	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1980 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Democratic Republic of Congo (Kinshasa)	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Djibouti	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2003 - 2012	1960 - 2011	n/a	1978-2005	1977-1985	1970-2011
Egypt	1950 - 2012	1950 -2011	1950-2011	1950 -2011	1970 - 2012	1950 -2011	1950 -2011	1953-2005	1951-1985	1950-2011
Equatorial Guinea	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1980 - 2012	1960 - 2011	n/a	1968-2005	1968-1969	1960-2011
Eritrea	1950 - 2012	n/a	n/a	n/a	2000 - 2012	n/a	n/a	n/a	n/a	n/a
Ethiopia	1950 - 2012	1950 - 2011	1950 - 2011	1950 - 2011	1992 - 2012	1950 - 2011	n/a	1950-2005	1970-1985	1960-2011
Gabon	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1990 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Gambia	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	1960 - 2011	1967-2005	1976-1985	1960-2011
Ghana	1950 - 2012	1955 - 2011	1955 - 2011	1955 - 2011	1952 - 2012	1955 - 2011	1955 - 2011	1960-2005	1962-1985	1955-2011
Guinea	1950 - 2012	1959 - 2011	1959 - 2011	1959 - 2011	1990 - 2012	1959 - 2011	n/a	1960-2013	1970-1985	1959-2011
Guinea Bissau	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	n/a	1975-2005	1976-1984	1960-2011
Kenya	1950 - 2012	1950 - 2011	1950 - 2011	1950 - 2011	1960 - 2012	1950 - 2011	1950 - 2011	1967-2005	1970-1985	1950-2011
Lesotho	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1988 - 2012	1960 - 2011	1960 - 2011	1967-2005	1966-1985	1960-2011
Liberia	1950 - 2012	1964 - 2011	1964 - 2011	1964 - 2011	2000 - 2012	1964 - 2011	1964 - 2011	1950-2005	1950-1985	1964-2011
Libya	1950 - 2012	n/a	n/a	n/a	1990 - 2012	n/a	n/a	1953-2005	1952-1985	
Madagascar	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1990 - 2012	1960 - 2011	n/a	1960-2005	1960-1985	1960-2011
Malawi	1950 - 2012	1954 - 2011	1954 - 2011	1954 - 2011	2002 - 2012	1954 - 2011	1954 - 2011	1967-2005	1970-1985	1954-2011
Mali	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1965 ; 1968-1985	1960-2011
Mauritania	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Mauritius	1950 - 2012	1950 - 2011	1950 - 2011	1950 - 2011	1970 - 2012	1950 - 2011	1950 - 2011	1968-2005	1976-1985	1950-2011
Morocco	1950 - 2012	1950 - 2011	1950 - 2011	1950 - 2011	1965 - 2012	1950 - 2011	1950 - 2011	1956-2005	1956-1985	1950-2011
Mozambique	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1999 - 2012	1960 - 2011	1960 - 2011	1975-2005	1975-1985	1960-2011
Namibia	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1993 - 2012	1960 - 2011	1960 - 2011	1978-2005	1978-1985	1960-2011
Niger	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1995 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Nigeria	1950 - 2012	1950 - 2011	1950 - 2011	1950 - 2011	1970 - 2012	1950 - 2011	n/a	1960-2005	1970-1985	1950-2011
Republic of Congo (Brazaville)	1950 - 2012	1950 - 2011	1950 - 2011	1950 - 2011	1990 - 2012	1950 - 2011	1950 - 2011	1960-2005	1964-1985	1970-2011
Rwanda	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1995 - 2012	1960 - 2011	1960 - 2011	1967-2005	1975-1985	1960-2011
São Tomé and Príncipe	1950 - 2012	1970 - 2011	1970 - 2011	1970 - 2011	2001 - 2012	1970 - 2011	n/a	1975-2005	1979-1984	1970-2011
Senegal	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2000 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Seychelles	1950 - 2012	n/a	n/a	n/a	1990 - 2012	n/a	n/a	1976-2005	1976-1985	
Sierra Leone	1950 - 2012	1961 - 2011	1961 - 2011	1961 - 2011	2000 - 2012	1961 - 2011	1961 - 2011	1967-2005	1976-1985	1961-2011
South Africa	1950 - 2012	1950 - 2011	1950 - 2011	1950 - 2011	1950 - 2012	1950 - 2011	1950 - 2011	1950-2005	1950-1985	1950-2011
Sudan	1950 - 2012	1970 - 2011	1970 - 2011	1970 - 2011	1992 - 2012	1970 - 2011	1970 - 2011	1956-2005	1956 ; 1961-1985	1970-2011
Swaziland	1950 - 2012	1970 - 2011	1970 - 2011	1970 - 2011	1993 - 2012	1970 - 2011	1970 - 2011	1968-2005	1968-1985	1970-2011
Tanzania	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2002 - 2012	1960 - 2011	1960 - 2011	1961-2005	1970-1985	1960-2011
Togo	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	2001 - 2012	1960 - 2011	1960 - 2011	1960-2005	1960-1985	1960-2011
Tunisia	1950 - 2012	1960 - 2011	1960 - 2011	1960 - 2011	1990 - 2012	1960 - 2011	1960 - 2011	1956-2005	1956; 1960-1985	1960-2011
Uganda	1950 - 2012	1950 - 2011	1950 - 2011	1950 - 2011	1997 - 2012	1950 - 2011	1950 - 2011	1967-2005	1970-1985	1950-2011
Zambia	1950 - 2012	1955 - 2011	1955 - 2011	1955 - 2011	1990 - 2012	1955 - 2011	1955 - 2011	1967-2005	1970-1985	1955-2011
Zimbabwe	1950 - 2012	1954 - 2011	1954 - 2011	1954 - 2011	1965 - 2012	1954 - 2011	1954 - 2011	1965-2005	1965-1985	1954-2011