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Development Research
University of Bonn

ZEF-Discussion Papers on
Development Policy No. 252

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From agricultural to economic growth: targeting investments across Africa

PARI

Bonn, March 2018

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Tigabu Getahun, Heike Baumüller, and Yalemzewd Nigussie. From agricultural to economic growth: Targeting investments across Africa, ZEF – Discussion Papers on Development Policy No. 252, Center for Development Research, Bonn, March 2018, pp. 40.

ISSN: 1436-9931

Published by:
Zentrum für Entwicklungsforschung (ZEF)
Center for Development Research
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Acknowledgements

We are grateful to Joachim von Braun, Alisher Mirzabaev, Oliver Kirui and participants at the PARI Annual Conference 2018 for numerous comments, guidance and insightful suggestions.

This paper was developed within the project “Program of Accompanying Research for Agricultural Innovation” (PARI), which is funded by the German Federal Ministry of Economic Cooperation and Development (BMZ).

Abstract

This paper examines whether investment in the agriculture and food sectors in Africa significantly increases overall economic growth and, hence, reduces food and nutrition insecurity. To this end, the study examines the causal link between agricultural growth, food production, quality of governance, and overall economic growth using panel data compiled from 44 African countries for a 53-year period from 1961 to 2014. The estimation result from the fully modified least squares, the panel cointegration, and Granger causality tests suggest that agricultural growth, government commitment, and quality of governance Granger causes overall economic growth. The study also identifies the 10 African countries where investment in the agriculture and food sectors is expected to yield the highest returns and the 10 African countries having the lowest returns in terms of reducing food insecurity and poverty. The result indicates that Botswana, Burkina Faso, Ethiopia, Kenya, Malawi, Mali, Mozambique, Rwanda, Seychelles, and Sierra Leone are the top 10 African countries where such an investment is expected to yield the highest returns. Cameroon, Congo, Egypt, Equatorial Guinea, Eritrea, Gabon, Gambia, Libya, Mauritania, and Somalia are the bottom 10 countries where such investment is expected to yield the lowest return.

Keywords: Granger causality, Agricultural growth, Economic growth, Investment return, Africa

1 Introduction

Africa has witnessed rapid and persistent growth since the turn of the 21st century (Wiggins, 2014). This economic growth is considered to be related to a host of factors, including agricultural growth, improvement in the rule of law and control of corruption, increases in foreign direct investment, government commitment to invest in the agriculture and food sectors, improvement in soft and hard infrastructure, higher prices for natural resources, and development assistance. In the 2014 Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods, the African leaders uncovered the central role of agricultural growth in enhancing the observed rapid growth performance. They also recognized the central importance of agriculture in producing the broad-based growth needed to reduce poverty and hunger (ReSAKSS, 2014). A strand of empirical studies such as Timmer (2009), Tiffin and Irz (2006), Diao et al. (2010), Gollin (2010) and Los and Gardebroek (2015) unveils a causal relationship running from agriculture to economic growth. According to these studies, increases in agricultural productivity are a prerequisite for overall economic growth and account for the lion's share of employment and overall gross domestic product (GDP) in Africa. In addition, agriculture is capable of producing surplus food and labor, which boosts the productivity and profitability of the non-agricultural sector.

In many African countries, the agricultural sector plays vital roles in the lives of the inhabitants, with such roles ranging from enhancing food security, creating employment and generating foreign exchange, supplying raw materials for industry, contributing to poverty reduction, and providing a buffer during shocks, to supporting environmental sustainability, among others. In addition to these traditional roles, the agriculture sector, through its contribution to food production and exports, does influence (and is influenced by) both domestic and international markets through forward (product market) and backward (factor market) linkages (Boansi, 2014). These spillover effects from the agriculture sector to the non-agriculture one will result in high overall productivity and growth.

However, the opponents of this argument claim that the agriculture sector in Africa is at its subsistence level and fails to trigger a positive spillover to the non-agriculture sector. According to these studies, the non-agriculture sector plays a key role in boosting agricultural productivity and the overall economy through its forward and backward linkage (Hwa, 1988; Matsuyama, 1992; Zortuk and Karacan, 2016). For example, the industry sector supplies important agricultural inputs, new technology, electricity, more irrigation, and better infrastructure that links it to lucrative regional food markets (World Economic Forum, 2016). Hence, the causal link and the direction of the relationship between agricultural growth and overall economic growth is complicated. Panel econometric evidence regarding the causal link and the direction of relationship between agricultural growth, the food sector, and quality of governance is limited in Africa.

Various empirical studies also have uncovered the role of political commitment and the quality of governance in sustainable development and agricultural growth as well as in harnessing food and nutrition security (Pelletier et al., 2012; Fox et al., 2015).

However, most of these studies, which sought to study the causal link between agriculture, government commitment, food and nutrition security, and overall economic growth, primarily use either time series data or cross-sectional data. Only a few studies attempted to investigate the causal link and direction of the relationship between overall economic growth and agricultural growth using rich panel data. The empirical evidence on reverse causality from overall economic growth to agricultural growth, especially, is limited (Tiffin and Irz, 2006). This study assesses the causal relation between agricultural growth, food production, quality of governance, and overall economic growth using panel data compiled from 44 African countries for a 53-year period from 1961 to 2014. As the strength and direction of the relationship between overall economic growth and agricultural growth might differ across countries, this study also conducts a time series cointegration analysis for each of the African countries.

Based on the finding from the panel cointegration analysis and other related strands of studies, we identify key variables that determine investment return in Africa, where the return is measured in terms of its impact on agricultural growth, food and nutrition security, and governance quality. Consequently, the study identifies the 10 African countries where investment in the agriculture and food sectors is expected to have the highest return and the 10 African countries expected to have the lowest.

The remaining part of the paper is organized as follows. Section 2 briefly identifies the data sources, the general research methodology, and the estimation results and discussions on the causal link and direction of the relationships between agricultural growth, food production, governance, and overall economic growth. Section 3 outlines an overview of the agricultural growth and overall growth performance of African countries. Section 4 details the expected return from investing in the Africa agriculture and food sectors, where the investment return is measured in terms of its impact on reducing poverty and food insecurity. The study concludes in Section 5.

2 The causal link and the direction of the relationship between agricultural growth and overall economic growth

As indicated above, evidence of the causal link and the direction of the relationship between agriculture and overall economic growth is thin and mixed. On the one hand, there is a strand of the literature that asserts causality runs from agriculture to overall economic growth and emphasizes the strong positive spillover effect of the agriculture sector. That is, as agricultural productivity increases over time, it frees labor and raw material to the industry sector and produces surplus food for the urban population and export goods for the international market. Additionally, it creates a demand for non-agricultural goods and services. For example, Johnston and Mellor (1961) identify five major channels through which agriculture growth triggers economic growth. These linkages include the;

- (i) Supply of surplus labor to firms in the industrial sector
- (ii) Supply of food for domestic consumption
- (iii) Provision of markets for industrial output
- (iv) Supply of domestic savings for industrial investment
- (v) Supply of foreign exchange from agricultural export earnings to finance the import of intermediate and capital goods.

In addition, Timmer (1995) discusses the indirect channel through which agriculture affects overall economic growth in addition to the five direct channels. That is, agriculture indirectly contributes to economic growth via its provision of a better caloric nutrient intake to the productive labor force. Federico (2005) also discusses three essential roles that agriculture plays in the process of economic growth – the product role, the factor role, and the market role. This strand of the literature is rooted in the dual economy model of Lewis (1954) and employs the extended and modified version of this structural change model to explain the causal link between agricultural growth and economic growth in developing countries. The economic structures of developing countries are mostly characterized by dual economies that comprise subsistence traditional agriculture and a modern urban sector (Schultz, 1953; Lewis, 1954; Jorgenson, 1961). This strand of studies that supports agriculture-led growth asserts that investment in the agriculture and food sectors in developing countries is key to harnessing economic growth (Timmer, 1995). It also asserts that growth in the agricultural sector is a catalyst for national income growth and poverty reduction through its effect on rural incomes and provision of resources for transformation into an industrialized economy (Eicher and Staatz, 1984; Dowrick and Gemmell, 1991; Datt and Ravallion, 1998; Thirtle et al., 2003).

On the other hand, another strand of studies, such as Hwa (1988), Matsuyama (1992), Zortuk and Karacan (2016), asserts that causality runs from overall economic growth to agricultural growth. In a theoretical analysis, Matsuyama (1992) used the comparative advantage argument to refute the claim that agricultural productivity is an engine of overall economic growth. He asserted that the agricultural sector is a sector with relatively low productivity, and, therefore, investing in the agriculture and food sectors may not stimulate productivity improvement and growth in other sectors and, hence, cannot be the driver of overall economic growth. Rather, it is overall economic growth and the non-agricultural sector that enables expansion of soft and hard infrastructures, agricultural innovation, and innovation on information and communication technology that enhances the market access of farmers and their productivity. This strand of studies claims that the non-agriculture sector plays a key role in increasing agricultural productivity. According to this, the forward linkages that run between the non-agriculture sector and the agriculture one are much stronger than the backward ones. According to these studies, particularly in Africa where the agricultural sector has been dominated by smallholder farmers and is highly dependent on the vagaries of nature, the agricultural sector neither creates surplus food for the urban population and export market, nor enables it to feed the rural population. Consequently, agriculture in Africa has failed to trigger the expected positive spillover effects to the non-agricultural sector. Rather, the industry sector supplies important agricultural raw materials and capital goods, modern technology, modern sources of energy such as electricity, more irrigation, and better infrastructure for the agriculture and rural sectors (World Economic Forum, 2016; Brookings Institution, 2016).

Other studies, such as Tiffin and Irz (2006), find a two-way causal relationship between agricultural growth and overall economic growth. They used bivariate Granger causality tests to examine the causal relationships between agricultural growth and overall economic growth for a panel of countries and found strong evidence in support of two-way causality from agriculture to economic growth for developing countries (Tiffin and Irz, 2006). However, their bivariate causality tests have been severely criticized by contemporary scholars for omitting all other potential variables that could stimulate agricultural and overall growth simultaneously (Estudillo and Otsuka, 1999; Gardner, 2003; Awokuse, 2008, 2009; Los and Gardebroek, 2015).

In the literature, quality of governance, political commitment to invest in the agriculture and food sectors, openness to international trade (see Edwards, 1993; Caporale and Pittis, 1997; Awokuse, 2008), natural resources abundance (Dercon, 2009), and institutional and political commitment (Acemoglu and Robinson, 2008; Fox et al., 2015) are frequently cited as the determinants of agricultural and overall economic growth. This study, therefore, controls for the effect of these relevant variables in testing the causal link and the direction of the relationship between agricultural growth and overall economic growth.

2.1 Econometric modeling and estimation

This study follows a 'let the data speaks for themselves- vector auto regressive (VAR)' approach instead of estimating model-based parameters. However, it makes extensive use of empirical and theoretical literatures to dictate relevant determinants of agricultural and overall economic growth variables in specifying the reduced version of the VAR model. The VAR approach minimizes the possibility of misleading inferences that will arise from incorrect model specifications. It also solves the endogeneity problem of single equation dynamic modeling. However, given the possible measurement error in the approximations of variables and other related problems in the model specification and estimation technique, the result of the test must be interpreted with greater care. In line with the theoretical and empirical studies, we estimate the reduced vector error correction model (VECM) specified below:

$$\Delta GDP_{it} = \alpha_{1i} + \sum_{n=1}^{P} \beta_{1\mathrm{in}} \Delta GDP_{it-\mathrm{n}} + \sum_{n=1}^{P} \varphi_{1\mathrm{in}} \Delta FOOD\_PRODUC_{it-\mathrm{n}} + \sum_{n=1}^{P} \vartheta_{1in} \Delta AGOUT\_GROWTH_{it-\mathrm{n}} + \sum_{n=1}^{P} \tau_{1in} \Delta AGTECH_{it-\mathrm{n}} + \sum_{n=1}^{P} \rho_{1in} MALNUT_{it-\mathrm{n}} + \mu_{it} \quad (1)$$

$$\Delta AGPROD_{\mathrm{it}} = \alpha_{2} + \sum_{n=1}^{P} \beta_{1\mathrm{in}} \Delta AGPROD_{it-\mathrm{n}} + \sum_{n=1}^{P} \varphi_{2\mathrm{in}} \Delta GDP_{it-\mathrm{n}} + \sum_{n=1}^{P} \vartheta_{2in} \Delta AGLAND_{it-\mathrm{n}} + \sum_{n=1}^{P} \tau_{2in} \Delta AGTECH_{it-\mathrm{n}} + \mu_{it} \quad (2)$$

$$\mathrm{F}OOD_{PRODUCE\,\mathrm{it}} = \alpha_{3\mathrm{i}} + \sum_{n=1}^{P} \beta_{3\mathrm{in}\Delta FOOD\_PRODUC_{it-1}} + \sum_{n=1}^{P} \beta_{3\mathrm{in}} \Delta GDP_{it-\mathrm{n}} + \sum_{n=1}^{P} \vartheta_{3in} \Delta AGLAND_{it-\mathrm{n}} + \sum_{n=1}^{P} \tau_{3in} \Delta AGTECH_{it-\mathrm{n}} + \mu_{it} \quad (3)$$

Where Δ refers to the first difference of the variable, ΔGDP_{it}refers to the overall economic growth at time t for country i, and $\Delta FOOD\_PRODUC_{it-1}$, $\Delta AGPRODUC_{it-1}$,$\Delta OPENESS_{it-1}$, $\Delta POLCOM_{it-1}$, $\Delta AGTECH_{it-1}$ $\Delta INSCOM_{\boldsymbol{t-1}}$, $\Delta NATUR_{\boldsymbol{t-1}}$, $MALNUT_{it-1}$ $EDU\_EXP_{it-1_{it}}$, $HEALTH\_EXP_{it-1}$, $FOODimport_{it-1}$ are lagged values of the first difference of food production, agricultural productivity, openness, political commitment, agricultural technology stock, institutional commitment, natural capital, malnutrition, educational expenditure, health expenditure, agricultural land, ration of food import to GDP ratio, respectively, and $\varepsilon_{\mathrm{it}}$ is an idiosyncratic error term.

2.2 Data

To make the estimation of the above equations operational, we compiled secondary data from various sources for 44 countries for the 53-year period from 1961 to 2014. Data on total factor productivity (TFP) and share of employment in agriculture were obtained from the United States Department of Agriculture database (USDA, 2016). We also extracted TFP data from the Fuglie and et al. (2013) report. They measured TFP as the ratio of total agricultural output to inputs used. Where agricultural output is measured as the total gross output of crops and livestock of the nation and agricultural inputs is measured as the weighted average of labor, land, livestock, capital, machinery power, and synthetic nitrogen/phosphorus/potassium fertilizers. For the political commitment variables, we used data from Fox et al. (2015). We also obtained food production, undernourishment, and global hunger index data from the Food and Agriculture Organization data base, the Regional Strategic Analysis and Knowledge Support System (ReSAKSS) website, and the Fuglie (2012) report. To measure an African government's commitment to invest in the agriculture and food sectors, we used the institutional support and commitment (*INSCOM*) index following Fox et al. (2015) and budgetary commitment (*BUDCOM*), which is measured as the share of government spending on agriculture. To measure the quality of governance, the World Bank data base comprises six governance indicators – control of corruption, government effectiveness, political stability, regulatory quality, rule of law, and voice and accountability. However, except for control of corruption the other indicators are available only for the short period 1996 to 2014. Accordingly, even if all six indicators are used in the expected investment return calculation, only the control of corruption index is used for the econometric analysis part of the study.

The data for many of the remaining variables that we used for our empirical analysis were also obtained from the World Bank database[1]. To measure openness, we followed the Los and Gardebroek (2015) approach. Accordingly, we use two measures of openness. The first is the share of food and beverage imports (*IMPORT_FOODBEV)* as a percentage of the total economy measured at purchasing power parity (Feenstra et al., 2013). The second is an index of the share of the sum of imports and exports to GDP. Agricultural innovation is customarily measured in terms of research and development expenditure in the agriculture sector. However, such data is available only for shorter periods. Consequently, we used the number of wheel and crawler tractors (excluding garden tractors) in use in agriculture per 100 km^2 of arable land as a proxy for agricultural innovation performance/stock of technology (*AGTECH*) of each country. This data was obtained from World Bank data base. We also obtained the rainfed crop land equivalent of agricultural land (*AGLAND*)) from World Bank database (WB, 2015, where rainfed cropland has a weight of 1, while irrigated cropland has a higher weight (between 1 and 3, depending on the fertility of the region), and permanent pasture has a lower weight (varying between 0.02 and 0.09, again depending on the region) (see Los and Gardebroek, 2015).

Natural resources abundance as a share of GDP *(NATURGDP)* is used to measure the total per capita earnings of the natural capital of a country. It is the sum of values of all crop and pasture land, timber and non-timber forest, protected areas, oil, natural gas, coal, and minerals (see Los and Gardebroek, 2015). To measure social infrastructural development, we used the expenditure share of GDP in health (*HEALTH_GDP*) and education (*EDU_GDP*) infrastructure development.

We measured food production (*FOOD_PRODUC*) in terms of the real value of all the food crops produced in the country that are considered edible and contain nutrients. The real agricultural output growth rate (*AGOUT_GROWTH*) is derived from USDA (2016) data base. The 1961 price is used to compute real values. The data is also obtained from the World Bank database (2014).

Malnutrition *(MALNUT)* is usually measured in terms of under-five mortality rates. However, because much of the required data is missing for various countries, we use the mortality rate

[1] http://data.worldbank.org/indicator

as a proxy for under nutrition. Data for undernourishment and the hunger index are also available only for the short span of the study period. As a result, these variables were dropped from the econometric estimation technique.

In this study, getting time series data for some important variables for some African countries posed challenges. For example, time series data for important determinants of overall economic growth and agricultural growth, such as institutional quality, agricultural trade restrictions, public and private investment in the agriculture and non-agriculture sectors, and sector disaggregated labor data, are not available. This clearly meant that our empirical analysis suffered from omitted variable bias problems and, hence, the findings of this study should be interpreted with a greater care, though an attempt has been made to attenuate endogeneity bias by using an appropriate analytical tool.

2.3 Panel unit root test

Since estimates based on stationary and non-stationary data have very different limiting distributions (Johansen, 1988), we will investigate in this subsection the time series properties of the right and left hand side variables of equations (1) to (3). We specifically conduct a panel unit root test to capture the time series and cross-sectional dimension of our panel data to increase the power of the test. The panel unit root test is critical for panel data regression analysis when stationarity is violated by the presence of a unit root with in each individual time series. One advantage of a panel unit root test over the standard unit root test is that the panel data unit root test statistics are asymptotically normally distributed (Hadri, 2000; Baltagi and Kao, 2000; Hall and Mairesse, 2002). According to the literature, two groups of panel unit root tests exist depending on whether they test for the null of the unit root or the null of stationarity[2]. In this study, we employed the Im-Pesaran-Shin(IPS) panel unit root test (Im et al., 2003), which tests for the null of the unit root instead of stationarity. The advantage of the IPS test is that it a better fit for an unbalanced panel and tests for the presence of unit roots in panels that combine information from the time series dimension with that from the cross-sectional dimension. Fewer time observations are required for the test to have power. The IPS test is an extension of the augmented Dickey-Fuller (ADF) test where the standard augmented Dickey-Fuller (ADF) regressions are augmented with the cross-section averages of lagged levels and first-differences of the individual series.

$$\Delta y_{it} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \qquad (4)$$

where i = 1,…, N and t = 1,…, T

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[2] In the first group we have the studies by Levin and Lin (1992), Im (2003, previously 1997), Maddala and Wu (1999), and Choi (2001); and in the second group we have Hadri (2000).

The IPS test uses separate unit root tests for the N cross-sectional units. The test is based on the ADF statistics averaged across groups. After estimating the separate ADF regressions, the average of the t-statistics for p_1 from the individual ADF regressions, $t_{iT_i}(p_i)$: . Hence the IPS test is the t-ratio of p_1 in the regression of $\Delta y_i = (\Delta y_{i1}, \Delta y_{i2}, \ldots, \Delta y_{iT})'$ on $\tau T = (1, 1, \ldots, 1)'$ and $y_{i,-1} = (y_{i0}, y_{i1}, \ldots, y_{i,T-1})'$ as specified below:

$$\bar{t}_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{iT}(p_i\beta_i) \qquad (5)$$

Where the $\bar{t}$ is the standardized t-statistic that converges to the standard normal distribution as N and $T \rightarrow \infty$.

Table 1a: Im-Pesaran-Shin(IPS) unit root test results

Variable	Level	First order difference
GDP_PER CAPITAGROWTH	-22.0006*	-31.3106*
IMPORT_FOOD&BEVE	-2.1393*	-19.7057*
OPENESS	-7.9581*	-28.3283*
INSCOM	0.000	0.000
POLCOM	-2.1132**	-9.8582*
FOOD_PRODUC	-1.6752	-21.1805*
AGOUT_GROWTH	-1.4393	-2.4091*
TFP	-29.0797*	-38.4420*
AGLAND	-0.4261	-25.3687*
MALNUT	-0.2735	-25.9916*
NATUR_GDP	-13.6229*	-31.5380*
AGTECH	-0.4587	-13.89*
EDUCATION_EXP	-25.9101*	-37.7648*
HEALTH_EXP	-21.8640*	-36.4536*

Note: *, ** indicate rejection of the null hypothesis of a unit root at the 1% and 5%, levels of significance; '-' the variable is time invariant.

The IPS tests for unit roots is conducted for the level and first difference of the variables stated in equations (1) to (3). The test results are reported in Table 1a. As it can be inferred from the table, the IPS panel unit root test rejects the null of a unit root for GDP growth, GDP share of food imports, openness, political commitment, TFP level, natural capital, and education and health expenditures. However, the IPS test does not reject the null of a unit root for food production, agricultural growth, agricultural land, malnutrition, and agricultural technology.

However, it should be pointed out that panel data models are likely to exhibit substantial cross-sectional dependence in the errors, which may arise because of the presence of common shocks and unobserved components that ultimately become part of the error term, spatial dependence, and idiosyncratic pairwise dependence in the disturbances with no particular pattern of common components or spatial dependence (Pesaran, 2007). Pesaran (2004) proposed a cross-sectional dependence (CD) test for possible CD among panels. The issue of cross-sectional dependency between individuals may be partially impeded in the IPS test if the time fixed effects are included in the ADF specification (Pesaran, 2007). Table 1b presents a test of the CD of our main variables of interest using the Pesaran and Friedman cross-sectional dependency test statistics.

Table 1b: Cross sectional dependency test statistics (xtcsd)

Variables	xtcsd-Pesaran		xtcsd-Friedman	
	Statistic	P-value	Statistic	P-value
GDP_PER CAPITAGROWTH	-0.058	0.935	60.685	0.03
AGOUT_GROWTH	8.551	0.000	131.034	0.000
TFP	-6.034	6.519	6.519	0.000

The results of both tests, which we applied (except for GDP per capita which has CD in one test only), clearly indicates the presence of strong cross-sectional dependency. This entails the need to conduct panel unit root tests accounting for cross-sectional dependency. Table 1c presents the Pesaran (2007) panel unit root test based on the cross-sectional ADF regression (CADF) model, which adds the lagged cross-sectional means of individuals' values.

Table 1c: Cross sectional Augmented Im-Pesaran-Shin (CIPS) unit root test

Variables	CIPS
GDP_PER CAPITAGROWTH	-5.746
IMPORT_FOOD&BEVE	-2.07**
OPENESS	-3.436
INSCOM	0.000
POLCOM	-1.984*
FOOD_PRODUC	-2.647*
AGOUT_GROWTH	-1.277*
TFP	-6.034
AGLAND	-1.995*
MALNUT	-2.201**
NATUR_GDP	-3.942
AGTECH	-0.828*
EDUCATION_EXP	-5.537*
HEALTH_EXP	-5.128*

As shown in Table 1c, similar to the panel unit root test results reported in Table 1a, our test for a unit root for these variables shows that, except for institutional commitment, all the variables are non-stationary in level. Estimating equations (1) to (3) by a standard regression model might, therefore, lead to the problem of spurious regression unless we find a cointegration vector that renders a linear combination of the variables that is stationary. To take care of the non-stationarity of the variables and confirm whether there exist long run equilibrium relationships among these non-stationary variables, we conducted a panel cointegration test and the result is reported and discussed in the next subsection.

2.4 Panel cointegration test

Like the time series cointegration tests, we have single equation based tests (Kao, 1999; Pedroni,1997 1999; McCoskey and Kao, 1998); and we have multi-equation based tests (Larsson et al., 2001; Groen and Kleibergen, 2001). In the present case, the Pedroni cointegration tests (Pedroni, 1999; 2004) are used to test whether the equation (1) variables are cointegrated. Unlike the Kao test, Pedroni's test of cointegration relaxes the assumption of homogeneous cointegrating vectors among individual members of the panel. Moreover, the test allows multiple regressors. The method utilizes residuals from the following regression equation:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \ldots + \beta_{Mi} x_{Mi,t} + e_{i,t} \tag{6}$$

for t = 1,…,T; i = 1,…,N; m = 1,…, M,

where T is the number of observations over time, N the number of cross-sectional units in the panel, and M the number of regressors. The heterogeneities are introduced as individual specific intercepts (α_i), individual specific time trends (δ_{it}), and member-specific slope coefficients. Based on equation (6), Pedroni developed seven different statistics for testing the null of no cointegration. Four of these statistics, which are termed as panel cointegration statistics, are based on pooling along the within dimension.

Table 2a: The Pedroni panel cointegration test results

Test statistics	Equation 1 (GDP)		Equation 2 (*AGPRODUC*)		Equation 3 (*AGOUT_GROWTH*)	
	Panel	Group	Panel	Group	Panel	Group
V	5.11*		3.162*		8.79*	
RHO	-17.49	-16.96*	-1.334***	-3.218*	-29.45*	-29.77*
T	-32.74*	-38.71*	-0.8564**	-2.113*	-36.05*	-44.54*
ADF	-24.32*	-27.57*	-3.357*	-5.994*	-30.21*	-33.98*
N	2141					

Note: *,*** show levels of significant at 1% and 10%, respectively, and rejection of the null that there is no cointegration.

The four panel cointegration statistics – the panel V, RHO, T, and ADF statistics – are reported in Table 2a. As shown by the four panel cointegration test statistics, the null hypothesis of no cointegrating relationship is rejected. However, the hypothesis that there is one cointegrating relationship could not be rejected and hence we have one cointegrating relationship among the variables and we maintained an alternative hypothesis that there is at least one cointegrating relationship. Most of the panel and group ADF statistics are significant at the P = 0.01 level, suggesting the existence of a long run relationship between economic growth, agricultural growth, the various governance and political commitment indicators, and other cointegrated variables.

However, the Pedroni panel cointegration test does not take in to account non-linearity of our main variable of interest. To account for non-linearity, structural breaks, and cross-sectional dependencies, we also run a Westerlund cointegration test (Westerlund et al., 2006). The results of the test are reported in Table 2b for the three primary variables of interest in equations (1) to (3). As shown in Table 2b, the various panel cointegration statistics again suggest that agricultural TFP, agricultural growth, and overall economic growth have a statistically significant long term causal relationship.

Table 2b: Westerlund cointegration test results

Test statistics	GDP per capita growth		Agricultural growth		TFP	
	Statistics	P-value	Statistics	P-value	Statistics	P-value
Gt	-4.907	0.00	-4.526	0.00	-4.942	0.00
Ga	-30.033	0.00	-15.535	0.00	-38.725	0.00
Pt	-29.216	0.00	-32.884	0.00	-32.712	0.00
Pa	-23.535	0.00	-15.706	0.00	-39.693	0.00

2.5 Granger causality tests

In this study Granger causality tests were performed based on equations (1) to (3) to formally examine the dynamic relationship between agricultural growth, food production, overall economic growth, governance, and other cointegrated variables. The three equations are estimated to test if the overall economic growth at time t is related to past agricultural growth and conditional on past overall economic growth, for each individual country. Conversely, agricultural growth and food production are the dependent variables to evaluate the null hypothesis that overall economic growth does not Granger cause agricultural growth. Similar tests are performed to examine causal links between economic growth and food production and other cointegrated variables. The Granger causality test results based on panel data from the 44 African countries are reported in Table 3. A time series cointegration and Granger causality test is also conducted for each country under investigation. The Granger causality test results for each individual country are reported in Annex 1.

The chi square (χ^2) test statistics associated with the null of no Granger causality are significant in most of the VAR models. This suggests that agricultural growth, government commitment – measured in terms of spending on research and development – Institutional commitment, quality of governance – measured in terms of control of corruption – and improvement in food and nutrition security Granger causes overall economic growth and vice versa.

Table 3: Granger causality test results

Null hypothesis	Chi-square statistics	Probability	Direction of relationship
Agricultural productivity growth does not Granger cause overall economic growth	4.252	0.039 **	One way
Overall economic growth does not Granger cause agricultural productivity	2.001	0.157	
Agricultural innovation does not Granger cause agricultural growth	1.905	0.167	One way
Agricultural growth does not Granger cause agricultural innovation	11.047	0.001*	
Trade openness does not Granger cause agricultural productivity	4.586	0.032**	Two way
Agricultural productivity does not Granger cause trade openness	3.344	0.067***	
Political commitment does not Granger cause food security	0.812	0.367	One way
Food production does not Granger cause political commitment	14.738	0.000*	
Political commitment does not Granger cause overall economic growth	2.822	0.093***	Two way
Overall economic growth does not Granger cause political commitment	3.150	0.076***	
Agricultural land expansion does not Granger cause agricultural productivity	9.398	0.002*	One way
Agricultural productivity does not Granger cause agricultural land expansion	0.095	0.758	
Trade openness does not Granger cause overall economic growth	7.053	0.008*	One way
Overall economic growth does not Granger cause trade openness	0.017	0.895*	
Government commitment to spend on agricultural R&D does not Granger cause agricultural output growth	14.436	0.000	Two way causality
Agricultural output growth does not Granger cause government commitment to spend on agricultural R&D	12.085	0.001*	
Government commitment to spend on agricultural R&D does not Granger cause agricultural productivity	6.331	0.012*	One way
Agricultural productivity does not Granger cause government commitment to spend on agricultural R&D	0.022	0.883	

Note: *,*** shows levels of significance at 5 and 0. 1% levels of significance, respectively, and rejection of the null that there is no Granger causality.

2.6 Fully modified ordinary least squares estimation result

To check the robustness of our findings, we estimated the nexus among overall growth, governance, and agriculture and food sectors by a panel group fully modified ordinary least squares (FMOLS) estimator. As widely stated in the econometric literature, the panel group FMOLS is believed to provide asymptotically efficient and consistent estimates in panel series.

It also helps to address non-exogeneity and serial correlation problems (Ramirez, 2006; Los and Gardebroek, 2015; Pedroni, 2001; Baltagi and Kao, 2000). The estimation results from the FMOLS estimation results is reported in Table 4. The result is qualitatively like the panel Granger causality test results.

Table 4: Panel group FMOLS regression results (1961-2014)

GDP_PERCAP	Coef.	Std. Err.	P>|z|
FOOD_PRODUC	0.0078303	0.0040312	0.052
AGOUT_GROWTH	17.23873	5.204656	0.001
MALNUT	0.0040042	0.00177797	0.024
AGTECH	-0.1346934	0.0019186	0.090
CONS	0.2702339	0.4477048	0.546

Note: * that we exclude time invariant variables, like *INSCOM*, because of high convergence problems and the inability to have a positive definite matrix when including the variable.

3 Overview of the agricultural and overall growth performance of African countries

3.1 Sustained growth performance

Africa's economic history since the 1960s is characterized by wide fluctuations. The continent has experienced two periods of growth – one between 1961 and 1975 and a second from 1995 to the present – with stagnation in between. Still, some countries experienced sustained economic growth, with growth rates often exceeding 5% per year. Interestingly the analysis of the time series data revealed a co-movement between economic growth and agricultural growth. To see the correlation between sustained economic growth and sustained agricultural growth, we categorized the African countries as high growth, medium growth, and low growth performing countries using both the average overall economic growth (real per capita growth) rate and the agricultural growth rate over the period 1960 to 2014. The results are reported in Table 5. Looking back to the years of sustained growth, there seems to be an overlap between countries that experienced high sustained overall economic growth and high sustained agricultural growth. This again suggests a strong association between overall economic growth and agricultural growth.

Table 5: Sustained growth performance (1960 to 2014)

Sustained economic growth (1960 to 2014)			Sustained agricultural growth (1960 to 2014)		
High growth performing countries	Medium growth performing countries	Low growth performing countries	High growth performing countries	Medium growth performing countries	Low growth performing countries
Congo, DR	Benin	Burkina Faso	Botswana	Comoros	Benin
Côte d'Ivoire	Botswana	Burundi	Burundi	Congo, DR	Burkina Faso
Ethiopia	Comoros	Congo, Rep.	Equ. Guinea	Congo, Rep.	Côte d'Ivoire
Gambia, The	Egypt, A. R.	Equ. Guinea	Ethiopia	Gabon	Egypt, A. R.
Ghana	Gabon	Guinea-Bissau	Gambia, The	Guinea	Ghana
Lesotho	Guinea	Libya	Lesotho	Mauritania	Guinea-Bissau
Morocco	Kenya	Madagascar	Liberia	Somalia	Kenya
Mozambique	Liberia	Mali	Madagascar	South Africa	Libya
Namibia	Malawi	Mauritius	Mauritius	Tanzania	Malawi
South Africa	Mauritania	Niger	Namibia	Togo	Mali
Swaziland	Rwanda	Nigeria	Senegal	Uganda	Morocco
Zambia	Senegal	Sierra Leone	Seychelles		Mozambique
Zimbabwe	Seychelles	Somalia	Sierra Leone		Niger
	Togo	Sudan	Zimbabwe		Nigeria
	Tunisia	Tanzania			Rwanda
	Uganda				

Note: Countries are categorized in to three quantiles based on both the average economic and agricultural growth over the period 1960 to 2014.

3.2 Recent growth performance

Since 2000, Africa has been experiencing a remarkable economic growth, where real GDP growth has risen by more than twice its pace in the last decade. During the same period the growth and productivity of the agricultural sector also show a remarkable growth for some African countries. To illustrate if the countries that experienced a high agricultural growth trajectory also experienced a high overall economic growth trajectory over the last decade, we also categorized African counties in to three categories based on their recent agricultural and economic growth performance. Based on the three quantile distributions of average real per capita growth and agricultural growth over the period 2005 to 2014, we categorized countries again as high, medium and low growing countries. As shown in Table 6 countries who have experienced a high agricultural growth trajectory over the last decade also experienced high or medium overall growth trajectories. This again suggests that agricultural growth triggers overall economic growth in Africa.

Table 6: Recent growth performance (2005-2014)

Recent overall growth (2005-2014)			Recent agricultural growth (2005-2014)		
High growth performing countries	Medium growth performing countries	Low growth performing countries	High growth performing countries	Medium growth performing countries	Low growth performing countries
Burundi	Benin	Burkina Faso	Burundi	Burkina Faso	Benin
Congo, Rep.	Botswana	Congo, DR	Egypt, Arab Rep.	Comoros	Botswana
Ethiopia	Comoros	Côte d'Ivoire	Ethiopia	Congo, Rep.	Congo, DR
Ghana	Egypt, Arab Rep.	Equatorial Guinea	Gambia, The	Côte d'Ivoire	Guinea-Bissau
Lesotho	Gabon	Gambia, The	Ghana	Equatorial Guinea	Kenya
Liberia	Kenya	Guinea	Lesotho	Gabon	Madagascar
Mali	Malawi	Guinea-Bissau	Liberia	Guinea	Malawi
Mauritius	Mauritania	Libya	Libya	Mauritania	Mali
Morocco	Seychelles	Madagascar	Mauritius	Nigeria	Morocco
Mozambique	Sierra Leone	Guinea	Mozambique	Somalia	Niger
Namibia	South Africa	Guinea-Bissau	Namibia	South Africa	Senegal
Niger	Sudan	Libya	Rwanda	Swaziland	Sierra Leone
Nigeria	Swaziland	Madagascar	Seychelles	Togo	Sudan
Rwanda	Tanzania	Togo	Tanzania	Tunisia	
Senegal	Tunisia	Zambia	Uganda		
Somalia	Uganda		Zambia		
Zimbabwe			Zimbabwe		

4 Investment in the agriculture and food sectors in Africa

The findings from both the econometric analysis and the simple descriptive analysis in the previous sections suggest that agricultural growth is a key driver of overall economic growth. Thus, investment in the agricultural and food sector in Africa might be suggested in those African countries that have:

1) Significantly increased their agricultural growth and productivity
2) Show a strong government commitment to invest in the agricultural sector, in general, and in agricultural innovation, in particular
3) A good track record of good governance measured in terms of their commitment to control corruption and ensure political stability, improvement in the quality of public service, formulated and implemented sound policies and regulations that permit and promote private sector development, and boost agents' confidence in the rules of society.
4) They should prioritize actions that reduce hunger and malnutrition and show progress. They should also prioritize actions focused on agricultural and rural development and nutrition interventions that are likely to make a significant difference, as indicated by public policy and civil society actions.

In this section, the agricultural growth performance, government commitment to invest in agriculture and agricultural R&D, progress in terms of food and nutrition security improvement, and governance quality of African countries is assessed. The analysis builds and expands on an earlier assessment applying similar criteria presented in Husmann et al. (2015). Under these criteria, the overall returns from investing in the African agriculture and food sectors are estimated as a weighted average of expected agricultural growth, expected food and nutrition progress, political commitment, and governance quality. Based on the computed weighted investment performance score, we identify the 10 countries where investment in the agriculture and food sectors is expected to have the highest returns and the 10 countries where investment is expected to have the lowest returns in the post-Comprehensive Africa Agriculture Development Programme (CAADP) period. The investment returns, in terms of improving agricultural production and food security, agricultural innovation, and governance quality, is also computed for the pre-CAADP period (see Annex 2).

4.1 Expected agricultural growth performance

Table 7 reports the top and bottom 10 countries in terms of agricultural performance during the post-CAADP period. The TFP scores are computed based on the distribution of TFP improvement across the African countries following Husmann et al. (2015) approach. The 20th, 40th, 60th, and 80th percentiles serve as cut off points. Countries experiencing a percentage point change in TFP below the 20th percentile received a score of 0%. Those with a TFP point change greater than or equal to the 20th percentile and less than the 40th percentile were scored 25%. Those with a TFP point change greater than or equal to the 40th percentile and less than the 60th percentile were scored 50%. Those with a TFP point change greater than or equal to the 60th percentile and less than the 80th percentile were scored 75%. Those that experienced a percentage point change greater than or equal to the 80th percentile was given a score of 100%. The agricultural growth score is computed as a percentage over 10 years. The expected agricultural growth performance is measured as a weighted average of agricultural productivity and agricultural growth. The results are reported in Table 7 and are briefly described below.

- Mozambique, Mali, and Rwanda had significantly increased their agricultural growth by more than the annual 6% agricultural growth target defined by CAADP between 2005 and 2014[3] for seven, six, and six years respectively.
- Between 2001 and 2014, the three highest TFP improvements were recorded by Chad, Mozambique, and Zimbabwe indicating that these countries' commitments to research and development in the agricultural and food sectors are the highest.
- In terms of expected agricultural growth performance, the three top performing countries were Mozambique, Zimbabwe, and Chad, while the three lowest performing countries were Cameroon, Cape Verde, and South Africa.

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[3] www.resakss.org

Table 7: Expected agricultural growth performance[4]

Country	Percentage point change in TFP (2005-2013)		Number of years with better than 6% agricultural growth (2005-2014)		Expected agricultural growth
	Index	Score (%)	Index	Score (%)	
10 best performing countries					
Botswana	3	75	4	40	58
Burkina Faso	3	75	4	40	58
Chad	19	100	4	40	70
Congo	4	75	5	50	63
Ethiopia	0	50	7	70	60
Liberia	3	75	5	50	63
Mali	3	75	6	60	68
Mozambique	7	100	7	70	85
Seychelles	11	100	3	30	65
Zimbabwe	5	100	5	50	75
10 countries with the lowest performances					
Cameroon	-3	0	1	10	5
Cape Verde	-11	0	2	20	10
Egypt	-4	0	3	30	15
Gambia	-3	0	4	40	20
Guinea- Bissau	-4	0	4	40	20
Malawi	-3	0	5	50	25
Senegal	-3	0	5	50	25
South Africa	-6	0	3	30	15
Tanzania	-3	0	4	40	20
Zambia	-2	25	2	20	22.5

Source: Own Computation using data from the USDA (2016) data base and www.resakss.org

4.2 Government commitment

Table 8 reports the top 10 and bottom 10 countries in terms of their governments' commitments to spend in the agriculture and food sectors during the post-CAADP period. The average government commitment score is measured as a weighted average of the government spending on agriculture, agricultural share spend on R&D, and the number of CAADP steps or processes completed by each African country during the CAADP period. The public spending and R&D investment are computed based on the distributions of the two variables across the 53 countries under study. The score for public spending on agriculture is computed as a percentage over 10 years, while the CAADP steps completed score is calculated as the percentage of the eight steps completed. The score for the average share of agricultural

[4] Due to the paucity of data, Eritrea, Somalia, South Sudan and Central African Republic were dropped from this analysis.

GDP spent on R&D is computed as percentage of the African Union (AU) target value of 1% spent on R&D. The results are briefly described below.

- Between 2005 and 2014[5], the Malawian government showed a strong willingness to invest in the agricultural sector by surpassing the CAADP 10% agricultural expenditure target for nine years and the Ethiopian government has done so for eight years.
- Mali spent 4.5% of its agricultural GDP on agricultural research and development, Burundi spent 1.3%, and Togo, 1.2%. These amounts are much higher than the sub-Saharan Africa average[6] and the AU target value of 1%.
- Ethiopia has a track record of political commitment to foster sustainable agricultural growth by being active in the CAADP process and having completed all the eight steps in the CAADP process[7]. Malawi, Burkina Faso, and Mozambique also have track records of political commitment by being active in the CAADP process and having completed seven of the steps.
- In respect of overall government commitment, Malawi, Mali, and Ethiopia are the three best performing countries, while Egypt, Eritrea and Somalia are the three least well performing ones.

[5] www.resakss.org
[6] www.asti.cgiar.org
[7] www.resakss.org

Table 8: Government commitment

Country	Number of years with government expenditure on agriculture better than 10% (2005-2014)		Average share of agricultural GDP spent on R&D (2005 to 2014)		Number of steps in CAADP process completed		Average score
	Index	Score	Index	Score	Index	Score	
10 best performing countries							
Burkina Faso	4	40			7	88	64
Burundi	0	0	1.3	100	5	63	54
Ethiopia	8	80	0.4	40	8	100	73
Malawi	9	90	0.9	94	7	88	91
Mali	6	60	4.5	100	5	63	74
Mozambique	2	20			7	88	54
Niger	4	40			5	63	52
Rwanda	0	0	0.8	80	6	75	52
Togo	0	0	1.2	100	6	75	58
10 least well performing countries							
Cameroon	0	0	0.13	13	2	25	13
Egypt	0	0			0	0	0
Eritrea	0	0	0.1	10	0	0	3
Lesotho	0	0			1	13	7
Namibia	0	0	3	30	0	0	10
Sao Tome and Principe	0	0			2	25	13
Seychelles	0	0			1	13	7
Somalia	1	10			0	0	5
South Africa	0	0	0.26	26	0	0	9
Tunisia	0	0	0.4	40	0	0	13

Sources: own computation using data extracted from Fox et al. (2015*),* www.asti.cgiar.org and www.resakss.org

4.3 Food and nutrition security progress and need

Table 9 reports the top and bottom 10 countries in terms of prioritizing actions for hunger and malnutrition reduction, where agricultural and rural development and nutrition interventions are likely to make a significant difference. The average food and nutrition security score is computed as a weighted average of the global hunger index (GHI) and the reduction in undernourishment. The scores corresponding to GHI and the percentage point improvement in undernourishment are computed based on the distribution of the two variables across the studied countries. Zero, first, second, and third quantiles serve as cut of points. Countries that experienced a negative or non-zero value received a score of 0 while countries that experienced a percentage point change in the given variable below the first, second, and third quartile points were scored 25, 50, and 75, respectively. Those that had a value in the respective variable above the third quartile were scored 100. The results are briefly described below.

- Angola and Sierra Leone are prioritizing actions for hunger and malnutrition reduction and showed a significant improvement in undernourishment between 2004 and 2014, which is above the 10% threshold level[8]. Mozambique and Ethiopia are substantially reducing undernourishment also.
- Chad at 30, Ethiopia at 28, and Nigeria at 25, have the highest average GHI scores, reflecting an alarming level of hunger (von Grebmer et al., 2014)9. This makes investment in the agricultural and food sectors in these countries very urgent in order to reduce the high numbers of food insecure people.
- In terms of prioritized actions for hunger and malnutrition reduction and need, Ethiopia, Mozambique, Malawi, Sera Leone, Chad, and Angola performed best while Ghana, Benin, Mauritius, and Mauritania performed least well.

Table 9: Food and nutrition security progress and need[10]

	Average GHI score (2005-2014)		Reduction in undernourishment (2004-2014)		Average score
Country	Index	Score	Index (%)	Score	
10 best performing countries					
Angola	21	75	16.7	100	88
Burkina Faso	23	75	4.9	75	75
Chad	30	100	1.6	75	88
Ethiopia	28	100	9.1	100	100
Kenya	18	50	9.9	100	75
Malawi	16	50	5.9	100	75
Mozambique	21	75	9.2	100	88
Nigeria	25	75	2.8	75	75
Rwanda	16	50	8.7	100	75
Sierra Leone	23	75	13.6	100	88
10 countries performing least well					
Benin	13	25	-30	0	13
Egypt	5	25	0	25	25
Gabon	6.8	25	0	25	25
Ghana	9.6	25	-34	0	13
Lesotho	14	25	0	25	25
Libya	5	25	0	25	25
Mauritania	13	25	-31	0	13
Mauritius	5.5	25	-7	0	13
Morocco	19	50	-7	0	25
South Africa	5	25	0	25	25

Source: Own computation using data extracted from Fuglie and et al. (2013) and www.resakss.org

[8] www.resakss.org
[9] GHI score values less than 5.0 reflect low hunger; values from 5.0 to 9.9 reflect 'moderate' hunger; values from 10.0 to 19.9 indicate a 'serious' level of hunger; values from 20.0 to 29.9 are 'alarming'; and values of 30.0 or greater are 'extremely alarming'. (von Grebmer et al., 2014)
[10] Due to the paucity of data, Cape Verde, Congo DR and Equatorial Guinea were dropped from this analysis.

4.4 Governance quality

To evaluate the performance of the 53 African countries in terms of their governance quality, we constructed a governance quality index based on the principal component analysis of the six Kaufmann aggregate worldwide governance indicators (WGI). These composite indicators are based on many underlying variables mainly capturing survey respondents' governance perceptions and the self-evaluations of business entities and public and government organizations.

In our analysis, each of the six indicators are expressed in terms of percentile rank, which indicates the country's rank among all countries covered by the aggregate indicator. Zero corresponds to the lowest rank and 100 to highest. Percentile ranks have been adjusted by the World Bank Group to correct for changes over time in the composition of the countries covered by the WGI. The definition of the six indicators are:

Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests. Botswana, Cape Verde, and Mauritius are the three highest ranked African countries in terms of controlling corruption during the post-CAADP period, while Libya, Chad, Sudan, and Congo are the lowest ranked.

Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. As shown in Table 8, Mauritius, Botswana, and South Africa have the most effective governments while Somalia, Congo, South Sudan, and Libya have the least effective ones.

Political stability and absence of violence/terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism. The results indicated that Botswana, Mauritius, and Namibia are the three most political stable African countries, while Somalia, Sudan, and Congo are the three most politically unstable ones.,

Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. In terms of regulatory quality Mauritius, Botswana, and South Africa have the three highest ranks while Libya, Somalia, and Eritrea have the lowest.

Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and, in particular, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. In terms of the strength of the rule of law, again Mauritius, Botswana, and South Africa have the highest ranks, while Somalia, Congo, and Libya have the lowest.

Voice and accountability captures perceptions of the extent to which a country's citizens can participate in selecting their government, as well as their freedom of expression, freedom of association, and the existence of a free media. As shown in Table 10, in terms of voice and accountability again Mauritius, Botswana, and South Africa have the highest ranks while Somalia and Eritrea have the lowest.

Overall governance quality

A principal component analysis (PCA)[11] method is employed to construct an overall governance index. The PCA helps to identify the most relevant indicators that determine the quality of governance. The estimated PCA of the correlation matrices indicated that the first principal component alone, which is the uncorrelated linear combination of the six governance indicators with maximal variance, explained more than 80% of the overall variance and/or information contained in all of the WGI indicators. The second and third principal components explained just 7% and 5% of the overall variation in the data (see Annex 2.1). This suggests retaining only the first principal component as it accounts for more than 80% of the variation in the data. The screen plot of the Eigen values at the mean and 95% confidence intervals also suggests retaining the first principal component (see Annex 2.2) or the first and second principal components. As the cost of retaining more than two components outweighs the benefit, we keep only the first component in the present analysis.

As shown in the first panel of the PCA reported in Annex 2.1, the first component has positive loadings of roughly equal size on all the six governance indicators. The test of equal loading of the first principal component also yields $^{chi2}{}_{(5)} = 1.52$,Prob > ^{chi2} =0.9112. Hence, we cannot reject the null hypothesis of equal loadings. We also estimate the squared multiple correlation (SMS) of each of the six governance indicators on all the other indicators to identify governance indicators that cannot be explained well from the other variables. As shown in Annex 2.3, none of the SMCs are so small as to warrant exclusion. Accordingly, the principal component score based on the first principal component can be computed as a weighted average of the standard deviation of the six indicators, where the weights are given by the corresponding Eigen values. This can be algebraically expressed as:

> Principal component score = 0.4156*std(corruption) + 0.4319*std(government effectiveness) + 0.3801*std(Political stability) + 0.4242*std(regulatory quality) + 0.4049*std(rule of law) + 0.3904*std(voice and actability)

The estimated result yields a principal component score (governance quality index) that ranges from -3.4 to 5.5. We then define top performers in terms of governance quality as those whose principal component scores lie at the top 20% of the principal component score

[11] Principal component analysis (PCA) is commonly thought of as a statistical technique for reducing the number of variables in an analysis by describing a series of uncorrelated linear combinations of the variables that contain most of the variance.

distribution (are at the 80th percentile distributions) and the worst performers as those whose principal component scores lie in the bottom 20% of the principal component score distribution. Table 10 reports the 10 top and 10 bottom countries in terms of their governance quality. The result indicated that Botswana, Cape Verde, Ghana, Lesotho, Mauritius, Namibia, Senegal, Seychelles, South Africa, and Tunisia are the 10 highest ranked countries in terms of governance quality, while Chad, Congo, Equatorial Guinea, Eritrea, Guinea, Libya, Somalia, South Sudan, Sudan, and Zimbabwe are the 10 lowest ranked countries.

In the study, countries that experienced a principal component score below the 20th, 40th, 60th, and 80th percentiles received a governance quality performance score of 20%, 40%,60%, and 80%, respectively. Those that experienced a principal component score above the 80th percentile received a governance performance score of 100% in the computation of the overall investment performance score.

Table 10: Quality of governance, average percentile rank (2004 to 2014)

	Percentile rank						Governance quality index (PC score)
Country	Corruption control	Government effectiveness	Political stability	Regulatory quality	Rule of Law	Voice and accountability	
10 best performing countries							
Botswana	79	69	84	69	69	62	5.17
Cape Verde	76	57	73	51	14	73	3.37
Ghana	58	53	47	54	54	61	3.09
Lesotho	61	43	48	30	47	48	1.99
Mauritius	71	76	74	74	79	73	5.53
Namibia	66	53	74	50	55	53	3.49
Senegal	41	44	43	47	48	45	1.88
Seychelles	65	55	65	30	51	49	2.73
South Africa	60	67	46	64	58	66	3.83
Tunisia	47	60	37	49	54	27	2.03
10 worst performing countries							
Chad	5	5	9	14	4	10	-2.65
Congo, DR	5	2	3	7	2	9	-3.04
Equatorial	2	2	53	7	8	3	-2.22
Eritrea	35	7	21	1	9	1	-2.18
Guinea	11	10	8	13	5	16	-2.32
Libya	1	3	4	0	3	16	-3.08
Somalia	11	0	0	0	0	0	-3.40
South Sudan	5	3	6	5	4	10	-2.95
Sudan	5	7	2	7	8	5	-2.91
Zimbabwe	13	12	19	4	4	11	-2.37

Source: Own computation using data from the World Bank (2015) data base

4.5 Overall return from investing in the Africa agricultural and food sectors

Table 11 reports the 10 top and 10 bottom countries where investment in the agriculture and food sectors is expected to have the highest and lowest returns, respectively. The economic, political, social, and nutritional frameworks in Botswana, Burkina Faso, Ethiopia, Kenya, Malawi, Mali, Mozambique, Rwanda, Seychelles, and Sierra Leone strongly suggest accelerated investment in the agricultural and food sectors of these countries.

As can be seen in the lower half of Table 11, Cameroon, Congo, Egypt, Equatorial Guinea, Eritrea, Gabon, Gambia, Libya, Mauritania, and Somalia are the bottom 10 countries where investment in the agriculture and food sectors is expected to yield the lowest returns in terms of food insecurity and poverty reduction. The economic, political, social, and nutrition frameworks in these countries do not suggest that they prioritize investment in the agriculture and food sectors.

Table 11: Overall return on investing in the Africa food and agriculture sectors

Country	Expected agricultural growth	Food and nutrition security progress	Government commitment	Governance quality	Total weighted score
10 best performing countries					
Botswana	58	19	63	100	60
Burkina Faso	58	64	75	80	69
Ethiopia	60	73	100	40	68
Kenya	48	41	75	60	56
Malawi	25	91	75	80	68
Mali	68	74	25	80	62
Mozambique	85	54	88	80	77
Rwanda	55	52	75	80	65
Seychelles	65	7	63	100	59
Sierra Leone	30	50	88	60	57
10 worst performing countries					
Cameroon	5	13	63	60	35
Congo, DR	58	31	25	20	33
Egypt	15	0	25	60	25
Equatorial	25	21	25	20	23
Eritrea		3	63	20	29
Gabon	35	24	25	60	36
Gambia	20	23	25	60	32
Libya	55	30	25	20	32
Mauritania	28	19	13	60	30
Somalia		5	25	20	17

Source: Own Computation using data from various source

Note: No country is excluded from the overall return index as long as data is available or imputed to compute at least for three of the four major components of the investment return index. The overall return index is thus the weighted average, i.e. the average of four or three components.

5 Concluding remarks

The findings from the econometric and descriptive analysis indicate that agricultural growth, government commitment to the sector, progress in food and nutrition security and improvements in governance quality are the fundamental determinants of overall economic growth in Africa.

In line with these findings, investment into the agricultural and food sectors are suggested in those African countries that

(1) significantly increased their agricultural growth and productivity,

(2) show a strong government commitment to invest in the agricultural sector in general, and on agricultural innovation in particular,

(3) prioritize actions for hunger and malnutrition reduction and

(4) have a good track record of good governance measured in terms of their commitment to control corruption and ensure political stability, improve the quality of public service, and formulate and implement sound policies and regulations that permit and promote private sector development and boost agents' confidence in the rules of society.

Based on these criteria Botswana, Burkina Faso, Ethiopia, Kenya, Malawi, Mali, Mozambique, Rwanda, Seychelles, and Sierra Leone are the 'top 10' African countries where investment in the Africa agriculture and food sectors is expected to yield the highest returns. The economic, political, social, and nutrition framework in these 10 countries strongly suggests accelerated investment in the agricultural and food sectors of the countries.

In contrast, based on these four criteria, Cameroon, Congo, Egypt, Equatorial Guinea, Eritrea, Gabon, Gambia, Libya, Mauritania, and Somalia are the 10 countries where investment in the agriculture and food sectors is expected to have the lowest returns.

However, it should be noted that for some African countries data was not available for all the indicators included in the present analysis. This data noise problem might affect the weighted investment return scores and thereby the country ranking.

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Annexes

Annex 1: Country-specific Granger causality test results

Country	Null hypothesis	chi2 statistics	probability	direction of causality
Benin	AGPRODUC does not Granger cause GDP_GROWTH	0.069	0.793	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0	0.997	
	AGOUTPUT does not Granger cause GDP_GROWTH	1.576	0.209	One way
	GDP_GROWTH does not Granger cause AGOUTPUT	8.408	0.004*	
Botswana	AGPRODUC does not Granger cause GDP_GROWTH	0.488	0.485	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	2.075	0.15	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.074	0.785	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.001	0.981	
Burkina Faso	AGPRODUC does not Granger cause GDP_GROWTH	0	0.996	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	1.095	0.295	
	AGOUTPUT does not Granger cause GDP_GROWTH	5.564	0.018**	Two way causality
	GDP_GROWTH does not Granger cause AGOUTPUT	7.596	0.006*	
Burundi	AGPRODUC does not Granger cause GDP_GROWTH	0.045	0.832	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	1.744	0.187	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.049	0.826	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.365	0.546	

Country	Null hypothesis	chi2 statistics	probability	direction of causality
Comoros	AGPRODUC does not Granger cause GDP_GROWTH	6.085	0.014*	One way
	GDP_GROWTH does not Granger cause AGPRODUC	0.029	0.866	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.097	0.756	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.004	0.95	
Congo Dr	AGPRODUC does not Granger cause GDP_GROWTH	7.176	0.007*	One way
	GDP_GROWTH does not Granger cause AGPRODUC	0.635	0.425	
	AGOUTPUT does not Granger cause GDP_GROWTH	4.762	0.029**	One way
	GDP_GROWTH does not Granger cause AGOUTPUT	1.811	0.178	
Congo Rep.	AGPRODUC does not Granger cause GDP_GROWTH	0.218	0.64	One way
	GDP_GROWTH does not Granger cause AGPRODUC	4.162	0.041**	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.063	0.802	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.498	0.48	
Côte d'Ivoire	AGPRODUC does not Granger cause GDP_GROWTH	0.001	0.975	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.15	0.698	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.006	0.939	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.413	0.521	
Egypt	AGPRODUC does not Granger cause GDP_GROWTH	1.804	0.179	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.001	0.976	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.008	0.93	One way
	GDP_GROWTH does not Granger cause AGOUTPUT	5.385	0.02**	
Equatorial Guinea	AGPRODUC does not Granger cause GDP_GROWTH	2.248	0.134	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.193	0.66	
	AGOUTPUT does not Granger cause GDP_GROWTH	1.56	0.212	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.581	0.446	

Country	Null hypothesis	chi2 statistics	probability	direction of causality
Ethiopia	AGPRODUC does not Granger cause GDP_GROWTH	4.411	0.036**	One way
	GDP_GROWTH does not Granger cause AGPRODUC	2.532	0.112	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.718	0.397	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.117	0.732	
Gabon	AGPRODUC does not Granger cause GDP_GROWTH	10.139	0.001*	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.206	0.65	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.335	0.563	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	3.527	0.06**	
Gambia	AGPRODUC does not Granger cause GDP_GROWTH	0.026	0.872	One way
	GDP_GROWTH does not Granger cause AGPRODUC	8.297	0.004*	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.298	0.585	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.637	0.425	
Ghana	AGPRODUC does not Granger cause GDP_GROWTH	4.287	0.038**	One way
	GDP_GROWTH does not Granger cause AGPRODUC	0.977	0.323	
	AGOUTPUT does not Granger cause GDP_GROWTH	2.274	0.132	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.139	0.709	
Guinea	AGPRODUC does not Granger cause GDP_GROWTH	0.977	0.323	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.003	0.954	
	AGOUTPUT does not Granger cause GDP_GROWTH	1.137	0.286	One way
	GDP_GROWTH does not Granger cause AGOUTPUT	7.322	0.007*	
Guinea-Bisau	AGPRODUC does not Granger cause GDP_GROWTH	1.075	0.3	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.016	0.9	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.14	0.709	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.468	0.494	

Country	Null hypothesis	chi2 statistics	probability	direction of causality
Kenya	AGPRODUC does not Granger cause GDP_GROWTH	0.35	0.554	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.106	0.745	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.226	0.635	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	1.655	0.198	
Lesotho	AGPRODUC does not Granger cause GDP_GROWTH	0.023	0.879	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	1.565	0.211	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.858	0.354	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	1.6	0.206	
Liberia	AGPRODUC does not Granger cause GDP_GROWTH	1.187	0.276	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	1.687	0.194	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.48	0.488	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.007	0.933	
Libya	AGPRODUC does not Granger cause GDP_GROWTH	0.206	0.65	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.36	0.548	
	AGOUTPUT does not Granger cause GDP_GROWTH	5.163	0.023**	One way
	GDP_GROWTH does not Granger cause AGOUTPUT	0.199	0.656	
Madagascar	AGPRODUC does not Granger cause GDP_GROWTH	0.006	0.938	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.001	0.97	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.496	0.481	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.202	0.653	
Malawi	AGPRODUC does not Granger cause GDP_GROWTH	1.645	0.2	One way (reverse)
	GDP_GROWTH does not Granger cause AGPRODUC	9.191	0.002*	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.022	0.881	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.11	0.74	

Country	Null hypothesis	chi2 statistics	probability	direction of causality
Mali	AGPRODUC does not Granger cause GDP_GROWTH	0.001	0.972	
	GDP_GROWTH does not Granger cause AGPRODUC	1.189	0.275	No long run relation
	AGOUTPUT does not Granger cause GDP_GROWTH	4.144	0.042**	
	GDP_GROWTH does not Granger cause AGOUTPUT	0.906	0.341	One way
Mauritania	AGPRODUC does not Granger cause GDP_GROWTH	0.018	0.895	
	GDP_GROWTH does not Granger cause AGPRODUC	0.581	0.446	No long run relation
	AGOUTPUT does not Granger cause GDP_GROWTH	0.013	0.911	
	GDP_GROWTH does not Granger cause AGOUTPUT	0.003	0.956	No long run relation
Mauritius	AGPRODUC does not Granger cause GDP_GROWTH	0.665	0.415	
	GDP_GROWTH does not Granger cause AGPRODUC	0.893	0.345	No long run relation
	AGOUTPUT does not Granger cause GDP_GROWTH	0.092	0.761	
	GDP_GROWTH does not Granger cause AGOUTPUT	1.786	0.181	No long run relation
Morocco	AGPRODUC does not Granger cause GDP_GROWTH	2.904	0.088***	
	GDP_GROWTH does not Granger cause AGPRODUC	0.008	0.93	No long run relation
	AGOUTPUT does not Granger cause GDP_GROWTH	0.033	0.857	
	GDP_GROWTH does not Granger cause AGOUTPUT	0.767	0.381	No long run relation
Mozambique	AGPRODUC does not Granger cause GDP_GROWTH	0.306	0.58	
	GDP_GROWTH does not Granger cause AGPRODUC	4.821	0.028**	One way
	AGOUTPUT does not Granger cause GDP_GROWTH	3.939	0.047**	
	GDP_GROWTH does not Granger cause AGOUTPUT	0.007	0.931	One way
Namibia	AGPRODUC does not Granger cause GDP_GROWTH	0.048	0.827	
	GDP_GROWTH does not Granger cause AGPRODUC	13.486	0.00*	One way
	AGOUTPUT does not Granger cause GDP_GROWTH	2.801	0.094***	
	GDP_GROWTH does not Granger cause AGOUTPUT	1.065	0.302	One way

Country	Null hypothesis	chi2 statistics	probability	direction of causality
Niger	AGPRODUC does not Granger cause GDP_GROWTH	0.421	0.517	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.014	0.906	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.368	0.544	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.688	0.407	
Nigeria	AGPRODUC does not Granger cause GDP_GROWTH	1.904	0.168	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.247	0.619	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.664	0.415	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	1.113	0.291	
Rwanda	AGPRODUC does not Granger cause GDP_GROWTH	2.587	0.108***	One way
	GDP_GROWTH does not Granger cause AGPRODUC	0.826	0.363	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.131	0.717	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.006	0.937	
Senegal	AGPRODUC does not Granger cause GDP_GROWTH	0.005	0.946	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	1.174	0.279	
	AGOUTPUT does not Granger cause GDP_GROWTH	4.489	0.034**	One way
	GDP_GROWTH does not Granger cause AGOUTPUT	0.137	0.711	
Seychelles	AGPRODUC does not Granger cause GDP_GROWTH	0	0.991	One way
	GDP_GROWTH does not Granger cause AGPRODUC	2.851	0.091***	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.391	0.532	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	1.748	0.186	
Sierra Leone	AGPRODUC does not Granger cause GDP_GROWTH	0.003	0.953	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.137	0.711	
	AGOUTPUT does not Granger cause GDP_GROWTH	4.639	0.031**	One way
	GDP_GROWTH does not Granger cause AGPRODUC	0	0.991	

Country	Null hypothesis	chi2 statistics	probability	direction of causality
Somalia	AGPRODUC does not Granger cause GDP_GROWTH	0	0.999	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.001	0.975	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.267	0.605	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.002	0.969	
South Africa	AGPRODUC does not Granger cause GDP_GROWTH	0.667	0.414	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.091	0.762	
	AGOUTPUT does not Granger cause GDP_GROWTH	2.3	0.129	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	1.792	0.181	
Sudan	AGPRODUC does not Granger cause GDP_GROWTH	0.034	0.853	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.329	0.566	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.021	0.884	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.979	0.322	
Swaziland	AGPRODUC does not Granger cause GDP_GROWTH	0.016	0.9	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.036	0.85	
	AGOUTPUT does not Granger cause GDP_GROWTH	7.441	0.006*	Two way causality
	GDP_GROWTH does not Granger cause AGOUTPUT	4.319	0.038**	
Tanzania	AGPRODUC does not Granger cause GDP_GROWTH	0.694	0.405	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.098	0.754	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.918	0.338	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.142	0.706	
Togo	AGPRODUC does not Granger cause GDP_GROWTH	0.073	0.787	One way
	GDP_GROWTH does not Granger cause AGPRODUC	7.397	0.007*	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.055	0.815	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.146	0.703	

Country	Null hypothesis	chi2 statistics	probability	direction of causality
Tunisia	AGPRODUC does not Granger cause GDP_GROWTH	0.347	0.556	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.964	0.326	
	AGOUTPUT does not Granger cause GDP_GROWTH	3.713	0.054**	One way
	GDP_GROWTH does not Granger cause AGOUTPUT	0.008	0.927	
Uganda	AGPRODUC does not Granger cause GDP_GROWTH	0.209	0.648	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.117	0.732	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.219	0.64	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	0.004	0.948	
Zambia	AGPRODUC does not Granger cause GDP_GROWTH	0.387	0.534	One way
	GDP_GROWTH does not Granger cause AGPRODUC	7.046	0.008*	
	AGOUTPUT does not Granger cause GDP_GROWTH	2.553	0.11	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	1.701	0.192	
Zimbabwe	AGPRODUC does not Granger cause GDP_GROWTH	0.126	0.722	No long run relation
	GDP_GROWTH does not Granger cause AGPRODUC	0.962	0.327	
	AGOUTPUT does not Granger cause GDP_GROWTH	0.168	0.682	No long run relation
	GDP_GROWTH does not Granger cause AGOUTPUT	1.231	0.267	

Note: *,**,** shows significant level at 1%, 5%, and 10% and rejection of the null of no Granger causality. AGPRODUC refers agricultural productivity measured in TFP, AGPRODUC refers agricultural production which is the sum of the value of 189 crops.

Annex 2.1: Principal component analysis

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Principal components/correlation                 Number of obs    =         53
                                                 Number of comp.  =          6
                                                 Trace            =          6
    Rotation: (unrotated = principal)            Rho              =     1.0000
```

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	4.80402	4.35894	0.8007	0.8007
Comp2	.445083	.135959	0.0742	0.8749
Comp3	.309123	.0638637	0.0515	0.9264
Comp4	.245259	.112493	0.0409	0.9672
Comp5	.132767	.0690169	0.0221	0.9894
Comp6	.0637496	.	0.0106	1.0000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
corruption	0.4156	0.0318	0.0699	-0.7924	0.1747	0.4038	0
gov_effect~s	0.4319	-0.3105	-0.0797	-0.2382	-0.2224	-0.7775	0
Polstablity	0.3801	0.6310	0.6067	0.1811	-0.2172	-0.0964	0
reg_quality	0.4242	-0.2762	-0.2177	0.2876	-0.6332	0.4612	0
rule_of_law	0.4049	-0.4565	0.3292	0.3961	0.5964	0.0815	0
voice_acct	0.3904	0.4688	-0.6818	0.2073	0.3408	-0.0614	0

Annex 2.2: Screen plot at confidence interval and mean of the Eigen values

(since we are analyzing a correlation matrix, the mean eigenvalue is 1.)