Effects of Agricultural inputs on Agricultural Productivity in Kenya: A Johansen Co-integration Approach

Harrison Kimutai Yego[1], Sharon Jebiwot Keror[1], Mathew Kipkoech Bartilol[1], Silas Kiprono Samoei[1], Carol Jeruto Rotich[2]

[1]*Department of Agricultural Economics and Resource Management, Moi University, Kenya*

[2]*Department of Environmental Sciences, Kenyatta University, Kenya*

Corresponding Author: Harrison Kimutai Yego

***Abstract:* - This paper empirically determined the effects of Agricultural inputs on agricultural productivity in Kenya utilizing time series data from 2001 to 2016. With agricultural productivity as the dependent variable, the study used a cointegration method to determine vector error correction estimatesof a Cobb-Douglass function. All factors kept constant a unit increase in Agricultural credit results to a to around 1.9% increase in agricultural productivity. An approximately 0.2% increase would be realized in agricultural productivity with a unit increase in agricultural capital formation. Climatic variables i.e. rainfall and temperature also influenced agricultural productivity positively with 0.8 and 4.4 coefficients respectively.Regarding Cobb-Douglas elasticity terms, the overall effect of the four variables (credit, capital formation, rainfall and temperature) results to an increasing returns to scale since7.2>1.**

***Key Words:* Agricultural productivity, Cobb-Douglas function, Cointegration**

I. INTRODUCTION

In Kenya, agriculture is the mainstay of the country's economy contributing 27 percent of the count's Gross Domestic Product (GDP) in 2014, [1] and Sub- Saharan economies should overlook the sector the their own peril. The sector, however, remains the major sector in the whole economy accounting for about 60 percent of the foreign exchange earnings in Kenya while also accounting for about 16 percent of the formal sector employment[1]and also providing self-employment. There is, therefore a very high correlation between the growth of the national economy and development in the agricultural sector.

Agriculture is the sector from which the mainstream of the region's people derive their livelihood, and their wellbeing is directly connected to the productivity of the means at their disposal. The nonfarm people also depend comprehensively on agriculture, as a majority of their revenue is spent on food. Enhancing agricultural productivity stimulates economic growth and poverty reduction in a number of ways[2].

Majority of the Kenyan population inhabit the rural areas deriving their livelihoods directly or indirectly from agriculture. The significance of the sector in the economy is revealed in the relationship between its performance and that ofmajor indicators like GDP and employment. Drifts in the growth rates for agriculture, GDP and employment, show that the declining trend experienced in the sector's growth especially in the 1990s, is reflected in the declines in employment and GDP as a whole.

This paper intends to evaluate the effect of agricultural inputs on agricultural productivity in Kenya from 2001 – 2016 using annual time series data by adopting an econometric approach.

II. LITERATURE REVIEW

Theoretical Literature

The production function is a mathematical illustration of the various technological procedures from which a firm can choose to design its production process. The production function tells us exactly the *maximum* amount of output the firm can produce given the amounts of the inputs that it might use. The production function is written in the following form:

$$Q = f(K, L) \qquad (1)$$

Where Q is the quantity of output, L is the quantity of labor used, and K is the quantity of capital employed.

Empirical Literature

[1] Kenya National Bureau of Statistics. (2014) and Economic Survey 2015.

[2]Johnston, B. F., & Mellor, J. W. (1961). The role of agriculture in economic development. *The American Economic Review*, *51*(4), 566-593.

Yego *et al.* [2], assessed the effect of climate change on Agricultural production in Middle and Eastern African countries using fixed effects regression. The study concluded that an increase in rainfall[3] negatively affects agricultural production while an increase in temperature leads to an increase in agricultural production. An increase in temperature might increase agricultural food production mainly in the Kenyan highlands if accompanied by an increase in precipitation [3].

A study by Enu & Attah-Obeng [4] in Ghana, sought to identify the macroeconomic determinants of agricultural production by adopting a Cobb-Douglas production function. The authors found out that real GDP per capita, labor, real exchange rate and inflation significantly determined agricultural productivity while inflation did not.

Ahmad and Heng[5]look at the determinants of agricultural productivity growth in Pakistan using an autoregressive distributed lag model from 1965 to 2009. Results from the study indicated that human capital, fertilizer and agricultural credit were significant both in the short run and in the long run whereas the area under cultivation was insignificant in both cases.

Odhiambo*et a*l [6] while evaluating the cradles and determinants of agricultural growth and productivity in Kenya concluded that a larger percentage (90%) of agricultural sector growth was attributed to factor inputs i.e. land, labor and capital with labor accounting for over 45% of agricultural growth. According to the study, other factors influence agricultural productivity including climatic variables, government expenditure on agriculture and the country's trade policy.

In his study to find out the determinants of agricultural productivity, Ekborn [7] used Ordinary Least Squares (OLS) regression with results indicating that the quality of soil conservation, agricultural input costs, availability of labor access to credit, off-farm non-agricultural income and soil capital investments were statistically significant and positively correlated to agricultural productivity.

III. MATERIALS AND METHODS

The study adopted a non-experimental research design approach using data from secondary sources.

3.1 Data types and sources

The study used annual time series data from 2001-2016 to estimate a Cobb-Douglas production function with agricultural GDP as the dependent variable and agricultural credit, inflation, rainfall, temperature and agricultural capital formation as the dependent variables. Data on inflation was obtained from the Central Bank of Kenya statistical bulletin while data on rainfall and temperature was obtained from the African climate change data portal. Data for agricultural credit and agricultural GDP was sourced from FAOSTAT and World Bank Development indicators databases respectively.

3.2 Definition of variables

Agricultural productivity (Y):Agriculture value added per worker (measure of agricultural productivity) is a proxy for agricultural productivity. This is the outcome variable

Agricultural credit (x1): Carter (1989) gave various explanations as to why credit is asignificant determinant of agricultural productivity. Hence we would expect credit to have a positive correlation with agricultural output.

Inflation (x2): Inflation is the continual general increase in price levels of goods and services. Inflation is measured in terms of consumer price index over time. When we consider the prices of outputs, the relationship between price level and agricultural productivity is expected to be positive. When inputs are considered the relationship between price levels and agricultural productivity is expected to be negative.

Rainfall (x3): Rainfall is a variable indexed by total annual rainfall in Kenya. It is used to represent climate as a factor of agricultural productivity. From theory, a positive relationship is expected between rainfall and agricultural productivity however, it can be negative if too much rainfall results to flooding.

*Temperature (x4):*It is indexed by total annual annual mean temperatures in Kenya. It is used to represent climate as a factor of agricultural productivity.

Agricultural capital formation (x5): Agricultural capital accumulation (capital formation) that encompassesstaticdevelopments, acquisition of machinery and changes in the portfolio of livestock is included as one of the explanatory variables. It should have a positive effect on agricultural productivity.

3.3 Model specification

An accepted view on the theoretical foundation on the analysis of agricultural productivity is the Cobb–Douglas production function[4]. The Cobb-Douglas functional form of production function is extensively used in economic works to denote the relationship of an output to input.The equation was

[3] Precipitation may have detrimental effects on Agriculture especially in case of flooding

[4] The Cobb-Douglas functional form of production function is extensively used in economic works to denote the relationship of an output to input. The equation was advanced by Knut Wicksell (1851 - 1926), and tested statistically by Charles Cobb and Paul Douglas in 1928.

advanced by Knut Wicksell (1851 - 1926), and tested statistically by Charles Cobb and Paul Douglas in 1928.

Although it has itsshortcomings, the model exhibitsstriking mathematical features, such as highlighting diminishing marginal returns to either factor of production. This paper adopted the model by Enoma [8] and Ahmad and Heng[5]. Having regard that the production function is non-linear, a log-transformed Cobb-Douglas model, derives the following equation:

LogAGDP (y_i) = $\beta 0$ (constant) + $\beta_1$logCredit (x1) + $\beta_2$logInflation(x2) + $\beta_3$lograinfall(x3) +$\beta_4$logtemperature(x4) + $\beta_5$logcapital accumulation(x5) + ε_i………… (2)

Where:

LogAGDP = log of Agricultural GDP in current US dollars

Logcredit = log of agricultural credit in current US dollars

Loginflation = log of annual inflationary rates

Lograinfall = log of mean annual rainfall in millimeters

Logtemperature in degree Celsius = log of mean annual temperatures

Logcapitalformation = log of annual increase in fixed farm assets (machinery and inventory)

$B_1 - \beta_5$ =parameter estimates

ε_i = Disturbance/error term/white noise

Equation (2) will then become:

$LogY_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon_i$…………… (3)

IV. RESULT AND DISCUSSION

4.1 Preliminary Analysis

Table 1 presents a summary of unit root tests results normally performed to check whether the variables are stationary or not as common in time series data analysis. Stationarity tests was performed by adopting the Augmented Dickey-Fuller (ADF) method. The variables were non-stationary at level but become stationary upon first differencing.

Table 2 presents cointegration results based on Johansen's method. From the results, it is evident that there are at most 4 cointegrating equations. Based on the results in Table 2, the study strongly rejects the null hypothesis of no cointegration and thus accepts the alternative hypothesis that there are four cointegrating equations in the multivariate model.

Table 1: Unit root test results

Augmented Dickey Fuller					
Variable	level	Order of integration	Variable	First differencing	Order of integration
Y	0.3659	I(1)	Dy	0.0127	1(0)
X1	0.9077	I(1)	Dx1	0.0025	1(0)
X2	0.0210	I(0)	Dx2	0.0000	1(0)
X3	0.0007	I(0)	Dx3	0.0000	1(0)
X4	0.0031	I(0)	Dx4	0.0001	1(0)
X5	0.7856	I(1)	Dx5	0.0080	1(0)
Test statistic: 1% (-3.750), 5% (-3.000), 10% (-2.630)					
Source: STATA version 13					

Table 2: Johansen Cointegration results using trace statistic

Hypothesized number of CEs	Log Likelihood	eigenvalue	Trace statistic	5% critical value
None	120.39351	.	145.6373	94.15
At most 1*	142.81699	0.95937	100.7903	68.52

At most 2*	160.68744	0.92215	65.0494	47.21
At most 3*	174.00527	0.85081	38.4138	29.68
At most 4*	186.2306	0.82561	13.9631*	15.41
At most five	192.02633	0.56306	2.3716	3.76
At most six	193.21216	0.15583		
*denotes rejection of the null hypothesis at the 0.05 level				
Source: STATA version 13				

Table 3 presents results of the long run relationship among the variables. All the explanatory variables except agricultural capital formation (x5) were insignificant with wrong signs as opposed to economic theory. Agricultural credit (x1) and rainfall (x3) have both negative and insignificant coefficients while inflation (x2) and temperature have positive and insignificant coefficients. A unit increase in gross agricultural formation for Kenya has a significant agricultural growth of approximately 0.6% meaning that there exist a positive relationship between agricultural gross formation and agricultural productivity in the long run. The other variables (x1, x2, x3 and x4) do not have a relationship with agricultural productivity in the long run.

Table 3: Long run coefficients

Independent variables	coefficient	Standard error	t	p>/t/
ECT	-0.1929	0.1894	-1.02	0.308
X1	-0.0001	0.1532	-0.00	0.999
X2	0.0432	0.0397	1.09	0.302
X3	-0.0545	0.2116	-0.26	0.802
X4	0.6586	2.841	0.23	0.821
X5	0.5962	0.0828	7.20	0.000*
Constant	-2.7947	4.131	-0.68	0.514
R-Squared: 0.9762/ Adjusted R-squared: 0.9643				
F statistic : 81.92, Probability (F statistic) : 0.0000				
Source: STATA version 13				

Table 4 presents results of the short run coefficients for the four explanatory variables. The Error Correction Term (ECT) was negative but insignificant. Credit to agriculture, rainfall, temperature and agricultural gross capital formation have a positive influence on agricultural productivity for the period under consideration. The coefficient of credit (1.925) was positive and significant at 0.01 level indicating that a unit increase in the amount of credit to agriculture would result to around 1.9% increase in agricultural productivity. An approximately 0.2% increase would be realized in agricultural productivity with a unit increase in agricultural capital formation. Similar results were obtained by Chisasa and Makina [10] in South Africa. Climatic varibles i.e. rainfall and temperature also influenced agricultural productivity positively with 0.8 and 4.4 coefficients respectively. An increase in rainfall with an increase in temperature leads to an increase in agricultural productivity[5]. This results are similar to those of Murays and Ruigu [11] in Kenya. Inflation however did not have any effect on agricultural production as its coefficient was positive and insignificant.

Regarding Cobb-Douglas elasticity terms, the effect of credit (1.9%) gives an increasing returns to scale (1.9>1), while the combined effect of rainfall (0.9%) with gross capital formation (0.2%) shows approximately a constant returns to scale (1.1=1) indicating that doubling the two inputs will double the agricultural output. The overall effect of the four variables (credit, capital formation, rainfall and temperature) results to an increasing returns to scale since7.2>1.

[5] Downing 1992 found out that an increase in temperature might increase agricultural food production mainly in the highlands especially if accompanied by a substantial increase in precipitation

Table 4: Vector error correction results

beta	coefficient	Standard error	z	P >/z/
ECT	-0.1929	0.1894	-1.02	0.308
Dx1	1.925	0.1710	11.96	0.000**
Dx2	0.008	0.0145	0.55	0.585
Dx3	0.856	0.0694	12.34	0.000**
Dx4	4.420	1.098	4.03	0.000**
Dx5	0.163	0.083	1.95	0.051*
Constant	0.1311			
R- squared	0.0798			
Ch^2 statistic: 295.823/ Probability of Ch^2 statistic: 0.0000				
'*' Significance at 5%, '**' significance at 1% levels				
Source: STATA version 13				

Section IV-B *Diagnostic tests*

Table 5 presents diagnostic results for serial correlation and heteroskedasticity using Breusch-Godfrey LM andBreusch-Pagan tests respectively. From the results the study rejected the null hypothesis of no serial correlation and heteroskedasticity. From the results therefore, there is an overwhelming evidence of absence of serial correlation and heteroskedasticity meaning that the errors homoscedastic

Table 5: Diagnostic tests results

Checks	χ^2	Prob $>\chi^2$
Breusch-Godfrey LM test for serial correlation	0.043	0.836
Breusch-Pagan test for heteroskedasticity	0.000	0.994
Source: STATA version 13		

V. CONCLUSIONS AND POLICY RECOMMENDATIONS

The paper analyzed the effect of Agricultural inputs on agricultural production in Kenya from 2001 to 2016 by utilizing Johansen Cointegration method. Agricultural productivity was used as the dependent variable explained by agricultural credit, inflation, rainfall, temperature and agricultural capital formation. Credit to agriculture, rainfall, temperature and agricultural gross capital formation have a positive influence on agricultural productivity for the period under consideration. The coefficient of credit (1.925) was positive and significant at 0.01 level indicating that a unit increase in the amount of credit to agriculture would result to around 1.9% increase in agricultural productivity. An approximately 0.2% increase would be realized in agricultural productivity with a unit increase in agricultural capital formation.Regarding Cobb-Douglas elasticity terms, the overall effect of the four variables (credit, capital formation, rainfall and temperature) results to an increasing returns to scale since7.2>1.

Based on the study results, the Government of Kenya should develop and initiate policies that are geared towards roust development and promotion of the Agricultural sector.

REFFERENCES

[1]. Kenya National Bureau of Statistics. (2014). Economic Survey 2015

[2]. Yego, H. K., Bartilol, M. K., Samoei, S. K., &Wafula, A. Estimating the effects of climate change on Agricultural production in Eastern and Middle African Countries: An Econometric Analysis

[3]. Downing, T. E. (1992). Climate change and vulnerable places: global food security and country studies in Zimbabwe, Kenya, Senegal and Chile

[4]. Enu, P., &Attah-Obeng, P. (2013). Which macro factors influence agricultural production in Ghana? *Academic Research International*, *4*(5), 333

[5]. Ahmad, K., &Heng, T. C. (2012). Determinants of agriculture productivity growth in Pakistan. *International Research Journal of Finance and Economics*, *95*, 163-173.

[6]. Odhiambo, W., Nyangito, H. O., &Nzuma, J. (2004). *Sources and determinants of agricultural growth and productivity in Kenya* (No. 34). Kenya Institute for Public Policy Research and Analysis

[7]. Ekbom, A. (1998, June). Some determinants to agricultural productivity: An application to the Kenyan highlands. In *World Conference of Environmental Economics, Venice, Italy* (pp. 25-27)

[8]. Anthony, E. (2010). Agricultural credit and economic growth in Nigeria: An empirical analysis. *Business and Economics Journal*, *14*, 1-7

[9]. Carter, M. R. (1989). The impact of credit on peasant productivity and differentiation in Nicaragua. *Journal of Development Economics*, *31*(1), 13-36

[10]. Chisasa, J., &Makina, D. (2013). Bank credit and agricultural output in South Africa: A Cobb-Douglas empirical analysis

[11]. Muraya, B. W., &Ruigu, G. (2017). Determinants of Agricultural Productivity in Kenya. *International Journal of Economics, Commerce and Management*, *5*(4)