Econometrics Model for the Contribution of Kenyan Agricultural Gross Domestic Product to Overall Gross Domestic Product

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Abstract — *The agriculture sector is the mainstay of the Kenyan economy. The sector contributes directly up to 24% to the national Gross Domestic Product (GDP) and 27% indirectly through linkages with manufacturing, distribution and other related sectors. In this paper, an econometric model relating Kenya's GDP and Agricultural Gross Domestic Product (AGDP) is developed. Data on Agricultural gross domestic product (quarterly), Gross domestic product (quarterly), Livestock value (annual), Crops value (annual), Fisheries value (quarterly), Purchased inputs value (annual) and Horticulture value (quarterly) collected from 2000-2012 is used for analysis. From the analysis, it was found out that an increase in ln AGDP by 0.1% increases ln GDP by 1.08%. Furthermore, the value of crops, livestock value and purchased inputs are significant in influencing Kenyan GDP in the long-run. Thus, in regard to policy implications, there is need for the government to allocate more resources on the significant variables so as to improve the economy*.

Keywords — *Agriculture, Econometric Model, Long-run.*

I. Introduction

Agriculture is the art and science of growing plants (crops) and the raising of animals for food, for economic gain or other human needs. The Agriculture sector is the mainstay of the Kenyan economy. The sector provides sustenance for more than 80% of the Kenyan population in terms of employment and food security [6]. The sector contributes directly up to 24% to the national GDP and 27% indirectly through linkages with manufacturing, distribution and other related sectors [6]. In addition, the sector employs more than 40% of the total population and more than 70% of Kenya's rural people. The sector accounts for 65% of revenue from exports [6]. The agriculture sector includes industrial crops, food crops, horticulture, livestock, fisheries and forestry sub sectors. The industrial crops and food crops contributes 17% and 32% of AGDP while horticulture and Livestock contributes 33% and 17% of AGDP respectively [6]. Livestock contributes to the wider economy through household consumption and expenditure, inputs into manufacturing and exports of hides, skins & leather goods [2]. Kenya's fisheries and aquaculture sector contributes approximately 0.54% to the country's GDP [5]. [8] studied on the performance of the horticultural sub-sector in Kenya and found that increase in horticultural exports leads to increased AGDP.

Gross domestic product (GDP) is the basic measure of the overall economic performance of a country. It is the market value of all final goods and services produced within the borders of a nation in a year. Information on GDP is regarded as an important index for assessing the national economic development and for judging the operating status of macro-economy as a whole [10].

The agriculture sector plays a significant role as far as the GDP growth rate of a developing country is concerned, [1]. For instance, [4] undertook a study to determine the impact of the agricultural sector on Ghana's economic growth using time series data from 1996-2006 and found that agricultural output had a significant positive impact on the nation's growth. [1] investigated the impact of agriculture and industrialization on GDP in Nigeria. In their study, they used Vector Autoregressive (VAR) and Structural Vector Autoregressive (SVAR) models using yearly data. Their study revealed from the SVAR models that agriculture and industry contributed to structural innovations of GDP in Nigeria.

In this paper, effort is made to analyse data on quarterly agricultural gross domestic product and gross domestic product of the Kenyan economy from 2000 to 2012 to come up with the model that gives the contribution of AGDP to GDP. In addition we also consider the determinants within the agricultural sector (livestock value, crops value, horticultural export produce, fisheries value and value of purchased inputs) other variables assumed to have constant relationship and assess their contribution to GDP.

II. MATERIALS AND METHODS

Secondary data on quarterly agricultural gross domestic product of the Kenyan economy was obtained from Kenya National Bureau of Statistics office in Nairobi from January 2000 to January 2014 at quarterly intervals. Secondary data on GDP was obtained from KNBS (Quarterly GDP reports) while data on value of livestock, crops, fisheries and purchased inputs was obtained from KNBS (various statistical abstract). Data on value of horticulture was obtained from Census and Economic Information Centre (CEIC); Kenya's Exports: Domestic Horticulture. The data for each series consisted of 57 observations and had no gaps. It was then entered into a spreadsheet in Excel and saved as CSV format. R statistical software was then used to read the data and for further analysis. However, because data on value of crops, livestock and purchased inputs was annual, using an R software package called 'tempdisagg', it was interpolated into quarterly intervals. The package ensures that either the sum, the average, the first or the last value of the resulting series (interpolated series) is consistent with the low frequency series (original series) [3]. This package also allows us to obtain the original series of the data. Thus, since the data consists of accumulated yearly values, the package interpolated the series by disaggregating each yearly value into its respective quarters such that once they are aggregated back, the original series is obtained.

A model that relates the Gross Domestic Product (GDP) and agricultural gross domestic product was developed. GDP is a function of various factors including productivity, labour, capital, technological innovations amongst others. However, in this study, the focus was on the determinants within the agricultural sector (other explanatory variables are assumed to have constant relationship to GDP). Thus, a model relating GDP value to value from livestock, value from crops, value of horticultural export produce, fisheries value & value of purchased agricultural inputs was fitted. This is important as the drivers within the agricultural sector were identified. Here we let Gross Domestic Product (GDP) to be a function of agricultural gross domestic product and again GDP to be a function of livestock value, crops value, horticultural export produce, fisheries value and value of purchased agricultural inputs. More formally we represent it as,

$$GDP = f(AGDP) \tag{1}$$

and

$$GDP = f(L, C, H, F, P) \tag{2}$$

where;

GDP is the gross domestic product
AGDP is the agricultural gross domestic product
L is the livestock value
C is the crops value
F is the fisheries value
H is the horticultural export produce
P is the value of purchased agricultural inputs.

We determine the functions that relates these variables and determine if the independent variables are significant in influencing the Kenyan GDP.

We performed the time series analysis to identify the linkages between Gross Domestic Product and Agricultural Gross Domestic Product and GDP and value of livestock, value of crops, value of fisheries, value of horticultural export produce and value of purchased agricultural inputs. Stationarity of the variables was done. Thus to test for stationarity, all the variables were tested for unit root using the Augmented-Dickey Fuller test as outlined in [7]. If non-stationary, differencing was applied to make the individual series stationary to enable us identify the integration order

III. RESULTS AND DISCUSSION

The model relating the GDP and AGDP is

$$GDP = \beta_0 AGDP^{\beta_1} e^{\mu_t} \tag{3}$$

Taking logs to both sides, for statistical estimation, we have

$$\ln GDP = \beta + \beta_1 \ln AGDP + \mu_t \tag{4}$$

To perform time series analysis in order to identify the relationship between the two, we first test for stationarity of the two variables. Applying the Augmented-Dickey Fuller test to log transformed variable we have the results as in Table 1

Table 1: ADF Test of ln of Variable

Variable	Dickey-Fuller	5% Critical value	P-value
$\ln GDP$	-1.8117	-2.86	0.6506
$\ln AGDP$	-1.6971	-2.86	0.6969

Since the Dickey-Fuller values are greater than -2.86 (the 5% critical value), the variables are nonstationary and thus differencing is required. Upon differencing and applying the ADF test we have the results in Table 2

Table 2: ADF Test on First Differences

Variable	Dickey-Fuller	5% Critical value	P-value
$\nabla \ln GDP$	-3.8577	-2.86	0.02219
$\nabla \ln AGDP$	-3.3558	-2.86	0.07189

The Dickey-Fuller values are less than -2.86, implying the variables are stationary after differencing. Since the two are cointegrated, I(1), a cointegration model for the two variables can be obtained. Regressing ln *GDP* on ln *AGDP* we obtain the results in Table 3.

Table 3: Cointegration Regression Results

Variable	Coefficient	Std. Error	Prob
Intercept	0.4877	1.3092	0.711
$\ln AGDP$	1.0834	0.1164	0.00000***

Note: Significance code *** = 0.1%

From this cointegration, we note that AGDP is significant in influencing Kenya's GDP. This is because the p-value which is 0.00000 is less than 0.1% the significance level. An increase in ln *AGDP* by 0.1% increases ln *GDP* by 1.08%. Though the individual variables are nonstationary, this cointegration model is not spurious. This is because the PP.test() gives; $Dickey - Fuller = -6.6229$, $Truncation - lag - parameter = 3$, $P-value = 0.01$. The Dickey-Fuller value is less than -3.74 at 5% significance level implying that the residuals are stationary. Thus the residuals are $I(0)$. This implies that the model

$$\ln GDP = 0.4877 + 1.0834 \ln AGDP \tag{5}$$

is a cointegrating regression.

Given that there is significant relationship between AGDP and GDP, there was need to identify the determinants of agricultural sector as related to GDP. Thus the following factors were investigated, including value of livestock, value of crops, value of fisheries, horticultural export produce and value of purchased agricultural inputs using a multiplicative model. Formally this is represented as

$$GDP = \beta_0 L^{\beta_1} C^{\beta_2} H^{\beta_3} F^{\beta_4} P^{\beta_5} e^{\mu_t} \tag{6}$$

where;

GDP is the gross domestic product

L is the value of livestock

C is the value of crops

F is the value of fisheries
H is the horticultural export produce
P is the value of purchased agricultural inputs and
β_0, β_1, β_2, β_3, β_4 and β_5 are constants while μ_t is the error term. Again, for statistical estimation, equation 6 can be expressed in log form as

$$\ln GDP = \ln \beta_0 + \beta_1 \ln L + \beta_2 \ln C + \beta_3 \ln H + \beta_4 \ln F + \beta_5 \ln P + \mu_t \quad (7)$$

or

$$\ln GDP = \alpha + \beta_1 \ln L + \beta_2 \ln C + \beta_3 \ln H + \beta_4 \ln F + \beta_5 \ln P + \mu_t \quad (8)$$

where $\alpha = \ln \beta_0$
All the variables are tested for the null hypothesis of unit root using the Augmented-Dickey Fuller test. Applying the adf.test() function command in R software to each log transformed variable we have the results in Table 4

Table: 4 ADF test of ln of variable

Variable	Dickey-Fuller	5% Critical value	P-value
$\ln GDP$	-1.8117	-2.86	0.6506
$\ln L$	-1.6614	-2.86	0.7113
$\ln C$	-2.49	-2.86	0.3769
$\ln H$	-2.3447	-2.86	0.4356
$\ln F$	-3.3881	-2.86	0.06667
$\ln P$	-2.0954	-2.86	0.5362

From Table 4, it is clear that the values from adf.test() are greater than -2.86, the 5% critical value except for the ln(*fisheries*) which shows that the fisheries series is stationary. This implies presence of unit root in the other variables hence they are nonstationary. Therefore, differencing is required. Applying first difference to each of the nonstationary variable and testing for unit root we have the output as in Table 5

Table: 5 ADF test on first differences

Variable	Dickey-Fuller	5% Critical value	P-value
$\nabla \ln GDP$	-3.8577	-2.86	0.02219
$\nabla \ln L$	-4.2497	-2.86	0.01
$\nabla \ln H$	-4.426	-2.86	0.01
$\nabla \ln C$	-5.4768	-2.86	0.01
$\nabla \ln P$	-3.5711	-2.86	0.04362

Clearly the Dickey-Fuller values are less than the 5% critical value which is -2.86. This implies that the variables are stationary, hence we can conclude that the variables (excluding fisheries) are integrated to order 1 i.e. I(1).

Now that all the variables are integrated to order 1, a cointegration (long run) regression model can be obtained. This is achieved through regressing ln *GDP* on ln *L*, ln *H*, ln *C* and ln *P* (i.e. variables that are integrated to same order). Performing this regression we have the results in Table 6.

Table: 6 Cointegration (long run) Regression Results

Variable	Coefficient	Std. Error	Prob
Intercept	5.66455	0.80191	0.0000***
$\ln L$	0.12184	0.07174	0.095402·
$\ln H$	0.05673	0.04162	0.178681
$\ln C$	0.40397	0.10928	0.000526***
$\ln P$	0.17168	0.05602	0.003450**

Note: Significance code *** = 0.1%, ** = 1%, · = 10%

The results in Table 6 show that the value of crops is statistically significant at 0.1% since the p-value which is 0.000526 is less than 0.1% the significance level. The value of purchased inputs and livestock are also statistically significant. This is because for the purchased inputs, the p-value which is 0.003450 is less than 1%, the significance level while for the livestock the p-value which is 0.095402 is less than 10%, the significance level. This implies the three have significant contribution to Kenya's GDP which agrees with the economic theory. From the results, an increase in value of ln C by 0.1% leads to an approximate 0.40% increase in ln GDP while an increase in ln P of purchased inputs by 1% increases ln GDP by 0.17%. Similarly, increase in ln L by 10%, increases ln GDP by approximately 0.12%. The results also shows that the value of horticulture sub-sector is not significant despite having the expected sign. This could be due to the challenges the sector faces as outlined by [9] such as price conflicts within the industry. However, it's key to note that the variables used in this regression are not stationary and thus there is possibility that this regression is spurious. This necessitates testing for cointegration. To test for cointegration, we test for stationarity of the residuals using the Phillip-Perron test. Using the PP.test() function in R software we get $Dickey - Fuller = -4.9133$, $Truncation - lag - parameter = 3$, $P - value = 0.01$. Since $-4.9133 < -3.74$ at 5% significance level we conclude that the residuals are stationary. Thus the residuals are $I(0)$. This implies that the model

$$\ln GDP = 5.66455 + 0.12184 \ln L + 0.05673 \ln H + 0.40397 \ln C + 0.17168 \ln P \qquad (9)$$

is a cointegrating regression and it's not spurious even though the individual variables are nonstationary.

Now, since the variables are cointegrated, then an error correction model (ECM) may be developed. This is developed by regressing the first differenced dependent variable on the first differenced independent variables plus the one-period lagged value of the error from the cointegrating (long run) regression. Thus, regressing the first differenced ln GDP on first differenced ln L, ln H, ln C and ln P plus the one-period lagged value of the error term we have the results in Table 7 where ∇ denotes first difference operator.

Table 7: ECM (Short-run) Regression Results

Variable	Coefficient	Std. Error	Prob
Intercept	0.006628	0.009752	0.49984
$\nabla \ln L$	-0.129015	0.219868	0.55999
$\nabla \ln H$	-0.028159	0.045599	0.53969
$\nabla \ln C$	0.241695	0.287462	0.40447
$\nabla \ln P$	0.173641	0.196847	0.38194
μ_{t-1}	-0.544039	0.155847	0.00102**

Note: Significance code ** = 1%

The ECM can now be written as

$$\nabla \ln GDP = 0.007 - 0.129\nabla \ln L - 0.028\nabla \ln H + 0.242\nabla \ln C + 0.174\nabla \ln P - 0.544\mu_{t-1} \qquad (10)$$

From Table 7 we observe that the coefficient of the error correction term is negative as expected and is statistically significant at 1% since the p-value which is 0.00102 is less than 1%, the significance level. Thus, if ∇ ln L, ∇ ln H, ∇ ln C and ∇ ln P are zero, then ∇ ln GDP will be negative to restore equilibrium. In other words, if gross domestic product is above its equilibrium, it will start falling in the next period to correct the equilibrium error. The results further shows that, in the short run, the independent variables are not significant in influencing the GDP.

Therefore, from this analysis, we conclude that the value of crops, livestock value and purchased agricultural inputs are significant in influencing Kenyan GDP in the long-run though they are not significant in the short-run. The horticulture sector is found to be not significant though it is one of the sectors that earn the country foreign exchange. Generally from the analysis, we conclude that the agriculture sector is significant in influencing the Kenyan GDP.

IV. CONCLUSION

The main objective of this study was to develop an econometric model relating Kenya's GDP and Agricultural gross domestic product. Data on annual quarterly Agricultural Gross Domestic Product, quarterly Gross Domestic Product, annual Livestock value, annual Crops value, quarterly Fisheries value, annual purchased inputs value and quarterly Horticulture value collected from 2000-2012 was considered. From the analysis, it is observed that an increase in ln AGDP by 0.1% increases ln GDP by 1.08%. In addition, crops value, livestock value and purchased inputs are found to be significant in influencing Kenyan GDP in the long-run but not in the short-run. However, given the importance of horticulture in Kenya, there may be need to investigate further why there is no significant effect on the economy.

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