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Empirical analysis of macroeconomic variables towards agricultural productivity in South Africa

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Abstract. Agricultural sector can impact positively the nation's development in terms of job creation and food security which promote good nutrition and boost well-being of every individual. However, in South Africa a developing country with a growing economy, the agricultural sector is still a traditional one with limited productivity and developments. Therefore, this study aims to analyses the impact of macroeconomic variables towards agricultural productivity in South Africa. The study used three variations of equations to acquire variety of conclusions to assist in determining which set of macroeconomic variables have strong impact on agricultural productivity. Nine variables were used to make the analyses of the three sets of equations and agricultural productivity as a dependent variable appeared in all the three equations. The results indicated that there is a long run equilibrium existing among the variables in all estimated equations. Overall results demonstrate that GDP and capital formation play a positive significant role in stimulating agricultural productivity. Furthermore, the results suggest that there is an evidence of causality between macroeconomic variables and agricultural productivity. In conclusion, the results suggest that for South Africa, in order to increase agricultural productivity, policy makers should give adequate financial support to the agricultural sector by ways of providing development skills and funding the improvement of agricultural infrastructure. In addition, the results provide guidance to the farmers on how various macroeconomic variables may impact productivity whether it is positive or negative.

Keywords: agricultural productivity, macroeconomic variables, VECM, South Africa.
JEL codes: B22, E23, Q1

1. INTRODUCTION

Studies carried out by a variety of neo-classical and classical scholars revealed that agricultural sector plays a crucial role in an economy. The agricultural sector's position can therefore be shown in terms of maximizing productivity and minimizing production costs within the sector. The sector can thus impact positively the nation's progression, social welfare, job creation, and food security. Most prominently, as South Africa is a developing country with a growing economy, its agricultural sector needs to be improved. DAFF[1] (2015) states that developing nations across the world can focus on the sector to increase job creation and improve economic development. This may result from the readily available food and earnings from foreign exchange. However, agricultural sector has certainly not been the pillar of South African economy. Thus, this has been the reason behind the misfortunes of this sector.

According to Cristea, Marcu, Meghisan (2015) the poor governance and policy implementation inconsistency play a leading role to the lack of development for agricultural sector. In the 21st century, the shift of agriculture and agricultural productivity structure continued to indicate an ongoing decline on agricultural productivity by 0.19% in South Africa according to BFAP[2] (2011). The slowdown of the sector's productivity was due to the low productivity, particularly in output of field crops which were surpassed by development in the agricultural sector. The reality is that agricultural sector has contributed less than 4% to the South African economy since 2004, from its highest contribution of 21% in 1910, as stated by the DAFF (2017).

The BFAP[2] (2011) states that the South African agricultural growth continued to decline further in 2010 due to the slow recovery of the economy and stagnant commodity of prices. In 2015, the agricultural productivity's total gross value in Rand was estimated at R233 million, compared to R220 million of 2014, marking an increase of 5.5%. The increase was mostly ascribable to the growth in the value of animal products. In 2016/2017, according to DAFF (2017), agricultural productivity registered an increase of 12.5% when compared to the prior year of 2014/2015, this was ascribable to an increase of field crops and animal products and its share to the GDP was approximately R80 million in 2016. According to Ramali, Mahlangu and Tuit (2015), 70% of agricultural products are used as intermediate products by other sectors of the economy. Those products are often partly processed, those include products such as vegetable oils, wheat flour and soybean meal among others. The agricultural sector is an imperative sector and one of the engines that improves the growth of the economy. Nonetheless, to argue that the sector is more important than its share to the economy is understandable, as the sector utilized 79.8% of total land available in the year 2014 and used almost 60% of the water available for irrigation. According to World Bank (2017) the sector also generated R243 million in income and R225 million in expenditure. The sector created job opportunities directly and indirectly for more than 700 000 people in 2015, this was in line with the government New Growth Path plan to generate 5 million vacancies not later than 2020, as indicated by Dewbre and Cervantes-Godoy (2010). This makes agricultural sector be one of the biggest employers among other sectors of the economy.

Limited studies have been conducted relating to this kind of study and previous empirical evidence does not give thorough analysis on the impact of macroeconomic variables on agricultural productivity in South Africa. It is on this basis that this study fills the gap of the previous empirical literature by adding other key macroeconomic variables that were not included before. Rather than focusing on environmental factors, most of which among the limited studies in South Africa have focused on, the current study focuses on macroeconomic variables. Moreover, the study attempts to carry on an investigation by using three variations of equations. The essence of such approach is to achieve a robust feedback on the analysis of macroeconomic variables to agricultural productivity. The key objective of the study is to investigate the impact of macroeconomic variables towards agricultural productivity in South Africa. This study attempts to identify what are macroeconomic variables determining agricultural productivity. Therefore, this study is structured as follows: next section examines the theoretical and empirical literature underpinning the subject; Section 3 presents the methodology applied in the study. Empirical findings of the study are reported and discussed in section 4 while section 5 presents conclusion and policy recommendation.

2. REVIEW OF RELATED LITERATURE

The study is underpinned by several theoretical literatures. According to Solow (1956), growth accounting framework of neo-classical indicates that the output of growth model is the sum of growth in labour and capital accumulation growth, technological progress and productivity growth. On the other hand, Schultz (1964) and Mellor (1966) focused on agricultural development models whereby each theorist indicated the types of agriculture, whether that agriculture is traditional or technologically dynamic agriculture. Mellor (1966) agrees with Schultz (1964) on those development models but, comparatively, his approach is more pragmatic and extensive in nature. Mellor (1966) explains systematically the evolution of agriculture from primitive technology to modern agricultural

[1] Department of Agriculture Forestry and Fisheries.

[2] Bureau for Food and Agricultural Policy.

technology, whereas Schultz focused on explaining traditional agriculture.

In addition, several studies have been carried out to investigate the impact of macroeconomic variables towards agricultural productivity. However, contradicting findings were reached based on econometric techniques, data and period of study along with countries that were studied. Many studies carried out by various authors, i.e. Oyetade, Applanaidu, Abdul-Razak (2015), Browson, Vincent, Emmanuel, Etim (2012), Kadir, Tunggal (2015), Enu, Atta-Obeng (2013) and Abba, Barro, Mosca (2015), Bhide, Rajeev, Vani (2005), Huffman, Evenson (2001), Wang, Heisey, Schimmelpfennig, Ball (2015), Gil, Kaabia (2000), Dritsakis (2003), Awokuse (2009) and Awan, Alam (2015) focused on macroeconomic variables and their influence on agricultural productivity. These studies have led to different conclusions, mainly due to several variables utilized. Most studies included variables such as inflation, whereby in most studies the variable resulted to having negative impact in relation to agriculture and its productivity in the long run. Variables such as agricultural exports, exchange rates, interest rates, human capital, money supply, GDP and external debt dominated in most studies above mentioned. Thus, the study at hand will continue to fill the gap of the above empirical literature by adding other key macroeconomic variables that were not included.

In the South African context, there are nonetheless studies by Letsoalo and Kirsten (2003) and Kargbo (2007) that were not mainly focused on macroeconomics variables and their impact on agricultural productivity. Conversely, the work of Letsoalo and Kistern (2003) focused on analysing macroeconomic importance of trade policies on the South African agricultural sector. Kargbo (2007), on the other hand, focused on the effect of macroeconomic factors on the South African agriculture. Therefore, it is necessary that this study takes place, as there is insufficient empirical literature for South Africa that focuses on the topic at hand. Furthermore, this study employs a variation of equations unlike the previous studies. The study does confirm the importance to refocus on agricultural productivity since this sector affects every individual and other economic sectors in different ways. The empirical literature shows that macroeconomic variables can have either negative or positive relationship towards agricultural productivity depending on estimation approach of each study. The literature that was reviewed has also pointed out that agricultural productivity mostly increases in developed countries compared to developing countries, as stated by Ramabali *et al.*, (2011). The following section discusses the methodology of this study.

3. RESEARCH METHODOLOGY

3.1. Model specification

The study modifies and adopts the model by Kadir and Tunggal (2015) by using three variations of equations. Agricultural productivity is a function of selected macroeconomic variables among the three equations. It also takes into consideration the study by Bentivoglio, Finco and Bucci (2018), Eita and Jordaan (2013) who applied similar econometric technique (Johansen cointegration and granger causality). These studies indicate that the Johansen approach is more powerful than the Engle-Granger. Therefore, the following equations are presented:

$$AGRI_t = \beta_0+\beta_1GDP_t+\beta_2GE+\beta_3GCF+\beta_4RINT+\mu_t \quad (1)$$

$$AGRI_t = \beta_0+\beta_1GDP_t+\beta_2GE+\beta_3GCF+\beta_4REER+\beta_5AX+\mu_t \quad (2)$$

$$AGRI_t = \beta_0+\beta_1GDP_t+\beta_2GE+\beta_3M2+\beta_4REER+\beta_5AX+\mu_t \quad (3)$$

Where β_0 is the intercept and $\beta_1,\beta_2,\beta_3,\beta_4,\beta_5$ are explanatory variables coefficients and μ_t is the error term. AGRI: Agricultural productivity, GDP: Gross Domestic Product, GE: Government Expenditure, GCF: Gross Capital Formation, M2: Money Supply, RINT: Real Interest Rate, REER: Real Effective Exchange Rate, CPI: Consumer Price Index and AX: Agricultural exports. Certain variables are therefore converted into logarithms to obtain the elasticity of coefficients and remove the outlier effect. In terms of log linear form, the functions are as follows:

$$LAGRI_t = \beta_0+\beta_1LGDP_t+\beta_2GE+\beta_3LGCF+\beta_4RINT+\mu_t \quad (1)$$

$$LAGRI_t = \beta_0+\beta_1LGDP_t+\beta_2GE+\beta_3LGCF+\beta_4REER+ \beta_5LAX+\mu_t \quad (2)$$

$$LAGRI_t = \beta_0+\beta_1LGDP_t+\beta_2GE+\beta_3LM2+\beta_4REER+ \beta_5LAX+\mu_t \quad (3)$$

Where LGDP is log of gross domestic product, LGCF is log of gross capital formation, LAX is log of agricultural exports, LAGRI log of agricultural productivity and LM2 is log of money supply.

3.2. Study area and data source

The study used annual time series data for the period 1975 to2016 in order to analyses the impact of macroeconomic variables towards agricultural productiv-

Tab. 1. Summary of the description of variables.

Variables	Indicator name	Measurement	Source of dataset
AGRI	Agricultural productivity	% of GDP	World Bank & DAFF
AX	Agricultural exports	Rand value	WTO
REER	Real effective exchange rate	Rand currency	Quantec
GCF	Gross capital formation	% of GDP	Quantec
GDP	Gross domestic product	% of GDP	Quantec
GE	Government expenditure	% of GDP	Quantec
INT	Real interest rate	Annual %	World Bank
CPI	Consumer price index	Annual %	World Bank
M2	Money supply	Rand value	Quantec

ity in South Africa. The data used was online sourced from Quantec, World Trade Organization, World Bank and Department of Forestry and Fisheries. The data covered a variety of macroeconomic variables such as gross domestic product, government expenditure, gross capital formation, consumer price index, agricultural exports, real effective exchange rate, real interest and money supply along with agricultural productivity. Table 1 summaries the description of the variables used in the study.

The data is firstly tested for stationarity based on the test of Dickey and Fuller (1979) and Phillips-Perron (1986). In order to test for cointegration, the Johansen (1991-1995) cointegration technique is applied using two statistics tests. These are the value of likelihood ratio test based on the trace value of the stochastic matrix and maximum Eigen-value. The likelihood ratio is used to test Johansen cointegration. Up to (r–1) co-integrating relationships may exist between a set of r variables. The Johansen statistic is also adopted to resolve the issue of endogeneity of explanatory variables by allowing error correction model with lag restrictions. It is chosen as it can test multiple cointegration vectors (Bentivoglio *et al.*, 2018). The VECM is used to determine the long run and short run determinants of the dependent variable in the model. The Johansen technique envisages therefore the following steps: *Firstly*, all variables have to be integrated in the same order before moving to the cointegration test. *Secondly*, the correct lag length of the model has to be determined. Furthermore, this step envisages the estimation of the model and the determination of the rank of Π. *Lastly*, after ascertaining the existence of co-integrating relationship, the vector error correction model is estimated to test dynamics of the short run. The Johansen approach considers the starting point of VAR of order P by the following:

$$Y_t = A_1Y_{t-1}+\ldots A_pY_{t-p}+\beta x_t+\varepsilon_t \tag{7}$$

Therefore, to apply the Johansen test, VAR needs to be transformed into VECM model and be written as:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1}\Gamma i \Delta Y_{t-1} + \beta x_t + \varepsilon_t \tag{8}$$

Where

$$\Pi = \sum_{i=1}^{p} Ai - 1 \ and\ \Gamma i = -\sum_{j}^{p} = i + 1Aj \tag{9}$$

If the coefficient matrix Π has reduced rank r < k then there exists k x matrices α and β each with rank r such that $\pi=\alpha\beta'$ and $\beta' Y_t$ is $I(0)$. R is the number of cointegrating relationships, the elements of α are known as the adjustment parameters in the vector error correction model and each column of β is a cointegrating vector. It can be shown that for a given r, the maximum likelihood estimator of β defines the combination of Y_{t-1} that yields the r largest canonical correlations of ΔY_t with Y_{t-1} after correcting for lagged differences and deterministic variables when present. The above process determines the number of co-integrating vectors. Thereafter causality test on the VECM is applied to identify a structural model and determine whether the estimated model is reasonable. Diagnostic tests were conducted afterwards to test the stochastic properties of the models, and all the models pass the basic tests. Lastly the granger causality test was employed.

4. EMPIRICAL RESULTS

Table 2 presents the descriptive statistics for the variables employed in the study. The results show that, on average, the variables of the study are AGRI 1.38, AX 21.78, REER 4.68, GCF 3.04, GDP 37.62, GE 2.87, RINT 3.74, CPI 54.34 and M2 26.14. Overall GE is the variable with the lowest mean value.

Tab. 2. Descriptive statistics for variables under study.

	AGRI	AX	REER	GCF	GDP	GE	RINT	CPI	M2
Mean	1.387	21.787	4.682	3.045	37.620	2.872	3.746	54.346	26.141
Median	1.373	21.634	4.672	3.000	37.707	2.921	3.848	45.366	26.319
Maximum	2.035	23.155	5.128	3.530	38.275	3.030	13.012	138.90	28.312
Minimum	0.844	18.643	4.241	2.719	32.976	2.555	-12.315	3.427	23.103
Std.Dev.	0.350	0.833	0.236	0.210	0.892	0.143	4.345	44.067	1.709
Skewness	0.055	-0.817	0.135	0.717	-3.987	-1.119	-0.895	0.520	-0.295
Kurtosis	1.871	6.292	2.171	2.598	20.092	2.934	6.571	1.979	1.793
Jarque-Bera	2.249	23.080	1.330	3.883	622.54	8.778	26.590	3.716	3.159
Probability	0.325	0.000	0.514	0.144	0.000	0.012	0.000	0.156	0.206
Sum	58.20	893.30	196.6	127.9	1580.0	120.64	149.85	2282.5	1097.9
Sum Sq.Dev	5.02	27.75	2.28	1.81	32.63	0.84	736.34	7967.4	119.71
Observation	42	42	42	42	42	42	42	42	42

4.1. Unit root test results

Often macroeconomics time series data are generally characterized by a stochastic trend which can be eliminated by differencing the series. Firstly, in Johansen procedure, time series data are tested for stationarity of all variables. Hence this part of the study examines the order of integration by applying two formal tests namely Augmented Dickey Fuller and Phillips-Perron. Table 3 and 4 disclose the results of ADF and PP unit root tests.

Johansen cointegration requires a preliminary test to be done to ensure that variables are integrated in the same order. The unit root test for all variables used was applied and the results are shown in Table 3 above which includes Augmented Dickey Fuller and table 4 which consists of Phillips-Perron test. The analysis from the ADF indicates that in levels majority of the variables were not stationary however after first difference all the variables became stationary. Similar goes to the PP test whereby in levels the variables were non stationary and, after having firstly differencing them, the variables became stationary. Overall it can be concluded that orders of integration for all series in ADF and PP are in mixed order as they are integrated of order zero and order one.

4.2. Lag length criterion

After determining that most of the variables are integrated of order one, it is part of the process to determine whether there is existence of long run relationship among agricultural productivity and macroeconomic variables. Before carrying out the cointegration test, the Johansen procedure requires that lag length is determined. Therefore, the Table 5 shows different criterions to determine the lag length.

Table 5 confirms the criteria selected for equation (4) which chooses lag length 2 and for equation (5) the lag length selected is 1 and lastly lag length 2 is selected for equation (6). Thus, the Johansen cointegration test is conducted using the lag length selected for each equation.

4.3. Long run cointegration results

The second step of the analysis is to identify the presence of cointegration among variables using the Johansen (1991) cointegration technique after the series has been integrated. The purpose of performing this cointegration test in the study is to determine existence of the long run relationship between macroeconomic variables and agricultural productivity. Table 6 shows the results of Johansen cointegration test.

The results of both trace and maximum eigenvalue statistics tests are reported in Table 6 for all equations. Equation (4) includes variables such as LAGRI, LGDP, LGCF, GE and RINT. The trace and maximum eigenvalue statistics results of equation (4) highlight that there is at least one co-integrating vector that exists at 5% level of significant. The null hypothesis of no cointegrating vectors is rejected since the trace statistics of 93.444 is greater than 5% critical value of 88.803. Equation (5) is represented by LAGRI, LAX, REER, LGCF, GE and LGDP and RINT as variables, in both trace and maximum eigenvalue statistics tests it indicated two cointegrating vectors. The results show that they are significant at 5% level. LAGRI, CPI, LGDP, GE, REER and LM2 for equation (6) shows that trace test reflects to be having two cointegrating vectors at 5% level of significant similar to equation (5), however equation (4) indicated 1 cointegrating vector for

Tab. 3. Unit root results for Augmented Dickey Fuller test.

Variables	Formula	ADF			
		Levels	5% Critical value	1st difference	5% Critical value
AGRI	Intercept	-1.312	-2.935	-5.368**	-2.943
	Trend & intercept	-5.079**	-3.533	-5.293**	-3.524
AX	Intercept	-4.451**	-2.937	-14.923**	-2.939
	Trend & intercept	-7.008**	-3.527	-14.364**	-3.530
REER	Intercept	-1.191	-2.935	-5.431**	-2.937
	Trend & intercept	-3.823**	-3.527	-5.364**	-3.527
GCF	Intercept	-2.383	-2.935	-6.447**	-2.937
	Trend & intercept	-2.085	-3.524	-6.520**	-3.527
GDP	Intercept	-5.173**	-2.935	-7.315**	-2.939
	Trend & intercept	-6.845**	-3.524	-7.219**	-3.530
GE	Intercept	-1.875	-2.935	-6.905**	-2.937
	Trend & intercept	-2.026	-3.524	-6.937**	-3.527
RINT	Intercept	-3.324**	-2.939	-6.698**	-2.943
	Trend & intercept	-3.466	-3.530	-6.621**	-3.537
CPI	Intercept	-4.926**	-2.935	-3.528**	-2.937
	Trend & intercept	0.120	-3.524	-5.291**	-3.527
M2	Intercept	-2.521	-2.937	-2.906	-2.937
	Trend & intercept	0.996	-3.530	-3.968**	-3.527

Notes: Reported values under levels and first difference are ADF t-statistics values.
* Statistically significant at 1% level.
** Statistically significant at 5% level.
*** Statistically significant at 10% level.

Tab. 4. Unit root for Phillips- Perron test.

Variable	Formula	PP			
		Levels	5% Critical value	1st difference	5% Critical value
AGRI	Intercept	1.275	-2.935	-11.006**	-2.937
	Trend & intercept	-3.746**	-3.524	-10.740**	-3.527
AX	Intercept	-3.993**	-2.937	-15.064**	-2.939
	Trend & intercept	-6.096**	-3.527	-14.364**	-3.530
REER	Intercept	-0.973	-2.935	-5.905**	-2.939
	Trend & intercept	-3.059	-3.524	-5.735**	-3.527
GCF	Intercept	-2.371	-2.935	-6.551**	-2.937
	Trend & intercept	-2.025	-3.524	-7.520**	-3.527
GDP	Intercept	-5.177**	-2.935	-24.180**	-2.937
	Trend & intercept	-6.918**	-3.524	-25.654**	-3.527
GE	Intercept	-1.911	-2.935	-6.905**	-2.937
	Trend & intercept	-1.996	-3.524	-7.018**	-3.527
RINT	Intercept	-3.322**	-2.939	-8.599**	-2.941
	Trend & intercept	-3.496	-3.530	-8.513**	-3.533
CPI	Intercept	-4.346**	-2.935	-3.444**	-2.937
	Trend & intercept	0.038	-3.524	-5.266**	-3.527
M2	Intercept	-2.919	-2.935	-2.864	-2.937
	Trend & intercept	1.956	-3.524	-3.701**	-3.527

Notes: Reported values under levels and first difference are ADF t-statistics values.
* Statistically significant at 1% level.
** Statistically significant at 5% level.
*** Statistically significant at 10% level.

Tab. 5. Lag length criterion.

Equation	Lag	Log L	LR	FPE	AIC	SC	HQ
4	1	20.934	NA	8.64e-07*	0.220*	2.883	1.473
	2	36.945	23.368	1.49e-06	0.706	1.308*	0.603*
	3	54.318	20.660	2.69e-06	1.118	4.383	2.269
5	1	25.925	NA	6.96e-08*	0.530*	2.082*	1.082*
	2	51.868	35.501	1.33e-07	1.060	4.162	2.164
	3	81.102	30.773	2.72e-07	1.416	6.070	3.072
6	1	87.667	NA	2.89e-09	-2.650	-1.140*	-2.099*
	2	132.349	61.867*	2.06e-09*	-3.095*	-0.024	-1.992
	3	165.607	35.817	3.30e-09	-2.954	1.653	-1.301

Notes: * indicates lag order selected by the criterion; LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

Tab. 6. Unrestricted cointegration rank tests results.

Equation	Hypothesis Number of CE	Eigenvalue	Trace	Statistics	Maximum statistics	Eigenvalue
			Trace Statistics	0.05 critical value	Maximum eigenvalue Statistics	0.05 critical value
4	None	0.647	93.445**	88.804	38.517**	38.331
	At most 1	0.390	54.927	63.876	18.319	32.118
	At most 2	0.361	36.608	42.915	16.568	25.823
	At most 3	0.268	20.041	25.872	11.555	19.387
	At most 4	0.205	8.486	12.518	8.486	12.518
	Trace test indicates 1 cointegrating equation(s) at the 0.05 level.					
	Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level.					
	* denotes rejection of the hypothesis at the 0.05 level.					
5	None	0.684	137.736**	117.708	44.902**	44.497
	At most 1	0.644	92.833**	88.804	40.279**	38.331
	At most 2	0.440	52.554	63.876	22.641	32.118
	At most 3	0.309	29.912	42.915	14.419	25.823
	At most 4	0.205	16.493	25.872	8.938	19.387
	At most 5	0.155	6.555	12.518	6.555	12.518
	Trace test indicates 2 cointegrating equation(s) at the 0.05 level.					
	Max-eigenvalue test indicates 2 cointegrating equation(s) at the 0.05 level.					
	* denotes rejection of the hypothesis at the 0.05 level.					
6	None	0.832	161.428**	117.708	69.560**	44.497
	At most 1	0.578	91.868**	88.804	33.602	38.331
	At most 2	0.523	58.266	63.876	28.885	32.118
	At most 3	0.307	29.380	42.915	14.322	25.823
	At most 4	0.234	15.058	25.872	10.419	19.387
	At most 5	0.112	4.638	12.518	4.638	12.518
	Trace test indicates 2 cointegrating eqn(s) at the 0.05 level.					
	Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level.					
	* denotes rejection of the hypothesis at the 0.05 level.					

trace test. This kind of results for equation (6) has been influenced by CPI and LM2 whereas in equation (4) and equation (5) those two variables do not exist. Therefore, the study concludes that there is significant long run relationship between agricultural productivity and macroeconomic variables.

4.4. Vector Error Correction Model

In this study the dynamics of agricultural productivity in the short run are investigated and their adjustment speed parameter. Also, how agricultural productivity responds to long-run equilibrium after random shock using the Vector Error Correction Model. Table 7 includes the long run parameters while Table 8 includes short run parameters.

Table 7 represents long run parameters; those estimated parameters do determine whether there is positive or negative relationship existing between macroeconomic variables and agricultural productivity. For equation (4), it shows that in a long run 1% increase in LGDP leads to 0.084 increase in agricultural productivity. In terms of GE a 1% increase will lead to a 1.212 increase in agricultural productivity. Also, an increase of 1% in LGCF will lead to a 0.475 increase in agricultural productivity. Lastly, a 1% increase in RINT will lead to 0.004 increase in agricultural productivity. In the long run all the variables of this model show a positive relationship with agricultural productivity. A 1% increase in LGDP for equation (5) will lead to -0.029 decrease in agricultural productivity. Also 1% increase in GCF will lead to -0.147 decrease in agricultural productivity. This indicates that LGDP and LGCF have a negative relationship with agricultural productivity in the long run. Whilst, on the other hand, 1% increase in GE will lead to a 0.134 increase in agricultural productivity. Furthermore, a 1% increase in LAX will lead to 0.055 increase in agricultural productivity.

Tab. 7. Long run parameter results.

ORDER	Equation 4 Coefficient	Equation 5 Coefficient	Equation 6 Coefficient
CONSTANT	5.92	2.034	37.81
TREND	0.038 (11.352)*	0.031 (6.676)*	0.059 (3.887)*
VARIABLES			
LGDP	0.084 (2.258)*	-0.029 (-1.547)	0.386 (7.996)*
GE	1.212 (3.326)*	0.134 (0.613)	3.364 (6.598)*
GCF	0.475 (2.621)*	-0.147 (-1.127)	-
RINT	0.004 (0.862)	-	-
LM2	-	-	0.835 (4.168)*
LREER	-	-	-0.004 (-2.798)*
CPI	-	-	-1.452 (-5.880)*
LAX	-	0.055 (0.921)	-

Notes: Values in brackets are t-statistics.
* Statistically significant at 1% level.
** Statistically significant at 5% level.
*** Statistically significant at 10% level.

In equation (5), since there was existence of more than one cointegrating vectors, it is not rational to take those unrestricted estimates of the vectors directly, as they are for long run parameter estimates. Thus, it is important that restrictions are imposed on the two vectors to obtain structural relationship among the variables. Therefore, the two cointegrating vectors that were established are shown in the following equation:

$$\Pi z_{t-1=\alpha\beta' z_{t-1}=} \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & 0 \\ \alpha_{31} & 0 \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \\ \alpha_{61} & \alpha_{62} \end{bmatrix} \begin{bmatrix} 1 & 0 & \beta_{31} & \beta_{41} & \beta_{51} & \beta_{61} \\ 0 & 1 & \beta_{32} & \beta_{42} & \beta_{52} & \beta_{62} \end{bmatrix} \begin{bmatrix} LAGRI_{t-1} \\ REER_{t-1} \\ LAX_{t-1} \\ LGCF_{t-1} \\ LGDP_{t-1} \\ GE_{t-1} \\ Constant \end{bmatrix} \tag{10}$$

In the first cointegrating vector, long run zero restriction was imposed on real effective exchange rate as it is a dependent variable in the second cointegrating vector. Also, zero restriction were imposing on agricultural productivity as it is dependent variable in the first cointegrating vector. The restrictions imposed do indicate that real effective exchange rate does not play an important role in determining agricultural productivity in South Africa. This implies that the study can have agricultural productivity equation without real effective exchange rate. In second equation we can have real effective exchange rate equation without agricultural productivity. The first long-run cointegration vector equation can be written as:

$$LAGRI= 0.649LAX+3.065\ LGCF+1.469LGDP+ 4.890GE-99.873 \tag{11}$$

In the long run a 1% increase in LAX increases agricultural productivity by 0.649. An increase of 1% in LGCF will lead to an increase of agricultural productivity by 3.065% and an increase by 1% in LGDP will lead to an increase of 1.469 towards agricultural productivity. Lastly, a 1% increase in GE will lead to an increase of 4.890 of agricultural productivity. Second long run cointegrating vector is presented by the equation below:

$$REER=2.708LAX-0.825LGCF+0.970LGDP+ 10.445GE-73.228 \tag{12}$$

The results of the second cointegration show that a 1% increase in LAX will lead to 2.708 increase in real effective exchange rate. LGCF has a negative impact on real effective exchange rate by -0.825. The 1% increase in GDP will lead to an increase of 0.970 towards real effective exchange rate. Lastly a 1% increase in GE will lead to increase of 10.445 of real effective exchange rate. However, it should be noted that the second cointegrating vector interpretation is not the interest of the study but was interpreted on the basis of econometrics purpose. Nonetheless, the first cointegrating equation results are of interest of this study.

Finally, equation (6) indicates that a 1% increase in LGDP will lead to 0.386 increase in agricultural productivity. Moreover a 1% increase in GE will lead to 3.364 increase in agricultural productivity in the long run. An increase of 1% in LM2 indicates an increase in 0.835 in agricultural productivity. However, with 1% increase in REER, agricultural productivity decreases by approximately -0.004, despite that, it resulted to be statistically significant. The equation reflects that CPI has a negative long run relationship with agricultural productivity. Consequently, the results suggest that a 1% increase in CPI decreases agricultural productivity by -1.452. The CPI indicates that it is statistically significant along with LGDP, GE and LM2.

Tab. 8. Short run parameters results.

ORDER	Equation 4 Coefficient	Equation 5 Coefficient	Equation 6 Coefficient
ECT	-0.466 (-3.504)*	-0.883 (-4.455)*	-0.243 (-2.508)*
VARIABLES			
D(LGDP)	5.714 (4.022)*	6.101 (3.516)*	3.045 (4.654)*
D(GE)	-0.081 (-0.095)	0.069 (0.563)	0.058 (1.109)
D(GCF)	0.373 (2.256)*	-0.216 (-0.818)	-
D(RINT)	0.790 (0.096)	-	-
D(LM2)	-	-	0.167 (0.262)
D(REER)	-	58.043 (2.525)*	17.761 (1.288)
D(CPI)	-	-	-0.026 (-0.407)
D(LAX)	-	-0.113 (-0.240)	-

Notes: Values in brackets are t-statistics.
* Statistically significant at 1% level.
** Statistically significant at 5% level.
*** Statistically significant at 10% level.

VECM results in Table 8 are presented to capture the short run dynamics in agricultural productivity equation and to determine the speed of adjustment. The results for equation (4) point out that the speed adjustment is approximately 46.6%. This implies that, if there is any deviation from equilibrium, only 46.6% of agricultural productivity is corrected in a single year as the variable moves towards restoring equilibrium. Equation (5) shows that the speed of adjustment is 88.3% whereas only that percentage can be corrected in one year. The ECT is also statistically significant at 1% level. Furthermore equation (5) imposed restrictions also in the short run since there was existence of two cointegrating vectors. Therefore, the exogeneity test results are presented in the table below which shows speed adjustment in long run equilibrium.

In Table 9, the exogeneity shows LR of 0.474 and probability of 0.490 which indicate that the equations are well specified. The error correction term of first cointegrating equation is negative with coefficient of -0.030 and t-statistics of -2.652 which is statistically significant. This implies that 3.0% of gap between agricultural productivity and equilibrium is eliminated every year. In the second cointegrating equation the error correction term in 0.032 and its t-statistics is 2.996, implying that 3.2% is adjusted in one year. The restrictions are imposed on real effective exchange rate and agricultural exports in cointegrating equation (10). This indicates that the study of agricultural productivity can function without those two variables. The coefficient of error term in equation (6) is found to be negative but statistically significant at 1% level. Approximately 24.3% of long-run disequilibrium is adjusted from lagged period

Tab. 9. Exogeneity test for Equation 10.

	Cointegrating equation 1	Cointegrating equation 2
ECT	-0.030 (-2.652)	0.032 (2.996)
D(LREER)	6.731 (5.196)	0.000 (NA)
D(AX)	0.017 (0.658)	0.000 (NA)
D(GCF)	-0.021 (-3.382)	-9.000 (0.007)
D(LGDP)	-0.492 (-4.849)	0.585 (-6.019)
D(GE)	0.003 (0.474)	-0.001 (-0.270)

LR test for binding restrictions (rank=2): X^2 = 0.474.
Probability = 0.490.

Tab. 10. Granger causality results.

Equation	Null hypothesis	Obs	Chi-Sq	Prob
4	Dlog_GDP does not granger cause Dlog_AGRI	37	5.374	0.068
	Dlog_AGRI does not granger cause Dlog_GDP	37	7.734	0.021**
	Dlog_GCF does not granger cause Dlog_AGRI	37	5.055	0.082
	Dlog_AGRI does not granger cause Dlog_GCF	37	2.091	0.352
	Dlog_GE does not granger cause Dlog_AGRI	37	13.323	0.001**
	Dlog_AGRI does not granger cause Dlog_GE	37	0.539	0.764
	Dlog_RINT does not granger cause Dlog_AGRI	37	5.048	0.080
	Dlog_AGRI does not granger cause Dlog_RINT	37	0.615	0.735
5	Dlog_REER does not granger cause Dlog_AGRI	39	0.119	0.730
	Dlog_AGRI does not granger cause Dlog _REER	39	0.647	0.421
	Dlog_AX does not granger cause Dlog _AGRI	39	2.901	0.089
	Dlog_AGRI does not granger cause Dlog_AX	39	0.899	0.343
	Dlog_GCF does not granger cause Dlog _AGRI	39	0.177	0.674
	Dlog_AGRI does not granger cause Dlog _GCF	39	1.070	0.301
	Dlog_GDP does not granger cause Dlog _AGRI	39	0.116	0.733
	Dlog_AGRI does not granger cause Dlog _GDP	39	1.070	0.301
	Dlog_GE does not granger cause Dlog _AGRI	39	4.289	0.038**
	Dlog_REER does not granger cause Dlog _GE	39	0.096	0.757
6	Dlog_CPI does not granger cause Dlog_AGRI	39	7.138	0.028**
	Dlog_AGRI does not granger cause Dlog_CPI	39	0.006	0.998
	Dlog_GDP does not granger cause Dlog_AGRI	39	9.755	0.008**
	Dlog_AGRI does not granger cause Dlog_GDP	39	5.703	0.058
	Dlog_GE does not granger cause Dlog_AGRI	39	18.103	0.000**
	Dlog_AGRI does not granger cause Dlog_GE	39	1.118	0.572
	Dlog_M2 does not granger cause Dlog_AGRI	39	1.398	0.497
	Dlog_AGRI does not granger cause Dlog_M2	39	5.663	0.059
	Dlog_REER does not granger cause Dlog_AGRI	39	2.078	0.354
	Dlog_AGRI does not granger cause Dlog_REER	39	1.961	0.375

Notes: Granger cause if P< 0.05.
* Statistically significant at 1% level.
** Statistically significant at 5% level.
*** Statistically significant at 10% level.

error shock. The diagnostic checks for the study were performed to the agricultural productivity models to validate the evaluation of parameter outcomes achieved by the three equations. In most of the checks the models have satisfied all the assumptions of linear modelling. Thus, after validating the parameters outcomes for the equations granger causality test is determined. According to Granger (1969) the test gives direction of casual association among the variables and it establishes directional causality between the two variables. Table 10 below gives an indication of causality results among the variables from equation (4), (5) and (6).

As stated by Erjavec and Cota (2003), if common trend exists between two variables then causality should exist in, at least, one direction. Therefore, after conducting the granger causality test in all three equations, the results show that government expenditure in all estimations granger causing agricultural productivity. It indicates that it is the most influential macroeconomic variable towards agricultural productivity. Following is gross domestic product in equation (4) and equation (6) whereas in equation (4) agricultural productivity granger causes gross domestic product and equation (6) is vice versa, where gross domestic product granger causes agricultural productivity. In equation (6) consumer price index granger causes agricultural productivity however the remaining variables do not have any casual relation with agricultural productivity. Overall, granger causality test results indicate that there is significant impact of macroeconomics variables towards agricultural productivity and vice versa. In summary, some of causalities in this study are similar to those of Kadir and Tunggal (2015).

5. CONCLUSION AND RECOMMENDATIONS

The purpose of this study was to investigate the impact of macroeconomic variables towards agricultural productivity in South Africa. On the estimation technique, the study employed VECM procedures for the period covering 1975 to 2016 using annual data. The results of Johansen cointegration show that there is long run relationship existing among variables within the three equations estimated. Furthermore, results from VECM indicated a positive relationship between most of macroeconomic variables and agricultural productivity, thus showing that an increase in GE, LGCF, LAX, LGDP and LM2 will lead to a certain increase of agricultural productivity.

The study has also determined the speed of adjustment for each estimated model, showing the correct expected signs. The equation (4) revealed a 46.6% convergence towards equilibrium in the long run compared to equation (5) of 88.3% and equation (5) of 24.3%. This concluded that equation (6) has the lowest speed of adjustment compared to other equations. Furthermore, the study applied granger causality and it was found that there is causality existing between macroeconomic variables and agricultural productivity in South Africa. It is on this base that the study recommends that government spend more on agricultural sector so that the sector can be able to acquire advanced machineries to increase its productivity. Also, policy makers should encourage the use of those machineries for the sector to maximize their production. As per estimation of results, the more productivity of the agricultural sector the more products can be exported to other countries, leading to an increase of foreign earnings. Moreover, increased capital formation through investment on labor, land and other agricultural machineries will tend to increase productivity, as it will enable farmers to use resources efficiently. Policy makers should also ensure sufficient financial support from both private and public sector as it can guarantee maximum productivity and development of the agricultural sector. This study could not focus on all aspects impacting agricultural productivity in South Africa. For example, it investigated only certain key macroeconomic variables, rather than the environmental factors such as land, climate, soil and water which also have an impact on the productivity of agriculture. Due to the lack of sufficient and consistent available data some of the macroeconomic variables were not included in the study, however for future studies, when data become available some environmental variables which were left out in the study may be incorporated.

REFERENCES

Abba M., Barros C., Mosca J. (2015). The macroeconomy and agricultural production in Mozambique. *Basic Research Journal of Agricultural Science and Review*, 4 (8): 246-255. Available at: https://basicresearchjournals.org/agric/pdf/Abbas%20et%20al.pdf (accessed 05 November 2018).

Awan A.G., Alam A. (2015). Impact of agriculture productivity on Economic growth. A case study of Pakistan, 5(7). Available at: https://iiste.org/Journals/index.php/IEL/article/viewFile/23896/24467 (accessed 10 November 2016).

Awokuse O.T. (2009). Does Agriculture Really Matters for Economic Growth in Developing Countries? 2009 Annual Meeting, July 26-28, Agricultural and Applied Economics Association. Available at: https://core.ac.uk/download/pdf/7130483.pdf (accessed 08 November 2016).

Bentivoglio D., Finco A., Bucci G. (2018). Factors affecting the Indonesian Palm Oil Market in Food and fuel industry: Evidence from a time series analysis. *International Journal of Energy Economics and Policy*, 8(5): 49-57. Available at: https://www.econjournals.com/index.php/ijeep/article/download/6795/3924 (accessed 08 November 2018).

Bhide S., Rajeev M., Vani B. (2005) Do Macroeconomics Conditions Matter for Agriculture. The Indian Experience. Institute for Social and Economic Change. 55(4): 647-670. DOI: 10.1142/s0217590810003997

Bureau for Food and Agricultural Policy (2011). The South African Agricultural Baseline. Available at: http://www.sagis.org.za/BFAP_2011.pdf (accessed 10 December 2016).

Brownson S., Vincent I., Emmanuel G., Etim D. (2012). Agricultural productivity and Macroeconomic variable fluctuation in Nigeria. *International Journal of Economics and Finance*, 4 (8). DOI: 10.5539/ijef.v4n8p114

Cristea M., Marcu N., Meghisan G. (2015). The Influence of Macroeconomic Variables on the Romanian agriculture. The publishing house of the Romanian academy, Available at: https://pdfs.semanticscholar.org/882f/e42656cbbfab88a4b033dc350846da85fa1e.pdf?_ga=2.158678136.333063144.1563612371-1311250018.1563612371 (accessed 11 January 2017).

Department of Agriculture Forestry and Fisheries (2015). Economic review on the South Africa African agriculture. Pretoria. Available at: https://www.daff.gov.za/Daffweb3/Portals/0/Statistics%20and%20Economic%20Analysis/Economic%20Analysis/Economic%20Review_2014_15.pdf (accessed 05 December 2016)

Department of Agriculture Forestry and Fisheries (2017). Trends in the agricultural sector. Available at: https://www.daff.gov.za/Daffweb3/Portals/0/Statistics%20and%20Economic%20Analysis/Economic%20Analysis/Economic%20Review%202016_17.pdf (accessed 02 August 2017).

Debrew J.H., Cervantes-Godoy D. (2010). Economic Importance of Agriculture for Poverty Reduction. *OECD Food, Agriculture and Fisheries Working Papers* No. 23. OECD Publishing. DOI:10.1787/5kmmv9s20944-en

Dickey D.A., Fuller W.A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root, *Journal of the America Statistics Association*, 74 (366): 427-431. DOI: 10.2307/2286348

Dritsakis N. (2003). The agricultural sector in the Macroeconomic Environment. An Empirical Approach for EU. University of Macedonia, 1(4). Available at https://ideas.repec.org/a/ags/aergaa/26419.html (accessed 02 August 2017).

Eita J.H., Jordaan A.C. (2013). Real Exchange Rate Misalignment and Economic Perfomance in Namibia. Coporate Ownership and Control, 10(3). Available at: http://hdl.handle.net/2263/43869 (accessed 01 June 2018).

Enu P., Attah-Obeng P. (2013). Which macroeconomic factors influence agricultural production in Ghana? *Academic Research international*, 4 (5): 333-346. Available at: http://www.savap.org.pk/journals/ARInt./Vol.4(5)/2013(4.5-33).pdf (accessed 01 June 2018).

Erjavec N., Cota B. (2003). Macroeconomic Granger-casual dynamics in Croatia: Evidence based on a vector error-correction modeling analysis. *Ekonomski pregled*, 54(1-2): 139-156. Available at: https://hrcak.srce.hr/25291 (accessed 01 June 2018).

Granger C.W.J. (1969). Investigating Causal Relations by Econometric Models and Cross-Spectral Methods. *Journal of Econometrica,* 37: 424-38. DOI: 10.2307/1912791

Huffman W.E., Evenson R.E. (2001). Structural and Productivity Change in US agriculture, 1950-1982. Agricultural Economics, 24 (2):127-147. DOI: 10.1016/S0169-5150(00)00065-7

Johansen S. (1991). Estimation and Hypothesis Testing of Co-integration Vectors in Gaussian Vector Autoregressive Models. *Econometrica*, 59: 1551-1580. DOI: 10.2307/2938278

Johansen S. (1995). Likelihood-Based Inference in Cointegration Vector Auto-Regressive Models. *Economic Theory.* 14(4): 517-524. Available at: https://www.jstor.org/stable/pdf/3533216.pdf?refreqid=excelsior%3A2b38df47e9d037316b88a922d6f8fe62 (accessed 01 June 2018).

Kaabia M.B., Gil J.M. (2000). Short and long run effects on macroeconomic variables on the Spanish agricultural sector. *European review of Agricultural Economics.* 27 (4): 449-471. Available at: https://ideas.repec.org/a/oup/erevae/v27y2000i4p449-471.html (accessed 20 July 2018).

Kadir S.U.S.A., Tunggal N.Z. (2015). The impact of macroeconomic variables towards agricultural productivity in Malaysia. *South East Asia journal of Contemporary Business Economics and Law*. University of Malaysia Sabar, 8 (3):21-27. Available at: http://seajbel.com/wp-content/uploads/2016/01/Econ-13.pdf (accessed 01 June 2018).

Kargbo M.J. (2007). The effects of macroeconomic factors on South African agriculture. *Applied Economics*, 39(17): 2211-2230. DOI: 10.1080/00036840600735374

Letsoalo A., Kirsten J. (2003). Modeling the impacts of macroeconomic and trade policies on the South Africa agricultural sector. Agricultural Economic Association of South Africa. Available at: https://ageconsearch.umn.edu/record/19085/files/cp03le02.pdf (accessed 08 November 2016)

Mellor J.W. (1966). The Economics of Agricultural Development, American *Journal of Agricultural Economics*, 49(2): 533-535. DOI: 10.2307/1237235

Oyetade O., Applanaidu S.D., Abdul-Razak N.A. (2015). Macroeconomic factors and agricultural sector in Nigeria, University of Utara, Malaysia, Elsevier Ltd. DOI: 10.1016/j.sbspro.2016.05.035

Perron P. (1986). Trends and Random Walks in Macroeconomic Time Series: Further Evidence from a New Approach. Universite de Montreal, Department de sciences economiques. *Biometrika*, 75(2): 335-346. https://doi.org/10.1016/0165-1889(88)90043-7

Quantec (2017). RSA economic data. Available at: http://quanteceasydata.co.za, (accessed 01 December 2016).

Ramalai M., Mahlangu S., Tuit D. (2011). Agricultural productivity in South Africa: Literature

Review, Department of Agriculture Forestry and Fisheries. Available at: https://www.daff.gov.za/docs/GenReports/AgricProductivity.pdf (accessed 11 January 2017).

Schultz T.W. (1964). Transforming the Agriculture. *The Economic Journal,* 74(296):996-999. DOI: 10.2307/2228861.

Solow R.M. (1956). A contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 70: 65-94. DOI: 10.2307/1884513

Wang S.L., Heisey P., Schimmelpfennig D., Ball E. (2015). Agricultural Productivity Growth in the United States: Measurement, Trends and Drivers. U.S Department of Agriculture, Economic Research Service. Available at: https://ideas.repec.org/p/ags/uersrr/207954.html (accessed 01 July 2019).

World Bank (2017). South African dataset; World Economic Indicators. Available at: http:/data.worldbank.org. (accessed 03 March 2018).

World Trade Organisation (2017). Statistics database. Available at: http://stat.wto.org. (accessed 29 November 2016).