



Crop Production, Livestock Production and Economic Growth in Botswana (1990-2017): An Application of ARDL Model

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ABSTRACT

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There are few studies in Botswana which have examined the relationship between agriculture and economic growth. The uniqueness of this study is grounded in investigating disintegrated agriculture components into crop production and livestock production and investigating their nexus with economic growth. This study estimated the short and long term effects between crop production, livestock production and economic growth in Botswana for the period 1990 to 2017. The Auto-Regressive Distributed Lagged (ARDL) bounds testing approach was employed to investigate the stated relationship. Study findings from the ARDL bound testing approach confirm evidence of a long-run equilibrium relationship between crop production, livestock production and economic growth. Results indicated that livestock production has a positive and significant impact on economic growth both in the short run and long run. On the other hand crop production has a positive and significant impact on economic growth only in the long run. Efforts towards supporting agricultural sector growth should be emphasized to promote agricultural sector productivity in a bid to forge a move away from dependence on imports of food in Botswana. To enhance economic growth, in both the short run and long run, the government of Botswana and all relevant stakeholders should invest in and promote livestock production. In the long term, policies that foster crop production are essential for economic growth.

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Introduction

Economic growth is proposed to be one of the primary and fundamental objectives of developing countries (Hussain and Khan, 2011). For most of these developing countries, the agriculture sector is generally observed as an engine for growth (Byerlee et al., 2005; Headey et al., 2005; Awokuse, 2008). Theoretically and empirically there is consensus that a change in agriculture could change an economy's overall output (Johnston and Mellor, 1961; Jorgenson, 1961; Chennery and Strout, 1966; Dawson, 2005; Tiffin and Irz, 2006).

However, the balance between agriculture and industry in the growth of developing countries is still an issue of debate. Ghatak (2003); Ofori (2006) and Tandrayen-Ragoobur (2010) noted that many developing countries notably Southern African countries, in their need for rapid economic growth, have sought to promote industrialization as quickly as possible. Despite various policies, trade agreements and growth enhancing policies, the growth prospects in African countries remained minimal. Southern

African countries have been pointed as lagging behind their Northern and Western African counterparts in terms of growth and development (World Bank, 2008).

Botswana's economic growth after its independence in 1966 was regarded as nothing short of a miracle. However, challenges which include food import dependence, youth unemployment, land shortages and slow agro-processing sector growth have been affecting Botswana. Lack of a dynamic agriculture sector and pro-service and mining industries policies in the twenty first century has limited Botswana's potential for growth and development (Badiane and Makombe, 2014). Although the contribution of the agriculture sector to GDP is minimal, it is vital to livelihood for many Botswana who operate farms for subsistence. Livestock production, especially cattle, contributes an estimated 80% to the agricultural GDP (MoA, 2017). Botswana's agriculture national significance stems from the fact that close to 50 per cent of the total population live in rural areas, and a significant proportion

of those rural dwellers still depend on agriculture for a substantial portion of their incomes and livelihoods (WDI, 2017). The agriculture sector accounts for 25 per cent of total employment, both formal as well as informal, (FAO, 2016).

The performance of the Botswana economy in recent years is shown on Table 1.

Botswana has maintained impressive economic growth and low stable inflation rate between 2010 and 2015. Interest rates have continually decreased which has been good for attracting investments. Most of the population reside in urban areas as compared to rural areas because people seek better amenities and job opportunities and better living standards in towns and cities. Imports have been continually higher than exports over the study period (FAO, 2016). Agriculture productivity in Botswana has been stagnant for the past three decades due to various socio-economic, environmental and technological factors (Leinberg, 2013; and MoA, 2017).

Agriculture food deficit draws down reserves for the country (Mazonde, 1993; and Jefferis and Nemaorani, 2014). There is need to improve production skills so as to increase agriculture output (Mbulawa, 2017). Of note is that livestock rearing is Botswana's key agricultural output and export (Makoni, 2015). The crop sub-sector is dominated by the growth of cereals, but is limited by unreliable rainfall, constrained productivity in the sector, and the fact that desert and poor soils cover 70% of the country (FAO, 2016).

Agriculture, value added, as a proportion to Gross Domestic Product (GDP) decreased significantly between 1980 and 2016 (FAO, 2016). The same trend was also expected for employment in agriculture (% of total employment). However, Botswana actually recorded increases in employment in agriculture. Botswana posted an increase from 26.4% to 29.9% between 2000 and 2016 (FAO, 2016). This further reiterates the importance of agriculture in Botswana and the need to promote agriculture growth as it has a large bearing on the livelihoods of many households and as a key driver of economic growth.

Agriculture's declining share of national output during the economic transformation is particularly responsible for the widespread misunderstanding in many countries that agriculture is unimportant and does not require public investment and a favorable policy environment (Timmer, 1990). But Timmer shows that the combination of agricultural growth and relative decline in economic growth is not a paradox of a normal and desirable process and that continuing public and private investments in

agriculture are essential to completing the transformation process. This is not the case for Botswana whose support for the agricultural sector has continued to decline over the years.

The objective of this paper is to analyze the impact of crop production and livestock production on economic growth in Botswana. Hence this study seeks to answer the following research questions:

- What is the impact of crop production on economic growth in Botswana?
- What is the impact of livestock production on economic growth in Botswana?

The motivation of the paper is based on the notion that theory presents a strong case for the positive influence of aggregate agriculture on economic growth, however empirical evidence on the effect of particular agriculture sub sectors is limited. The norm has been generalizing agriculture in totality instead of focusing on its various sub-sectors. On this front, this study extends the agriculture contribution by reviewing two main sub-components indicators of agriculture in Botswana namely crop production and livestock production. Such inferences especially on crop production will enable the study to provide specific recommendations which can aid developing countries in achieving not only increase in production but also food security, poverty reduction and economic growth.

Some scholars believe that the development of the agriculture sector is a precondition of growth (Ehui and Tsigas, 2009; Ocholi, 2011; and Herath, Bashir, Gebremedhin, 2013), others are of the belief that industrial sector development is a pre-condition to growth in the economy (Szirmai, 2009; and Loto, 2012). Empirical evidence on agriculture sector effect on economic growth in Botswana is also limited.

Advocates of agriculture-led growth contended that development of the agriculture sector was a pre-requisite for industrialization through rural income increase, raw materials provision and resource release to support the industry (Chennery and Strout, 1966). Neglecting the agriculture sector in favor of the industrial sector would thus lead to slow economic growth (Riezman, 1996). Early advocates like physiocrats argued that development of an economy depended on agriculture sector growth. Physiocrats emphasized that agriculture was critical in economic development and the economy was regulated by productivity in agriculture (Matthew and Mordecai, 2016).

Table 1. Botswana - Performance of the economy in recent years

	2010	2011	2012	2013	2014	2015
GDP per capita (US\$)	6,346.1	6,610.3	6,779.3	7,409.4	7,574.2	7,308.6
Imports (US\$) ('000 000)	6,554	7,815	10,322	11,431	11,371	11,413
Exports (US\$) ('000 000)	5,579	7,116	8,386	11,430	11,321	10,212
Lending interest rate (%)	11.4	11	11	10.1	9	7.95
Inflation (%)	6.9	8.4	7.5	5.8	4.4	3
Rural population	881,806	893,009	904,694	916,578	928,431	940,146
Urban population	1,133,060	1,158,330	1,184,621	1,211,929	1,240,142	1,269,051
Exchange rate (LCU per US\$)	6.7	6.8	6.8	8.3	8.9	10.1

Source: WDI, (World Bank, 2017)

Fisher- Clark theory of structural change by Fisher (1935) and Clark (1940) stated that every economy pass through three stages - agricultural, industrial and then services. Hirschman (1958) also strongly influenced development philosophy in the fifties. Hirschman proposed the concept of linkages as a tool for examining how investment in one type of activity induced successive investment in the other income-generating activities. This influenced the development thinking which supported import substitution industrialization as well as agriculture being a supportive role to the industrial sector. The notion of agriculture led growth approach was thus further influenced by Johnston and Mellor (1961), as well as Schultz (1961) among others. Emphasis was put on the role of smallholder farming in stimulating growth and development. (Prebisch and Singer, 1949; Rostow, 1960; Jorgenson, 1961; Fei and Ranis, 1961).

Other advocates of the process of development being characterized by a movement of labour from low-productivity agriculture to high-productivity manufacturing also cropped up (Lewis, 1954; Johnston and Mellor, 1961; Kuznets, 1968). Schultz (1964) was among the earlier economists who emphasized that productivity led agricultural transformation could make a much more important contribution to the economy than just providing surplus labour and savings to support industrialization. These sector linkages were further emphasized by Singer (1979) who stated that, because of production and consumption linkages, a country's development strategy should not be export driven but rather agriculture driven. Therefore, increased agricultural productivity would be the initiator of industrialization (Dethier and Effenberger, 2011).

Jatuporn et al. (2011) investigated the long run relationship between agriculture and economic growth for Thailand between 1961 and 2009. The study findings revealed a long run relationship between agriculture and economic growth and concluded that policy makers should regard agriculture as playing an important role in enhancing economic growth. Faridi (2012) employed the Johansen's cointegration technique for the period 1972 to 2008 to examine the contribution of agricultural exports to economic growth. The study findings showed that the agricultural exports had a negative and significant effect on economic growth. Thus, the study suggested the promotion of non-agricultural exports.

Vogal (1994) as cited in (Byerlee et al., 2005) analysed the strength of agriculture sector as a factor of economic growth for 27 countries. He discovered that agriculture through its backward and forward linkages leads to positive integration of the sector with the broader economy. Using ordinal least square regression analysis method Onunze (2012) found out that agriculture influenced economic growth positively.

In North Carolina, for the period 2000 to 2010, Herath, Bashir and Gebremedhin (2013) examined the relationship between agricultural sector and economic growth. Increasing income was found to increase agricultural activities and vice versa. The study concluded that countries with high income were more capable of improving agriculture production as high income would prompt more investment in the agricultural sector, thereby increasing production. Farooqi and Qureshi (2015) investigated agriculture sector share role in Pakistan's

GDP. Data for 1975 to 2012 period was used. For estimation of the parameters, the ordinary least squares methodology was employed. Several variables which include industry, agriculture and trade were reviewed. The study results reflected significant and positive relationship between agriculture and GDP.

A causal relationship between agricultural value addition and economic growth in Namibia employing annual data for the period 1980 to 2015 was investigated by Odero (2017). Using the Vector Autoregressive approach, the results revealed a unidirectional causal relationship running from agricultural value added to economic growth. More studies also pointed to the important role of agriculture to economic growth (Arndt et al., 2000; Thirtle et al., 2001; Hanmer and Nashchold, 2000; Irz et al, 2001; Kanwar, 2000; Matsuyama, 1992; Ravallion and Datt, 1999; Stern, 1996; Timmer, 2003; Wichmann, 1997; Dorosh et.al, 2003; Byerlee, De Janvry and Sadoulet, 2009; Awokuse and Xie, 2015).

Initially based on agriculture and heavily dependent on foreign aid, the rapid economic growth and general development in Botswana have been driven by the mining sector, (Maipose and Matsheka, 2010). With a decrease in international mineral prices and depletion of the non-renewable mining resources, the need to diversify the economy so as to ensure sustainable economic growth has been of great concern. Accelerating productivity in agriculture is seen as one of the alternatives to support the diversification initiatives by the government and drive growth in Botswana (Mbulawa, 2017). Mbulawa (2017) investigated the relationship between agriculture productivity and economic growth in Botswana. Results of the study showed that economic growth can be improved in the short term by improvements in agricultural productivity. Agricultural productivity can be enhanced by providing adequate infrastructure, additional farming machinery per hectare of arable land and having a targeted approach in the provision of funding towards agricultural oriented initiatives.

A study by the GoB (2008) on diversification of the Botswana economy possibilities concluded that agriculture provides an avenue for diversification with potential contribution to economic growth, employment and poverty reduction. Hence, meaningful diversification of the economy can be achieved by supporting agro-based projects. Agriculture has potential to create a new platform for exports and to bring meaningful industrial activity among the rural populace. Matambo (2014) also reiterated that agriculture in Botswana is labour intensive absorbing much of the unskilled labour force. It has potential to be part of the global value chains and gain access to prime international markets.

In earlier debates on economic development, the agricultural sector's role was somewhat controversial. While dualistic models highlighted the importance of agriculture, the mainstream literature placed a greater emphasis on the creation of a modern industrial sector. Soon agriculture disappeared from the mainstream development literature to re-emerge recently with a variety of multiple-sector growth models emphasizing the key role of agriculture in economic growth. This paper seeks to re-examine the impact of agriculture via disaggregated sectors (crop production and livestock production) on economic growth using modern econometric techniques.

Materials and Methods

Autoregressive Distributed Lag (ARDL) procedure will be adopted to estimate long run and short run dynamic interactions. ARDL approach includes lags of both endogenous variable and exogenous variables as regressors

(Greene, 2008). Pesaran and Shin (1999) and Pesaran et al. (2001) developed the ARDL method. The ARDL representation of the general empirical model to be estimated in this study is specified in equation (1):

$$\begin{aligned} \Delta OUTP_t = & \psi_0 + \sum_{k=1}^p \psi_{1k} \Delta OUTP_{t-k} + \sum_{k=0}^{q_1} \psi_{2k} \Delta AGRI_{t-k} + \sum_{k=0}^{q_2} \psi_{3k} \Delta CAPL_{t-k} \\ & + \sum_{k=0}^{q_3} \psi_{4k} \Delta LABR_{t-k} + \sum_{k=0}^{q_4} \psi_{5k} \Delta EXPO_{t-k} + \sum_{k=0}^{q_5} \psi_{6k} \Delta INFL_{i,t-k} + \beta_1 OUTP_{t-1} \\ & + \beta_2 AGRI_{t-1} + \beta_3 CAPL_{t-1} + \beta_4 LABR_{t-1} + \beta_5 EXPO_{t-1} + \beta_6 INFL_{t-1} + \eta_{1t} \end{aligned} \tag{Eq(1)}$$

Where: *OUTP* – Economic growth; *AGRI* - Agriculture production; *CAPL* - Capital; *LABR* - Labour; *EXPO* - Exports; *INFL* - Inflation; ψ_0 -constant; β_1, \dots, β_6 , and $\psi_{1k}, \dots, \psi_{6k}$ are the respective coefficients; Δ - the first-difference operator;

p, q_1, q_2, q_3, q_4 and q_5 are optimal lag length; t is the time period and; η_{1t} - the error term that are assumed to be normally distributed and white noise. Considering main subcomponents of agriculture in Botswana namely crop production and livestock production we have:

$$\begin{aligned} \Delta OUTP_t = & \psi_0 + \sum_{k=1}^p \psi_{1k} \Delta OUTP_{t-k} + \sum_{k=0}^{q_1} \psi_{2k} \Delta CROP + \sum_{k=0}^{q_1} \psi_{3k} \Delta ANIM_{t-k} \\ & + \sum_{k=0}^{q_2} \psi_{4k} \Delta CAPL_{t-k} + \sum_{k=0}^{q_3} \psi_{5k} \Delta LABR_{t-k} + \sum_{k=0}^{q_4} \psi_{6k} \Delta EXPO_{t-k} \\ & + \sum_{k=0}^{q_5} \psi_{7k} \Delta INFL_{i,t-k} + \beta_1 OUTP_{t-1} + \beta_2 CROP_{t-1} + \beta_3 ANIM_{t-1} + \beta_4 CAPL_{t-1} \\ & + \beta_5 LABR_{t-1} + \beta_6 EXPO_{t-1} + \beta_7 INFL_{t-1} + \eta_{2t} \end{aligned} \tag{Eq(2)}$$

Where: *CROP* – Crop production and *ANIM* – livestock production. The optimal lag structure will be selected using SBC. Initial step in the ARDL method is used for estimation of equations (2) by Ordinary Least Squares (OLS). F-test will be applied to test for existence of long-run relationship between variables by restricting coefficients of lagged levels of variables to zero. The above model is estimated for Botswana. The test imposes the following null hypotheses of no cointegration relationship:

$$H0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$$

Tested against the alternative hypothesis of the existence of a cointegration relationship:

$$H1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$$

For a given level of significance two critical value sets can be determined (Pesaran et al., 2001). First level is estimated assuming that all variables in ARDL model are zero order integrated, while second level is estimated

assuming all variables are order one integrated. Null hypothesis of no cointegration will be rejected if test statistic value is above upper critical bounds value, and will not be rejected when the F-statistic is below the lower bounds value. Otherwise, the cointegration approach would be inconclusive if the result of the F-statistic lies in-between the critical value of lower bounds and critical value of the upper bounds.

ARDL approach is preferred for this study as it can be used for small sample size for more robust and consistent results. ARDL approach is not restricted by the order of integration amongst the variables as it can be applied whether the variables under the study are not integrated of the same order. Finally, different number of lags is plausible for different variables under the ARDL approach (Nayaran, 2005).

Error Correction Model

The error correction model, associated with the long-run equation above, is represented by:

$$\begin{aligned} \Delta OUTP_t = & \psi_0 + \sum_{k=1}^p \psi_{1k} \Delta OUTP_{t-k} + \sum_{k=0}^{q_1} \psi_{2k} \Delta CROP_{t-k} + \sum_{k=0}^{q_1} \psi_{3k} \Delta ANIM_{t-k} + \sum_{k=0}^{q_2} \psi_{4k} \Delta CAPL \\ & + \sum_{k=0}^{q_3} \psi_{5k} \Delta LABR_{t-k} + \sum_{k=0}^{q_4} \psi_{6k} \Delta \ln EXPO_{t-k} + \sum_{k=0}^{q_5} \psi_{7k} \Delta \ln INFL_{t-k} + \lambda ECM_{t-1} \\ & + \mu_t \end{aligned} \tag{Eq(3)}$$

Where all the variables are as already defined, with the exception of ECM_{t-1} , which is the error correction term lagged one period and its coefficient (λ). The coefficient of the error-correction term lagged one period (ECM_{t-1}), which is also the speed of adjustment parameter, is expected to be negative and statistically significant to further confirm the existence of a cointegration relationship.

Results and Discussion

Unit Root Tests

Time series unit root tests was carried out using the Perron (1997) Unit Root test (PPURoot) as shown on Table 2.

For Botswana, Table 2 above confirms that all the variables under consideration are at most integrated of order 1. The ARDL approach is only applicable for the analysis of variables that are integrated of an order not more than one. Table 2 confirms that the ARDL bounds testing procedure will not breakdown because all variables are integrated of maximum order 1.

Cointegration Test – ARDL

The existence of cointegration between variables was tested using the ARDL bounds testing approach to cointegration. Schwartz Bayesian Criterion (SBC) was used to select the appropriate lag length.

SBC was used for selection of the lag length. Table 3 above presents the empirical results of the ARDL bounds tests for cointegration.

Bounds F-test for cointegration indicates that the computed F-statistic is greater than the upper critical bound at the 1% level of significance. This implies that there is cointegration between the series and it confirms that output, crop production, livestock production, capital, labour, exports and inflation are cointegrated over the period of study. Thus, given the confirmation of cointegration, the optimal lag length selected based on SIC is ARDL (1,0,0,1,1,2,1). The results from the bounds cointegration test indicate that both long run and short-run relationships exist for the variables under study.

Table 4 and Table 5 shows the estimated long run and short run results respectively. Table 4 presents the results of the long run coefficient estimates of the ARDL model. Consistent with economic theory, crop production and livestock production have a positive and significant effect on economic growth in the long run. This can be stated that, in the long-run, an increase in crop production and livestock production would result in an increase in economic growth respectively. Thus crop and livestock production drives the agriculture sector which presents an opportunity to drive economic growth expansion. These results are similar to the findings of Oje-Okoro, (2011); Izuchukwu, (2011); Behnke and Muthami, (2011); and Gelan, Ermias, Stefano and Kaugia, (2012).

Other results from Table 4 show that the coefficient of capital is positive and significant in the long run. This confirms a positive impact of capital on economic growth in Botswana.

Table 2. Unit Root Tests for Botswana - Perron (1997) Unit Root Test (PPURoot)

Variable	OI	Stationarity in levels		Stationarity in first differences	
		Without trend	With trend	Without trend	With trend
OUTP	I(1)	-4.46632	-4.27576	-9.61838***	-8.23235***
CAPL	I(1)	-4.57928	-4.34301	-6.23771***	-6.47043***
LABR	I(1)	-4.78102	-3.08174	-6.52858***	-9.71355***
EXPO	I(0)	-5.81673**	-6.52163***	-	-
INFL	I(0)	-5.57397**	-5.74695**	-	-
CROP	I(1)	-3.82944	-3.12687	-6.6723***	-6.12042**
ANIM	I(0)	-6.20203***	-7.27585***	-	-

OI: Order of integration, Note: *, ** and *** denote stationarity at the 10%, 5% and 1% significance levels respectively

Table 3. Bounds F-Test for Cointegration

Dependent Variable	Function	F-statistic	Cointegration Status		
OUTP	F(OUTP CROP, ANIM, CAPL, LABR, EXPO, INFL)	5.1967***	Cointegrated		
Asymptotic Critical Values includes unrestricted intercept and no trend		1% level	5% level	10% level	
Pesaran et al. (2001:300) Table CI(iii) Case III		3.15	4.43	2.45	3.61
				2.12	3.23

Note: *, ** and *** denotes significance at the 10%, 5% and 1% significance levels respectively

Table 4. Estimated Long-run Coefficients

Panel A: Estimated Long-Run Coefficients – Dependent Variable is OUTP				
Regressor	Coefficient	Standard Error	T-Ratio	Prob-Values
CROP	0.2723	0.10516	2.590	0.022**
ANIM	0.01267	0.00698	1.81307	0.071*
CAPL	0.61143	0.09723	6.28915	0.000***
LABR	-0.2037	0.2516	-0.8097	0.433
EXPO	0.24451	0.1440	1.6975	0.113
INFL	-0.29212	0.12808	-2.28041	0.023**
C	-3.3971	11.9341	-0.2847	0.780

Table 5. Estimated Short-Run Coefficients

Panel B: Estimated Short-Run Coefficients – Dependent Variable is dOUP				
Regressor	Coefficient	Standard Error	T-Ratio	Prob-Values
dCROP	0.0273	0.0906	0.3016	0.767
dANIM	0.1859	0.0779	2.3874	0.029***
dCAPL	0.2317	0.0741	3.1274	0.006***
dLABR	-0.2047	0.2623	-0.7804	0.446
dEXPO	0.6232	0.1079	5.7746	0.000***
dINFL	-0.3098	0.1483	-2.0884	0.052*
ECM (-1)	-0.7110	0.1819	-5.4643	0.000***

R-Squared 0.9273 R-Bar-Squared 0.8602
S.E. of Regression 2.2665 F-Stat.F(8,17) 20.7339 [0.000]
Residual Sum of Squares 66.7811 DW-statistic 2.0803
Akaike Info. Criterion -62.1556 Schwarz Bayesian Criterion -70.3332

Note: *, ** and *** denotes significance at the 10%, 5% and 1% significance levels respectively

Table 6. ARDL-ECM Diagnostics Tests for Botswana

LM Test Statistics	Results
Serial Correlation	3.0898 [0.079]
Functional Form	10.3128 [0.001]
Normality	0.6066 [0.738]
Heteroscedasticity	0.1392 [0.709]

These results are similar to findings by Beddies, (1999); Aubyn and Afonso (2008); and Assaf (2014) who found a positive and significant relationship between capital and economic growth in developing countries. Furthermore, in line with economic theory, inflation has a negative and significant effect on economic growth in the long run. This implies that price instability has a negative impact on economic growth in Botswana. These results are similar to Manoel (2010), Ziaur (2013), Ferdinand and Isidore (2014); and Chude and Chude (2015).

Table 5 indicates that livestock production has a significant and positive impact on economic growth while crop production has a positive but insignificant impact on economic growth in the short run. Crop production is severely affected by land type, ownership and fertility as well as erratic rains in Botswana. Hence majority of farmers in Botswana are into livestock production as the semi-arid climatic conditions are more suitable for livestock production (Badiane and Makombe, 2014).

From table 5, it can be stated that, in the short-run, an increase in capital by 1% would result in 0.23% increase in economic growth. This results conforms to the study expectations and economic theory. This implies a positive impact of capital on economic growth in Botswana. This result is similar to the findings of Sallam, (2014); and Makuyana and Odhiambo, (2018). More so, exports exhibited a positive sign and it was significant at 1% in the short-run. Empirical results by Njikam (2003); and Nyasulu (2013) suggested an evidence of a positive association between the exports and the growth rate of developing economies. The entire coefficients are significant in the short run except for labour and crop production. The estimated short-run coefficients for the subcomponents of agriculture reveals and implies that livestock production contributes significantly to economic growth in the short run as compared to crop production in Botswana.

Given the findings presented in table 5 above, the error correction term [ECM (-1)] is both significant and negative. This endorses the economic theory expected results. The error correction term [ECM (-1)] of -0.7110 is interpreted as the speed of adjustment to long run equilibrium. Therefore, this indicates that approximately 71% of all the deviations in the past will be corrected (adjusted to the equilibrium) during the present period. The high value of the error term indicates that the economic agents remove a large percentage of disequilibrium in each period. R^2 of 0.9273 implies that approximately 92.73% of the changes in the explained variable are brought about by the changes in independent variables.

Diagnostic Tests

Diagnostic tests were employed to ascertain the goodness of fit of the ARDL models. LM test statistics were observed and the key diagnostic tests focused mainly on assessing serial correlation, the functional form, normality and heteroscedasticity incidence. Table 5 below summarizes the results of the diagnostic tests for Botswana:

Whereas the diagnostic test results in Table 6 indicate that the model passes all the diagnostic tests, it fails on the functional form. Therefore, to check for model stability, the study plotted the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMQ) and the results are displayed in Figure 1 and Figure 2. The null hypothesis may be accepted if the plots of both statistics lie inside the critical boundaries at 5 % level of significance.

As shown in Figures 1 and 2, the model pass the stability test as revealed by CUSUM and CUSUMQ plots which are within the boundaries at 5% significance level, signifying that the estimated results are consistently reliable.

Conclusion and Recommendations

In this study, we empirically investigated the impact of crop production and livestock production on Botswana's economic growth. The results revealed that during the chosen period of study (1990 – 2017) crop production and livestock production had positive and significant effect on economic growth in the long run. Livestock production contributes positively and significantly to economic growth in the immediate period as compared to crop production which was positive but insignificant in the short run. As hypothesised, the error correction term $ECM(-1)$ is found to be negative and statistically significant at 1%. CUSUM and the CUSUMSQ stability test confirmed that the long-run coefficients and all short-run coefficients in the error correction model were stable.

In light of the above findings, this study confirms the role and importance of agriculture as a backbone in feeding developing nations towards achieving food security and increasing economic growth. Agriculture in Botswana resonates with Sustainable Development Goal (SDG) number 2 which seeks to end hunger (Van Niekerk, 2020). This can only be achieved by promoting sustainable crop production and livestock production not only in the short run but also in the long run. The following recommendation are proposed to encourage and improve agriculture output and economic growth in Botswana:

- All relevant ministries and organizations should be extremely sensitive and definitely take steps in their action plans to promote the agriculture sector.
- Government should provide adequate infrastructure and policy framework that will be conducive for increasing agriculture output.
- Government's effort towards an integrated agricultural sectorial policies in Botswana is essential towards achieving sustainable agriculture and economic growth.
- Finally, Government of Botswana's effort towards investing and promoting scientific research in technological advancement in crop yield and livestock yield will be essential to achieving a sustainable agriculture and economic growth.

Limitations of the Study and Areas for Further Research

As is the case with many scientific studies, this research has a few limitations, despite the effort made to ensure that the study is analytically defensible. Foremost, the short time series data used in the empirical analysis is one probable limitation. Though the use of the ARDL approach might have lessened the problem of insufficient data, future research work should be carried out when there is sufficient data available to ascertain whether their result will differ fundamentally from the results of this study.

The study also made use of only two sub sectors of agriculture namely crop production and livestock production. Future studies may wish to explore the use of other subsectors to determine whether their findings will differ fundamentally from the results of this study.

An inference into the effects of climate change on subsectors of agriculture is also suggested.

Despite the said limitations, this research paper provides a comprehensive insight into the agriculture and economic growth nexus in Botswana.

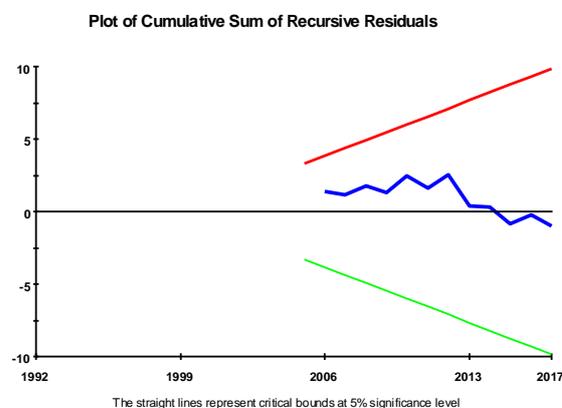


Figure 1. Plot of CUSUM

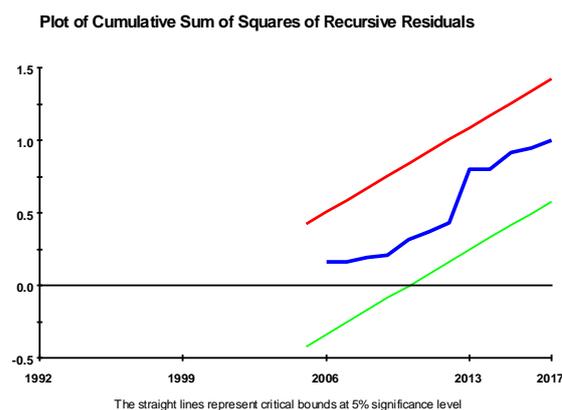


Figure 2. Plot of CUSUMSQ

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