THE NEXUS BETWEEN AGRICULTURAL PRODUCTIVITY, OIL PRICES, ECONOMIC GROWTH, AND FINANCIAL DEVELOPMENT IN THE USA

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ABSTRACT

Purpose. *The study aims to examine the nexus between agricultural productivity by connecting oil prices, economic growth, and financial development.*

Design/Methodology/Approach. *A newly formulated ARDL model was used to estimate an agricultural productivity nexus model using annual time-series data from 1962 to 2016. Innovation and additive structural break unit root tests were applied to determine the existence of unit roots, and the results reaffirmed that all the variables were stationary at first difference. The Chow Breakpoint test was applied to confirm a structural break in the year 2008 caused by the effects of the 2008 financial crisis.*

Findings and Implications. *The results depicted a long-run relationship linking agricultural productivity, oil prices, economic growth, financial development and a financial crisis. The results also showed that financial development and economic growth have positive effects on agricultural productivity. The empirical findings further suggested that an increase in oil prices and the prevalence of a financial crisis have severe adverse effects on agricultural productivity.*

Originality. *The study provides a novel viewpoint of agricultural productivity by connecting oil prices, economic growth, and financial stability and development. The study successfully demonstrated that the financial sector and oil price stability are pivotal for enhancing agricultural productivity initiatives. This study highlights the policy implications of the estimated results for policymakers seeking to boost agricultural productivity by addressing economic misfortunes induced by oil shocks and a financial crisis.*

1. INTRODUCTION

Agriculture used to be the centre of national and global decision making with organizations such as the United Nations and the World Food Programme underscoring the need to boost agricultural productivity (Garnett et al., 2013). This stemmed from ideas that asserted that agricultural productivity goes a long way towards alleviating poverty (Irz, Lin & Thirtle, 2001; Thirtle, Lin & Piesse, 2003). With more than 9 billion stricken in poverty and huge need of food, one cannot deny the need to promote agricultural productivity (Godfray et al., 2010). Onoja (2017) acknowledges that an effort to promote food security can be made possible by promoting agricultural productivity. On a large note, agricultural productivity is mainly engineered to foster economic growth and development and its importance in an economy still remains undoubtedly significant. It is highly believed that agricultural productivity is one of the critical strategies that can be used to attain Sustainable Development Goals (SDGs), (Bebbington & Unerman, 2018). Diao, Hazell, and Thurlow (2010) believe that agricultural productivity is tied to quite several macroeconomic indicators. like financial development, economic growth, and stability, which highlights the existence of a nexus linking agricultural productivity, economic growth, and financial development. The oil industry is one of the most lucrative economic industries an economy can have, and economies such as the United States of America (USA) have gained a lot from oil production. It is estimated that revenue oil resulted in a surge in the USA's gross domestic product by 10% in 2018 (Journal of Petroleum, 2019).

Although the literature is relatively vast so far, to the best of our knowledge, no study has attempted to examine how financial development and economic growth coupled with commodity market (oil prices) and financial sector stability interact to boost agricultural productivity. With this backdrop, the study contributes in three different angles:

1. We assert that the combined effects of oil price and financial sector stability are vital for enhancing agricultural productivity, and this is the crucial point upon which we formulated a new Autoregressive Distributed Lag (ARDL) model.
2. Although there is a wide variety of research examining the linkage between financial development, financial sector stability, and agricultural productivity in advanced countries, far less is known about this relationship in the USA.
3. To our knowledge, this is the first study that combines these two different approaches to examine the nexus between agricultural productivity by connecting oil prices, economic growth, and financial development.

2. LITERATURE REVIEW

2.1. Theoretical background - the high payoff input model

The study applied the high payoff input theoretical model to examine the nexus between agricultural productivity by connecting oil prices, economic growth, and financial development. The high payoff input theoretical model offers an insight into the micro and macroeconomic factors required to boost agricultural productivity (Yaron, Voet & Dinar, 1992). The microeconomic aspects of the theory seek to improve labour productivity, while the macroeconomic aspects relate to efforts to provide high-payoff technology and other inputs. Thus, this theory shows that improvements in agricultural productivity are not solely based on microeconomic factors such as labour and capital. Nevertheless, instead of other external players and institutions' existence, financial institutions provide farmers with funds to acquire high-payoff technology (Udemezue & Osegbue, 2018). Efforts to understand how such a theory explains the nexus between agricultural productivity, oil prices, economic growth, and financial development is achievable by looking at the model assumptions.

Ruttan (1998) postulates that the high payoff input model is based on the assumption that economic growth is influenced by the availability and affordability of high-payoff technology. It also assumes that financial investments in the agriculture sector are affected by the ability of farmers to allocate and use resources effectively. The first assumption illustrates an interaction between economic growth and financial development, in the sense that the financial sector provides farmers with loans that they use to acquire high-payoff technology. Therefore, a positive association exists between economic growth and financial development. Udemezue and Osegbue (2018) acknowledge that this assumption helps explain why there exist differences in economic growth between developing countries and well-developed economies such as the USA. That is, it contends that developing countries do not have access to high-payoff technology. As such, their ability to attain a high level of economic growth depends on their potency to acquire high-payoff technology. Contrarily, the USA, which has a high availability of high-payoff technology, explains why its agriculture sector productivity and growth levels are high, traceable to the viability, growth, and development of their respective financial sectors. It is implying that high growth economies have high agricultural productivity levels due to having well-developed financial sectors.

It is also imperative to note that much of the high-payoff technology used in the agriculture sector relies on the use of petroleum products as a source of energy (Ruttan, 1998). Oil shocks will impose severe adverse effects on the agriculture sector. Binuomote and Odeniyi (2013) concurred with the idea and established that the same happened in Nigeria. If oil prices increase to a severe and unstainable level,

they may trigger a financial crisis in the form of an oil bubble (Sornette, Woodard, & Zhou, 2009). Stability in the financial and commodity markets is essential for a sound improvement in agricultural productivity.

The second assumption illustrates that investments in the agriculture sector are determined by the effective and efficient use of resources in the agriculture sector. Thus, effective and efficient resources are indicators that investors can utilize to make investment decisions, which also translates to a decline in non-performing loans allocated to the agriculture sector by the financial sector (Louzis, Vouldis, & Metaxas, 2012). Besides, an increase in agricultural productivity improves the ability of farmers to repay their agriculture loans leading to a decline in non-performing loans. Alternatively, banks can be said to benefit profit-wise from an improvement in agricultural productivity.

The major challenge with this theoretical aspect is that it does not offer sound explanations about the roles played by educational and research institutions. However, this theory is a close reflection of real economic situations because it acknowledges the importance and role of the government in influencing economic activities. The high payoff input theoretical model also emphasizes the importance of maintaining stability in financial and commodity markets and the economy at large. It highlights that economic growth strategies targeted at improving agricultural productivity through the effective and efficient use of resources have positive implications for financial development. However, such relies on financial, commodity markets, and economic stability and shows a nexus between agriculture growth, economic and financial stability, and macroeconomic variables.

2.2. Empirical literature review

The integration of oil prices in the context of agricultural productivity is a long-forgotten cause and an advancing phenomenon that this contemporary study addresses by examining related empirical voids. Besides, the driving factors of agricultural productivity are much restricted to factors like financial development (Zakaria, Jun & Khan, 2019), economic development (Schmidt, Jensen & Naz, 2018) and agricultural input subsidies (Simtowe & De Groote, 2021).

The examination of factors driving agricultural productivity is still gaining momentum in academic research. As such, it remains an exciting query to note that agricultural input costs, financial development, and economic stability and performance, are integral components driving agricultural productivity. Our suggestion is congruent with Liu and others (2020) suggestions denoting that changes in agricultural productivity are intertwined with several geographic-related, input-specific and country-specific factors. Thus, it becomes apparent that agricultural productivity strategies revolve around oil prices, financial development, financial stability (absence of financial crisis), and economic growth. However, connections between

some of these variables are contemporary and were still yet to be originally analysed in the context of the USA. Hence, they command academic researchers' attention.

Though it is quite prevalent in some studies that agricultural productivity is best enhanced in a thriving economy (Liu et al., 2020) in which farmers can easily and cost-effectively access funding from financial institutions (Fowowe, 2020), the stability of both the financial sector and economy are still yet to be considered. This concurs with related suggestions depicting that stability is vital for the effective and efficient functioning of institutions and economies worldwide (Abaidoo, Agyapong, & Boateng, 2021; Memeti & Memeti, 2021; Stubbs et al., 2021). Besides, previous qualitative analysis by Banett (2000) on the impact of the financial crisis on agriculture demonstrates that the financial crisis has ripple short-term and long-term effects on an economy and that much of the effects are also observable in the agriculture sector. Besides, the findings showed that equilibrium in agriculture markets does not remain stable during a financial crisis. Thus, this study's novelty will also be embedded in its efforts to establish and test both the short-term and long-term connection between these variables.

Amone (2014) did a study that focused on proving that agricultural productivity has effects on quite several macroeconomic indicators. As a result, Amone established that agricultural productivity causes positive changes in employment, food security, poverty alleviation, economic growth, and human development. This provides the support that improvements in agricultural productivity will help to stir economic growth and development. Hence, we can expect a similar effect in the USA. The results also revealed that the relationship between agricultural productivity and economic growth is a two-way relationship. This implies that efforts to promote economic growth will also cause an increase in agricultural productivity. Ismail and Kabuga (2016) also concurred with the same notion. However, they highlighted that positive developments in the labour and agriculture markets would lead to an increase in economic growth. This suggests the importance of the need to instil institutional stability in the economy. However, the arguments of our study are based on the need to prove that economic growth can also cause an increase in agricultural productivity.

Dhrifi (2014) focused on examining the effects of financial development on agriculture in 44 African countries using a GMM panel data estimation approach. Dhrifi argues that the effects of financial development on agriculture vary with the continent. As such, the results illustrated that financial development has no positive implications on agricultural productivity in African countries. Financial development is more likely to have positive implications for agriculture in the USA and this is because the USA has a well-developed financial sector that is capable of providing the agriculture sector with the required funds and services at affordable rates. The study also contends that the effective functioning of financial institutions is of paramount importance to the growth and productivity of the agriculture sector. Any form of in-

stability like a financial crisis and oil shocks can hinder financial development will hinder agricultural productivity and economic growth. In another study by Rizwan-ul-Hassan (2017), it was illustrated that the interaction between agriculture growth and financial development requires positive changes in financial access, capital, and labour. These results, therefore, provide strong evidence of the essential role of financial development in stirring agricultural productivity.

The present study has enhanced related literature by incorporating oil prices, financial development, financial stability (absence of financial crisis), and economic growth connection and their combined effects in circumstances where agricultural productivity varies distinctly. Thus, we provide in the next section the methodological procedures that were applied in analysing such connections in the next section.

3. METHODOLOGY

In this section, we briefly review the general framework for examining the nexus between agricultural productivity, oil prices, economic growth, and financial development. Firstly, we provide details of how the study's empirical model was developed. An Autoregressive Distributed Lag (ARDL) model was used for this study because an ARDL model can significantly yield consistent and efficient estimators (Pesaran & Shin, 1998). Godfrey (1978) also acknowledges that an ARDL model works the best when variables are integrated of different orders. That is when the variables have mixed stationarities in which some variables are stationary at a level while others are stationary at first difference. At this stage, we can posit that positive changes in agricultural productivity require a well-functioning economy that is free from the effects of a financial crisis and a developed financial system. This can mathematically be expressed in a functional form as follows;

$$AP = F[OP, EG, FD, FC] \qquad (1)$$

where AP denotes changes in agricultural productivity, OP represents variations in oil prices, EG provides an indication of changes in economic performance as measured by gross domestic product (GDP), FD shows the economy's level of financial development and the dummy variable FC caters for structural breaks caused by the prevalence of a financial crisis. The variables were converted to logarithms to remove the skewness of the data and normalise it.

By including a constant α, regression analysis coefficients (β_1-β_n) and error term (μ) to equation (1), the resultant expression is a regression model as expressed by equation (2).

$$LAP = \alpha + \beta 1 LOP + \beta 2 LEG + \beta 3 LFD + \beta 4 DVFC + \mu \qquad (2)$$

The ARDL model was thus developed based on the model expression depicted by equation (2). The long-run ARDL model was therefore specified as follows:

$$LAPt = a01 + b11LOP + b22LEG + a33LFD + DVFCt +$$

$$e1tLAP\, cLOP(-1)\, LEG(-1)\, LFD(-1)\, DVFCt(-1)$$ (3)

Secondly, the study proceeded to employ a long-run bounds test to determine the existence of a long-run interaction between the model variables. The bounds test works under the proposition of a null hypothesis that variables are not cointegrated in the long run (Pesaran, Shin & Smith, 2001) or simply that there exists no joint significance (Frimpong & Oteng-Abayie, 2006). That is:

- $H_N: a1 = a2 = a3 = a4 = 0$

- $H_A: a1 \neq a2 \neq a3 \neq a4 \neq 0$

Long run cointegration is established when the computed F-statistic lies beyond both the lower and upper bounds values leading to the rejection of H_N and acceptance of H_A. Computations of the bounds test are based on the inclusion of an error correction term (ECT), (Engle & Granger, 1987). The importance of an ECT is attached to its ability to offer insights into the model's speed of adjustment. Given regressors and X and R, and a regressand Y, the ECT can be computed as follows:

$$ECTt - 1 = [YT - 1\, \eta Xt - 1 - \xi Rt - 1]$$ (4)

Based on the computed ARDL model that was utilized in this study, the error correction model was specified as follows:

$$\Delta LAPt = a_0 \sum_{i=1}^{p} a_{1i} \Delta LAP_{t-1} + a_{2i} \sum_{i=1}^{p} a_{3i} \Delta LOP_{t-1} + a_{4i} \sum_{i=1}^{p} a_{5i} \Delta LEG_{t-1} +$$

$$a_{6i} \sum_{i=1}^{p} a_{7i} \Delta LFD_{t-1} + a_{8i} \sum_{i=1}^{p} a_{9i} \Delta DV_{FCt-1} +$$

$$e_{1t}\, d(LAP)\, c\, d(LAP(-1))\, d(LOP(-1)) d(LEG(-1))\, d(DV_{FC}(-1)) \text{ECT}(-1)$$ (5).

Thirdly, we employed sensitivity analysis to test the robustness of our using the Ramsey Reset test to determine whether the variables have an element of non-linearity, Arch and Breusch-Godfrey-Pagan heteroscedasticity tests to ascertain if the agricultural productivity nexus model had heteroscedasticity problems. Furthermore, the Breusch-Pagan-Serial Correlation LM test was used to test for serial correlation at 0.05% while the Jarque-Bera test statistic was used to determine whether the variables were normally distributed over the period 1962-2016.

Lastly, we applied Cusum and Cusum of squares tests to determine if the estimated model is capable of offering useful policy-making suggestions (Ploberger & Krämer, 1990). Table 1. provides details of the model variables, unit of measure and data period used in this study.

Table 1.: Model variables, unit of measure and data period

Variable	Variable proxy	Unit of measurement	Period
Agriculture productivity	Agricultural imports	%	1962-2016
Oil prices	Average annual OPEC crude oil price from 1960 to 2018	US$ per barrel	1962-2016
Financial development	Domestic credit to the financial sector	% of GDP	1962-2016
Economic growth	GDP	Annual % change	1962-2016
Financial crisis	Dummy variable	Categorical (0=no financial crisis, 1=presence of a financial crisis)	1962-2016

Source: Authors.

4. RESULTS

4.1. Unit root tests

Unit root tests were conducted to determine if innovation and additive outlier breaks influence the variables' order of integration. Based on the computed innovation-outlier unit root results (Table 2.), we can establish that LAP and LOP are stationary at first differences while LEG and LFD are stationary at level.

Table 2.: Innovation structural break unit root test

Variable	Level	Prob.	1st difference	Prob.	Decision
LAP	-3.35	0.78	-7.06	<0.01	I(I)
LOP	-3.19	0.93	-7.27	<0.01	I(I)
LEG	-12.99	<0.01	-16.44	<0.01	I(0)
LFD	-5.75	<0.01	-5.36	0.0307	I(0)

Source: Authors.

The results entail that the 2008 financial crisis (structural break) did not influence the variables' order of integration. Consequently, we can infer that the variables do not have unit roots illustrating that the results will not be spurious (Madala, 2001). The innovation-outlier break type test results shown in Table 3. confirmed that all

the variables are stationary at first difference. These results entail that the variables have similar integration orders, which were not affected by the 2008 structural break did not influence the variables' order of integration. Accordingly, that makes it feasible to estimate an ARDL model, and thus, the researchers proceeded to estimate an ARDL model.

Table 3.: Additive structural break unit root test

Variable	Level	Prob.	1st difference	Prob.	Decision
LAP	-3.53	0.80	-7.56	<0.01	I(I)
LOP	-3.25	0.91	-7.60	<0.01	I(I)
LEG	-6.71	<0.01	-11.17	<0.01	I(0)
LFD	-5.67	0.01	-5.54	0.02	I(0)

Source: Authors.

4.2. Structural break test

The reliability and sufficient forecasting capability of a model such as an ARDL model require that such structural breaks be catered for. Hence, it is always essential to include a dummy variable when estimating the ARDL model. In this study, the notable structural break observed in the USA during the concerned period under study (1962-2016) is the 2008 financial crisis. Concerning this study, the 2008 financial crisis had severe effects on many macroeconomic indicators and commodity prices such as oil prices. The US's economic growth, financial development, and GDP fell to as low as -0.83% in 2008, while the banking sector succumbed to bank runs (Multpl, 2018)[1]. Hence, the Chow Breakpoint test was applied to confirm a structural break in the year 2008, and the established results are depicted in Table 4.

Table 4.: Chow Breakpoint test

F-stat.	3.67	Prob. F(5,45)	0.01
Log L.R.	18.81	Prob. Chi-square (5)	0.00
Wald stat.	18.35	Prob. Chi-square (5)	0.00

Source: Authors.

Using the depicted breakpoint test results, we can affirm that there was a structural break in 2008. Such reinforces the 2008 financial crisis's influence on agricultural productivity, oil prices, financial development, and economic growth. Hence, a dummy variable (DVFC) was incorporated into the model estimation to capture the prevalence of the financial crisis.

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1   Since the study relied on using secondary data, we made an assumption that the financial crisis experienced in the USA ensued in 2008 and dissipated in the same year, and this affects structural breaks.

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4.3. ARDL Bounds test

The study adopted the bounds test to strive to establish if agricultural productivity, oil prices, economic growth, and financial development are cointegrated in the long run. The obtained significant F-statistic lies above both the lower and upper bounds values. Hence, we concluded that the model variables are cointegrated in the long run.

Table 5.: ARDL Cointegration Test

F-Statistic	Significance level								
	1%		2.5%		5%		10%		
	L_B	U_B	L_B	U_B	L_B	L_B	L_B	U_B	DW
9.488540 k=4	3.29	4.37	2.88	3.87	2.56	3.49	2.20	3.09	2.24
R^2 = 0.77 Adj. R^2 = 0.64 Prob. F stat. = 0.00									

Source: Authors.

An R-square value of 0.77 was obtained and this implied that 77.21% of the observed variations in agricultural productivity were explained by LOP, LFD, LEG and FC (see Table 5.).

4.4. Short-run bounds test results

The depicted results denote that previous levels of agricultural productivity influence proceeding levels of agricultural productivity. This is because agricultural productivity remained in an unfavourable state at lags 1, 2, and 3 with respective values of -0.12, -0.31, and -0.29. The results also show a series of short-run volatile changes in oil prices between the period 1962 to 2016, as evidenced by a decline in oil prices from a positive effect of 0.01 to an adverse effect of 0.01 in the first lag. The effect later increased from an adverse effect of -0.12 to a positive effect of 0.07 in the second lag.

In the short run, GDP can be observed to have been significantly falling at both the first lag and second lag, suggesting a decline in economic performance triggering adverse effects in other sectors through contagion effects, which can affect agricultural productivity. The period 1962 to 2016 was linked to substantial improvements in agricultural productivity caused by positive developments in the USA's financial sector. The extent to which financial development contributed towards improving agricultural productivity went up from -1.25 to 0.63 in the first lag. Also, the capacity of financial development to increase and contribute positively towards agricultural productivity went down in the second lag.

Table 6.: Short-run bounds test estimations

Variable	Coefficient	Std. Error	t-statistic	Prob.
D(LAM(-1))	-0.12	0.11	-1.15	0.26
D(LAM(-2))	-0.31	0.09	-3.56	0.00
D(LAM(-3))	-0.29	0.08	-3.91	0.00
D(LOP)	0.00	0.02	0.08	0.94
D(LOP(-1))	-0.01	0.02	-0.52	0.61
D(LOP(-2))	0.07	0.02	3.01	0.01
D(LEG)	0.03	0.01	3.03	0.00
D(LEG(-1))	-0.03	0.01	-1.85	0.07
D(LEG(-2))	-0.05	0.01	-4.04	0.00
D(LFD)	-1.25	0.27	-4.66	0.00
D(LFD(-1))	0.63	0.38	1.65	0.11
D(LFD(-2))	-1.32	0.34	-3.84	0.00
D(LFD(-3))	0.47	0.27	-1.76	0.09
C	-1.44	0.62	-2.31	0.03
Coint EqT (-1)	-0.15	0.02	-8.11	0.00*
R^2 = 0.89 Adj. R^2 = 0.81 Prob. F stat. = 0.00 DW. Stat. = 2.25				

Source: Authors.

Table 6. results show that the cointegration term is negative and significant at 1% signifying the existence of cointegration in the short run between AP, OP, EG, FD, and FC. The related cointegration value of 0.15 implies that the previous years' deviations from long-run equilibrium are corrected in the same year at a speed of 15%.

4.5. Long-run bounds test

Table 7. long-run bounds test results show that financial development and agricultural productivity are unilaterally linked by 2.27, suggesting that an improvement in financial development by 1 unit will initiate favourable variations in agricultural productivity by 2.27 units. The results align with Rizwan-ul-Hassan's (2017) results, asserting that this results from the financial sector's capacity to finance the acquisition of high-payoff agricultural technology. Our findings of a positive relationship

between economic growth and agricultural productivity of 0.48 units are consistent with Amone (2014) and Ismail and Kabuga (2016). These studies highlighted that economic growth's positive effects on agricultural productivity result from the enactment of growth strategies, agricultural policies, and institutional stability measures.

Table 7.: Long run bounds test

Variable	Coefficient	Std. Error	t-statistic	Prob.
Financial Development	2.27	1.05	2.17	0.04**
Economic Growth	0.48	0.12	3.95	0.00*
Oil Prices	-0.20	0.07	-2.94	0.01*
Financial Crisis	-0.64	0.18	-3.50	0.00*
C	-9.46	4.39	-2.16	0.04**
R^2 = 0.77 Adj. R^2 = 0.64 Prob. F stat. = 0.00 DW. Stat. = 2.24 * and ** = $p < 0.01$ and $p < 0.05$ respectively				

Source: Authors.

The obtained results denote and reinforce the idea that a surge in oil prices has severe adverse effects on agricultural productivity, as noted by a negative coefficient of 0.20 (see Table 7.). Wang and McPhail (2014) acknowledged this and hinted that it is a considerable challenge for the agriculture sector to thrive when oil prices surge up high, as implied by the high payoff input.

Table 7. results also support ideas deduced from the high payoff input model, suggesting that economic disturbances like the financial crisis hinder agricultural productivity as an increase in the financial crisis by 1-unit results in a decline in agricultural productivity by 0.64 units. Deepak (2012) also accepted this idea and outlined that farmers usually fail to access the required capital funding during a financial crisis. As such, agricultural productivity tends to decline during a period characterised by incidences of a financial crisis.

The obtained long-run R-square value of 0.77 suggests that 77.21% of the variations in agricultural productivity are explained by changes in agricultural productivity, oil prices, economic growth, financial crisis, and financial development. Thus, 22.79% of the changes in agricultural productivity are attributed to changes in other variables outside the estimated model.

4.6. Sensitivity analysis, and stability tests

Ramsey Reset test by Ramsey and Schmidt (1976), was employed to determine whether the variables have an element of non-linearity or not. In light of the reported Ramsey Reset test findings, conclusions can be made that the ARDL model has no non-linearity features (χ^2=0.39; ρ=0.54). Sensitivity analysis was also undertaken concerning normality, heteroscedasticity (arch, Breusch-Pagan-Godfrey) and serial correlation tests (see Table 8.). Respective p-values of 0.97, 0.82, 1.0.0 and 0.08 were recorded and this purports that the variables are normally distributed and that heteroscedasticity and serial correlation problems are not evident.

Having a redundant variable test F-statistic value of 14.34 with an associated p-value of 0.00 implies that the null hypothesises of no joint insignificance between LOP, LFD, LEG and FC (H_o: LOP, LFD, LEG and FC are not jointly insignificant) can be rejected at 5% (ρ<0.05). The results thus, provide strong evidence that OP, FD, EG and FC are jointly significant in explaining possible variations in agricultural productivity in the USA (see Table 8.).
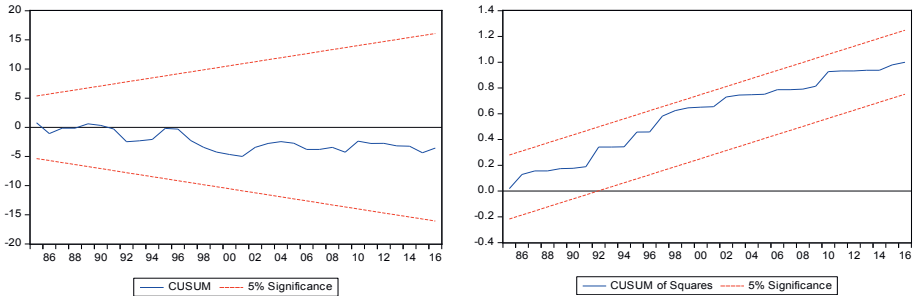
Table 8.: Sensitivity analysis[2]

	χ^{2N}	χ^{2AR}	χ^{2BR}	χ^{2SC}
0.39 (0.54)	0.06 (0.97)	0.05 (0.82)	0.51 (1.00)	1.67 (0.08)
Redundant test on LOP, LFD, LEG and DVFC				
		Value	Df	Prob.
F-statistic		14.34	(4, 32)	0.00

Source: Authors.

Cusum and Cusum of squares stability inquiries were employed to ascertain if the formulated model can be declared to be stable throughout the study which has been established to be 1960 to 2016. Based on Figure 1. presentation, it can be heeded that the model confines within the critical bounds. Hence, inferences are established that the formulated ARDL model is stable over the period 1960-2016.

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2   RR, χ^{2N}, χ^{2BR}, χ^{2AR} and χ^{2SC} Ramsey Reset Test, langrage multiplier for normality, Arch test for heteroscedasticity at lag 1, Breusch-Godfrey-Pagan test for heteroscedasticity and serial correlation at 2 lags. The values in parenthesis are the corresponding P-Value. As a result, it can thus be concluded that that the estimated model does meet the necessary sensitivity standards and can be safely used for policymaking.

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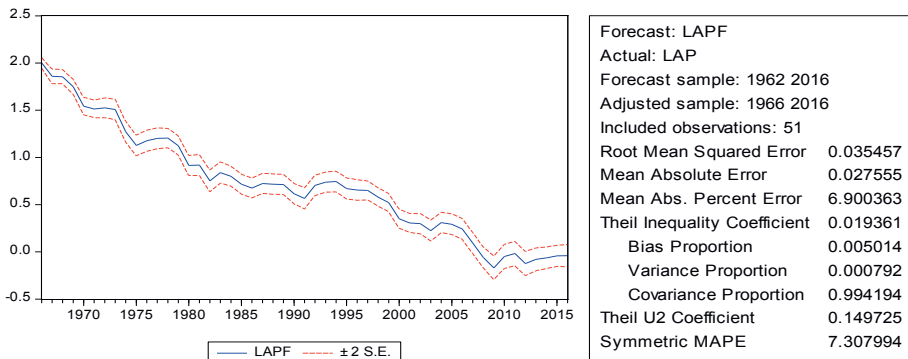**Figure 1. :** Cusum stability inquiries (Researchers, 2021)

Source: Authors.

4.7. Model performance and forecast error diagnosis

Model performance and forecast error diagnosis were also undertaken to determine whether the predictive power of the computed ARDL model is satisfactory and free from biases. This was accomplished using a dynamic forecasting technique. The reason behind the use of a dynamic forecasting model is justified by the fact that it accounts for time-dependent changes or events (Evensen, 1994). This is of paramount importance, especially when considering the effect of structural breaks and seasonal changes that impose effects on economic variables.

Figure 2.: Model performance and forecast error diagnosis

Forecast: LAPF	
Actual: LAP	
Forecast sample: 1962 2016	
Adjusted sample: 1966 2016	
Included observations: 51	
Root Mean Squared Error	0.035457
Mean Absolute Error	0.027555
Mean Abs. Percent Error	6.900363
Theil Inequality Coefficient	0.019361
Bias Proportion	0.005014
Variance Proportion	0.000792
Covariance Proportion	0.994194
Theil U2 Coefficient	0.149725
Symmetric MAPE	7.307994

Source: Authors.

The Theil inequality of 0.0019 is almost 0 and this implies that there is a perfect fit as it is associated with a very low bias proportion or systematic error of 0.5% (Figure 2.). The root mean square is very low and stands at 0.04 and this indicates that the forecasting model is in a good position to offer reliable estimates for policy formulation and decision making. The estimated agricultural productivity nexus model

is thus a useful tool and ought to be used to formulate economic policies at both national and global levels.

4.8. Effects of financial development on agricultural productivity

One of the fundamental aspects of econometrics states that an effect between variables does not always imply that it causes possible changes in each other (Gujarat, 2012). Accordingly, Granger (1988) proposes that causality tests be done to establish the existence of causality between the variables. The established long-run bounds test results confirmed a positive linkage between financial market developments and agricultural productivity. However, it remained proven if financial development stirs up a surge in agricultural productivity or if agricultural productivity causes financial development. It is in this regard that the Granger causality test was applied.

Table 9.: Pairwise Granger causality test

	AP		OP		FD		EG		FC	
	χ^2	prob.	χ^2	prob.	χ^2	prob.	χ^2	prob.	χ^2	prob.
AP	–	–	2.56	0.09	0.59	0.56	4.69	0.01	0.16	0.85
OP	6.25	0.00	–	–	1.27	0.29	2.86	0.07	5.50	0.01
FD	0.49	0.61	0.36	0.70	–	–	3.05	0.06	0.03	0.97
EG	2.04	0.14	0.32	0.73	7.12	0.00	–	–	1.86	0.17
FC	4.87	0.01	0.37	0.69	0.56	0.57	1.24	0.30	–	–

Source: Authors.

Table 9. results indicate that during the period 1962 to 2016, financial development did not Granger cause an increase in agricultural productivity. Alternatively, agricultural productivity did not also Granger cause financial development, an increase in oil prices, and economic growth during the same period. Similar effects were observed regarding economic growth, while the financial crisis granger caused an increase in oil prices between 1962 to 2016.

5. CONCLUSIONS

The study examined a nexus linking agricultural productivity, oil prices, economic growth, and financial development. Such an interaction works towards improving agricultural productivity but can be impaired by oil shocks and financial crises. The computed Bounds test proved a nexus linking agricultural productivity, oil prices, economic growth, and financial development in both the short run and long run. Our results support the view that positive economic and financial sector developments are vital for enhancing agricultural productivity. When imposing a linear relationship, the results suggest that the 2008 financial crisis and economic growth

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are negatively related in the long run. We found evidence showing that the impact of economic growth on agricultural productivity can be undermined by rising or volatile oil prices undermine agricultural productivity as oil is a significant energy source in the agriculture sector. Several studies agree with this notion and establish that reducing factor input costs is pivotal in improving agricultural productivity.

The study's theoretical implications suggest that it is imperative for the financial sector to effectively supply farmers with the required funds to aid them in securing agricultural productivity-enhancing high payoff input technology needed to produce more agricultural produce at a relatively low cost. The study practically demonstrated that agricultural productivity and economic growth are positively related. Such a notion is considered authentic by a significant number of studies that strongly argue that economic growth and development policies inevitably work towards improving agricultural productivity on the condition that the effects of oil shocks and financial crises are minimised and stability instilled in all markets.

We believe that our results are of potential importance to policymakers in terms of financial institutions developing measures to curb the effects of a financial crisis by adopting recapitalisation and risk management strategies, and availing of new financing programs (microloans and direct operating loans), financial mechanisms and instruments (aggie bonds) to the agriculture sector. Policymakers should seek to introduce economic policies that boost economic growth and development and favour financial development. Besides, the policy implications demand the government to support the effective use of the agriculture policy by promoting institutional stability (establish safety nets to cushion against the effects of a financial crisis), creating a conducive environment in which the agriculture sector can thrive, introducing agricultural development programs and providing subsidies to farmers.

The study's knowledge judgments are limited to the USA and restrict how they can be generalised and applied in other countries. More so, oil shocks and the 2008 financial crisis affected many countries. Future studies must conduct a comparative analysis of the affected countries to enhance the study's coverage. For some future research, a pandemic crisis should be considered as well as its impact on the observed variables.

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