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Macroeconomic Variables, Finance and Agricultural Output in Sub-Sahara Africa Countries

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Abstract:

The study examined macroeconomic variables, finance and agricultural output in Sub-Sahara Africa (SSA) countries. The data for the study were sourced from the World Development Indicator database and covers 1990 to 2023. The study employed GMM panel data estimator, autoregressive distributed lag model and Dumitrescu and Hurlin Panel Causality Tests to achieve the specified objectives of the study. Macroeconomic variables were revealed to be significantly related to agricultural output in SSA countries with coefficient value of 0.188 and at 5%. Bank credit shows a significant impact on agricultural output in SSA countries. The study also revealed that there exists a unidirectional causality between macroeconomic variables on agricultural output in Sub-Sahara African countries at 5% significant level. The study concluded that macroeconomic variables (such as foreign direct investment, interest rate, exchange rate and banking credit) have significant impact agricultural output in SSA. Therefore, the study recommends that Government of SSA should operate a single exchange rate rather than operating dual exchange rate which will encourage SSA economy to openness of trade so as to improve the performance of agricultural sector in Sub-Sahara Africa.

Keywords:

Macroeconomic Variables, Finance, Agricultural Output

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Introduction

Agriculture is vital for fostering inclusive growth by driving economic development, alleviating poverty, and generating employment for a significant number of individuals, particularly in developing nations. Gomina et al. (2024) note that agriculture contributes 29% of GDP and employs over 65% of the labor population in emerging nations that are experiencing poverty. Moreover, over 75 percent of those living in poverty in the developing world reside in rural environments, with a majority deriving their incomes directly or indirectly from agriculture (Akpan & Zikos, 2023). The agricultural sector is a key player in most economies across Sub-Saharan Africa (SSA), accounting for more than a third of the regional gross national product (GNP) and providing jobs for more than three-quarters of the workforce. While Sub-Saharan African countries' agricultural industries prospered in recent decades, its recent performance has been disappointing. The decrease in commodity prices has adversely affected agricultural export countries like Ghana, South Africa, and Zambia (Wanzala & Obokoh, 2024), while the Ebola outbreak severely hindered growth in Sierra Leone and Guinea due to a contraction in agricultural output. The impact of extreme drought in various southern and eastern African nations, including Ethiopia, Malawi, and Zimbabwe, has exacerbated food insecurity and hurt exports of agricultural products (Ngcamu & Chari, 2020).

Inflation in Sub-Saharan African countries has consistently obstructed the agricultural sector's growth. Additionally, the exchange rate serves as a crucial relative price due to its effect on the international competitiveness of agricultural products in Sub-Saharan African nations. Policymakers have frequently faced the challenge of establishing the suitable exchange rate system that connects the domestic economy to the global landscape. Nonetheless, the exchange rate in Sub-Saharan African countries has steadily declined across every section of the foreign currency market, including parallel, official, and bureau de change markets (Kemoe et al., 2024; Bikorimana et al., 2024). Funding has been reallocated from the agriculture sector to the trading sector as a result of the exchange rate depreciation. The historical distribution of foreign exchange resources lends credence to this assertion. The amount of foreign exchange required to import agricultural products and raw materials decreased between 2001 and 2011, while the amount used to import completed goods stayed high (World Bank, 2022).

The limited access to financial resources within the agricultural sector in SSA has continued to hinder agricultural progress, leaving farmers in these countries struggling beneath the poverty threshold. They face minimal opportunities for credit and employment in the agricultural domain; indeed, the lack of credit access has led to reduced land area under cultivation, subpar farming practices, and insufficient or nonexistent use of fertilizers. The agricultural sector consistently faces challenges such as small farm sizes, low output, meager income, and poor socio-economic status. Several investigations have examined how macroeconomic variables affect Nigerian agriculture (Okeke & Okeke, 2022; Ewubare &

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Asimiea, 2020; Osuagwu, 2020), utilizing various variables like inflation, interest rates, and exchange rates. Nevertheless, external factors such as public debt and foreign direct investment have not received adequate focus. Additionally, a range of econometric models has been applied. Few investigations in Nigeria have considered the stationarity of the variables involved.

A handful of studies, such as those by YIsmail et al. (2025) and Okeke & Okeke (2022), investigated the long-term variables affecting Nigeria's agricultural production. The majority of the studies (Adeleye et al., 2020) has been centered on single-country analyses, while only a limited number have tackled cross-country investigations like those involving Sub-Saharan African nations. Likewise, previous studies employed approaches such as Multiple regression models are analyzed using the ordinary least squares approach and fully modified OLS (FMOLS). On the other hand, this study makes use of a panel data collection that spans the years 1990–2023 and includes four Sub-Saharan African nations. The various overlooked areas identified in previous research are significant, which creates research gaps that this current study appropriately addresses.

Literature Review

The Cobb-Douglas Production Function

To evaluate how individual or combined inputs influence output, a production function must be established. The neoclassical production framework typically takes the form Y = F (X1, X2, X3,….Xn) or more specifically, Y=AKαLβY, where Y denotes output, and Xs are input variables. In this model, K and L represent capital and labor, respectively; A represents total factor productivity, while the constants α and β represent the labor and capital output elasticities. According to Bannaga and Lezar (2024), these factors are thought to be constant and depending on technology.

Depending on the sum of the exponents α + β = 1, the Cobb-Douglas production function displays varying returns to scale; nonetheless, the function consistently displays returns to scale. When α + β is less than 1, returns to scale are falling; when α + β is more than 1, returns to scale are growing. This flexibility allows the Cobb-Douglas function to model various production scenarios depending on the values of the input elasticities (Bannaga & Lezar, 2024). To reduce estimation bias, the function can be linearized by taking the logarithm of both sides. Compared to the Cobb-Douglas model, the transcendental logarithmic (translog) function offers greater adaptability and is preferable when the production relationship lacks a clearly defined structure. The Cobb-Douglas model is often favored due to its analytical simplicity, interpretability, and proven effectiveness in similar empirical studies, as highlighted by Enu and Attah-Obeng (2013).

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Empirical Review

Sanchi, Alhassan, and Sabo (2022) examined the short-, medium-, and long-term implications of increased agro-input costs on wet season farming in 2022, taking uncertainty factors into account. The study explored how increased input costs affected household food security and the economic activities of rural households. Key contributors to these rising costs included escalating commodity prices, surging demand, input shortages, and transportation barriers. Historical trends in input price fluctuations were also assessed to contextualize the 2022 farming season, which was characterized by exceptional price hikes in Northwest Nigeria. The authors proposed strategies for reducing input costs to lessen the negative impacts on rural life and agricultural output.

Chukwu (2023) Using OLS, the agricultural sector's contribution to Nigeria's economic development between 1981 and 2020 was evaluated. The results showed that crop and livestock production significantly influenced economic growth, while forestry and fish production had no significant impact. Despite all variables showing positive correlations with GDP, no causal relationship was found between crop or livestock output and growth. However, a unidirectional causality was observed from forestry production to GDP. Based on these results, the study recommends prioritizing productivity in crop production to improve food security and foster sustainable economic growth.

Ayinuola and Gumel (2023) considered GMM to examine how credit and liquidity concerns affected the stability of 12 Nigerian banks from 2010 to 2021. The results showed that both risks, separately and together, had a negative and considerable impact on bank stability. Additionally, a strong positive connection between credit risks and liquidity, demonstrating a causal relationship between the two were revealed. Bank-specific indicators like size, equity, and capital adequacy positively influenced performance, as did economic growth. Inflation had an insignificant negative impact. The study recommends coordinated risk management and emphasizes regulatory actions to limit credit and liquidity risk exposure to safeguard financial stability.

Haladum et al. (2024) explored the asymmetric employing a nonlinear ARDL model to examine the long-term impacts of macroeconomic factors on Nigeria's economic development from 2000Q1 to 2021Q4. All variables, with the exception of inflation, were shown to be stationary at first difference using unit root tests. The findings showed that GDP was positively impacted by interest rates and crude oil prices, while exchange rates and inflation negatively impacted growth. The study highlighted long-run asymmetries in how these macroeconomic indicators affect the economy. Recommendations include policies to stabilize interest and exchange rates, curb inflation, and increase crude oil production to foster economic growth.

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Mbelu and Ifionu (2022) investigated the relationship between agricultural finance and Nigeria's GDP from 1981 to 2019 using Granger causality, ECM, and cointegration models. Results indicated that community microfinance loans, commercial bank loans, and agricultural credit programs had a major and favorable long-term influence on economic growth. A demand-following connection was validated by the causality analysis, indicating that higher agricultural production stimulates greater capital inflows into the industry. According to the report, the government should provide incentives for banks to provide farmers with reasonably priced financing, run awareness campaigns on loan availability, and create enabling conditions like enhanced security, pest control, and quality seeds.

Liu et al. (2020) used stochastic frontier analysis (SFA) to evaluate agricultural total factor productivity (TFP) between 2002 and 2016 in 15 South and Southeast Asian nations. The study found a general decline in TFP, primarily due to negative changes in scale and technical efficiency, although technological advancement remained the main driver of productivity. Southeast Asia experienced more consistent productivity growth than South Asia. Determinants such as human capital, urbanization, and financial flows positively affected TFP, while economic development levels and agricultural imports had adverse effects. The study advises investments in human capital, technology, and regional collaboration to reverse productivity decline.

The dependent variable considered in the work of Ukpong et al. (2022) was real GDP, and its predictors were spending on economic, social, and administrative services. The findings showed that agricultural output was positively but statistically insignificantly impacted by these government expenditures. The authors concluded that public spending does not significantly enhance agricultural performance. They recommend that the Central Bank and federal government strengthen the banking system to improve agricultural credit access, citing agriculture’s importance in national economic development and growth.

Ugwu et al. (2022) analyzed food imports and Nigeria's balance of payments (BOP) and local food output between 1960 and 2020. The findings showed that while food imports had a short-term and long-term negative effect on food production, they had a long-term positive effect on the BOP. Correction of errors terms indicated that deviations from equilibrium were adjusted at rates of 40% (food production) and 85% (BOP) annually. The study found that while food imports may support foreign exchange, they harm local production. It recommends encouraging foreign investment to strengthen domestic agricultural productivity.

Bright et al. (2023) investigated the link between agricultural productivity and Nigeria’s economic growth from 1986 to 2021 using co-integration and error correction models. Agricultural productivity, capital productivity, and interest rates were the explanatory variables. In the long term, agriculture negatively impacted economic growth, while capital productivity had a positive effect. However, agriculture and productivity of labour in the short term shows positively influenced growth, while capital productivity had

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a negative effect. The study recommends comprehensive agricultural reforms, including input provision, interest-free loans, and increased capital investment to address infrastructure deficits such as poor roads and unreliable electricity supply.

Ho1*: There is no significant impact of macroeconomic variables and agricultural output in Sub-Sahara Africa (SSA) countries.*

Ho2*: There is no significant impact of finance and agricultural output in Sub-Sahara Africa (SSA) countries.*

Methodology

The World Bank Indicators and the International Monetary Fund provided the secondary data used in this study, which covered a thirty-four (34)-year period from 1990 to 2023. Because the data from the World Bank Indicators starts in 1990, that year was used. It's also germane to consider the global financial crises of 2008 which prompted this study to investigate how these crises affected Sub-Saharan African financial systems. The study was conducted in 2023 because the 2024 World Bank Indicators had not yet been released. Although Ghana, Kenya, South Africa, and Nigeria are included in the sample, the study's focus is on Sub-Saharan African countries. These four countries were selected as they have the highest average number of agricultural companies in the region and have instituted social and governance (ESG) reporting requirements on their respective stock exchanges. The selection process was also based on their population size, market development, and economic standing in the region. To achieve the study's goals, the research uses an Autoregressive Dynamic Model (ARDL), a dynamic panel Generalized Method of Moments (GMM) estimator, and Dumitrescu and Hurlin Panel Causality Tests (DH). The first hypothesis is tested using GMM panel data to determine whether a short-term relationship exists and how quickly adjustments occur; the second hypothesis is tested using DH Tests to ascertain the direction of the causal relationships between the independent and dependent variables; and the third hypothesis is tested using the ARDL.

Model Specification One

For this study, the model has been adjusted to better align with the objectives presented. It is crucial to acknowledge that various macroeconomic factors significantly influence the agricultural productivity of any economy. Consequently, the model has been revised and expressed as:

$\mathrm{AGROUT} = f(\mathrm{INTR, EXRA, INF, BC, PD, FDI})$……1

Econometrically, it can be written thus:

$$\Delta \ln \mathrm{AGROUT}_{it} = \beta 0 + \beta_1 \Delta \ln \mathrm{AGROUT}_{it-1} + \beta_2 \Delta \mathrm{INT}_{it} + \beta_3 \Delta \mathrm{EXR}_{it} + \beta_4 \Delta \mathrm{INF}_{it} + \beta_5 \Delta \mathrm{BC}_{it} + \beta_6 \Delta \mathrm{PD}_{it} + \beta_7 \Delta \mathrm{FDI}_{it} + \mu_i + \varepsilon_{it} \ldots\ldots 2$$

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Where:

AGROUT= Agricultural Output (Proxy with contribution of Agricultural Sector to GDP)

INTR= Interest Rate

EXRA= Exchange Rate

BC = Banking Credit (proxy with Credit to private sector to GDP)

INF = Inflation

PD= Public Debt

FDI= Foreign Direct Investment

Model Specification Two

The DH Tests were employed to examine the causal relationship between agricultural output and the macroeconomic variables included in the model. The Granger causality relationship for the macroeconomic variables affecting AGROUT, based on the DH Tests, is defined as;

$$AGROUT_t = \alpha + \sum_{i=1}^{\eta} \beta_i MC_{t-i} + \sum_{i=0}^{b_1} \theta_i InAGROUT_{t-i} + \Omega t \ldots\ldots\ldots\ldots\ldots 3$$

So also, the DH Tests for agricultural output granger cause macroeconomic variables are specified as

$$MC_t = \alpha + \sum_{i=1}^{\eta} \beta_i AGROUT_{t-i} + \sum_{i=0}^{b_1} \theta_i InMC_{t-i} + \Omega t \ldots\ldots\ldots\ldots\ldots\ldots 4$$

Model Specification Three

In this study, the model has been adjusted to incorporate macroeconomic factors that affect agricultural production. Thus, the model has been revised and presented as:

AGROUT = *f* (FDI, EXR, BC, INFL, INTRA).....5

$$\ln\mathrm{AGROUT}_t = \beta_0 + \beta_1 \mathrm{FDI}_t + \beta_2 ln\mathrm{EXR}_t + \beta_3 \ln\mathrm{BC}_t + \beta_5 \mathrm{INFL}_t + \beta_6 \mathrm{INTRA} + \mu_t \ldots\ldots 6$$

The model can be transformed into ARDL-ECM form as:

$$\Delta\ln\mathrm{AGROUT}_t = \beta_0 + \beta_1 \Delta\ln\mathrm{AGROUT}_{t-1} + \beta_2 \Delta\mathrm{FDI}_t + \beta_3 \Delta\mathrm{FDI}_{t-1} + \beta_4 \Delta ln\mathrm{EXR}_t + \beta_5 \Delta ln\mathrm{EXR}_{t-1} + \beta_6 \Delta ln\mathrm{BC}_t + \beta_7 \Delta ln\mathrm{BC}_{t-1} + \beta_8 \mathrm{INFL}_t + \beta_9 \mathrm{INFL}_{t-1} + \beta_{10} \Delta\mathrm{INTRA}_t + \beta_{11} \Delta\mathrm{INTRA}_{t-1} + \beta_{12} ECM_{t-1} + \mu_t \ldots\ldots 7$$

All terms are as defined in model one.

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Data Presentation and Analysis

Statistics	AGROUT	EXRA	FDI	INF	INT	BC	PDEBT
Mean	1322.0	68.8	319210.5	21.2	13.7	2993.0	1224.4
Median	620.2	22.1	110456.2	12.0	13.5	525.6	617.3
Maximum	7233.3	157.5	1278765.0	76.8	26.0	15689.0	4890.3
Minimum	27.1	0.8	721.8	0.2	6.0	23.4	14.8
Std. Dev.	1746.3	61.2	433180.2	20.0	4.2	4754.2	1427.3
Skewness	1.9	0.2	1.2	1.5	0.7	1.7	1.4
Kurtosis	6.5	1.2	3.9	3.9	4.0	4.5	3.5
Jarque-Bera	32.6	3.9	7.4	11.8	3.3	16.4	9.4
Probability	0.0	0.1	0.0	0.0	0.2	0.0	0.0
Observations	34	34	34	34	34	34	34

Table 1: Descriptive Statistics (Source: Authors computation (2025))

Table 1 shows the summary of the study's variables. It makes clear that the mean values for AGROUT, EXRA, FDI, INF, INT, BC, and PDEBT over the 34-year period are approximately 1322.0, 68.8, 319210.5, 21.2, 13.7, 2993.0, and 1224.4 respectively in their respective units. Additionally, the data indicates that all variables experienced significant variation over this time frame, as evidenced by the large difference between the lowest and highest values for each variable and the large standard deviations. Therefore, examining their fluctuations over the period is crucial. The skewness indicates that all variables are positively skewed. Concerning kurtosis, a distribution is considered leptokurtic when the kurtosis value exceeds three, and platykurtic when the kurtosis is below three. As a result, the series for AGROUT, FDI, INF, INTR, BC, and PDEBT are leptokurtic (indicating a distribution with thinner tails than the normal distribution), while EXR is platykurtic (indicating a distribution with fatter tails than the normal distribution). The Jarque-Bera statistics show significance (with a probability value of less than 5%) for AGROUT, FDI, INF, BC, and PDEBT; conversely, it is not significant (with a probability value greater than 5%) for all other variables. This suggests that the dependent variable does not follow a normal distribution. Given the evidence that the dependent variable is not normally distributed as indicated by the relevant statistics, employing the Ordinary Least Squares estimator is deemed inappropriate.

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Dependent variable: **Agricultural Output**	
	(4)
Independent variables	Sub-Sahara Africa
Lagged AGROUT	0.16***
	(0.046)
Foreign Direct Investment	0.039**
	(0.015)
Inflation	47.3
	(36.9)
Banking Credit	0.68**
	(0.23)
Public Debt	-0.55
	(0.31)
Interest Rate	-0.062**
	(0.021)
Exchange Rate	-0.00068**
	(0.00029)
Observations	234
Number of countries	4
Diagnostic tests	
Wald chi2 statistic	255.53 (0.000)
Sargan test statistic	389.0084 (0.3150)
Autocorrelation test (Arellano-Bond test) AR(2)	0.04325 (0.9655)

Table 2: Impact of macro-economic variables on Agricultural Output in Sub-Sahara Africa Countries (Source: Author's computation, (2025))

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Note: Standard errors in parentheses, ***, ** and * denote 1%, 5% and 10% levels of significance respectively)

A Dynamic System GMM panel regression analysis was performed to investigate the impact of macroeconomic variables on agricultural productivity in SSA nations; the findings are shown in Table 2. The initial lag of agricultural production, the currency rate, foreign direct investment, inflation, interest rates, banking credit, and state debt are the independent variables, whereas agricultural output is considered the dependent variable. With the exception of state debt, interest rates, and the currency rate, the research shows that all macroeconomic factors have a positive correlation with agricultural output in SSA for the period under study. Thus, improvements in agricultural output are associated with rises in key macroeconomic indices, with the exception of public debt, interest rates, and the currency rate, and vice versa. Only the currency rate, foreign direct investment, interest rates, banking credit, and the lag of agricultural production, however, are statistically significant at the 1% and 5% levels, according to the results. This suggests that the agricultural production of the countries in SSA that are being studied is significantly impacted by these five factors. The lag of agricultural output, exchange rate, foreign direct investment, interest rates, and banking credit all have coefficients of 0.16, 0.00068, 0.039, 0.68, and 0.62, respectively, with their corresponding standard errors of 0.046, 0.00029, 0.015, 0.23, and 0.021, supporting this conclusion. These variables can be categorized as statistically significant as half of the coefficients are greater than their standard errors. This suggests that increases of 0.16, 0.039, and 0.62 units in agricultural production, respectively, would result from a one unit rise in the lag of banking credit, agricultural output, and foreign direct investment. On the other hand, the reverse outcome would occur if interest rates and the currency rate declined. Accordingly, the results suggest that, between 1990 and 2023, macroeconomic factors had a positive and considerable impact on agricultural output in Sub-Saharan African nations. The lower part of Table 5 displays the findings from the diagnostic tests. An excellent fit for the model is shown by the Wald chi2 statistic, which is reported as 255.53 with a probability value of 0.000. 389.0084 is the Sargan test statistic, and 0.3150 is the corresponding probability value.

It is impossible to reject the null hypothesis, which claims that the over-identifying limits are genuine and that the instruments employed are suitable. Furthermore, the Arellano-Bond test, which assesses zero autocorrelation in first-differenced errors, yields a probability value of 0.9655 and a Z-statistic of the second order (AR 2) of 0.04325. The model does not have an autocorrelation issue, as evidenced by the inability to reject the null hypothesis that autocorrelation does not exist. To sum up, the model has passed all diagnostic tests, producing results that are reliable for policy considerations pertaining to how macroeconomic factors affect agricultural output in countries in Sub-Saharan Africa.

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Agricultural Output (AGROUT)

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
AGROUT does not homogeneously cause EXR	3.07708	-1.66524	0.0059
EXR does not homogeneously cause AGROUT	5.67238	-0.24080	0.8097
AGROUT does not homogeneously cause FDI	4.71072	-0.76861	0.4421
FDI does not homogeneously cause AGROUT	5.36186	-0.41123	0.6809
AGROUT does not homogeneously cause INF	2.74818	0.63509	0.5254
INF does not homogeneously cause AGROUT	2.10263	-0.14440	0.8852
AGROUT does not homogeneously cause INT	2.60752	0.34677	0.0028
INT does not homogeneously cause AGROUT	1.86323	-0.32310	0.7466
AGROUT does not homogeneously cause BC	3.87439	-0.91502	0.3602
BC does not homogeneously cause AGROUT	4.15422	-0.80054	0.4234
AGROUT does not homogeneously cause PD	8.37528	0.92625	0.3543
PD does not homogeneously cause AGROUT	6.39551	0.11634	0.0004

Table 3: Dumitrescu-Hurlin Panel Causality Tests Sub-Sahara Africa
(Source: Author's Computation (2025))

All of the AGROUT variables have a causative relationship with both EXR and INT, according to the findings of the Dumitrescu-Hurlin Panel Causality Tests examined for Sub-Saharan Africa in Table 4.3, whereas PD is shown to be a Granger cause of AGROUT. Since several P-values of the Z-bar statistics fall below the 5% cutoff, the null hypothesis is thus rejected.

Variables	Augmented dickey-fuller (ADF)	5% Critical level	Philip-Perron (PP)	5% critical level	Order of integration	
					AD F	PP
AGROUT	-4.056293	-3.557759	-3.799008	-3.552973	I(1)	I(1)

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EXR	-5.268181	-3.552973	-5.268197	-3.552973	I(1)	I(1)
FDI	-3.920558	-3.603202	-4.912139	-3.574244	I(0)	I(0)
INF	-3.874811	-3.622033	-4.080318	-3.557759	I(0)	I(0)
INT	-7.956984	-3.552973	-3.055098	-2.951125	I(1)	I(0)
BC	-2.112040	-1.955020	-203.1998	-3.552973	I(1)	I(1)

Table 4: Result of Unit Root (Stationarity) Test (Source: Authors computation (2025))

A typical characteristic of time series data is non-stationarity. Using the typical Ordinary Least Squares (OLS) estimator on non-stationary or trending data is a difficulty since it might result in biased and erroneous regression estimates, leading researchers to draw the wrong conclusions. Put more simply, OLS can produce inaccurate regression findings when applied to non-stationary series. In order to prevent spurious regression, a unit root test is essential for determining the series' order of integration. When the dependent variable and one or more independent variables are not stable at their levels, the regression is deemed spurious. A false regression may provide a very high R^2 and t statistics that appear to suggest significant estimates, but the findings may lack logical interpretation. This happens because tests of statistical inference may be incorrect due to conflicting OLS estimations. Both the Phillips-Perron and Augmented Dickey-Fuller (ADF) unit root tests were used in this study to prevent these issues; the findings are shown in Table 4.4 above. The results of the Phillips-Perron and Augmented Dickey-Fuller tests indicate that AGROUT, EXR, and BC are stationary at first differences, indicating they are integrated of order one, or I(1), whereas FDI, INF, and INT appear to be stationary at their levels, indicating they are integrated of order zero [I(0)]. However, INT is classified as I(0) by the Phillips-Perron test and as I(1) by the Augmented Dickey-Fuller test. The Phillips-Perron test is preferred in this situation as it takes possible heteroscedasticity into consideration. As a result, FDI, INF, and INT are all level and stable. The ARDL Bound Test of cointegration was used to analyze these series, which comprise both I(0) and I(1). The findings are described below.

Model	Test F-Statistic	5% Critical Value Bounds	
		Lower Bound (I_0)	Upper Bound (I_1)
AGROUT model for Ghana	3.59	2.14	3.35
AGROUT model for Kenya	4.21	2.14	3.35

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AGROUT model for Nigeria	3.63	2.14	3.35
AGROUT model for South Africa	4.04	2.14	3.35

Table 5: Cointegration Test (Bound Testing Approach) (Source: Authors computation (2025))

According to the unit root test results, certain variables are stationary at levels I(0), while others are integrated of order one, I(1). Consequently, of the four models analyzed in this work, the ARDL's Bound test is thought to be the best suitable technique for assessing cointegration. Table 4.5 above contains the results. For this test, the null hypothesis states that there is no long-term link (i.e., no cointegration). The F-statistics must be greater than the Critical Value of the upper limit at the designated significance level (5% in this study) in order to meet the condition for rejecting the null hypothesis.

According to the results, the upper limit Critical Values for the AGROUT models are 3.35, and the F-statistics are 3.59, 4.21, 3.63, and 4.04, respectively. This implies that in every case, the F-statistic for all four models is greater than the Critical Value of the Upper Bound. The null hypothesis is thus disproved. Consequently, the results show that all models exhibit cointegration. To sum up, the ARDL's bound test shows that each model's variables have a long-term equilibrium connection. This is in favor of employing autoregressive distributed lags (ARDL) to construct a long-term link.

ΔlnAGROUT	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.066820	0.145670	-0.458709	0.6530
ΔAGROUT(-1)	2.803207	2.151206	0.130118	0.8982
ΔlnEXR	-0.129609	0.060064	-2.157849	0.0465
ΔlnEXR(-1)	-0.1 88983	0.088543	-2.134364	0.0486
ΔlnFDI	-0.203027	0.128298	-1.582466	0.1344
ΔlnFDI(-1)	-0.036269	0.146714	-0.247208	0.8081
ΔlnBC	-0.669619	0.333252	-2.009347	0.0617
ΔlnBC(-1)	-0.671108	0.291791	-2.299961	0.0352
ΔINFL	0.004963	0.003640	1.363613	0.1928
ΔINFL(-1)	0.001143	0.003166	0.361025	0.7231

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ΔINTRA	0.010077	0.021572	0.467135	0.6471
ΔINTRA(-1)	0.006192	0.021586	0.286864	0.7781
ECTAGROUT(-1)	0.912957	0.290566	3.141998	0.0067

R-squared	0.755614	F-statistic	6.728138
Adjusted R-squared	0.698644	Prob(F-statistic)	0.008425
Log likelihood	15.53972	Durbin-Watson stat	1.967573

Table 6: Regression Result for Agricultural Output Model in Ghana
(Source: Authors computation (2025))

Table 6 displays the findings from the autoregressive distributed lags (ARDL) model for Ghana, which show how macroeconomic variables affect the country's agricultural production. The model has a high fit with an R-squared value of 0.7556, suggesting that lagged agricultural production, currency rate, foreign direct investment, inflation, interest rate, banking credit, and state debt account for 76% of the systematic fluctuations in AGROUT in Ghana. The error correction term (ECTAGROUT(-1)) is recorded as -0.913, as shown in Table 4.6. As anticipated, a t-statistic of -3.142 supports the notion that this term is positive and has a considerable impact on the model at the 1% level. This suggests that, at a rate of 91%, agricultural output is adapting to the effects of the selected macroeconomic factors, moving from a short-term state of disequilibrium to a long-term equilibrium state.

In addition to the initial lag of exchange rate changes (ΔlnEXR(-1)), the study shows a negative correlation between agricultural production and variations in foreign exchange rates, with coefficients of 0.1296 and 0.189, respectively. At a 5% significance level, we are able to reject the null hypothesis that foreign exchange rates have no discernible effect on agricultural production thanks to the t-statistics of -2.158 and -2.134. Therefore, if all other factors stay the same, a decrease in agricultural output is linked to an increase in currency rates (depreciation). Likewise, the coefficients for ΔlnFDI (0.669) and ΔlnFDI(-1) (0.671) indicate that agricultural output and foreign exchange rates are negatively correlated. At the 10% significance level, we can rule out the null hypothesis that exchange rates have no discernible impact on agricultural production based on the t-statistics of 2.009 and 2.299. Therefore, ceteris paribus, more foreign direct investment would lead to higher agricultural output.

Their relatively low t-statistics indicate that the coefficients for banking credit, inflation rate (INFL), and interest rate (INRA) are statistically inconsequential, according to a deeper examination of the ARDL model findings. The F-statistic of 6.7281, which shows that we can reject the underlying null hypothesis that the external reserves, balance of payments, GDP, EXR, INFL, and INTRA are all equal to zero at

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the 1% significance level, validates the model's overall viability. Therefore, foreign direct investment in Nigeria is significantly impacted by macroeconomic factors.

ΔAGROUT	Coefficient	Std. Error	t-Statistic	Prob.
C	1.342947	1.729498	0.776495	0.4504
ΔAGROUT (-1)	0.662397	0.130043	5.093695	0.0002
ΔlnEXR(-1)	-3.191330	1.467900	-2.174078	0.0451
Δln(EXR))	-4.048559	2.058013	-1.967217	0.0720
ΔBC	3.421205	1.340105	1.985458	0.0056
ΔBC(-1)	4.010005	1.183305	1.962492	0.0024
ΔlnFDI	-1.236958	0.374690	-2.899808	0.0334
ΔlnFDI(-1)	-1.946168	0.458599	-2.334272	0.0234
ΔINFL	0.036185	0.045299	0.798816	0.4377
ΔINFL(-1)	-0.050960	0.043908	-1.160612	0.2652
ΔINTRA	0.378903	0.281268	1.347125	0.1993
ΔINTRA(-1))	0.546561	0.313721	1.742187	0.1034
ECTAGROUT (-1)	-0.250002	0.109471	-2.283738	0.0385
R-squared	0.779214	F-statistic		10.744989
Adjusted R-squared	0.695346	Prob(F-statistic)		0.000372
Log likelihood	-69.77992	Durbin-Watson stat		2.049390

Table 7: Regression Result for Agricultural Output Model in Kenya
(Source: Authors computation (2025))

The outcomes of the autoregressive distributed lags (ARDL) model are displayed in Table 7 which was evaluated to determine how macroeconomic variables affect agricultural output. The R-squared value of 0.779 indicates a good fit for the model, suggesting that 78% of systematic changes in agricultural output (AGROUT) can be accounted for by foreign exchange rates S(FER), banking credit (BC), inflation rates (INFL), and interest rates (INRA).

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Moreover, as illustrated in the table, The error correction term's coefficient (ECTAGROUT(-1)) is -0.2500. At the 5% level, this finding is statistically significant with a t-statistic of -2.2837. Its negative value indicates that shocks from foreign currency rates and other macroeconomic variables are gradually absorbed by agricultural output (AGROUT). This suggests that agricultural output shifts from a short-term state of disequilibrium to a long-term equilibrium at a pace of 25%.

A closer look at Table 7 reveals a positive correlation between the present value of agricultural output (AGROUT(-1)) and its lagged value, with a coefficient of 0.662397. This relationship is statistically significant at the 1% level, as indicated by the corresponding t-statistic of 5.094. Furthermore, with values of -4.0486 and -3.1913, respectively, the results demonstrate an inverse relationship between changes in agricultural production and changes in the natural logarithm of the exchange rate (∆lnFER) and its first lag (∆lnFER(-1)). The hypothesis that the exchange rate has no discernible impact on agricultural production may be rejected at the 10% level, according to the t-statistics of -1.9672 and -2.1741. This implies that a decrease in agricultural production results from a rise (or depreciation) in the exchange rate.

Furthermore, the results indicate that ∆AGROUT has a positive correlation with banking credit (∆lnBC=3.421205 and ∆lnBC(-1)=4.010005). The t-statistics of 1.985458 and 1.962492 suggest that we cannot dismiss the hypothesis of no significant effect of banking credit on agricultural output at the 1% level of significance. Thus, ceteris paribus, AGROUT increases with a rise in banking credit at a rate of 3.42%.

High t-statistics in the table further demonstrate that the coefficients of FDI=-1.237, -1.946 are statistically significant. Therefore, at the 5% level, the null hypothesis may be disproved. Conversely, due to their low t-statistics, the interest rate coefficient (INTRA=0.379, 0.547) and inflation rate coefficient (INFL=0.036, -0.051) are not statistically significant. As a result, each of these variables can independently accept the null hypothesis. In conclusion, the F-statistic of 10.745 validates the importance of the ARDL model. This suggests that, at the 1% level of significance, the null hypothesis which holds that the money supply, public debt, inflation rate, interest rate, banking credit, foreign direct investment, and foreign exchange rate are all equal to zero can be rejected. Thus, it can be said that every macroeconomic element examined has a significant effect on Kenya's agricultural production.

ΔlnAGROUT	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.042621	0.071537	-0.595785	0.5624
ΔlnAGROUT (-1)	0.897332	0.319173	2.811430	0.0157

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ΔlnFER(-1)	-0.166771	0.066081	-2.523736	0.0064
ΔlnFER(-2)	0.139855	0.098605	1.418329	0.1815
ΔBC(-1)	8.8106	2.920007	3.145521	0.0084
ΔBC(-2)	4.100006	1.152107	1.198591	0.2538
ΔlnFDI(-1)	0.107449	0.059296	1.812081	0.0851
ΔlnFDI(-2)	0.098433	0.050078	1.965591	0.0729
ΔINFL(-1)	-0.003827	0.001691	-2.263114	0.0430
ΔINFL(-2)	-0.000539	0.001582	-0.340951	0.7390
ΔINTRA(-1)	-0.011050	0.009049	-1.221141	0.2455
ΔINTRA(-2)	-0.001300	0.009110	-0.142668	0.8889
ECTAGROUT (-1)	-0.620553	0.259510	-2.391248	0.0074
R-squared	0.767281		F-statistic	9.082335
Adjusted R-squared	0.738810		Prob(F-statistic)	0.007763
Log likelihood	48.30698		Durbin-Watson stat	2.006693

Table 8: Regression Result for Agricultural Output Model in Nigeria
(Source: Authors computation (2025))

The results of the autoregressive distributed lags (ARDL) model, which are shown in Table 8, assess how macroeconomic factors affect Nigerian agricultural production. The ARDL model is a decent match, according to the R-squared value of 0.767. This indicates that the exchange rate (FER), foreign direct investment (FDI), banking credit (BC), inflation rate (INFL), and interest rate (INTRA) account for 76.7% of the systematic fluctuations in AGROUT.

Additionally, the coefficient that represents the long-term equilibrium connection between AGROUT and the core macroeconomic variables is denoted by the term ECTAGROUT(-1). This term measures how much the error in the response variable is corrected each period due to shocks from the predictor variables. Consequently, a coefficient of -0.62 is seen in Table 4.7. With a t-statistic of -2.3912, this value is negative and statistically significant at the 1% level, in accordance with economic theory. This shows that, at an annual pace of 62%, agricultural output is transitioning from a state of short-term

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disequilibrium to long-term equilibrium as it adjusts to shocks from the currency rate, banking credit, and other macroeconomic variables.

The ∆lnAGROUT is positively correlated with the first and second lagged changes in the natural log of agricultural output (∆lnAGROUT(-1)=0.897 and ∆lnAGROUT(-2)=0.618), according to a thorough examination of the short-term relationship between agricultural output and the major economic variables. T-statistics of 2.811 and 2.149, respectively, show that these coefficients are statistically significant at the 5% and 10% levels of significance. This suggests that, under the assumption that all other variables stay constant, historical agricultural output may have an impact on the sector's success today. In contrast, there is a negative correlation between the change in logarithmically converted agricultural production and the coefficient for the delayed change in the log-transformed exchange rate (∆lnEXRA(-1) = -0.167). The t-statistic of -2.524 at the 1% significance level supports the statistical significance of this coefficient. This implies that, if all other variables remain same, a 1% increase in the currency rate (depreciation) would lead to a 0.167% drop in Nigerian agricultural production.

Additionally, Table 8 shows a significant correlation between the first and second lags of the change in the natural logarithm of foreign direct investment (∆lnFDI(-1)=0.107 and ∆lnFDI(-2)=0.098) and the change in the natural logarithm of agricultural production. At the 10% significance level, we can rule out the null hypothesis that there is no meaningful correlation between agricultural production and foreign direct investment based on the t-statistics of 1.812 and 1.966, respectively. Thus, if all other things remain the same, a 1% increase in foreign direct investment should result in a 0.10% rise in agricultural production.

The results of the ARDL model indicate a direct relationship between the change in banking credit delayed by one period (∆BC(-1)=2.81006) and the change in the natural logarithm of agricultural production. At the 1% significance level, the t-statistic of 3.1455 permits us to test the null hypothesis of a link. This suggests that, under normal circumstances, agricultural productivity would be increased by an expansion of banking credit. Furthermore, the data shows a negative connection (∆INFL(-1)=-0.0038) between the first lag of the change in the inflation rate and the change in the natural logarithm of agricultural production. At the 5% significance level, we can reject the null hypothesis that the inflation rate has no discernible effect on agricultural production thanks to a t-statistic of -2.263. Therefore, if all other factors remain constant, a 1% increase in the inflation rate would result in a 0.0038% drop in agricultural production.

The table shows that agricultural production and interest rate have an inverse connection, however the low t-statistics (-1.221 and -0.1426) show that this link is not statistically significant. Overall, the relevance of the ARDL model is confirmed by the F-statistic of 9.082. At the 1% significance level, the null hypothesis that the interest rate, inflation rate, banking credit, and exchange rate are all equal to

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zero can be safely rejected. Consequently, Nigeria's industrial value added is significantly impacted by macroeconomic conditions.

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	-10.11718	2.994057	-3.379087	0.0118
AGROUT (-1)	9.974128	3.002186	3.322289	0.0127
FDI(-1)	9.399794	2.933257	3.204558	0.0150
EXR	-2.130490	0.093362	-1.97680	0.0049
EXR (-1)	-2.083624	0.076684	-1.97496	0.0046
BC	0.335763	0.412734	0.813509	0.4427
BC(-1)	4.601459	1.490740	3.086695	0.0176
INFL	-6.642108	1.661009	-2.462817	0.0433
INFL(-1)	-7.693408	1.402108	-3.200066	0.0151
INTRL	-3.311211	1.551009	-0.021435	0.9835
INTRL(-1)	-8.022309	2.482109	-3.229035	0.0145
ECTAGROUT (-1)	-0.927578	0.250363	-3.704930	0.0076

R-squared	0.705457	Mean dependent var	5.571464
Adjusted R-squared	0.662346	S.D. dependent var	3.731959
S.E. of regression	2.168568	Akaike info criterion	4.535363
Sum squared resid	32.91881	Schwarz criterion	5.454742
Log likelihood	-39.95972	Hannan-Quinn criter.	4.800111
Durbin-Watson stat	1.934833		

Table 9: Regression Result for Agricultural Output Model in South Africa
(Source: Author's Computation, (2025))

Table 9 displays the autoregressive distributed lags model (ARDL) findings. The results of the unit root test showed that all variables were trailing because of their integration of order one (I(1)). According to the ARDL model's findings, agricultural output (AGROUT) is positively correlated with foreign direct

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investment (FDI) and banking credit (BC), but negatively correlated with exchange rates (EXR), inflation (INFL), and interest rates (INTRL). This suggests that although rises in EXR, INFL, and INTRL hinder agricultural productivity in South Africa, increases in FDI and BC encourage it. Lagged AGROUT, FDI, EXR, BC, INFL, and INTRL, however, are statistically significant, according to the research.

Several statistics, including as p-values, t-statistics, and standard errors, corroborate this relevance. For example, the t-statistic for the coefficient (3.204558) exceeds the crucial t-value of ±1.96 at the 5% significance level, and the standard error (2.933257) associated with the coefficient (9.399794) of delayed FDI (FDI (-1)) is less than 50% of the coefficient value itself. Similarly, EXR, EXR(-1), and BC(-1) have coefficients of 2.130490, 2.083624, and 4.601459, respectively, with standard errors of 0.093362, 0.076684, and 1.490740. These coefficients have t-statistics of -1.97680, -1.97496, and -3.086695, together with p-values of 0.0176, 0.0049, and 0.0046. The t-statistics surpass the key t-value of ±1.96 at the 5% significance level, the p-values are below the 5% threshold, and half of the coefficient values are greater than their standard errors.

The statistical significance of variables EXR, EXR(-1), and BC(-1) is confirmed by these data. This implies that the main factors influencing South Africa's agricultural production are EXR, EXR(-1), and BC(-1). With standard errors of 2.402108 and 2.4809, corresponding t-statistics of 3.200066 and -3.229035, and p-values of 0.0151 and 0.0145, the coefficients for INFL(-1) and INTRL(-1) are 7.693408 and -8.023309, respectively. Once more, the t-statistics are higher than the key t-value of ±1.96 at the 5% significance level, the p-values stay below 5%, and half of the coefficient values exceed their standard errors. With a p-value of 0.0076 and an error correction term (ECT) coefficient of -0.927578, the model's dynamics from the short to the long term are shown. At the 5% level, it is equally negative and significant, indicating that around 92.75% of the model's disequilibrium is resolved each year. According to the R-squared value (0.705457), alterations to the independent variables account for 70% of the fluctuations in AGROUT. As a result, the model's projections are suitable for suggesting policies.

	Breusch-Pagan-Godfrey Heteroscedasticity Test:		Breusch-Godfrey Serial Correlation LM Test	
Models	F-statistic	P- value	F-statistic	P-value
AGROUT model for Ghana	2.877988	0.2251	0.761304	0.4868
AGROUT model for Kenya	2.825285	0.1022	0.479229	0.6306

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AGROUT model for Nigeria	2.511090	0.1428	0.286673	0.7567
AGROUT model for South Africa	2.773121	0.2146	0.432214	0.5317

Table 10: Result of Diagnostic Test for all the Models (Source: Author's computation, (2025))

All models examined were subjected to the Breusch-Pagan-Godfrey test for heteroscedasticity and the Breusch-Godfrey LM test for serial correlation; the results are shown in table 10. To determine if heteroscedasticity—a variation in variance throughout the series—exists in the model, a heteroscedasticity test is often conducted. The test's null hypothesis states that the series are homoscedastic, meaning that heteroscedasticity is not present. If the p-value linked to the F-statistics is less than the designated significance level, which is often set at 5%, the null hypothesis will be rejected. The results of the Breusch-Pagan-Godfrey heteroscedasticity test in this instance are shown in table 4.8. The F-statistics for the tests are 2.877988, 2.825285, 2.511090, and 2.773121, and the corresponding p-values for the AGROUT models for Ghana, Kenya, Nigeria, and South Africa are 0.2251, 0.1022, 0.1428, and 0.2146, respectively. We do not reject the null hypothesis because all p-values are more than 5%, suggesting that heteroscedasticity does not exist in any of the models.

Additionally, the LM test for Breusch-Godfrey Serial Correlation was used. According to the null hypothesis, there is no serial correlation, which means that there is no association between the error terms from different time periods. If the p-value associated with the test's F-statistics is less than the predefined significance level, which is typically 5%, the null hypothesis is rejected. AGROUT model for Ghana = 0.761304, AGROUT model for Kenya = 0.479229, AGROUT model for Nigeria = 0.7567, and AGROUT model for South Africa = 0.5317 are the F-statistics values for the serial correlation tests across all models in this investigation. We accept the null hypothesis and conclude that no serial correlation was found in any of the models since the p-values for the F-statistics in each model are all above the 5% significance level. As a result, results for all models show that there are no problems with serial correlation (autocorrelation) or heteroscedasticity.

Discussion

The findings of this research indicate a notable relationship between macroeconomic indicators and agricultural output in Sub-Saharan African nations. Consequently, the null hypothesis, which asserts that macroeconomic variables do not significantly impact agricultural production in the region, is disproven. These results align with previous studies by Sanchi, Alhassan, and Sabo (2022), reinforcing the idea that macroeconomic conditions are vital in influencing agricultural performance across these countries.

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Further investigation revealed a causal relationship between macroeconomic trends and agricultural productivity, echoing earlier research by Mbelu and Ifionu (2022). Notably, the causation identified is unidirectional, moving from macroeconomic indicators to agricultural output, suggesting that variations in the macroeconomic environment have a direct effect on agricultural performance. Therefore, the null hypothesis proposing no causal link between these variables must also be dismissed, affirming the directional influence of macroeconomic factors on the agricultural sector.

Moreover, the research illustrated that the effect of macroeconomic variables on agricultural output is significant across various regions in Sub-Saharan Africa. This supports the dismissal of the hypothesis claiming no regional impacts, consistent with the conclusions of Sanchi, Alhassan, and Sabo (2022), as well as corroborating evidence from Chukwu (2023), Haladum et al. (2024), Mbelu and Ifionu (2022), and Liu et al. (2020). Using data from the World Development Indicators from 1990 to 2023, the study assessed the connection between agriculture and macroeconomics. Its objectives were to (i) assess the overall impact of macroeconomic variables on agricultural production, (ii) ascertain the causal relationship, and (iii) investigate regional impacts in a subset of Sub-Saharan African nations. Using the ARDL model, the GMM Estimator, and the DH tests, the study applied techniques appropriate for datasets in which the number of cross-sectional units (N) surpasses the temporal dimension (T). The findings supported a directional and statistically significant association between the region's agricultural productivity and macroeconomic factors.

Conclusion and Recommendations

The research's conclusions indicate that macroeconomic variables affect Sub-Saharan Africa's agricultural output. Additionally, the study found a strong correlation between interest rates and agricultural output in this area. Additionally, it was shown that banking lending had a significant impact on agricultural production in Sub-Saharan African nations. The study also found a causal relationship between Sub-Saharan Africa's agricultural output and macroeconomic variables. Crucially, a one-way influence was noted between the countries in this region. These findings led to many policy recommendations being made: A single exchange rate system, as opposed to a dual exchange rate, should be implemented by Sub-Saharan African governments as it will encourage trade openness and boost the region's agriculture sector's performance. Interest rates and other monetary policies should be designed to promote Nigeria's agriculture industry since macroeconomic factors are known to affect its performance. In order to promote job creation and eventually boost growth and development in Sub-Saharan Africa, governments should concentrate on boosting budgetary allocations for the agricultural sector.

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