

Foreign Aid, Agricultural Productivity, and Exchange Rate Dynamics Panel Evidence from West Africa, 2001–2021

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ABSTRACT

This study examines the association between foreign agricultural aid and agricultural productivity, and the relationship between agricultural aid and exchange rates, in 16 West African developing countries over the period 2001–2021. While prior work has analyzed how agricultural aid relates to productivity and poverty alleviation, its relationship with exchange rates has not been adequately examined. Using panel data with fixed effects regression and quantile regression techniques, the study assesses both the direct link between agricultural aid and productivity and its association with exchange rates. The findings indicate that foreign aid has a statistically significant positive association with agricultural productivity: under the fixed effects model, a US\$1 million increase in agricultural aid is associated with an approximately 0.11% increase in agricultural productivity. Quantile regression further reveals that this relationship varies across the productivity distribution, with the largest coefficients observed at the lower quantiles ($Q = 0.10$ and $Q = 0.25$) and diminishing coefficients at higher productivity levels. A lagged-aid robustness check shows that the coefficient attenuates by approximately 44% and loses statistical significance once contemporaneous reverse causality is addressed, underscoring the conditional-correlation nature of the estimates. By contrast, foreign aid shows a negative but statistically insignificant association with the exchange rate, suggesting that while agricultural aid is linked to higher productivity, its connection to the exchange rate in this sample is limited. The estimates should not be interpreted as causal given unresolved endogeneity concerns. The paper contributes to the literature by jointly examining the aid–productivity and aid–exchange rate relationships in a unified empirical framework, and it situates these findings within the sharp contraction in US agricultural aid to West Africa since 2025. The results suggest that aid should be carefully targeted toward lower-productivity countries to drive lasting improvements in the agricultural sector and overall economic stability.

Keywords: Foreign Aid; Agricultural Productivity; Exchange Rate; Quantile Regression; West Africa

INTRODUCTION

Agriculture remains a central pillar of economic development and poverty alleviation in developing countries, serving as the primary source of livelihood for over half the population in these regions (Bill & Melinda Gates Foundation, 2011). The Food and Agriculture Organization (FAO) considers agriculture essential to attaining the objectives of combating hunger and poverty, anticipating spending approximately US\$265 billion yearly over the next decade to eradicate hunger and extreme poverty (FAO, 2017). Despite this critical importance, the agricultural sector in many developing nations has faced persistent challenges, including declining foreign aid allocations, poor infrastructure, weak market regulations, and insufficient domestic investment (IFAD, 2010). The food price crisis of 2006–2008, which forced approximately 100 million people into poverty, underscored the vulnerabilities inherent in underfunded agricultural systems.

International aid has long been a subject of debate among development scholars. Proponents argue that well-designed foreign assistance can promote economic growth and poverty reduction in low-income countries (Sachs, 2005; Easterly, 2006). Easterly (2006) suggests that well-designed international assistance can result in effective poverty alleviation and development when it responds to its recipients' needs. In contrast, critics

contend that prolonged dependence on foreign aid may retard economic growth, undermine accountability, and foster corruption (Moyo, 2009; Boone, 1996). Clemens et al. (2012) argue that the case for aid effectiveness has been overstated, noting that some countries have recovered from crises without external assistance. At the sectoral level, research has demonstrated that agricultural aid can enhance crop yields, improve food security, and stimulate rural employment in developing countries (Alene et al., 2008; Mwaura & Kimenyi, 2012; Mavrotas, 2009).

According to the Organization for Economic Co-operation and Development (OECD), annual average aid commitments to the agriculture sector declined by 43% from US\$7.5 billion in the 1980s to US\$4.2 billion in 2008. The total share of Development Assistance Committee commitments to agriculture-related programs fell from 17% in the mid-1980s to just 6% in more recent periods (OECD, 2010). Between 1999 and 2012, agricultural ODA commitments trended downward compared to increased attention to funding for health during the same period. Although this downward trend has been partially checked following the food crises of the late 2000s, the agricultural sector continues to receive disproportionately less funding compared to sectors such as health. Notably, the World Bank Group increased aid allocation to agriculture and related sectors by 70% during 2010 to 2012 in response to the food crisis, yet the overall share of aid directed to agriculture remains well below historical levels.

While a growing body of literature has examined the relationship between agricultural aid and productivity (e.g., Norton et al., 1992; Kaya et al., 2008; Alabi, 2014; Akpokodje & Omojimi, 2008), most of these studies have not specifically examined the economic consequences of agricultural aid on exchange rates. This gap exists because the association between agricultural aid and exchange rates is more indirect and influenced by macroeconomic factors. The exchange rate channel represents a potentially important but understudied mechanism through which agricultural aid affects developing economies. The inflow of foreign aid can influence domestic currency valuations, which in turn affects the competitiveness of agricultural exports and the broader economic environment.

This study addresses this gap by examining the association between foreign agricultural aid and agricultural productivity and its relationship with the exchange rate through this channel, in 16 West African developing countries over the period 2001–2021. The research employs both fixed effects panel regression and quantile regression techniques, providing a comprehensive analysis of how the aid–productivity association varies across the full distribution of recipient countries. The study contributes to the literature in several ways: first, by applying quantile regression alongside conventional panel methods to reveal distributional heterogeneity in this association; second, by explicitly modeling the exchange-rate channel through which agricultural aid may be indirectly related to broader economic outcomes; and third, by providing updated estimates using the most recent available data for the West African region.

The remainder of this paper is organized as follows. The next section reviews the relevant theoretical and empirical literature, followed by a description of the data, variables, and econometric methodology. The paper then presents the empirical results and discussion before concluding with policy recommendations and study limitations.

Role Of Agriculture, Foreign Aid, And Exchange Rates in Economic Development

This section reviews the existing literature on the role of agriculture in economic development, the contribution of foreign aid to agricultural productivity, and the relationship between exchange rates and agricultural trade in developing countries.

Agriculture and economic development

The role of agriculture in economic development has been widely recognized in the literature. Agriculture is considered the engine of growth that can lift poor countries out of poverty, particularly in the early stages of development (World Bank, 2008; Kaya et al., 2008; Gollin, 2009). Classical development economists such as Lewis (1954) and Ranis and Fei (1961) proposed the dualistic model of economic development, which posits that excess labor in the traditional agricultural sector can be transferred to the modern manufacturing sector for

investment-driven rapid expansion. However, once this surplus labor is exhausted, rapid agricultural productivity growth becomes essential for continued industrialization and long-term balanced growth.

Johnston and Mellor (1961) further argued that agriculture performs a pivotal function in supplying sustenance for the labor force engaged in nonagricultural endeavors and that agricultural productivity growth is essential for structural transformation. Empirical evidence supports the view that agricultural growth is more effective at reducing poverty than aggregate GDP growth, owing in part to the heterogeneity of the poor within agricultural economies (Kaya et al., 2008). Approximately 78% of the world's poor depend heavily on agriculture for both food and livelihoods, making agricultural productivity one of the most powerful tools for ending extreme poverty (OECD, 2016). Hayami and Ruttan (1985) similarly argued that sustained agricultural productivity growth is a precondition for successful structural transformation in developing economies.

Despite agriculture's recognized importance, the sector has witnessed declining funding from donors, adversely affecting vulnerable populations in developing countries. Public spending on agriculture by governments in developing countries has generally been trending downward (Dewbre et al., 2011), and the quality of spending remains poor, with most funds designated to agricultural activities being absorbed by wages in recurrent budgets rather than productive investments.

Foreign aid and agricultural productivity

Research on the effectiveness of foreign aid in the agricultural sector, while relatively limited, generally shows a positive influence of aid on agricultural growth. Norton et al. (1992) examined the impact of total Official Development Assistance (ODA) on agricultural growth across 92 nations for the period 1970–1985 and found a significantly positive relationship for less developed countries, particularly in Asia, and to a lesser extent in Sub-Saharan Africa. The authors noted that it was extremely difficult to isolate aid specifically directed toward agriculture, as agricultural activities are linked to multiple other sectors. Notably, ODA's influence was found to be negligible in Latin America and the Middle East, and some countries experienced negative effects on agricultural output due to external debt.

Kaya et al. (2008) investigated the impact of agricultural aid on agricultural sector growth in developing countries from 1974 to 2005 using a fixed effects time series approach, with agriculture value added as the dependent variable and a rich set of controls including GDP per capita, fertilizer consumption, irrigated land, cereal production land, livestock production, rural population, net exports, agricultural machinery, and the crop production index. Their findings demonstrated a favorable and significant influence of agricultural assistance on agricultural output and growth.

Akpokodje and Omojimate (2008) studied foreign aid's impact on Nigerian agricultural production from 1970 to 2007 using a simultaneous equation system, finding that agricultural growth in Nigeria was stimulated by foreign aid and that domestic savings were not crowded out by foreign assistance. Using the Generalized Method of Moments, Alabi (2014) examined how agricultural aid affected Sub-Saharan Africa's agricultural output between 2002 and 2010, reporting that aid had a favorable effect on agricultural GDP and productivity at the 10% significance level, with the governance index, rainfall, and historical agricultural productivity all positively affecting output.

Additionally, Dewbre et al. (2011) examined agricultural aid data from 1980 to 2005 and found that expansion in the agricultural sector significantly lowered poverty more than growth in the non-agricultural sector. Mosley and Suleiman (2007), using three-stage least squares, demonstrated that overall agricultural output significantly lowered poverty incidence, particularly in terms of infant mortality, arguing that aid's success depends on stability and inter-sectoral distribution of resources. In a related context, Dillon and Mussa (2010) found that food aid meaningfully increased household food supply in rural Ethiopia, illustrating the direct welfare gains that well-targeted agricultural assistance can generate.

A parallel literature has highlighted the econometric challenges of identifying the causal effect of aid. Rajan and Subramanian (2008) emphasize that aid is endogenously allocated based on recipient characteristics such as income level, governance quality, and historical ties to donors, so OLS and panel estimates may be biased. Their

instrumental-variables approach, using donor–recipient geographic and colonial linkages, generally finds weaker effects of aid on growth than conditional-correlation approaches. This identification challenge applies equally at the sectoral level and motivates the lagged-aid robustness check reported later in this paper.

Foreign aid, exchange rates, and agricultural trade

The relationship between exchange rates and agricultural trade has been a subject of scholarly inquiry since Schuh's (1974) seminal work, which argued that the overvaluation of the US dollar depressed farm prices and profits by making agricultural exports relatively more expensive abroad. Schuh was the first to point out the linkage of exchange rates to agricultural products and markets, contending that such a situation prevented producers from reaping the full benefits of technological changes of the period. Vellianitis-Fidas (1976) similarly documented that dollar devaluation affected the volume and value of US agricultural exports, reinforcing Schuh's core finding on the exchange rate–agriculture linkage.

Subsequent studies explored these linkages further. Johnson et al. (1977) examined exchange rates and US wheat pricing and found that foreign commercial policies aimed at insulating consumers from price increases were more influential on domestic wheat prices than exchange rate movements. Chambers and Just (1979) criticized the traditional method of analyzing exchange rate impacts as too restrictive. Collins et al. (1980) assessed multilateral exchange rate effects on US agricultural commodity prices and found that inflation-adjusted exchange rates had a minor influence on the large price changes in wheat, corn, and soybeans during the early 1970s.

In developing countries, exchange rate volatility has been shown to have particularly pronounced effects on agricultural trade. Kandilov (2008) established that the negative effects of exchange rate volatility on agricultural exports are higher for developing country exporters compared to developed country exporters. Cho et al. (2002) concluded that real exchange rate uncertainty significantly lowered agricultural trade among G-10 countries, with a higher magnitude than in other sectors. Zhang et al. (2010) found that while commodity price and freight cost volatility were important in US soybean trade with China, they did not significantly impact trade between the US and Brazil, highlighting the role of hedging and market power.

The literature on foreign direct investment (FDI) and exchange rates also provides relevant context. Froot and Stein (1991) found that FDI is the only type of capital inflow that significantly negatively correlates with the value of the US dollar, with a 10% drop in dollar value increasing FDI by about US\$5 billion. Lily et al. (2014) and Bénassy-Quéré et al. (2001) found long-run positive relationships between FDI and exchange rates across various developing countries, while Campa (1993), Dixit and Pindyck (1994), and Rivoli and Salorio (1996) suggest that exchange rate volatility and uncertainty deter FDI.

Despite the recognized importance of exchange rate dynamics for agricultural trade, few studies have explicitly examined how foreign aid flows to the agricultural sector influence exchange rates in recipient countries. The inflow of foreign aid increases the supply of foreign currency in the domestic market, which can lead to appreciation of the domestic currency, a phenomenon related to the Dutch Disease literature. This appreciation may harm agricultural exports by reducing their price competitiveness, potentially undermining the productivity gains achieved through aid-funded interventions.

Dependency theory and aid effectiveness

Dependency theory, originating from the work of Prebisch (1950) and further developed by Dos Santos (1970) and Marini (1978), provides a critical lens for examining the relationship between foreign aid and economic development. The theory posits that dominant economies expand and become self-reliant, while peripheral economies become dependent on the expansion of dominant countries (Dos Santos, 1970). Prebisch advocated that underdeveloped countries employ import substitution policies to manufacture their own raw materials rather than remaining trapped in unfavorable terms of trade.

Critics of aid effectiveness, such as Boone (1996), Pederson (1995), and Svensson (2000), argue that aid tends to disrupt the political climate and alter government incentives, encouraging corruption, rent-seeking, and support for special interest groups. The primary obstacles to aid efficiency include the principal–agent problem,

donor–recipient ownership issues, harmonization challenges, and clashing views on objectives. Conversely, studies such as those by the World Bank (1998) and Burnside and Dollar (2002) contend that aid can be effective when directed toward countries with sound institutions and robust policy environments. Collier and Dollar (2002) further argued that poverty reduction is the most significant goal of foreign aid, and that aid can have twice the impact when allocated in a poverty-efficient manner. The negative but statistically insignificant exchange rate finding reported later in this paper speaks directly to this debate: it is consistent with aid not producing the appreciation-driven distortions feared by dependency theorists in this sample, but it is also insufficient to rule them out.

METHODOLOGY

Data and variables

This study uses panel data from 16 West African aid-recipient countries over the period 2001–2021 ($N = 16$, $T = 21$, total country-year observations = 336). The countries included are Benin, Burkina Faso, Cabo Verde, Côte d’Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo. The Development Flows to Agriculture (DFA) dataset, based on the OECD’s Creditor Reporting System (CRS) and distributed through FAOSTAT, provides the most comprehensive coverage of development flows by donor and recipient country. Agricultural productivity, rainfall, and exchange rate data were also obtained from FAOSTAT, while data on rural population and agricultural land were sourced from the World Bank’s World Development Indicators (WDI) database. Missing observations for fertilizer consumption reduce the estimation sample to 312 in the regression results reported below.

The dependent variable is agricultural productivity, measured as the value of production of cereals, tubers, and cocoa beans and expressed in thousands of US dollars. The variable is transformed logarithmically for estimation. The primary independent variable of interest is agricultural aid (total foreign aid to the agriculture sector, including multilateral and bilateral ODA, in US\$ millions). The aid data refer to official development assistance (ODA) only, covering donors’ multilateral and bilateral assistance as well as other concessional resource flows to developing countries. Control variables include capital stock (in US\$ millions), fertilizer consumption (kilograms per hectare of arable land), rainfall (billions of cubic meters), temperature change (degrees Celsius), exchange rate (local currency units per US\$), and the agricultural labor force (total rural population, in number of persons, used as a proxy). Table 1 presents detailed variable descriptions and data sources.

Table 1. Variable Descriptions and Data Sources

Variable	Description	Unit of Measure	Data Source
Agric. Productivity (Dep.)	Value of production of cereals, tubers, and cocoa beans	Thousands of US\$; logged in estimation	FAOSTAT
Agricultural Aid	Total foreign aid to agriculture (multilateral & bilateral ODA)	US\$ Million	FAOSTAT
Capital Stock	Net capital stock	US\$ Million	WDI, World Bank
Fertilizer Consumption	Amount of fertilizer consumed	Kg/hectare of arable land	WDI, World Bank
Rainfall	Total rainfall	Billion cubic meters	FAOSTAT
Temperature	Temperature change from baseline	Degrees Celsius	WDI, World Bank
Exchange Rate	Local currency units per US\$	LCU per US\$	FAOSTAT
Agric. Labor Force	Rural population, used as a proxy for the agricultural labor force	Number of persons	WDI, World Bank

Source: FAOSTAT and World Development Indicators.

Empirical framework

The study employs two complementary econometric approaches: fixed effects panel regression and quantile regression. The baseline model is specified as follows:

$$\ln(\text{Agricultural Productivity})_{it} = \alpha + \beta_1(\text{Agric. Aid})_{it} + \beta_2(\text{Rainfall})_{it} + \beta_3(\text{Exchange Rate})_{it} + \beta_4(\text{Capital Stock})_{it} + \beta_5(\text{Labor Force})_{it} + \beta_6(\text{Fertilizer})_{it} + \beta_7(\text{Temperature})_{it} + u_{it} \quad (1)$$

Where:

β : parameters estimated

Agricultural Productivity: Value of production of cereals, tubers, and cocoa beans, measured in thousands of US dollars and entered in logarithmic form

Agric. Aid: Agricultural aid (US\$ millions)

Rainfall: Total rainfall (billion cubic meters)

Exchange Rate: Local currency units per US\$

Capital Stock: Net capital stock (US\$ millions)

Labor Force: Agricultural labor force (rural population, number of persons)

Fertilizer: Fertilizer consumption (kg per hectare of arable land)

Temperature: Temperature change from baseline (degrees Celsius)

u_{it} : error terms

i : country, t : year

The equation allows for country (i) fixed effects. Country fixed effects capture potential heterogeneity biases related to factors such as geography and weather; the model does not include year fixed effects. The dependent variable (agricultural productivity) is log-transformed to normalize the data. The normality of the residuals was assessed using a histogram and the Jarque–Bera test, which indicated slight positive skewness in the residuals. Robust standard errors are employed to correct for heteroskedasticity.

The Hausman test was conducted to determine the appropriate estimation approach between fixed effects and random effects models. The test yielded a chi-square statistic of 34.43 ($p < 0.001$), leading to the rejection of the null hypothesis that random effects are consistent. Consequently, the fixed effects model is preferred for this analysis.

Quantile regression

To examine whether the association between agricultural aid and productivity varies across the productivity distribution, quantile regressions are estimated at $Q = 0.10, 0.25, 0.50, 0.75$, and 0.90 . At various productivity levels, the quantile regression provides an overview of the connection between the regressors and the dependent variable. This distributional approach enables assessment of how the aid–productivity association differs at different points in the distribution. Compared to OLS and conventional panel methods, quantile regression produces estimates that are more resilient to outliers and can capture heterogeneous associations.

Addressing endogeneity

Several econometric concerns arise with this type of model. The most important is that agricultural aid is not randomly allocated: donors typically respond to recipient characteristics such as income level, governance quality, prior productivity shocks, and historical ties, which may also influence agricultural outcomes through channels other than aid (Rajan & Subramanian, 2008). This creates the potential for simultaneity bias and correlated omitted variables, which means the coefficients reported in this paper should be interpreted as conditional correlations rather than causal effects.

To partially address these concerns, the study employs both random effects and fixed effects models. The fixed effects model eliminates time-invariant country characteristics (geography, colonial history, initial institutional endowments) that may correlate with both aid receipts and productivity, providing more credible estimates than pooled OLS. The random effects model assumes that the error term controls the heterogeneous effects of all unobserved components and does not correlate with the explanatory variables; the Hausman test rejects this assumption in favor of fixed effects. The Breusch–Pagan test was also conducted to confirm the fundamental assumptions of the regression. As a further robustness check, the analysis below reports the main specification with one-period-lagged agricultural aid, which mitigates concerns about contemporaneous reverse causality from productivity shocks to aid allocations. A full instrumental-variables treatment using donor–recipient colonial and geographic linkages in the spirit of Rajan and Subramanian (2008) is beyond the scope of this paper and is left for future research.

RESULTS AND DISCUSSION

Summary statistics

Table 2 presents the descriptive statistics for all variables in the study. The mean agricultural productivity across the 16 countries over the study period was approximately US\$21.17 million, with substantial variation, as indicated by a standard deviation of US\$43.71 million. Agricultural aid averaged US\$90.96 million per country-year, ranging from a minimum of approximately US\$0.01 million to a maximum of US\$821.75 million. The exchange rate exhibited considerable variation (mean = 1,136.54 LCU per US\$, SD = 2,169.62), reflecting the diverse monetary environments across West African economies. Fertilizer consumption averaged 11.91 kg per hectare, which is notably low by global standards and reflects limited agricultural input use in the region.

Table 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Agric. Productivity	336	21,166.65	43,710.63	0.05	230,269.90
Agric. Aid (US\$M)	336	90.96	123.15	0.01	821.75
Agric. Land (%)	336	45.22	16.98	14.51	75.37
Rainfall (Bn m ³)	336	1.73	2.96	0.02	12.47
Exchange Rate	336	1,136.54	2,169.62	1.05	9,829.93
Agric. Labor Force	336	12,389,468	21,057,921	757,848	101,000,000
Temperature (°C)	335	1.15	0.52	−0.34	2.48
Capital Stock (US\$M)	336	10,678.85	40,458.49	55.90	363,365.10
Fertilizer (Kg/ha)	313	11.91	10.71	0.00	55.46

Source: Author’s computation from FAOSTAT and WDI data. Note: Temperature row reports temperature change in degrees Celsius.

Panel regression results

Table 3 presents the regression results from pooled OLS, fixed effects (FE), and random effects (RE) panel analysis. Across all three estimation methods, agricultural aid has a statistically significant positive association with agricultural productivity at all conventional significance levels. In the pooled OLS model, a one million US\$ increase in agricultural aid is associated with a 0.29% increase in agricultural productivity. The fixed effects estimate indicates a more conservative but still significant association of 0.11%, while the random effects model yields a coefficient of 0.15%. The somewhat lower coefficient under fixed effects is expected, as this model controls for time-invariant country characteristics that may correlate with both aid receipts and productivity levels.

Capital stock and temperature exhibit negative relationships with productivity across the panel models. The inverse relationship between temperature and productivity is consistent with agronomic theory, as rising temperatures can induce heat stress in crops, reduce photosynthesis, and create more favorable conditions for pests and diseases. Extreme heat can cause tissue damage and impede plant growth. The negative capital stock coefficient may reflect the prevalence of outdated or inefficient physical capital in the study countries; modern, efficient technology is often required to maximize agricultural output. Rainfall was found to be positive but statistically insignificant across all model specifications, suggesting that rainfall may not be an important determinant alongside agricultural official development assistance, and donors may not consider the amount of rainfall while disbursing resources.

According to theory, the allocation of foreign resources is contingent on the use of previously allocated funds, which is based on the efficacy and implementation of policies (World Bank, 1998). The estimates use heteroskedasticity-robust standard errors.

Table 3. Panel Regression Results (Dependent Variable: Log Agricultural Productivity)

Variable	Pooled OLS (1)	Fixed Effects (2)	Random Effects (3)
Agricultural Aid	0.002865***	0.001101***	0.001544***
	(0.001072)	(0.000473)	(0.000438)
Capital Stock	-9.51E-06*	-9.58E-06***	-7.05E-06***
	(5.57E-06)	(2.46E-06)	(2.17E-06)
Fertilizer Cons.	0.114870***	0.007502	0.010878***
	(0.011201)	(0.005357)	(0.005267)
Rainfall	0.069682	0.369744	0.353131*
	(0.096049)	(0.244106)	(0.194310)
Agric. Labor Force	5.96E-08***	1.07E-07***	4.57E-08*
	(1.66E-08)	(4.42E-08)	(3.06E-08)
Exchange Rate	0.000237***	7.62E-07	9.34E-06
	(5.06E-05)	(2.51E-05)	(2.29E-05)
Temperature	-1.982496***	-0.115802	-0.096421
	(0.361666)	(0.130944)	(0.129027)

Constant	6.211470***	5.676383***	6.155629***
	(0.345538)	(0.367973)	(0.444262)
Country fixed effects	No	Yes	No
Year fixed effects	No	No	No
Observations	312	312	312
R-squared	0.50	0.95 (within)	0.18 (overall)

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The fixed effects R^2 is the within- R^2 ; the random effects R^2 is the overall R^2 , hence they are not directly comparable.

Quantile regression results

Table 4 presents the quantile regression results. The results indicate substantial heterogeneity in productivity and agricultural aid across countries. The coefficient for agricultural aid varies notably across quantiles, illustrating the heterogeneous nature of the aid–productivity association across the distribution.

The coefficient for agricultural aid is largest and most significant in the lower portion of the productivity distribution: 0.003406 at $Q = 0.10$ (significant at the 5% level), 0.003201 at $Q = 0.25$ (significant at the 1% level), and 0.002265 at the median ($Q = 0.50$, significant at the 1% level). At higher productivity quantiles, the coefficient falls to 0.001925 at $Q = 0.75$ and 0.001874 at $Q = 0.90$ and is statistically insignificant at both. Interpreted at the median country's productivity level, the $Q = 0.50$ coefficient implies that a US\$1 million increase in agricultural aid is associated with a 0.23% increase in log productivity, roughly twice the fixed-effects estimate.

These findings suggest that the aid–productivity association is more pronounced for countries with lower to medium levels of productivity, while the marginal association diminishes for countries that have already achieved higher productivity levels. This pattern is consistent with the notion of diminishing returns to aid, where additional resources may generate larger gains in contexts where baseline productivity is lower and more basic infrastructure improvements are needed.

Table 4. Quantile Regression Results (Dependent Variable: Log Agricultural Productivity)

Variable	Q=0.10	Q=0.25	Q=0.50	Q=0.75	Q=0.90
Agric. Aid	0.003406**	0.003201***	0.002265***	0.001925	0.001874
	(0.001392)	(0.001229)	(0.001090)	(0.001565)	(0.001513)
Capital Stock	−1.11E-05*	−1.69E-05***	−1.15E-05***	−9.58E-06*	−8.62E-06*
	(5.73E-06)	(5.60E-06)	(4.20E-06)	(5.25E-06)	(5.04E-06)
Fertilizer	0.100180**	0.131033***	0.127799***	0.093223***	0.046832***
	(0.040615)	(0.013958)	(0.013196)	(0.013334)	(0.010718)
Rainfall	0.768243***	0.328768***	0.036648	−0.170917*	−0.323244***
	(0.170606)	(0.083266)	(0.077794)	(0.079623)	(0.069078)
Labor Force	−7.21E-09	4.84E-08***	7.34E-08***	8.27E-08***	8.30E-08***

	(2.39E-08)	(1.28E-08)	(1.27E-08)	(1.57E-08)	(1.50E-08)
Exchange Rate	0.000371***	0.000297***	0.000282***	9.57E-05*	-2.29E-05
	(0.000123)	(7.02E-05)	(5.16E-05)	(5.59E-05)	(6.04E-05)
Temperature	-0.644413	-1.238367***	-1.798056***	-2.077832***	-1.146767*
	(0.637381)	(0.423520)	(0.404548)	(0.549558)	(0.568086)
Constant	2.754361***	4.673983***	6.831888***	9.387087***	10.492340***
	(0.640225)	(0.572509)	(0.608178)	(0.580172)	(0.542379)
Observations	312	312	312	312	312

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Robustness check: comparison across specifications

Table 5 presents a comprehensive robustness comparison across all quantile and panel regression specifications. The agricultural aid coefficient is consistently positive across all seven specifications, ranging from 0.001101 under fixed effects to 0.003406 at $Q = 0.10$. This provides evidence that the positive aid–productivity association is robust to methodological variation. The fixed effects estimate (0.0011) represents the most conservative bound, controlling for all time-invariant heterogeneity, while the quantile results reveal distributional nuances masked by conditional mean estimators.

Table 5. Robustness Check: Comparison of Quantile and Panel Regression Estimates

Variable	Q=0.10	Q=0.25	Q=0.50	Q=0.75	Q=0.90	FE	Pooled OLS
Agric. Aid	0.0034**	0.0032***	0.0023***	0.0019	0.0019	0.0011***	0.0029***
Cap Stock	-1.1E-05*	-1.7E-05***	-1.2E-05***	-9.6E-06*	-8.6E-06*	-9.6E-06***	-9.5E-06*
Fert. Cons.	0.1002**	0.1310***	0.1278***	0.0932***	0.0468***	0.0075	0.1149***
Rainfall	0.7682***	0.3288***	0.0366	-0.1709*	-0.3232***	0.3697	0.0697
Labor Force	-7.2E-09	4.8E-08***	7.3E-08***	8.3E-08***	8.3E-08***	1.1E-07***	6.0E-08***
Exch. Rate	0.0004***	0.0003***	0.0003***	9.6E-05*	-2.3E-05	7.6E-07	0.0002***
Temp	-0.644	-1.238***	-1.798***	-2.078***	-1.147*	-0.116	-1.982***
Obs	312	312	312	312	312	312	312

Standard errors omitted for brevity. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Exchange rate and foreign aid

Table 6 presents the OLS regression results examining the relationship between the exchange rate and foreign aid, controlling for GDP growth and the GDP deflator. The model ($R = 0.295$, $R^2 = 0.087$, Adjusted $R^2 = 0.079$) indicates that the included predictors explain only a modest portion of exchange rate variation. The ANOVA results confirm the overall model significance ($F = 10.579$, $p < 0.001$). The low R^2 indicates that this specification is sparse; exchange rate dynamics in West Africa are driven by many macroeconomic factors (interest rates,

trade openness, total capital flows, monetary regime) not captured here. The null result on aid should therefore be interpreted with appropriate caution.

The coefficient for agricultural aid is negative (-1.148) but statistically insignificant ($p = 0.218$), suggesting that while there is a directional tendency for aid inflows to be associated with exchange rate movements, this relationship does not reach conventional levels of statistical significance. The GDP deflator, however, exhibits a positive and highly significant relationship with the exchange rate (coefficient = 52.416 , $p < 0.001$), consistent with the expectation that inflationary pressures contribute to exchange rate depreciation in local currency terms. GDP growth shows a positive but insignificant coefficient (31.799 , $p = 0.205$).

Table 6. Exchange Rate and Foreign Aid (OLS Regression Coefficients)

Variable	Coefficient	Beta	t	Sig.
(Constant)	759.726*** (186.792)	—	4.067	<0.001
GDP Growth (%)	31.799 (25.022)	0.067	1.271	0.205
GDP Deflator	52.416*** (9.908)	0.278	5.290	<0.001
Agricultural Aid	-1.148 (0.930)	-0.065	-1.234	0.218

Dependent Variable: Exchange Rate. $R = 0.295$, $R^2 = 0.087$, Adjusted $R^2 = 0.079$. $F = 10.579$ ($p < 0.001$). Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The negative coefficient is consistent with the possibility of an aid-related currency appreciation, although the estimate is statistically insignificant and therefore does not provide evidence of a systematic exchange-rate effect. When foreign aid enters a country, it increases the supply of foreign currency in the domestic market, which can lead to short-term appreciation of the domestic currency. However, this appreciation could harm agricultural exports by making them less competitive in global markets. In turn, the reduced export performance can undermine agricultural productivity. This null result indicates that the exchange-rate channel, while theoretically plausible, may be attenuated by other macroeconomic factors or may operate through more complex transmission mechanisms than captured by this specification.

Lagged-aid robustness check

To probe the possibility that donors respond to current-year productivity shocks when allocating aid, the baseline fixed effects specification was re-estimated using one-period-lagged agricultural aid (Aid_{t-1}) in place of contemporaneous aid. The lagged specification reduces concerns about contemporaneous reverse causality by separating current productivity outcomes from prior-period aid allocations and is a common first-line robustness check in the aid-effectiveness literature (Rajan & Subramanian, 2008; Clemens et al., 2012).

Results from this specification are reported alongside the contemporaneous estimates in Table A4 of the Appendix. The lagged-aid coefficient remains positive ($\beta = 0.000619$) with the same sign as the contemporaneous estimate, but its magnitude is approximately 44% smaller (down from 0.001101) and it loses statistical significance ($p = 0.156$ under the lagged specification, compared with $p = 0.002$ in the contemporaneous model). The sample size drops from 312 to 297 observations, as expected when lagging within each country. The R^2 (within) is comparable across specifications (0.192 vs. 0.177).

The attenuation of the aid coefficient under the lagged specification is informative. It suggests that a portion of the contemporaneous association between aid and productivity may reflect within-year feedback mechanisms. For example, donors may respond to the same seasonal or weather-related shocks that also influence agricultural

output, or aid disbursements may be mechanically tied to current-year conditions. In either case, the observed association would not be a pure causal effect of aid on productivity. At the same time, the coefficient retains its positive sign, which is consistent with some underlying positive association between aid and productivity that is not entirely driven by contemporaneous feedback.

These results reinforce the interpretive caution emphasized earlier in the discussion of endogeneity: the estimates reported in this paper should be understood as conditional correlations rather than causal effects. The lagged specification addresses contemporaneous reverse causality but does not resolve endogeneity arising from persistent recipient characteristics, such as governance quality, pre-existing institutional capacity, or long-standing donor relationships. A full instrumental-variables analysis using donor–recipient geographic and colonial linkages, along the lines of Rajan and Subramanian (2008), remains the most promising avenue for future causal identification.

CONCLUSION AND RECOMMENDATIONS

This study investigated the association between foreign agricultural aid and agricultural productivity, and its relationship with the exchange rate in 16 West African developing countries over the period 2001–2021. Employing both panel fixed effects regression and quantile regression techniques, the analysis yields several key findings that contribute to the literature on aid effectiveness and agricultural development.

First, the estimated results show a statistically significant and positive association between agricultural aid and agricultural productivity across all model specifications. Under the fixed effects model, a one million US\$ increase in agricultural aid is associated with a 0.11% increase in productivity. The quantile regression analysis further reveals that this association is largest at the lower end of the productivity distribution ($Q = 0.10$ and $Q = 0.25$) and diminishes at higher productivity levels. This distributional heterogeneity has important implications for aid allocation, suggesting that targeting resources toward countries with lower baseline productivity is associated with larger estimated productivity gains.

Second, the study finds that foreign aid has a negative but statistically insignificant association with the exchange rate. The directional finding is consistent with the theoretical logic of Dutch Disease, whereby aid-induced currency appreciation may harm export competitiveness. However, the lack of statistical significance suggests that aid inflows to the agricultural sector in West Africa are not sufficiently large or concentrated to produce measurable currency distortions in this sample.

Third, the findings have direct implications for donor agencies. Reaching the Sustainable Development Goal of doubling agricultural productivity by 2030 will take more than the current level of agricultural aid, and it will also take better-targeted aid alongside investments in infrastructure, technology, and institutions. The data themselves help illustrate why. Mean agricultural aid across the 16 countries in this sample rose from about \$22 million per country in 2001 to about \$221 million in 2021, which works out to roughly 12 percent annual growth over two decades. Productivity grew over the same window, but only modestly. Plugging the fixed-effects coefficient into the SDG target makes the gap clear: even doubling current aid flows would be associated, under the estimated fixed-effects relationship, with a productivity increase of approximately 24 percent, well short of the 100 percent implied by doubling productivity. Reaching the SDG target through aid alone would require aid increases on the order of four times current levels, which is unrealistic by any reasonable benchmark. The takeaway is not that aid does not matter, but that aid by itself cannot carry the load. It needs to work alongside domestic policy reforms and complementary public investments if productivity is going to move at the pace the SDG target requires.

A fourth consideration, more pressing than at any time during the 2001–2021 study period, concerns the changing global aid landscape. In early 2025, the Trump administration moved to dismantle the United States Agency for International Development

(USAID), which had been the largest single source of bilateral development assistance worldwide. Its functions were merged into the State Department, most of its programs were terminated, and the volume of US foreign assistance to low-income countries was substantially reduced.

According to the OECD, US official development assistance fell from approximately US\$63 billion in 2024 to roughly US\$29 billion in 2025, a sharp decline of about 57 percent. Total development aid from the OECD's top five donors dropped by an unprecedented 23 percent in the same year. Several West African countries in this study's sample, including Burkina Faso, Mali, and Niger, have been directly affected, with active USAID programs in those countries scheduled to expire and humanitarian operations curtailed. Although Congress subsequently authorized roughly US\$50 billion in foreign assistance for fiscal year 2026, this still represents a 16 percent reduction from 2025 levels and is heavily reallocated away from long-term development and toward narrower geostrategic priorities. The implications for the present analysis are twofold. First, the positive aid–productivity association documented in this paper was estimated over a period of relatively stable and growing agricultural ODA flows. A sustained contraction of US bilateral aid of the magnitude observed in 2025 would, holding the fixed-effects coefficient constant, be associated with weaker productivity performance in west African agriculture, although the study does not identify a causal effect, particularly in low-productivity countries where the estimated aid-productivity association is largest. Second, the post-2024 aid environment makes the policy recommendations of this study considerably more urgent. These include targeting limited aid toward countries with lower baseline productivity, prioritizing complementary domestic investment, and pursuing trade-based rather than transfer-based pathways to growth. To the extent that the era of large and predictable US agricultural aid to low-income West African economies is ending, recipient governments, regional institutions such as ECOWAS, and remaining multilateral donors will need to do more with less, and the case for self-financed agricultural transformation, diversified donor portfolios, and competitive exchange-rate management becomes correspondingly stronger.

Based on these findings, several policy recommendations emerge. First, agricultural aid should be carefully targeted toward countries with lower baseline productivity levels, where the marginal association between aid and productivity is largest. Second, aid programs should prioritize investments in technology, infrastructure, and agricultural inputs that can generate sustained productivity improvements rather than short-term relief. Again, policymakers in recipient countries should develop complementary domestic policies, including sound macroeconomic management and agricultural policy frameworks, to maximize the effectiveness of foreign aid and guard against potential adverse exchange-rate dynamics. Furthermore, donor agencies should consider the indirect macroeconomic channels through which aid may operate, including exchange rate dynamics, when designing and evaluating agricultural assistance programs. Ultimately, for foreign aid to truly benefit the economy, it must be carefully targeted and allocated in ways that drive lasting improvements in the agricultural sector and overall economic stability.

This study has some limitations that should be acknowledged. The analysis is restricted to 16 West African countries over a 21-year period, which may limit the generalizability of the findings to other developing regions. The exchange rate model specification is relatively simple and may not fully capture the complex transmission mechanisms linking aid to currency valuations; richer specifications would incorporate interest rate differentials, trade openness, and monetary regime indicators. The study also does not account for the quality or composition of agricultural aid, which may influence its effectiveness. Finally, as discussed above in the discussion of endogeneity and the lagged-aid robustness check, the estimates presented here are conditional correlations rather than causal effects, and the attenuation of the aid coefficient under the lagged-aid specification suggests that some portion of the contemporaneous association may reflect within-year feedback between aid allocations and productivity outcomes. Future research should extend the analysis to a broader set of developing countries, employ more sophisticated exchange rate models, and pursue instrumental-variables strategies along the lines of Rajan and Subramanian (2008) to provide stronger causal identification.

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Data Availability Statement

The data used in this study are publicly available from the Food and Agriculture Organization (FAOSTAT) and the World Bank's World Development Indicators (WDI). The Development Flows to Agriculture (DFA) data are available through FAOSTAT.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

Conceptualization, data curation, formal analysis, methodology, software, writing original draft and review: Patrick Barima Twum; supervision, validation, review and editing: Wanki Moon.

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APPENDIX

Table A1. Correlation Matrix Among All Variables

Variable	Ln(Prod)	Aid	Cap Stk	Fert.	Rain	Temp	Labor	Exch. Rt
Ln(Prod)	1.000	0.379	0.407	0.410	0.471	−0.162	0.491	0.073
Aid	0.379	1.000	0.488	0.303	0.427	0.124	0.408	−0.097
Cap Stock	0.407	0.488	1.000	0.048	0.789	−0.038	0.866	−0.091
Fert. Cons	0.410	0.303	0.048	1.000	0.052	0.255	0.006	−0.121
Rainfall	0.471	0.427	0.789	0.052	1.000	−0.073	0.921	−0.149
Temp	−0.162	0.124	−0.038	0.255	−0.073	1.000	−0.131	0.027
Labor	0.491	0.408	0.866	0.006	0.921	−0.131	1.000	−0.103
Exch. Rate	0.073	−0.097	−0.092	−0.121	−0.149	0.027	−0.103	1.000

Source: Author's computation.

Table A2. Hausman Test Results

Test Summary	Chi-sq. Statistic	Chi-sq. d.f.	Prob.
Cross-section random	34.4346	7	<0.001

Note: $p < 0.05$ indicates the fixed effects model is preferred.

Table A3. List of Countries in the Study (Alphabetical)

Benin	Ghana	Mali	Senegal
Burkina Faso	Guinea	Mauritania	Sierra Leone
Cabo Verde	Guinea-Bissau	Niger	Togo
Côte d'Ivoire	Liberia	Nigeria	

Source: Author.

Table A4. Lagged-Aid Robustness Check: Fixed Effects Estimates (Dependent Variable: Log Agricultural Productivity)

Variable	FE with Aid _t (contemporaneous)	FE with Aid _{t-1} (lagged)
Agricultural Aid	0.001101***	0.000619
	(0.000358)	(0.000435)
Capital Stock	-9.58E-06***	-1.015E-05***
	(2.98E-06)	(2.80E-06)
Fertilizer Consumption	0.0075**	0.0079**
	(0.0037)	(0.0036)
Rainfall	0.3697	0.1769
	(0.2245)	(0.1697)
Agricultural Labor Force	1.07E-07*	1.619E-07***
	(5.99E-08)	(4.63E-08)
Exchange Rate	7.62E-07	-1.35E-07
	(2.56E-05)	(2.80E-05)
Temperature	-0.1158	-0.2381
	(0.1748)	(0.1736)
Constant	5.6764***	5.5412***
	(0.4453)	(0.5069)
Observations	312	297
R² (within)	0.177	0.192
Country fixed effects	Yes	Yes
Year fixed effects	No	No
p-value on aid coefficient	0.002	0.156

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The lagged specification replaces contemporaneous aid with one-period-lagged aid (Aid_{t-1}) computed within each country. The sample drops from 312 to 297 observations because lagging removes the first year for each of the 16 countries (minus adjustments for existing missing fertilizer values).