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Agricultural Growth in Sub-Saharan Africa: The Role of Financial Institutions, Energy Efficiency PPPs, Global Uncertainty, and Political Instability

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Abstract

In Sub-Saharan Africa (SSA), the agricultural sector is a fundamental driver of job creation, economic progress, and structural shifts, even as it confronts persistent macroeconomic, energy, institutional, and financial barriers. This research investigates the intersecting impacts of energy efficiency, political volatility, global economic policy uncertainty, and financial institutions on the agricultural expansion of 48 SSA nations between 2000 and 2022. We measure agricultural progress using employment in agriculture (EIAG) and agricultural value added (AVD), while evaluating financial institutions via indices of stability (FISI), efficiency (FIEI), access (FIAI), and depth (FIDI). Furthermore, our models integrate control and explanatory variables such as interest rates, exchange rates, public-private partnerships in energy (PPPE), political instability (PINS), global economic policy uncertainty (GEPU), and energy efficiency. After conducting panel cointegration tests, we utilized the Fully Modified Ordinary Least Squares (FMOLS) for robustness checks and the System Generalised Method of Moments (System GMM) as our primary estimator. The empirical outcomes highlight significant persistence in agricultural trends and uncover diverse impacts depending on the specific dimension of financial institutional advancement. Notably, the interplay between energy efficiency and financial development yields substantial positive outcomes for agricultural growth, indicating that financial intermediation achieves its highest efficacy when paired with optimized energy use. Additionally, political turbulence and global unpredictability significantly alter how financial institutions affect agricultural success, as evidenced by multiple significant interaction variables. Ultimately, these results underscore that achieving agricultural transformation across SSA demands cohesive policies that merge institutional robustness, macroeconomic steadiness, efficient energy use, and financial sector progression. By illustrating that the success of financial institutions relies heavily on the encompassing energy and economic landscape, these discoveries enrich the dynamic literature on agricultural finance.

Keywords: Sub-Saharan Africa, Agricultural Development, Energy Optimization, Financial Intermediation, Macroeconomic Volatility, Public-Private Partnerships.

1. Introduction

For Sub-Saharan Africa (SSA), expanding agricultural output is essential for ensuring food security, alleviating poverty, and propelling overall economic development. The sector sustains the livelihoods of a massive segment of the population and is inextricably tied to rural wealth generation, food supply, and job creation. Beyond direct production, a thriving agricultural base fosters vital connections with non-farm sectors such as trade, warehousing, logistics, and agro-processing, thereby fortifying the continent's wider economic capabilities. However, agriculture's ability to fulfill these roles hinges on a dependable macroeconomic and political climate, alongside access to technology, infrastructure, institutional backing, and productive inputs. Recent analyses reveal that SSA's agricultural output is dictated not solely by raw farming inputs, but by a complex web of external, institutional, energy, and financial variables. For example, energy generation, oil revenues, and credit availability critically impact SSA's agricultural trajectory, while environmental dynamics and energy scarcity are recognized as primary drivers of farming productivity across the continent. These insights emphasize that analyzing agricultural expansion requires a comprehensive look at the broader institutional and economic contexts surrounding farming operations.

Financial entities serve as a primary conduit for pooling and directing capital into the agricultural domain. With robust financial services, agribusinesses and rural cultivators can secure essential inputs like irrigation systems, modern machinery, fertilizers, and premium seeds, while effective financial intermediation spurs capital allocation toward marketing, storage, and processing ventures. Yet, academic consensus regarding finance's true impact on agricultural success remains divided. Certain studies demonstrate that financial development, including bank credit and specific agricultural guarantee funds, significantly boosts output and fosters technological innovation in rural farming. Conversely, the correlation between agricultural progression and finance is not universally positive. Several investigations have detected no meaningful causal link between farm output and agricultural funding, while others report a statistically insignificant U-shaped correlation involving agricultural credit funds. Crucially, some evidence even points to credit channels exerting a detrimental effect on SSA's agricultural advancement, with market structures dictating whether the relationship supports demand-following or supply-leading paradigms. These conflicting perspectives suggest that tracking the mere volume of agricultural loans fails to encapsulate how the broader financial ecosystem influences farming growth. Therefore, this study adopts a multifaceted approach by evaluating financial institutions through their stability, efficiency, accessibility, and depth, offering a comprehensive view of their capacity to catalyze SSA's agricultural metamorphosis.

Energy stands as another pivotal factor dictating farming success. Contemporary agriculture relies heavily on energy across the entire value chain—from mechanization and irrigation to storage, refrigeration, processing, and transit. In regions burdened by erratic electricity and poor infrastructure, inefficient energy use and inflated costs severely stunt productivity. Research underscores the necessity of factoring productive agricultural energy use into the design of SSA's energy grids. Furthermore, the interplay between agrarian economic activity and renewable energy usage varies dynamically between long- and short-term horizons. Severe energy poverty substantially diminishes technical efficiency in farming, proving that restricted access to suitable power stifles the sector's output potential. This dynamic is further complicated by the imperatives of environmental sustainability and energy optimization. The depth of energy poverty heavily influences regional agricultural productivity across Africa, though the exact impacts fluctuate

geographically. Strategic land use, reliable food supply chains, and optimized energy consumption are critical for mitigating the ecological fallout of farming activities, as agricultural and energy demands often accelerate environmental degradation. Thus, evaluating agricultural expansion must account for both the availability and the efficiency of energy, measured in this research as the ratio of primary energy consumption to economic output.

Environmental legislation directly intersects with this energy-agriculture dynamic. Mechanisms like green taxation alter the financial viability of polluting energy sources, thereby incentivizing the integration of eco-friendly practices and efficient technologies. While these policies might introduce upfront financial burdens for farmers, well-structured incentives can secure enduring sustainability and productivity improvements. This is exceptionally pertinent for SSA, where farming is highly vulnerable to resource depletion, ecological decay, and climate fluctuations. Implementing economically viable energy and land-use strategies is vital to curbing greenhouse emissions without sacrificing crop yields. Consequently, the synergy between eco-taxes and energy efficiency warrants rigorous empirical investigation within the context of SSA's agricultural growth.

Public-Private Partnerships (PPPs) offer a viable strategy to bypass the technological, financial, and infrastructural roadblocks hindering African agriculture. Constrained national budgets often prevent governments from single-handedly delivering the rural roads, energy grids, processing facilities, and irrigation networks necessary for sectoral reform. PPPs merge the public sector's regulatory oversight with the private sector's innovation, managerial acumen, and capital. Localized partnerships have proven effective in driving innovation within specific supply chains, such as cocoa production. Nevertheless, the success of a PPP is intimately tied to its operational environment. Challenges such as inadequate governance, poor corporate oversight, financial instability, and weak feasibility planning frequently derail these initiatives, while poor readiness limits PPP adoption in various African nations. Therefore, their presence alone does not guarantee success. While flexible contracts and equitable risk distribution attract private investment, rigid post-contract risk allocations can stifle ongoing innovation. Because agricultural infrastructure necessitates durable institutional stability and long-term commitments, this study specifically examines whether energy-focused PPPs tangibly enhance SSA's agricultural output.

Agricultural prosperity is equally susceptible to fluctuations in global policy and economic stability. Shifts in geopolitical climates, exchange rates, interest rates, trade regulations, and international commodity valuations heavily dictate food prices, export demand, and investment strategies. Heightened economic policy uncertainty has been shown to degrade food security and hamper long-term agricultural growth, as unpredictability deters capital injection and complicates long-range planning for producers. However, the dynamic is intricate; global shocks and oil price volatility exhibit complex, nonlinear spillovers into agricultural commodity markets. Energy price fluctuations and policy uncertainty asymmetrically impact food costs, meaning global volatility affects farming via multiple intertwined pathways, justifying its inclusion in our empirical framework. Finally, political stability is an indispensable prerequisite for farming development. Thriving agriculture demands the effective execution of public policies, dependable infrastructure, functioning markets, and secure assets and labor. Political unrest dismantles these foundations by crippling support programs, severing supply chains, destroying infrastructure, and displacing rural populations. Empirical data corroborates that political turmoil, especially when compounded by

climate anomalies, drastically lowers crop yields and exacerbates food insecurity, as weak governance degrades extension services and institutional frameworks.

Despite this interconnected reality, prior research frequently isolates these variables. Financial studies usually fixate on credit volumes rather than holistic institutional traits, while energy research often emphasizes environmental decay instead of explicit efficiency metrics linked to agricultural growth. PPP literature tends to focus on project governance rather than sectoral outcomes, and studies on political or global uncertainty rarely interact these factors with energy and financial constraints. This fragmentation overlooks critical synergies: financial systems fund green technologies, PPPs deliver energy networks, global volatility impacts investment risk, and political climates dictate policy execution. To bridge this substantial empirical void, this research analyzes the concurrent impacts of political stability, global economic policy uncertainty, energy PPPs, green taxes, energy efficiency, and financial institutions on SSA's agricultural trajectory. We evaluate agricultural growth using value added and employment metrics, and examine whether institutional effects change under varying degrees of political and global uncertainty. We deploy dynamic panel system GMM to handle endogeneity and persistence, alongside panel FMOLS for long-run robust verification. This multidimensional framework provides robust evidence for designing synchronized pan-African agricultural initiatives.

2. Review of Related Literature

2.1. Financial Institutions and Agricultural Growth

Recent scholarship reveals diverse outcomes regarding financial development's impact on farming. Research utilizing autoregressive distributed lag (ARDL) models confirms that financial evolution yields a significantly positive influence on short- and long-term agricultural output. Investigations into credit market structures identify evidence validating both demand-following and supply-leading paradigms. Contrastingly, time-series analyses spanning 2001 to 2021 demonstrate that credit channels exert a detrimental effect on SSA's agricultural development, whereas oil revenues and energy generation display mixed yet significant impacts. Other analyses highlight that expanding the scale and efficiency of rural finance actively fosters agricultural technological innovation. Granger causality tests in certain regions have found zero causal linkages between farming output and agricultural financing, while alternative ordinary least squares (OLS) studies argue that specialized agricultural credit guarantee funds drastically improve crop yields. Similar positive correlations between bank credit access and regional agricultural productivity have been documented across both Central African and West African contexts. Conversely, threshold regression analyses have uncovered statistically insignificant, U-shaped relationships between real agricultural GDP and credit guarantee schemes.

2.2 Energy Efficiency Policy and Agricultural Growth

Regarding energy optimization, scholars investigating agricultural microgrid designs in SSA determined that integrating local productive energy usage scales up system requirements without substantially altering the levelized cost of energy. Pooled Mean Group ARDL evaluations of agrarian economies demonstrate that short-term economic activity boosts renewable energy usage, whereas long-term growth tends to suppress it. Furthermore, the volatility of clean energy stock returns is negatively influenced by the pricing of natural gas, coal, and oil. Utilizing a system GMM approach across Chinese provinces, researchers identified that energy poverty drastically reduces

agricultural technical efficiency, though this negative impact diminishes as structural industrialization improves. Additional findings suggest that agriculture exacerbates climate change vulnerabilities in SSA, necessitating strategic adaptations in food supply, energy application, and land use to ensure environmental sustainability and curb greenhouse emissions. Analyses employing Dynamic Ordinary Least Square (DOLS) and FMOLS frameworks indicate that combined energy and agricultural demands accelerate ecological degradation. In SSA, energy poverty positively influences agricultural footprints, while ecological degradation inversely affects farm productivity, with outcomes varying widely across subregions due to disparate economic and resource baselines.

2.3 Public-Private Partnerships and Agricultural Growth

The literature exploring agricultural innovation systems suggests that robust localized public-private partnerships (LPPPs) successfully drive advancements within specific sectors, such as the cocoa value chain. Conversely, case studies on failed PPPs highlight severe risks, including unsupportive governance frameworks, poor corporate oversight, a lack of financial foresight, force majeure, and mid-project financial instability. In regions like Uganda, the deployment of PPPs is heavily stymied by a lack of institutional readiness and widespread ignorance regarding partnership mechanics. Despite this, PPPs have successfully financed critical infrastructural and health programs in various contexts. Extensive barriers hinder private partner selection, including the absence of pre-feasibility studies, weak political oversight, poor business case formulation, and logistical hurdles in assembling technical evaluation teams. Furthermore, research into private sector motivation reveals that equitable risk-sharing and flexible contracting significantly elevate corporate interest in public projects. Finally, while PPP frameworks cultivate an innovative atmosphere prior to contract finalization, restrictive post-award risk allocations often suffocate subsequent innovation.

2.4 Global Uncertainty and Agricultural Growth

Evaluations of panel data from 1995 to 2019 confirm that economic policy uncertainty (EPU) exerts a profoundly negative impact on global food security. Similar analyses highlight that EPU consistently damages short- and long-term agricultural growth. Paradoxically, other panel data studies focusing on listed agricultural entities suggest that policy uncertainty actually stimulates technological innovation within these firms. Spillover and Granger-causality models evaluating the COVID-19 pandemic era reveal severe cross-market connectedness between agricultural commodities and oil-induced shocks. This interconnectedness among softs, grains, and livestock futures intensified remarkably during major pandemic waves. In contrast, agricultural futures in specific domestic markets exhibit lower correlation with global oil fluctuations than their international counterparts. Quantile-conditioned transmission analyses show that volatility spillovers between agricultural and energy commodities peak at the extreme upper and lower distribution tails. Global food prices respond asymmetrically and nonlinearly to energy shocks, while EPU consistently drives food prices upward. Nonparametric quantile-on-quantile regressions demonstrate that while crude oil fails as a safe haven for agriculture, its volatility can hedge against farming shocks; simultaneously, US-based EPU negatively correlates with global agricultural commodities.

2.5 Political Instability and Agricultural Growth

Two-step system GMM evaluations spanning 2002 to 2020 verify that political instability actively devastates crop production, which is otherwise bolstered by expanded agricultural land but strained by growing rural populations. In East Africa, the lethal combination of climate anomalies and political chaos has been shown to crash agricultural productivity by up to 25%, as instability paralyzes the state's ability to deploy climate adaptation and agricultural support mechanisms. Studies concentrated in the Horn of Africa mirror these conclusions, demonstrating that political unrest slashes the availability of inputs and disrupts farming, leading to diminished yields for staples like sorghum and maize. Cross-national analyses of African states endure similar trends, correlating sustained political turmoil with severe spikes in food insecurity. Governance deeply dictates agricultural success; poor governance paired with political volatility cripples extension services and farming programs, triggering massive productivity losses through resource misallocation. Finally, conflict zones experience drastic agricultural declines due to severed market access, crop destruction, and labor shortages.

2.6 Research Gap

The existing literature harbors vital blind spots regarding SSA's agricultural trajectory. Foremost, financial analyses obsess over raw credit metrics, ignoring the holistic dimensions of institutional stability, efficiency, access, and depth. This narrow focus produces conflicting narratives, with credit showing negative, neutral, and positive impacts across different studies. Energy research similarly obsesses over degradation and poverty indices rather than directly quantifying how energy efficiency scales agricultural growth. The PPP landscape is heavily skewed toward project governance rather than sectoral outcomes, leaving energy PPPs largely unexamined in an agricultural context. Furthermore, literature mapping political and global uncertainty is highly fragmented, generating contradictory evidence regarding asymmetric market responses and food security. Most glaringly, no prior investigation unites political instability, global uncertainty, energy PPPs, energy efficiency, and financial institutions into a cohesive framework assessing SSA's agriculture. Methodologically, past reliance on threshold models, ARDL, and OLS fails to address the inherent endogeneity and persistence of these variables. This study rectifies these omissions by deploying FMOLS and System GMM to analyze this multidimensional nexus comprehensively.

3. Methodology and Data Description

3.1 Data and Sources

To robustly evaluate the intersections of political instability, global uncertainty, energy PPPs, green taxes, energy efficiency, and financial development with SSA's agricultural expansion, this research utilizes data from 2000 to 2022 covering 48 Sub-Saharan nations. Data was sourced from the global economic uncertainty database, the International Monetary Fund (IMF), and World Bank repositories (World Governance Indicators and World Development Indicators). Based on rigorous literature reviews, the variables were selected as follows: Agricultural growth is quantified by employment in agriculture (EIAG) and agricultural value-added (AVD). Financial institutional parameters include the Stability Index (FISI), Efficiency Index (FIEI), Access Index (FIAI), and Depths Index (FIDI). Energy intensity (ENIT) is captured via primary energy usage levels (MJ/$), while green taxation (GTAX) is represented by environmental levies. Public-Private partnerships are tracked via energy-sector PPPs (PPPE), global uncertainty via the economic policy uncertainty index (GEPU), and political climate via the absence of violence/political stability metric (PINS).

Control variables encompass interest rates (INTR), exchange rates (EXR), and financial deepening (the M2/GDP ratio). The 2000–2022 timeframe was dictated by strict data availability constraints.

Acronym	Definition	Repository
AVD	Agricultural Value-Added	World Bank Data
EIAG	Employment in Agriculture	World Bank Data
FIDI	Financial Institution Depths Index	IMF Data
FIAI	Financial Institution Access Index	IMF Data
FIEI	Financial Institution Efficiency Index	IMF Data
FISI	Financial Institution Stability Index	IMF Data
ENIT	Energy Intensity level of primary energy	World Bank Data
PPPE	Public-Private Partnerships on Energy	World Bank Data
GEPU	Global Economic Policy Uncertainty	Policy Uncertainty Database
PINS	Political Instability	World Governance Indicators
M2/GDP	Financial Deepening – broad money to GDP ratio	World Bank Data
EXR	Exchange Rate	World Bank Data
INTR	Interest Rate	World Bank Data

3.2 Model specification

The analytical framework is constructed to determine if political instability, global economic policy uncertainty, energy PPPs, energy intensity, and financial institutions drive agricultural growth across SSA. We utilize EIAG and AVD as our dual agricultural growth indicators. Financial dynamics are broken down into FISI, FIEI, FIAI, and FIDI, serving as core explanatory factors alongside PINS, GEPU, PPPE, and ENIT. INTR, EXR, and M2/GDP act as macroeconomic controls. The foundational relationship for agricultural value-added is defined as:

$$AVD_{it} = f(FIDI_{it}, FIAI_{it}, FIEI_{it}, FISI_{it}, ENIT_{it}, PPPE_{it}, GEPU_{it}, PINS_{it}, M2GDP_{it}, EXR_{it}, INTR_{it}) \quad (1)$$

Correspondingly, for the agricultural employment alternative:

$$EIAG_{it} = f(FIDI_{it}, FIAI_{it}, FIEI_{it}, FISI_{it}, ENIT_{it}, PPPE_{it}, GEPU_{it}, PINS_{it}, M2GDP_{it}, EXR_{it}, INTR_{it}) \quad (2)$$

where t signifies the year and i represents the country.

3.2.1 System GMM Baseline Model

Recognizing that agricultural expansion exhibits temporal persistence and that several predictors are likely endogenous, we rely on the dynamic panel System GMM as our primary estimator. We embed the prior period's agricultural output into the model to capture this persistence. The baseline equation for AVD is:

$$AVD_{it} = \alpha_0 + \alpha_1 AVD_{i,t-1} + \alpha_2 FIDI_{it} + \alpha_3 FIAI_{it} + \alpha_4 FIEI_{it} + \alpha_5 FISI_{it} + \alpha_6 ENIT_{it} + \alpha_7 PPPE_{it} + \alpha_8 GEPU_{it} + \alpha_9 PINS_{it} + \alpha_{10} M2GDP_{it} + \alpha_{11} EXR_{it} + \alpha_{12} INTR_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Here, ε_{it} is the idiosyncratic error, λ_t handles time-specific characteristics, μ_i accounts for country-specific unobserved effects, and $AVD_{i,t-1}$ is the lagged dependent variable. For EIAG, the setup is identical:

$$EIAG_{it} = \beta_0 + \beta_1 EIAG_{i,t-1} + \beta_2 FIDI_{it} + \beta_3 FIAI_{it} + \beta_4 FIEI_{it} + \beta_5 FISI_{it} + \beta_6 ENIT_{it} + \beta_7 PPPE_{it} + \beta_8 GEPU_{it} + \beta_9 PINS_{it} + \beta_{10} M2GDP_{it} + \beta_{11} EXR_{it} + \beta_{12} INTR_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

Integrating lagged variables establishes the models' dynamic nature. System GMM expertly mitigates unobserved heterogeneity and endogeneity by amalgamating first-differenced and leveled equations using internal instruments. This is crucial as macroeconomic metrics, farming performance, PPP investments, energy intensity, and financial growth mutually influence each other. Theoretically, robust financial indices (stability, efficiency, access, depth) are anticipated to yield positive signs, indicating enhanced resource utilization by agribusinesses. ENIT should yield a negative coefficient, as elevated intensity reflects wasteful energy use inflating production expenses. PPPE is projected to be positive due to infrastructure upgrades. Conversely, PINS and GEPU are expected to negatively impact growth by destabilizing markets and deterring investment. The directional impacts of INTR, EXR, and M2/GDP remain empirically ambiguous.

3.2.2 Panel FMOLS Robustness

Model To validate our baseline outcomes, we deploy the panel FMOLS technique, which excels at evaluating cointegrated long-run panel relationships fraught with serial correlation and endogeneity. By offering a distinct estimation architecture, FMOLS tests the durability of the System GMM findings. The FMOLS equation for AVD is formulated as:

$$AVD_{it} = \gamma_0 + \gamma_1 FIDI_{it} + \gamma_2 FIAI_{it} + \gamma_3 FIEI_{it} + \gamma_4 FISI_{it} + \gamma_5 ENIT_{it} + \gamma_6 PPPE_{it} + \gamma_7 GEPU_{it} + \gamma_8 PINS_{it} + \gamma_9 M2GDP_{it} + \gamma_{10} EXR_{it} + \gamma_{11} INTR_{it} + u_{it} \quad (5)$$

For agricultural employment, the structure is:

$$EIAG_{it} = \delta_0 + \delta_1 FIDI_{it} + \delta_2 FIAI_{it} + \delta_3 FIEI_{it} + \delta_4 FISI_{it} + \delta_5 ENIT_{it} + \delta_6 PPPE_{it} + \delta_7 GEPU_{it} + \delta_8 PINS_{it} + \delta_9 M2GDP_{it} + \delta_{10} EXR_{it} + \delta_{11} INTR_{it} + v_{it} \quad (6)$$

We expect aligning magnitudes, statistical significance, and coefficient signs across both FMOLS and System GMM, confirming that the empirical realities are not mere artifacts of the chosen statistical method.

4. Empirical Results and Discussions

4.1 Descriptive Statistics

The descriptive data highlights the variability and distribution of the metrics influencing SSA's agricultural landscape. Lagged AVD averages 8.120 alongside a 1.840 standard deviation, pointing to consistent but moderate regional variability over the two decades. The financial metrics showcase distinct averages: FISI (0.570), FIEI (0.510), FIAI (0.390), and FIDI (0.430), underscoring stark disparities in the maturity of national financial architectures. Energy efficiency (ENEF) averages 4.760 with a high standard deviation (2.910), revealing massive cross-country disparities in energy optimization. The PPPE mean sits low at 0.080, yet stretches to a maximum of 1.720, indicating highly unequal private sector participation in energy across borders. A GEPU mean of 104.730 demonstrates that these nations endure intense global economic unpredictability. PINS averages -0.610 (ranging from -2.940 to 1.310), reflecting a widespread deficit in political stability, albeit with notable outliers. Significant fluctuations in EXR and INTR (mean 13.470, max 49.870) align with the diverse macroeconomic realities of the 48 nations. Positive skewness in INTR, EXR, GEPU,

and ENEF suggests heavy upper-tail outliers. Ultimately, this profound dataset heterogeneity perfectly justifies utilizing the dynamic System GMM, which natively adjusts for specific country-level differences.

4.2 Correlation Test

Correlation matrices demonstrate that AVD positively aligns with all four financial indices. FIDI exhibits the strongest bond, followed closely by FIAI, FIEI, and FISI, tentatively suggesting that robust financial structures boost farming outcomes. PINS and PPPE similarly align positively with AVD, while INTR, EXR, GEPU, and ENEF inversely correlate. Predictably, the four financial indices display strong inter-correlations, though none breach the critical 0.80 threshold that typically signals severe multicollinearity. The remaining factors showcase moderate to low correlations, meaning standard multicollinearity is not an immediate threat, though variance inflation factor (VIF) checks remain prudent before finalizing models. These matrices merely confirm associations; definitive causation is deferred to the rigorous FMOLS and System GMM models.

4.3 Unit Root Test

Panel unit root evaluations were executed via Fisher ADF, IPS, and LLC methodologies to determine integration orders. Relying on diverse tests fortifies the reliability of our stationarity conclusions. The panel data presents a mix of I(1) and I(0) integrations. INTR, PINS, ENEF, FIEI, EIAG, and AVD are stationary at their level, with all three test frameworks soundly rejecting the unit root null hypothesis, classifying them as I(0). In contrast, EXR, PPPE, GEPU, FISI, FIAI, and FIDI retain unit roots at level but achieve strict stationarity after first differencing, securing an I(1) classification. Crucially, no variables exhibit an I(2) integration order, validating the use of our selected dynamic models. Economically, this implies employment and output remain stable long-term, while exchange rates, energy partnerships, and financial depths carry higher persistence. This satisfies the foundational requirements for System GMM, though final validity hinges on Hansen and Arellano-Bond diagnostics.

4.4 Cointegration Testing

Pedroni cointegration diagnostics run across all eight models (four for EIAG, four for AVD) consistently verify stable, enduring relationships between agricultural progress and its predictors. Across the board, Panel v statistics present as positive and significant. Furthermore, Group ADF/PP/rho and Panel ADF/PP/rho metrics overwhelmingly reject the no-cointegration null hypothesis at the 5% or 1% thresholds. The profound significance of the ADF and PP statistics firmly proves that these variables are locked in a shared long-term equilibrium. Because these results hold true regardless of whether output or employment is measured, the cointegration is structurally robust, thereby sanctioning the subsequent deployment of long-run FMOLS estimations.

4.5 Baseline System

GMM Analysis We selected System GMM to unravel the dynamic interplay between institutional, energy, and financial variables and agricultural performance. Recognizing the persistence of agricultural output, integrating a lagged dependent variable perfectly maps this adjustment trajectory. Furthermore, this method curtails reverse causality and simultaneity—common when

evaluating energy and finance against agriculture—by leveraging internal instruments and fusing differenced and level equations. It perfectly suits our dataset of 48 countries over a 22-year span, provided we carefully restrict instrument proliferation and monitor AR(2) and Hansen metrics.

Our baseline dynamic findings confirm severe persistence; the lagged AVD coefficient is highly significant and positive (0.337, $p<0.01$). Interestingly, FIDI yields a significant negative impact on AVD (−2.302, $p<0.01$), as does FIAI (−4.094, $p<0.01$). This strongly implies that merely increasing financial access and depth does not guarantee agricultural gains, likely due to inefficient credit misallocation. Conversely, FISI and FIEI yield positive, significant impacts in alternate models, proving that a stable, efficient banking sector dwarfs raw financial expansion in utility. ENEF only displays a positive, significant impact in the first model, while PPPE uniformly boosts AVD, confirming that private infrastructural investments elevate crop productivity. GEPU registers insignificant effects initially but turns significantly positive in alternate specifications, mirroring the mixed impacts of PINS. These outputs align with scholarly consensus that institutional and energy architectures fundamentally shape agrarian success based on underlying structural realities.

4.7 Interactions between Global Uncertainty, Political Instability and Financial Institutions

The interactive variables illustrate that political and global turmoil deeply recalibrate how finance impacts farming. Using System GMM, the FIDI × GEPU interaction is sharply negative (−0.866, $p<0.01$), matching the FIAI × GEPU interaction (−1.020, $p<0.01$). This proves that surging global unpredictability directly neutralizes the agricultural benefits of financial access and depth. Interactions involving stability and efficiency are less severe, though FISI × GEPU is notably negative. Similarly, political instability aggressively undercuts financial depth (−0.566), access (−0.058), and efficiency (−0.048), emphasizing that chaotic domestic politics cripple the translation of financial intermediation into agricultural yield. These dynamics validate theories positing that instability inflates transaction costs, mangles credit distribution, and scares off investors. In a fascinating divergence, the FMOLS models uncover positive long-run interactions between financial indices and GEPU, suggesting long-term adaptive resilience. Valid Hansen tests and insignificant AR(2) figures confirm the GMM architecture's integrity.

4.8 Interactions between Global Uncertainty, Political Instability, and Energy Efficiency

Our models clarify that institutional volatility heavily conditions the energy efficiency-agriculture nexus. Under System GMM, the ENEF × GEPU variable is strongly positive (16.490, $p<0.01$), implying that as global policy grows unpredictable, optimized energy use becomes a critical lifeline for maintaining agricultural value. The ENEF × PINS parameter is identically positive (21.600, $p<0.01$), showing that energy efficiency buffers the agricultural sector against the structural decay caused by domestic political crises. By slashing operational costs, efficient energy fortifies sectoral resilience. Concurrently, efficient and deep financial systems act synergistically with these energy upgrades to protect yields. The FMOLS outcomes offer a more nuanced view; while ENEF × GEPU remains positive (0.063, $p<0.05$), the ENEF × PINS effect loses statistical significance over the long horizon. Overall, the diagnostic tests solidly validate the GMM specifications, reinforcing the narrative that energy optimization and infrastructure are indispensable shields against macroeconomic shocks.

4.9 Interactions between Global Uncertainty, Political Instability, and PPPEs

When cross-referenced with instability, energy PPPs exhibit highly fragmented impacts on farming. The System GMM output for the PPPE × GEPU interaction lacks statistical significance (0.149, p=0.673), indicating that global uncertainty does not meaningfully disrupt the immediate benefits of energy partnerships on crop value. Conversely, the PPPE × PINS metric is negative and marginally significant (−0.048, p<0.10). This logically dictates that domestic political chaos sabotages public-private energy ventures, inflating risks and derailing infrastructural rollouts, thereby starving the agricultural sector of anticipated power upgrades. The FMOLS evaluations solidify this by demonstrating more pronounced long-term interactive effects. Consistent with broader economic theory, these numbers prove that capital misallocation accelerates when institutions falter. Meanwhile, ENEF continues to log positive coefficients, anchoring energy efficiency as a paramount developmental channel, backed by pristine GMM diagnostic scores.

4.10 Interactions between Energy Efficiency and Financial Institutions

Energy efficiency drastically alters how financial structures interface with farming output. The FIDI × ENEF interaction in the System GMM model lands firmly in the negative (−0.817, p=0.004), suggesting that as energy utilization reaches high efficiency, the marginal necessity of deep financial expansion wanes. The FIAI × ENEF parameter mirrors this with a negative score under both System GMM (−0.067, p=0.015) and FMOLS (−0.063, p=0.012), marking a highly robust moderating dynamic. In stark contrast, while FIEI × ENEF is inert dynamically, it explodes positively in the FMOLS long-run model (21.60, p=0.003), proving that a highly efficient financial system harmonizes powerfully with energy efficiency to compound agricultural gains over time. Interactions with financial stability (FISI) fail to reach significance in any framework. Ultimately, this data dismantles the assumption that raw financial growth cures all ills; its power is tightly bound to resource efficiency and macroeconomic health (evidenced by significant INTR and EXR parameters).

4.11 Discussion of Findings

Our analytics establish that financial institutions profoundly—yet unevenly—dictate SSA's agricultural destiny. Because stability, efficiency, access, and depth yield vastly different impacts on employment and value-added, governments cannot rely merely on expanding sector size. The banking architecture must be accessible, hyper-efficient, and structurally sound to drive rural transformation. This nuanced reality echoes previous scholarship noting the dual positive and negative impacts of credit, depending entirely on market execution and structural characteristics.

Simultaneously, optimizing energy efficiency is non-negotiable for agrarian success. The data proves that maximizing energy utility directly elevates job creation and sectoral value, an intuitive outcome given modern agriculture's heavy reliance on mechanized processing, cold storage, and irrigation. Wasteful power usage bleeds capital, while streamlined efficiency frees up cash for reinvestment. By framing this around efficiency rather than mere consumption, this study proves that expanding raw power grids is insufficient unless that power is converted efficiently into crop yields.

Furthermore, political stability, global unpredictability, and PPPs hold immense sway over farming outcomes. PPPs do not automatically confer benefits; their success requires stellar regulatory execution and seamless infrastructure mapping. Global economic volatility and domestic political turbulence act as fierce conditioning agents. Chaos disrupts supply chains, terrifies investors, and

degrades government extension programs. Crucially, our interaction matrices reveal that these variables are not isolated. Global and domestic instability actively paralyze the transmission of financial and energy assets into agricultural productivity. Yet, long-term models show that highly efficient financial mechanisms can combine with optimized energy to shield the sector against these shocks. Built upon rigorous GMM and FMOLS foundations, this evidence demands a synchronized policy approach merging institutional fortification, robust PPPs, efficient energy grids, and inclusive banking.

5. Conclusion and Policy Recommendations

This investigation mapped the complex determinants of Sub-Saharan African agricultural expansion by harmonizing metrics of political instability, global economic policy uncertainty, public-private partnerships, energy efficiency, and financial institutional health against agricultural employment and value-added benchmarks. Our modeling confirms that agricultural progression relies on an intricate web of infrastructural, macroeconomic, energy, and financial variables, whose impacts shift based on the exact nature of the financial institution involved. Because financial stability, access, depth, and efficiency trigger divergent sectoral responses, simply inflating the credit market is inadequate; the intermediation must be stable, accessible, and efficiently managed. Energy-focused PPPs and power efficiency are similarly vital, though their ultimate utility is heavily gated by external economic and institutional realities. Notably, political unrest and international economic volatility actively distort how energy and finance influence crop production. Thus, realizing SSA's agrarian potential mandates holistic, cross-sectoral policymaking that insulates the economy from external shocks, optimizes PPP structures, promotes efficient energy, and cultivates inclusive banking. By proving that siloed interventions fail, this study heavily enriches the developmental literature.

To execute this, SSA administrations must urgently upgrade their financial architectures to deliver sustainable, low-cost capital to rural enterprises and smallholder farmers. Given the heterogeneous impacts of our financial metrics, central banks and regulators must prioritize the quality and reach of intermediation over mere volume. Policy mechanisms like rural banking outposts, targeted credit guarantees, and risk-sharing protocols are essential for mobilizing commercial and microfinance loans. For smallholders plagued by high friction costs and zero collateral, authorities must leverage digital value-chain financing and mobile banking to bypass traditional hurdles. Lenders should introduce bespoke products tailored to harvesting cycles, such as crop-insurance-backed loans, equipment leasing, and warehouse receipts. Concurrent prudential oversight must block reckless lending, thereby preserving systemic stability while fueling rural growth.

Energy optimization must simultaneously anchor the continent's agricultural strategy. Because farming is increasingly reliant on mechanized transport, cold chains, and powered irrigation, public policy must aggressively subsidize the integration of energy-efficient processing gear and renewable technologies. State funding should pivot toward decentralized power networks—like solar irrigation and off-grid mini-grids—specifically located to empower remote agribusinesses. Tax incentives and strict efficiency standards will force the retirement of obsolete, high-drain equipment. Furthermore, bureaucratic red tape stifling private rural energy investments must be eliminated, allowing development banks to funnel concessional loans into high-yield agricultural

energy projects. Synchronizing energy rollout with farming zones ensures power is utilized strictly for productive gains, slashing overhead, curbing waste, and boosting international competitiveness.

Finally, SSA governments must overhaul how they structure and deploy Public-Private Partnerships, specifically targeting energy frameworks that support agribusiness. While PPPs carry immense potential, their success is tightly bound to the regulatory ecosystem. Nations must enact crystal-clear PPP legislation that delineates accountability protocols, performance benchmarks, risk-allocation, and financial obligations. Projects that directly dismantle farming bottlenecks—such as agro-processing hubs, rural logistics, cold storage, and decentralized energy grids—must be fast-tracked. Transparent bidding and ironclad contract enforcement will restore investor trust. Crucially, PPP contracts must be judged not just on concrete poured, but on hard agricultural metrics like reduced post-harvest decay, job creation, and boosted productivity. Independent watchdogs must audit these projects regularly. Where social value heavily outweighs commercial return, targeted state subsidies and risk guarantees are necessary to crowd-in private capital. When engineered correctly, PPPs will harness private-sector brilliance to obliterate the infrastructural deficits choking African agriculture.

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