The impact of African agriculture production on bank stability through bank risk and profit

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A B S T R A C T

The African farming sector suffers from insufficient finance. Climate changes and socio-political issues hold down the required production level while food on the continent is still inadequate, with more vulnerable people on the one side. On the other side, credit institutions need reasons and guarantees to raise their risk-taking level (financial benefits). Then, this study tries to conciliate those two sides with new shreds of evidence by demonstrating the short and long-run effects of agricultural production on bank sustainability in 40 Sub-Saharan African countries. The study used different agro-production factors (Food and Cereal production factors), bank stability proxies (Liquidity Ratio, NPLs, LLRs), and bank profitability proxies (ROA and ROE). The GMM, DFE, and FMOLS models were used for short (with the 2010-2019 dataset) and long-run analysis (with the 1970-2018 dataset). The results demonstrated that agricultural production increases bank stability and profitability but reduces bank risks. The study concludes that farming finance increases agro-production and stabilizes banks (win-win). Governments, via central banks, should encourage commercial banks to increase bank risk-taking levels to sustain their banking system, increase farming production, and improve food security.

Introduction

The world food program (WFP) reported that a quart of billions of people worldwide would be at risk of acute food in the post-Covid pandemic period (Anthem, 2020). Moreover, one of the nine people in the world is in a food insecurity state, as testified by the technical report of the world health organization (Andree et al., 2020).

Developing countries are expected to have more than 80% of the world's population growth in less than a decade, and Africa is becoming the most populated continent. Its population is expected to double by 2050 (De la Croix & Gobbi, 2022). Yet, the basic needs for human life are still deficient in many African countries, where malnutrition and obesity remain challenges (Noort et al., 2022). Households are rural, and farming is essential to increase agricultural production and reduce hunger and poverty in Africa (Sikandar et al., 2021; Zhang et al., 2021). As discussed by these authors, those challenges remain the pressing objectives for developing countries, especially African governments (Ngong et al., 2021). In addition, the effects of the pandemic on food security and nutrition in low-income countries have increased uncertainty (Picchioni et al., 2021).

Since the 1990s, researchers have been interested in the relationship between bank credit and agricultural production efficiency to suggest policies related to economic development (Swinnen & Gow, 1999). Strategic development goals, especially in the second generation (related to food security), have addressed the same challenges and associated promoting sustainable agriculture and investment plans with achieving food security goals (Chadare et al., 2022). For such targets, government intervention is crucial when evaluating appropriate public policies (Martin & Clapp, 2015).

Agricultural production depends on effective food production policies, which depend on many complex developmental plans and strategies, including financial, technical, labor, and environmental policies. Agricultural production depends on effective food...
production policies, which depend on many complex developmental plans and strategies, including financial, technical, labor, and environmental policies (Babu & Akramov, 2022). Such public policies determine and define the quantity and quality of agricultural production through crop production indices and actual agricultural production, such as cereal production quantity in tons (He et al., 2022; Klerkx & Rose, 2020).

The agricultural system and policy implementation process in emerging countries is to define deficiencies in food production and implement public policies to meet the food demand of the population growth in terms of quality and quantity (Babu & Akramov, 2022). That objective requires new farming technologies, mechanization, seed quality and quantity, smart technologies, and an updated production and transformation system to eliminate underproduction (Liu et al., 2021; Yitayew et al., 2022). Such a persistent and resilient agricultural system can eliminate undernourishment, boost agricultural production, and sustain economic development and banking in emerging economies (Kumar et al., 2017; Martin & Clapp, 2015; Suri & Udry, 2022).

**Figure 1:** Evolution of Gdp Growth Versus Cereal Production Growth in Ss Africa.

**Figure 1:** This Figure Presents Parfait Co-Movements Between Gdp and Cereal Production and Justifies The Part That Cereal Production Takes in The Entire African Gdp Growth (Suri & Udry, 2022).

**Figure 2:** Evolution of Food Production and Gdp Growth in Ss Africa.

**Figure 2:** This Figure Illustrates The Cointagration Movement Between Gdp and Food Production As the Main Contributors to Africa’s Gdp Growth (Suri & Udry, 2022).

**Figure 3:** Evolution of Food Production Versus Cereal Production Growth in Ss Africa.

**Figure 3:** This Figure Illustrates the Cointegration Movement Between Cereal and Food Production as the Main Contributors to Africa’s GDP Growth.
Agricultural production is the backbone of most developing African economies and the primary supporter of GDP (Suri & Udry, 2022). Figures 1-3 show the cointegration between GDP growth and agricultural production factors (food and cereal production) from 1970-2018. However, 80% of farmers are smallholders with less than two hectares of land, predominantly for cereal production for self-consumption (Suri & Udry, 2022). Moreover, agriculture in developing countries remains an undeveloped and unfinanced field that is based on a traditional production system (Mellaku & Sebsibe, 2022), while in developed countries, agricultural production has had access to scientific and modern methods to boost production and satisfy the market demand in terms of quality and quantity (He et al., 2022).

In Africa, agricultural production still has some challenges that include but are not limited to
i. the bank credit constraints for farmers (Ogunyiola et al., 2022);
ii. lack of credit insurance (Binswanger-Mkhize, 2012);
iii. lack of government policies and investment from the private sector (Yigezu et al., 2018);
iv. low mechanical production rates (He et al., 2022; Shita et al., 2018a);
v. unavailability of new technologies such as “geo-farming” (Eitzinger et al., 2019; Trnka et al., 2021);
vi. lack of quality in innovation (Janaiah et al., 2006).

African governments should consider these significant challenges to boost agricultural production effectively and reduce poverty (Shita et al., 2018b; Sikandar et al., 2021).

Increasing production levels requires either government intervention or investment policies (Babu & Akramov, 2022; Jayne et al., 2010). Such investment and policies must invite the private sector to maximize their investment, output, and social impact (Kaya & Kadanah, 2021; Kumar et al., 2017). Private actors, including financial institutions and commercial banks, should consider offering agricultural credit to the larger-scale production farms and the smallholder farms in Africa. That could mitigate underproduction, unemployment, and poverty issues to meet the market demands of SSA’s population growth (Kumar et al., 2017). Furthermore, it has been proven that FDI net inflows and innovation as agricultural inputs improve production levels, especially in cereal production (Chinseau et al., 2022; Sikandar et al., 2021). Therefore, financing agriculture is a crucial solution for agricultural output and socio-economic and financial development in Africa (Gollin, 2020; Suri & Udry, 2022).

Different questions concerning these challenges in this sector arise, as questioned by a recent study (Dorinet et al., 2021): How can governments in SSA increase bank stability and reduce the related risks while improving agricultural production through agricultural financing? How do they motivate commercial banks and private actors to invest in farming projects? Why should financial institutions offer specific credit services to smallholders without sufficient guarantee when credit risk is the primary barrier for farmers and a significant criterion for bank credit (Nshakira-Rukundo et al., 2021)? This analysis intends to answer those questions (especially the last one) by demonstrating the bank benefits/security received from loan services offered to the farmers invested in agricultural production. While studying food security, Carthy and Berry discuss introducing the concept of sustainability in food security analysis (Berry et al., 2015; Mc Carthy et al., 2018).

This paper aims to show how the African banking sector profit from long-run stability (in terms of risk and profit) from agriculture production boosted by bank loans and related services offered to farmers, as shown in figure 4. At the same time, the agriculture sector benefits from bank credits to sustain its production capacity on the continent. Our theoretical thinking is illustrated in figure 4.

**Figure 4:** Illustrates The Framework of Our Thinking on The Crucial Mediating Role of The Agro-Production on Bank Risk and Profit, Attribute of Bank Stability; *Source:* Own Design.

The final result of such lending (long-run bank stability) is a boomerang effect: starting from bank loans, affecting bank risk and profit proxies, and ending back to increase bank stability and profitability. These later are defined in our preliminary models as crucial foundations and functions on which bank stability is based for the long run.

Secondly, by doing so, we presented an alternative solution to this question regarding the need for agricultural financing in Africa, as raised by recent review studies conducted on government strategies and policies regarding agricultural finance in Africa.
Thirdly, this study aimed to increase the confidence of financial institutions and potential private investors sensitive to the support of smallholder farmers, especially Non-Government Organizations working for malnutrition and poverty alleviation in Africa. Finally, we provided suggestions to assist policymakers in their duties: for the central bank to consider appropriate policies that would motivate investors, improve bank confidence, then increase the volume of agricultural credit offered to farmers. This policy will sustain African banks and boost farmers' economies and the entire African economic structure. Recent tentative studies in Africa have been limited only to agricultural finance policies and recommendations (Sikandar et al., 2021). One study done in turkey found that agriculture loans and deposits positively impact agriculture production (Kaya & Kadanali, 2021). Likewise, Nigeria discovered the same effects (Asalye et al., 2020). Another researcher examines the strategic objectives and beneficiaries of the government's agriculture investing policies and the barriers to farmers' access to credit in emerging markets (Onyiriuba et al., 2020). Some others suggested the insurance plans to boost agriculture credit and tackle the stated problem of bank confidence toward farmers (Binswanger-Mkhize, 2012; Martin & Clapp, 2015; Nshakira-Rukundo et al., 2021). On the one hand, some researchers have tried to link financial development and agriculture production proxies such as cereal and food production, especially after the covid-19 period (Özden et al., 2022; Sánchez et al., 2022). However, others have evidence of the one-way relationship between FDI and agriculture production (Sikandar et al., 2021). On the other hand, some others have only suggested monetary policies in developing countries to boost agro-production (Kubik & Husmann, 2019; Nedumaran & Manida, 2019). Although bank riskiness using NPLs/LLRs (Abbas et al., 2021; Ding & Sickles, 2019) and profitability determinants using ROA and ROE (Joquist-Varandica et al., 2022) have been analyzed recently by different studies, none established a relationship between bank Stability and agricultural production. Many studies presented the need for farming finance and raised the question of investment deficiency without bringing potential alternatives as solutions to this problem (Nshakira-Rukundo et al., 2021). One study proved that mobile money adoption by farmers increases agricultural productivity and technology in Uganda (Smetana et al., 2022).

The study aims to find an alternative solution to the stated problem (lack of farming credits in Africa) by demonstrating a positive relationship between agriculture production and domestic financial capacity through local banks. Thus, this study wants to underline the bank benefits and stimulates investors' confidence towards farming finance in Africa as one of the alternative local solutions. Then it brings a new contribution to the existing literature by ensuring investors about the positive short and long-run effects of agriculture production on bank stability (via bank riskiness alleviation on the one side and increase in bank profitability on the other side). Some new and important aspects to notice are:

i. This study conciliates credit institutions (Banks) and farmers with a win-win logic
ii. It brings local solutions to farmers' credit needs via an increase in bankers' confidence in farmers and promotes African food security.
iii. The study demonstrates that bank stability is a long-run result of both bank risk alleviation and profitability shocks from agriculture production in Africa
iv. It also provided further evidence on the long-term effects of agricultural production on bank liquidity ratio and profitability.

These pieces of evidence bring a potential solution to the problem of lack of finance for African farmers raised by (Fowowe, 2017; Nshakira-Rukundo et al., 2021; Tabe-Ojong et al., 2022) in their study on this topic. That problem was also underlined by Carthy on global solutions and investment reforms while calling for reforms to achieve global food security (McCarthy et al., 2018) and by (Bjornlund et al., 2022) for the persistence of food insecurity in Africa. The potential solution is that this evidence on bank benefits could boost investors' and especially African banks' confidence and push them to step up in increasing risk-taking behavior. Once done, it can thus increase the credit volume in the agriculture sector and resolve persisting problems of lack of farming credit in SS Africa. To our humble knowledge, no study demonstrated the positive boomerang effects of agricultural finance services on bank stability in Africa, especially in the long term, with both risk and profit aspects.

The study’s structure: the following section provides a literature review and hypothesis development. The third section describes the material and methodology used for analysis. The fourth discusses results performed with different models, results, and their findings. Finally, our conclusions include policy implications.

**Literature Review**

When analyzing the interaction between sustainability and food security, a review of global food security synthesized four pillars that can guarantee world food security in terms of food availability, transportation, accessibility, and production (McCarthy et al., 2018). An analysis of sustainable food and diet concluded that policies and programs could become the causes of increased food insecurity in the future if the concept of sustainability is not considered as a fifth explicit dimension of food security (Berry et al., 2015). Carthy and Berry converge on introducing the concept of sustainability in food security analysis (Berry et al., 2015; McCarthy et al., 2018). One study in Thailand suggested twelve indicators linked with 41 requirements to measure little progress toward sustainable rice farming for policy making (Mungkung et al., 2022). Phillip used Kabeer gender analysis and empowerment to assess inequalities in sustainable agriculture intensification (Grabowski et al., 2021), while Corlos found disparity in the sustainability performance of fruits and vegetable production (Moreno-Miranda & Dries, 2022).

Generally, African businesses and projects experience serious credit access constraints and slow growth (Fowowe, 2017). A study in Africa found a unidirectional causality flow from agricultural value added to market capitalization and stock value traded (Ngong et
al., 2022). Andrew proposed a scaling finance strategy for sustainable agriculture production by mobilizing investments (Apampa et al., 2021). Better credit market situations improve agriculture productivity and accessibility of agriculture inputs to African farmers and raise productivity levels (Shuaibu & Nchake, 2021). Big corporate owning all farmers, namely Big Ag, are closely tied to Big Finance and exclude other peripheral actors in the agriculture finance system, such as regional banks (Ashwood et al., 2022). One analysis categorized the studies on agriculture into four major domains: studies on fallout in policy-formulating focus, finance-related issues corroborating experiences, the fallout in food security, and finally, risk and risk-taking orientations (Onyiriuba et al., 2020). Government interventions with subsidies to farmers are needed as they have significantly affected economic development in rural areas (Meyer, 2011). The same findings underlined the government's historical and mediating role between financial actors and the food production system (Onyiriuba et al., 2020).

Agricultural credit permitted rural villages to invest in farming systems and increase their production and income (Gehrke, 2019; 2017). Innovations in rural and agriculture finance have the potential to significantly develop the food security and livelihood of the poor (Kloeppinger-Todd & Sharma, 2010). Gehrke and Kloeppinger converge on the role of technology and innovation in promoting agriculture finance accessibility and farmers-related lives (Gehrke, 2019; Kloeppinger-Todd & Sharma, 2010), and joined He et al.’s findings on the significant influence of mechanical and technical progress on cereal production (He et al., 2022). Yanbykh said that those two factors necessitate financial support and can attract more farmers as they provide huge budgetary support (Yanbykh et al., 2019). Studies in China and Pakistan found that bank loans for agricultural production positively impacted rural development and improved agricultural innovation (Saqib et al., 2018). The same findings were discovered in developing countries (Chisasa & Makina, 2013; Rehman et al., 2019; Sikandar et al., 2021).

In India, agriculture policy has focused on rural areas, where formal credit was positively associated and increased Indian smallholders’ income (Kumar et al., 2017). A program for rural employment in that same country (NREGS) has guaranteed income risk for householders (regardless of crop failure). It has helped to mitigate agricultural shocks, increase crop production and the profitability of farm products, and boost smallholder farmers’ income (Gehrke, 2019). These two authors agree with Shkodra on the collateral need for agriculture finance (Shkodra & Shkodra, 2018). Irrigation facilities and access to formal agricultural credit positively impacted contract farming, boosting food security through agricultural production (Kumar et al., 2017). Credit access based on farm size, education, and distance from a market has been the driver for adopting agricultural technology in Ethiopia (Shita et al., 2018a). He converged with (Meyer, 2011) and recommended the government to promote the use of new technologies and fertilizers at an affordable price for smallholder farmers (government intervention).

A study done in Nigeria testified unidirectional causality effect resulting from the agricultural credit scheme (ACGS) guarantee to the -AGDP- agriculture gross domestic product (Suri & Udary, 2022). Blockchain technology solutions unlocking finance access to smallholder farmers enrolled in the supply chain have proven a long-term relationship between cash financing and agricultural production performance, especially in palm oil, as found in a Nigerian study (Asaleye et al., 2020). In Ghana, rural bank credit access permitted technical efficiency and increased cassava production considerably more than the smallholder farmers without credit access (Missiame et al., 2021). An association between agricultural production and women’s economies is positively correlated in rural areas of developing countries where marginalized women made self-helping groups to finance their crops (Saha & Kasi, 2022). One study showed that the allocation of a loan-loss reserve for insurance companies insuring against agro-climatic change factors improved agricultural production performance due to the effectiveness of relatively low rates of interest (Tleubayev et al., 2022). Access to agricultural credit volume showed that banks provided more loans than microfinance institutions according to the total number of large loans issued for agriculture in Kosovo (Shkodra & Shkodra, 2018). He added that easily accessed loans and credit size determine the good return to the farmer. The author finally proposed the government to promote an insurance scheme for farmers (Shkodra & Shkodra, 2018). He joins Gehrke’s point of view regarding agriculture insurance (Gehrke, 2019). To increase farmer performance in the USA, some mechanisms are required to facilitate credit access and lending for small farms, regardless of gender, land acreage, or specialization (Khanal & Omobitan, 2020). Studies assessed the link between agricultural credit and economic growth in Tanzania and Nigeria and found evidence of asymmetric interactions between studied variables in the short- and long term (Okunlola et al., 2019; Paul & Lema, 2018).

Based on the above literature, four research-focused groups were identified: 1) Fist group is focused on the benefits of agricultural finance to poverty alleviation and employment creation (Gehrke, 2019; Kloeppinger-Todd & Sharma, 2010; ZHANG et al., 2021). 2) The second group is related to credit access and technical efficiency to boost production (Missiame et al., 2021; Rezitis et al., 2003; Shkodra & Shkodra, 2018; Tleubayev et al., 2022). 3) The third group suggested government intervention by proposing related policies to increase the budget allocated to the agricultural sector (Martin & Clapp, 2015; Onyiriuba et al., 2020; Shuaibu & Nchake, 2021; Smetana et al., 2022). 4) In contrast, the fourth category stressed on technologies update and new farming methods to increase the production output in terms of quality and quantity (Gehrke, 2019; He et al., 2022; Kloeppinger-Todd & Sharma, 2010; Kumar et al., 2017; Saqib et al., 2018; Yanbykh et al., 2019). 5)While the fifth group stressed the insurance scheme/plan to secure credit and crops from natural risks (Kumar et al., 2017; Shkodra & Shkodra, 2018; Tleubayev et al., 2022).

In comparison, in Africa, farmers, like other businesses, have had significant challenges obtaining credits (Fowowe, 2017), which has significantly impacted farm investment (Sabasi et al., 2021). Two studies assessed the link between agricultural credit and economic growth in Tanzania and Nigeria and found evidence of asymmetric interactions between studied variables in the short- and long term (Okunlola et al., 2019; Paul & Lema, 2018). Most studies focused on the relationship between farming finance in general
and production efficiency. In contrast, others focused on the role of environmental factors, government subsidies, and insurance programs to boost production. None paid attention to the boomerang effect of farming finance on credit institutions. In other words, none pay attention to raising bank risk-bearing behavior to give evidence on what banks can benefit/gain once engaged in farmer financing, especially in Africa, to solve the question related to the lack of finance raised by many authors. This study then focuses on the feedback effects of agro-production on bank stability.

Hypothesis development

Therefore, this study looks for potential solutions and benefits for bankers (stability in terms of riskiness and profit benefits) and farmers (increase in production capacity), once they engage more credit in agricultural financing. This study aims at raising the banker's confidence in agricultural credit supply. But how?

Bank stability is negatively affected by crop and cereal production via the effect on NPLs. The study wants to demonstrate, on one side, the long-term positive effects (in the form of boomerang effects, from and to banks) of agriculture production factors on African bank's riskiness and profitability proxies, which constitute the pillars of the sustainable bank (see theoretical framework figure4). On the other side, agriculture production is boosted by investment from the banking sector and improves farmers' livelihood. It is a win-win situation for both sides (bankers and farmers). This analysis wants to demonstrate such interaction effects to stimulate the desirable bankers' and investors' confidence suggested by other studies. We developed some main and specific hypotheses based on the stated questions in the introduction to achieve such objectives. The banking sector needs the real economy to sustain its lending/credit activities. When credit is given to an individual or a business unit, it has to be productive and generate the intended income/benefit for both borrowers and lenders to facilitate the money circuit and bank liquidity and profit from the interest margin.

From that main hypothesis, two sub-hypotheses were developed to ensure each effect of the crop and cereal production on each specific bank riskiness factor (LLRs and NPLs):

H1a: Agro-production sustains bank stability via an increase in LLRs.
H1b: Agro-production alleviates bank risk via a decrease in NPLs.
H2: Agricultural production sustains banks via an increase in returns (ROA/ROE).

This study believes that banks benefit from Africa's agriculture production sector is profit on both returns (ROE and ROA). Suppose the African farmers are facilitated with farming credits. In that case, they produce more, increase the productive goods to sell in the market, and then earn enough to repay the bank credit quickly with the principal and bank interest rate. The more they produce enough to meet the market demand, the more the banks earn through the margin. Two sub-hypotheses were deducted from these assumptions to ensure each effect of the crop production index and cereal production on each specific bank profitability factor (ROE and ROA).

H3a: Crop and cereal production increase bank profitability (via ROE and ROA).

This study assumed that agricultural production factors would influence bank stability in three different ways: a) through the long-term effect of agricultural production proxies on the bank liquidity-to-asset ratio (liquidity ratio); b) increase in bank stability via the impact of the crop, food, and cereal production on the bank risk factors (NPLs and LLRs); and c) rise the profitability effect via the influence of crop, food, and cereal production on bank profit (ROE and ROA). These effects played an important role in sustaining the banking sector and promoting African economic development, which relies mostly on agricultural production (Suri & Udry, 2022). This study assumed that bank stability is a long-term concept requiring long-term results regarding bank riskiness and profitability. At the same time, stability and profitability are vital for a sustainable banking system. Stability prevents bankruptcy, profitability ensures bank prosperity, and riskiness ensures bank resilience to corrupting external shocks via liquidity availability. These assumptions bring us to the third hypothesis that combines the two stated above.

H3b: Agricultural production proxies and bank liquidity ratio have a long-term causal relationship. This study believes there is a correlation between bank liquidity ratio, bank stability, and the agriculture production sector. The long-run relationship between these three sectors is linked by domestic credit volume offered by local African banks and deposit activities/rates. Therefore, bank liquidity and credits are key factors for both bank stability and profitability, they determine the bank's resilience to external shocks, such as unexpected high liquidity demand, which can provoke bankruptcy. Therefore, liquidity is a shield for a bank's crush on one side.

On the other side, the real production sector (including agriculture production, the backbone of the African GDP) serves as a backup that sustains and protects the bank's activities against inflation. The more productive the real production sector is, the more the bank credits/deposits are, and the more the bank liquidity/stability and profit are.

Methodology and Materials

Data, Study Scope, Variable Definitions and Sources

The ratio of bank liquidity reserves variables was chosen to check the long-run relationship between agriculture production factors (Crop, Food, and Cereal Production) and bank liquidity. Likewise, the same agriculture production variables were used to test their effects on bank risk (NPLs and LLR) and profitability aspects (ROA and ROE). This later analysis covers the period from
2010-2019 (available period in Bank Focus with new interface), while the other research for the long-run covers the period starting from 1970-2018. Table 1 describes and defines the variables used in this study in two groups: macroeconomic variables and bank specific variables.

**Table 1: Variable Definitions and Source**

<table>
<thead>
<tr>
<th>S/N</th>
<th>Variables Names</th>
<th>Definitions</th>
<th>Sources</th>
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<tbody>
<tr>
<td></td>
<td><strong>Macroeconomic variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>BALIQ_RATIO</td>
<td>The ratio of bank liquid reserves to bank assets is the ratio of domestic currency holdings and deposits with the monetary authorities to claims on other governments, nonfinancial public enterprises, the private sector, and other banking institutions.</td>
<td>Development Indicators</td>
</tr>
<tr>
<td>2</td>
<td>CROP-XO</td>
<td>The crop production index shows agricultural production for each year relative to the base period 2014–2016. It includes all crops except fodder crops.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>FOOD-XO</td>
<td>The food production index covers food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because, although edible, they have no nutritive value.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CERE-XO</td>
<td>Production data on cereals relate to crops harvested for dry grain only. Cereal crops harvested for hay or harvested green for food, feed, or silage and those used for grazing are excluded.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>GDP</td>
<td>GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>INFLAT</td>
<td>Inflation, as measured by the consumer price index, reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.</td>
<td></td>
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<tr>
<td>7</td>
<td>DOMECRE</td>
<td>Domestic credit to the private sector by banks refers to financial resources provided to the private sector by other depository corporations (deposit-taking corporations except for central banks).</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>FDI_IN</td>
<td>Foreign direct investment refers to direct investment equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital.</td>
<td>World Bank database</td>
</tr>
<tr>
<td>9</td>
<td>METRADE</td>
<td>Merchandise trade as a share of GDP is the sum of merchandise exports and imports divided by the value of GDP.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>GOVEXP</td>
<td>General government final consumption expenditure (formerly general government consumption) includes all current government expenditures for purchases of goods and services (including compensation of employees).</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>ROE</td>
<td>Return on Average Equity</td>
<td>Bank Focus Data base</td>
</tr>
<tr>
<td>12</td>
<td>ROA</td>
<td>Return on Average Assets</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>LLRS</td>
<td>Loan loss reserves to gross loans</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>NPLS</td>
<td>Non-Performing loans to gross loans</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>B-SIZE</td>
<td>Represent the bank capital ratio</td>
<td></td>
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The bank liquidity ratio, a measure for bank solvency (Ali & Iness, 2020), is used for two purposes: to assess the relationship between its evaluation and agriculture production proxies since 1970. Another reason is that bank Liquidity is a perfect measure for bank insolvency while using the Z-Score approach (Ali & Iness, 2020). The lower the liquidity is, the higher the risk is, and vice versa. Agriculture production was represented by three proxies to ensure the consistency of the results: crop production (Crop-Xo) as an index that covers all factors that influence agricultural output for a given period (productivity) such climate factors, land factors, fertilizers and technical factors. Food production (Food-Xo) is used to assess the real edible food that contain nutrients nourishment which is crucial for life maintenance and health growth of human being. Cereal Production (Cereal-Xo) is used as a part of food production (Food-Xo) but focusing on grains for feeding and serves as additional proof.

Besides the variables of interest described above, we also used some other macroeconomic factors (as controllable variables) that may potentially influence in the long run as well as the short-run bank stability and profitability. Those macroeconomic variables are GDP growth, foreign direct investment net inflows, domestic credit, total government expenses, and inflation. Many studies have proven their effect on bank risk and profit (Almaskati, 2022; López-Penabad et al., 2022; Zhao et al., 2022). But none used the real productive factors, especially food and cereal Production. Five dependent variables were used for bank stability: Bank liquidity ratio, Z-Score, LLRs, and NPLs for bank riskiness analysis, while ROE and ROA were used for bank profitability.
Table 1 summarizes the definition of the variable taken from the world bank (development indicators), while the table 2 presents the scope of the study. The data used in this study were collected from two different sources: one in the world bank development indicators database (www.data.worldbank.org) for macroeconomic variables. Another is in the Bank Focus database for bank-specific variables (www.moodysanalytics.com).

Three regions of Sub-Saharan African Countries and the percentage share of the banks presented in each area are presented in table 2. The ECOWAS is the biggest, with a big share of 42.82% of actively studied banks.

### Table 2: The Study Region: Ssa African (Sub-Saharan African Countries)

<table>
<thead>
<tr>
<th>Region (Sub-Saharan African Countries)</th>
<th>Regions</th>
<th>No of States</th>
<th>States Names</th>
<th>Bank % Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSA</td>
<td>EAC</td>
<td>6</td>
<td>Burundi, Kenya, Tanzania, Rwanda, Uganda, and South Soudan</td>
<td>22.13</td>
</tr>
<tr>
<td></td>
<td>ECOWAS</td>
<td>15</td>
<td>Benin, Burkina Faso, Cap Verdo, Ivory coast, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Sierra Leone, Senegal, and Togo.</td>
<td>42.82</td>
</tr>
<tr>
<td></td>
<td>SADC</td>
<td>16</td>
<td>Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zambia, and Zimbabwe</td>
<td>33.91</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>2</td>
<td>Ethiopia, Djibouti</td>
<td>1.15</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>40</td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

### Descriptive Statistics

Table 3 presents the results of the descriptive statistics of the first dataset used for the long-run analysis. However, for short-run and bank-specific variables, more details on their descriptive statistics are given in Appendix A, table 1. We used a dataset of 350 active banks across 40 countries over ten years for bank-specific variables.

### Table 3: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observ.</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>BANK LIQUID_</td>
<td>689</td>
<td>2.691</td>
<td>0.791</td>
<td>0.128</td>
<td>4.628</td>
</tr>
<tr>
<td>CROP-XO</td>
<td>774</td>
<td>4.441</td>
<td>0.255</td>
<td>3.446</td>
<td>5.026</td>
</tr>
<tr>
<td>FOOD-XO</td>
<td>763</td>
<td>13.143</td>
<td>2.884</td>
<td>2.197</td>
<td>17.224</td>
</tr>
<tr>
<td>CERE-XO</td>
<td>756</td>
<td>4.461</td>
<td>0.224</td>
<td>3.702</td>
<td>4.897</td>
</tr>
<tr>
<td>GDP</td>
<td>767</td>
<td>22.788</td>
<td>1.552</td>
<td>18.146</td>
<td>27.027</td>
</tr>
<tr>
<td>INFLAT</td>
<td>701</td>
<td>1.622</td>
<td>1.063</td>
<td>-3.305</td>
<td>5.886</td>
</tr>
<tr>
<td>DOMECRE</td>
<td>692</td>
<td>2.664</td>
<td>0.878</td>
<td>-0.910</td>
<td>5.076</td>
</tr>
<tr>
<td>FDI_IN</td>
<td>738</td>
<td>6.208</td>
<td>1.209</td>
<td>-7.908</td>
<td>9.909</td>
</tr>
<tr>
<td>METRADE</td>
<td>522</td>
<td>1.458</td>
<td>0.8221</td>
<td>3.546</td>
<td>3.905</td>
</tr>
<tr>
<td>GOVEXP</td>
<td>350</td>
<td>-1.411</td>
<td>4.061</td>
<td>-3.212</td>
<td>1.112</td>
</tr>
<tr>
<td>INFLAT</td>
<td>701</td>
<td>1.621</td>
<td>1.062</td>
<td>-3.305</td>
<td>5.885</td>
</tr>
<tr>
<td>ROAA</td>
<td>3480</td>
<td>1.688</td>
<td>1.84</td>
<td>-5.077</td>
<td>6.599</td>
</tr>
<tr>
<td>ROAE</td>
<td>3480</td>
<td>2.286</td>
<td>1.492</td>
<td>-3.353</td>
<td>8.449</td>
</tr>
<tr>
<td>NPL</td>
<td>3480</td>
<td>3.318</td>
<td>0.217</td>
<td>3.027</td>
<td>3.612</td>
</tr>
<tr>
<td>LLR</td>
<td>3480</td>
<td>2.395</td>
<td>0.666</td>
<td>1.211</td>
<td>3.941</td>
</tr>
<tr>
<td>ROAA</td>
<td>3480</td>
<td>1.688</td>
<td>1.84</td>
<td>-5.077</td>
<td>6.599</td>
</tr>
<tr>
<td>B-SIZE</td>
<td>3480</td>
<td>2.628</td>
<td>0.107</td>
<td>2.425</td>
<td>2.753</td>
</tr>
</tbody>
</table>

Among the agricultural production variables of interest (crop production, food and cereal production represented by LNCROP-XO, LNFOOD-XO, and LNCERE-XO), two had similar means of crop production with 4.441 and cereal production with 4.461 and similar standard deviations of 0.255 and 0.224, respectively. These similar mean and standard deviations could explain the status quo of the crop and cereal production that needed improvement and investment to meet the current nutrition needs of the population in SSA. The same trends are also signified the same in Figure 3. However, food production had a higher mean value (13.143) and a higher standard deviation (2.884). It preceded the government expenses, with the highest standard deviation of 4.061 and a mean of -1.411. This variation was explained by the total government expenditure in SSA countries varying across the year and by country (high versus low spending). The highest mean among the controlled variables was gross domestic product growth (GDPGR) with
22.788, while the lowest was total government expenses with -1.411. The statistics of the second dataset related to the second model are available in Appendix A1.

**Methodology**

The preliminary correlation test among variables was conducted with Pearson's correlation matrix to verify the preliminary linear assumptions, and the results showed no collinearity among the studied variables.

The unit-roots test was run to check the stationarity in values. Many unit-root tests are available, depending on the nature of the data (Im et al., 2003; Levin et al., 2002; M. H. Pesaran et al., 1999; Phillips & Perron, 1988). We performed only Augmented Dickey-Fuller (ADF) and Philip and Perron (PP). For both ADF and PP tests: if there are no variables that are stable at the order I(2), then all variables should be integrated with I(0) or I(1). These tests are compulsory for cointegration regressions.

After preliminary tests, the study used different econometric models and techniques. For the long-run analysis, ARDL-Dynamic Fix Effects (DFE) and Fully Modified ordinary least squares (FMOLS) were used for long-run analysis (Erdal & Erdal, 2020). However, a two-step GMM (General Method of Moments) was employed for the short-run analysis. However, we also applied some technics for robustness check: Z-Score approach, Z-Score, and IRF graphs analysis.

**Preliminary tests: unit-root test.**

Generally, the unit-roots model is parametrized as follows (Bhowmik et al., 2019):

\[
\Delta Y_t = \varnothing Y_{t-1} + Y_{t-1} + \mu_t
\]  

(1)

Bank stability is a function of both bank riskiness and bank profitability. The concept of bank sustainability includes various long-term aspects of a real productive economy. Furthermore, a sustainable banking system depends on the real productive economy, such as agriculture production, represented by three proxies: crop production, food production, and cereal production. Bank stability was measured by bank risk factors, including LLRs and NPLs as bank proxies. However, profitability was measured by the bank profit factors, which were ROA and ROA proxies (Almaskati, 2022; Naili & Lahrichi, 2022b). This study assumed a functional relationship between agricultural production and bank stability (and this latter is also a function of bank riskiness and profitability). The functional relations are specified as follows:

**Bank Stability** = \( f(\text{Bank riskiness} + \text{Bank Profitability}) \)  

(2)

**Bank Riskiness** = \( f(\text{Agri-Variable Proxies; Controllable Variables}) \)  

(3)

**Bank Profitability** = \( f(\text{Agri-Variable Proxies; Controllable Variables}) \)  

(4)

These functional relationships will be specified later in different econometric models (such as DFE, FMOLS, and GMM) and IRF and Z-Score approaches

**General ARDL model**

The GMM method does not offer long-term output. Therefore, the study used pooled mean group (PMG) techniques with the ARDL-DFE method to analyze the long-term effect. As the bank liquidity-to-asset ratio was available since 2000 in the World Bank database, we used a different dataset for bank stability assessment to ensure the consistency of the results. The autoregressive distributed lag model (ARDL) is based on ordinary least squares (OLS). This model was appropriate for the time-series dataset and had different advantages. The model has been broadly recognized for its cointegration analysis in a time-series dataset. As in our case study, the ARDL model was efficient for our sample size. Another key benefit of this method was that it did not determine whether the regressors were I(0) or I(1). ARDL allows for a considerable number of lagging factors. Moreover, it expanded a dynamic error correction model that organized short- and long-term effects with unbiased estimates, considering all long-term effects. The generalized form of the ARDL \((p, q)\) model was specified as follows:

\[
Y_t = \gamma_0 + Y_{t-1} + X_{t-1} + \epsilon_t
\]  

Where \(Y_t\) represents the independent variable and is explained by its own lags \(Y_{t-1}\). \(\Delta\) and \(\beta\) are the coefficients to be estimated. \(X_{t-1}\) represents the repressors. It is well defined by the current and lag values of the repressors. The \(p\) is related to the lag of the dependent variable. \(q\) is associated with the lag of the repressors, which cannot necessarily have equal lag numbers. The \(\gamma\) is the intercept of the constant in the model, while \(\epsilon\) represents the error term vector.

**The ARDL-PMG, ARDL-MG, and ARDL-DEF techniques.**

The ARDL method uses three different techniques: pooled mean group (PMG), mean group (MG), and dynamic fixed effect (DFE). These techniques are appropriate based on the aim of the research. These estimators are flexible whether variables exhibit I(0), I(1), or a mixture of both (Garratt et al., 1998) and can consider such heterogeneity, especially with dynamic fixed effect techniques. Additionally, this method has the power to capture interesting variable dynamics in both the long- and short-term (H. H. Pesaran & Shin, 1998). The PMG technique uses the averaged and pooled coefficients of the cross-sectional units. It allows the long-term effect...
restriction to be consistent across all panels. However, it permits the short-term effects across panels to be country-specific (heterogenous) as caused by differences in country-specific issues.

Contrary to the MG technique, allowing heterogeneity in long- and short-term relationships, the two-way DFE technique allows homogeneity in long and short-term relationships. We decided to use that DFE technique after comparing the best estimation results using the Hausman test selection among PMG, MG, and DFE (M. H. Pesaran et al., 1999; M. H. Pesaran & Smith, 1995). Furthermore, the slope, speed of adjustment, and short-term coefficient were restricted with DFE methods to exhibit homogeneity across countries.

Then, the ARDL-DFE error correction model for the long-term was reparameterized as follows:

$$
\Delta Y_{it} = \Theta_{i} \{ Y_{i(t-1)} - \delta_{i} X_{i(t-1)} \} + \Delta Y_{i(t-1)} + \alpha \Delta X_{i(t-1)} + \varphi Y_{i(t-1)} + \epsilon_{it}
$$

(6)

Where $\Theta_{i}$ is a long-term relationship vector. $Y_{i(t-1)} - \delta_{i} X_{i(t-1)}$ represents the error correction term, and $\delta_{i}$ is a short-term dynamic coefficients. From equation (10), we then obtained the DFE models, specified as follows:

$$
\Delta Y_{it} = \gamma_{0} + \Delta Y_{i(t-1)} + \Delta X_{i(t-1)} + \Delta X_{i(t-1)} + \Delta X_{i(t-1)} + \varphi \Delta X_{i(t-1)} + \epsilon_{it}
$$

(7)

Where $\Delta$ denotes the variation, $X_{i(t-1)}$ represents agricultural production proxies, $X_{i(t-1)}$ and $X_{i(t-1)}$ represent the macroeconomic and controllable variables, respectively, and $Y_{i}$ is a vector. The coefficients are $\beta_{i}, \beta_{1},$ and $\beta_{2},$ to determine slope, and $\gamma_{i}$ represents the constant. $i=1, k,$ $p,$ and $q$ are the optimal lags orders. Finally, $\epsilon_{it}$ is the vector of the error term. $\varphi \Delta X_{i(t-1)}$ captures the long-term coefficients. The variables of interest were in groups $X_{i(t-1)}, X_{i(t-1)},$ and $X_{i(t-1)},$ as we were interested in how they would influence the bank's sustainability in the long term. By reparameterizing the model (11), we obtain the following ARDL-DFE model:

$$
\Delta \text{LNBALIQ\_RATIO}_{i,t} = \alpha_{1} + \Delta \text{LNBALIQ\_RATIO}_{i,t-1} + \beta_{1} \Delta \text{LNCROPXO}_{i,t} + \beta_{2} \Delta \text{LNOODXO}_{i,t} + \Delta \delta_{i} \Delta \text{LNControl.Var} + \delta_{i} \epsilon_{it}
$$

(8)

Where $\sum \delta_{i} X_{i}$ represents the controllable variables (bank-specific and macroeconomic factors) that were deemed to influence bank stability, these were included to avoid the misspecification problem in modeling, while $\epsilon_{it}$ accounted for the error term.

**General Method of Moment (Two-Step System GMM)**

GMM estimators are used in different situations, especially in panel data with a small T and a large N, in cross-sectional datasets, and for variables that are not strictly exogenous, suggesting the presence of endogeneity (Arellano & Bond, 1991; Roodman, 2009). GMM confers many advantages, such as using many instruments (internal and external) to improve estimations and overcome the problem of endogeneity (Baum et al., 2003; Newton & Cox, 2012). The Arellano–Bond test for AR(1) and AR(2) was used to analyze the second-order serial correlation, and the Hansen test for under- and over-identifying restrictions was also employed to fit the model and ensure the strength of the instruments (Arellano & Bond, 1991; Baum et al., 2003).

Furthermore, GMM uses additional options to improve the consistency of the estimates: a collapse option to control and maintain the number of instruments below the number of groups and a robust command to report heteroscedasticity and autocorrelation consistently (Arellano & Bond, 1991; Roodman, 2009). The GMM also allows lagged values to mitigate the endogeneity among the variables. For these reasons and based on the nature of our dataset, we selected the GMM estimator to obtain the best and most unbiased estimates (Newton & Cox, 2012; Richard Blundell; Stephen Bond, 1998). We used Stata software version 15, with the xtobond2 extended command (Roodman, 2009).

Hence, the econometric models for GMM models that could be deducted from the functional relationship between those variables were parameterized in two different ways: two models for bank risk/stability analysis and two other models for bank profitability analysis with GMM models. Models for bank stability were parametrized to measure the effect of agricultural production on bank risk:

$$
\text{NPL}_{i,t} = \alpha_{1} + \beta_{1} \text{FOODOXO}_{i,t} + \beta_{2} \text{CEREXO}_{i,t} + \beta_{3} \text{DOMECRED}_{i,t} + \beta_{4} \text{B\_SIZE}_{i,t} + \beta_{5} \text{GDPGR}_{i,t} + \beta_{6} \text{GOVEXPXO}_{i,t}
$$

$$
\text{LLR}_{i,t} = \alpha_{1} + \beta_{1} \text{FOODOXO}_{i,t} + \beta_{2} \text{CEREXO}_{i,t} + \beta_{3} \text{DOMECRED}_{i,t} + \beta_{4} \text{B\_SIZE}_{i,t} + \beta_{5} \text{GDPGR}_{i,t} + \beta_{6} \text{GOVEXPXO}_{i,t}
$$

(9)

(10)

Bank performance has been studied so far by different researchers using different bank-specific variables. Still, two traditional types of returns are the most popular to assess bank profit: return on equity and return on assets (Joaqui-Barandica et al., 2022). To ensure the effect of agricultural production proxies on bank profitability, two models were parametrized using ROE and ROA as dependent variables:
\[ \Delta \text{ROA}_it = \beta_1 (\Delta \text{ROA})_{i,t-1} + \beta_2 \text{FOODXO}_i + \beta_3 \text{CEREXO}_i + \beta_4 \text{DOMECRED} + \beta_5 \text{BALIQ\_RATIO} + \beta_6 \text{GDP} + \beta_7 \text{GOVEXP} + \beta_8 \Delta \text{INFLAT} + \epsilon_{it} \]  

\[ \Delta \text{ROE}_it = \beta_1 (\Delta \text{ROE})_{i,t-1} + \beta_2 \text{FOODXO}_i + \beta_3 \text{CEREXO}_i + \beta_4 \text{DOMECRED} + \beta_5 \text{BALIQ\_RATIO} + \beta_6 \text{GDP} + \beta_7 \text{GOVEXP} + \beta_8 \Delta \text{INFLAT} + \epsilon_{it} \]  

\[ Z\text{-score Metrics for Bank Risks/Stability: Measures for Robustness} \]

The Altman Z-score equation was specified to ensure the consistency of the bank stability outcomes (Altman et al., 2017; Chouhan et al., 2014). The Z-score was used as a dependent variable in the model and was the proxy for bank risk. The study followed (Ma & Yao, 2022) by employing the natural log of the

**Z-Score as the dependent variable.** The following was the specification model of the Z-score model:

\[ Z\text{-score}_{it} = \alpha_1 + \text{Z-score}_{i,t-1} + \beta_1 \Delta (\text{LN\_CROPXO})_i + \beta_2 \Delta (\text{LN\_FOODXO})_i + \beta_3 \Delta (\text{LN\_CEREXO})_i + \sum \Delta \text{Control\_Var} + \epsilon_{it} \]  

This model was introduced to assess the bank risk and served as robustness in this study. A volatility measurement was employed to assess how consistent bank earnings were towards the agricultural production factors (Hafeez et al., 2022). Z-score = (ROA + bank liquidity)/(σ (ROE)) for liquidity and for the bank capital ratio, which was the proxy for bank size in the GMM model (Ali & Innes, 2020). The Z-score formula: (ROE + bank liquidity)/(σ (ROE)) for liquidity earnings, with σ (ROA) and σ (ROE) as the standard deviation of returns for liquidity (Beck et al., 2013). The standard deviation of both earnings (ROA and ROE) was calculated for bank "i" in the year "t", as in (Kasman & Kasman, 2016), and the equations were specified as follows:

\[ \sigma (\text{ROE})_{it} = \frac{1}{\sqrt{T-1}} \left( \sum_{t=1}^{T} \left( \text{ROE}_{it} - \frac{1}{T} \sum_{t=1}^{T} \text{ROE}_{it} \right) \right)^2 \]  

**Empirical Results and Discussions**

Results for preliminary tests: the unit-roots tests.

Table 4 presents the results of the two unit-roots tests, ADF and PP. The results confirmed that all variables were integrated at level I(0), while FOOD\_Xo, GDP, DOMECRED, and FDI\_IN were integrated at first order I(1). These results permitted us to conduct the cointegration test and the ARDL-DFE model.

**Table 4: ADF and PP Test Results.**

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller (ADF)</th>
<th>Philip and Perron (PP)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At level</strong></td>
<td><strong>1st difference</strong></td>
</tr>
<tr>
<td>BALIQ_RATIO</td>
<td>-1.497**</td>
</tr>
<tr>
<td>CROP_Xo</td>
<td>-1.497**</td>
</tr>
<tr>
<td>FOOD_Xo</td>
<td>-0.242</td>
</tr>
<tr>
<td>CEREX_Xo</td>
<td>-1.497**</td>
</tr>
<tr>
<td>GDP</td>
<td>5.558</td>
</tr>
<tr>
<td>INFLAT</td>
<td>-10.969***</td>
</tr>
<tr>
<td>DOMECRED</td>
<td>3.518</td>
</tr>
<tr>
<td>FDI_IN</td>
<td>-0.884</td>
</tr>
<tr>
<td>METRADE</td>
<td>-1.532**</td>
</tr>
</tbody>
</table>

The ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.

**Results for Bounds Test for Cointegration**

Before performing a bounds test with the data in the raw form, the test for maximum lags was conducted to ensure adequate lag level while running the models (He et al., 2022). The results showed that optimal lags were (2,0,1,0,0,1,0,1). This test was conducted for two models of the long-run relationship only.

The table 5 presents the results of the bounds test for cointegration. The null hypothesis is that there is no level relationship between variables; critical values (0.1–0.01). The rejection criteria are as follows: Accept if F is inferior to the critical value for I(0) regressors; reject if F is the superior critical value for I(1) regressors. The F-Statistic for the first model is 8.162, and the p-value is 0.000. however, the F-Statistic for the second model is higher than the first, is 10.194, and the p-value is 0.001. They are both higher than the low and upper bound. Then the decision is that the null hypothesis is rejected, meaning there is a level relationship between variables.
Table 5: Results of The Cointegration Test

<table>
<thead>
<tr>
<th>Models</th>
<th>Bounds critical value</th>
<th>F-statistic value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Significance Levels</td>
<td>Lower Bound I(0)</td>
<td>Upper Bound I(1)</td>
</tr>
<tr>
<td>MODEL1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td>3.205</td>
<td>4.540</td>
</tr>
<tr>
<td>5%</td>
<td></td>
<td>2.484</td>
<td>3.677</td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td>2.147</td>
<td>3.264</td>
</tr>
<tr>
<td>MODEL2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td>2.836</td>
<td>4.173</td>
</tr>
<tr>
<td>5%</td>
<td></td>
<td>2.241</td>
<td>3.443</td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td>1.959</td>
<td>3.090</td>
</tr>
</tbody>
</table>

Table 5 describes the results of the bound test for cointegration. Note that this cointegration test was only used for two models with macroeconomic variables, as the available data are from 1970.

Based on the results obtained in the two unit-roots tests, we could not use the Johanson cointegration test as the series would be integrated with different orders (at the level and first difference). Therefore, it was advisable to use the bounds test for cointegration. The null hypothesis of the bound test states no cointegration among variables. However, the alternative hypothesis states cointegration among studied variables (M. H. Pesaran et al., 2001).

Therefore, Table 5 displays the bounds test results for the cointegration tests. They evidenced that the F-statistic absolute values of both models were higher than the bound critical values at all significance levels (10%, 5%, and 1%). Moreover, the P-values of F statistics were also statistically significant at a 1% level. From those results, the null hypothesis was rejected. The conclusion was that there was a long-term convergence among independent and dependent variables. These results from the bound test for cointegration were validated by the figure 5-7, which exhibits long-term relationships from 1971 to 2018 and from 2000 to 2019. These cointegration results and the evidence from the graphs confirmed Hypothesis 3.

**Figure 5**: Bank Liquidity Ratio Vs. Food Production. **Figure 6**: Bank Liquidity Ratio Vs. FDI Net Inflows

*Figure 5*: This figure presents the inverse movement between bank liquidity and the food production index in Africa since 2000. Their movements seem to have scissors effects. When one variable goes up, the other partner goes down, and vice-versa. *Figure 6*: This figure presents the inverse movement between bank liquidity and foreign direct investment net inflows since 2000. Their movements seem to have scissors effects. Generally, when one variable goes up, the other partner goes down, and vice-versa. However, they exhibit the same short declining trends in crisis periods from 2008-2010 and 2013-2016.

**Figure 7**: Crop production index versus Cereal production **Figure 8**: Bank liquidity ratio Vs. GDP
\textbf{Figure 7:} This figure shows the relationship between crop production index and cereal production in Africa. Their perfect correlation movements let us consider the effect of fertilizers' finance on crop productivity, including cereal productivity. This fertilizer finance gives an idea of farming finance. \textbf{Figure 8:} This figure illustrates the relationship between bank liquidity ratio and GDP Growth in Africa. This relationship reflects the potential correlation between bank risk and DGP, backed by agriculture production.

\textbf{Agro-Production Effects on Bank Liquidity Ratio: Ardl-DFE Regression Results}

In the long-term, the three main variables of interest were all positive and statistically significant: A 1% increase in Crop-Xo (crop production index) provoked an increase in bank liquidity by 0.506% at the 10% significance level, ceteris paribus, and consequently reduced the Z-score for bank stability by -0.267% significance levels, ceteris paribus. A 1% increase in Food-Xo (food production) increased the bank liquidity ratio by 1.143% and reduced the Z-score for its stability by -0.350% at both a 1% significance level, ceteris paribus. Likewise, a 1% increase in Cere-Xo (cereal production) was associated with a significant increase in bank liquidity of 0.898% and contrary to a decrease of -0.456% in Z-score for bank stability, at a 5% and 1% significance level, respectively, ceteris paribus.

Concerning the other controllable variables, a 1% increase in GDP positively affected bank liquidity by 0.337% with a 1% significance level, ceteris paribus. It decreased the Z-score by 0.308% with a 1% significance level, ceteris paribus. Likewise, a 1% increase in INFLAT positively influenced the bank liquidity ratio by 0.261%, with a 1% significance level, ceteris paribus.

Table 6 displays the dynamic fixed effect results for the two short and long-run results where bank liquidity ratio and Z-Score are the dependent variables. Model 8 is for bank liquidity ratio, while model 13 is for Z-Score.

\textbf{Table 6: ARDL-DFE Results}

<table>
<thead>
<tr>
<th>Variables</th>
<th>PMG-DFE</th>
<th>Model8 (Bank Liquidity)</th>
<th>Model13 (Z-SCORE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Long-term</td>
<td></td>
<td>Short-term</td>
</tr>
<tr>
<td>CROP_Xo</td>
<td>0.506*</td>
<td>0.680</td>
<td>-0.267**</td>
</tr>
<tr>
<td>FOOD_Xo</td>
<td>1.143***</td>
<td>0.032</td>
<td>-0.350***</td>
</tr>
<tr>
<td>CERE_Xo</td>
<td>0.898**</td>
<td>0.738</td>
<td>-0.456***</td>
</tr>
<tr>
<td>GDP</td>
<td>0.337**</td>
<td>0.0622</td>
<td>-0.308***</td>
</tr>
<tr>
<td>INFLAT</td>
<td>-0.116*</td>
<td>0.064</td>
<td>-0.029</td>
</tr>
<tr>
<td>DOMEcred</td>
<td>0.261**</td>
<td>0.086</td>
<td>-0.294***</td>
</tr>
<tr>
<td>FDI_IN</td>
<td>0.081*</td>
<td>0.046</td>
<td>-1.060</td>
</tr>
<tr>
<td>METRADE</td>
<td>0.231**</td>
<td>0.151</td>
<td>0.023**</td>
</tr>
</tbody>
</table>

Table 6 presents the results of the ARDL-DFE regression. The ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. The first compartment is for long-run results, and the second compartment is for short-run results.

Concerning the other controllable variables, a 1% increase in GDP positively affected bank liquidity by 0.337% with a 1% significance level, ceteris paribus. It decreased the Z-score by 0.308% with a 1% significance level, ceteris paribus. The domestic credit foreign direct net inflows were also statistically significant and affected the bank liquidity and Z-score differently: A 1% increase in domestic credit affected the bank liquidity positively by a 0.357% increase with a 5% significance level, ceteris paribus. In comparison, it decreases the Z-score by -0.294 with a 1% significance level, ceteris paribus, in the long run. Likewise, a 1% increase in foreign direct net inflows (FDI_IN) positively influenced the bank liquidity ratio by 0.081, with a 10% significance level, ceteris paribus. In contrast, the percentage change in foreign direct net inflows reduced the Z-score by -1.060 in the long run, with a 1% significance level, ceteris paribus. The trade positively affected bank liquidity and the Z-score by 0.231 and 0.023%, respectively, at a 5% significance level in the long-run, ceteris paribus. However, inflation was only significant, with bank liquidity at a 10% significance level, even if this negatively affected its Z-score positively.

Regarding the short-term results: Among the interested variables, two were statistically significant (food and cereal production), while one (crop production index) was not statistically significant in the short term. A 1% increase in food and cereal production...
positively influenced bank liquidity by 0.705% and 1.154%, with a 1% significance level, ceteris paribus. However, the same % change negatively affected the Z-score by -0.061% and -1.144% with a 5% and 1% significance level, respectively, ceteris paribus.

The same effects were observed with GDP, affecting bank liquidity and the Z-score differently by 0.790% and -0.215%, respectively, at a 1% significance level, ceteris paribus. A 1% increase in DEMOCRE increased bank liquidity by 0.357% at a 5% significance level and simultaneously reduced the Z-score by -0.260% at a 5% significance level, ceteris paribus.

However, in the short-run, a 1% increase in inflation provoked a decrease of -0.005% in bank liquidity ratio and an increase of 0.166 % in Z-score decrease, respectively, at a 10% and 1% significance level, ceteris paribus. The foreign direct investment increased bank liquidity and decreased Z-Score, respectively, at 0.053% and -0.052% at both 5% significant levels.

The effects of the three agricultural proxies on bank liquidity and stability confirmed our hypotheses 1, 1a, and 1b. They corroborated the findings in Table 5, especially for two agricultural productions (Food production and Cereal production) proxies' effects on bank risk reduction. When agricultural production in GDP growth was considerably higher, especially in the West African region (Suri & Udry, 2022), its influence should also be bigger. It indicated that agricultural production proxies were the main determinants of GDP Growth in SSA and, consequently, the main influencers of bank liquidity and stability in the region (Gollin, 2020). Furthermore, cointegration results and the trends between GDP Growth in food, and cereal production supported these findings by exhibiting cointegration movement since 1970 (refer to the figure 1-3). These results confirmed Hypothesis 3.

### Agro-Production effect on Bank Risk and Profit (GMM Results).

The table 7 presents the GMM results obtained with the GMM models while testing the effect of agriculture and cereal production on bank stability through their impact on bank risk using loan loss reserves and non-performing loans (LLRs and NPLs). These results corroborated the first results obtained in the first model using the ARDL-DFE model (Table 5).

**Table 7: Presents Gmm Results for Bank Risk And Profitability (Short-Run Analysis).**

<table>
<thead>
<tr>
<th>GMM models</th>
<th>Model 9 (LLRs)</th>
<th>Model10 (NPLs)</th>
<th>Model 11 (ROA)</th>
<th>Model12 (ROE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAG-X</td>
<td>-0.003***</td>
<td>0.015</td>
<td>-0.003***</td>
<td>0.015</td>
</tr>
<tr>
<td>FOOD-Xo</td>
<td>0.078***</td>
<td>0.004</td>
<td>0.078***</td>
<td>0.004</td>
</tr>
<tr>
<td>CERE-Xo</td>
<td>1.285***</td>
<td>2.923</td>
<td>1.285***</td>
<td>2.923</td>
</tr>
<tr>
<td>DOMECRED</td>
<td>0.251*</td>
<td>0.182</td>
<td>0.251*</td>
<td>0.182</td>
</tr>
<tr>
<td>B_SIZE</td>
<td>-0.0128</td>
<td>0.007</td>
<td>-0.0128</td>
<td>0.007</td>
</tr>
<tr>
<td>GDPGR</td>
<td>0.266***</td>
<td>0.054</td>
<td>0.266***</td>
<td>0.054</td>
</tr>
<tr>
<td>GOVEXP</td>
<td>1.020</td>
<td>1.916</td>
<td>1.020</td>
<td>1.916</td>
</tr>
<tr>
<td>INFLAT</td>
<td>-0.047**</td>
<td>0.021</td>
<td>-0.047**</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Aregelano–bond tests for AR (1) and AR(2) are, respectively, 0.337 and 0.812 for the LLR model; 0.712 and 0.973 for the NPL model. Harsen statistic is 0.152 for the LLR model and 0.479 for the NPL model. The *** , **, and * indicate significance at 1%, 5%, and 10%, respectively. For bank profitability, Arellano–bond tests for AR(1) and AR(2) are 0.135 and 0.266 for the ROA model and 0.817 and 0.798 for the ROE model, respectively. Harsen's statistics are 0.196 for the ROA model and 0.798 for the ROE model, ***, **, and * indicate significance at the 1%, 5%, and 10%, respectively.

For the short-run GMM results, a 1% change in Food-Xo (food production) influenced bank stability positively by increasing loan loss reserves (by 0.078%) at a 1% significance level, ceteris paribus. In contrast, the same change decreased non-performing loans by -0.605% (meaning an increase in bank profit and stability), at a 5% significance level, ceteris paribus. A 1% change in cereal production (Cere-Xo) increased bank stability by augmenting LLRs (loan loss reserves) by 1.285% at a 1% significance level, ceteris paribus. The exact change influenced the bank's profitability via a reduction in non-performing loans (NPLs) by -0.57% at a 5% significance level, ceteris paribus. These opposite trends and effects were the same for DGP growth as it depended on both two variables of agriculture production proxies (Suri & Udry, 2022).

The domestic credit and GDP growth had significant positive effects on bank risk and profit: A 1% increase in GDP growth increased bank stability by increasing loan loss reserves (LLRs) by 0.078% at a 1% significance level. The same change reduced bank risk by diminishing non-performing loans (NPLs) by -0.605%, at a 1% significance level, ceteris paribus. Likewise, the signs go in the same direction, with a 1% change in domestic credit. The bank size and government expenses were not statistically significant. However, inflation (INFLAT) was negatively correlated to bank stability: a 1% increase in inflation (INFLAT) reduced bank risk by reducing loan loss reserves (LLRs) and non-performing loans (NPLs). However, its effects were not statistically significant (-0.047 and -0.201, respectively).

For the effects of Agro-Production effects on bank profitability, the results showed that both bank profit proxies were positively affected by agriculture and cereal production: a 1% increase in food production (Food-Xo) provoked a rise in return on assets and return on equity (ROA and ROE), respectively, by 0.453% and 0.712% at a 1% significance level, ceteris paribus. Likewise, a 1% increase in cereal production (Cere-Xo) affected return on assets and equity (ROE and ROE) by 0.017% and 0.050 %, respectively.
at a 1% significance level ceteris paribus. However, this latter effect was not strong enough. These results also converged well with the economic expectations and the previous findings in Table 5. They confirmed that bank profitability was supported by food and cereal production in Sub-Saharan Africa, as underlined in other studies (Suri & Udry, 2022). These results confirmed our hypotheses 2, 2a, and 2b.

Furthermore, domestic credit (DOMCRED) and GDP growth positively affected bank profitability at a 1% significance level, ceteris paribus. While government expenses (GOVEXP) were insignificant, bank size was positive and statistically significant at a 1% level. Likewise, inflation (INFLAT) is also statistically significant. These results corroborate the results from Table 5 on the long-run relationship between bank factors and agriculture production factors. Furthermore, as agricultural production plays an important role in the GDP growth in Sub-Saharan Africa, especially in western countries (Gollin, 2020; Suri & Udry, 2022), it is normal to expect that agricultural production also would sustain the banking system, similar to the GDP (Naili & Lahrichi, 2022a, 2022b). For the overall findings; the first finding is from cointegration analysis (results1 in table4):

Agriculture production proxies exhibit perfect inverse movements with the bank liquidity for the long run, as shown in figures 5-8. This confirms a relationship between bank stability and agriculture production factors. The second finding (Model 12 and Model 3 results, in table 5) is that agriculture production proxies increase bank liquidity ratio and consecutively reduce bank risk (i.e., augment bank stability) via reduction of Z-Score. The third finding (Model 5 and model6 in table6) is that agriculture production proxies reduce bank risk in two ways: decreasing non-performing loans and increasing loan loss reserves. The fourth finding (Model 7 and model8, in table7) is that the agriculture production proxies increase both returns. Note that the second finding confirms the third finding and vice versa. Then the last finding for bank stability (as a function of the combination of bank riskiness and profitability) is that the first and second findings, plus the third and fourth findings as parameterized in models 2-4; all together confirm this assumption that “bank stability is the function of both long-run results of bank riskiness reduction and short run bank profitability”.

Figure 9: Cointegration between LLRs and ROE Figure10: Inverse moves between NPLs & ROE

Figure 9: This figure presents the perfect cointegration between loan loss reserves and returns on equity in Africa, since 2010. After a 2015 recession and stock market fall, these performance indicators took a sharp increase in the following years to come back down in 2017. Figure 10: Illustrates the opposite trends between non-performing loans and returns on equity in Africa from 2010 until 2016. From that period, they took a rise to come back down from 2018.

However, the figure10 reflects the inverse movement (negative correlation) between bank risk proxy (NPLs) and bank profit proxy (ROAE), which corroborate the findings of the signs in the regression outputs for both risk and profit results (table 6 and 7). Figure 11 proves one more convergence trend between credit growth risk and the ratio of loan loss reserves to non-performing loans. The domestic credit variable was also used in the controllable variables alongside foreign direct investment net inflows. Both variables indicate a positive correlation with bank profitability proxies and a negative relationship with bank risk proxies. It is also confirmed that they are both moving in the same direction and are main contributors to GDP, as shown in figures 2-3. These later effects and signs support these findings that bank risk and profitability are oppositely affected: risk being reduced and profit being increased (see figure10 and 12).
Figure 11: Ratio of llr/Npls & Credit Growth Trends. Figure 12: Scissors Movements: Npls vs. Bank Liquidity Ratio

**Figure 11:** This figure presents the cointegration movement between the ratio and loan loss reserves to non-performing loans and the domestic credit in Africa since 2010. These movements infer the relations between bank credit and related risks. Figure 12 shows the opposite relationship between non-performing loans and bank liquidity ratio in SS Africa since 2010. The higher the capital, the lower the non-performing loans and the lesser the bank risk is. This increases the LLRs and stabilizes the banks in SS African.

These different effects of agricultural production factors on bank risk and profit had three crucial meanings to this study: The first one is that they corroborated the long-run results obtained in the first model when using the DFE model. The second one is that they responded to the central question in the introduction. In the third one, they confirmed the hypotheses regarding the effect of agricultural production proxies on bank stability (H1, H1a, and H1b). Economic expectations support these results because, in normal conditions, the two variable groups (risk and profit proxy groups) seemed to react differently: The more the bank risk factors are affected, the less the bank profits, and vice versa (Zheng & Jean-Petit, 2022): In ten last years (2010-2019), the proxies that defend the same interest (bank profitability) tend to move in the same direction (figure9 and 11), while the proxies that protect different interest (cause bank riskiness) trend to move opposite direction (figure10 and 11). When the LLRs increased, it indicated that the Non-Performing loans (NPLs) decreased and could provide a better profit from the net margin to the bank. That is why LLRs move together with ROE. These movements support the logic of bank stability in the long run (Zheng & Jean-Petit, 2021).

**Agro-Production effects on Bank Riskiness and Profitability: FMOLS for long-run**

The results in table 8 were obtained using the same main models 9-12 while testing the effect of agriculture and cereal production on bank stability. The dependent variables for bank risk are NPLs and LLRs and ROA and ROE for bank profitability, both being functions of bank stability (as specified in models 2-4). This regression used the Fully Modified Least Squares method (Erdal & Erdal, 2020), and the results corroborate with the GMM and DFE results.

**Table 8:** Presents The Fully Modified Least Squares Results (FMOLS for long-run analysis).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model9 (LLRs)</th>
<th>Model10(NPLs)</th>
<th>Model11 (ROA)</th>
<th>Model12 (ROE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xo</td>
<td>1.677**</td>
<td>1.547</td>
<td>-2.739***</td>
<td>0.842</td>
</tr>
<tr>
<td>LNCERE</td>
<td>0.966**</td>
<td>0.575</td>
<td>-0.002*</td>
<td>0.029</td>
</tr>
<tr>
<td>LNDOMECRED</td>
<td>-2.708</td>
<td>2.092</td>
<td>-0.030*</td>
<td>0.115</td>
</tr>
<tr>
<td>LN_SIZE</td>
<td>-0.406*</td>
<td>1.012</td>
<td>-0.130*</td>
<td>0.000</td>
</tr>
<tr>
<td>LNGDPGR</td>
<td>-0.306**</td>
<td>0.141</td>
<td>-0.134</td>
<td>0.058</td>
</tr>
<tr>
<td>LNGOVEXP</td>
<td>1.488*</td>
<td>7.871</td>
<td>1.673**</td>
<td>4.012</td>
</tr>
<tr>
<td>LNINFLAT</td>
<td>-0.805</td>
<td>1.940</td>
<td>0.230**</td>
<td>0.127</td>
</tr>
</tbody>
</table>

Table 8 presents Fully Modified Least Squares results for bank stability and profitability. ***, **, and * indicate significance levels at the 1%, 5%, and 10%, respectively.

The results presented in the table 8 testify to the effects of food-cereal production on bank risk and profitability. Food and cereal production has adverse effects on bank risk and a positive impact on bank profitability. However, bank size and domestic credit have a similar negative impact on bank risk proxies, while both positively affect the bank profitability proxies. Gross domestic product has identical effects to food-cereal production –as they are its main contributor (Suri & Udry, 2022). They have a negative impact on bank risk proxies and a positive on bank profitability proxies.

Indeed, these long-run FMOLS results confirm the relationship between agro-production proxies and bank stability and profit proxies. As they corroborate with the GMM short-run results, we can confirm that there are effects of agro-production factors that affect bank stability.

These graphs also corroborate the results obtained in the DFE model 12-13 (table5). They are linked with the economic theory and other findings on the role of bank liquidity in reducing bank risk and increasing bank solvency via cash availability (Raz et al., 2022). Moreover, the more the bank cash has, the more credit volume is offered, and the low the risk.
As bank credit plays an important mediating role in the relationship between ago-production, bank liquidity, bank risk, and profits proxies these later are functions of credit portfolio. We tried to check the relationship between domestic credit and food-cereal in the sub-region of SS Africa as the bank credit moderates the effects of agro-production and bank risk and profit proxies. FDI, a backup of domestic credit, is also correlated to agro-production (Sikandar et al., 2021) and GDP Growth (Okunlola et al., 2019; Paul & Lema, 2018).

Conclusion

This study examined the long-term effect of agricultural production on bank stability using three different variables of agricultural production with other models and methods. Based on the results obtained in the GMM regression for short-term results, FMOLS, and Dynamic fixed Effects –DFE- for long-term outcomes, we concluded the following: First, crop and cereal production has a short and long-term influence in sustaining African banks through bank risk (non-performing loans and loan loss reserves) and profitability (return on assets and return on equity). Second, food-cereal production also had short and long-term impacts on bank profitability and stability. Third, the bank liquidity ratio, as a proxy for bank stability, was also influenced by crop and cereal production on one side and food-cereal production on the other. Fourth, the bank liquidity ratio positively correlates with agricultural production proxies (as demonstrated by IRF graphs), increasing bank stability. Moreover, the domestic credit offered by private banks in the studied region has a causal effect on food-cereal production, especially in the sub-region, as demonstrated by the IRF graphs and causality results presented in related table. Finally, we conclude that those variables exhibited perfect cointegration trends, as shown in cointegration results and attested in Figures 1-3, 9, 10, 11, and 12.

These partial conclusions allowed us to make two general conclusions: first, bank stability in Sub-Saharan Africa is affected by agricultural production, the region’s major contributor to GDP growth (Okunlola et al., 2019; Paul & Lema, 2018). Secondly, bank stability is a function of both bank riskiness and bank profitability (model 9-12, in both GMM and FMOLS, results in table 7 and 8). And finally, farming finance sustains the African banking system in terms of risk alleviation and profit aspects. As long as agriculture production proxies have a crucial role in sustaining the African banking system while farmers increase production output due to their financed projects, both (bankers and farmers) are interested in collaborating for further development on both sides. Then, complementarity and interdependency sustained both sectors (finance and agriculture) as each depends on another. We confirm that it is a” win-win relationship for better stability and prosperity in both sectors.’’

Hopefully, these results will increase banks' and investors' confidence in farming finance.

We recommend that the central banks in SSA establish and implement measures/strategies that may incentivize commercial banks to increase their risk-taking level to augment credit volume allocated to the agricultural sector (e.g., reducing the interest rates on agricultural credit). The governments' interventions (Meyer, 2011), via central banks, should collaborate with commercial banks to ensure agricultural credits (Gehrke, 2019; Pavlov et al., 2016) - as they do for other types of loans- so that agriculture output level can be increased in Africa for a better sustainable banking system. Finally, as every business involves risk-bearing, we recommend commercial banks to change their risk-taking behavior, increase confidence and step up for diversified agricultural credit services for large-scale and smallholder farms with different proposed insurance plans (Tabe-Ojong et al., 2022). By doing so, banks will solve the stated problem, simultaneously sustain their banking affairs in a win-win way, and improve food security in the region.

Future studies could analyze agricultural production's effect on other non-financial sectors such as insurance companies. As a limitation, the data used for bank profitability analysis were limited from 2010 to 2019. Another boundary was geographical, as the study focused only on SSA countries.

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References


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