

# Access to Credit and Agricultural Productivity

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## Abstract

Access to agricultural credit remains a critical challenge in developing countries, limiting the adoption of modern technologies essential for productivity growth. This study investigates the impact of credit access on agricultural productivity among maize producers in Benin, utilizing data from a 2016 survey conducted by the National Agricultural Research Institute of Benin. Employing an endogenous switching regression model, the analysis accounts for selection bias and unobserved heterogeneity. Results indicate that access to credit increases productivity by 40.07% per hectare and 31.97% per FCFA invested. These findings underscore the need for comprehensive policies to enhance agricultural financing and productivity.

**Keywords:** Access to credit, Agricultural productivity, Maize Producers, ESR model, Benin.

# 1. Introduction

Access to credit is widely recognized as a critical determinant of agricultural productivity. Agricultural productivity, particularly in developing economies, underpins food security, rural incomes, and broader economic growth. However, persistent barriers to credit access in Sub-Saharan Africa (SSA) constrain farmers' ability to adopt productivity-enhancing inputs and technologies. Despite the extensive body of literature exploring this nexus, significant gaps remain, particularly in country-specific contexts where structural, institutional, and crop-specific dynamics may vary considerably. This study contributes to this discourse by examining the relationship between access to credit and agricultural productivity in Benin, with a specific focus on maize, the country's second most important crop after cotton.

The relevance of this focus lies in Benin's economic structure, where agriculture accounts for 27.8% of GDP and 71.5% of export earnings (MAEP<sup>1</sup>, 2022). Maize production, critical for food security, has shown inadequate marketable surpluses, attributed to persistently low yields. As illustrated in Figure A1 (Appendix), maize yields in Benin averaged 1,347 kg/ha between 2011 and 2020 – substantially lower than the regional average of 1,642 kg/ha for West Africa and far below the global benchmark of 5,530 kg/ha (FAO, 2022). The resulting low productivity not only limits foreign exchange earnings but also perpetuates poverty and income disparities in rural areas. Addressing these yield gaps is imperative for enhancing rural livelihoods and achieving national development goals.

Empirical evidence identifies multiple constraints to agricultural productivity, including climate variability, pest infestations, and poor infrastructure. However, endogenous factors, such as limited access to credit, remain a recurring theme in the literature (Guirkinge and Boucher, 2008; Nakano et al., 2016). Credit enables farmers to finance essential inputs and invest in productivity-enhancing technologies, mitigating the adverse effects of the agricultural production cycle's inherent delays (Feder et al., 1990). Despite its potential, access to agricultural credit remains limited for smallholder farmers due to systemic issues such as collateral requirements and high transaction costs (Stiglitz and Weiss, 1981).

While previous studies underscore the positive effects of credit on agricultural productivity (Akudugu, 2016; Khandker and Koolwal, 2016), emerging evidence challenges this consensus, suggesting that outcomes are context-specific and may vary significantly across regions and crops (Nakano and Magezi, 2020; Agbodji et al., 2019). For instance, Agbodji et al. (2019) found that the effects of credit on productivity were mixed, highlighting the need for tailored analyses within specific country contexts.

This study makes two principal contributions to the literature. First, it addresses the specific case of maize production in Benin, a crop of critical importance yet underexplored in existing research. Unlike prior studies (e.g., Acclassato Houensou et al., 2021), which pooled data across various crops, this study focuses exclusively on maize to avoid biases arising from heterogeneous production processes and input requirements. Second, it employs a dual productivity metric—yield per hectare and productivity per CFA invested—providing a more comprehensive assessment of agricultural performance.

To achieve these objectives, the study leverages nationally representative survey data and applies an endogenous switching regression model to estimate the productivity differences between farmers with and without access to formal credit. The findings reveal that access to credit leads to significant productivity gains, with increases of 40.07% in yield per hectare and 31.97% in productivity per CFA invested. These results underscore the transformative potential of credit in enhancing agricultural performance and offer actionable insights for policymakers seeking to refine agricultural finance strategies.

In addition to its implications for Benin, this research provides lessons that can inform agricultural policies in similar contexts across SSA. The remainder of this paper is structured as follows. The next section

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<sup>1</sup> MAEP (Ministère de l'Agriculture, de l'Élevage et de la Pêche)

contextualizes the study by examining the structural and institutional factors influencing productivity in Benin. Section 3 reviews the literature on credit constraints and agricultural performance. Section 4 details the data and methodological framework. Section 5 presents the empirical results, and Section 6 concludes with policy implications.

## 2. Literature review

The relationship between access to credit and agricultural productivity has been extensively explored in the literature, yet there remains considerable debate regarding the nature and magnitude of the impact. This divergence is shaped by variations in socio-economic contexts, agricultural endowments, and institutional frameworks, as well as methodological differences in the studies themselves. The absence of consensus underscores the complexity of the subject, necessitating a nuanced understanding of the mechanisms through which credit influences productivity and the contextual factors that mediate this relationship.

This review categorizes the existing literature into three broad strands: studies reporting positive effects of credit on agricultural productivity, those identifying limited or neutral effects, and those suggesting negative impacts. Each strand is critically assessed to uncover the underlying factors driving these divergent findings, with an emphasis on methodological approaches and contextual nuances.

### Positive effects of credit on agricultural productivity

A significant body of research highlights the positive impact of access to credit on agricultural productivity. For instance, Diallo et al. (2020), using stochastic frontier analysis on a sample of 216 Senegalese farmers, report a 37.32% productivity increase among credit recipients. Similarly, Diamoutene and Jatoe (2021) find that access to credit enhances maize yield in Mali, as demonstrated through an endogenous switching regression model. These findings are corroborated by Ali et al. (2014), who show that lifting credit constraints improved productivity by 17% among Rwandan households, as evidenced by regime-switching models.

In Ghana, Akudugu (2016) provides nuanced insights, showing that interactions between credit types and farm size significantly boost production. Martey et al. (2019), using propensity score matching, further demonstrate that credit enables timely input acquisition and efficient factor allocation, leading to enhanced productivity in Northern Ghana. Such results emphasize the potential of credit to alleviate input constraints and optimize resource use, thereby improving farm outputs.

However, these studies often focus on regions with relatively developed financial infrastructure or effective credit schemes tailored to agricultural needs. The findings may not generalize to contexts where structural inefficiencies or socio-economic barriers limit the efficacy of credit as a productivity-enhancing tool.

### Limited or neutral effects of credit on agricultural productivity

Contrary to the optimistic findings above, some studies reveal limited or neutral effects of credit on productivity. For instance, Njeru et al. (2016) find no significant differences in fertilizer use or yields between Kenyan farmers with and without credit access. Similarly, Nwaru and Onuoha (2010) even report better performance among non-beneficiaries, attributing this to inefficiencies in credit delivery mechanisms and suboptimal loan utilization.

Seck (2021) interprets these outcomes as indicative of flawed lending systems that fail to address the specific needs of farmers. Issues such as high-interest rates, delays in loan disbursement, and cumbersome administrative procedures undermine the potential benefits of credit. These results underscore the importance of not only providing credit but also ensuring its alignment with farmers' operational realities and timing requirements.

## Negative effects of credit on agricultural productivity

A third strand of literature points to the potentially adverse effects of credit on agricultural productivity. Nakano and Magezi (2020) argue that access to credit alone is insufficient to drive productivity gains, particularly when farmers face structural barriers to technology adoption. Agbodji and Johnson (2019) highlight the contrasting effects of credit types, showing that cash credit negatively impacts maize productivity in Togo, whereas in-kind credit has a positive effect. They attribute this disparity to the precarious financial situations of small farmers, which often compel them to divert cash loans to non-productive uses such as basic consumption.

Such findings reveal the critical role of credit design and delivery mechanisms. For example, cash loans may exacerbate liquidity constraints if they are not accompanied by measures to promote productive investment. These studies highlight the need for tailored credit solutions that consider farmers' socio-economic conditions and financial literacy.

The divergence in findings across the literature can be attributed to several factors. First, variations in socio-economic and institutional contexts shape the effectiveness of credit schemes. Countries with robust agricultural policies, effective extension services, and well-functioning credit markets are more likely to report positive impacts. Second, methodological differences, including sample selection, econometric techniques, and definitions of productivity, contribute to the inconsistencies. For instance, studies employing cross-sectional data may overlook dynamic effects, while those using small samples may suffer from limited external validity.

Third, the heterogeneity of credit types and their respective terms – such as interest rates, repayment schedules, and collateral requirements – also plays a role. Studies that do not account for these differences may yield misleading conclusions. Finally, farmers' financial literacy and risk preferences influence how credit is utilized, further complicating the relationship.

In the context of Benin, existing studies primarily focus on the determinants of credit access or sector-specific financing mechanisms (Assogba et al., 2017; Sossou, 2015). Few have empirically examined the link between credit and productivity, and those that do often aggregate data across crops, risking biased policy implications. Acclassato Houensou et al. (2021), for example, combine diverse crop producers in their analysis, potentially obscuring crop-specific dynamics.

This study addresses these gaps by focusing specifically on maize farmers in Benin, employing advanced econometric techniques to account for selection bias and unobserved heterogeneity. By doing so, it provides a more precise understanding of the role of credit in enhancing agricultural productivity, contributing valuable insights to the ongoing debate.

## 3. Financing and productivity challenges of agriculture in Benin

Agricultural production in Benin, like in other developing countries (DCs), is mainly practiced by smallholder farmers. The average land area is estimated at 1.7 ha, with about 34% of farms covering less than one hectare. Smallholders, estimated at 550,000, account for nearly 95% of the output of the agricultural sector (MDAEP<sup>2</sup> and UNDP, 2015). This sector has a preponderant share in GDP, averaging nearly 36% (WFP, 2017). Despite the importance of agriculture in Benin's economy, the sector faces many financing challenges.

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<sup>2</sup> Ministry of Development, Economic Analysis and Forecasting of Benin

Agricultural financing in Benin, like in most sub-Saharan African countries, has long been provided by the public authorities. These direct State interventions in rural financial markets ended up in failure in the 1960s and 1970s, leading to the questioning of the state's mandate in financing agriculture in favour of the Structural Adjustment Programs (SAP) in the 1980s. The return of the Government to the agricultural sector was observed gradually towards the end of the 2000s, notably from 2006, following the change of regime which occurred in the country's top leadership. The authorities then expressed the desire to make agriculture the backbone of the economy. The 2007-2008 food crisis further reinforced this and led to the establishment of an emergency plan to support food security (PUASA<sup>3</sup>). In addition to this plan, subsidies were established to support increased food production.

The various agricultural financing instruments planned in Benin are supposed to combine public actions with private initiatives (MAEP, 2016). The intent to develop the agricultural sector, as displayed by the public authorities, will result in the development of the strategic plan to revive the agricultural sector and the national plan of agricultural investment (PSRSA/PNIA). Despite the political will, the development of the agricultural sector is slowed down by the low level of funding. Budgetary allocations and external financial support mobilized through technical and financial partnerships have fallen short of the sector's needs. Between 2011 and 2015, agricultural investments were estimated at 1,531.05 billion FCFA<sup>4</sup>, yet only 742.31 billion FCFA – less than half of the projected amount – was effectively invested by both the state and private actors, yielding a financial execution rate of just 48.48% (See Table A3 in the Appendix). Similarly, financing gaps persist in the implementation of the National Agricultural Investment, Food Security, and Nutrition Plan (PNIASAN), with a shortfall amounting to 27.5% of the total budget under the Ministry of Agriculture's mandate (see Table 1).

Table 1: Estimation of PNIASAN (2017-2021) Financing Gaps by MAEP (in Million)

Priority Areas of the PNIASAN	MAEP Needs	Total Acquired Budgets		Additional Budgets (Gap)		
		Lower Estimate	Upper Estimate	Lower Estimate	Upper Estimate	
<b>A1 Productivity</b>	(a)	291,265.56	220,276.31	263,513.73	70,989.25	27,751.83
	(b)	444.03	335.81	401.72	108.22	42.31
<b>A2 Added Value Chain</b>	(a)	40,507.26	23,307.34	23,828.28	17,199.90	16,678.97
	(b)	61.75	35.53	36.33	26.22	25.43
<b>A3 SAN Resilience</b>	(a)	111,286.64	76,425.16	86,843.82	34,861.48	24,442.83
	(b)	169.66	116.51	132.39	53.15	37.26
<b>A4 Governance</b>	(a)	244,474.58	178,072.04	225,476.93	66,402.54	18,997.65
	(b)	372.70	271.47	343.74	101.23	28.96
<b>A5 Financing</b>	(a)	38,538.99	28,489.79	31,094.45	10,049.19	7,444.53
	(b)	58.75	43.43	47.40	15.32	11.35
<b>Total</b>	(a)	<b>726,073.03</b>	<b>526,570.64</b>	<b>630,757.21</b>	<b>199,502.37</b>	<b>95,315.81</b>
	(b)	<b>1,106.89</b>	<b>802.75</b>	<b>961.58</b>	<b>304.14</b>	<b>145.31</b>

Note: SAN refers to Nutritional Food Security. Figures in line (a) are expressed in FCFA, while those in line (b) are in Euros. Currency conversions are based on the exchange rate as of April 10, 2019, set at €1 = FCFA 655.957.

Source: Authors, MAEP (2017).

<sup>3</sup> PUASA (Plan d'Urgence d'Appui à la Sécurité Alimentaire)

<sup>4</sup> FCFA known as Franc de la Communauté Financière d'Afrique

The gaps in funding result in ineffective public administration, including “the National Fund for Agricultural Development (FNDA)” created in 2014 and confirmed in 2017<sup>5</sup>. The FNDA is indeed the main instrument expected to finance agricultural activities. The counters dedicated to implementing this fund have not been operational since their establishment. The activities of this fund were only launched in 2018. In the absence of operationalization of the main financing instruments, actors in agricultural value chains continue to turn to decentralized financial services (DFS) to obtain funding despite the difficult conditions they face accessing finance and the inappropriate services they receive in respect to agricultural activities. Farming households continue to struggle in their attempts to develop their farms because of the lack of an adequate financing mechanism.

Producers, especially cotton farmers, have for a long time relied on FECECAM<sup>6</sup> whose activities have been able to prosper thanks to a credit repayment mechanism favoured by the public monopoly in the sector (Wampfler and Mercoiret, 2003). These important initiatives, however, struggle to be effective. Most of the products provided by microfinance institutions (MFIs) in the agricultural sector are often either poorly designed or poorly adapted to the needs of the sector. This lack of access to credit is exacerbated by the virtual absence of an appropriate agricultural insurance mechanism. The nature and frequency of risks in agriculture demotivate insurance structures from providing insurance products to this sector. The experiences in this field are very recent in Benin and relate to the actions of private operators who include AMAB<sup>7</sup>.

The association of farmers applying for group credit has not always been accompanied by a sustained increase in access to credit because of the high arrears resulting from the rejection of the solidarity guarantee by some members (MDAEP and UNDP, 2015). The situation in central Benin illustrates this difficulty. Agricultural cooperatives in this region are still not very familiar with the behaviour and history of their members, particularly in terms of loan repayments. This uncertainty about the credit repayment capacity associated with the hazards affecting agriculture justifies, among other things, the pronounced shortfall of financing in this sector. Due to the lack of adequate means to enlarge cultivated areas, many farmers in Benin, like in developing countries, work on a small scale.

These production constraints hinder public policies that are mainly aimed at diversifying agriculture. Indeed, the potential of agriculture in Benin, particularly with regard to food crops, is still poorly exploited despite the increase in production. However, the public authorities have opted to develop the food sectors hitherto left behind in favour of cash crops such as cotton. In this perspective, the corn sector is ranked second out of the six (06) flagship agricultural sectors after cotton (WFP, 2017). If the level of production of this cereal makes it possible to cover the food needs of households, the fact remains that the generated marketable surpluses are not sufficient to meet the country's real needs (MAEP, 2017). Meeting farmers' specific financing needs would significantly increase production and put maize in the range of cash crops that generate significant foreign exchange for the country and reduce poverty among farmers.

The above development indicates the challenges of financing in the agricultural sector and calls for attention from public authorities. However, the effectiveness of public policies requires clarification of the relationship between financing and performance issues.

## 4. Methodology and data

This section discusses the data utilized in the study and outlines the empirical methodology employed to analyze the relationship between access to credit and agricultural productivity among maize producers in Benin.

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<sup>5</sup> The FNDA was created in 2014 by decree n ° 2014-100 of January 31, 2014 but was not really operational. A more recent decree n ° 2017-304 dated June 21, 2017 with the same purpose was taken by the new political regime.

<sup>6</sup> Federation of Local Agricultural Mutual Credit Banks.

<sup>7</sup> Benin Mutual Agricultural Insurances

## 4.1. Data

This study utilizes data from the National Institute of Agricultural Research of Benin (INRAB), collected as part of the Agricultural Policy Analysis Program (PAPA) survey conducted in 2016. The survey aimed to identify the optimal conditions for increasing maize and cotton production in Benin. It covered 490 maize producers across 49 communes, selected based on their agroecological suitability for maize cultivation and the presence of seed multiplication activities and extension systems.

To ensure representativeness, the sample was designed to reflect the diversity of maize producers across Benin. The producers included in the survey were identified as control producers by INRAB, implying they possess characteristics representative of their respective communities. However, given the relatively modest sample size, it is crucial to address concerns regarding its representativeness. The distribution of respondents across communes was designed to minimize sampling bias, and the inclusion criteria were guided by the technical and economic realities of maize production in the region. Nevertheless, this sample size may limit the generalizability of findings to the national level.

The survey provided detailed data on socio-economic characteristics, agricultural practices, credit constraints, input usage, production costs, yields, and adoption of improved maize varieties. For this study, the analysis focuses on maize producers engaged in cultivation for household consumption. This choice stems from the distinct technical constraints and risk profiles between producers cultivating maize for household consumption and those producing improved maize seeds. For instance, the latter group often faces different credit utilization patterns and higher risks associated with seed quality standards and market fluctuations.

After excluding nine observations due to data inconsistencies, including missing values or implausible entries such as negative or zero production figures, the final dataset comprises 347 respondents. These omitted observations primarily involved cases where responses to critical variables were incomplete or contained clear recording errors. This cleaned sample serves as the foundation for the empirical analysis.

## 4.2. Methodology

This section describes the empirical approach used to analyse the impact of access to credit on agricultural productivity and the extent of the productivity lost due to the lack of access to financial services by farmers in Benin. Several techniques are used in the literature, including the Heckman Selection Model (Pham and Talavera, 2018; Aristei and Gallo, 2016), the Propensity Score Matching Method (PSM) (Liu et al., 2019; Duta and Banedji, 2018; Alemu and Adesina, 2017), and the Regime Switching Model (ESR) (see Liu et al., 2019). The advantage of the ESR technique is that it takes into account selection issues. Specifically, it is a matter of assessing the differences in productivity between producers who have access to credit and those who do not. Estimating the effects of access to credit poses two methodological problems: unobserved heterogeneity and sample selection bias.

To control for these potential problems of selection and unobserved heterogeneity, we apply the Endogenous switching regression model to estimate the yield of farmers that have access to credit and those who do not (Diamoutene and Jatoo, 2021; Agbodji and Johnson, 2019; Ali and Deininger, 2012; Guirkingner and Boucher, 2008; Lokshin and Sajaia, 2004). In a first step, a probit model is used to estimate the determinants of farmers' access to credit from several socio-economic and credit variables identified as theoretically likely to influence the availability of access to or non-access to credit. Second, regressions of productivity models are applied separately depending on whether or not the producer has access to credit.

### *Model Specification*

The ESR model consists of a probit model for credit access and separate productivity regressions for farmers with and without credit access. Let us consider  $d_i^*$ , a latent variable that defines the status of the producer with or without access to credit, and  $y_i$  his level of productivity.

The regression model with a change of regime is specified as follows:

$$y_i = \begin{cases} y_{1i}^a = \alpha^a X_i + \beta^a Z_i + \mu_{1i}^a & \text{si } d_i = 1 \\ y_{0i}^n = \alpha^n X_i + \beta^n Z_i + \mu_{0i}^n & \text{si } d_i = 0 \end{cases} \quad (1)$$

$$d_i^* = \gamma X_i + \delta W_i + \vartheta_i \quad (2)$$

$$d_i = \begin{cases} 1 & \text{si } d_i^* > 0 \\ 0 & \text{si } d_i^* \leq 0 \end{cases} \quad (3)$$

Where  $a$  and  $n$  are the exponents of credit access and non-access, respectively. In Equation 3, the binary variable  $d_{it}$  takes the value 1 if the latent variable  $d_i^*$  in equation 2 is strictly positive, which corresponds to the situation where the producer has access to credit. Otherwise, the binary variable  $d_i$  takes the value 0; which implies instead that the farmer does not have access to the credit market.

In equations 1 and 2,  $X_i$  denotes a vector of variables that can influence both the state of access to credit and the productivity  $y_i$  such as the characteristics of the producer, such as age, gender, and the level of education.  $W_i$  designates the set of variables that affect only the productivity of the farmer without having any influence on the possibility of having access to credit or not, such as access to extension services.  $Z_i$  is a vector of instrumental variables that do not directly influence the productivity of the farmer, but that do influence access to credit.

We use in this study as an instrument the ownership of non-agricultural assets because these assets can be used as collateral for obtaining credit from microfinance institutions (MFIs). This variable does not have a direct impact on productivity. Ali et al. (2014) used the sale value of household assets in their case. In the absence of such a variable, we believe that using the ownership of non-agricultural assets as an instrument is appropriate, given the practices in MFIs in Benin.  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$  are parameters to be estimated. The error terms in the two regimes ( $\vartheta_i$ ,  $\mu_{1i}^a$ ,  $\mu_{0i}^n$ ) are assumed to follow a trivariate normal distribution with a zero mean and a covariance matrix equal to  $\Omega$ .

### ***Estimation Strategy***

Unobserved factors affecting the selection regime may also affect the productivity of the farmer. Lee (1978) and Maddala (1983) note that the terms  $\mu_i$  and  $\vartheta_i$  can be correlated and make estimators from ordinary least squares (OLS) inconsistent. To address this problem with the endogenous switching regression model, the estimation of the selection and productivity equations is performed simultaneously using the full information likelihood method. This method has the advantage of obtaining estimates of robust standard errors, in contrast to methods that proceed step by step by estimating the equations separately (Guirkingier and Boucher, 2008; Petrick, 2004; Lee, 1978).

Under the assumptions made on the distributions of the error terms of Equations 1 and 2, and according to Lokshin and Sajara (2004), the log likelihood function of the switching regression model is given by:

$$\ln L = \sum_i \{d_i [\ln(F(\eta_{1i})) + \ln(f(\mu_{1i}^a/\sigma_1)/\sigma_1)] + (1 - d_i) [\ln(1 - F(\eta_{2i})) + \ln(f(\mu_{0i}^n/\sigma_2)/\sigma_2)]\} \quad (4)$$

Where  $F(\cdot)$  a cumulative normal distribution function,  $f(\cdot)$  is a normal density distribution function and:

$$\eta_{ji} = \frac{(\gamma X_i + \delta W_i) + \rho_j \varepsilon_i^j / \sigma_j}{\sqrt{(1 - \rho_j^2)}}, \text{ with } j = 1, 2 \quad (5)$$

With  $\rho_1 = \sigma_{1v}^2 / \sigma_v \sigma_1$  the correlation coefficient between  $\vartheta_i$  and  $\mu_{1i}^a$ ;  $\rho_2 = \sigma_{2v}^2 / \sigma_v \sigma_2$  the correlation coefficient between  $\vartheta_i$  and  $\mu_{0i}^n$ , with  $\sigma_{1v}$  and  $\sigma_{2v}$  respectively the covariance of  $\vartheta_i$  and  $\mu_{1i}^a$ ,  $\vartheta_i$  and  $\mu_{0i}^n$ .  $\sigma_v$ ,  $\sigma_1$  and  $\sigma_2$  represent the respective standard deviations of  $\vartheta_i$ ,  $\mu_{1i}^a$  and  $\mu_{0i}^n$ .

The results of estimating Equation 4 using the full information likelihood method will be used to determine the potential productivity gains or losses resulting from the removal of access to agricultural credit or the level of productivity that could be reached by farmers without access to credit if they saw the removal of barriers to access to credit. The procedure will therefore consist of estimating of  $\Delta y_i = y_{1i}^a - y_{0i}^n$  for farmers who do not have access to credit. Using Equations 1 and 2, and according to Guirkingner and Boucher (2008), the expected value of the productivity differential  $\Delta y_i$  conditionally in the state of no access to credit ( $d_i = 1$ ) is given by:

$$E(\hat{\Delta}y_i | d_i = 1) = (\hat{\alpha}^a - \alpha^n)X_i + (\hat{\beta}^a - \beta^n)Z_i \quad (6)$$

Where  $\hat{\alpha}$  and  $\hat{\beta}$  are parameters to be estimated from the regression model with change of regime.

The higher the value of the differential forecast, the greater the loss of the productivity due to the lack of access to credit. If this is the case, then it would be urgent to put in place a mechanism to correct the problems of imperfections in the credit market to improve access to financial services for small farmers.

Prior to the estimation of the different models that have just been described, we will present the descriptive analysis showing the possible links between the main variables of the study. This descriptive analysis is discussed in Section 5.

### *Variable selection and justification*

The variables included in Equations (1) and (2) are carefully selected based on the literature to account for their theoretical and empirical relevance to agricultural credit and productivity. Agricultural productivity, measured as yield per hectare, serves as the primary dependent variable. Access to credit, referring to formal sector institutions providing agricultural credit, is a key explanatory variable influencing productivity. Additionally, a range of socio-economic and contextual factors, identified in the literature as significant determinants, are incorporated to ensure the robustness of the analysis.

Socio-economic characteristics such as the producer's age, gender, education level, and farm size are included for their established effects on productivity. Age, often linked to farming experience, is expected to positively influence productivity, while education is associated with improved managerial skills and decision-making, further enhancing productivity (Ali & Deininger, 2012). Farm size captures potential economies of scale, which are also expected to have a positive impact on productivity.

Access to extension services is another variable considered, given its role in disseminating technical knowledge and improving farming practices. While these services are not directly associated with access to credit, their inclusion ensures a robust differentiation between factors driving productivity and those influencing credit access.

The ownership of non-agricultural assets is employed as an instrumental variable, chosen for its relevance in determining access to credit while satisfying the exclusion restriction. These assets, which are commonly used as collateral in microfinance institutions in Benin, do not directly affect productivity. This choice is consistent with similar studies, such as Ali et al. (2014), which used household asset sales as an instrument. The statistical significance of non-agricultural asset ownership at the 10% level further reinforces its suitability in explaining access to credit within this context.

## **5. Results and discussions**

This section presents and analyses the econometric estimates, preceded by a descriptive analysis of the data.

## 5.1. Descriptive analysis

As part of this work, a descriptive analysis is done before the actual econometric estimates. Thus, a descriptive analysis was performed on the main variables included in the study. Table 2 below presents the main results. From the results in Table 2, it appears that the surveyed maize producers recorded an average yield of 1283.38 Kg per ha with a maximum yield of 5650 Kg/ha against a minimum of 183.33 Kg/ha.

The variability around this average is of the order of 761.25 Kg/ha. Producers achieved this average yield while averaging an area of 2.39 ha. The largest area planted by the producers in the sample is 4 ha, compared to a minimum of 0.1 ha. To plant this area, a number of factors of production have been used. The producers surveyed used, on average, 198.83 kg of inputs per hectare, 94.74 kg of seed per plot. In addition, the surveyed producers have an average age of 52.05 years, with the oldest aged 95, versus 30 for the youngest producer.

Table 2: Descriptive statistics of the main variables

	Yield (Kg/ha)	Age (years)	Land area (ha)	Quantity of inputs used per hectare (kg/ha)	Quantity of seeds used on the plot (Kg)	Capital per hectare (FCFA/ha)
Mean	1283.38	52.05	2.39	198.83	94.74	8247.53
Minimum	183.33	30	0.1	0	5	6574.00
Maximum	5650.00	95	4	1342	250	69661.80
Std, Dev,	761.25	10.49	0.84	102.17	58.52	5468.80
Obs.	356	356	356	356	356	356

Source: Authors from PAPA data, 2016.

Trying to fill the resource gap, some producers resort to financial institutions. Out of the 356 producers in the sample, 19,94% have access to credit against 80,06% who do not. A cross-analysis was performed between yield and access to credit, as shown in Table 3. Approximately 19.94% with access to credit produce an average of 1672.268 Kg per ha against 1186.499 Kg per ha for producers without access to credit (80.06%). Farmers who have access to credit, therefore, realize an average yield slightly above the average of their counterparts who do not have access to it. The Chi2 test of equality between the means reveals that the difference observed between these two groups is significant. This result predicts a positive effect of access to credit on yield. In contrast, producers with access to credit have an average of 2.29 ha, which is below the average for all producers (2.38 ha) and that of producers who do not have access to credit. Those who do not have access to credit exploit an area of 2.41 ha, which is therefore above the average for all producers. However, the equality test carried out shows that the difference in the farmed area observed between the two groups of producers is not significant.

Table 3: Socioeconomic characteristics of producers according to access to credit

Variables	All	No access to credit	Access to credit	T-test
Yield (kg/ha)	1283.38	1186.499	1672.268	-4.969***
Area (ha)	2.386	2.409	2.294	1.034
Capital productivity	0.172	0.160	0.221	-4.607***
Age (years)	52.05	52.05	52.06	-0.008
Gender (Man=1) (±)	96.63	96.14	98.59	-1.023

<sup>8</sup> This result has confirmed by the kernel density (see Figure 2).

Agriculture as main activity ( $\pm$ )	90.73	90.53	91.55	-0.265
Education (At least primary=1, No level=0) ( $\pm$ )	50.3	49.8	52.1	-0.344
Adoption of improved seed (Yes=1) ( $\pm$ )	57.3	53.7	71.8	-2.788***
Observations	356	285	71	

Notes: \*\*\*, \*\* and \* indicate the significance levels at the 1%, 5% and 10% thresholds respectively.

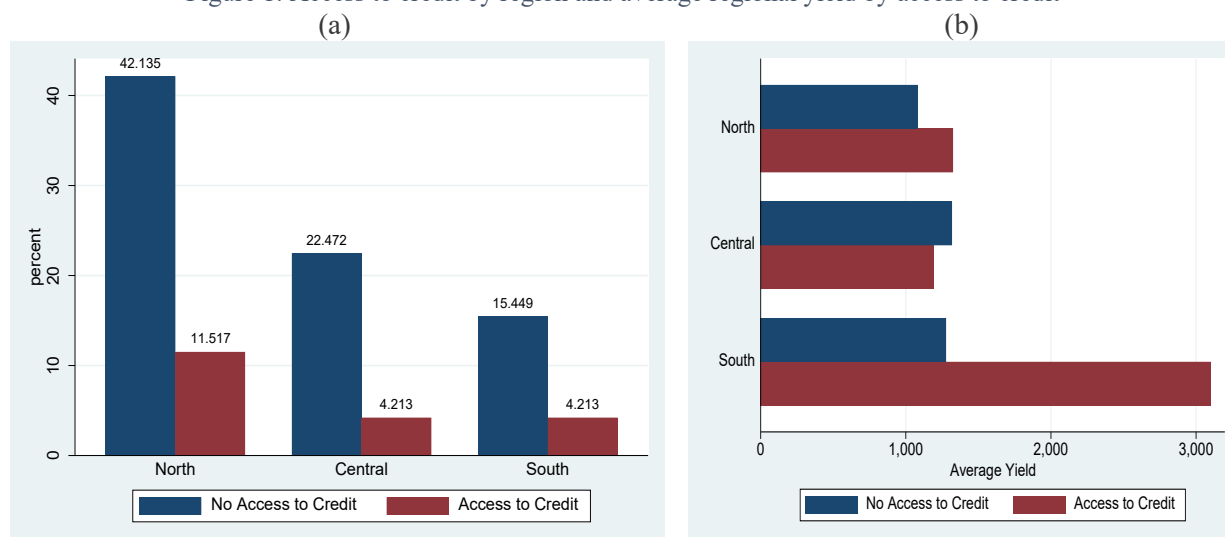
( $\pm$ ) indicates that the statistics presented are the frequencies (in percent).

Source: Authors from PAPA's data 2016.

In addition, access to credit differs sensitively across regions of the country. Overall, the trend shows that problems of access to credit are common in all regions of Benin. Farmers who have access to credit are largely in the Northern region, where more than half of the producers in the sample (53%) are concentrated. However, the North is also the region of the country where the problem of inaccessibility to credit is more pronounced (Figure 1). North Benin is also the region where population density is lowest, thus allowing for access to large areas of agricultural land. Unfortunately, most farmers in this region do not have access to credit. However, as described in Figure 1b, we find that access to credit could lead to an increase in the yield per hectare for these producers in the North.

Despite these statistics, we note that the best performances in terms of average yield were obtained overall in the South and the Centre (see Figure 1b). However, it is not easy to show the likely effect of access to credit on the producers' performance in terms of yield based only on these descriptive statistics. We therefore conducted further analysis using econometric techniques and present the estimates in the next section.

Figure 1: Access to credit by region and average regional yield by access to credit



Note: The proportions are in %. The yield is measured by relating the volume of production (Kg) to the area planted (ha).

Source: Authors using data from PAPA (2016)

## 5.2. Determinants and impacts of access to credit

This section presents the main econometric results regarding the effects of access to credit on the productivity of farmers. The estimated coefficients of the variables by the full information maximum likelihood method using the endogenous switching regression model are reported in Table 4. The estimated correlation coefficient between the credit access equation and the productivity equations ( $\rho$ ) is significantly different from zero. The results confirm that there are both observable and unobservable factors that determine farmers' access to credit and their productivity, depending on whether or not they have access to credit. The significance of the correlation coefficient between the access to credit equation and the productivity equation of farmers who have access to credit suggests that there was self-selection in accessing

credit. Likewise, the differences in the coefficients of the productivity equation of farmers with access to credit and those without access illustrate the presence of heterogeneity in the sample.

More concretely, the estimates lead to two main results. They make it possible to identify the main determinants of farmers' access to credit. The main explanatory factors of agricultural productivity depending on access or not to credit are also highlighted.

### *Determinants of access to credit*

The selection equation with coefficients reported in Column (3) of Table 4, identifies the factors that influence farmers' access to credit.

Among the various factors influencing access to credit, the adoption of improved seed varieties stands out as a critical determinant. Financial institutions are more inclined to extend credit to farmers who adopt modern agricultural practices, such as using improved seeds, because these practices are associated with higher productivity and reduced lending risks. The use of improved seeds is seen as an indicator of a farmer's commitment to modernizing agricultural methods, which in turn increases the likelihood of successful crop production and repayment of loans. This association between improved seed adoption and productivity serves as an intangible guarantee for financial institutions, bolstering their confidence in lending. The findings of Houeninvo et al. (2019) further corroborate this relationship, demonstrating that the adoption of improved seed varieties is positively linked to increased agricultural productivity, thereby enhancing farmers' incomes. Moreover, the availability and use of high-quality inputs, including seeds, are among the primary conditions set by microfinance institutions (MFIs) in Benin for disbursing agricultural loans (AgriProFocus, 2016). By reducing the uncertainties associated with agricultural activities, the use of improved seeds acts as a form of risk mitigation, facilitating access to credit. This risk-reducing factor is integral to the PAPA program, which seeks to enhance farmers' access to credit by addressing the uncertainties inherent in agricultural production.

Table 4: Estimation of the endogenous switching regression model

Variables	Dependent variable: Yield (kg/ha)		
	Not access to credit (1)	Access to credit (2)	Selection Equation (3)
Age (years)	0.001 (0.002)	0.002 (0.005)	0.000 (0.008)
Gender (Male=1, Female=0)	-0.195 (0.121)	0.275 (0.277)	0.591 (0.401)
Education (At least Primary School=1, None=0)	0.098** (0.042)	0.175 (0.124)	0.152 (0.149)
Log farm size (ha)	-0.364*** (0.045)	-0.883*** (0.194)	0.456*** (0.134)
Use of improved seeds (Yes=1, No=0)	0.005 (0.050)	0.306* (0.167)	0.590*** (0.202)
Central region	0.424 (0.065)	0.387* (0.208)	-0.404* (0.233)
Northern region	0.088 (0.066)	-0.181 (0.333)	-0.032 (0.248)
Agriculture as main activity (Yes=1, No=0)	0.018 (0.047)	-0.246 (0.218)	0.113 (0.218)
Extension services (Yes=1, No=0)	0.036 (0.037)	-0.010 (0.131)	0.193 (0.184)
Use of fertilizer (Kg/ha)	0.068*** (0.015)	0.092 (0.068)	
Total labour (in Man/day)	0.064***	0.064	

Ownership of non-farm assets (Yes=1, No=0)	(0.019)	(0.059)	0.289*
			(0.146)
Constant	6.619***	5.790***	-1.820***
	(0.210)	(0.633)	(0.617)
$\sigma$	0.358***	0.636***	
	(0.024)	(0.104)	
$\rho$	-0.877***	0.900***	
	(0.041)	(0.098)	
Wald test of indep. eqns. (chi2(2))		63.930	
Prob		0.000	
Log pseudolikelihood		-255.402	
$N$		356	

Note: Standard Errors are in parenthesis. \*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$

Source: Authors from PAPA's data 2016.

Farm size also emerges as a significant determinant of credit access. Larger farms, which are typically associated with higher production capacities, are perceived as less risky by financial institutions. The greater the farm size, the higher the potential for increased agricultural output, making these farmers more attractive candidates for credit. This perception is grounded in the understanding that larger farms are better able to absorb the shocks of market fluctuations and climate variability, thereby increasing their ability to repay loans.

Additionally, the ownership of non-farm assets further enhances farmers' chances of securing credit. Non-farm assets, such as livestock or land, serve as collateral for financial institutions, which are more likely to provide loans when they have a tangible guarantee to mitigate potential risks. This form of collateral acts as an assurance to MFIs that loans will be repaid, even in the event of crop failure or other adverse conditions.

However, regional disparities also influence access to credit. Farmers located in certain regions, particularly the central region, face greater challenges in accessing credit. This disparity can be attributed to the relatively low concentration of agricultural development programs and financial services in these areas. The lack of targeted support in these regions limits farmers' access to both financial resources and agricultural extension services, which are essential for improving agricultural productivity and securing loans. As a result, farmers in these areas are at a disadvantage compared to those in more developed regions where agricultural programs and financial institutions are more concentrated.

#### ***Determinants of agricultural productivity: Disparities between farmers with and without access to credit***

Regarding the explanatory factors of farmers' productivity, there are differences depending on their access to credit or not. The estimated parameters of the productivity model for farmers without access to credit and those who do have access to it are reported in Columns (1) and (2), respectively.

In examining the estimated parameters of the productivity model, the findings suggest that access to credit significantly impacts the key determinants of agricultural productivity. For farmers without access to credit, the use of fertilizers emerges as a particularly important factor in explaining productivity. This result underscores the crucial role that fertilizers play in enhancing agricultural output. Fertilizer application improves soil fertility and increases crop yields, which is a well-documented phenomenon in agricultural economics (Rehman et al., 2019; Chandio et al., 2019; Asante et al., 2019). While fertilizers remain a significant determinant of productivity, their use is constrained by the inability to finance such inputs. This creates a barrier to productivity improvement, as these farmers may not be able to access or afford the necessary inputs, leading to suboptimal agricultural outcomes. The economic implications of this finding suggest that limited access to credit restricts farmers' ability to invest in key productivity-enhancing factors, ultimately curbing their potential for higher agricultural yields.

Farm size, however, presents a more complex picture. Our analysis reveals a negative relationship between farm size and productivity for both categories of farmers, contrary to the more conventional view that larger farms typically yield higher productivity. This finding suggests that the extensive nature of Beninese agriculture may be a key contributing factor. Larger farm sizes in Benin are often associated with less intensive agricultural practices, which may lead to diminishing returns as farms become more spread out. In this context, the negative association between farm size and productivity aligns with the argument that large-scale farming in Benin is often characterized by lower input intensity, rather than the high levels of mechanization or improved techniques that typically drive productivity growth on larger farms in other contexts. This result diverges from studies such as those by Chandio et al. (2019), Abdallah (2016), and Tijani (2006), who found a positive and significant relationship between farm size and rice yield. In their case, larger farms benefited from investments in specialized equipment and high-quality seeds, which are not as prevalent in the predominantly small-scale, labour-intensive farming practices observed in Benin. This contrast highlights the contextual specificity of the farm size-productivity relationship and suggests that, in the case of Benin, larger farm sizes may not inherently translate into higher productivity due to the reliance on traditional, low-input agricultural methods.

Additionally, the results indicate that the productivity of farmers without access to credit is also influenced by education, fertilizer use, and total labour. These factors are particularly significant for farmers who lack access to the financial resources that could otherwise enable them to improve their agricultural practices. Education, for example, enhances a farmer's ability to adopt better farming techniques and make more informed decisions, while the availability of labour allows for more intensive farming practices. However, the ability of these farmers to fully capitalize on these factors is constrained by the lack of credit, which limits their capacity to purchase inputs or adopt more advanced technologies.

For farmers with access to credit, geographic location appears to play a significant role in determining productivity. Specifically, farmers in the central region of Benin experience greater productivity than those in the northern region, which can be attributed to the uneven distribution of agricultural support and resources across regions. The policy of distributing agricultural inputs, particularly fertilizers, is skewed in favour of cotton producers, who predominantly reside in the northern and central regions. As a result, farmers in these areas, who grow cotton as their main crop, benefit disproportionately from fertilizer use. Maize, grown as a back-season crop in these regions, benefits indirectly from the residual effects of fertilizer application to cotton fields, but it does not receive the same level of direct support. This regional disparity in input distribution ultimately affects the productivity outcomes of farmers in these areas. The economic significance of this finding lies in the fact that the uneven distribution of agricultural resources across regions creates productivity gaps that could be mitigated by more equitable policy interventions.

Finally, the use of improved seeds emerges as a clear positive determinant of agricultural productivity, particularly for farmers with access to credit. The availability of improved seeds, often provided by government programs and agricultural extension services, significantly enhances farmers' ability to increase production. This result illustrates how access to credit can facilitate the adoption of improved seeds, which in turn leads to higher yields. The government's decision to deploy technical agents across the country has undoubtedly played a role in this outcome, ensuring that even farmers in more remote areas can access high-quality seeds. This highlights the importance of supporting access to improved agricultural inputs as part of broader efforts to enhance productivity in the sector.

### ***Productivity Gains from Access to Credit***

The results presented in Table 5 and Figure 2 highlight the significant impact of credit access on agricultural productivity, particularly in maize farming. The analysis reveals that farmers with access to credit experience a marked increase in productivity compared to their counterparts without access. Specifically, farmers with credit recorded an average maize yield of 1,602.625 kg/ha, while the counterfactual (those without credit) achieved only 1,144.151 kg/ha, which corresponds to a productivity gain of approximately

40.07%. This substantial difference underscores the important role that access to credit plays in boosting agricultural output.

Several factors can explain this marked improvement in productivity for farmers with access to credit. Otsuka and Larson (2016) emphasize that access to credit facilitates the adoption of advanced production technologies and the procurement of high-quality inputs, both of which are crucial for enhancing productivity. Farmers with credit are also able to hire skilled labour, further optimizing production conditions and maximizing yields. Credit access, therefore, provides not only the financial resources necessary for acquiring essential inputs but also enables farmers to operate under more favorable conditions, both technologically and operationally.

Table 5: Productivity difference according to access to credit or not

Sub-samples	Access to credit	No access to credit	Average treatment effect on treated (ATT) C=A-B
Farmers have access to credit	(a) 1602.625	(b) 1144.151	458.473***
Farmers do not have access to credit	(c) 746.721	(d) 463.352	283.369***

**Notes:** (a) and (d) represent the observed yield of maize (kg/ha).  
(b) and (c) refers to the counterfactual expected yield of maize (kg/ha).

**Source:** Authors, based on estimation results.

The results in Table 5 reinforce the observed productivity advantage among farmers with credit access. Specifically, the "Average Treatment Effect on the Treated" (ATT) indicates a notable increase in maize yield for credit recipients. The ATT for farmers with access to credit is 458.473 kg/ha, while for those without access to credit, it is 283.369 kg/ha. This demonstrates that credit access is not only linked to higher yields but also has a substantial impact on the overall productivity of maize farmers in Benin.

The findings of this study are consistent with previous empirical research, which has highlighted the positive relationship between access to credit and agricultural productivity. For instance, Diamoutene and Jatoe (2021) found that credit availability is positively associated with maize yield in Mali, with an average productivity increase of 477 kg per acre. Similarly, Agbodji and Johnson (2019) reported a 10.7% increase in maize productivity among Togo's credit beneficiaries. These results corroborate the findings of this study, further establishing the positive effects of credit on maize farming productivity in the region.

However, it is also important to consider the variability in the effect of credit access across different contexts. For example, Ali and Awade (2019) found that the productivity gains from credit access for soybean farmers were relatively modest, estimated at 1.35%. Similarly, Nakano and Magesi (2020) reported that although credit access had a positive impact on rice farmers in Tanzania, the benefits were tempered by adverse weather conditions, which could have undermined the potential productivity gains from credit. These contrasting findings suggest that while credit access is generally beneficial, its effectiveness may be influenced by other factors such as climatic conditions, crop type, and local agricultural practices.

Figure 2 provides additional visual insight into the distribution of maize yields, highlighting the stark contrast between farmers with and without access to credit. The kernel density plot of the logarithmic yield illustrates a clear shift toward higher productivity for credit recipients, reinforcing the quantitative results from Table 5. This graphical representation further emphasizes the significant role that credit plays in enhancing agricultural performance and improving economic outcomes for maize farmers.

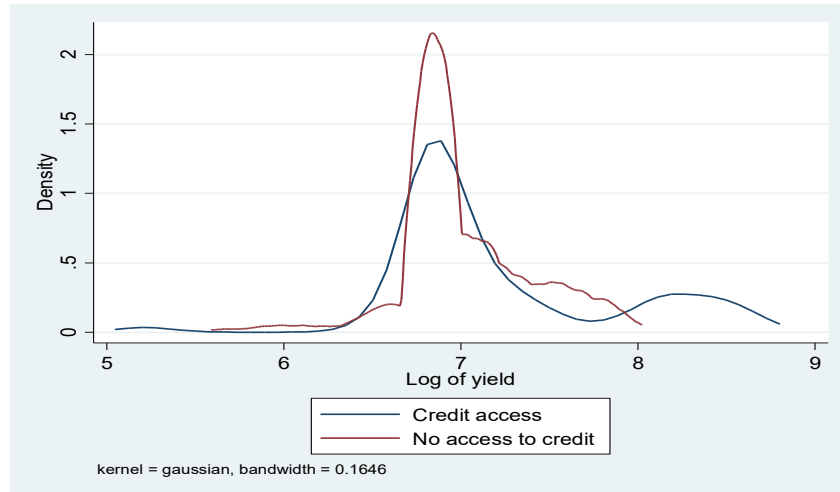


Figure 2: Kernel density of the logarithm of yield according to access to credit. (Source: Author based on estimating results).

## 6. Robustness analysis

To test the robustness of our results, we use another productivity indicator, capital productivity, measured as the ratio of output to capital. The results obtained are consistent with the estimates made with the variable yield per hectare. More concretely, the preliminary verifications lead us to validate the model thus estimated (see Table A2 in the appendix). Indeed, we obtain a significant correlation coefficient between the productivity equations and the credit access equation ( $\rho$ ). The coefficient is indeed significantly different from zero, suggesting that access to credit affects producers in the two groups differently.

The results broadly confirm those obtained previously. On the one hand, the use of improved seed varieties and ownership of non-farm assets positively determine farmers' access to credit. On the other hand, the quantity of fertiliser used positively affects the farmer's productivity. Another more interesting result is that, according to the productivity gain estimate, access to credit improves capital productivity by 31.97% (see Table 6).

Table 6: Capital productivity difference according to access to credit or not

Sub-samples	Access to credit	No access to credit	Average treatment effect on treated (ATT) C=A-B
Farmers have access to credit	(a) 0.194	(b) 0.147	0.047***
Farmers do not have access to credit	(c) 0.239	(d) 0.085	0.154***

**Notes:** (a) and (d) represent the observed capital per hectare (FCFA/ha).  
(b) and (c) refers to the counterfactual expected capital per hectare (FCFA/ha).

**Source:** Authors, based on estimation results.

In other words, a franc invested in maize production would yield more for the farmer who has access to credit than for his counterpart without access to credit. However, the effect is slightly below the 40.07% obtained with yield measured in Kg per hectare. This suggests that access to credit leads to an improvement in production per CFA, but less than proportionally to the resulting increase in Kg per hectare. The difference may be attributable to the magnitude of the transaction costs faced by farmers. An illustration is

the effect of the cost of fertiliser used, which in absolute terms reduces the productivity of farmers with access to credit more than those without (see Table A2 in the Appendix).

## 7. Conclusion and policy implications

Agricultural productivity remains a persistent challenge in many developing countries (DCs), where it often falls short of potential levels. This underperformance is a key obstacle to achieving food security, exacerbating poverty and vulnerability in these regions. Limited access to financial services, particularly agricultural credit, is a critical factor that constrains productivity in these economies. This paper aimed to assess the role of credit in enhancing agricultural productivity, specifically among maize producers in Benin, using the Endogenous Switching Regression (ESR) model.

The findings highlight two central issues: the factors that determine access to credit, and the impact of this access on productivity. Our analysis reveals that farmers' access to credit is significantly influenced by factors such as the adoption of improved seed varieties, geographic location, the area cultivated, and ownership of non-farm assets. Furthermore, our results demonstrate a clear positive impact of credit access on maize yield, with farmers who benefit from credit displaying significantly higher productivity levels compared to those without access.

While the evidence presented is specific to Benin, its implications extend to broader contexts, particularly for other developing countries where access to credit is similarly constrained. In these economies, credit can serve as a crucial lever to improve agricultural productivity, but its impact depends on the effective targeting of resources and the ability to address underlying barriers. For policymakers, the results underscore the importance of strengthening financial infrastructure and ensuring that credit mechanisms are accessible and efficient for small-scale farmers.

In Benin, the findings advocate for targeted policy interventions aimed at facilitating credit access for maize producers. The government should further enhance the capacity of the National Agriculture Development Fund (FNDA), reevaluating its financing instruments and promoting greater collaboration with microfinance institutions (MFIs). Additionally, improving the flexibility of credit conditions, especially for smallholders, is essential to ensuring that these farmers can utilize financial resources to increase productivity.

Beyond credit access, the study also suggests the need for complementary measures. Literacy and adult education programs are critical for empowering farmers to effectively access and manage credit, particularly through better project design skills. Furthermore, extending support for the adoption of improved seed varieties, which significantly boost productivity, should be a priority. A well-structured subsidy policy, alongside a clear exit strategy, could facilitate wider access to high-quality seeds without undermining long-term sector sustainability.

Importantly, regional disparities in access to credit, particularly between Southern and Northern Benin, highlight the need for tailored interventions. In the South, where maize production is pivotal to local food security, targeted financial support could yield substantial gains in productivity. Strengthening technical assistance and extension services is also critical, particularly through the Agricultural Territorial Development Agencies (ATDAs), which can provide essential training and support.

This study is a pioneering contribution to understanding the effects of credit access on agricultural productivity in Benin. However, further research is needed to refine our understanding, particularly in distinguishing between farmers with access to credit and those constrained by its absence. Future studies should focus on evaluating how credit constraints vary within different farmer categories to better tailor policy interventions.

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# Appendix

Table A1: Definitions and measures of study variables

Variables	Measure	Source
<i>Dependent variable</i>		
Productivity	Total yield per hectare (Kg/ha).	
<i>Explanatory variables</i>		
Age (in years)	Producer's completed age measured in years	See Diamoutene and Jatoe (2021); Agbodji and Johnson (2019); Saqib et al. (2018)
Type	Binary variable to capture the gender of the producer (Female=0, Male=1.)	See Diamoutene and Jatoe (2021); Ali et al. (2014)
Education	Refers to producers with at least a primary level of education (None=0, At least primary level=1)	See Diamoutene and Jatoe (2021); Saqib et al. (2018); Ali et al. (2014)
Fertilizer (kg/ha)	Quantity of fertilizer used expressed in kg per hectare	See Diamoutene and Jatoe (2021); Asante et al (2019)
Use of improved seeds	Producer adoption of improved corn seed (No=0, Yes=1)	Improved seed is considered a primary source of productivity improvement (Houeninvo et al, 2019)
Location	The producer's region of residence is measured by considering the Southern (0), Central (1) and Northern (2) regions.	Agbodji and Johnson (2019) use geographic location by considering the village.
Extension Services	Producer who has benefited from the extension services of official producer support structures. (No=0, Yes=1)	See Asante et al (2019)
Capital per ha (FCFA)	Represents the amount of capital held by the producer and valued in CFAF.	
Agriculture as main activity	Measures producers who have farming as their primary activity. This variable takes the value 1 if farming is a main source of income for the producer and 0 otherwise.	
Ownership of a non-farm assets	Binary variable measuring the possession of non-farm assets (No=0, Yes=1)	

Table A2: Estimation of the endogenous switching regression model

Variables	Dependent Variable: Productivity of capital (Kg/FCFA)		Selection Equation (3)
	Not access to credit (1)	Access to credit (2)	
Age (years)	0.002 (0.002)	0.006 (0.007)	-0.001 (0.008)
Gender (Male=1, Female=0)	-0.075 (0.178)	0.302 (0.324)	0.993 (0.692)
Education (At least Primary School=1, None=0)	-0.054 (0.053)	0.052 (0.163)	0.200 (0.168)
Use of improved seeds (Yes=1, No=0)	0.008 (0.072)	0.091 (0.172)	0.485*** (0.186)
Central region	-0.151* (0.082)	-0.522** (0.250)	-0.300 (0.273)
Northern region	0.008 (0.089)	-0.156 (0.337)	0.014 (0.246)
Log area planted (ha)	-0.160** (0.063)	-0.762*** (0.230)	0.421*** (0.143)
Agriculture as main activity (Yes=1, No=0)	0.006 (0.055)	-0.255 (0.270)	0.262 (0.269)
Extension services (Yes=1, No=0)	0.101 (0.062)	0.310 (0.286)	0.204 (0.192)
Total labor (in Man/day)	0.033 (0.023)	0.092 (0.077)	
Fertilizer (Kg/ha)	0.038** (0.017)	0.122* (0.070)	
Ownership of non-farm assets (Yes=1, No=0)			0.491*** (0.173)
Constant	-2.132*** (0.286)	-3.417*** (0.929)	-2.218*** (0.806)
$\sigma$	0,439*** (0.042)	0.653** (0.111)	
$\rho$	0.631* (0.238)	0.583*** (0.154)	
Wald test of indep. Eqns. (chi2(2))		10,880	
Prob		0,004	
Log pseudolikelihood		-369,345	
$N$		356	

Note: Standard Errors are in parenthesis. \*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$

Source: Authors from PAPA's data 2016.

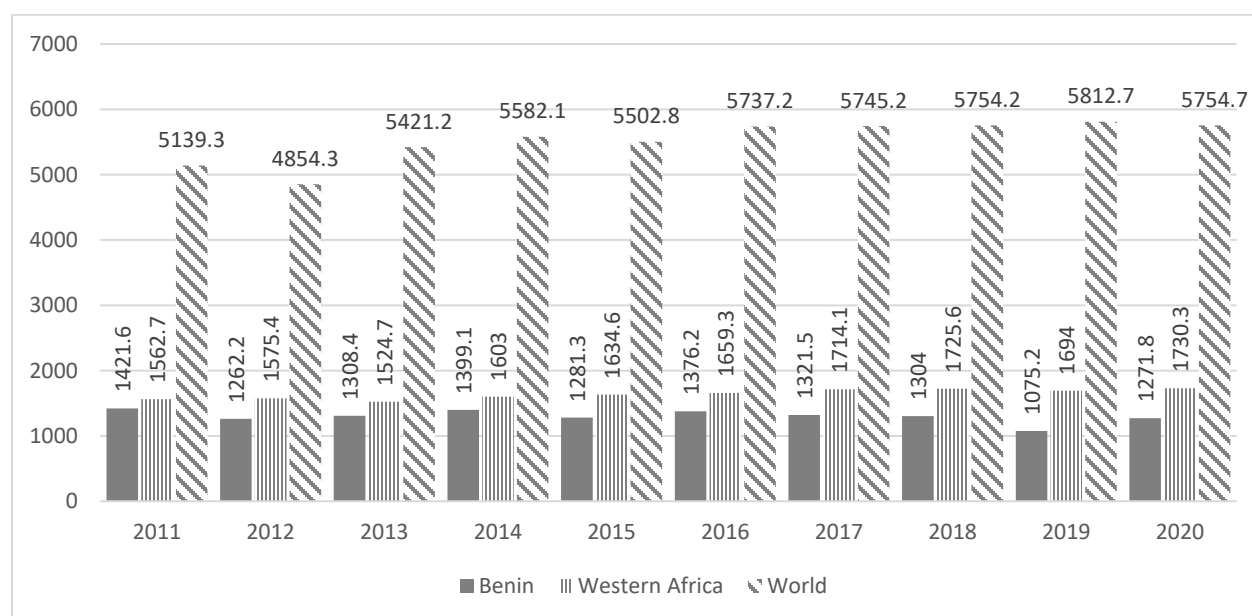
Table A3: Financing of the Agricultural Sector Strategic Recovery Plan (PSRSA)

Indicators		2011	2012	2013	2014	2015	Cumulus between 2011 and 2015
Annual forecast	(a)	209.98	253.79	292.9	353	421.36	<b>1531.03</b>
	(b)	320.11	386.9	446.52	538.15	642.36	<b>2334</b>
Annual Realizations	(a)	84.41	119.5	160.68	180.49	197.22	<b>742.3</b>
	(b)	128.68	182.18	244.96	275.16	300.66	<b>1131.6</b>
Annual Deviation	(a)	125.57	134.29	132.22	172.51	224.14	<b>788.73</b>
	(b)	191.43	204.72	201.57	262.99	341.70	<b>1202.4</b>
Annual financial execution rate (%)		40.20	47.09	54.86	51.13	46.81	<b>48.48</b>

Note: All amounts on line (a) are in billions of FCFA and those on line (b) are in millions of Euros. The conversions are based on the exchange rate in effect on April 10, 2019, i.e. € 1 = FCFA 655.957. The annual financial execution rate is obtained by dividing the annual achievements to the annual forecasts. The annual deviations are given by the difference between the objectives set at the start of the year (annual forecasts) and the annual achievements.

Source: Authors, MAEP (2016).

Figure A1: Maize yield from 2011 to 2020 (Kg/ha)



Source: Authors from FAOSTAT data (2022)



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