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Research Paper 492

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AFRICAN ECONOMIC RESEARCH CONSORTIUM
CONSORTIUM POUR LA RECHERCHE ÉCONOMIQUE EN AFRIQUE

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AERC Research Paper 492
African Economic Research Consortium, Nairobi
November 2021

This research study was supported by a grant from the African Economic Research Consortium. The findings, opinions and recommendations are those of the authors, however, and do not necessarily reflect the views of the Consortium, its individual members or the AERC Secretariat.

Published by: The African Economic Research Consortium
P.O. Box 62882 - City Square
Nairobi 00200, Kenya

ISBN 978-9966-61-191-8

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Abstract

Access to credit constitutes a major challenge for agricultural productivity improvement in rural Burkina Faso. This paper analyses the impact of credit rationing on maize producers' technical efficiency, using survey data collected in 2014. Applying a stochastic frontier approach with the data, the results of the estimation show that the average level of maize producers' technical efficiency was 0.496. Using an interval regression model with endogenous treatment to assess the impact of credit rationing on technical efficiency, the results show that maize producers' technical efficiency can be improved by 0.173 units if credit constraints were removed. The results also show that access to information and membership in farmer-based organizations were factors lowering the probability of being rationed in credit market in rural Burkina Faso.

Acknowledgments

This research received grant support from African Economic Research Consortium (AERC). The authors acknowledge the members of the AERC research network who acted as resources for their valuable comments and colleagues who provided expertise that greatly assisted this research.

1. Introduction

It is well documented in development economics that structural change of an economy requires the development of the agricultural sector through a consequent increase in agricultural productivity and the shift of labour in the sector toward the industry and services (Lewis, 1954; Jorgenson and Griliches, 1967). This agriculture-led development pattern leads to the decline in the share of agriculture in gross domestic product (GDP), with the consequent increase in the combined share of industry and services. For the agriculture sector to lead the development process, it is critical for the farm households to adopt appropriate technological packages such as irrigation, seeds, fertilizers, farm equipment and professional extension services. required for a significant improvement of the agricultural productivity and income rising in rural areas. In countries like Burkina Faso, with the development strategy based on this pattern and where the per capita income is very low with more than 50% of rural poverty incidence (INSD, 2015), access to credit market is essential to finance those technological packages, particularly among farmers too poor to accumulate sufficient saving to invest. The country's agriculture sector is dominated by smallholder farmers (72% of farmers) and cereals (77% of land used for agriculture) and cotton are the main crops grown in the country with sorghum and millet representing, respectively, 44% and 31% of total production of cereals, followed by maize and rice representing 21% and 4%, respectively (MAFAP, 2013).

Although agriculture sector provides up to 35% of the Burkina Faso's GDP and employs about 92% of the labour (FAO, 2014), the sector receives on average only 3.5% of total amount of loan supplied by banks (Banque Mondiale, 2007; BCEAO, 2014) and 22% of loans disbursed by the main microfinance institutions of the country (MCC, 2015). The financial market of Burkina Faso, like much of developing countries, is divided into three segments: the banking sector, the microfinance sector and the informal loan sector (Andersen and Malchow-Møller, 2006; Barslund and Tarp, 2008; Besley, 1995; Hoff and Stiglitz, 1990). Agriculture represents a marginal part of banks and microfinance institutions lending activities because of high risk related to the sector due to transaction costs and asymmetric information in rural areas. In such a situation, financial institutions lend less than what they can do and choose to ration out the credit even if some individuals are ready to pay higher interest rate or to bring more collaterals (Aleem, 1990; Barham et al, 1996; Besley, 1994; Boucher et al, 2009; Guirkinger and Boucher, 2008; Hoff and Stiglitz, 1990; Stiglitz and Weiss, 1981; Turvey, 2013). According to Porgo et al (2018), about 40% of farm households were credit constrained in rural Burkina Faso. Following the PNGT2's baseline survey in 2004, 42.2% of Burkina Faso's rural households were having access to credit with 19% coming from informal loan sector, 13% from banking sector and 3.4% from microfinance institutions (Savadogo et al, 2010). From 2009 to 2010, only 19.6% of farm households had access to agricultural credit for the purchase of inputs (fertilizers, seeds) and 2.1% for equipment (DPSAA, 2011). This low level of access to credit restricts farmers' possibilities to adopt recommended technological packages. According to INSD (2003) and DPSAA (2009), 71.2% of farmers in Burkina Faso still use traditional means of production, only 0.2% use tractors and 1.2% area sown for cereal crops receives improved seeds, resulting into low agricultural productivity and not enough to face the poverty and food security challenges in rural areas.

Earlier studies on credit rationing concept define credit rationing as a situation in which the existence of an excess demand of credit leads lenders or financial institutions to quote an interest rate on loan and choose to not satisfy the demand of some borrowers. The phenomenon was viewed as a temporary disequilibrium on credit market and was explained through a full information framework, risk of default of lenders and exogenous institutional factors (Freimer and Gordon, 1965; Hodgman, 1960; Jaffee and Modigliani, 1969; Miller, 1962). The behavioural interaction between borrowers and lenders, namely the information asymmetry was missing in the analysis. Stiglitz and Weiss (1981) filled this gap by explaining credit rationing phenomena on the basis of asymmetric information, using adverse selection concept. The basic theory of credit rationing has been extended through the enforcement problem (Eaton and Gersovitz, 1981) and collateral requirement (Bester, 1985). Boucher et al (2009) revealed that information asymmetry does not lead to credit rationing only at supply-side (quantity rationing) in credit market, but it can also create credit rationing at demand-side through transaction cost and risk rationing.

The economic literature identifies two methodologies for measuring household credit constraints. The first method, which is indirect, links the presence of credit constraints to violations of the life-cycle or permanent income hypothesis (Deaton, 1992; Hall, 1978; Morduch, 1995; Zeldes, 1989) and the second method, which is direct, collects information directly from household surveys by asking them whether they perceive themselves as credit constrained or not (Ali et al, 2014; Boucher et al, 2009; Feder et al, 1990; Foltz, 2004; Guirkinger and Boucher, 2008). However, only the approach of elicitation of credit constraints capture most sources of credit constraints, including quantity rationing, transaction costs, and discouraged or risk-rationed borrowing. According to Kumar et al (2013) being credit constrained is a sufficient but not necessary condition for being credit rationed. Therefore, a household that is credit rationed is by definition credit constrained.

Evidence from rural areas of developing countries showed that credit constraints have significant adverse effect on farm output (Ali et al, 2014; Feder et al, 1990; Petrick, 2004; Sial and Carter, 1996; Guirkinger and Boucher, 2008), farm profit (Carter, 1989; Foltz, 2004), farm investment (Carter and Olinto, 2003), and farm land allocation (Porgo et al, 2018). Studies that have used the direct elicitation approach to analyse the effect of credit constraint on agricultural productivity have used either partial productivity approach (Ali et al, 2014; Awunyo-Vitor and Al-Hassan, 2014; Feder et al, 1990; Guirkinger and Boucher, 2008; Petrick, 2004) or total factor productivity (TFP) approach (Zhao and Barry, 2014). Studies using partial productivity approach relied on endogenous switching regression model to assess the impact of credit constraints on productivity (Ali et al, 2014; Awunyo-Vitor and Al-Hassan, 2014; Gurkinger and Boucher, 2008), since the outcome variable is continuous and the treatment variable (credit constraints) is endogenous. However, studies using TFP approach generally fail to control the endogeneity of the treatment variable in the estimation process. In fact, the technical efficiency score (outcome variable) is censored in this approach and standard endogenous switching regression cannot be employed to assess the impact of credit constraints on agricultural productivity, using the technical efficiency scores as measurement of productivity. To account for the specificity of the outcome variable when using TPF approach and control for the endogeneity of the treatment variable, this study uses an interval regression model with endogenous treatment and aim to assess the effect of credit constraints on smallholder farmers' productivity in Burkina Faso, using direct elicitation approach of credit constraint.

2. Theoretical framework

The literature highlights two types of measurement of productivity: the partial productivity and the total factor productivity (TFP). This study focuses on TFP and uses technical efficiency approach to compute the household TFP. Technical efficiency reflects an enterprise (farm) ability to produce a maximum level of output from a given set of inputs, or to produce a given level of output with a minimum quantity of inputs. It indicates the change in total production relative to a more complete measure of all measurable inputs such as land, labour, capital, chemical fertilizers, pesticides, etc. (Alston et al, 2009).

The concept of technical efficiency originated from Debreu (1951), Koopmans (1951) and Farrell (1957) seminal papers. Farrell (1957) was the first to propose an approach to estimate the efficient frontier. There are two methods of estimating the frontier. The first is a parametric method or Stochastic Frontier Analysis (SFA) developed by Aigner and Chu (1968) and Aigner et al (1977), and the second is a non-parametric method or Data Envelopment Analysis (DEA) developed by Charnes et al (1978) and Banker et al (1984). While the stochastic frontier method relies on economic theory to establish the efficiency frontier, DEA does not require special assumptions.

The earlier DEA models (Charnes et al, 1994) assume that inputs and outputs are measured by exact values based upon well-defined factors (Despotis and Smirlis, 2002). However, the efficiency evaluation process sometimes involves stochastic estimations because of the uncertainties inherent in many real-life problems. To compete with SFA in error handling, the Stochastic Data Envelopment Analysis (SDEA) (Land et al, 1993) approach was developed by considering the value of inputs and outputs as random variables. This paper will use the Stochastic Frontier Analysis (SFA) approach for the estimation of the technical efficiency.

Following Coelli et al (1998) and Kumbhakar and Lovell (2000), let us assume a farm household i that produces a good Y with a set of inputs X. The household production function is as follows:

$$Y_i = f(x_i, \beta) e^{v_i - u_i} \tag{1}$$

Where, Y_i represents the production of the ith farm household in a given period; x_i a (1× k) input vector used by the household i; β is a (k× 1) vector of unknown parameters to be estimated. $f(x_i, \beta)$ is the deterministic part and $e^{v_i - u_i}$ is the random part.

$v_i (v \sim N(0, \sigma_v^2))$ is a regular, random disturbance.

u_i is a non-negative random disturbances assumed to represent the technical inefficiency in the production and assumed to be always independent and identically distributed. u_i follows a semi-normal law so that $u_i(u \sim N(|0,\sigma_u^2)|)$ and $u_i \geq 0$.

It is assumed that u_i *and* v_i are independent.

By taking the logarithm of the Equation 1 of the production frontier model we have:

$$\ln Y_i = \ln f(x_i, \beta) + v_i - u_i \tag{2}$$

$v_i \sim N(0,\sigma_v^2)$ is independent of x_i.

The variance of the stochastic element $v_i - u_i$ is σ^2 which is decomposed into $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

The term λ defined by $\lambda = \frac{\sigma_u}{\sigma}$ is the proportion of the total variance due to inefficiency.

Estimating Equation 1 using the method of maximum likelihood or the ordinary least squares method gives estimators for β and λ. The parameter λ is an indicator of the relative variability of both sources of variation. If λ is close to zero, the difference between the observed level and the maximum feasible output level is dominated by random factors beyond the farmers' control. Otherwise, the more λ is close to 1 the more production is affected by technical inefficiency.

The level of technical efficiency (TE) between 0 and 1 is given by:

$$TE_i = \frac{y_i}{\exp(x_i\beta + v_i)} \frac{\exp(x_i\beta + v_i - u_i)}{\exp(x_i\beta + v_i)} = \exp(-u_i)$$

Two functional forms are generally used for the estimation of the frontier of production. The Cobb-Douglass production function (Coelli et al, 1998; Kumbhakar and Lovell, 2000) and the translog production function (Battese and Coelli, 1995). However, the choice of the functional form is based on the results of the likelihood ratio test.

For a sample of i=1,2,.., N households, the frontier of a translog production function can be specified as followed:

$$\ln y_i = \alpha_0 + \sum_{j=1}^{5}\alpha_j \ln x_j + \frac{1}{2}\sum_{j=1}^{5}\sum_{k=1}^{5}\alpha_{jk} \ln x_j \ln x_k + v_i - u_i$$

To be consistent with economic theory, the translog production function must satisfy the symmetry and homogeneity properties. The symmetry property imply $\alpha_{jk} = \alpha_{kj}$ and the homogeneity property imply $\sum_{j=1}^{5}\alpha_j = 1$. However, if $\alpha_{jk} = 0$, we have a Cobb-Douglass production function. The choice of the correct function form will be on the basis of the likelihood ratio test.

3. Method of analysis

To investigate the factors which contribute to the household's technical inefficiencies, we assume that the estimated technical efficiency (y_i) depends on a latent variable, y_i^*, which is linearly related to a series of independent variables that affect the household's real technical efficiency (y_i^*):

$$y_i = \begin{cases} y_{li} & if\ y_i^* \leq 0 \\ y_i^* & if\ y_{li} < y_i^* < y_{ui} \\ y_{ui} & if\ y_i^* \geq 1 \end{cases} \tag{4}$$

$$y_{i=} \alpha + X_i \beta + D^*{}_i \beta_{ci} + \mathcal{E}_i \tag{5}$$

Where, y_i is technical efficiency score of farm i with $y_{li} < y_i^* < y_{ui}$, D* the household's credit status. X_i is all the explanatory variables of technical efficiency except credit constraints, β and β_{ci} are vectors of parameters, and $\mathcal{E}_i$ is the error term.

The main econometric challenge when estimating the impact of credit constraints on productivity is endogeneity related to the self-section bias. Boucher et al (2009) have highlighted credit rationing phenomenon within the framework of agricultural lending by distinguishing credit rationing at both supply- and demand-side of the market. Credit rationing on the supply-side or quantity rationing refers to the fact that the presence of information asymmetry and the absence of collateral lead to the exclusion from credit markets farmers who cannot meet collateral required by lenders. However, Boucher et al (2009) revealed that information asymmetry does not lead to credit rationing only at supply-side (quantity rationing) in credit market, but it can also create credit rationing at demand-side through transaction cost and risk rationing. Transaction coast rationing occurs when a farmer does not apply for credit because, once the transaction costs associated with loan application (and monitoring) are factored in, the credit is no longer profitable. And risk rationing occurs when a farmer has a profitable project but does not apply for credit because he is unwilling to assume the risks associated with default. Therefore, possible endogeneity due to observed and unobserved variables may arise in case of quantity, transaction cost or risk rationing. For example, a household participation in credit market depends on its degree of risk averse or endowment in asset that can be used as collateral.

The credit constraint condition of a household i is described by an excess credit demand function, D^*, that is postulated to be a function of a vector of explanatory variables (Ali et al, 2014; Feder et al, 1990; Foltz, 2004; Guirkinger and Boucher, 2008):

$$D_i^* = \gamma' Z_i + \mu_i \tag{6}$$

Where, Z a vector of exogenous variables such as households' characteristics, γ is a vector of parameters and μ is a random disturbance. Households are credit constraint if the excess demand is greater than zero. The function that indicates the household's credit constraint status is defined as

$$D_i = \begin{cases} 1 & \text{iff} \quad \gamma' Z_i + \mu_i > 0 \\ 0 & \text{iff} \quad \gamma' Z_i + \mu_i \leq 0 \end{cases} \tag{7}$$

Beyond the endogeneity of credit constraint, the second econometric issue related to the empirical strategy is relative to the nature of the technical efficiency variable. The technical efficiency variable is censored between 0 and 1, and to account for all these aspects, we use an interval regression model (Bettin and Lucchetti, 2012) with endogenous treatment to estimate the impact of credit constraint on agricultural productivity. This model, called Extended Regression Model (STATA, 2017), allows the control of the endogeneity of credit variable through a joint estimation of both technical efficiency and the equation of credit constraint and takes into account the nature of the technical efficiency variable.

4. Data and descriptive statistics

This study uses a Living Standards Measurement Study (LSMS) survey data collected in 2014 by the National Institute of Statistics In Demography of Burkina Faso (INSD). Two-stage stratified sample technique was used to select the sample. All the 13 regions and 45 provinces were considered in the sampling. In the first stage, the primary units or enumeration areas (EAs) were selected with proportional probability to the number of households counted in the EA, making a total number of 905 EAs. In the second stage, 12 households were selected with equal probability in each EA on the basis of the list of households enumerated during the EA enumeration operation. In total, a sample of 10800 households was selected for the whole country.

For the purpose of this study, only households located in the rural area and growing maize as main crop were considered, making a sample size of 2,828 households. Indeed, among cereal crops grown in Burkina Faso, maize is one that requires more chemical fertilizers and in the context of high poverty, access to credit is therefore critical for the production process.

The descriptive statistics on the nature of credit rationing in rural Burkina Faso is reported in Table 1. Using direct elicitation approach for the measurement of credit constraint, Table 1 shows that 44.12% of the farm households are credit unconstrained in rural Burkina Faso while 56% are constrained. Indeed, 28.38% of farm households do not need credit for their production process and 15.74% applies for credit and get the full amount requested. In contrast, 20.81% of farm households have their loan application rejected or partially satisfied; 17.05% of the farm household decide to withdraw from the credit market because of high transaction cost related to loan application, and 18.01% of farm households do not apply for credit because of the risk related to loan default. The summary of descriptive statistics on credit status distribution highlights that about 71% of farm households are in credit needs in Burkina Faso (when excluding those that do not need credit) and only 22% of this demand is satisfied. In other words, 78 % of farm households have their demand of credit not satisfied.

Table 1: Credit status distribution

Credit status	Frequency	Percentage
Unconstrained	1,009	44.12
Do not need credit	649	28.38
Access to credit	360	15.74
Constrained	1,278	55.88
Quantity rationing	476	20.81

Transaction rationing	390	17.05
Risk rationing	412	18.01

Source: LSMS (2014).

The different sources of credit are presented in Table 2. The main sources of credit in rural Burkina Faso are informal and semi-formal credit with, respectively, 58% and 41%. Formal credit represents only 2% in rural Burkina Faso.

Table 2: Source of credit

Source of credit	Frequency (%)
Formal	1.68
Semi-formal	40.80
Informal	57.51

Source: LSMS (2014.

Based on literature review (Petrick, 2004; Ali et al, 2014; Foltz, 2004; Guirkinger and Boucher, 2008; Dong et al, 2012) the variables retained for the empirical analysis are presented in Table 3:

Table 3: Descriptive statistics of the variables

Variables	Measurement	Mean
Age of the head of household ((hage)	Numbers of years	47.158
Sex of the head of household (hgender)	Dummy (1=male; 0=female)	0.932
Family size (hhsize)	Number of household's members	8.402
Literacy of the head of household (hliteracy)	Dummy (1=literacy; 0=if not)	0.223
Land size (lsize)	Hectare	2.207
credit status (credit_constr)	Dummy (1=constrained; 0=Unconstrained)	0.570
Production (prod)	Quantity in kilogramme	1413.072
Access to news (news)	Dummy (1=Ownership of radio set; 0= if not)	0.500
Member of FBOs (fbo)	Dummy (1=yes; 0=No)	0.278
Family labour (lab)	Man-day	381.771
Use of organic fertilizer (orgfert)	Quantity in kilogramme	314.735
Use of chemical fertilizer (NPK)	Quantity in kilogramme	77.069
Use of chemical fertilizer (urea)	Quantity in kilogramme	43.025
Quality of the seed (seed)	Dummy (1=improved seed; 0=local seed)	0.289
Soil quality	Categorical	
	0= sandy	0.4647

	1=clayey	0.2698
	2= red laterite	0.2386
	3= others	0.0269
Relief of the plot	0= plain	0.4834
	1= plateau	0.4093
	2= shallows	0.0762
	3= versant	0.0312
Agroclimatic zone	0= north sahelian	0.0105
	1= south sahelian	0.0504
	2 =north soudanise	0.5613
	3=south soudanise	0.3778

Source: Authors.

5. Results and discussion

Households' technical efficiency

The results of the estimation of both translog and Cobb-Douglass production function are presented in Table 4. The results of the likelihood - ratio test show that the translog production function was more adequate for the analysis of the production frontier than Cobb-Douglass production function (LR= -2 [Lcobb-douglas-Ltranslog] =257.4002> $\chi^2_{(15;\, \alpha=0.05)} = 25$) .

Table 4: Results of stochastic production function

Variables	(1) Translog	(2) Cobb-Douglas
Ln(urea)	0.0449**	0.0152***
	(0.0190)	(0.00546)
ln(npk)	0.110***	0.0213***
	(0.0155)	(0.00513)
ln(labour)	0.0160	0.0406***
	(0.0131)	(0.00703)
ln(manure)	0.0151*	-0.00469
	(0.00883)	(0.00309)
ln(herbicide)	0.0409	0.0491***
	(0.0331)	(0.00542)
$\ln(\text{urea})^2$	0.00324	
	(0.00892)	
$\ln(\text{npk})^2$	0.0714***	
	(0.00729)	
$\ln(\text{manure})^2$	0.0292***	
	(0.00595)	
$\ln(\text{labour})^2$	0.0192***	
	(0.00302)	
$\ln(\text{herbicide})^2$	-0.00365	
	(0.0103)	
ln(urea)ln(npk)	0.00171*	
	(0.000958)	
ln(urea)ln(manure)	0.000859	
	(0.000940)	
ln(urea)ln(labour)	-0.00326	
	(0.00248)	

ln(urea)ln(herbicide)	-0.000408	
	(0.00143)	
ln(npk)ln(manure)	-0.000383	
	(0.000891)	
ln(npk)ln(labour)	-0.000641	
	(0.00238)	
ln(npk)ln(herbicide)	-0.00235*	
	(0.00140)	
ln(manure)ln(labour)	-0.000638	
	(0.00159)	
ln(manure) ln(herbicide)	0.00258***	
	(0.000946)	
ln(herbicides) ln(labour)	-0.000253	
	(0.00235)	
Constant	5.450***	7.400***
	(0.175)	(0.0518)
$l\sigma_v^2$	-1.147***	-1.225***
	(0.0821)	(0.0886)
$l\sigma_u^2$	0.201***	0.451***
	(0.0755)	(0.0650)
σ_v	0.563	0.541
	(0.0231)	(0.024)
σ_u	1.105	1.253
	(0.0417)	(0.041)
λ	1.962	2.312
	(0.0604)	(0.0597)
Log likelihood	-2967.2152	-3095.9153
Observations	2,347	2,347
(LR= -2 [Lcobb-douglas-Ltranslog] = -2 [-3095.9153+ 2967.2152] = 257.4002		
$H_0 : \alpha_{jk} = 0$	$\chi^2_{(15)} = 463.87$	$\chi^2_{(15;\, \alpha=0.05)} = 25$

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors.

Unlike Cobb-Douglass production function, the estimates of the translog production are not input elasticities. The translog production function input elasticities are computed as follows:

$$\varepsilon_{ij} = \frac{\partial \ln y_i}{\partial \ln x_j} = \alpha_j + \sum_j \alpha_{jk} \ln x_k$$

The results of the estimation of the inputs elasticity are presented in Table 5. The results show that 1% increase in the quantity of urea and herbicide used per hectare induced an increase of maize production by 0.02% and 0.053%, respectively. This result was expected since chemical weed management plays an important role in improving the growth and productivity of maize plants (Rapparini et al, 2001; Sharara et al, 2005). However, 1% increase in the quantity of manure used per hectare induced a decrease of maize production by 0.063%. This result seems surprising since application of organic fertilizers usually leads to increased crop yields (Chivenge et al, 2011; Wang et al, 2017) but some studies have also reported a decrease in crop yields with organic fertilizers use (Bado et al, 1997; Mugwira and Murwira, 1997). This reduction in yield can be attributed to excessive use of organic fertilizers and a poor combination of mineral and organic fertilizers which contributes to reduced crop yield (Bado et al, 1997). Indeed, since the structural adjustment programme, the budget allocated to agricultural extension services has been reduced, and this limited the provision of technical assistance to farmers (MAHRH, 2010). Regarding the labour used per hectare, the results revealed that 1% increase in the quantity of labour per hectare increases maize production by 0.11%, suggesting that labour is the main input used in maize production in rural Burkina Faso.

Table 5: Elasticities of the inputs

Inputs variables	Coef	Z
urea	0.0208***	3.05
NPK	-0.00046	-0.08
labour	0.1130***	7.91
manure	-0.0635***	-5.35
herbicide	0.0531***	4.22

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors.

Descriptive statistics on the score of the technical efficiency predicted from the production frontier are presented in Table 6. Credit constrained households have on average 0.486 units of score of technical efficiency and non-credit constrained households have on average 0.509 units of score of technical efficiency. In other words, non-credit constrained households allocate productive resources (inputs) more efficiently than credit constrained households. The efficiency gap between the two groups seems low (0.023) but significant at 1%. However, this gap does not represent the real impact of credit constraint on maize productivity.

Table 6: Descriptive statistics of technical efficiency

	Observations	Mean	Std dev
Unconstraint	1,009	0.509	0.0053
Constraint	1,338	0.486	0.0048
Difference of mean (t-student)		0.023*** (3.172)	

Source: Authors.

*** p<0.01, ** p<0.05, * p<0.1

Impact of credit constraints on maize productivity

The results of the estimation of the interval regression model with endogenous treatment are presented in Table 7. Regarding the value of Wald chi2 (179.44) the results show that the model is globally significant. The coefficient of correlation between the error terms of the model (Rho) is positive and significant at 1%. This implies that there are unobserved factors influencing the probability of being rationed on credit market (selection equation) that positively affect the determinants of technical efficiency among maize producers in Burkina Faso. In other words, credit constraint variable was endogenous and not controlling this would have yield biased estimates. The model is therefore appropriate for the analysis of the impact of credit constraint on maize productivity.

The results of the estimation show that access to information and membership in farmer-based organisation (FBO) reduces the probability of being rationed in credit market in rural Burkina Faso. In fact, access to information contributes to reduction in transaction cost and master credit application process. In the same way, membership into a FBO constitute a form of collateral (joint liability) that financial institutions accept in rural Burkina Faso because it minimizes the adverse selection and hazard moral risks related to information asymmetry. Similar results were found in Rwanda (Ali et al, 2014) and Nigeria (Awotide et al, 2015). However, the results show that an increase in the age of the head of households increases the probability of being rationed in rural Burkina Faso, suggesting that households headed by old persons are more likely to be credit constrained than those headed by young persons.

The results of the estimation also show that the age and gender of the head of household, the agro-ecological zone, the seed and soil quality, the relief, and credit constraints were significant determinants of technical efficiency among maize producers (Table 7). Indeed, the age of head of household has negative effect on maize productivity. This could be explained by the fact that aged persons are less likely to access credit and this could limit their access to productive resources. In addition, aged head of households are generally less engaged in technology adoption. The results indicate that male headed households were more productive than female headed households. The results also show that households residing in north and south Sudanian agro-ecological zones are more productive than those residing in Sahelian (north and south) agro-ecological zone. This result was expected given that

Sudanian agro-ecological zones are endowed with good rainfall and fertile land than Sahelian agro-ecological zone. Similarly, the relief of land surface has a positive effect on maize productivity. Obviously, land on a plateau is less exposed to water runoff than land lying on a slope. The quality of the soil also improves maize producers' technical efficiency. Households growing maize on red laterite and clayey soil are more productive than those using sandy soil. In the same way, households using improved seed are more productive than those not using improved seed. This was consistent with the findings of Chibwana et al (2011) in Malawi.

Table 7: Estimation of the interval regression model with endogenous treatment

	(1)	(2)
VARIABLES	Technical efficiency	Credit constraints
Age of the head of household	-0.000573**	0.00498***
	(0.000260)	(0.00177)
Sex of the head of household	0.0330*	-0.103
	(0.0174)	(0.111)
Literacy of the head of household	-0.0125	0.113
	(0.0124)	(0.0845)
Agroclimatic zone		
south Sahelian	0.0199	
	(0.0416)	
north Soudanise	0.0974**	
	(0.0379)	
south Soudanise	0.119***	
	(0.0383)	
Relief of the plot		
plateau	0.0170**	
	(0.00796)	
shallows	0.0126	
	(0.0163)	
versant	0.0173	
	(0.0209)	
Quality of the seed	0.0150*	
	(0.00911)	
Soil quality		
clayey	0.0346***	
	(0.00954)	
red laterite	0.0242**	
	(0.00971)	
others	0.00556	
	(0.0239)	
Credit constraint	-0.173***	
	(0.0348)	
Household size		-0.00229
		(0.00499)
Access to news		-0.205***
		(0.0513)

Membership in FBOs		-0.207***
		(0.0575)
Constant	0.466***	0.206
	(0.0472)	(0.132)
Wald chi2 (14)	179.44	
Prob >chi2	0.000	
Rho	0.498***	
Observations	2,333	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors.

Finally, results reveal that if credit constraints were removed, maize producers' technical efficiency could be increased by 0.173 units. This represents an increase of their average technical efficiency by 17.3%. The results are in line with those found in China (Zhao and Barry, 2014), in Peru (Guirkinger and Boucher, 2008), and in Rwanda (Ali et al, 2014). However, the extent of the impact was larger than the one found by Zhao and Barry (2014) in China which was 0.06 units.

6. Conclusion and policy implication

Building a practical and reliable system of financing smallholder farmers' production is still a big challenge in Burkina Faso despite the liberation of the financial sector since 1990. Access to credit constitutes a major challenge for agricultural development in Burkina Faso. This study examined the impact of credit rationing on the technical efficiency of maize producers in Burkina Faso. The SFA approach was applied for estimation of the production frontier, using survey data collected in 2014. The results show that maize producers in Burkina Faso have average technical efficiency. However, the results indicated that manure was lowering maize productivity and this seems surprising regarding the literature on maize productivity. Providing technical assistance to farmers on input combination could help to address this yield reduction related to the use the manure.

Using interval regression model with endogenous treatment to assess the effect of credit on farmers' technical efficiency, the results show that access to information and membership in FBO lowered the probability of being rationed in credit market in rural Burkina Faso. The results also revealed that credit constrained households' technical efficiency could be increased by 0.173 units if the credit constraints were removed. There is, therefore, a need to establish a good rural finance system in Burkina Faso. Providing credit to farmers to acquire agricultural inputs on time could boost their productivity and lower vulnerability to poverty. The results of the study suggest that promoting information dissemination and the development of FBOs could be policy instruments for improvement of farmers' access to credit in rural Burkina Faso. In addition to access to credit, policies aiming at increasing maize productivity in Burkina Faso must promote farmers' access to improved seed and fight against cropland degradation.

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