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Research Article

Rural Credit and Farms Efficiency: Modelling Farmers Credit Allocation Decisions, Evidences from Benin

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This paper analyses farmers' credit allocation behaviors and their effects on technical efficiency. Data were collected from 476 farmers using the multistage sampling procedure. The stochastic frontier truncated-normal with conditional mean model is used to assess allocation schemes effects on technical efficiency. Tobit model reveals the impact of farmers' sociodemographic characteristics on efficiency scores. Results reveal that farm revenue (about 2,262,566 Fcfa on average) is positively correlated with land acreage, quantity of labour, and costs of fertilizers and insecticides. Farmers' behaviors respond to six schemes which are categorized in two allocations contexts: out-farm and in-farm allocations. The model shows that only scheme (e) positively impacts technical efficiency. This scheme refers to the decision to invest credit to purchase better quality of pesticides, herbicides, fertilizers, and so forth. The positive effect of the scheme (c) may be significant under conditions of farmers' education level improvement. Then, scheme (e) is a better investment for all farmers, but effect of credit allocation to buy agricultural materials is positive only for educated farmers. Efficiency scores are reduced by household size and gender of the household head. Therefore a household with more than 10 members and a woman as head is likely to not be technically efficient.

1. Introduction

In Benin, 75% of the total population is involved in agriculture. The sector accounts for about 29.89% of the gross domestic product (GDP) and roughly 80% of the exportation shares [1]. Smallholder farmers are the most representative actors in Beninese agriculture and the increase of their productivity requires the adoption of improved technologies [2]. However, the adoption of these technologies needs to be supported by a rural funding system, which fits with smallholder famers features and needs [2]. Given that smallholder farmers are poor and often suffer a lack of institutional services [3]; improvement of the farm productivity could be achieved by a better access to agricultural credit. Access to credit services is identified as one of the most important constraints to the development of agriculture in Benin. Only 14% of the credit offer in Economic Community of West African States (ECOWAS) is towards agriculture [4]. Furthermore, according to [5], Benin Microfinance Institutions offer 79.18% of their funding services to the business sector and 16.4% to agriculture. Besides the issues of access to credit and the amounts offer which are less in comparison to farmers' needs, there is the problem of credit refunding. In this paper, we assume that one reason of this recurrent phenomenon is poor farmers' allocation behaviors. And these behaviors do not permit to gain profit from the credit investment and be able to refund the loan. The aim of the study is to assess the effect of Benin farmers' credit allocation decisions on their technical efficiency. In fact developing countries farmers allocate the credit obtained in two ways: (1) investments in household and social requirements: debts refunding, weddings, death, housing, health, and so forth; and (2) investments in farming requirements: inputs purchasing, labor, and so forth. In this paper we model the credit investments in these two situations to identify which combination allows improving technical efficiency. Based on the credit allocation decisions, we set the following hypotheses: H_0: credit investments in farming requirements improve technical efficiency, H_1: credit investments in farming requirements do not improve technical efficiency.

2. Literature Review

A study on the influence of access to credit on technical efficiency has been led in Chile. Crops producers and livestock producers were sampled. The translog stochastic frontier function has been used to capture the effect of credit provision on these specialized small farmers. Results show that credit access and credit volume have opposite effects on crop production and livestock production, respectively [6]. In Ethiopia, the influence of credit on both constrained and unconstrained households has been assessed [7]. The idea is to capture efficiencies differences between these categories. Results show that credit constrained households are 12% less efficient than the ones unconstrained. Besides, education level, land fragmentation, and loan size are significant sources of inefficiency between these groups.

In [8], the stochastic frontier analysis was used to assess institutional credit impact on farm production efficiency in Pakistan. The mean efficiency score is 0.84 indicating 16% of inefficiency. Farming experience, education, access to farming credit, herd size, and number of cultivation practices has significant effects on farmers' technical efficiency. Moreover, the variable credit has the highest coefficient value: showing the importance of agricultural credit to farmers. In Nigeria, [9] classified farmers into beneficiaries and nonbeneficiaries to understand how the lack of capital affects their productivity. The capital here is the provision of credit or not. As results, farm production operations are correlated with the investment of credit towards crop production, the adoption of new technologies, and proper processing and storage. All that depends on farmers' socioeconomic status and its way to understand and deal with issues: its behaviour.

In the above mentioned studies, analysis focused on credit provision impacts on different groups and types of farm households. None of them took account of the step after getting the credit: farmer allocation behaviour. In fact, farmers have several ways to manage the credit obtained and they differently affected farms production efficiency. Therefore farmers' credit allocation behaviors is a relevant topic worthy to highlight. The current paper is the first to model farmer credit allocation behaviours and to assess their impacts on farms technical efficiency in Sub-Sahara Africa.

3. Methodology

Data were collected in the whole country and a total of 476 farmers were interviewed. The multiple stage multistage sampling procedure was used to target the areas covered by development projects offering microfinance services and the farmers involved. A total of 20 districts with an average of 25 farmers per district were accounted in the study.

Multistage sampling is a procedure allowing dividing a population into groups: this is the first stage. The second stage is the choice of some groups from the ones obtained from the first stage; this is randomly done. Then households are selected from the chosen groups: this is the third stage. In this study the choice of surveyed areas is based on microfinance services coverage rate. And the selection of surveyed households is based on the criteria of attendance to microfinance services. The advantages of this sampling procedure are: data collection costs reduction; data collection feasibility: it is the whole population no more but representative groups which constitute the sample. It is appropriate for this survey because everyone does not have access to credit, then it permits to target the beneficiaries, while accounting for the sample representativeness in the total population.

4. Theoretical Framework

The theoretical background relies on the neoclassic theory which states that the objective of all company is to maximize its profit [10]. A company allocates resources according to market conditions so that to maximize its profit. Thus a farmer is rational when for producing a specific output, with n inputs $x = x_1 \cdots x_2$, purchased at prices $w = w_1 \cdots w_2$; the production system runs on the production frontier. Meaning that, for fixed inputs the production system optimizes the inputs combination so as the outputs are closer to the production frontier. Then, technical efficiency (TE) seeks the best inputs combination allowing being closer to the production frontier. And any other deviations from the production frontier measure the technical inefficiency (TI) of the production system [11]. A production system which optimizes the inputs combination to reach a fixed output level is input-oriented. It is output-oriented for fixed quantities of inputs to reach the optimal level of outputs; this is the case for most agricultural production systems. In fact, farmers decide the quantities of inputs to use before producing, then quantities are fixed and during the farming process farmers try to optimize their yields.

5. Empirical Framework

Two approaches are used to analyze TE: (1) the parametric approach and (2) the nonparametric approach [12]. The parametric approach involved two methods. The first is (1) the estimation of TE scores and a Tobit regression with farmers sociodemographics features to identify TE scores determinants. From an econometric view, this model is not consistent with the independent and identically distributed assumption. The second method (2) is estimation in one step of the TE and its determinants. It is done by "*stochastic* *frontier truncated-normal: conditional mean with explanatory variable*" model. This model has been used by [6, 8, 13] to estimate TE of several economic sectors. Dinar et al. [14] used the same model to assess the effects of the access to extension services on farms TE. It allows capturing the double effect of the variable of interest as production input and as determinant of TE of a production system. Here the variables of interest are the amount of credit given and farmers divers' allocation schemes of the credit. The determinants of TE are of two types: (1) human capital: age, gender, education level, and farming experience; and (2) institutional features: access to credit, access to extension services, and so forth. To capture the effect of the credit allocation schemes on the farms TE, the one step stochastic model is used. And a Tobit model with the human capital variables is used to identify the determinants of the TE scores.

5.1. The Stochastic Frontier Model. The hypothesis is the credit alone and in combination with the production inputs increase the production system TE. In this scheme the credit is a production input and, in combination with others inputs (labour, pesticides, capital, etc.), it determines farms TE. This combination is mathematically showed by the interaction between the variable credit and the inputs variables. And each variable obtained from this interaction represents the credit allocation scheme; for example, a variable credit × labour showed the allocation of the credit to increase the quantity of labour needed. The effects of these interactions are captured by the following stochastic model:

$$y_i = f(x_i)\exp(v_i - u_i(z_i)), \tag{1}$$

where y_i is the production level of a farm i; x_i is the vector of inputs; $f(\cdot)$ represents the production frontier; and $w_i = v_i - u_i$ is the composite error term. The error term v_i is related to the omitted variables and factors uncontrollable by the farmer, such as climate variability and soil fertility. u_i is a nonnegative component, accounting for the inefficiency; such as the TE output-oriented is $ET_i = \exp(-u_i) \in [0,1]$ [12, 15, 16]. The output-oriented approach fits with agricultural production; in this system the inputs quality and quantity are predetermined before starting the production process [17]. Then, in the production function, there is no link between the stochastic error term and the predetermined inputs. Equation (1) estimation will not present simultaneity bias [14, 18]. The assumptions on the error terms are u_i is half-normal distributed; v_i normal distributed and $\text{Cov}(v_i, u_i) = 0$.

The translog form of (1) is

$$\begin{aligned}\ln(y_i) &= \beta_0 + \sum_k \beta_k \ln(x_{ki}) \\ &\quad + 0.5\sum_k\sum_p \beta_{kp}\ln(x_{ik})\ln(x_{ip}) + v_i - u_i.\end{aligned} \tag{2}$$

Under the following assumptions: (1) symmetry of $\beta_{kp} = \beta_{pk}$; (2) v_i is a normal variable i.i.d, with constant variance σ_v^2; (3) any deviations from the frontier u_i are assumed i.i.d and follow a normal distribution which is not correlated with v_i [19, 20].

The variance of u_i is

$$\ln(\sigma_{u_i}^2) = \sigma_0 + \sum_j \theta_j z_j + \varepsilon_i, \tag{3}$$

where θ_j are the estimators which capture the effect of the z_j on the TE and ε_i is the error term i.i.d, normal distributed.

5.1.1. Variables Specification. In (2), y_i is the income of a farm (i) in Fcfa. The inputs vector x_i included four variables: acreage (in hectare), the quantity of labour (in man-day), the capital (in Fcfa), the intermediary inputs (in Fcfa), and others variables (see Table 1). The vector z_j includes the amount of credit (in Fcfa), the credit square, and the interaction variables [14].

The elasticities of the inputs vector x_i are expected to have a positive impact on the production level. Regarding the effects of the credit and the interaction variables on the TE, there is no assumption.

5.2. The Tobit Model. The human capital variables (age, gender, education level, etc.) are regressed on the TE scores to capture their marginal effects on the technical efficiency [21, 22]. That is,

$$Y_i^* = X_i\beta + \varepsilon_i, \tag{4}$$

where Y_i is the dependent variable; X_i are the independent variables vector to estimate; and ε_i is the error term normally distributed, having a null mean and a constant variance σ_{ε_i}. Given that, for a farm i, the TE scores vary between 0 and 1, it leads to

$$\begin{aligned} Y_i &= Y^* \quad \text{if } 0 < Y^* < 1; \\ Y_i &= 0 \quad \text{if } Y^* \leq 0. \end{aligned} \tag{5}$$

Therefore the empirical model is

$$Y_i^* = \beta_0 + \sum_{n=1}^{11} \beta_n X_i + \varepsilon_i. \tag{6}$$

The Maximum likelihood model is used to avoid the errors noticed in the OLS model [23].

6. Results and Discussion

6.1. Descriptive Statistics. With an average of 44 years old, farmers interviewed are mostly men (90%). The average household size is 10 members and the area under crops is 6.09 hectares on average. Most household heads are married (96.25%); but less has been to formal school (46.47%) and traditional school (33.03%). All the respondents are in contact with extension services.

The variables in (2) were divided by their arithmetic means so that their estimates are their elasticities. The logarithm allows controlling the data variability showed by standard errors. Table 2 presents a descriptive statistics of the quantitative variables included in the stochastic frontier and Tobit models.

TABLE 1: Variables introduced in the stochastic frontier model.

Variables	Definitions	Units
Dependent variable		
y_i	Farm income	Fcfa
Vector x_i		
Capital	Agricultural materials costs	Fcfa
Acreage	Area under crops	Hectare
Labour	Quantity of labour	Man-day
Intermediary inputs	Costs of chemicals (pesticides, herbicides, and fertilizers)	Fcfa
Capital^2	Threshold of agricultural materials investment	—
Acreage^2	Threshold of area under crops	—
Labour^2	Threshold of labour used	—
Intermediary inputs^2	Threshold of chemicals used	—
Capital × acreage	Interaction capital and acreage	—
Capital × labour	Interaction capital and labour	—
Capital × intermediary inputs	Interaction capital and intermediary inputs	—
Acreage × intermediary inputs	Interaction acreage and intermediary inputs	—
Acreage × labour	Interaction acreage and labour	—
Labour × intermediary inputs	Interaction labour and intermediary inputs	—
Vector z_j		
Credit	Given amount	Fcfa
Credit^2	Threshold	—
Credit × acreage	Interaction credit and acreage	—
Credit × capital	Interaction credit and capital	—
Credit × labour	Interaction credit and labour	—
Credit × intermediary inputs	Interaction credit and intermediary inputs (pesticides, herbicides, etc.)	—

Source: authors' calculations.

TABLE 2: Descriptive statistics of the variables in the stochastic frontier and Tobit models.

Variables	Units	Means	S.E	Minimum	Maximum
Age	Years	44.23418	11.22224	21	80
Farming experience	Years	21.91983	11.07947	1	55
Household size	Number of people	10.80842	6.604174	1	54
Revenue	Fcfa	2262566	4016968	7500	34100000
Acreage	Hectare	6.090127	8.310743	0.36	84
Intermediary inputs	Fcfa	645453.1	1165424	15100	14100000
Labour	Man-day	4.192144	3.126197	0	22.25
Capital	Fcfa	712020.4	2670723	0	31100000
Credit	Fcfa	35213.09	67563.82	0	761429

Source: authors' calculations.

6.2. The Stochastic Frontier Model. The one-step stochastic frontier model applied relies on [16] application. The farming revenue 2,262,566 (±4016968) Fcfa is diversely affected by the production inputs. The model indicates that an increase of the acreage and the quantity of labour positively affects the revenue. In fact, an increase up to 1% of these inputs increases the farms output by 0.32% and 0.55%, respectively. The same effect (positive) is noticed for an increase in the same range of the intermediary inputs expenses (pesticide, herbicides, fertilizers, etc.). A 1% increase in the expenses to purchase pesticides, herbicides, fertilizers, and so forth increases the output up to 0.86%. Previous studies have reported that an increase in the use of pesticides, herbicides, fertilizers, acreage, and labour contributed to a higher yield [24]. Regardless of their positive elasticities, the use of these inputs needs to be regulated based on the values of their thresholds. Indeed, for the double of the average values of each input; only acreage^2 increases the farms output up to 0.15% with a significance of 10%. It is worth to note that, the positive effect of acreage^2 is less important than the effect of acreage and is less significant also (see the Appendix). Doubling the quantities of labour, intermediary inputs (pesticides, herbicides, and fertilizers), and agricultural materials reduces the revenue by −0.064%, −0.156%,

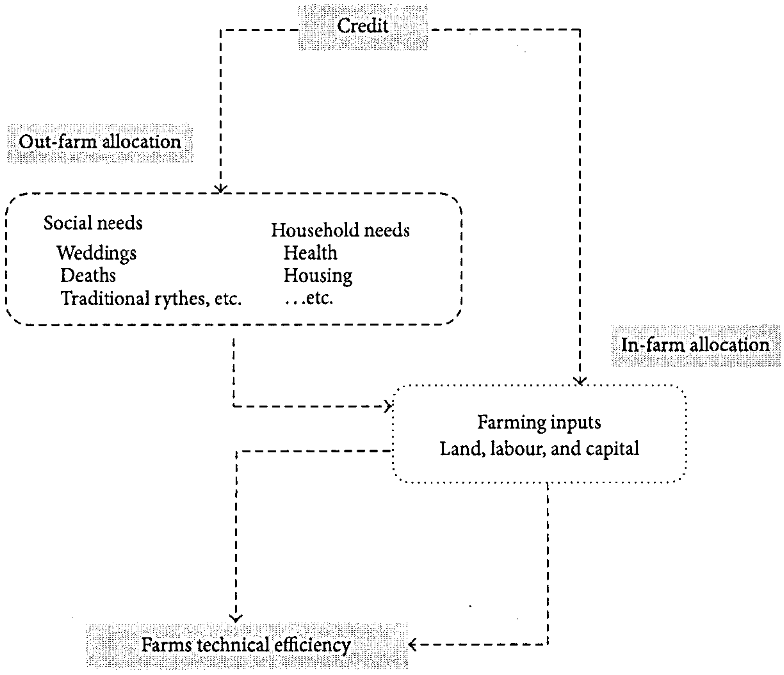

FIGURE 1: Farmers credit allocation schemes model. Source: authors' representation.

and −0.025%, respectively. On the side of the interactions between inputs, only capital × labour increases the revenue up to 0.04%, meaning that a better combination of the labour to use the agricultural materials leads to higher income. A positive effect was expected from the interaction of labour × intermediary inputs on the revenue, but it is not the case. The reasons may be the overuse of pesticides and fertilizers and difficulties to master the agricultural process; which faces climate variability issues.

6.2.1. Credit Allocation Schemes Effects on Farms Technical Efficiency. The average technical efficiency score is 0.6752943 (±0.137443). The scores are diversely distributed across farms, with a median score that is equal to 0.7132979. The difference between the mean and the median of the technical efficiency score is validated by the negative sign of the Skewness coefficient (−0.7272118). Farmers credit allocation behaviours can be categorized in two allocations contexts: out-farm allocation and in-farm allocation (see Figure 1).

When farmers use the credit obtained to pay their debts, for weddings, death ceremonies, and others, the credit is invested towards *out-farm* purposes. The out-farm context includes the schemes (a) and (b). The scheme (b) identifies the credit threshold and the extent to which doubling the given amount of credit can positively impact farms technical efficiency. On the other hand, the *in-farm* context is when farmers invest the credit given towards farming purposes. This context includes the schemes (c), (d), (e), and (f), which identify farmers decision to invest to increase or improve their production inputs (see Table 3). To design farmers credit allocation model, we assume that each context (out-farm and in-farm) corresponds to more than 50% of the amount of credit invested for each purpose. The assumption is based on the notification that smallholder farmers do not invest all the credit towards a specific context, either out-farm or in-farm. That means that for in-farm purposes, a farmer may invest 70% of the given credit and the rest for out-farm goals. The opposite is observed for out-farm investments; 30% of the given credit is used for farming process.

The schemes (a) and (b) regard the context where farmers use the given credit for out-farm purposes (see Table 3). In the scheme (a), farms are less efficient for an increase of 1% of the credit amount given; this was expected due to the fact that more than 50% of the credit is not oriented into farming production. The scheme (b) concerns the same context and presents the level to which an increase of the credit amount given may positively affect farms TE. The model shows that doubling the average amount of credit given has no effect on the production system: no degree of significance and no error standard. And moreover the coefficient sign is negative. The credit amount should not exceed the threshold of credit[2]. Regarding the scheme (a) it should not reach the threshold because is it mostly used for out-farms purposes. The schemes (c), (d), (e), and (f) correspond to the credit used for farming purposes. In this context, the schemes (e) and (f) are significant but have opposite effects on the TE of the production system. The credit invested to purchase better quality of pesticides, herbicides, fertilizers, and so forth allows an improvement of the technical efficiency for an increase up to 1% of this investment (see Table 4), while an increase of the credit investment, in the same range, to have more workers distorts the farms efficiency by −0.00000549%.

Table 3: Allocation schemes, contexts, and definitions.

Inputs	Schemes	Contexts	Definitions
Credit	(a)	*Out-farm*	Credit to debts refunding, weddings, deaths, housing, and so forth
Credit^2	(b)		Doubling the given amount (threshold)
Credit × capital	(c)	*In-farm*	Credit to increase agricultural materials
Credit × acreage	(d)		Credit to increase acreage
Credit × intermediary inputs	(e)		Credit to increase pesticides, herbicides, and so forth
Credit × labour	(f)		Credit to increase workers

Source: authors' calculations.

Table 4: Effects of credit allocation schemes on farms technical efficiency.

TE		**0.6752943 (±0.137443)**	
Inputs	Schemes	Elasticities	$P > \|t\|$
Credit	(a)	**−0.0000135 (0.00000633)**	0.033**
Credit^2	(b)	**−0.00000000000364 (—)**	—
Credit × capital	(c)	**0.000000488 (0.00000166)**	0.769
Credit × acreage	(d)	**−0.00000428 (0.0000052)**	0.410
Credit × intermediary inputs	(e)	**0.00000873 (0.00000522)**	0.094*
Credit × labour	(f)	**−0.00000549 (0.00000287)**	0.055*

Note: *,**,*** significant at 10%, 5%, and 1%, respectively.
Source: authors' calculations.

This result suggests that a better use of the labour may be reached through the use of family labour, allowing reducing production costs related to workers payments.

The schemes (c) and (d) are expected to be significant and both positive, but these schemes are not significant. The allocation of the credit to increase the acreage increases farms inefficiency by −0.00000428%, meaning that a wider farm lead to greater related inputs costs and to more difficulties to master the agricultural process. Therefore, the scheme (d) does not allow improving technical efficiency. This result is supported by the effects of acreage^2 and acreage on the revenue, which were positive but less increasing for an increase of the area under crops from acreage to acreage^2. Then investment in land is not advisable to farmers.

The scheme (c), even though positive, is not significant, meaning that few farmers are involved in this scheme. Actually, smallholder farmers do not to improve the quality of the agricultural materials and the fewer that are so doing, are the ones with a higher level of education.

6.3. The Tobit Model. Gender and household size significantly reduces farms technical efficiency (Table 5). A shift of the household head gender from man to woman status diminished farms efficiency by 0.0656572%. This result reveals women's limited access to production inputs: land, capital, and credit. In fact in rural area the assets are owned by the husband and he gives a part of these assets to his wife/wives. In this resources allocation scheme, women have to work with the husband before working on their own field. Then, with less time allocation to their own production it is technically difficult to them to be efficient. On the side of access to credit, women were left behind for having no assets; they face collateral issues to get credit. An increase of 1% of the household size reduces farms technical efficiency by 0.0034473%. This unexpected result is supported by the sign of the variable labour^2 in (2), meaning that there is a threshold that farmers must not exceed. This threshold may equal the quantity of labour obtained from an average household size of 10.80842 (±6.604174) persons. According to the literature variables such as household head age, education level, and farming experience, access to extension services may significantly influence farms technical efficiency but they do not.

This fact may be explained as follows: most farmers are young, 44.23418 (±11.22224) years in average. And this fact does not facilitate credit access due to collateral issues, which are often required in kind (land or houses). In rural area and for farmers, these assets can be valued as collateral after several years of savings then cannot be owned by young farmers. Moreover, with an average 21.91983 (±11.07947) years in farming and 53.52% with no access to formal education, it is difficult for farmers to adapt to environmental variations and master new agricultural technologies.

7. Conclusion

Using the one step stochastic frontier model the study captures credit allocation schemes and identifies the ones that improve farms technical efficiency. Estimations reveal that out of six only three schemes have significant effect on technical efficiency and from these three just one scheme has positive effect on the technical efficiency: scheme (e). Therefore, farmers that use the given credit to purchase better quality of fertilizers, pesticides, and herbicides are likely to improve their farms efficiency. This efficiency can also be

Table 5: Tobit model results.

Variables	Coefficients	$P > \|t\|$	Expected signs
Age	−0.0002498 (0.0009398)	0.790	+
Gender	−0.0656572 (0.0238994)	0.006**	Men +/women −
Education	−0.003613 (0.0145079)	0.803	+
Extension service	0.0105402 (0.0241567)	0.663	+
Household size	−0.0034473 (0.0010865)	0.002**	+
Farming experience	0.0013197 (0.0009311)	0.157	+
Constant	0.7451122 (0.0432094)	0.000*	—

Note: *,**,*** significant at 10%, 5%, and 1%, respectively.
Source: authors' calculations.

Table 6: Results of stochastic frontier with conditional mean model.

Variables	Coefficients	Standards errors	$P > \|t\|$
	Lrevenu		
cons	0.5639018	0.0789205	0.000***
lcapital	0.0258756	0.0193221	0.181
lacreage	0.3210206	0.0588239	0.000***
llabour	0.5577022	0.0300458	0.000***
linterm_input	0.0867108	0.049874	0.082*
$0{,}5 * \text{lcapital}^2$	−0.0252712	0.0144483	0.080*
$0{,}5 * \text{lacreage}^2$	0.1591446	0.0946285	0.093*
$0{,}5 * \text{llabour}^2$	−0.0645713	0.0262547	0.014
$0{,}5 * \text{linterm\_input}^2$	−0.1568689	0.0810997	0.053*
Lcapital × lacreage	−0.0481295	0.0354144	0.174
Lcapital × llabour	0.0495199	0.0160244	0.002**
Lcapital × linterm_input	−0.0241044	0.0265636	0.364
Lacreage × linterm_input	0.0604558	0.080368	0.452
Lacreage × llabour	0	(omitted)	
linterm_input × llabour	0.035108	0.0333955	0.293
	Mu		
Credit	−0.0000135	$6.33e-06$	0.033**
Credit^2	$-3.64e-12$	.	.
Credit * lcapital	$4.88e-07$	$1.66e-06$	0.769
Credit * lacreage	$-4.28e-06$	$5.20e-06$	0.410
Credit * linterm_input	$8.73e-06$	$5.22e-06$	0.094*
Credit * llabour	$-5.49e-06$	$2.87e-06$	0.055*
Sigma_$v2$	0.1377795	0.0323337	—
Sigma_$u2$	0.5679396	0.1314753	—
Sigma2	0.7057191	0.1101696	—
Gamma	0.8047672	0.0680913	—
Log likelihood = −315.32666 Wald chi2(13) = 1266.53 Prob > chi2 = 0.0000			

Note: *,**,*** significant at 10%, 5%, and 1%, respectively
Source: authors' calculations.

technically improved by the scheme (c), with a prerequisite which is farmers' better access to education. This condition will make them willing to accept change for improvements of their agricultural materials.

Appendix

See Table 6.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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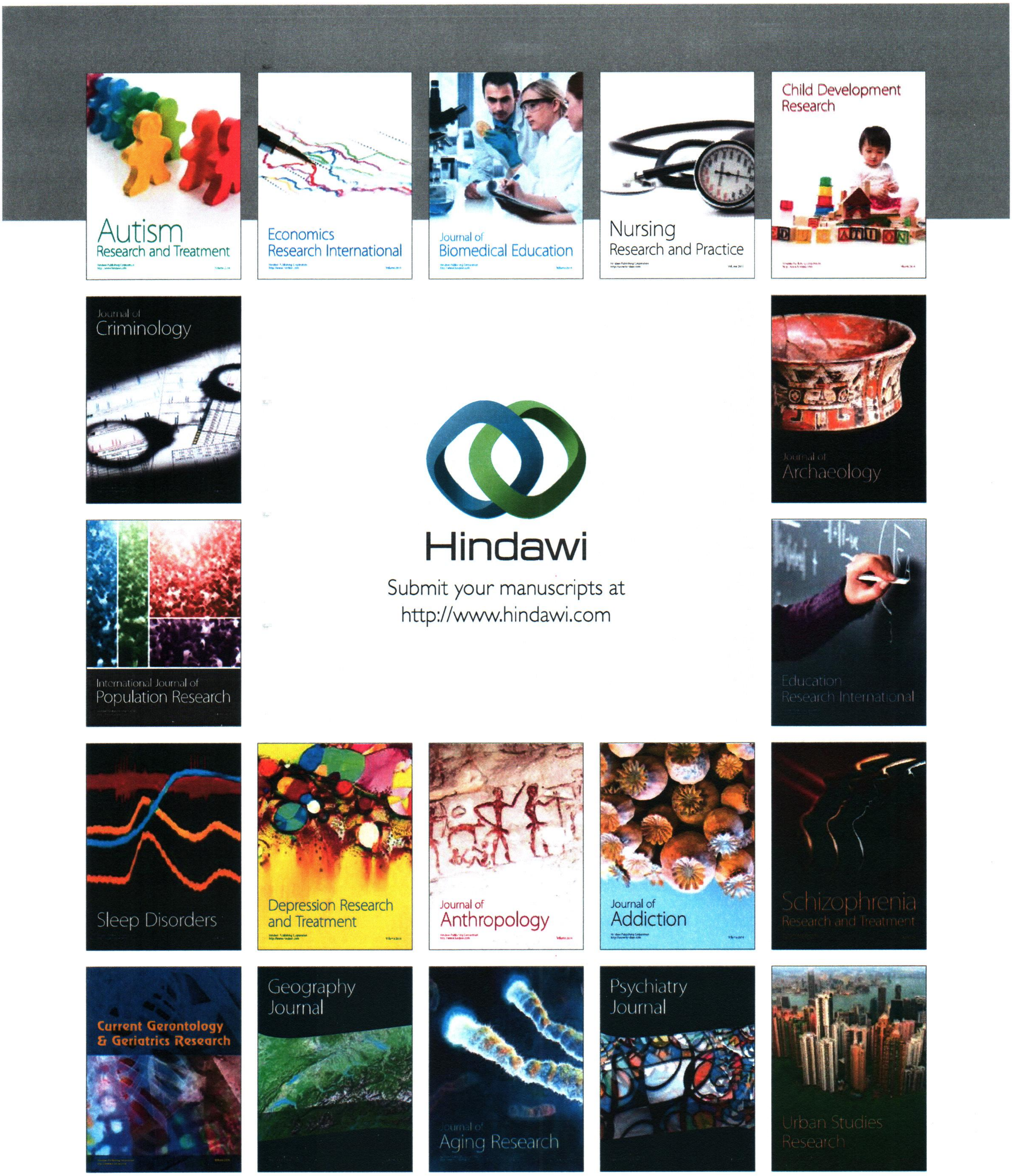

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