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RESEARCH PAPER

For efficient use of arable land in Central African Republic: Performance analysis of agricultural land through major food crops

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Abstract

Throughout sub-Saharan Africa, land is a fundamental issue for economic development, food security, and poverty reduction. Land has a great importance for the economies and societies of a region, contributing a major share of GDP and employment in most countries, and constituting the main livelihood basis for a large part of the population. However, land is becoming gradually rare in many regions due to a variety of pressures. In the Central African Republic (CAR), most of the population is rural, dependent largely on farming or animal husbandry (primarily in nomadic systems) for food and incomes. Therefore, as in other region in Africa the land issue is becoming more and more a preoccupation although the abundant space in the country. In term of this work, we are analyzing the performance of agricultural land through major food crops in CAR by tempting to determine agricultural land efficiency used to increase its performance. That is to say, the work uses panel data, leading our analysis which is focused on the land performance for an efficient use, and the result shows that the relationship between crops yield per unit of land area, production and land area has period random effects. Regarding our model, the land area has a negative effect on the land performance.

Keys words: Agriculture, arable land, performance, food crops, panel data

Introduction

Throughout sub-Saharan Africa, land is a fundamental issue for economic development, food security, and poverty reduction. Land has a great importance for the economies and societies of a region, contributing a major share of GDP and employment in most countries especially in Africa, and constituting the main livelihood basis for a large part of the population. In many areas, however, land is becoming gradually rare due to a variety of pressures, including human population growth and army conflicts. Even in different regions of the planet, the analysis of land values also raises several policy issues, regarding government support, taxation, and environmental protection (Saguatti A et al., 2014).

We can find these situations particularly in countries where agriculture and livestock play an important role in the economy. Practicing agriculture and extensive livestock, farmers and breeders of these countries are frequently in competition in certain lands (Odhiambo & Nyangito, 2003). Social groups have developed written rules or not, to specify the use, sharing and transmission of this precious commodity among people. For this property is at the same time the object of all disputes and conflicts (Zhang et al., 2000).

Indeed, although in some regions, the empty spaces are abundant, in others, the pressure on land begins to be felt and raises tensions to appear. These pressures have resulted in increased competition for land between different groups, such as multiple land users (farmers, herders, etc.), urban elites, and foreign investors. Moreover, socio-economic change has in many places eroded the customary rules and institutions that have traditionally administered land rights: wealthy individuals can acquire land formerly reserved for members of the lineage or tribe, therefore, appears a poor class that has no more right to the land.

Moreover, agricultural land is managed in important investments; those who are using do not want to be dispossessed. African society is undergoing many changes, cities are born and develop, and with them, the emerging urban owner. The recent exploitation of oil fields and mineral resources in some African countries mobilize the entire land.

In the Central African Republic (CAR), most of the population is rural, dependent largely on farming or animal husbandry (primarily in nomadic systems) for food and incomes. Although, there is abundant space in this country, but agricultural land is becoming more and a preoccupation. Conflict and violence have periodically displaced people from their homes; also, with the presence of foreign investors that can acquire a big amount of land, farmers began to be worried about the access to land (Serneels et al., 2012).

Hence, this study is aimed to answer the question how to make the agricultural land efficiently used in order to increase its performance? Therefore, the analysis of the performance of agricultural land through major crops in CAR will help us to answer this question.

Literature Review

Agriculture

Agriculture is defined as the science or practice of farming, including cultivation of the soil, portion of the earth's surface that houses the biosphere (Ehirim, 2013), for the growing of crops and the rearing of animals to provide food, wool, and other products. In other words, Agriculture is the culture of the soil by the human to transform it into plants or pet's production. The purpose of agriculture is to produce food for humans and domestic animals, but also the raw materials used in the industry (Applegate et al., 2002).

Agriculture was invented at the end of prehistory, the Neolithic, there are about 10 000 years (Svizzero et al., 2019) in the Middle East, when the man realizes that his initial activities, hunting, fishing, and harvesting take a long time and energy, and do not relate much food. The invention of this technology changes the lifestyle of local people: they pass a lifestyle nomad to a lifestyle sedentary, creating the first large village. The invention of agriculture has had positive effects, such as time savings but also negative effects. The prehistoric man began to have a less balanced diet richer in carbohydrates. There has been an increase in malnutrition, the number of cavities, and a reduction in the size of 1.78m to 1.68m ways for men and 1.68m to 1.55m for women. Researchers state that there is substantial evidence of agricultural communities whose skeletons show marks of poorer nutrition than forager communities in similar areas at similar or slightly earlier dates (*Property Rights , Warfare and the Neolithic Transition*, 2010). Today the men returned to their size "natural" in most parts of the world through a balanced diet. Agriculture could also be the cause of social stratification. Indeed, at the time of the hunter-gatherer everyone involved in the food search. Then as agriculture demand less work than picking and hunting, it took just a few farmers to work to feed the whole tribe, the other did not need to work. There are two ways of farming: extensive and intensive farming.

Extensive farming

Extensive farming is a way of farming in which the yields are low. The bit is produced in each area. Extensive agriculture is often linked to the natural conditions of the regions where it is practiced. Lack of rainwater disadvantage livestock because of the small plane often accompanied poverty of vegetation cover: farmers must have large areas to be able to feed their herds annually. For the farmer, the lack of water for part of the year allows him to only one crop. The lack of natural fertilizers (especially manure) lack of sufficient livestock also forced the farmer to practice fallow, that is to say, he must renounce cultivate some of his lands for a year to allow reloading of the topsoil nutrient for plants.

Intensive farming

Intensive agriculture is a way of farming in which the returns are high. We produce as much as possible in each area. In other words, intensive farming is a system of raising crops and animals, usually on small parcels of land, where a comparatively large amount of production inputs or labor are used per acre. The oldest because of intensive agriculture must feed a large population while available arable land is reduced, either because of the conditions of terrain or water supply. Ancient Egypt, where only the land receiving water Nile could be grown practiced intensive cultivation. In Western Europe in the seventeenth and eighteenth centuries, farming has become more intensive through the Agricultural Revolution (has more fertilizer, animal by the introduction of forage crops). Today what is sought, is the financial income from the sale of a major production. For this, the plants receiving fertilizer chemicals in large quantities and are protected from pests by chemical treatments (which causes pollution from fertilizers, pesticides...). Farmers are organized as manufacturers and sell to distant markets places of production. This was described by Monchuk, Deininger, and Nagarajan in their work on the efficiency of land fragmentation (Monchuk et al., 2010). They stipulated that many households produce on one or more fragments and may even produce multiple crops on a single, contiguous fragment. Consequently, the value of output (*yield*) is thus aggregated to form a single measure since inputs are reported only at the fragment level and do not necessarily differentiate between field crops where two or more crops are produced on the same fragment in a given season. Land fragmentation can be considered as one of the solutions in the land equity issues in an agrarian society. For instance, in South Asian countries land has a closer link with the livelihoods of the people as the majority depends on agricultural activities (Wickramaarachchi & Weerahewa, 2016).

Land performance

They are several ways to measure land performance such as agricultural productivity and crop yield. Agricultural productivity is measured as the ratio of agricultural outputs to agricultural inputs (FAO, 2017). Agricultural productivity may also be measured by what is termed total factor productivity (TFP) as mentioned by Loomis in his earlier research (Loomis et al., 1971). This method of calculating agricultural productivity compares an index of agricultural inputs to an index of outputs. This measure of agricultural productivity was established to remedy the shortcomings of the partial measures of productivity; notably that it is often hard to identify the factors that cause them to change (Wikipedia). However, the yield of a crop is the relationship between the quantity harvested and the factor of production (land, seed, labor, water, etc.) deemed relevant in the agricultural situation. It is a way to judge the effectiveness of this culture, compared to yields in other areas or with other techniques or varieties. In our analysis, we are focusing on the relationship between the quantity harvested (production) and the land area.

Overview of land issues in Central African Republic

The most crucial land issue in CAR is the land policy which is defined as the course of action established by the state in order to govern modalities of access to land (in rural and urban areas) and natural resources, the modalities of land acquisition, and security of rights to land and natural resources, usage and management of space. A land policy is invariably determined by national and international challenges, which are economic and political. These challenges may vary depending on political and economic orientations of the concerned country (Africa & Assessment, n.d.).

In the Central African Republic, the establishment of modern land legislation was an economic issue during the colonial period. These land laws made prosper the activities of economic operators (industrialists, traders) to the detriment of the most disadvantaged social strata, in particular the natives. This land legislation increases the resources of the colonial administration but also of the metropolitan power through the collection of taxes and fees. These texts of land laws were taken to guarantee the exploitation of the settlements (Wall, 2017).

Unfortunately, after independence, the texts which constitute the legal basis of land still remain these colonial texts, notably the decrees of 1899, because they are modeled on the French model, which was inspired by the Belgian model (Dickerman et al., 1970).

In the Central African Republic, two types of land tenure coexist. Article 20 of the Draft Law on the Agropastoral Land Code stipulates that the modes of access to land and natural resources are modern (formal) and customary (informal) mode.

The modern and formal mode is provided by state services with the issuance of title deeds while customary and informal mode consists of access to land and natural resources of village communities according to traditional rules established locally to land and natural resources where they live and without title deed (Wily, 2012).

Materials and Methods

Model specification

To lead this analysis, we are using panel data, seven cross-sectional data (cassava, corn, pinnate, rice, sesame, millet/sorghum, squash) over four years (2010-2013). The term panel data refer to any data set that has both cross-sectional and time-series dimensions. More precisely Panel Data following the same cross-section units over time (Balanced Panel).

Panel data allow control for individual unobserved heterogeneity (Torres-Reyna, 2007). Since unobserved heterogeneity is the problem of non-experimental research, this benefit is especially useful. They also help in increasing the estimation accuracy. Moreover, they are more informative (more variability, less co-linearity, more degrees of freedom), estimates are more efficient. They give information on the time ordering of events (allow to study individual dynamics).

Our analysis is based on the following equation:

$\boldsymbol{R_{it}} = \boldsymbol{\alpha} + \boldsymbol{X_{it}\beta_{it}} + \boldsymbol{\mu_i}$ (1)
With $\boldsymbol{\mu_{it}} = \boldsymbol{\delta_i} + \boldsymbol{\gamma_t} + \boldsymbol{\varepsilon_{it}}$ (2)

Where R_{it}, denote the dependent variable; in our analysis, the land performance (yield) is taken as the dependant variable. X_{it} denote two vectors regressors, therefore, in our analysis, they are production and surface of the land. The parameter α represents the overall constant in the model and β_{it} the vector of all coefficients in the model.

Equation (2) is called an error components model, where$\delta_i$denotes the unobservable individual-specific effect. It is time-invariant and accounts for any individual-specific effect that is not included in the regression. γ_t denotes the period (time) effect. $\varepsilon_{it} \sim N(0, \delta_\epsilon^2)$ is called idiosyncratic error (Random error Normally distributed). It can be thought of as the usual disturbance in the regression. Therefore, the result of our analysis will come out from the following model:

$$\boldsymbol{R_{it}} = \boldsymbol{\alpha_i} + \boldsymbol{\beta_1 P_{it1}} + \boldsymbol{\beta_2 S_{it1}} + \boldsymbol{\delta_{it}} + \boldsymbol{\gamma_{it}} + \boldsymbol{\varepsilon_{it}} \text{ (3)}$$

Where R_{it} denotes the land performance (yield) per unit of land area (ha), P_{it1} the production and S_{it1} land area.

Model regression

In this part, we just make the regression of different models without any considerations. According to different types of panel data, we will use pooled regression model, panel regression model with variable intercepts to test the cross-sectional and period random effect. Before we go forward, let us establish the variables naming, because we need identifier to specify each variable.

In order to make our pooled data, our model has to categories of series (ordinary series pooled series which is cross-section specific series). Therefore, in our model we have seven cross-section series (Cassava, Corn, Pinnate, Rice, Sesame, Millet/Sorghum and Squash) and three pooled series (Land performance, production and area).

Let's make variables identifiers

Cross Section Identifier:

_MA: Cassava
_MS: Corn
_AR: Pinnate
_RI: Rice
_SE: Sesame
_MI: Millet/Sorghum
_CO: Squash

From these cross-section identifiers, we can make the pooled data:

R_MA: Land performance of Cassava
P_MA: Production of Cassava
S_MA: Area used for Cassava
R_MS: land performance for Corn
P_MS: production of Corn
S_MS: area used for Corn
R_AR: land performance for Pinnate
P_AR: production of Pinnate
S_AR: land used for Pinnate
R_RI: land performance for Rice
P_RI: production of Rice
S_RI: area used for Rice
R_SE: land performance for Sesame
P_SE: production of Sesame
S_SE: area used for Sesame
R_MI: land performance for Millet/Sorghum
P_MI: production of Millet/Sorghum
S_MI: area used for Millet/Sorghum
R_CO: land performance for Squash
P_CO: production of Squash
S_CO: area used for Squash

Results

Pooled regression model

Table 1: Pooled regression model output

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.332135	0.169041	7.880525	0.0000
P?	7.66E-06	1.21E-06	6.333406	0.0000
S?	-1.42E-05	3.80E-06	-3.733698	0.0010
R^2 = 0.744160 Adj. R2 = 0.723693 F-statistic = 36.35872 Prob(F-statistic) = 0.000000				

According to the result of the pooled regression reported in the table 1, we can notice from the different t-Statistic (7.88, 6.33, -3.73) and the probabilities (0.000) that all the coefficients are statistically significant.

Panel regression model with cross-sectional random effect

Table 2: Cross-sectional random effect output

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C P? S?	1.581114 2.85E-06 -9.47E-06	0.128742 8.31E-07 1.97E-06	12.28126 3.431574 -4.809857	0.0000 0.0021 0.0001
R^2 = 0.234431 Adj. R2 = 0.173185 F-statistic = 3.827721 Prob(F-statistic) = 0.035465				
Random Effects (Cross)				
_MA—C	1.744956			
_MS—C	-0.158330			
_AR—C	0.099115			
_RI—C	-0.038946			
_SE—C	-0.569466			
_MI—C	-0.283515			
_CO—C	-0.793813			
Effects Specification				
Cross-section random S.D. / Rho			0.295421	0.8205
Idiosyncratic random S.D. / Rho			0.138184	0.1795

We can notice from this table (table 2) that all the parameters are statistically significant and also the model has a cross-section random effect.

Panel regression model with period random effect

Table 3: Period random effect output

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C P? S?	1.332135 7.66E-06 -1.42E-05	0.179941 1.29E-06 4.05E-06	7.403175 5.949771 -3.507536	0.0000 0.0000 0.0017
R^2 = 0.744160 Adj. R2 = 0.723693 F-statistic = 36.35872Prob(F-statistic) = 0.000000				
Random Effects (Period)				
2010—C	0.000000			
2011—C	0.000000			
2012—C	0.000000			
2013—C	0.000000			
Effects Specification				
Period random S.D. / Rho			0.000000	0.0000
Idiosyncratic random S.D. / Rho			0.512227	1.0000

This table (tables 3) shows us that all the parameters are statistically significant (because they all have a t-Statistic greater than 2) but the model do not have period random effect.

Models testing: Random effect test

In so far, we found that all the models are statistically significant, but we cannot establish which model is valid; this is what we are going to do in the following part.
We are using Hausman test for random effect testing. If Hausman test *p*-value≈0, it indicates the results for the two models are significantly different from each other, indicating that assumptions required for the RE model to be valid are violated. However, according to the Rule of thumb, if Hausman p-value ＞ 0.1, random effects are applicable.

Table 4: Test cross-section random effects

Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random		77.742100	2	0.0000
Cross-section random effects test comparisons				
Variable	Fixed	Random	Var (Diff.)	Prob.
P?	-0.000003	0.000003	0.000000	0.0000
S?	-0.000000	-0.000009	0.000000	0.0000

Table 5: Test period random effects

Test Summary		**Chi-Sq. Statistic**	**Chi-Sq. d.f.**	**Prob.**
Period random		0.049419	2	0.9756
Period random effects test comparisons				
Variable	Fixed	Random	Var (Diff.)	Prob.
P?	0.000008	0.000008	0.000000	0.8861
S?	-0.000014	-0.000014	0.000000	0.8829

** WARNING: estimated period random effects variance is zero

According to the Hausman test and the role of thumb, period random effect model is valid. Therefore, our estimate model can be written as following:

Table 6: Estimate model output

Cassava equation		
Variable	**Values**	**Effect**
C P_MA S_MA	1.332134633 7.655161216e-006 -1.419807653e-005	Period Effect
Corn equation		
C P_MS S_MS	1.332134633 7.655161216e-006 -1.419807653e-005	Period Effect
Pinnate equation		
C P_AR S_AR	1.332134633 7.655161216e-006 -1.419807653e-005	Period Effect
Rice equation		
C P_RI S_RI	1.332134633 7.655161216e-006 -1.419807653e-005	Period Effect
Sesame equation		
C P_SE S_SE	1.332134633 7.655161216e-006 -1.419807653e-005	Period Effect
Millet equation		
C P_MI S_MI	1.332134633 7.655161216e-006 -1.419807653e-005	Period Effect
Squash equation		
C P_CO S_CO	1.332134633 7.655161216e-006 -1.419807653e-005	Period Effect

Discussion

In order to get a consistent result, we have started our analysis from pooled regression model and the result shown us that the intercept and the variables are statistically significant with respectively t-Statistic (7.88, 6.33, -3.733) all greater than 2, and all the probabilities less than 0.05 (table 1).

After running pooled we have introduced random effect model to check whether the model has a cross-section random effect or a period random effect. According to our analysis which is focused on the land performance analysis for an efficient use, we found that the relationship between crops yield per unit of land area, production and land area has period random effects (table 5). This can be explained by the difference between periods due to the variation of seasons. During some periods, there is an abundant rain, however in some it is not. Moreover, we can have some phenomenon like insects and pest, etc. that can affect the crops.

Regarding our model, the land area has a negative effect on the land performance (yield) with a coefficient of -1.419807653e-005 in the table 6, that's to mean the more we increase the land area its performance decreases. Economically this makes sense according to the low of diminishing marginal returns (Sampieri, n.d.). However, although the production has a positive effect on the land performance but remain small. Since CAR's government doesn't have enough means to support farmers, it can push them toward intensive farming to produce more with less land area. We should also draw attention on the fact that in this analysis we don't emphasize on the coefficient value (that is very closed to zero because of the data availability) but we care about their statistical significance and the relevant relationship between variables.

Conclusion

In sum, we can note that the land access is a crucial problem that we should care about. Although, in some regions, the empty spaces are abundant, in other, the pressure on land begins to be felt and raise tensions to appear. In Central African Republic (CAR), the majority of the population is rural, dependent largely on farming or animal husbandry (primarily in nomadic systems) for food and incomes. Therefore, as in other regions of Africa, land issue is becoming more and more a preoccupation although there is an abundant space in the country. Conflict and violence have periodically displaced people from their homes; also, the presence of foreign investors that can acquire a big amount of land, farmers began to be worried about the access to land. Therefore, the Government should implement some land property policy to regulate the land access.

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