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Effects of human capital on agricultural productivity in Senegal

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ABSTRACT

To feed the African's population from a strong agriculture able to fight food insecurity requires to increase the level of human capital operators (education, training and experience). This study aims to analyze the effects of human capital on the efficiency and productivity of farmers. Using stochastic frontier model and simple Tobit, we examined the impact of human capital on agricultural productivity of 183 operators spread over three communes (Diama and Ronkh Gandon) of Senegal River valley. The results from the estimates show that human capital affects positively and significantly the productivity. These results imply that improving the level of education and experience is likely to increase yields and to make them more efficient.

***Keywords*:** Human capital; agricultural productivity; production function; non-parametric model; tobit model

1. INTRODUCTION

Agriculture plays an important role in terms of food security. This is why it occupies a prominent place among the Sustainable Development Goals (SDGs) that lead to the economic prosperity of the poorest nations. It is a mechanism to provide poor households with the means to cover their food expenditure and, above all, to improve their nutritional status. In the African context, the agricultural sector occupies an important place. It employs more than

65% of the available workforce. But its contribution to the Gross Domestic Product (GDP) remains very low; it is 36% (World Bank, 2014). At present, it is urgent for governments and international organizations to make agriculture a mean of combating poverty and reducing hunger in Africa. However, to achieve this, a broadly agreed consensus seems to emerge between the different actors: a high level of human capital is a necessary condition for increase agriculture productivity.

Senegal, like other developing countries, is committed to achieving food self-sufficiency in certain types of speculation, particularly for rice and onion by 2017. Thus, for more than two decades, a variety of programs and policies have been adopted by the government. The main objective was to create the conditions for a strong agriculture capable of promoting sustained and sustainable growth capable to reduce significantly the hunger. These include the 1984 General Assembly with the implementation of agricultural policy and strategy defined in the Letter of Agricultural Development Policy (LPDA), the Agricultural Sector Adjustment Program (PASA), a logical continuation of the New Policy Agricultural (NPA-1984), and finally the Law of Guidance Agro-Sylvo Pastoral (Loasp) constituting a consensual text adopted in 2004 favoring a more global approach in the management of the agricultural questions.

However, the 2008 food crisis showed all the shortcomings of these policies to guarantee food security in Senegal. This fragility and lack of dynamism in the sector raises several questions and attempts to explain. To describe this underperformance of African agriculture, several studies highlight its dependence on climatic changes, and its weak mechanization. A limited level of fertilizer use, low use of new agricultural technologies and lack of innovation among farmers are also mentioned as constraints to successful African agriculture.

Consequently, the success of any action taken in favor of this sector remains dependent on the ability of farmers to take ownership of all reforms and innovations. Therefore, it is important to use a level of human capital that is responsive to the demands of modern and efficient agriculture; as highlighted by the World Bank, the low level of human capital in the African agricultural sector remains a major obstacle to economic growth, poverty reduction, and thus food security.

The empirical literature that has developed on the link between human capital and agricultural productivity has revealed two approaches. The first is to model technical efficiency using different methods, the most common of which is the stochastic boundary model. The second approach highlights the nature of the link between human capital and productivity. Some authors emphasize the need to model in time series. It becomes important to examine the interactions between human capital and productivity of farmers in Senegal. In other words, does human capital increase productivity?

The role played by human capital on agricultural productivity is still poorly appreciated quantitatively and especially not taken into account in agricultural policies in Senegal. The general objective of this study is to analyze the impact of human capital on the productivity of farmers in Senegal. The specific aim is to seek, on the one hand, to understand the farmer's profile and, on the other, the direct and indirect effects of human capital on productivity.

The study of human capital impact on productivity is important for the Senegalese authorities. It enables them to implement, as efficiently as possible, measures to improve the education and training of farmers. However, there is a limited amount of research aimed at

examining the interaction between human capital and productivity. This study aims to fill this gap of empirical studies.

To achieve the objectives of this study, we use a simple censored Tobit. The results obtained from the estimates of a sample of 183 farmers in three communes show that human capital as a whole, represented by education and experience, has a positive impact on agricultural productivity.

The remainder of this study is organized as follows: Section 2 gives an overview of the literature, Section 3 details the methodology, Section 4 describes the data, Section 5 presents and discusses the results, and Section 6 offers some conclusions and remarks.

2. REVIEW OF THE LITERATURE

The study of the impact of human capital on agricultural productivity goes back to the work of Schultz (1961). It shows that education and training of workers is a means of increasing productivity and agricultural income. Later, Welch (1970) distinguishes the channels through which human capital has an effect on agricultural productivity. Initially, thanks to the education acquired, the farmer significantly improves the quality of his work. Secondly, from his experience, he uses inputs more efficiently. The second channel is explained by a better adaptation of the peasants to the price signals sent by the market. Finally, thanks to the education acquired, the farmer becomes more apt to select the best inputs.

Later, Klasen and Remeirs (2011) try to find the channels of transmission of education on agricultural productivity. Education is a key driver in the search for and possession of information. The operator, taking advantage of the information available to him, will make better decisions, resulting in better management capacities and efficient allocation of resources. As a result, it is able to innovate through the development of new processes and products.

There is a variety of empirical studies of human capital impact on productivity. Lockheed and Lau (1980), using different types of production functions used in the literature, show that education has a positive and significant effect on agricultural productivity. On average, an increase in production of 7.4% can be explained by the fact that farmers have spent at least four years of education. Philips (1994), using the same database as those previously mentioned and extending it by adding twenty other observations, confirms the same result. It shows that this impact could be in the range of 6% to 8%.

The positive impact of human capital on agricultural productivity is reinforced by the study by Mohapatra and Sen (2013). Using a model, Data Envelope Analysis (DEA), applied to 200 farmers in India, they show a positive impact of the level of education on technical and allocative efficiency. Djomo (2012), using the Stochastic Production Function (SPF) model, measures the effect of human capital on agricultural productivity and income of farm managers in Cameroon. An additional year of study and experience significantly increases agricultural productivity.

In other empirical studies, the impact of human capital on productivity is zero or even negative. Danquah and Ouattara (2014), using a time series (1960-2003) on the economies of African countries south of the Sahara, show that human capital has no effect on productivity. When decomposing total factor productivity from its main components, human capital

positively impacts technical efficiency. Aurojo et al. (1999) find a negative effect when they have integrated the average level of education of farmers in the production function. This is attributed to a data aggregation bias. Gurgand (1993) explained this paradox by the existence of dualism in the agricultural sector in the economies of African countries. It showed that in Africa the education of some family members diminishes their productivity.

3. METHODOLOGY

Stochastic boundary models were introduced by Aigner and Schmidt (1977) and Meeusen and Broeck (1977). Since then, they have become popular through their econometric applications (Kumbhakar and Lovell, 2000). The use of the boundary is adapted for production functions to determine inefficiencies. According to the work De la Fuente (2013), our analysis of the relationship between human capital and agricultural productivity is based on a Cobb Douglass production function:

$$q_i = A_i K_i^{ka} H_i^{ah} L_i^{al} \tag{1}$$

where, q_i represents the level of production of the operator i, L_i represents the level of employment, K_i the stock of physical capital, H_i the average stock of human capital of the farmer and A_i other factors that may influence production. α_i $(i = k, h, l)$ mesure the elasticity of production.

The analysis of the stochastic boundary assumes that, due to a given degree of inefficiency, the farmer reaches a level of production below potential output. Taking into account the degree of efficiency, the production function will be given by:

$$q_i = f(Z_i, \beta) \tag{2}$$

We suppose that: $q_i = A_i K_i^{ka} H_i^{ah} L_i^{al} = f(Z_i, \beta).$

where ξ_i is the level of efficiency of the farmer, ξ_i being therefore between [0, 1].

If $\xi_i = 1$, the operator achieves optimum production with the technology given by the production function $f(Z_i, \beta)$. Si $\xi_i < 1$, the producer does not fully utilize inputs during production. Because production is assumed to be strictly positive $(q_i > 0)$, the degree of technical efficiency is also assumed to be strictly positive $\xi_i > 0)$.

The Production is also assumed to be impacted by random shocks; which implies:

$$q_i = f(Z_i, \beta)\xi_i \exp(v_i) \tag{3}$$

Taking into account the logarithm function on both sides, we have:

$$\ln(q_i) = ln\{f(Z_i, \beta)\xi_i\} + ln\xi_i + v_i \tag{4}$$

Assuming that there are k inputs and a linear production function, with $u_i = -ln\xi_i$, the function becomes:

$$ln(q_i) = \beta_0 + \sum_{j=0}^{k} \beta_j \ln(z_{ji}) + v_i - u_i \quad (5)$$

Because u_i is obtained from (q_i), posed $u_i > 0$ suppose that $0 < \xi_i < 1$.
The resulting boundary model is of the form:

$$y_i = \beta_0 + \sum_{j=1}^{k} \beta_j x_{ji} - su_i \quad (6)$$

where $s = 1$ for the production function $y_i = \ln(q_i)$, $x_{ji} = ln(Z_{ji})$.

$u_i \, et \, v_i$ are assumed to be independent and follow a normal distribution $N(0, \sigma_u^2) \, et \, N(0, \delta_v^2)$

Considering the equation of the following form:

$$q_i = X_i\beta + v_i - su_i \quad (6)$$

The likelihood function is given by:

$$lnL = \sum_{i=1}^{N} \left\{ \frac{1}{2} \ln\left(\frac{2}{\pi}\right) - ln\sigma_s + \Phi\left(\frac{-s\epsilon_i\lambda}{\delta_s}\right) - \frac{\epsilon_i^2}{2\delta_s} \right\} \quad (7)$$

where $(\sigma_s = \delta_u + \sigma_v)^2$, $\lambda = {}^{\sigma_u}/_{\sigma_v}$ $\epsilon_i = y_i - X_i\beta$ and Φ is the cumulative function of normal error distribution.

4. DATA

Table 1 in the appendix provides some descriptive statistics of the data. When the education variable is considered, most of the farmers surveyed state that they have followed Koranic studies. These individuals account for 29.67% of the 183 respondents. The teaching of the French language seems not to be favored. Of the total number of farmers who studied in French, only 24.8% completed primary school. Analysis of the data also indicates that 1% of farmers report having reached tertiary education.

To improve their productivity, and thus their production, farmers organize themselves as cooperatives. This association constitutes an illustrative mechanism generating positive externalities which pass through the mutual sharing of knowledge and know-how. The statistical information shows that the proportion of farmers who are members of a cooperative is greater compared to farmers who are not members. More than 85% of them are members of a cooperative.

5. RESULTS AND DISCUSSION

Table 2 gives the results of estimates of the impact of human capital on agricultural productivity. Before proceeding with the discussion of the results from the estimates, heterocédasticity was tested to ensure the robustness of the model. Since the data used is of the cross-section type, there is a potential risk of heterogeneity of errors (Green, 2008).

The results from the Breusch and Pagan test indicate that the null hypothesis of homocedasticity cannot be rejected. It is therefore important to correct this heterogeneity before model estimation.

The results of the estimates clearly show that human capital has a positive impact on the productive efficiency and productivity of farmers. Indeed, the coefficients are positive and significant in both models. Specifically, the level of education of the farmer acts positively on productive efficiency. The coefficient is significant and equal to 0.0299. Thus indicated by the marginal effects, productivity increases when the education level of agriculture is on a rising slope. The elasticity of production in relation to the level of education is equal to 0.0247 and appears to be significant when compared with those obtained in the empirical literature (Djomo, 2012). Any economic policy on the agricultural sector to improve significantly the level of education of farmers increases the level of efficiency and productivity. Education acts positively on productivity by allowing the farmer better selection of the inputs needed for production. Table 1 gives the results of the estimates.

Table 1. Estimated results.

Variables	Tobit	Frontière stochastique
Ln farmer education	0.0247*	0.0299***
	(0.10)	(0,00)
Member association	0,016	0,0971*
	(0,27)	(0,10)
Property title	-0.0054	-0.0054
	(0,70)	(0,59)
Type of crop	0.0436**	0,1372*
	(0.02)	(0,07)
Funding	0.0336*	0,0278***
	(0.09)	(0,00)
Distance from field	0.0000**	0,002***
	(0.04)	(0,00)
Ln area	-0.0353**	-0,0072***
	(0.03)	(0,00)
Years of experience	0.018**	0,0006***
	(0.03)	(0,00)
Constant	-0,1754**	-1,254
	(0.05)	(0,12)
N	183	183
Likelihood Ratio	20,76	5,88
	0.05	(0,005)

Notes: Values in parentheses represent probabilities. Significance levels of 1, 5, and 10 percent are indicated by ***, * * and * respectively.

The number of years of experience positively impacts productivity and productive efficiency. Productivity increases considerably when the farmer acquires an important level of experience. Thus, ten years of experience increase productivity by 0.01%. The level of experience affects productivity on several levels. First the farmer uses rations more inputs, given a level of arable land. In addition, it adapts the crop according to the season of the soil. Finally, the level of experience, in addition to having a positive impact on productivity, generates positive externalities since the farmers come together in a cooperative to exchange knowledge.

The type of crop positively impacts productivity. Thus, field crops prove to be more beneficial than small crops; in the sense that their yields are higher. Diversification is a factor in increasing agricultural yields. When the farmer passes from small crops to field crops, he increases his productivity by 0, 04%.

The positive impact of the distance variable on productivity caught our attention. A 10% increase in the distance between home and field increases agricultural productivity considerably by 0.01. Indeed, on the valley of the river Senegal, the peasants far from their fields spend the day in their cultures. This increases the time spent on exploitation and monitoring.

In the econometric model, other control variables were used to obtain much more robust results. The monetary variable (access to finance) positively impacts agricultural productivity. Farmers who have more access to external financing sources increase their productivity.

6. CONCLUSION

In this paper, using a stochastic boundary model and a simple Tobit model, we examined the impact of human capital on the agricultural productivity of 183 farmers in the Senegal River Valley. Using a Cobb Douglass production function, human capital, represented by education and level of experience, has a positive impact on the agricultural productivity of farmers in the Senegal River Valley. These human capital variables also have positive effects on technical efficiency.

Any policy aimed to increase the level of agricultural productivity needs to identify several factors. One of the factors is the choice of the measure to be taken since the components of human capital do not have an equal impact on the productivity of the farmers. Even if, it is possible to directly influence the level of training and education of farmers by a policy, it is difficult to do the same on the level of experience. Another factor could be taking to account the existence of potentials and positive externalities generated by cooperatives' implementation. A good understanding of all the elements that increase productivity is crucial for sustainable agriculture. It is therefore important to focus on education and training of farmers for the challenges of self-sufficiency and food security.

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Appendix

Tableau A1: statistiques descriptives

Données	Fréquence	Pourcentage
Education		
Primary	51	28,02
Secondary	38	20,88
University	2	1,10
Technical education	6	3,30
Arabic education	54	29,67
uneducated	25	13,74
other	6	3,30
Diploma		
CEPE	21	16,15
CFEE	20	15,38
BEFEM	14	10,77
BAC	2	1,54
CAP	2	1,54
LICENCE	1	0,77
MAITRISE	1	0,77
BTS AUCUN	1	0,77
AUCUN	62	0,77
AUTRES	6	4,62
Coopération member		
yes	156	85,25
no	27	14,75
Type of crop		
Great crop	141	77,05
Market gardening	42	22,95
Funding	124	67
Own funds	59	33
borrowing		

Tableau A2: résumé statistique

	Moyenne	Intervalle
Production (en tonnes)	9,68 (16,19)	[0,01, 70]
area (en hectare)	2,53 (6,63)	[0,15, 180]
Years of experience (en années)	39,77 (156,17)	[2, 35]