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MODELLING INVESTMENTS IN COTTON PRODUCTION IN THE MUNICIPAL AREAS OF KOUANDÉ AND KÉROU IN THE NORTHERN PART OF REPUBLIC OF BENIN, WEST AFRICA

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ABSTRACT

This study aims at analysing the effects of the investments in cotton production on the output elasticity in Kouandé and Kérou, Republic of Benin, West Africa. Data were collected from June to September 2012 by surveying one hundred and forty (140) cotton farmers, randomly selected in the study area. The Cobb-Douglas and Translog models were estimated by considering six (06) inputs, namely: acreage of cotton, quantities of mineral fertilisers used, insecticides, herbicides, capital and family labour. The results revealed that the average acreage of cotton per farmer was 3.05 ha. Per hectare, farmers used on average 145.01 Man-Day of family labour, 305.15 kg of fertilisers (NPK and Urea), 1826.30 ml of insecticides (Thian, Serfox, Tunder, and Miticide), 3692.70 ml of herbicides (Calah and Califor G), and Francs CFA 42411 as capital. The Cobb-Douglas model showed that investing in land, mineral fertilisers, insecticides, and herbicides was technically efficient. In contrast, the Translog model revealed that the cotton productivity was rather determined by the interactions between “labour and herbicides”, “labour and capital”, and “capital and herbicides”; which have significantly impacts on the cotton output elasticity. Among these options, only the combination “labour and herbicides” ensure a positive and significant output elasticity and therefore, appears to be the best investment alternative.

Key words: Cotton production, Investments, output elasticity, Kouandé and Kérou, Republic of Benin.

INTRODUCTION

In developing countries, most people living in rural areas are engaged in agriculture. Hence the sensitivity of the agricultural sector that is subject to various policy interventions. In Republic of Benin, agriculture accounts for about 39% of the Gross Domestic Product (INSAE, 2004). This performance is mainly ensured by cotton, a cash crop, which provides up to 18% of the GDP (INSAE, 2004), representing the most important agricultural production in term of foreign exchange earnings (Morris, 1990; Paraïso *et al*., 2012).

In the Beninese cotton production zones, most of the farming systems are smallholdings (Sinzogan *et al*., 2004). To improve this small scale production and enhance export earnings, cotton farming in Benin Republic has become one of the priorities of the rural development policy. Consequently, projects

(AIC, OBEPAB, etc.) and policy interventions (extension services, subsidies of inputs, etc.) have been initiated and implemented. The overall socioeconomic impact expected from these projects and interventions was to make efficient the cotton production systems, and therewith, improve the living conditions and livelihoods of cotton farmers. As a result of these interventions, cotton production in Benin has increased fourfold in the last 20 years (Raymond and Beauval, 1995; Biaou and Ahanchede, 1998), thus ranking the country in the second place in sub-Saharan Africa in terms of production from 1994 to 1996 (Sinzogan *et al.*, 2004).

Despite this performance, cotton production is currently facing many challenges, implying severe problems for the economy. These challenges that are among others the high price of inputs, the delayed of payments to producers, the problems of non-judicious use of chemicals, and the increased insects' resistance to pesticides (Sinzogan *et al*., 2004), had led to a drop in cotton yields below 1000 kg/ha between 1997 and 2000 (Raymond and Beauval, 1995; Ton, 2002). After the highest production of 412 309.81 tons of cotton seed in 2001, the total production declined to 211 751.35 tons, 157 968.27 tons, and 136 958.02 in 2008, 2009, and 2011, respectively (CeRPA, 2012).

In addition to this situation associated with the instability of the cotton prices, it has become riskier and riskier for farmers, well known as risk averse agents, to invest in cotton production. However, to some extends, farmers need to produce cotton for generating cash income in order to meet food or non-food needs (foods purchasing, level of education, health expenses, etc.) of their households. As a result, farmers have to be careful on the allocation of their production resources for cotton cultivation. This situation is also important for policy makers since they should be able to advice farmers on profitable and efficient ways to invest in cotton production. In order to meet this need of both farmers and policy makers, this paper aims at analysing the effects of the investments in cotton production on the output elasticity in two municipal areas in Republic of Benin.

Theoretical background

Agricultural production in general and cotton production in particular require a lot of investments on inputs. Beyond the set of inputs, the biggest challenge of investing in any economic activity is to decide on the amount of the different inputs for various activities involved in order to maximise output. In agriculture, especially in developing countries characterised by low input use (low mechanisation, low irrigation, etc.), it is quite difficult to predict the final output at the beginning of the production. In fact, many factors such as climate, soil fertility, pests and diseases make very uncertain any projection of yield. Given this, investing in agriculture becomes riskier, uncertain, and also irreversible since the inputs are involved from the beginning of the production while the output is the final result, determined by the inputs previously invested. In such context, farmers have to sustain their profitability by applying the principles of Production Theory.

Based on the concepts of uncertainty and irreversibility of investments, Malinvaud (1987), highlighted the importance of profitability calculations in investment decisions. Indeed, a a non-optimal allocation of inputs might lead to a situation of under or over-production. Whatever the case, it is costly for farmers to have excess or insufficient capacities in comparison to its expected average level of production. To some extents, the investment decisions that farmers have to make regarding production inputs lie in the determination of a rate (level) of utilisation on the basis of an anticipated demand and risk related to the anticipation of error (uncertainty).

Investment often refers to a value or a cost. However, it may be well appreciated in terms of quantity (kg, ha, ml, etc.). According to general economic theory as well as the producer theory, a farmer is an economic agent looking forward to maximize its profit under the constraint of production costs (Rasmussen, 2011). In other words, his aim is to maximize the amount of output while using minimum input combinations which minimise costs. Subsequently, the output elasticity defined as the percentage change of output induced by one percentage change of any investment might be accessed through the impact of marginal cost (or quantity) of investment on the marginal revenue (or quantity of output). This refers to the modelling of the production.

MATERIALS AND METHODS

Study area and data

The study area is situated in the North Western Region of Republic of Benin, in West Africa. In this region, two municipal areas (Kouandé and Kérou) well known for cotton production have been selected. Kouandé is located on North latitude10° 19'54'' and East longitude 1°41'29'' while Kérou is on North latitude 10°49'30' and East longitude 2°6'34'' (Figure 1). In both municipalities from June to September 2012, the climate is a Sudano-guinean one (Afrique Conseil, 2006a; 2006b). In each municipality, two villages (Firou and Kérou Centre in Kérou, Niekene-Bansou and Becket in Kouandé) were selected according to their importance in cotton production.

Primary data were collected from a random sample of 140 farmers producing cotton, after rapid a census of all cotton farms in the study villages. Data related to socio-economic and demographic characteristics of the selected cotton farmers and the quantities of inputs and output were collected. The data collection took place as a field study from June to September 2012, using an individual survey questionnaire and some structured and semi-structured interview guides. Some focus groups were also organised to collect data at the village level. Data were processed and analysed by using Excel and SPSS 16.0.

Methods of data analysis

Empirical modelling of production

Throughout the literature, the Cobb-Douglas model is widely used to estimate the production functions that represent the relationship between the output and two or more inputs. Moreover, the Cobb-Douglas model appears to be the easiest to analyze, provides a good estimate of current productions (Romer, 2001; Minna *et al.*, 2007), gives directly the elasticities, and allows to deal with the problems related to the heteroscedasticity (Wolff, 1997). In general, the Cobb-Douglas specification can be viewed as a function transforming the production factors or inputs, mainly capital (denoted by K) and labour (denoted L) in a product or output (denoted Y) (Brown, 1967). The implicit form of the Cobb-Douglas equation is as indicated in equation 1.

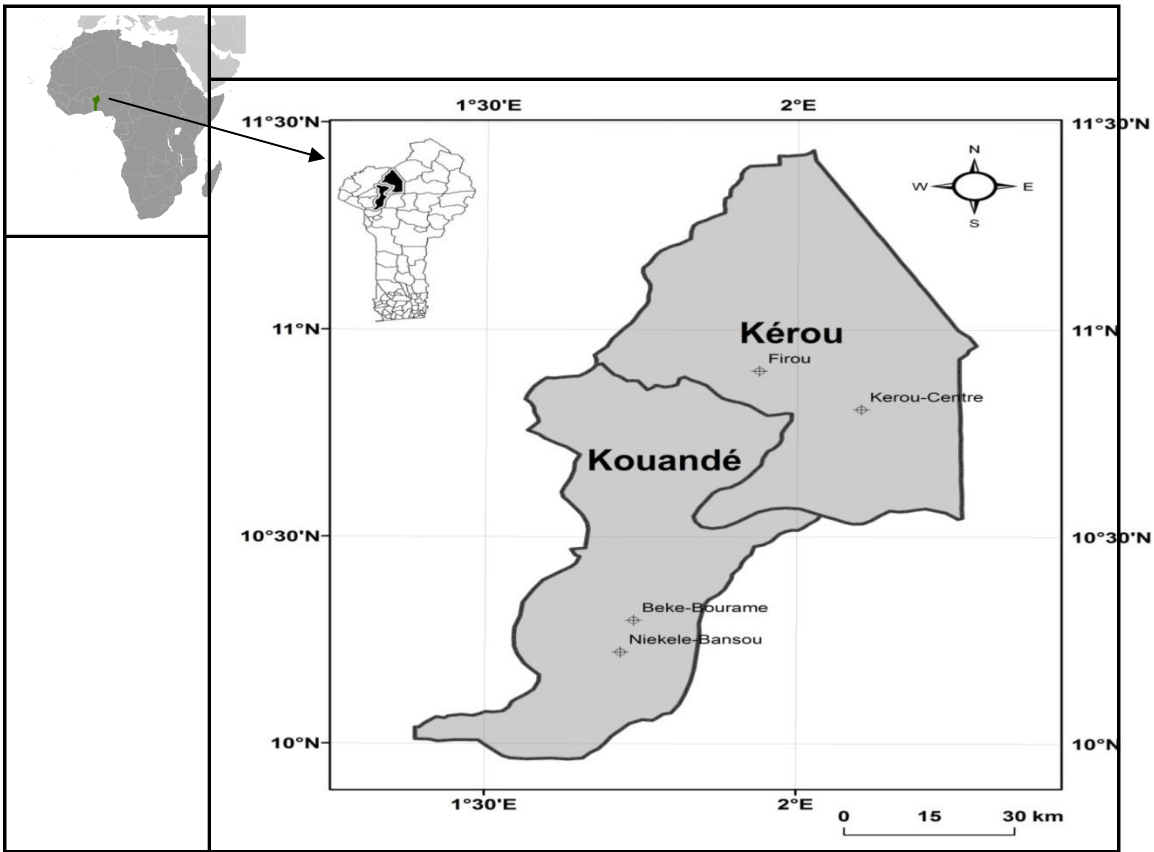

Figure 1: Study zone
Source: Authors' compilation

$$Y = y(K; L) = AK^{\alpha}L^{\beta} \quad \text{with} \quad 0 < \alpha < 1 \text{ and } 0 < \beta < 1 \qquad [1]$$

Where: A stands for a constant terms; α and β are parameters to be estimated. By applying the logarithm function to this equation we reach the most simplified form written as follows:

$$\ln Y = \ln(K; L) = \ln A + \alpha \ln K + \beta \ln L$$
$$\text{with } 0 < \alpha < 1 \text{ and } 0 < \beta < 1 \qquad [2]$$

From this function, the elasticities of production are determined using the following formulas:

$$\text{For K: } \partial \ln Y.\ (\partial \ln K)^{-1} = \partial \ln(K; L).\ (\partial \ln K)^{-1} = \alpha$$
$$\text{For L: } \partial \ln Y.\ (\partial \ln L)^{-1} = \partial \ln(K; L).\ (\partial \ln L)^{-1} = \beta \qquad [3]$$

As elasticities, α and β are proportions of change that would be observed the quantity of output if farmers increased the quantities of capital (denoted by K) and labour (denoted L) by 1%, respectively. Hence, positive values of α and β indicate increases of the quantity of output while the quantities of inputs increase.

Although simple and widely used, this specification is accurate and relevant if there were no interactions between the production factors. Thus, the Cobb-Douglas function is a special case of production function built upon the assumption that the interactions between inputs have no statistically significant effect on the output. Otherwise, the production is better translated while using a Translog function. Following Christensen *et al.* (1971), the flexible and most used form for this Translog function is defined by:

$$lnY = A + \sum_i \beta_i lnX_i + \sum_i \sum_j \beta_{ij} lnX_i lnX_j \quad [4]$$

Where: Y stands for the quantity of output, A for a constant term, X for the inputs, and β for the parameters to be estimated. Like in the case of a Cobb-Douglas function, the estimated coefficients using a Translog model allow a reconstruction of the output elasticities for each production factor, calculated at the mean. As suggested by Charlot *et al.* (2002), the output elasticity with respect to each factor is expressed by:

$$\partial lnY.\,(\partial lnK)^{-1} = \beta_i + 2\beta_{ij} lnX_i + \sum_{(j>i)} \beta_{ij} lnX_j \quad [5]$$

By reconsidering the two previous inputs (capital (denoted by K) and labour (denoted L)), the Translog model as presented in equation [4] becomes:

$$lnY = lny(K; L) = lnA + a lnK + \beta lnL + (1/2)\gamma lnK^2 + (1/2)\delta lnL^2 + \theta lnK lnL \quad [6]$$

Subsequently, the output elasticities of the inputs as in equation [5] become:

$$\text{For K: } \partial lnY.\,(\partial lnK)^{-1} = \partial ln(K; L).\,(\partial lnK)^{-1} = a + \gamma lnK + \theta lnL$$

[7]

$$\text{For L: } \partial lnY.\,(\partial lnL)^{-1} = \partial ln(K; L).\,(\partial lnL)^{-1} = \beta + \delta lnL + \theta lnK$$

Unable to assume the non-significance of the interactions between inputs involved in the production process, this work used both Cobb-Douglas and Translog specifications for analysing the investments in cotton production. Six inputs were considered for this purpose (Table 1).

Table 1: Variables introduced in the models

Variables	Notation in the models	Unit
Quantity of Cotton a	Q	kg/ha
Acreage of cotton	S	Ha
Quantity of Labour	M	Man-day/ha
Quantity of Fertilisers	E	kg/ha
Quantity of Insecticides	I	ml/ha
Quantity of Herbicides	H	ml/ha
Quantity of Capital	C	Francs CFA/ha

[a] :Output and endogenous variable
Source: Authors' specifications

By integrating these inputs in equations [2] and [6], we obtained the following empirical models:

Cobb-Douglass model :

$$lnQ = \delta_0 + \delta_1 lnS + \delta_2 lnM + \delta_3 lnE + \delta_4 lnI + \delta_5 lnH + \delta_6 lnC + u \quad [8]$$

Translog model :

$$lnQ = \lambda_0 + \lambda_1 lnS + \lambda_2 lnM + \lambda_3 lnE + \lambda_4 lnI + \lambda_5 lnH + \lambda_6 lnC + (1/2)\lambda_7 lnS^2 + (1/2)\lambda_8 lnM^2 + (1/2)\lambda_9 lnE^2 + (1/2)\lambda_{10} lnI^2 + (1/2)\lambda_{11} lnH^2 + (1/2)\lambda_{12} lnC^2 + \lambda_{13} lnSlnM \; \lambda_{14} lnSlnE + \lambda_{15} lnSlnI + \lambda_{16} lnSlnH + \lambda_{17} lnSlnC + \lambda_{18} lnMlnE + \lambda_{19} lnMlnI + \lambda_{20} lnMlnH + \lambda_{21} lnMlnC + \lambda_{22} lnElnI + \lambda_{23} lnElnH + \lambda_{24} lnElnC + \lambda_{25} lnIlnH + \lambda_{26} lnIlnC + \lambda_{27} lnHlnC + v \quad [9]$$

n these models, u and v stand for the error terms, δ_0 and λ_0 for the constant terms, and δ_i and λ_i for the regression coefficients to be estimated. From the equations [8] and [9], the elasticities as defined in equations [3] and [7] become:

	Cobb-Douglass	Translog
S: $\partial lnQ.(\partial lnS)^{-1}$	δ_1	$\lambda_1 + \lambda_7 lnS + \lambda_{13} lnM + \lambda_{14} lnE + \lambda_{15} lnI + \lambda_{16} lnH + \lambda_{17} lnC$
M: $\partial lnQ.(\partial lnM)^{-1}$	δ_2	$\lambda_2 + \lambda_8 lnM + \lambda_{13} lnS + \lambda_{18} lnE + \lambda_{19} lnI + \lambda_{20} lnH + \lambda_{21} lnC$
E: $\partial lnQ.(\partial lnE)^{-1}$	δ_3	$\lambda_3 + \lambda_9 lnE + \lambda_{14} lnS + \lambda_{18} lnM + \lambda_{22} lnI + \lambda_{23} lnH + \lambda_{24} lnC$
I: $\partial lnQ.(\partial lnI)^{-1}$	δ_4	$\lambda_4 + \lambda_{10} lnI + \lambda_{15} lnS + \lambda_{19} lnM + \lambda_{22} lnE + \lambda_{25} lnH + \lambda_{26} lnC$
H: $\partial lnQ.(\partial lnH)^{-1}$	δ_5	$\lambda_5 + \lambda_{11} lnH + \lambda_{16} lnS + \lambda_{20} lnM + \lambda_{23} lnE + \lambda_{25} lnI + \lambda_{27} lnC$
C: $\partial lnQ.(\partial lnC)^{-1}$	δ_6	$\lambda_6 + \lambda_{12} lnC + \lambda_{17} lnS + \lambda_{21} lnM + \lambda_{14} lnE + \lambda_{26} lnI + \lambda_{27} lnH$

[10]

Likewise, the elasticities of the different interactions could be derived from the Translog model.

RESULTS AND DISCUSSION

Socio-economic and demographic characteristics of the respondents

Cotton production in the study area mainly involves (98.6%) men. The interviewed cotton producers are about 37 years old on average, and all married, and are employed secondary economic activities. In most of the cases, the respondents have a side activity. The levels of education and literacy are very low while the household sizes are up to (10 members). All the respondents are in contact with extension services. The main socio-economic and demographic characteristics of the respondents are summarised in Table 2.

Table 2: Socio-economic and Demographic Characteristics of the Respondents

Qualitative Variables	Frequency	Percentage
Sex	--	--
Female	02	1.40
Male	138	98.6
Side activity	116	82.9
Level of education	29	20.70
Literacy	49	35
Contact with extension	140	100
Quantitative Variables	Mean	Standard deviation
Age	36.93	11.75
Household size	15.22	10.01

[a]: Stands for secondary occupation. In addition to agriculture, activity (commerce, hand works, services, etc.) respondents are engaged in.
Source: Authors' calculations

Descriptive statistics of the variables included in the models

Table 3 shows that the average **a**creage of cotton per farmer is 3.05 ha (± 4.12). This farm size indicator is lower than the one found out by Sinzogan *et al*. (2004), who observed that the average size of cotton farms in Republic of Benin is 5 ha. The average quantities of labour (family support and employee), fertilisers (NPK and Urea), insecticides (Thian, Serfox, Tunder, and Miticide), herbicides (Calah and Califor G) and capital per hectare of land under cotton cultivation were 145.01 Man-Day, 305.15 kg, 1826.30 ml, 3692.70 ml; and Francs CFA 42,411, respectively.

In the municipal areas of Kouandé and Kérou, the agricultural production mainly depends on the household labour availability. According to Yegbemey *et al*. (2013), bigger households have more labour available for performing agricultural activities. As a result, on the one hand, the average household size of 10 members seems to sufficiently supply the labour demand of the small scale cotton farming. On the other hand, this might be a constraint to large scale cotton farming that have to hire labour.

The use of fertilisers and pesticides (especially insecticides) is a must in cotton production. The average quantity of fertilisers currently applied by farmers (305.15 ± 497.46 kg/ha, Table 3) is higher than the recommended doses (200 kg/ha: 150 kg of NPK and 50 kg of urea). This finding is closed to the one of Sodohoué (2003) who found out that the average quantity of fertilisers used for cotton in south-eastern of Republic of Benin was 486.5 kg/ha. Such excessive application of fertilisers also features in rice farming in northern of Republic of Benin (Yegbemey, 2010). Farmers attribute this overuse of fertilisers to the low fertility of soils that have been under production for long periods. Considering the recommended doses (2 vials/ha/treatment of Thian, 1L/ha of Sherphos, 0.25 L/ha of Acaricide, 3 or 4L/ha of Calah, and 3L/ha of Californian-G) the pesticides are most of the time applied in quantities less than the recommended doses.

The average amount of capital (Francs CFA 42,411) used by the respondents is low whereas the household's capital is also an important production factor. It serves to hire labour when the household labour available is not enough for performing all production activities. Besides, the level of capital might determine the use of certain equipments (tractor for instance) or production techniques.

Following Sinzogan *et al*., (2004), the low yields (less than 1000 kg/ha) is one of the main problems facing cotton producers in Republic of Benin. Indeed, combining the previous inputs at different levels, farmers recorded an average yield of about 984.24 kg/ha (Table 3). This value is close to the one of 1085.29 kg/ha found out by Paraïso *et al*. (2012) in the north-western part of Republic of Benin. As well, this average yield is close to national yield level estimate of 1105.36 kg/ha, but by far, is lower than the highest values of 1400 kg/ha experienced by Mali and Burkina in the middle part of the 1980s (Jeffrey *et al*., 2011).

Table 3: Descriptive statistics of the variables included in the models

Variables	Minimum	Maximum	Mean	Standard deviation
Acreage of cotton (ha)	0.25	37	3.05	4.12
Labour (Man-Day/ha)	66.50	988.08	145.01	93.93
Fertilisers (kg/ha)	100	6000	305.15	497.46
Insecticides (ml/ha)	226	5300	1826.30	1077.83
Herbicides (ml/ha)	400	14000	3692.70	2676.09
Capital (Franc FCA/ha)	7119.05	301000	42411	47236.69
Yield (kg/ha)	98	2700	984.24	403.13

Note: Franc CFA 655.95 = Euro 1
Source: Authors' calculations

Estimation of the production functions

The Cobb-Douglass and Translog models results are summarised in Table 4. Both models are highly significant at 1% level (p = 0.000). However, the coefficient of determination (R^2) obtained with the Cobb-Douglas model (0.183) is lower than the one of the Translog model (0.362). Moreover, the constant predicted by the Cobb-Douglas model is statistically highly significant at 1% level, while the one predicted by the Translog model is not significant. These findings imply that the Translog model better reflects the phenomenon under study. Furthermore, the Cobb-Douglas function might be less relevant than the Translog while recommending suggestions for investments in cotton production.

The Cobb-Douglas model reveals that the estimated coefficients of land size under cotton cultivation and the quantity of fertilisers are both positive and significant at 10% level while the quantities of insecticides and herbicides are positive and significant at 5% level. The Cobb-Douglas model becomes:

$$lnQ=5.021+0.086lnS+0.157lnE+0.108lnI+0.052ln+ u \quad (11)$$

This model indicates that farmers can invest in land, fertilisers, and pesticides with the expectation to gain more output (positive elasticities). In contrast, the Translog model highlights that investment in inputs considered individually have no significant effects on the quantity of cotton harvested. This model indeed reveals indeed that the quantity of cotton is determined by the interactions between "herbicides and labour", "labour and capital", and "herbicides and capital", giving the equation.

$$lnQ=0.127lnMlnH–0.313lnMlnC– 0.133lnHlnC + v \quad (12)$$

Output elasticities induced by the investments in cotton production

The Cobb-Douglas and Translog models as specified and used in this study estimate the average production functions. Such functions are built on the average characteristics of the survey farmers and, in the case in point, provide general guidelines for investing in cotton production.

Table 4: Results of the regression models

Inputs	Cobb-Douglass Model		Translog Model	
	Coefficients	P>t	Coefficients	P>t
Constant	5.021***	0.000	-2.083	0.866
Acreage	0.086*	0.068	-0.5496	0.866
Labour	-0.009	0.926	3.509	0.721
Fertilisers	0.157*	0.069	0.185	0.291
Insecticides	0.108**	0.013	-0.290	0.943
Herbicides	0.051**	0.001	1.021	0.879
Capital	-0.024	0.627	-0.641	0.135
Interactions between inputs				
Acreage *Acreage	--	--	-0.045	0.537
Labour*Labour	--	--	-0.305	0.269
Fertilisers*Fertilisers	--	--	-0.088	0.690
Insecticides*Insecticides	--	--	-0.031	0.649
Herbicides*Herbicides	--	--	0.031	0.235
Capital*Capital	--	--	0.098	0.513
Acreage*Labour	--	--	0.026	0.798
Acreage*Fertilisers	--	--	0.065	0.701
Acreage*Insecticides	--	--	0.065	0.505
Acreage*Herbicides	--	--	-0.119	0.169
Acreage*Capital	--	--	0.068	0.493
Labour*Fertilisers	--	--	-0.126	0.744
Labour*Insecticides	--	--	0.127	0.705
Labour*Herbicides	--	--	0.127**	0.040
Labour*Capital	--	--	-0.313*	0.096
Fertilisers*Insecticides	--	--	-0.166	0.437
Fertilisers*Herbicides	--	--	-0.022	0.680
Fertilisers*Capital	--	--	0.236	0.145
Insecticides*Herbicides	--	--	-0.036	0.370
Insecticides*Capital	--	--	0.114	0.345
Herbicides*Capital	--	--	-0.133*	0.066
	R^2	0.183	R^2	0.3622
Model	F (6, 131)	6.12	F (27, 110)	11.03
	P > F	0.0000	P > F	0.0000

Note: *, **, *** significant at 10%, 5%, and 1%, respectively
Source: Authors' estimates

According to the Cobb-Douglass model, it is technically efficient to invest in land, fertilisers and pesticides. An increase in the amount of land, fertilisers, insecticides, and herbicides in the range of 1% will approximately lead to increases in yield up to 0.09%, 0.16%, 0.11%, and 0.05%, respectively (Table 5). On average, farmers should mainly invest in fertilisers and insecticides that provide the highest elasticities. With comparison to the quantities of fertilisers and insecticides, increasing the quantities of land and herbicides will lead to lower increases of cotton output. Variables such as farm size, labour, seed, fertiliser, irrigation, number of cultivation and working capital have been reported to be the important variables in the cotton production process Nabi (1991). Previous studies reported that an increase in the use of fertilisers, insecticides, land, and herbicides, contributed towards higher yield. For instance, analysing the factors affecting cotton yield in Sargodha (Pakistan), Bakhsh *et al.* (2005) found out that the cost of plant protection measure (related to the quantities of fertilisers and pesticides) have positive impacts on the cotton yields. Such findings are very common throughout the literature.

Beyond the classical inputs, various factors may also influence cotton yield. Following Khuda *et al.* (2005), these factors include physical factors (land preparation, irrigation, climate factors, etc.), managerial factors (farming practices for instance), and qualitative variables such as education, age, farming experience, etc. The effects of these factors which are not included in this study might explain the low coefficients of determination (R^2) found out in Table 4.

Coming back to the results as suggested by the Cobb-Douglass model, enhancing cotton production by investing more in inputs such as fertilisers and insecticides might lead to environmental problems in the long run. To deal this new issue, the Translog model suggests alternatives. Since the Translog model rejects the hypothesis of non-significance of the interactions between inputs, investing in the production factors separately might not be efficient as predicted by the Cobb-Douglass model. The output elasticities induced by individual inputs are therefore meaningless.

Considering the cotton output elasticities as predicted by the Translog model, if farmers increased both quantities of herbicides and labour at a time, they would be likely to expect more (0.67% increase) output. However, if farmers increase at a time the quantities of labour and capital in one hand, and the quantities of herbicides and capital on the other hand, they would come up in both cases with reduction up to 2.32% and 1.47% of the total cotton output, respectively. The negative effect of the combination "labour and capital" can be explained by the fact that the labour quantity might be increased through more salaried labour, meaning an increase of capital. The same mechanism of interaction is applicable for the quantities of herbicides and capital. As a result, the best investment in cotton farming would be to increase the quantities of herbicides and labour at a time. A practical application could be to use more herbicides for saving labour use for soil preparation or weeding activities. The labour saved could be use to reform (within a shorter time period) other activities such as fertilising and harvesting that have to be perform at a proper time.

Table 5: Elasticities of cotton production

Inputs	Cobb-Douglass		Translog	
	Elasticities	P>z	Elasticities	P>z
Acreage	0.086 (.004)*	0.066	-0.054 (0.150)	0.720
Labour	-0.009 (0.072)	0.924	2.529 (2.385)	0.289
Fertilisers	0.157 (0.069)*	0.066	0.150 (2.120)	0.943
Insecticides	0.108 (0.045)**	0.012	-0.311 (2.035)	0.878
Herbicides	0.051 (0.016)**	0.001	1.097 (0.728)	0.132
Capital	-0.024 (0.075)	0.628	-0.968 (2.650)	0.715
Interactions between inputs				
Acreage*Acreage	--	--	-0.004 (0.006)	0.536
Labour*Labour	--	--	-0.542 (0.488)	0.267
Fertilisers*Fertilisers	--	--	-0.200 (0.502)	0.689
Insecticides*Insecticides	--	--	-0.123 (0.271)	0.648
Herbicides*Herbicides	--	--	0.138 (0.115)	0.232
Capital*Capital	--	--	0.771 (1.175)	0.511
Acreage*Labour	--	--	0.012 (0.049)	0.798
Acreage*Fertilisers	--	--	0.034 (0.090)	0.701
Acreage*Insecticides	--	--	0.046 (0.069)	0.504
Acreage*Herbicides	--	--	-0.100 (0.072)	0.166
Acreage*Capital	--	--	0.066 (0.096)	0.492
Labour*Fertilisers	--	--	-0.503 (1.538)	0.744
Labour*Insecticides	--	--	0.668 (1.760)	0.704
Labour*Herbicides	--	--	0.671** (0.323)	0.038
Labour*Capital	--	--	-2.320* (1.385)	0.094
Fertilisers*Insecticides	--	--	-0.987 (1.266)	0.435
Fertilisers*Herbicides	--	--	-0.135 (0.329)	0.679
Fertilisers*Capital	--	--	1.976 (1.345)	0.142
Insecticides*Herbicides	--	--	-0.288 (0.320)	0.368
Insecticides*Capital	--	--	1.262 (1.333)	0.343
Herbicides*Capital	--	--	-1.472* (0.792)	0.063

Note: *, **, *** significant at 10%, 5%, and 1%, respectively
Source: Authors' estimates

CONCLUSION

Using the Cobb-Douglas model the study revealed that investments in fertilisers, insecticides, herbicides, and land are the most valuable investment options in cotton production in the municipal areas of Kouandé and Kérou. However the Translog model pointed out that farmers should rather focus on the combination of inputs while setting up their investment decisions. The combinations "herbicides and labour", "labour and capital", and "herbicides and capital" are the most important investment options to focus on in order to improve cotton production in the study areas.

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