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APPROPRIATION AND IMPACT ON AGRICULTURAL HOUSEHOLD INCOME FROM THE MECHANIZATION OF PRODUCTION AND PROCESSING OF FOOD PRODUCTS IN THE PROVINCE OF KONGO CENTRAL: THE CASSAVA

Author's Name: [1]J L. Bissangilwa, [2]C. Kamenga, [3]R. Nduengisa

Affiliation: *[1]Lecturer in the faculty of economic sciences, University of Kinshasa/Kinshasa, Congo*

[2]Lecturer in the faculty of economic sciences, University of Nouveaux Horizons/Lubumbashi, Congo

[3]Lecturer in the Department of agricultural science, Institut Supérieur Pédagogue et Technique de Kinshasa/ Kinshasa, Congo

E-Mail: nduengisarene@gmail.com

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Abstract

Among the main food crops, cassava ranks second behind rice in West and Central Africa with a potential economic value of $ 4.7 billion over the next 10 years. Cassava is the most common of all the roots and tubers grown in Africa with a productivity representing 60% of African countries (Kapuku, B.T.1983); it is the staple food of more than 800 million people in the third world (De BRUIJN et al., 1989). But the process of production and the transformation of this food product involves painful stages for the peasants. Thus, mechanization was considered during certain phases of production of this product. In light of this innovation, this study aims to evaluate the appropriation and the socio-economic impact of this mechanization in the western region of DR Congo. To do this, from the survey data, we implemented a multinomial probit model on a stratified sample of 198 cassava producers. The counterfactual approach served as a framework for estimating the impact of this mechanization on the income of women processors. The results show that the ownership of electrical machines is influenced by the presence of electricity in the locality and the availability of family labor for the activity; that of the cassava mill by belonging to a group of cassava food producers, literacy in the local language and the availability of family labor. In addition, the appropriation of this mechanization generates a positive and significant increase in the annual income of female producers of 103,914 FC on average.

***Keywords**: Ownership, impact, cassava, mechanization, income, Kongo Central.*

INTRODUCTION

In most developing countries, the majority of the population resides in rural areas and is much more involved in agriculture. In DR Congo, the agricultural sector is of paramount importance for the economy. In fact, in 2002 it contributed about 39% of Gross Domestic Product (GDP) (UNDP, 2003).

Nevertheless, this sector is mainly based on cassava, which is the main self-sustaining crop (75% of the total agricultural production of DR Congo in 2002) (INS, 2003)

In recent years, however, the cassava sector has been experiencing serious difficulties both nationally and internationally. Indeed, the price of cassava has become very unstable on the international market. Specifically, subsidies to producers in northern countries (Brazil) are causing a general downward trend in prices.

Due to lack of standardized processes, trade in cassava products is very limited and the majority of products are only accessible to the local market. Only cassava starch has begun to penetrate international trade even in the countries of the European Union.
By continuing to support the same efforts, researchers predict a production of 42 million tonnes in 2020 in the DRC. Still less than Nigeria, which currently produces 45 million tonnes and is likely to increase production by 2020.

In addition, the agricultural sector is characterized by low productivity (Ministry of Planning, 2000). This can be explained by the fact that agriculture does not yet benefit from modern techniques and methods for its development both in terms of production and the conservation, processing and marketing of agricultural products (Ministry of Planning, 2000).

Thus, in recent years, efforts to increase productivity through mechanization have been made to increase the quantities produced. Little effort is being made to reduce the drudgery of processing cassava products, mainly by women. The mechanization of the production of the cassava food product is aimed at improving the product both in quality and in quantity.

In order to alleviate the plight of the processing of cassava into food products and increase the income of women farmers, Congolese agricultural equipment manufacturers have developed equipment for four stages of the processing process alongside the tractors, plow and harrow used for production.

The first mechanized step is the grating for the production of the microcosets using the mechanical grater also called grating. The second step is retting. In order to improve the quality of the processed cassava product, retting should be monitored; the mechanized technique introduced the retting tank. The third step is pressing the milling which can now be done using the cassava mill, more appropriate than the corn mill. The combination of the tractor and the cassava mill gave a third type of technology which is the complex tractor cassava mill. The last mechanized step is churning by introducing the churn into the process. This last technology is almost unknown to the producers, so only the first three have been taken into account in this study.

These equipments tested by the PTAA with groups of producers of cassava food products, have been popularized by several structures.
The results revealed rather interesting technical performance indicators (Singbo and Ahouanssou, 2004). However, important socio-economic research is still needed to ensure that these technologies are appropriate.

OBJECTIVE

The present study proposes to evaluate the appropriation and the socio-economic impact of the mechanization of the process of transformation of cassava kernels into foodstuff in the West of DR Congo.

METHODOLOGY

Description of the data used

The data used in this document was collected in a single pass, in August 2014, in 20 villages in the Territory of KASANGULU. In total, a stratified random sample of 198 producers of cassava food was

investigated. The surveys were conducted using a questionnaire, which provided data on: the production and processing techniques, the socio - demographic and economic characteristics of the producer; the technical and economic environment related to the use of mechanization technologies in the production of the cassava product; the system of support for the appropriation of mechanization technologies for the production of the cassava food product; the determinants of income.

THEORETICAL APPROACHES

a. ***Determinants of appropriation***

In theory, the analysis of households' decision to choose a technology may be based on the randomized utility model (Mc Fadden 1973, 1974, Green 2008, Verbeek 2003). Consider an individual i in a population of N cassava-based product producers, who have to choose a production equipment for this product in a set that includes j alternative equipment, with j = 0 is the use of mechanical production equipment , j = 1 is the use of the plow tractor alone, j = 2 is the use of the cassava processing equipment and, j = 3 for the use of the cassava complex plus.

Let Uj denote the level of utility that technology provides to the individual i. Thus, the individual i will choose the alternative q if it gives him the maximum of utility, and this, when $U_j = U_q > U_j, j = 0, \dots, 3, j \neq q$ or when the non-observed variable (latent) randomized $y^* = U_q - U_j > 0$. Since these utility levels are not observed, there is a need to make assumptions to operationalize them.

Suppose, then, that the utility level of the i[th] processor having chosen the jst alternative equipment of the technology is

$$U_j = x_j\delta_j + \varepsilon_j \qquad (1)$$

With $x_j\delta_j$, the non-stochastic function of variables x_j and unknown parameters δ_j; and ε_j the unobserved error term. From this consideration and according to Amemiya, (1985), Verbeek, (2003) and Green, (2008) the probability that the transformator i adopts the alternative q in the set of equipment is a function of the independent variables and alternatives, that is,

$$\begin{aligned} Prob(y_j &= Prob(U_q > U_j \\ &= Prob\{\varepsilon_l - \varepsilon_q > (x_q - x_l)\delta, \dots, \varepsilon_j - \varepsilon_q > (x_q - x_j)\delta\} \qquad (2) \\ &= F_j(x_j, \delta_j) \end{aligned}$$

To estimate the maximum likelihood of in equation (2), we must define

$\sum_{i-1}^{n}(j+1)$ According to the binary variable

$$y = 1 \; si \; y_j = q \; = 0 \; si \; y_j \neq \text{q} \qquad (3)$$

The likelihood log function is then

$$\log L = \sum_{i=0}^{n}\sum_{j-0}^{3} y_j \log F_{ij} \qquad (4)$$

with, F_{ij} which is the probability of choosing the alternative q among the other three.

In addition, let's assume that ε_j there is a normal multinomial distribution ε_j and ε_h are correlated for every $j \neq h$.

Recall that the study deals with four alternative equipment. The econometric model indicated for analyzing appropriation in this case is a multinomial logit.

However, the estimation of the latter raises the condition of independence of irrelevant alternatives or "Independence from Irrelevant Alternatives (IIA)". But, this constraint can be lifted by the multinomial probit. The model to be used in this study is therefore a multinomial probit model (Hausman and Wise, 1978, Wooldridge, 2000).

The probability F_{ij},of choosing the alternative q from the other three choices in equation (2) is the cumulative probability of the three variants of the normal distribution (Greene, 2003).

b. Annual income impact assessment

The impact assessment of a technology can be based on several approaches, two of which are frequently used. The first is the experimental or random approach where randomly selected participants in the experiment, and therefore any difference with non-participants are only due to treatment.

This is the reason why this approach is generally considered to be reliable (unbiased estimates) and to give the easiest results to interpret (Cochrane and Rubin, 1973, Bassi, 1984). However, this type of evaluation is difficult to apply in practice because it poses ethical problems in the case of social phenomena (Diagne, 2003).

The second approach, which is the one used for this study, is said to be non-experimental and uses the method of instrumental variables (IV). This evaluation approach is relatively inexpensive and easy to apply, but the interpretation of the results is not straightforward and the results themselves may be less reliable (Diagne, 2003).

Suppose that Y_1 andY_0 , two random variables that represent the level of income for an individual i. If he uses the new technology of cassava food product production he has (Y_1) or does not use it (Y_0). Let the binary variable wi = 1 when it adopts the technology and$w_i = 0$, if not. The observed impact variable for the individual can be written as follows:

$$\boldsymbol{y = (1 - w) + wY_1 = Y_0 + w(Y_1 - Y_0)} \qquad \textbf{(1)}$$

But the main difficulty encountered is that for a given individual, the income is observed, either following the appropriation, or before the appropriation, but never the two at a time. This missing datum is called the "counterfactual" (non-factual elements) (Rubin, 1977). However, an average causal effect of technological change in a population could be determined if a hypothesis of conditional independence is accepted between Y_1 , Y_0 and w(Rosenbaum and Rubin, 1983).

Thus, the average treatment effect (ATE)[1] is estimated by differentiating between the average level of the beneficiary indicator and the non-beneficiary indicator. We have :

$$\boldsymbol{ATE \equiv E(Y_1 - Y_0)} \qquad \textbf{(2)}$$

Better, one can estimate the average effect of treatment on the treaty commonly noted ATE1[2].

$$\boldsymbol{ATE_1 \equiv E(Y_1 - Y_0 | w = 1)} \qquad \textbf{(3)}$$

By breaking down each counterfactual according to the observable elements (x), we can write:

$$\boldsymbol{Y_0 = \mu_0 + \nu_0} \qquad \textbf{(4)}$$

$$Y_1 = \mu_1 + \nu_1 \qquad \textbf{(5)}$$

By introducing equations (4) and (5) in (1), we obtain:

$$\boldsymbol{Y = \mu_0 + (\mu_1 - \mu_0)W + \nu_0 + W(\nu_1 - \nu_0)} \qquad \textbf{(6)}$$

$$\boldsymbol{E(y/w, x = \mu_0 + aw + g_0(x) + w\,|\,g_1(x) - g_0(x)\,|} \qquad \textbf{(7)}$$

Where $\boldsymbol{\alpha = ATE}$; $\boldsymbol{g_0(x) \equiv E(\nu_0/x)}$ ***and*** $\boldsymbol{g_1(x) \equiv E(\nu_1/x)}$ x is the vector of the variables influencing the appropriation.

Assuming $g_0(.) et g_1(.)$ linear in x, we can write:

$$\boldsymbol{g_0(x) = \eta_1 + h_0(x)\beta_1} \qquad \textbf{and} \qquad \textbf{(8)}$$

$$\boldsymbol{g_1(x) = \eta_1 + h_1(x)\beta_1} \qquad \textbf{(9)}$$

Equations (8) and (9) in (7) give:

$$E(Y/w,x) = \gamma + Y_j + w.(x - \Psi)\delta_2 \qquad \textbf{(10)}$$

Where β_0 and δ are the vectors of the parameters to be estimated, $\Psi = E(x)$ and $\alpha \equiv ATE$
The estimation of equation (10) gives a consistent value of ATE (Wooldridge, 2002).
The institutional environment of the cassava sector is very weak but promising. Above all, we note the lack of support systems for transformers set up by the public services concerned. Thus, for a long time the DRC was the first producer of cassava in sub-Saharan Africa. However, despite its importance in human nutrition (Food for 90% of the Congolese population) and livestock, the processing of cassava as a household task has a low yield and the majority of cassava production is consumed locally in the country where even in the production site.

Transformation of tubers into flour, cossette and Chikwangue is the weakest link in the value chain in the true sense of the word. In the villages the tubers are peeled or not and soaked in ponds and ponds around the village for two to three weeks in order to obtain the fermentation which destroys the cyanide of the cassava. This procedure is unsuitable and unhygienic at all and carries a lot of risk for the product itself in terms of being attractive to the market and to the consumer because of the risks of microbial contamination.

ESTIMATION METHODS

i. Estimation of the model for determining the factors influencing appropriation
In order to understand the factors determining the appropriation of each type of mechanization technology of the production process of the cassava food product. The variables introduced in the multinomial Probit model whose theory is developed previously are detailed in the following paragraph.

The dependent variable (ADOPTANT) has several modalities which are as follows:

- ADOPTANT = 0: The processor does not use the tractor, the cassava mill or the complex
- ADOPTANT = 1: the processor uses only the tractor.
- ADOPTANT = 2: the processor uses only the cassava mill.
- ADOPTANT = 3: the processor uses only the tractor + cassava mill complex.

To rotate the model, the chosen reference situation is ADOPTANT = 0. The model presents the results of all the modalities simultaneously. The justification for choosing these variables is as follows:

1. Membership in a group of producers of cassava food product (GROUP):
   It is a binary variable whose expected sign is positive. The presence of a group allows the contact of a locality with support structures or extension workers. However, contact with extension workers provides reliable information on innovations (Adégbola and Adékambi, 2008). In addition, belonging to a group promotes access to information through other members (Adégbola and Adékambi, op.cit.).

2. Availability of electricity in the village (ELECT):
   It is binary and the expected sign is positive. The availability of electricity in the village testifies to the opening up of the locality and will facilitate contact with the support structures.

3. Literacy in local language (ALPHA):
   It is a binary variable whose predicted sign is positive. Formal education favors the

appropriation of a new technology (McBride and El-Osta, 2002, Ouédraogo, 2003, Bravo-Ureta et al., 2005, Adégbola and Adékambi, 2008). Since literacy is another form of education, it is thought that it could have the same consequences as formal education.

4. The production of cassava product is the main activity of the respondent (ACTPBEUR):
   It is a binary variable which we hope a positive sign. The table shows that the exploratory survey revealed that the equipment is more established in the localities where many women have as main activity the production of the cassava product.
5. Family manpower equivalent (EFEQH):
   it is a continuous variable that could negatively influence the appropriation of the mechanization of the production of the cassava food product. Transformers essentially use family labor, the availability of which would reduce the need to use new technologies. The number of farm household assets was also used by Glèlè et al. (2008) to show its relation with the appropriation of an innovation.

6. Age of the individual (AGE):
   This is a continuous variable whose sign can not be defined in advance because subject to conflicting results. Several authors have shown that young producers adopt less technologies than older ones (Sall et al., 2000, Adégbola and Azontondé, 2006), unlike Zegeye et al. (2001); Ouedraogo (2003); Glèlè et al. (2008).
   The result obtained by the former is justified by the frequency of the contacts of the oldest with the extension agents, which allows them to be more informed. The latter, on the other hand, argue that young people are more willing to take risks than older people.

The descriptive statistics of the explanatory variables included in the model are presented in Table 1.

Table 1: Descriptive statistics of the explanatory variables of the multinomial probit model.

Independent variables	Description	Units	expected Signs
GROUP	Membership of the respondent in a group	1 if the respondent belongs to a cassava food production group, 0 otherwise.	+
ELECT	Electricity availability in Village	1 if the village has electricity, 0 otherwise	+
ALPHA	Literacy of the respondent in local language	1 if the respondent is literate in the local language, 0 otherwise	+
ACTPBEUR	The production of the cassava food product is the main activity of the respondent	1 if the production of the cassava food product is the main activity of the respondent, 0 otherwise	+
EFEQH	Family Workforce in Men Equivalent	Equivalent Men	-
AGE	Age of the respondent	Years	

NB: Values in parentheses represent standards deviation.
Source: Survey Results, August 2014

Before specifying the model, a correlation analysis should be made between the independent variables that will be included in the model. Indeed, multicollinearity has several consequences including, for example, obtaining imprecise and unstable coefficients. This instability can even lead to perverse signs (Adegbola et al., 2003). Appendix 1 presents the results of the correlation matrix to see the degree of correlation between the explanatory variables.

ii. Estimation of the annual income impact model

The evaluation of the impact of the appropriation of the mechanization of the cassava food production process was carried out in two stages. The first is the determination of the factors affecting the appropriation of at least one type of technology from a probit model. The results of this step are presented in Appendix 2.

The second step is the evaluation of the impact by the Generalized Method of Moment (GMM) method.

In addition to the appropriation variable, the following variables were introduced into the model to control the effect of women's socio-economic characteristics on the impact.

1. Availability of family labor (EFTHJ): It is a continuous variable that positively influences income (Bravo-Ureta and al., 2005). It will promote an increase in production and therefore revenue. The predicted sign is then positive.For this study, it is the natural logarithm of this variable that is used (LEFTHJ).

2. Annual expenses related to machine use (COUMACH): This is a continuous variable. High variable costs, which are limited for this study to those related to the use of machinery, will reduce the resulting gross margin. So we hope for a negative sign. Variable costs were also used by Bravo-Ureta andal. (2005) as a determinant of income.

3. Years of experience in the production of the cassava food product (EXPE): It is a continuous variable. The skill of the processor increases with experience and can help improve performance. McBride and El-Osta, (2002); Glèlè et al. (2008) also identified the year of experience as a factor affecting income. This variable is in logarithmic form (LNEXPE) in the model.

4. The production of the cassava food product is the main activity of the respondent (ACTPBEUR): It is a binary variable which takes the value 1 if the production of the cassava food product is the main activity of the respondent and 0 otherwise. We hope for a positive sign for this variable.

5. Distance from the village to the nearest market (DMARCHE): This is a continuous variable. The proximity between the village and a market will allow the easy flow of products and consequently an increase in income. Several authors like Tomoyo et al. (2006); Bravo-Ureta et al. (2005) used this variable as a determinant of income. The expected sign is therefore negative. Note that it is the natural logarithm of this variable (LDMARCHE) that is used in this document.

6. Formal Education (EDUCF): This is a binary variable that takes the value 1 when the individual has been to school and 0 otherwise. Formal education can enhance the managerial capacity of

women processors. Bravo-Ureta et al. (2005) found that formal education positively determines farm income.

In order to test the heterogeneity of the impact of the appropriation of the mechanization of cassava food product production on the annual income of female transformers among the adoptive women, the variable (ASM) was crossed with other variables of the model.

These variables thus obtained are interaction variables and their coefficients measure the variation in the impact of one adopter to another. The ones used in the model are:
- ASM * LEFTHJ = ABLEFTHJ
- ASM * COUMACH = ABCOUMACH
- ASM * LDMARCHE = ABLDMARCHE

The descriptive statistics of the mechanization impact model variables of the cassava foodstuff production process on the annual income of female producers are presented in Table 6.1.
Table 2: Descriptive statistics of the explanatory variables used to evaluate the impact of the appropriation of mechanization of the cassava food product production process on the annual income of the processors.

Variables	Unit	Adopting	No adopting
LEFTHJ	Man-day / year	4,903 (0,758)	4,972(0,828)
COUMACH	FC / year	117218,7 (94008,3)	101421,2(54653,38)
LNEXPE	Years	2,473 (0,830)	2,339(0,864)
ACTPBEUR	1 if the main activity of the respondent is the production of the cassava product, 0 otherwise	0,766 (0,425)	0,706(0,458)
LDMARCHE	Kilometer (Km)	0,478(0,708)	0,899(0,950)
EDUCF	1 if the respondent received a formal education, 0 otherwise	0,047(0,212)	0,047(0,213)
ABLEFTHJ		-0,030 (0,758)	0
ABCOUMACH		6993,692 (94008,3)	0
ABLDMARCHE		- 0,186(0,708)	0
Nombre d'observations		107	85

NB: the standard deviation values are placed in parentheses.
LEFTHJ = Nepalese logarithm of the annual man-day labor force;
LNEXPE = natural logarithm of the year of experience;
LDMARCHE = Natural logarithm of the distance from the locality to the nearest market.
Source: Survey Results, August 2014

RESULTS AND DISCUSSION
Determinants of ownership

1. **Appropriation rate of each type of technology**

From the analysis in Table 3, we note that the complex is the most adopted technology with a rate of 38.64%. The tractor comes in second and with an appropriation rate of 10.94% and finally the cassava mill has the lowest rate of ownership, which is 6.20%.

The low rate of appropriation of the cassava mill could be attributed to the availability of the corn mill which is an alternative solution accessible in all environments. In addition, technical studies have shown that the maize mill has been as good at milling cassava chips as the innovative cassava mill (Ahouansou and Singbo, 2005). This type of technology is therefore not so essential to the producers as to the others. On the other hand, the tractor reduces to a large extent the time and the hardness of the work, compared to the mortar that it replaces. Indeed, the performance tests have proved that the mortar has an hourly capacity of 7.2 Kg / h against respectively 368 Kg / h and 177 Kg / h for the tractors '' bio gando '' and '' COBEMAG '' (Ahouansou and Singbo, 2005). Therefore, its rate of appropriation is certainly related to its utility.

The highest rate is observed for the complex which is a combination of the other two types. This result can be explained by assuming that the producers see through the complex a utility that encompasses the two previous ones, which makes them prefer it.

Table 3. Ownership of each type of technology

Type of Technology	Appropriation rate (%)	Standard Deviation
Tractor	10,94	6,79
Cassava mill	6,20	7,73
Tractor complex + Cassava mill	38,64	27,03

Source: Survey Results, August 2014

2. **Econometric model**

The results of the Multinomial Probit model of the determinants of ownership of semi-mechanization of the cassava food production process are presented in Table 4.

Table 4: Econometric results of the determinants of the appropriation of each type of technology from the semi-mechanization of the cassava food product production process (regression coefficients)

Variables	Tractor	Cassava mill	Tractor complex + Cassava mill
GROUP	0,0144(0,376)	0,974(0,439)**	1,153(0,294)***
ELECT	1,259(0,355)***	-0,185(0,556)	2,003(0,302)***
ALPHA	-0,189(0,718)	1,011(0,539)*	-0,077(0,554)
ACTPBEUR	0,640(0,446)	-0,194(0,466)	0,335(0,331)
EFEQH	-0,336(0,172)*	-0,353(0,167)**	-0,403(0,143)***
AGE	-0,006(0,013)	0,0211(0,015)	0,006(0,014)
CONS	-1,192(0,666)*	-2,079(0,890)**	-1,270(0,681)*
Sample size	192		
% of correct prédiction	69,87		
Log of likelihood	-173,756		
χ^2 (ddl=18)	95,47***		

NB: the values of the distribution of the parameters or their probabilities are placed in parentheses.
*, **, *** indicate the meaning respectively at 10%, 5% and 1%
Source: Survey Results, August 2008

The estimation of the multinomial Probit model has yielded satisfactory results. Indeed, the model is globally specified because, the value of the statistic $\chi 2$ (ddl = 18) which made it possible to test the null hypothesis that all the coefficients of the explanatory variables are zero is significant at 1% and is equal to 95 47. We can therefore conclude that, statistically, all the coefficients of the explanatory variables of the model are not zero simultaneously. The significance of the coefficients of the explanatory variables that determine the appropriation of each type of technology from the mechanization of the cassava food production process varies from one type of technology to another.

As expected, the coefficient of the GROUP variable is significant and positive in the cassava mill (5%) and the complex (1%) submodels. As for the tractor, this coefficient is not significant, but has the expected positive sign. This result implies that the presence of groupings in a village influences the probability of appropriation of equipment and more particularly the cassava mill and the complex. This variable favors contact with support structures or extension services and the exchange of information between groups and group members from different localities.

In a word, it can convey information. This result is consistent with that of Adégbola and Adékambi (2008) who showed the relevance of access to information in the ownership process. The insignificant result obtained in the sub-model of the tractor, has explanations.

On the one hand, the corn mill replaces the cassava mill in the localities where it does not exist. On the other hand, grinding is a very painful step in the production process of the cassava food product because in the absence of the tractor, it is the mortar that is used, which requires a high energy expenditure. Transformers do not need special knowledge by the extension to adopt the tractor, it is enough to have the opportunity to acquire it.

Taking the variable ELECT, as predicted, it is positive and significant at 1% in the sub-models of the tractor and the complex. This implies that the presence of electricity in a locality is important in the decision to appropriate the tractor or the complex. By becoming part of the realities of the study area, electricity is a sign of opening up. However, the opening up of a locality could facilitate its access to new technology. This result confirms the precedent which states that access to the tractor is sufficient for its appropriation.

Literacy (ALPHA) is significant only for the appropriation of the cassava mill (10%) and its sign is positive according to the theoretical prediction. This result indicates that literacy promotes ownership of the cassava mill. Literacy then plays an important role in enabling women producers to understand the importance of using technology adapted to the activity. Indeed, it favored the choice of the cassava mill at the expense of the corn mill. These results are consistent with that of Bravo-Ureta et al. (2005) who found that the level of schooling positively determines the appropriation of a technology. While literacy is different from formal education, both aim for the same goals.

The coefficient of the family labor force variable (EFEQH) is negative but significant in the three sub-models. This indicates that processors with a strong workforce are less adopting semi-mechanization. This result is not surprising since mechanization aims among other things to reduce the hardness of work and the demand for labor. It is therefore normal that producers with a strong workforce do not feel the need to opt for semi-mechanization. These results are contrary to those obtained by Glèlè et al. (2008) regarding the appropriation of new varieties of cassava. Improved varieties of cassava fall into the category of labor-intensive innovations in contrast to mechanization. Both innovations have adverse effects on the workforce and this justifies the contradictory results obtained.

3. **Impact of significant variables on appropriation**

The probability of appropriation of the different equipment can vary with changes in values of the explanatory variables. It is therefore important to analyze these changes as well.
The marginal effects of the explanatory variables used in the equipment appropriation model are presented in Table 5.

Table 5: Marginal effects of the explanatory variables on the probability of appropriation of the semi-mechanization of cassava product production.

Variables	Tractor	Cassava mill	Tractor complex + Cassava mill
GROUP	-0,088	0,040	0,312***
ELECT	0,064	-0,090***	0,515***
ALPHA	-0,037	0,082**	-0,040
ACTPBEUR	0,080	-0,033	0,062
EFHJ	-0,021	-0,010	-0,087**
AGE	-0,002	0,001	0,0015

NB: *, **, *** indicate respectively the meaning at 10%, 5% and 1%
Source: Survey Results, August 2014

The variable GROUP is positive and significant at 1% for the appropriation of the complex. It is therefore apparent that by promoting the formation of cassava food crop producer groups in the localities, the likelihood of ownership of the complex could be increased. Since support structures do not target individuals, but rather groups, this variation is understood.

The marginal effects of the ELECT variable are significant at 1% in the cassava mill and complex models. The marginal effect has a perverse sign with respect to the cassava mill, but this is understandable since this variable may not be significant given some theoretical requirements in the cassava mill appropriation sub-model.
As for the marginal effect concerning the complex, it is the highest and its sign is positive. Broadening the rate of electricity coverage in the study area would then increase the likelihood of appropriation of the complex.
Indeed, the electrification of localities will improve their use by support structures or extension services. This may encourage the producers to contact the donors, who will help them acquire the equipment.
Literacy (ALPHA) has a positive and significant marginal effect at 5% in the tractor model. An increase in the literacy rate of women producers would therefore increase the probability of

appropriation of the cassava mill.

The availability of family labor (EFEQH) has a negative and significant marginal effect on the probability of ownership of the complex. Low availability of family labor would increase the likelihood of ownership of the complex. This technology is therefore timely because, with free education, child labor is no longer available. This situation could therefore jeopardize activity if there was no such technology.

In conclusion, it can be noted that the appropriation of technologies for the mechanization of the production process of the cassava food product is influenced by the availability of family labor, the membership of a group of producers of cassava food product and the availability of electrical energy in the villages. In addition, this last factor has the highest marginal effect, and this on the probability of appropriation of the complex.

Econometric results of the impact model of the mechanization of the production process of the cassava food product on the annual income of the producers.

Table 6 presents the econometric results of evaluation of the impact of the appropriation of the semi-mechanization of the process of production of the cassava food product on the annual income of the food product of the producers.

The F statistic is used to test the null hypothesis which states that all the coefficients of the variables of the model are all simultaneously equal to zero. The result of this test indicates that the model is globally significant at the 1% threshold, the null hypothesis is rejected. Hansen's over-identification test tested the independence between the instruments and the error term and was not significant at the 10% threshold (p = 0.110). The null hypothesis that the instruments are not correlated with the error term can not therefore be rejected. The specification of the model is therefore correct. The validity of the two variables ELECT and CONTUL as an instrument in the impact model is tested with the C statistic.

The value of this statistic is equal to 2.706 and is statistically different from 0 (p = 0.258). This confirms the null hypothesis that the instruments used are valid. The meaning of the interaction terms was tested by the Wald test. The value of the latter is equal to 74.29 and is significant at 1%. The null hypothesis that all interaction terms are null can not be accepted. As a result, the impact on annual income varies from one adopter to another. In addition, the probability density function is positive and significant at the 5% threshold. This result means that, statistically, there is a dependence between the variables of appropriation and the anticipation of the impact of the appropriation of the mechanization of the production of the cassava food product on the annual income by the transformers. In other words, women have anticipated a potential income improvement before adopting technology.

The coefficient of the appropriation variable (ASM) is positive and significant at the 1% threshold. As a result, there is a positive correlation between income and ownership. In other words, it can be said that the increase of the annual income of the foodstuff of the producers is caused by the appropriation of semi-mechanization. In addition, some explanatory variables of the model also influence income. Thus, the annual family labor force (EFTHJ) and the production of the cassava food product as the main activity (ACTPBEUR) have positive coefficients as predicted and significant at the 1% level. On the other hand, variable costs (COUMACH) are significant at 5% with a perverse sign.

From these results, it can be said that women processors who have a large number of girls or women available have high incomes. The focus is on the feminine gender and on the availability because it is a predominantly female activity, in which only family labor is used. Transformers who do not benefit from this availability can not incorporate this factor into their income growth strategies.
The significance of the variable ACTPBEUR, for its part, makes it possible to say that, to exert the production of cassava foodstuff as main activity is determining in the improvement of the income. This result is not surprising because processors who produce cassava food as their main activity spend most of their time there, unlike those who have other main activities and do so temporarily. It is therefore normal that the income from the production of cassava food is higher in the first category, when this variable is considered.

The positive perverse sign obtained for COUMACH could be explained. this sign is already in line with the microeconomic theory of the producer since these costs are annual, they are proportional to the annual quantity of food product produced. However, during discussions during the exploratory phase, the producers affirmed that "the mechanization of the production of the cassava product has led to an increase in the amount of processed cassava roots and leaves, which makes it possible to earn more money. " The annual income is therefore positively affected by the annual quantity produced.

It is then understood that it is positively correlated with variable costs, since it is those that produce in large quantities that invest more in these costs. It is important to implement a policy to reduce the costs associated with the use of machinery in order to further improve the income of women producers and, indirectly, to get more women into this activity.
Finally, what is the impact of the appropriation of mechanization of cassava food production on the annual income of current adopters? The ETA1 estimate estimates the increase in annual food income among current adopters of the technology.

The average impact of the appropriation of the semi-mechanization of cassava food product production on the annual income of the processors is 103914.1 FC / year.
The advantage of appropriating the technology is therefore on average 103914.1FC / year (Table 6.4). This result confirms the statement of female adopters during the "focus group" according to which mechanization induces an increase in income. On the other hand, the positive impact obtained is in line with the general trend observed regarding the impact assessment of new agricultural technologies on income.
Several authors have indeed reached the result according to which the appropriation of the agricultural innovations induces an improvement of the income of the producers. Thus, Glèlè et al. (2008) found that adopters of new improved varieties of cassava get more income per hectare than non-adopters and earn an average of CFAF 140,358 per hectare compared to about CFAF 46,984 for their non-adoptive counterparts.

Table 6: Econometric results of the evaluation of the impact of the appropriation of semi-mechanization on the annual income of the transformers

Variables	Coefficients	Standard error	Probability of significance
CONS	-331096,3	151548,8	0,029

ASM	101412,1	33517,14	0,002
LEFTHJ	121118,3	26406,15	0,000
COUMACH	0,862	0,388	0,026
LNEXPE	-13481,9	10116,4	0,183
ACTPBEUR	87007,48	24020,91	0,000
LDMARCHE	-29876,21	22102,64	0,176
EDUCF	33563,45	46969,87	0,475
ABLEFTHJ	-115777,3	52033,01	0,026
ABCOUMACH	4,520474	0,585	0,000
ABLDMARCHE	84192,76	43031,93	0,050
FXBETA	313700,3	146221,3	0,032
Average impact (ATE1) on adopters (FC/year)	103914,1	37031,38	0,006
Wald test (H0 : all interaction terms = 0)		χ^2 (3)= 74,29	0,000
Hansen over-identification test		χ^2 (27)=36,226	0,110
Statistics C		χ^2 (2)=2,706	0,258
F (11, 180)		53,14	0,000
Number of observations	192		

NB: LEFTHJ = Nepalese logarithm of the annual workforce in Man - day;
LNEXPE = natural logarithm of the year of experience;
LDMARCHE = Natural logarithm of the distance from the locality to the nearest market.
Source: Survey Results, August 2012

CONCLUSION

The mechanization of the production process of cassava products aims at reducing the difficulty of the activity and the increase of the income of the transformers and enters the process of organization of the cassava sector in DR Congo.

In order to make a contribution to this ongoing process, this study analyzed the appropriation and socio-economic impact of this mechanization on cassava food producers in western DR Congo. More specifically, she dwelt on the rates and determinants of the appropriation of equipment and the impact of appropriation on the annual income of the foodstuff of producers in the sectors of Kasangulu, Luila and Lukunga M'putu.

The results show that the determinants and rates of ownership of modern cassava food production equipment vary from one type of equipment to another.

Thus, the appropriation of the tractor is determined by the presence of electricity in the locality and the family labor available in the household and its appropriation rate is estimated at 10.94%. The lowest rate of ownership is recorded at the cassava mill level (6.20%) and the factors affecting its ownership are group membership, local language literacy and labor availability. family.

As for the tractor + cassava mill complex, it has the highest rate (38.64%) and its appropriation is influenced by the membership of a group, the presence of electricity in the locality and the family labor force. available in the household.

The goal of semi-mechanization, which is to improve the income of cassava food producers, is

achieved. Analysis of the impact of the appropriation of cassava food production equipment on the annual income of women processors revealed that female adoptive women had an average gain of 103,914.1FC / year more than non-adopters.

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