Non-farm Activities and Adoption of Improved Cassava and Beans Varieties in South-Kivu, DR Congo

P.M. Dontsop-Nguezet[1*], V. Manyong[2], T. Abdoulaye[3], A. Arega[4], M.S. Amato[5], J.H. Ainembabazi[6], D. Mignouna[2] & C. Okafor[1]

Keywords: Adoption- Improved cassava and Beans varieties- Non-farm activities- South-Kivu- DR Congo

Summary

Non-farm activities have been generally considered as important strategy for overcoming credit constraints faced by rural households as well as for reducing poverty through income effect. This paper employs binary probit and average treatment effect to estimate the impact of participation in non-farm activities on adoption of improved cassava and beans varieties in South-Kivu, DR Congo. Results showed on one hand that the participation rate in non-farm activities in South-Kivu was 38% and 52.1% respectively for crafts and small businesses. On the other hand, the rate of adoption of new cassava and beans varieties were 14 and 28% respectively. Factors affecting the adoption rate were gender, education, household size, the presence of non-farm activities, household assets in terms of livestock owned, market access and access to the information on new technologies. These results demonstrate the tendency of rural households to include the practice of non-farm activities among their strategies for survival and diversify their sources of income or supplement farm income. Results of this study indicate a positive relationship between engagement of rural households in non-farm activities and their propensity to adopt improved varieties. There is still a huge gap between potential adoption rate and actual rate of adoption for cassava and beans improved varieties in the study area. Therefore, actors involved in the development of the agricultural sector have to be aware of the importance of these factors even when they are working for the promotion of purely agricultural activities.

Résumé

Les activités non agricoles et l’adoption de variétés améliorées de manioc et de haricot dans le Sud-Kivu, en RD Congo

Les activités non agricoles sont généralement considérées comme une importante stratégie pour surmonter les contraintes des ménages ruraux pour l’obtention de crédit ainsi que pour réduire la pauvreté à travers l'effet revenu. Cette étude analyse un probit binaire et l'effet moyen de traitement pour quantifier l'impact de la participation des ménages aux des activités non agricoles sur l'adoption des variétés améliorées de manioc et de haricot au Sud-Kivu, en RD Congo. Les résultats ont montré, d'une part, que le taux de participation aux activités non agricoles au Sud-Kivu était de 38% et 52,1% respectivement pour l'artisanat et le petit commerce. D'autre part, les taux d'adoption de nouvelles variétés ont été respectivement de 14% et 28% pour le manioc et pour le haricot. Les facteurs influant sur le taux d'adoption sont le genre, l'éducation, la taille du ménage, la présence d'activités non agricoles, les actifs des ménages en termes de possession de bétail, l'accès au marché et l'accès à l'information sur les nouvelles technologies. Ces résultats montrent une tendance des ménages ruraux d'inclure la pratique d'activités non agricoles parmi leurs stratégies de survie et de diversification comme autres sources de revenu. Les résultats montrent une relation positive entre l'engagement des ménages ruraux dans les activités non agricoles et de leur propension à adopter les variétés améliorées.

[1]International Institute of Tropical Agriculture, Bukavu, DR Congo.

[2]International Institute of Tropical Agriculture, Dar Es Salaam, Tanzania.

[3]International Institute of Tropical Agriculture, Ibadan, Nigeria.

[4]International Institute of Tropical Agriculture, Lilongwe, Malawi.

[5]Evangelic University in Africa, Bukavu, DR Congo.

[6]International Institute of Tropical Agriculture, Kampala, Uganda.

*Corresponding author: E. Mail: P.Dontsop@cgiar.org

Received on 17.11.15 and accepted for publication 21.12.15

Il existe, toutefois, un grand écart entre les taux d'adoption potentiels et les taux réels observés pour les variétés améliorées de manioc et de haricot dans la zone d'étude. Par conséquent, les acteurs impliqués dans le développement du secteur agricole doivent être conscients de l'importance de ces facteurs, même s'ils travaillent pour la promotion d'activités purement agricoles.

Introduction

Non-farm activities have been generally considered as important strategy for overcoming credit constraints faced by rural households (5, 8, 18, 32) as well as for reducing poverty through increase in income (4, 16, 21,). They are found to be particularly important for poor smallholder farmers who are pushed out of agriculture due to limited and poor land resources. However, the literature on their effect on farming decisions is limited and presents mixed conclusions with respect to empirical evidence of the linkage between the farm and non-farm activities.

Studies show that non-farm income activities are a good substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (16). In addition, non-farm work may serve as collateral to facilitate access to credit by small-scale farmers (5). Generally, non-farm activities are expected to provide farmers with liquid capital for purchasing productivity enhancing inputs such as improved seeds and fertilizers (11, 37). However, pursuit of non-farm activities by farmers may undermine their adoption of modern technologies (especially labor-intensive technologies) by reducing the amount of household labor allocated to farming enterprises (18).

Despite its impressive natural and climatic resources (80 million ha of arable land) suitable for high levels of agricultural productivity (receiving annually more than 8 months of rain), the agricultural sector in the Democratic Republic of Congo (DRC) is unable to ensure food self-sufficiency and enhance the socio-economic development of the country.

Annual food production is considerably below 20 million t although the estimated total demand is 25 million t (14). This gap is filled by imports from neighboring countries and Europe. To reverse this trend, the development of improved technologies including seeds and practices has been one of the prioritized strategies in recent years to meet the challenge of low productivity since the expansion of cultivable land is no longer a viable option in the medium and long term (10). This strategy is seen as a means to increase agricultural productivity, ensure food security, increase farm income, and, in turn, reduce poverty. However, the success of this strategy is based on the widespread use of new technologies. Evidence shows that although these technologies have the capacity to improve productivity and profitability, the level of their use is generally low, estimated at 34% in the region covered by the project titled Consortium for Improving Livelihoods in Central Africa (CIALCA) (28). Difficulties in accessing agricultural credit by smallholder farmers are among the reasons explaining this low rate of adoption. At the same time, the region is experiencing a resurgence of much more lucrative non-farm activities in the rural areas. Some analysts have argued that non-farm income sources may already account for as much as 40-45% of the average rural household's income in many developing countries (5, 30). Most recently, in a study in Nigeria, (35) showed that they represented about 78% of rural incomes. This growing involvement is justified partly by ''attraction'' factors such as high returns and ''constraint'' factors such as inadequate agricultural income (6).

This paper contributes to the literature by testing the hypothesis that smallholder farmers' participation in non-farm activities reduces the credit constraint they face and increases their adoption intensity of improved agricultural technologies such as fertilizer, improved seeds, and practices. Specifically, the study aims at showing evidence of the effect of participation on the adoption of improved varieties of cassava and beans which are among the five most grown crops in the region as well as the level of crop commercialization on such adoption.

Non-farm income activities and improved technologies in South-Kivu

Agriculture remains the main employment and income-generating activity and accounts for 45% of GDP in the DRC (38). However, the sector has not been capable of helping farmers to generate enough income to satisfy their basic needs and create sufficient gainful employment opportunities for the increasing population in South-Kivu. This situation has led to the resurgence of the non-farm sector which is becoming increasingly important. Smallholder farmers face decisions every day on how to optimize their land use. Such decisions include discrete choices of adopting modern technologies intended to increase farm production and profit. However, the tryout (adoption) rate has been low despite the desirable impacts of new varieties of cassava and beans (the major crops in the area) and the considerable energies put into persuading farmers to adopt those (23). The choice of technology adoption was assumed to have been affected by a combination of conditions, socioeconomic, institutional (including access to credit), and agro climatic. In South-Kivu, a region with poor soil fertility and devastated by many years of civil war and political instability, farmers face serious credit constraints due to their poverty status coupled with a lack of collateral and the risky nature of agricultural activities. To these challenges is added the limited or dysfunctional agricultural credit market in the area. These have effects on the farmers' capability to invest in household basic needs, such as food, health, school fees for their children, as well as improved agricultural inputs. As a result, households in the area are increasingly diversifying their sources of income through expanding the base of non-farm activities as a way to tackle these challenges, relax agricultural credit constraints, and foster the impetus to achieve sustained income through increased adoption of improved technologies. Careful examination shows that the major non-farm activities in South-Kivu include full-time and part-time labor, small commerce, crafts, and mining (28). Out of this wide range, handicrafts and small commerce emerge as major non-farm activities practiced by the smallholder farmers which are the non-farm activities considered in this paper. Small businesses in this paper consist of the detailed product sales of miscellaneous items such as salt, matches, sugar, soap, vegetables, oil, flour, eggs, oil, or beer. It is important to note that the sale of harvested produce by farmers was not considered here as a small business activity. Crafts are defined as the exercise of a manual art business and in this study consisted of the production of items such as baskets, ropes, mats, mortars, and pestles.

Different improved agricultural technologies have been introduced in south-kivu since 2006 through the CIALCA project with a set of soil fertility management practices (that necessarily include the use of fertilizer and organic inputs) and improved germplasm, combined with the knowledge on how to adapt these practices to local conditions. The aim was to maximize the agronomic use efficiency of the applied nutrients and improve crop productivity, a process known as Integrated Soil Fertility Management (ISFM) (23).

Although each component can have a positive contribution to soil fertility and crop productivity, the aim was to integrate multiple technologies to exploit complementarities among them. Mineral fertilizer use, planting in rows, and several improved crops varieties were introduced through the project (28). The program set up demonstration trials on the participants' plots to show differences between the traditional practice and the use of improved ISFM technologies. These included improved varieties of grain legumes, cassava, and maize, specific crop arrangements ("row planting"), and mineral fertilizer application: these are the technologies towhich this study refers.

Materials and methods

Theoretical and empirical framework

Definitions from several authors agree that non-farm activities are a range of activities carried out in the rural area with the exception of those related to agricultural production, livestock, forestry, hunting, and fishing which constitutes the non-farm rural economy (6, 24).

These income-generating activities may be related to types of employment or self-employment that are not agricultural although carried on in rural areas. The decision by a household to participate in any of these activities as well as to adopt a given technology falls within the theoretical framework of "household model" which considers the household as both producer and consumer. As producer, the household seeks to maximize profits by choosing between different groups of income-generating activities in relation to its resource endowments and the prices of products and goods. As consumer, the household maximizes its utility by choosing between different levels of consumption and leisure, given the budget constraints. However, consumption decisions become non-separable in the case of market imperfect production, implying that households maximize utility, given their resources, the available technology, market access, and prices (36).

The interaction between participation in non-farm activities and the decision to adopt a given technology is dependent on liquidity constraints or access to credit (12, 27) and risk aversion. Considering the credit market failure these authors suggest that the low level of liquidity reduces, to a large extent, the choices of production possibilities. Thus, the farmer needs non-farm activities to finance the establishment of agricultural production as demonstrated by in their household model. The growth of non-farm activities reduces the stress of the need for credit and liquid assets for agricultural production and can therefore boost the competitiveness of agriculture (39).

Adoption impact is perceived as the change in farmers' adoption rates due to their participation in non-farm activities. In an assessment based on non-experimental observations, adopting and non-adopting households may be systematically different. This is because participation in non-farm activities is not randomly distributed between the two categories as households themselves decide whether to participate or not in these activities on the basis of "constraints" and "attraction" factors. This result in the problem of selection bias attached to observable household characteristics which may stain the results with errors (9). To correct for this problem of selection bias economists use the non-experimental approach based on economic and econometric theories which minimizes potential errors in estimating impact (9, 11). To achieve this, it is imperative to follow the canonical model of evaluation introduced by Rubin (33).

Let the adoption output indicator be y, W be a binary variable which takes a value of one (W_1= 1) if the individual participated in at least one non-farm activity and zero (W_0= 0) if otherwise. Correspondingly, let Y1 and Y0 be two random variables that represent the two potential adoption statuses. The causal effect of participation for this individual is the difference between Y_1 and Y_0 as shown in equation (I):

$$\Delta Y = Y_1 - Y_0 \tag{I}$$

The causal effect has two important features: it is unobservable since only one of the two potential variables is observed for each individual (either Y_1 or Y_0) implying missing data called "counterfactual"; and it is individual, and thus there is a distribution of the causal effect in the population (9, 33). Nevertheless, due to the assumption of conditional independence between Y_i and W_i (i= 0,1), an average causal treatment effect (ATE) can be determined in a population as shown in equation II (32), which measures the impact of participation of an individual drawn at random from the population. It is also equal to the average impact of participation in the entire population (9).

$$ATE = E\left(Y_1 - Y_0\right) \tag{II}$$

We could also determine the average treatment effect in the sub-population of participants ($ATE1$) which is given by equation III:

$$ATE1 = E\left(Y_1 - Y_0 / W = 1\right) \tag{III}$$

Specifically, with W_i, the observed variable of interest (Y) can be written as in equation IV:

$$y=(1-W)Y_0+WY_1=Y_0+W(Y_1-Y_0) \quad \text{(IV)}$$

Assuming that the treatment variable W_i is statistically independent from (Y_1, Y_0), as is the case when the treatment is random, the estimation of *ATE* becomes simple with the use of equation (IV) (11). Under this independence assumption, *ATE* and *ATE1* are obtained by the difference between the mean of *Y* for participants and non-participants. The challenge we face, however, is that the independence assumption is relevant only in the case of randomized experimental design and may not apply in our case where participation in a non-farm activity depends to a large extent on the socioeconomic characteristics of individuals as well as the benefits the individuals expect from the activity (34, 40). The consistent estimate of *ATE* and *ATE1* requires a correction for this bias. This correction can be obtained through the use of parametric, semi-parametric, or non-parametric methods. This paper uses the semi-parametric method to control for certain restrictive assumptions resulting from the statistical distribution of the variables of interest; see (11) for mathematical details.

This method reduces the bias due to the difficulty related to the counterfactual.

Rosenbaum and Rubin (32) show that if, in addition to the assumption of conditional independence,

$$P(x)=Pr(w=1/x)=E(w/x)$$

satisfies the condition: 0<*P* (x)< 1, then, *ATE* and *ATE1* can be written as in equations V and VI:

$$ATE=E\left(\frac{(w-P\ x))y}{px(1-(p(x))}\right) \quad \text{(V)}$$

$$ATE1=\frac{1}{p(w=1)}E\left(\frac{(w-P(x))y}{px(1-p(x))}\right) \quad \text{(VI)}$$

To estimate equations 5 and 6, we first estimate *P(x)* by a *Probit* or *Logit regression* model (9) and then use the estimated *P(x)* values to obtain *ATE* and ATE1 in replacing the conditional expectation by the finite sample, as shown in equations VII and VIII:

$$ATE=\frac{1}{N}\sum_{i=1}^{n}\frac{[w_i-p(x)]yi}{p(x)[1-p(x)]} \quad \text{(VII)}$$

$$ATE1=\left[N^{-1}\sum_{i=1}^{N}w_i\right]^{-1}\sum_{i=1}^{n}\frac{[wi-p(x)]yi}{p(x)[1-p(x)]} \quad \text{(VIII)}$$

where W_i is the participation status of i^{th} individual; Y_i is the variable of interest (level of adoption), *N* is the sample size.

Empirical specification

In this paper, we use the binary logit model for both decisions of a farm household, whether to participate in non-farm activities and to adopt a technology package. A literature review brings out the fact that, with few differences, the determinants of participation in non-farm activities are also the factors determining the farmers' adoption of technological packages (11, 34, 40). Therefore, the specification of these two models (adoption and participation) is made at the same time in this section. The empirical models of participation noted "*p*" and adoption noted "a" are specified in equation IX.

$$Y\ (p,\ a) = f\ (I,\ M,\ AM,\ RN,\ RM) \quad \text{(IX)}$$

Where Y_p and Y_a are the dependent variables referring to participation in non-farm activities (petty trade and crafts) and the adoption of new varieties of cassava and beans. Other variables (*I, M, AM, INF* and *RM*) are groups of independent variables including factors that may affect the dependent variables.

Data used and description of variables

The data used in this paper were collected from 19 June 2006 to 21 February 2007 in northern Walungu and southern Kabare in South-Kivu. Villages and farms were selected with a two-stage stratified random cluster sampling strategy (23). To correct for oversampling, we use sampling weights, calculated as the inverse of the probability that the farm-household is selected in the sample. The total sample includes data from 475 farm-households. The questionnaire consisted of modules on different topics, including agronomic and socio-economic questions.

Respondents were asked about their awareness and use of improved agricultural technologies, specifically those introduced by the project, as well as non-farm income activities.

Explanatory variables included in the binary models were classified into five groups: farmer's individual characteristics, household's characteristics, household's assets and resources, institutional factors, and extension services. They are defined (Table 1) along with the expected signs on their coefficients. The dependent variable is adoption of improved beans or cassava varieties; the discriminating variable is participation in non-farm activities (petty trade and crafts). Participation here is a dichotomous variable taking the value 1 if the household participates in at least one of the non-farm activities studied and 0 otherwise. Adoption of new varieties is the binary variable that indicates the status of use of the improved varieties by the household during the growing season considered by the survey. It takes the value 1 if the farmer grows at least one improved variety and 0 otherwise. Prior expectations about the relationship of the explanatory variables to technology adoption are based on theoretical underpinnings and also previous empirical results. Education increases a farmer's sense of innovation and the capacity and facility to assess new technologies and therefore positively affects the use of new technologies. In addition, it influences both participation and income from non-farm activities (11, 29). Men would be more likely than women to adopt new agricultural technologies (11, 26). Women are more likely to engage in activities requiring the small amount of capital that can be derived from a loan or from their own accumulated savings. This fact makes them the social group most engaged in non-farm activities. The farmer's decision to adopt new technologies to use is associated with a certain level of risk and younger farmers are willing to take more risks than older farmers (11). The relationship between age and participation in non-farm activities is mixed. Non-farm activities generally require a certain level of ability, mobility, and training but, as pointed out by Zahonogo (40), the probability that rural households will diversify their income through non-farm activities increases with age. In addition, some non-farm activities, such as crafts, can be well adapted to the situation of elderly farmers. Several studies confirm that large households adopt new technologies more often than smaller households (1, 13). In terms of participation, several studies have found a positive relationship between household labor allocation and non-farm activities (7). (69) argues that households with married heads have greater nutritional needs that push them to improve their agricultural production through the adoption of high yielding varieties. Several studies show a positive relationship between this variable and both adoption of new technologies and participation in non-farm activities (34, 40).

In Africa, several studies have argued that land has a positive impact on the likelihood of participation in non-farm activities as well as on adoption of improved varieties and the biggest landowners are those who receive the largest share of income from non-farm activities (21). However the sign of the relationship between the area owned and adoption varies in functions of socioeconomic and geographic contexts (26). According to Lay *et al.* (25), the number of livestock has also proved to be an important determinant of participation in non-farm activities. However, possession of livestock can have two opposite effects (34). In terms of the probability of adoption it has a positive relationship with the number of cattle available to the household. The characteristic of location and access to infrastructure is an important factor both for participation as well as for adoption (3). Better access to market and credit will therefore increase the propensity of households to adopt the technology available at the same time as their propensity to participate in non-farm activities (12, 21, 34). In most cases, participation in non-farm activities positively affects the probability of adopting agricultural technologies (21, 26). When producers are well monitored by the extension service this eventually leads to a change in their decision in favor of the new technology. Contact with extension agents facilitates access to information and promotes the adoption of innovations (12).

Table 1

Summary statistics of variables and their expected signs.

Variables	Definition	Expected sign
Individual characteristics		
Age	Age of the household in years	Positive/Negative
Gender	1 if the farmer is male; 0 otherwise	Positive
Marital status	1 if the farmer is married; 0 otherwise	Positive
Formal education	1 if the farmer has formal education; 0 otherwise	Positive
Household characteristics		
Household size	Number of family members	Positive
Number of children enrolled in school	Total number of children enrolled in school	Positive
Household assets		
Number of livestock	Total number of livestock owned measured in TLU	Positive
Total land owned	Total land area owned by the household in ha	Positive/Negative
Access to infrastructures		
Access to credit	1 if the farmer has access to credit; 0 otherwise	Positive
Access to market	Frequency of monthly visits to the market	Positive
Has non-farm revenue	1 if the farmer has access to credit; 0 otherwise	Positive/Negative
Relations with extension services		
Information on new technologies	1 if the farmer has an adequate source of water for irrigation; 0 otherwise	Positive

Belonging to a farmers' association allows contact with support structures or extension and the exchange of ideas among producers and facilitates access to reliable information on innovations.

Results and discussion

Table 2 contains the descriptive statistics of the variables for participants and non-participants in non-farm activities and shows that young people were more engaged in petty trade while older people were engaged in crafts. Farmers' characteristics such as education, gender, age, marital status, household size, and market access vary significantly across different groups. It is also observed that households who participated in small businesses as well as in crafts were those with large household sizes. This can be attributed to the fact that having a high number of members increases the probability of such households participating in non-farm activities (34). Large households rely on their members to generate additional income. Women engaged more in small businesses than in crafts but were less engaged in non-farm activities than men. Also noteworthy is the fact that the proportion of farmers with formal education was higher among non-participants. Furthermore, non-participants in any of the non-farm activities had better access to credit and information on new varieties than those who participated. Market access was unequally distributed among participants and non-participants but households with easy access who visited markets more frequently were also those who participated most in at least one of the non-farm activities. Table 3 also summarizes the frequency of farmers adopting each non-farm activity in South-Kivu.

Table 2

Socio-economic characteristics of households by participation status.

	Crafts			Small businesses			All		
	Participants	Non- participants	[b]Test of difference	Participants	Non- participants	[b]Test of difference	Participants	Non- participants	[b]Test of difference
Number of respondents	30	437	-	152	315	-	192	278	-
Percentage	7	93	-18.58***	38	62	-5.18***	41	59	
Average age	49,6	45,1	-1,63	41,8	47,1	3.70***	43,3	46,8	2.55**
% Female	3,4	96,6	- 2.40**	41,1	58,9	-3.54***	51,4	39,6	-2.47**
% Married	7,2	92,8	-1,38	39,2	60,8	-6.45***	51,5	90,2	-7.09***
% Formal education	8,2	91,7	- 1.68*	38	61,9	-2.62***	55,5	63	-1,64
Average number of children enrolled in school	2,5	2,3	-0,69	2,3	2,3	0,1	2,3	2,3	-0,24
Average total land owned	1,9	0,8	- 3.88***	0,9	0,8	-0,79	0,9	0,7	-1,49
Number of livestock owned	0,3	0,4	0,27	0,4	0,3	-1,04	0,4	0,3	-0,98
Household size	9,6	7	- 4.12***	8,2	6,7	- 4.63***	8,2	6,6	-5.41***
% Access to credit	1,3	98,7	4.43***	31,4	68,5	0,5	64	54,5	2.09**
Market visit frequency	6,4	3,6	- 2.84***	5,1	3,1	- 3.90***	3,6	2,6	-3.62***
% Access to information	8,3	91,7	-1,64	31,5	68,4	-0,43	58	60,1	-0,45

Note: *** Significant at 1%; ** Significant at 5%; * Significant at 10%.

[b]Represents the probability of student T test between different groups.

Table 3

Rate of participation in non-farm activities in the study area.

Territory	Study area	Participation		All
		Crafts	Small businesses	Non-farm activities
Kabare	Kabamba	34(19.4%)	54(22.2%)	57(20.7%)
	Luhihi	40(22.9%)	52(21.4%)	58(21.0%)
Walungu	Lurhala	37(21.1%)	49(20.2%)	67(24.3%)
	Karhongo	23(13.1%)	35(14.4%)	34(12.3%)
	Burhale	40(22.9%)	53(21.8%)	60(21.7%)
Total		175(38%)	243(52.1%)	276(59.2%)

Note: The figures in parentheses represent the percentages.

A majority of farmers (59.2%) in the sample participated in non-farm activities; 52.1% were involved in small businesses and 24% in handicrafts.

The two groupments Lurhala (24.3%) and Burhale (21.7%) were distinguished by their high rate of participation and Karhongo had the lowest rate (12.3%). The estimated coefficients of the parameters and the marginal effects in the binary probit model are summarized (Table 4). The LR chi2 of 95,65 is greater than the $_{x}2$-critical value at 1% level of significance, which suggests that the Probit model is an adequate representation of the data. Among the variables representing farmers' characteristics, significant factors in the choice of the new improved crops were household size, number of children educated, presence of non-farm income, level of household wealth expressed by the access to information on new technologies, gender, and education level of the farmers. As expected, more male farmers tend to adopt new varieties than female farmers. This result corroborates those of several empirical studies. These have argued that women have a low probability of adoption of agricultural technologies and attributed this to their limited access to information on innovations and inputs (11). Household size positively influenced the adoption of the new varieties but the significance was observed only for beans at 5%. It increases the workforce while reducing related costs and thereby encourages the adoption of new technologies (12, 13). The marginal effect indicates that the adoption of improved beans varieties would increase by 1.8% if the household size increased by one person. The number of children who attended school in the household is significantly and positively correlated with the probability of adopting improved varieties of cassava (at 5%) and beans (at 1%) and complements the education level of the decision-maker in the household. Children who receive a certain level of education are more likely to understand the performance of new varieties and propose them to their family. However the presence of a large number of children attending school can push the household to adopt improved varieties so as to make more income to cover school fees. In addition, a further increase of the number enrolled in school would increase the adoption of improved varieties of beans by 4.1% and of cassava by 1.7%. As hypothesized, the presence of a non-farm income source in the household positively and significantly (at 5%) influenced the use of the improved varieties. Households with non-farm activities therefore have a higher propensity to adopt new varieties of the studied crops. These results are in the same direction as those of (26) who found that the presence of non-farm activities increases the propensity to adopt new agricultural technologies. Farmers who are better educated have greater ability to process information and search for beans technologies suitable for their production constraints than those who are not educated. Unexpectedly, this variable is inversely related to the adoption of cassava technology at the 5% significance level but has a low marginal effect. Household assets (wealth) represent to a farmer not only a guarantee against the risk inherent in the use of new technologies but also a source of cash for the purchase of agricultural inputs. The number of livestock as an asset of the household positively influences the adoption of improved varieties of the two crops. Market access promotes very significantly (1%) the adoption of improved bean varieties. Other empirical studies have indicated that market access facilitates access to information on new varieties and promotes the orientation of the production to the market. Access to information on new varieties was found to drive positively the adoption of new technologies. Several authors have demonstrated empirical evidence of the positive role that information plays in the adoption behavior of farmers. Diagne and Demont (9); and Dontsop Nguezet *et al.* (11) found that considerable knowledge of the technology by the farmer could lead to a higher rate of adoption. With the same aim to capture the access to information, (29) found that contact between producers and extension agents and information about innovations including new high-yielding varieties are important in adoption.

Table 4

Drivers of adoption of improved cassava and beans varieties in South-Kivu.

	Beans			Cassava		
	Coef.	Std error	Marginal effects	Coef.	Std error	Marginal effects
Age of the household head	-0,041	0,505	-0,007	0,933	0,06	0,008
Gender of the household head :1 if female and 0 otherwise	- 0.479*	0,268	- 0.082*	0,263	0,328	0,024
Marital status: 1 if the household head is married and 0 otherwise	0,489	0,361	0,078	0,372	0,049	0,031
Household size	0.105**	0,04	0.018**	0,048	0,323	0,004
Formal education: 1 if the household head has a formal education and 0 otherwise	0.434*	0,26	0.076*	- 0.674**	0,078	- 0.062**
Number of children that have attended school	0.233***	0,065	0.041***	0.186**	0,178	0.017**
Access to credit	0,003	0,247	0	0.663**	0,31	0.061**
Frequency of visits to market	0.126***	0,041	0.022***	-0,086	0,055	-0,007
Access to information on improved technologies	1.004***	0,262	0.176***	1.128***	0,338	0.106***
Number of obs.		447				443
LR chi2(11)		95.65***				49.36***
Prob> chi2		0				0
Pseudo R2		0,1876				0,1404
Log likelihood		-207,019				-151,055

Note: *** Significant at 1%; **Significant at 5%; *Significant at 10%.

Table 5

Semi-parametric estimation of the population parameters of adoption rate.

Activity	Culture	Estimated parameters						Obs
		ATE	ATE1	ATE0	JPA	GAP	PSB	
Small businesses	Beans	0.52***	0.54***	0.50***	0.28***	-0.25***	0,01	457
		(-0.05)	(-0.07)	(-0.06)	(-0.03)	(-0.03)	-0,04	
	Cassava	0.43***	0.39***	0.45***	0.14***	-0.28***	-0,03	456
		(-0.06)	(-0.06)	(-0.07)	(-0.02)	(-0.04)	-0,04	
Crafts	Beans	0.74***	0.76***	0.73***	0.28***	-0,46***	0,01	457
		(-0.08)	(-0.09)	(-0.09)	(-0.03)	(0,06)	-0,02	
	Cassava	0.43***	0.39***	0.45***	0.14***	- 0.28***	0,03	457
		(-0.06)	(-0.06)	(-0.07)	(-0.02)	(-0.05)	-0,04	

Note: *** p<0.01; ** p<0.05; * p<0.10. The figures in parentheses represent the robust standard errors; Obs.: Number of observations.

In the above result, the participation in non-farm activities is captured as a variable in the adoption model. Hence it may be subjected to the endogeneity problem since the direction of the relationship between adoption and non-farm income is debatable.

In addition, even if no problem of endogeneity is assumed, Table 4 does not give the magnitude of the impact on adoption rate of participation in non-farm income activities. Table 5 presents the summary of the semi-parametric estimation of the population parameters of adoption using participation in non-farm income activities as the instrumental variable. Following (9) we therefore estimate the causal effect of participation in non-farm activities (small businesses and crafts) on the adoption of new varieties of cassava and beans using the parameters of the average treatment effect (*ATE*). The semi-parametric method was used to obtain the propensity scores and the results are presented (Table 5). The actual adoption rate which represents the current demand for those varieties while considering participation in non-farm activities (JPA Joint participation and adoption) was 28% for beans and 14% for cassava. The average treatment effects (*ATE*), which reflect the potential adoption rates in the population if all households participated in non-farm activities, were estimated. The observed values of this parameter for their participation in crafts were 74% for beans and 43% for cassava. Those observed for the participation in small businesses were 52% for beans and 43% for cassava. The rate of cassava adoption remained constant (43%) for the two non-farm activities. This constancy is confirmed when the parameter of *GAP* which is the difference between the potential and the current adoption rates (*JPA* Join participation and adoption) is examined. The differences show that unconstrained participation in petty trade as well as in crafts would improve the rate of cassava adoption by 28%. For beans, however, the value of *GAP* varies considerably from 25% (small businesses) to 46% (crafts). Crafts thus appear to be an activity where participation would affect very strongly and significantly the adoption of new bean varieties.

This is explained by the fact that some craft activities are directly related to agriculture which provides them with raw materials, unlike small businesses which consist of the buying and reselling of goods, whether agricultural or not.

In addition, *ATE1* and *ATE0* parameters express the potential adoption rate among participants and non-participants. The values of these parameters show that unconstrained non-agricultural activities have greater effects among participating farm households than those who do not participate.

It is pertinent to note that the population selection biases (*PSB*) are low (range 2-3%) and not significant. This gives more confidence to the *ATE* parameters, certifying that they play a full primary role which is to reduce or eliminate selection bias (32).

Taking into account the constant changes observed in the rural world, these results have shown that participation in non-farm activities enhances adoption; it is a good strategy to relax the credit constraint faced by smallholder farmers in South-Kivu in acquiring improved seeds. Therefore the expansion of non-agricultural activities is essential in the process of modernizing agriculture to increase productivity.

Conclusion

This paper used the Probit and average treatment effect to estimate the potential impact of participation in non-farm activities on the adoption of improved beans and cassava varieties in South-Kivu, DRC. Results showed that the participation rate of households in non-farm activities in the area concerned was 38% for crafts and 52.1% for small businesses. However, the rates of adoption of these new varieties were 14% for cassava and 28% for beans. Factors affecting the adoption rate as determined based on a logistic regression were found to be gender, education, household size, the presence of non-farm activities, household assets in terms of livestock owned, access to market and to information on new technologies. These results demonstrate the tendency of rural households to include the practice of non-farm activities among their strategies to modernize farm production for survival and to diversify their sources of income or to supplement farm income.

This study also indicates that there is still a huge gap between the potential adoption rate (with unconstrained participation) and the actual rate of adoption for both crops studied. The differences observed for beans adoption were 25% (for small business) and 46% (for crafts) and are averagely larger than the 28% observed for cassava. These results show a positive relationship between the engagement of rural households in non-farm activities and their propensity to adopt improved varieties. This link could happen through the re-investment of non-farm income in agricultural innovations and there is a reduction of the risk in agricultural innovation through the diversification of income sources. The involvement of the farmers' households in non-farm activities may reduce the amount of additional labor for agriculture.

Therefore, the different actors involved in the development of the sector through projects and programs are expected to consider these non-farm activities even when they are working to promote purely agricultural technologies.

Acknowledgements

We are grateful to staff from national and Regional Research Centers and development actors who were consulted during the surveys and who assisted in data collection. We greatly appreciate the financial support from the Directorate General for Development (DGC), Belgium which has funded CIALCA since 2006.

Literature

1. Abdulai A., Owusu V. & Goetz R., 2011, Land tenure differences and investment in land Improvement measures: Theoretical and empirical analyses. *J. Dev. Econ.*, **96**, 1, 66–78.
2. Adégbola P.Y. & Adékambi S.A., 2008, *Taux et déterminants de l'adoption des variétés améliorées d'igname développées par l'IITA*. Rapport d'étape. 31.
3. Atamanov A. & Van den Berg M., 2012, Rural Nonfarm Activities in Central Asia: A Regional Analysis of Magnitude, Structure, Evolution and Drivers in the Kyrgyz Republic, *Europe-Asia Studies*, **64**, 2, 349-368.
4. Awoyemi T.T., 2004, *Rural non-farm and poverty reduction in Nigeria*. A report submitted to AERC, Nairobi, Kenya.
5. Barrett C.B., Reardon T. & Webb P., 2001, Non-farm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy implications, *Food Policy*, **26**, 315-331.
6. Davis J., 2006, Rural non-farm livelihoods in transition economies: emerging issues and policies, *Electron. J. Agric. Dev. Econ.*, **3**, 2, 180–224.
7. Davis B., Winters P. & Zezza A., 2007, *Rural Income Generating Activities: A Cross Country Comparison*, ESA Working Paper N°. 07-16, The Food and Agriculture Organization of the United Nations, Rome, Italy.
8. De Janvry A. & Sadoulet E., 2001, Income Strategies among Rural Households in Mexico: The Role of Off-farm Income, *World Dev.*, **29**, 3, 467-480.
9. Diagne A. & Demont M., 2007, Taking a new looks at empirical models of adoption: Average treatment effect estimation of adoption rates and their determinants, *Agric. Econ.*, **37**, 2-3, 201-210.
10. Dontsop N.P.M., Okoruwa V. & Adéoti A., Adenegan, K., 2012, Productivity Impact Differential of Improved Rice Technology Adoption among Rice Farming Households in Nigeria, *J. Crop Improv.*, **26**, 1, 121.
11. Dontsop N.P.M., Diagne A., Okoruwa V., Ojehomon V. & Manyong V., 2013, Estimation of Actual and Potential Adoption Rates and Determinants of NERICA Rice Varieties in Nigeria, *J. Crop Improv.*, **27**, 5, 561-585.
12. Doss C., 2006, Analyzing technology adoption using micro studies: limitations, challenges, and opportunities for improvement, *Agric. Econ.*, **34**, 3, 207-219.

13. Doss C., 2003, *Understanding Farm-level Technology Adoption: Lessons Learned from CIMMYT's Micro Surveys in Eastern Africa*, Economics working paper, 03-07.
14. DSCRP, Ministère du plan RDC, 2011, D*ocument de Stratégie de Croissance et de Réduction de la Pauvreté (DSCRP), Volume* **3***,* Rapport macroéconomique et budgétaire, Mars 2011.
15. Ellis F., Bahiigwa G., 2003, Livelihoods and Rural Poverty Reduction in Uganda, *World Dev.*, **31**, 6, 997-1013.
16. Ellis F., Freeman H.A. & Ade H., 2004, Rural Livelihoods and Poverty Reduction Strategies in Four African Countries, J*. Dev. Studies,* **40**, 4, 1-30.
17. Giiro G.M., 2013, *Impact of Off-farm Income on Agricultural Technology Adoption Intensity and Productivity: Evidence from Rural Maize Farmers in Uganda.* Working paper, International Food Policy Research Institute.
18. Goodwin B. & Mishra A., 2004, Farming Efficiency and the Determinants of Multiple Job Holding by Farm Operators. *Am. J. Agric***.** *Econ.*, **86**, 3, 722-729.
19. Iiyama M. P., Kariuki P., Kristjansonn P. S., Kaitibie S. & Matimali J., 2008, Livelihood Diversification, Incomes and Soil Management Strategies: A Case Study from Kerio Valley, Kenya, *J. Inter. Dev*., **20**, 380–397.
20. Jonasson, E., 2005, *Non-farm employment as rural poverty exit path? Evidence from Peru: Department of Economics*. Lund University, Sweden.
21. Kassie M., Shiferaw B. & Muricho G., 2010, *Adoption and Impact of Improved Groundnut Varieties on Rural Poverty: Evidence from Rural Uganda. Environment for Development*, Discussion Paper Series May 2010, EfD DP 10-11.
22. Kijima Y., Matsumoto T. & Yamano T., 2006, Nonfarm Employment, Agricultural Shocks and Poverty Dynamics: Evidence from Rural Uganda, *Agric***.** *Econ.*, **35**, 459-467.
23. Lambrecht I., Vanlauwe B., Merckx R. & Maertens M., 2014b, Understanding the process of agricultural technology adoption: mineral fertilizer in eastern DR Congo. *World Dev.*, **59**, 132-146.
24. Lanjouw O.J. & Lanjouw P., 2001, The rural non-farm sector: issues and evidence from developing countries, *Agric. Econ.*, **26**, 1–23.
25. Lay J., M'Mukaria G. & Mahmoud T., 2007, B*odaBodas Rule: Non-farm Activities and Their Inequality Implications in Western Kenya*, Kiel Working Paper No. 1314, Kiel Institute for the World Economy.
26. Nkamleu G.B., Coulibali O. & Endamana D., 2001, *Transfert de nouvelles technologies dans les systèmes de production au Nord du Cameroun: cas des variétés améliorées du niébé.* Document de travail, p 20. IITA, Mimeo, HFS- Yaoundé Cameroun. http://www.fidafrique.net/IMG/pdf/Technology_adoption_Pronaf_Cameroon.pdf
27. Ouédraogo S., 2003, Impact économique des variétés améliorées du niébé sur les revenus des exploitations agricoles du plateau central du Burkina Faso, *Tropicultura*, **21**, 4, 204-210.
28. Ouma E., Birachi E., Vanlauwe B., Ekesa B., Blomme G., Chianu J., Bouwmeester H. & Van Asten P., 2011, *CIALCA Baseline Survey.* International Institute of Tropical Agrculture (IITA), www.iita.org.
29. Reardon T., Berdegué J., Barrett C. & Stamoulis K., 2006, *Household Income Diversification into Rural Nonfarm Activities. Transforming The Rural Nonfarm Economy,* Available at SSRN: http://ssrn.com/abstract=1846821.
30. Reardon T., Berdegue, J. Escobar G., 2001, Rural Nonfarm Employment and Incomes in Latin America: Overview and Policy Implications. *World Dev.*, **29**, 3, 395-409.
31. Reardon T., Stamoulis K. & Pingali P., 2007, Rural Nonfarm Employment in Developing Countries in an era of Globalization, *Agric. Econ.*, **37**, 173-183.
32. Rosenbaum P.R. & Rubin D.B., 1983, The central role of propensity score in observational Studies for Causal Effect*, Biometrica*, **70**, 1, 41-55.
33. Rubin D.B., 1974, Estimating causal effects of treatments in randomized and nonrandomized studies, *J. Educ. Psychol.*, **66**, 688- 701.
34. Sanchez V., 2005, T*he determinants of rural non-farm employment and incomes in Bolivia*, MSc thesis. Department of Agricultural Economics. Michigan State University, USA.
35. Tasie C., Offor U. & Wilcox G., 2012, Determinants of off-farm income diversification in Rivers State, Nigeria, *J. Agric. Res.*, **1**, 8, 331-334.

36. Taylor E. & Adelman I., 2003, Agricultural Household Models: Genesis, Evolution, and Extensions, *Rev. Econ. Household,* **1**, 1, 33-58.
37. Wang Y., Chenggang W. & Suwen P., 2011, *The Impact of Nonfarm Activities on Agricultural Productivity in Rural China,* Department of Agricultural and Applied Economics, Texas Tech University, USA.
38. *World Bank,* 2013, World DataBank. http://databank.worldbank.org/data/home.aspx.
39. *World Bank*, 2008, World Development Report 2008: Agriculture for Development, Washington DC: USA.
40. Zahonogo P., 2011, Determinants of non-farm activities participation decisions of farm households in Burkina Faso, *J. Dev. Agric. Econ.*, **3**, 4, 174-182.

P.M. Dontsop Nguezet, Cameroonian, Impact Economist, International Institute of Tropical Agriculture, Bukavu, DR Congo.

V. Manyong, Congolese (DR Congo), PhD, Director, Eastern African hub, International Institute of Tropical Agriculture, Dar Es Salaam, Tanzania.

T. Abdoulaye, Nigerien, PhD, Outcome/Impact Socio-Economist, International Institute of Tropical Agriculture, Ibadan, Nigeria.

A. Arega, Ethiopian, PhD, Impact Assessment Economist, International Institute of Tropical Agriculture, Lilongwe, Malawi.

M.S. Amato, Congolese (DR Congo), MSc Student, Evangelic University in Africa, Bukavu, DR Congo.

J.H. Ainembabazi, Ugandan, Post-Doctoral Fellow-Agricultural Economist, International Institute of Tropical Agriculture, Kampala, Uganda.

D. Mignouna, Togolese, Post-Doctoral Fellow-Agricultural Economist, International Institute of Tropical Agriculture, Ibadan, Nigeria.

C. Okafor, Nigerian, PhD, East and Central African Action Area coordinator of the Humidtropics program, International Institute of Tropical Agriculture, Bukavu, DR Congo.