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Intensity of adoption of agricultural innovations in risky environment: the case of corn producers in West-Cameroon

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DOI: 10.1481/icasVII.2016.c22

ABSTRACT

This study identifies factors that affect the intensity of use of improved maize seed and chemical fertilizer, the main modern inputs used to produce maize in West-Cameroon, by producers in West-Cameroon. The multivariate tobit model is used to take account of correlation between the disturbances. Results mainly indicate that the perception of risks is an impediment to a simultaneous adoption of agricultural innovations such as improved maize seeds and chemical fertilisers by corn producers in West-Cameroon and that, as a consequence, the price of corn has no effect on the intensity of use of modern inputs. We conclude that policies aiming at setting up sustainable risks management could greatly promote the adoption of agricultural innovations by farmers of the western region of Cameroon in general and probably by their peers in other regions of this country.

Keywords: Intensity of use of agricultural innovations; Multivariate Tobit model; Risks; West-Cameroon.

PAPER

1. Introduction

Despite the fact that agriculture is a very risky activity, it continues to be a fundamental instrument for sustainable development, poverty reduction and enhanced food security in developing countries. It is a vital developmental tool for achieving the Millennium Development Goals. However, Africa faces huge food supply challenges due to increasing human population, limited opportunities to increase arable land, and declining yields associated with continually declining soil fertility. Currently, agricultural productivity growth in sub-Sahara Africa lags behind that of other regions in the world, and is well below that required to achieve food security and poverty goals (Morris, 2007). Increasing agricultural productivity in Africa is an urgent necessity and one of the fundamental ways of improving agricultural productivity is through the introduction and use of improved agricultural technologies.

In Cameroon as in most countries of sub-Saharan Africa, although agriculture is a predominant sector, there is a low adoption of agricultural innovations, particularly among producers of food crops (INS/ECAM 3). In this regard, this paper analyses the determinants of intensity of adoption of improved maize seeds and chemical fertilizers by farmers (especially corn[1] producers) in western Cameroon. This is aimed at providing an empirical basis that would guide effective programs to promote agricultural innovations use[2] in Western Cameroon. A study on the intensity of adoption of agricultural innovations being more complete than that which is only limited to the examination of the adoption decision, then, while introducing the risks, this paper analyses the factors influencing the intensity of use of modern inputs by corn producers in West-Cameroon.

Although there is a well-developed literature on the impact of a host of explanatory variables on technology intensity adoption (Eba and Bashargo, 2014; Arslan et al, 2014; Turinawe et al., 2014), there is a dearth of the analysis which provides new evidence on policy relevant variables such as prices (particularly the price of output) and risks. In fact, facing some economic incentives such as the rising price of output, some atypical behaviours of producer (i.e. negative or absence of production/input demand response to output price incentives) in developing countries can be better explained only if risks are introduced in the analysis.

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[1] This interest for corn stems from the fact that it is among the main food crops that is most consumed in Cameroon. Indeed, almost 67% of Cameroonians consume corn, about 12 million people; corn is also used in animal feed and in industry (ACDIC, 2008). In addition, maize is consumed in all regions of Cameroon. It should also be noted that today, this product is also used to make energy (corn is a bio fuel).

[2] A survey of 564 corn producers in West-Cameroon indicates that the intensity of the use of agricultural innovations is very low in this region.

Even if Asfaw et al. (2011) and Beshir (2013) take into account risks, they don't take into account the interdependence of adoption of agricultural innovations.

The contributions of this paper are twofold: First, in this study, farmers' perceptions of different types of risk are introduced in the list of factors influencing the intensity of adoption of agricultural technologies. We also introduce prices, particularly the price of output (here, the price of corn) as a driver of adoption. Second, we provide a rigorous analysis of the interdependent adoption of agricultural innovations by using a simultaneous equation Tobit model for estimating the intensity of technologies adoption.

The remainder of the paper is organized as follows: data and methods which are discussed in section 2; section 3 presents and discusses the results and section 4 concludes.

2. Materials and methods

2.1. Study area and data collection

This study was conducted in West-Cameroon, one of the ten regions of Cameroon. This region is known to be the barn of Cameroon since it is the main production area of food crops, especially corn. Corn production in West-Cameroon is estimated at nearly 20% of national production of corn (MINADER, 2012). West-Cameroon is divided into eight divisions among which four distinguish themselves in terms of maize production by their high density of production. These are: Hauts-Plateaux, Koung-Khi, Mbamboutos and Mifi.

According to the divisions of the Central Bureau of Census and Population Studies in Cameroon (BUCREP), regions in Cameroon are divided into divisions which are also divided into subdivisions, which in turn are subdivided into Enumerated Areas[3] (ZD) with known geographical boundaries. It is on the basis of these divisions that we gather our sample.

Data were collected in 2012 using the three-stage sampling technique. At the first stage, subdivisions with the highest density in maize production were selected from the four highly dense divisions in maize production, making a total of seven subdivisions. At the second stage, and on the basis of BUCREP's cartographic maps, we randomly selected from the selected subdivisions and in proportion to the population size, 25 ZD among the 282 ZD in the urban area and 17 ZD among the 291 ZD in the rural area. At the third stage, 11 corn farmers were randomly selected from each urban ZD selected and 17 corn farmers in each rural ZD selected. This choice was made in such a way that the number of producers surveyed should be the same in the rural and urban areas. The sampling process ended up with a sample of 564 corn producers. According to the formula of Cochran (1977), this sample size should be sufficient for this study.

Six students trained for this survey were used for data collection. These students were divided into two teams of three. Every day, each team had to go to one selected ZD and within the ZD, they would select, using the systematic sampling method, households (in each household, the surveyor would interview the farmer with the aid of a questionnaire) by steps of 18 households in urban ZD and by steps of 11 households in rural ZD.

Data were collected on the socioeconomic characteristics of the farmers[4] and their farm, the use of agricultural innovations such as improved seeds and chemical fertilisers, farmer's corn selling price during the year preceding the survey and the perception of risks by farmers.

2.2. Modeling and description of variables

As Arslan et al. (2014), Eba et Bashargo (2014) and Turinawe et al. (2014) we employed the Tobit model to examine the intensity of adoption of various technologies. But, in contrast to these authors, especially the work of Arslan et al. (2014) and Turinawe et al. (2014) which various technologies had been examined as in ours, we took into account possible inter-relationships between the various practices by using a simultaneous equation Tobit model for estimating the intensity technologies adoption. In fact, the adoption decision of the farming household for any one practice does not rule out the adoption of the other available practices, but as noted by Isgin et al. (2008), the adoption of a given technology might not be independent of another since the effects of certain technologies might be complementary.

In this paper, we adopt a multivariate Tobit econometric technique to estimate simultaneous equation Tobit model. The Multivariate Tobit model is estimated by maximum simulated likelihood that uses the Geweke-Hajivassiliou-Keane (GHK) simulator.

The intensity adoption equations for each modern input can be represented by:

$$y_i^* = X_i\beta_i + u_i \qquad i = 1,\ldots m \text{ (in our case } m = 2) \qquad (1)$$

[3] An enumerated area is a geographical area that can accommodate approximately 200 households.

[4] In this study, a farmer is a person who operates a farm (farm owner). A farm owner or a farmer is not necessarily the owner of the land where he cultivates.

where y_i^* is a latent variable representing the intensity of adoption of the agricultural innovation i (y_i), X_i is a vector of exogenous variables (These variables are presented in Table 1), β_i is the vector of parameters to be estimated and u_i is a random disturbance with mean zero and variance σ_i^2. The relationship between the latent variable y_i^* and the intensity of adoption for a modern input i (y_i) can be represented by:

$$y_i = y_i^* \quad if \quad y_i^* > 0 \qquad (2)$$
$$= 0 \quad \text{otherwise.}$$

Table 1 - Variables definition and descriptive statistics (N=564)

Variables	Variable names	Measure	Mean	Standard deviation
Dependent variables				
intsam	Intensity of use of improved maize seeds	percent of area planted to improved maize seeds	12.906	28.644
intanch	Intensity of use of chemical fertilisers	quantity of fertiliser (in gram) applied per m^2	10.278	14.996
Independent variables				
riskmala	Perception of risk of illness or death of a key member of the household	1 if a risk, 0 otherwise	0.521	0.500
riskprix	Perception of risk of decline in the price of corn	1 if a risk, 0 otherwise	0.943	0.232
riskphyt	Risk perception of pest-disease infestations	1 if a risk, 0 otherwise	0.568	0.496
riskclim	Perception of climate risk	1 if a risk, 0 otherwise	0.941	0.235
riskfina	Risk perception of default to finance a crop production	1 if a risk, 0 otherwise	0.334	0.472
dist_ch	Average distance from the farmer's home to the farm	Distance in kilometres	11.664	
fem	Gender of farmer	1 if the producer is a woman, 0 otherwise	0.824	0.381
fertilbais	Evolution of the farmland fertility over the past 5 years	1 if the farmland fertility has declined, 0 if soil fertility has not changed	0.237	0.426
fertilhaus	Evolution of the farmland fertility over the past 5 years	1 if the farmland fertility has increased, 0 if soil fertility has not changed	0.248	0.432
primary	Educational level of farmer	0 if no education, 1 if has primary education level	0.420	0.494
secondary	Educational level of farmer	0 if no education, 1 if has secondary education level or higher	0.374	0.484
credit	farmer's credit access	1 if access to credit, 0 otherwise	0.342	0.475
div-act	Exercise of the non-agricultural activity by the farmer	1 if has a non-agricultural activity, 0 otherwise	0.404	0.491
asso	Farmer participation to a producer organisation	1 if adhere to a producer organisation, 0 otherwise	0.688	0.464
propr	Ownership of land cultivated	1 if owner, 0 otherwise	0.894	0.309
experience	Agricultural experience of the farmer	Number of years during which the producer has been engaged in corn production	23.608	14.184
experience2	Agricultural experience of the farmer squared	Number of years during which the producer has been engaged in corn production (squared)	758.175	791.978
tailmenag	Household Size	number of persons in the household	6.596	3.056
dist_mark	Average distance from the farmer's home to usual market	Distance in kilometres	2.026	2.320
super	Farm size	Acreage (in m^2)	11493.010	10652.460
pmoy	Average sale price of a kilogram of maize	Amount in FCFA	140.971	45.757
tauxsal	Cost of labour	Amount in FCFA/week	10508	5994
revenu	The annual income of the farmer	Amount in FCFA	598351	1169125
rural	Area	1 if rural area and 0 if urban area	0.5124	0.500
coutfiente	Cost of 50 Kg of manure	Amount in FCFA	1757.307	431.015

Note: In this study, the farmer is the interviewee.

Regarding dependent variables, we examined in this study two main modern inputs which are used to produce corn in western Cameroon, these are: improved seeds of maize and chemical fertilisers. We noted that in average, farmers used 10.278 gram of fertiliser per m^2 and allocated only 12.906 % of their cultivated land to improved seeds. Among those who used chemical fertilisers on their corn, 15.2 grams on average of chemical fertiliser[5] were applied per m^2 of land; which is well below the average quantity regularly recommended for corn in western Cameroon (i.e. 20 to 30 grams per m^2 (IRAD, 2010)).

Table 1 shows that about 82 percent of surveyed farmers were female[6], 89.4 percent owned their lands[7] and about 50 percent reside in rural zone. 42 percent of survey farmers had primary education level while 37.4 percent had secondary education level or higher. The average size of farm was about 1.15 hectares and the farmer's average annual income was about 598,351 FCFA (about 1,196 US $). In average, maize price was about 140 FCFA, the cost of labour and manure were about 10,508 FCFA and 1,757 FCFA, respectively.

Regarding risk variables, in this study, as in the works of Glynn et al. (2009) and Kurihara et al (2014), the perception of farmers of the importance of events that could have a negative impact on their income will be retained as a means of quantifying the principal risks which farmers face. In fact, this perception of risk by the producer is nothing more than an assessment by him of the risk in terms of probability that risk has a negative impact on his income. So, to capture farmers' risk perception, farmers were asked to score their perception of the importance of events/shocks that could have a negative impact on their income based on previous shocks (on a scale of 1 to 5; where 5 signifies high negative impact on their income).

5 Chemical fertiliser most used in western Cameroon is the composite variety 20-10-10.

6 This is in conformity with national estimations which reveal that Cameroonian women accomplish more than 75 % of agricultural work and contribute for 60 % of food production (FAO, 2007).

7 In the western region of Cameroon most of the land belongs to families and all family members including women claim to be co-owners of land.

This variable is converted into a dummy variable, where 1 indicates that there is a risk perception and 0, the absence of risk perception. Because this method of quantification of risk does not require either knowledge of the probability distribution of the loss of income, nor the values of those potential losses that may be incurred by the producer, this method will be used to capture the main agricultural risks which farmers face.
As regards statistics of the risk perception variables, we noted that farmers that perceived risk was 52.1, 94.3, 56.8, 33.4 and 94.1 percent for risk of illness or death of a key member of the household, for risk of decline in the maize price, for risk of pest-disease, for risk of default to finance a crop production and for climate risk respectively.

3. Results and discussion

The significant effect of the perception of some risks (see Table 2) indicates that the econometric specification in an uncertain environment is most appropriate. Table 2 presents the econometric results concerning variables influencing the intensity of adoption of agricultural innovations by corn farmers in western Cameroon. The likelihood ratio test [chi2(1) = 2.95456, Prob ↑ chi2 = 0.0856] of the independence of the disturbance terms is rejected, implying that multiple technology adoption in West-Cameroon is not mutually independent and supporting the use of a multivariate Tobit model (See Table 2). In addition, the binary correlations between the error terms of the two adoption equations show that these practices are complements (positive correlation).
It appears from Table 2 that the cost of labour has a negative effect on the intensity of adoption of chemical fertilisers. In fact, the use of this agricultural innovation is labour intensive, so an increase in labour costs will decrease its intensity of adoption. Conversely, the high cost of organic fertiliser could drive farmers who want to increase their production to increase the intensity of adoption of chemical fertiliser (which is a substitute for organic fertiliser because it is also added to the soil in order to increase the quantity of nutrient in the soil).

Table 2 - Estimation result of the intensity of use of modern inputs model (multivariate Tobit model results)

VARIABLES	Intensity of use of improved seeds (1)		Intensity of use of chemical fertilisers (2)	
	Coefficients	t-statistics	Coefficients	t-statistics
fem	-2.857	-0.201	-0.654	-0.315
dist_ch	-1.417**	-2.078	0.0938	1.052
fertilbais	-40.83**	-2.388	6.424***	3.216
fertilhaus	6.118	0.487	-3.901**	-2.015
primary	28.68	1.593	0.0749	0.0342
secondary	60.96***	3.037	1.757	0.678
credit	1.964	0.161	1.595	0.886
div-act	5.496	0.467	-0.561	-0.332
asso	33.04**	2.382	1.350	0.744
propr	-13.50	-0.714	-6.575***	-2.619
experience	0.748	0.504	-0.387*	-1.828
experience2	-0.0155	-0.578	0.00768**	2.101
super	0.00165***	3.109	-0.000233***	-2.790
pmoy	0.138	1.244	0.000686	0.0374
revenu	0.00769**	2.060	0.00551***	8.111
tailmenag	0.955	0.517	-0.328	-1.197
dist_mark	-2.145	-0.754	0.300	0.908
riskprix	-20.68	-0.893	-3.991	-1.200
riskclim	-44.68*	-1.900	5.763*	1.650
riskmala	29.65**	2.417	-3.623**	-2.182
riskphyt	-15.72	-1.255	0.731	0.427
riskfina	-15.73	-1.264	6.848***	4.028
tauxsal	-0.0353	-0.0346	-0.414***	-2.746
coutfiente	0.0200	1.529	0.00592***	3.127
rural	-12.80	-0.993	-0.660	-0.369
Constant	-121.7**	-2.317	5.056	0.666
Number of observations	562			
Wald chi2(50)	269.25			
Prob > chi2	0.0000			
Log likelihood value	-2535.5003			
sigma1	85.048***			
sigma2	16.359***			
ρ_{12}	0.123*			
LR test of ρ_{12} : Chi2(1)	2.95456			
Prob > chi2	0.0856			

Note: * (**)(***) represent statistical significance at 10% (5%) (1%);
Prices of improved maize seed, fertilisers and pesticides were excluded because there is lack of variation in our data for these variables.

In general, risks perception does not allow the combined adoption of agricultural innovations by corn producers in West-Cameroon (Table 2). Indeed, the perception of climate risk has a negative and positive effect respectively on the intensities of adoption of improved seeds and fertilisers. Similarly, while the perception of risk of financing a crop has a positive influence on the intensity of adoption of chemical fertilisers, it has no effect on the intensity of adoption of improved seeds. According to Feder (1980), these results would be related to the facts that poor farmers in developing countries (including Cameroon) face credit constraints; which leads them to intensify chemical fertilisers more (at the expense of improved seeds). However, the perceived risk of illness or death of a key member of the household (as potential

labour) leads these producers (with a binding credit constraint) to reduce the intensity of adoption of chemical fertilisers that are labour intensive and to increase the intensity of adoption of improved seeds. All this shows that the presence of multiple agricultural risks combined with the constraints of credits facing Cameroonian producers do not favour the combined adoption of agricultural innovations; yet, according to Perkins et al. (2008), it is the combined use of these agricultural innovations which ensures higher crop yields.

Table 2 also shows that the intensity of adoption of chemical fertilisers do not continually decreases with the increase of agricultural experience of the farmer. Which indicates that it is only at a certain level of experience in agriculture that the farmer understands the need to intensify the use of chemical fertilizers. The proportion of land allocated to improved seeds only increases with the level of secondary education or higher; it is probably at this level of education that farmers understand the agro-economic potential of the use of improved seeds. Similarly, producer participation in one (or more) organisation(s) has a positive effect on the percentage of land allocated to improved seeds. In fact, it is usually within producer organisations that farmers discuss their work with their peers and share information and their experiences on the advantages of using new technologies. It also notes that the ownership of cultivated plots has a negative effect on the quantity of grams of chemical fertiliser used per 2 m of land. In fact, the farmers who own farmland, aware of the potential long-term negative impact related to the intensive use of chemical fertilisers, therefore use this input less intensely.

Contrary to theoretical predictions, farm size negatively influences the intensity of adoption of fertilisers. This might be due to the fact that farmers with larger farm sizes have the possibility to reconstitute soil fertility by allowing some of their land fallow. However, it influences positively the intensity of using improved seeds. This implies that farm size is an indicator of wealth and a proxy for social status within a community which influences positively the intensity of use of improved seeds. Similarly, as an indicator of wealth, the farmer's income has a positive influence on the intensity of adoption of improved seeds and fertilisers. Moreover, we note that the decreased fertility of cultivated land has a positive influence on the intensity of use of chemical fertilisers and a negative influence on the intensity of use of improved seeds. In fact, in the face of declining fertility of cultivated land, poor farmers (with a binding credit constraint) spend their income to the purchase of fertilisers (at the expense of the purchase of improved seeds). The increase in fertility of cultivated land is an unfavorable factor for the intensity of use of chemical fertiliser. This is quite intuitive because the land being fertile, farmers will no longer need to intensify the use of chemical fertilisers.

4. Conclusion

This study determines the factors influencing the intensity of use of agricultural innovations by corn producers in western Cameroon. Rather than univariate Tobit model which is commonly used, the multivariate Tobit model is employed to take account of correlation between the disturbances. The study shows that, beside the perception of many agricultural risks, multiple characteristics related to the producer or to his farm affect adoption of improved maize seed and chemical fertiliser by corn producers in West-Cameroon. Results mainly indicate that, faced to risks perception, farmers in West-Cameroon tend not to adopt improved maize seed in combination with fertiliser. Yet, according to Perkins et al. (2008), it is the combined use of these agricultural innovations which ensures higher crop yields. Furthermore, the price of corn has no effect on the intensity of use of modern inputs. This result might be linked to the presence of multiple agricultural risks that could make farmers insensitive to incentives of output prices. The implication of this is that the policies aimed at setting up sustainable risk management markets could greatly promote the adoption of agricultural innovations by farmers of Cameroon in general and in the western region in particular where the markets of risk management do not exist or are malfunctioning.

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