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Factors influencing smallholder crop commercialisation: Evidence from Côte d'Ivoire

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In this study, we analysed factors that influence crop output commercialisation among smallholder farmers in Cote d'Ivoire. Unlike previous studies, we correct for sample selection bias by using the Heckman maximum likelihood sample selection model with village fixed effects. We rely on a unique and detailed dataset that covers 3,393 smallholder farmers. The dataset was gathered from the 2014 National employment survey collected by the National Institute of Statistics (INS) Côte d'Ivoire. Results from the study suggest that cooperative membership and land tenure security raise the level of marketed outputs of Ivorian farmers. Female headed households sold lower proportions of their outputs than their male counterparts. Labour shortage is a major constraint to crop output commercialisation. From a policy perspective, the Government should revive its interest in collective actions such as cooperatives, facilitate farmer's access to credit, improve food crop productivity and enhance mechanization.

Key words: Crop commercialisation, Côte d'Ivoire, smallholder farmers, agriculture.

INTRODUCTION

Smallholder farming activities continue to be a dominant livelihood activity in most low- and middle-income countries. Most of them, in regions such as West Africa rely on subsistence farming for their livelihood. Participating in crop market commercialisation usually requires a long transformation process from subsistence to semi-commercial and then to fully commercialised agriculture (Pingali and Rosegrant, 1995). In recent years, The World Bank has listed Africa among the fastest growing regions in the world. As an illustration, Côte d'Ivoire has recently had a stable economy and is currently growing at an approximate rate of 8.3% according to the African Development Bank. As the economy of a country grows, households shift away from subsistence goals to the commercialisation of agricultural products.

In recent years, smallholder farmers in many African countries have been selling a portion of their outputs on

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the market. For rural development and poverty reduction, promoting commercialisation of agricultural products appears to be an essential process. Pender and Alemu (2007) using a survey of 7,186 farm households in Ethiopia, prove that net buyers and autarkic households are poorer in many respects than net sellers. It is therefore important to understand the factors that are more likely to affect the extent of commercialisation. Significant research efforts have been made and are still underway to investigate farmer's ability to switch from a mostly subsistence farming to commercialisation, a process that could help improve their livelihood.

Martey et al. (2012) found that output price, farm size, households with access to extension services, distance to market and market information determine the extent of commercialisation in Ghana. Pingali and Rosegrant (1995) show that, in Asia, irrigated lowlands by their nature are inherently more market oriented because of their ability to generate a surplus and because of better transport infrastructure. Osmani and Hossain (2015) used a Probit model to explore the factors that affect the decision of farmers to participate in output markets to sell their products. Findings from their study suggest that variables such as farm size, household labour and farm income are likely to increase the probability of farmers participating in output markets. However, the probability decreases when a farmer has income from livestock. While many studies have been devoted to this issue, investigating the driving force at household level in Cote d'Ivoire is yet to be explored.

Our objective is to determine the factors that influence smallholder farmer's crop commercialisation in Côte d'Ivoire. The commercialisation issue is closely related to the employment issue in Cote d'Ivoire, which is fully in line with the Ivoirian government's agricultural policy. Our study is similar to that of Martey et al. (2012) and Rahut et al. (2015). They use the Tobit regression analysis. Such econometric specification rests on the basic assumptions of homoscedasticity of variance and no selection bias. However, given the nature of our sample, a Tobit specification may lead to biased estimates since The Breusch-Pagan test indicates that the null hypothesis of homoscedasticity should be rejected. Therefore, we control for selection bias by using the Heckman two stage procedures. We rely on a unique and detailed dataset that covers 3,393 smallholder farmers for the whole agricultural sector of the year 2014. Our estimations yield a number of predictions.

The rest of the paper is organized as follows. First is our conceptual and empirical framework, followed by a presentation of the data used as well as some descriptive statistics. Thereafter, the empirical results along with conclusion and policy implications are presented.

CONCEPTUAL AND ECONOMETRIC FRAMEWORK

Following Strasberg et al. (1999), we used a household commercialisation index (HCI) to measure the intensity of smallholder farmers' engagement in the market. The household commercialisation index is defined as the ratio of the gross value of all crop sales and the gross value of all crop production

$$HCI = \left[\frac{Gross\ value\ of\ crop\ sales\ (in\ XOF)}{Gross\ value\ of\ all\ crop\ production\ (in\ XOF)}\right] \times 100 \quad (1)$$

It could be seen as a measure of a household's market orientation. The larger the index the higher the degree of commercialisation or market orientation. A value of zero signifies no market participation—the household only produces for its own consumption; that is, full subsistence.

In this paper we aim at exploring the determinant of both the probability and the intensity of the level of commercialisation. The advantage of this approach is that commercialisation is treated as a continuum thereby avoiding crude distinction between commercialised and "non-commercialised" households. One approach to achieve our objective is to use a Tobit model which has an advantage over other discrete models in the sense that it reveals both the probability and the intensity of the level of commercialisation. Most empirical studies on smallholder agricultural commercialisation use the Tobit model (Holloway et al., 2000; Martey et al., 2012; Rahut et al., 2015). However, the validity of a Tobit model is based on the assumption of normality and homo-scedasticity. Our diagnostic checks in our empirical work clearly reject both the assumptions of normality and homoscedasticity at 1% level and 5%, respectively. Furthermore, an OLS regression of HCI will lead to biased and non-convergent estimates, because the sample (Selling households) is unrepresentative of the population we are interested in (farming households).

There is an evidence of a sample selection problem. As a result, a Tobit specification would lead to biased estimates. To overcome this issue, we rely on Heckman's approach to analyse the determinants of commercialisation.

Our approach is closed to Alene et al. (2008) who employ the Heckman selection model to analyse the effects of transactions cost on smallholder marketed surplus and input use in Kenya. However we differ from them by estimating the Heckman two step method simultaneously. Heckman (1976, 1979) treated the selection problem as an omitted variable problem. The Heckman sample selection model has two features such as the two-step estimator and the full information maximum likelihood. However, Puhani (2000) showed that in the absence of collinearity problem, the full information maximum likelihood estimator is preferable to the two-step method of Heckman. Since there is no collinearity among the independent variables that we used in the empirical estimation, we adopt the full information maximum likelihood estimator of Heckman. Following Heckman (1979), we model the determinant of crop output commercialisation as follows:

$$Y_{1i}^{*} = X_{1i}^{'}\beta_1 + u_{1i} \quad (1)$$

$$Y_{2i}^{*} = X_{2i}^{'}\beta_2 + u_{2i} \quad (2)$$

The selection equation could be written as:

$$Y_{1i} = \begin{cases} 1 & if \quad Y_{1i}^{*} > 0 \\ 0 & if \quad Y_{1i}^{*} \le 0 \end{cases} \quad (3)$$

Heckman (1976, 1979) has proposed a simple practical solution for such situations, which treats the selection problem as an omitted variable problem.
The outcome equation is as follow:

$$Y_{1i} = \begin{cases} Y_{2i}^{*} & if \quad Y_{1i}^{*} > 0 \\ - & if \quad Y_{1i}^{*} \le 0 \end{cases} \quad (4)$$

The Model (1) is a Probit-type selection equation describing the probability of selling crop output in the market. The variables Y_1^* and Y_2^* are not observed whereas Y_1 and Y_2 are observed. In another note, one of the X_1 variables may be number of people in the household. For example, we could be interested in the effect of an extra household member on the level of commercialisation. We will not observe such effect for households who do not sell. This is expressed in Equations 3 and 4. It is commonly assumed that the correlated errors are jointly normally distributed, that is,

$$\begin{bmatrix} u_1 \\ u_2 \end{bmatrix} \square \left[\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_{22}^2 \end{bmatrix} \right] \quad (5)$$

Given that assumption, the likelihood function for the model (2) can be written (Cameron and Trivedi, 2010):

$$L = \prod_{i=1}^{n} \left\{ \Pr(y_{1i}^{*} \le 0)^{1-y_{1i}} \right\} \left\{ f(y_{2i} \mid y_{1i}^{*}) X \quad \Pr(y_{1i}^{*} > 0) \right\}^{y_{1i}} \quad (6)$$

Where the first term is the contribution when $Y_{1i}^{*} \le 0$, because $Y_{1i}^{*} = 0$, and the second term is the contribution when $Y_{1i}^{*} > 0$. For the subsample with positive Y_1^* the conditional expectation of Y_1^* is given by

$$E(y_{1i}^{*} \mid x_{1i}, y_{2i}^{*} > 0) = x_{1i}^{'}\beta_1 + E(u_{1i} \mid u_{2i} > x_{2i}^{'}\beta_2) \quad (7)$$

Given the normality assumption, Puhani (2000) showed that the conditional expectation of Y_1^* in Equation (7) can be rewritten as:

$$E(y_{1i}^{*} \mid x_{1i}, y_{2i}^{*} > 0) = x_{1i}\beta_1 + \frac{\sigma_{12}}{\sigma_2} \frac{\phi(-(x_{2i}^{'}\beta_2 / \sigma_2))}{1 - \Phi(-(x_{2i}^{'}\beta_2 / \sigma_2))} \quad (8)$$

Where $\emptyset(.)$ and $\Phi(.)$ denote the density and cumulative density functions of the standard normal distribution, respectively. The inverse Mills ratio in the two-step Heckman estimates is represented by:

$$\lambda(x_{2i}^{'}\beta_2 / \sigma_2) = \frac{\phi(-(x_{2i}^{'}\beta_2 / \sigma_2))}{1 - \Phi(-(x_{2i}^{'}\beta_2 / \sigma_2))} \quad (9)$$

And the Probit model is estimated by the Equation 10:

$$y_{1i} = x_{1i}^{'}\beta_1 + \frac{\sigma_{12}}{\sigma_2} \lambda(x_{2i}^{'}\hat{\beta}_2 / \sigma_2) + \varepsilon_1 \quad (10)$$

Our estimation consists of a set of covariates these include the gender of the household head (*Gender*), age of the household head (*Age*), age of the household head squared, education level of household head *(Educ*) grouped into three categories (primary, secondary and tertiary); marital status (*Status*); household size (*Hsize*); land operated per adult in the household (*Land*); land tenure security (*Tenure*); cooperative membership (*Coop).* The use of hired labour (*Hlabor*), the use of unpaid or relatives labour (*Ulabor*) typically through mutual labor exchange arrangements; the use of other inputs such as organic fertiliser (*Orga*); inorganic fertiliser (*Inorga*) and pesticide (*Pest*); household access to off-farm income (*Offincome*) and village dummies variables (*Dvillage*). For the education variables groups, we used no formal education as reference category while the Southern region is used as a reference for residency variables. We expect male-headed households to commercialise more crops than female-headed households. The higher the household head is educated, the better he may be aware of new agricultural practices toward commercialisation. Cooperatives usually provide various services including transportation, packaging, distribution, and marketing of farm products. Therefore, being member of cooperative is expected to be positively correlated with household market participation. Many studies in the literature on consumption (e.g., Omiti et al., 2009; Aderemi et al., 2014) have used the distance to market variable which is found to have significant impact on output commercialisation. However, since our data lack information on the distance to market, we used village dummies variables to remove the distance to market effect (assuming that the distance to market is essentially the same for all households in a village). Therefore, the remaining determinants of commercialisation are based on within-village comparisons across households.

Table 1. Description of the explanatory variables used in the regression.

Variables	Description	Measurement
Female headed	Gender of household head	Dummy (1=female; 0=male)
Age	Household head age	Number of years
Age squared	Household head age squared	Number of years
HH head has primary education	HH head has primary education	Dummy (1= if head has primary education; 0=Otherwise
HH head has secondary education	HH head has secondary education	Dummy (1= if head has secondary education; 0=Otherwise
HH head has tertiary education	HH head has tertiary education	Dummy (1= if head has tertiary education; 0=Otherwise
HH is married	Marital status	Dummy (1=if married; 0=Otherwise
Household size	Number of household member (head count)	Number of person
HH land operated size per adult	Ratio of household farm land operated size per number of adults in the household	Hectare
Land tenure security	Farm land with land title or sale attestation	Dummy (1=if yes, 0=Otherwise)
Cooperative	Membership of cooperative	Dummy (1=if yes, 0=Otherwise)
HH used hired labour	Household used hired labour	Dummy (1=if yes, 0=Otherwise)
HH used relatives labour	Household used relatives labour	Dummy (1=if yes, 0=Otherwise)
HH Used organic fertiliser	Household used organic fertiliser	Dummy (1=if yes, 0=Otherwise)
HH Used inorganic fertiliser	Household used inorganic fertiliser	Dummy (1=if yes, 0=Otherwise)
Share of off-farm income in total HH income	proportion of off-farm income in total annual household income	Ratio
$Dvillage_j$	Household in a particular village	Dummy (1=if yes, 0=Otherwise)

Thus the intensity of market participation is estimated with the following equation (Outcome equation).

$$Y_2^* = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 Age^2 + \sum_{i=2}^{4} \beta_{4i} Educ_i + \beta_5 Status + \beta_6 Hsize + \beta_7 Land + \beta_8 Tenure + \beta_9 Coop + \beta_{10} Hlabor + \beta_{11} Ulabor + \beta_{12} Orga + \beta_{13} Inorga + \beta_{14} Pest + \beta_{15} Offincome + \sum_{j=2}^{194} \beta_{16j} Dvillage_j \quad (11)$$

Where Y* is the household commercialisation index specified in equation (1). As recommended by Cameron and Trivedi (2010), for more robust identification, it is important to impose exclusion restriction to the model. This requires that the selection equation has an exogenous variable that is excluded from the outcome equation. More specifically, in specifying such a model, we need at least one variable that explains the decision to participate in output market while not affecting the resulting marketed output, which provides an exclusion restriction by which the model can be identified. We used the number of children under two years old in the household as exclusion restriction variable. Economic and social shocks and stresses are more likely to increase the probability of market participation by a farmer at a certain point in time. Rural households that have very young children have higher levels of vulnerability. For example, children under the age of two are usually more prone to being affected by diseases, than adults. The presence of very young children in the household makes women more likely to leave the output market. We expect the number of children under the age of two to negatively affect the decision. However, we assume that having children under the age two will not have incidence on the quantity of marketed output. In fact, very young children do not constitute a part of workforce in the household. Table 1 presents the description of the explanatory variables used in the regression.

DATA AND DESCRIPTIVE STATISTICS

Data

This study relies on comprehensive primary data collected by Côte d'Ivoire National Institute of Statistics (INS) between January and February 2014 as part of the National employment survey. The

Table 2. Agricultural household main characteristics.

Variable	Mean	Standard deviation
Male headed	0.852	0.355
Female headed	0.148	0.355
Age of household head (year)	44.59	15.72
Marital status		
Married Monogamous	0.664	0.472
Married Polygamous	0.112	0.315
Single (never married)	0.125	0.331
Divorced/Separated	0.025	0.155
Widow	0.075	0.263
Household head education		
[1] None	0.590	0.492
[2] Primary	0.261	0.439
[3] Secondary	0.142	0.349
[4] Tertiary	0.008	0.090
Household size (Head count)	4.619	2.997
Number of Adults (14 years and above)	2.620	1.584
Child dependency ratio (# of children under 10 years/ # of HH member over 10 years)	1.184	0.330
Dwelling characteristics		
Drinking Water from pipeline	0.120	0.325
Drinking Water from Borehole	0.379	0.485
Main Source of Lighting Electric	0.366	0.482
Flush Toilet	0.081	0.273
Public garbage collection	0.192	0.394
Main Cooking Fuel Biomass (Wood/Dung/Coal)	0.978	0.145
Observations	3,393	

survey focuses extensively on agriculture and offers a wealth of data on the range of agricultural production for the country. Data were collected using household questionnaires in which information was obtained at the individual, household and plot level. Agricultural production data were collected at plot and crop level, with detail on the allocation of production and the use of inputs such as fertilizer, pesticides, hired labour, shared labour and household labour activity.

The survey is nationally representative at the urban, rural and agro-climatic zone level. The final sample consists of 11,971 households, 3,393 of this sample is involved in agriculture. In this study we focus on agricultural households.

Socio-economic characteristics of agricultural households

As showed in Table 2, around 85.2% of agricultural households are male-headed against 14.8 female-headed. The age of the agricultural household head is on average 45 years. Table 2 also shows that the majority of household heads are monogamous (66.4%). However, around 11.2% of household heads are polygamous. Very few household heads are single (12.5%).

Most of agricultural household heads in Cote d'Ivoire have not been to school (Table 2). An average of 59% of household heads has no level of formal education. About 26.1% of them attended primary school, 14.2% attended secondary school and less than 1% has a tertiary level education. That said, the level of education of agricultural household head is in generally very low.

Agricultural household size is around 5 members. The average number of adults (members of working age) per household is around 3 persons accounting for 60% of the total size of the household. The dependency ratio is 1.1 children per household.

Access to infrastructure and basic services is problematic for many agricultural households (Table 2). Only 12% of agricultural household have access to piped water and 38 % through borehole. More than 60% of them do not have access to electricity. Approximatively 8% of agricultural households' report having access to an internal flush toilet and 19.2% have access to a public garbage collection service. Almost all agricultural households use wood or dung or coal as their main source of energy for cooking.

Land holding

Households in Cote d'Ivoire own an average of 2 plots. The average landholding size is 4.75 ha. The average land size per adult in the household is on average around 2.2 ha. Compared to other Sub-Saharan African countries, farm land size in Côte d'Ivoire appears to be large. In fact, using LSMS-ISA data, Carletto et al. (2015) reported an average of 0.9; 2.6 and 2.3 ha respectively for Malawi, Tanzania and Uganda which are far less than what we observed in Côte d'Ivoire.

However, the distribution of land holdings and operation

Table 3. Average land holdings (in ha) by quintiles of land operated.

Quintiles of land operated	Count	Mean	SD
1	687	0.675	0.369
2	663	1.990	0.327
3	688	3.449	0.443
4	619	5.642	0.833
5	736	11.48	3.618
Total	3393	4.488	4.059
Observations	3393		

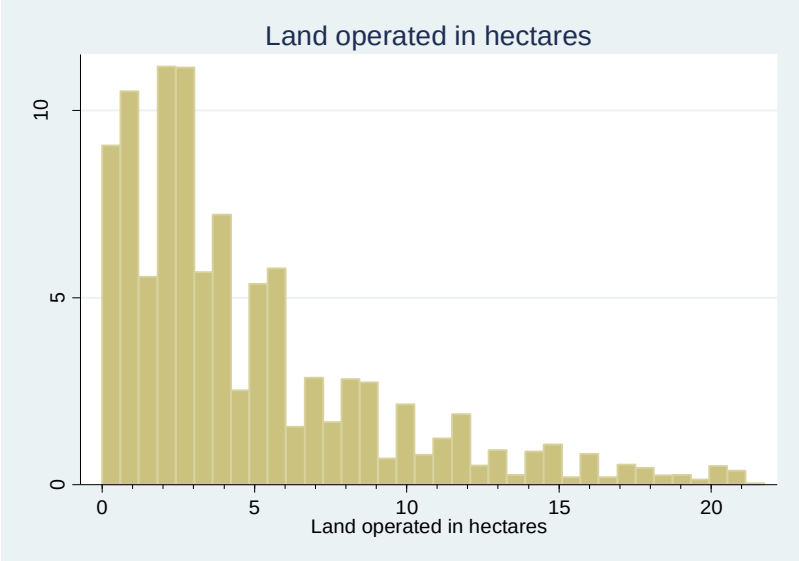

Figure 1. Histogram of area of land operated by households.

in Table 3 and Figure 1 shows the prevalence of smallholder farmers in the country. About 40% of agricultural households operate less than 2 hectares on average. The land holding in the top land quintile appear to be large (averaging 11.5 ha) suggesting that land is concentrated among a small share of household.

Labour and input utilisation

A critical complement to land in the agricultural production process is labour. Households use a combination of family labour and hired labour and also rely on relatives and friends. Our data show that 92% of households used family labour while 48.8% hired agricultural labour and 44.9% benefit from the assistance of relatives and friends to work on their farm (typically through mutual labor exchange arrangements which are especially common in the North). Only 28.1% of the households relied only on family labour.

In addition to employing agricultural labour to increase agricultural production, agricultural households use inputs such as fertiliser, pesticides/herbicides, and manure. Pesticides/herbicides utilisation has the highest rate. Close to 48% of households reported using pesticides/ herbicides. Fertiliser utilisation is reported by 27% of households. Only 18.6% of households reported using manure. Pesticide utilisation rise with increasing area of operated land, from 24.7% in the bottom quintile to 54.9% in the top quintile of land operated.

Fertiliser utilisation in Côte d'Ivoire is very low. Around 27% of the survey household reported using inorganic fertiliser while only 19% used organic fertiliser. Among other factors, the low input utilisation could prevent farmers from achieving higher crop yields.

Crop portfolio

Agricultural households in Côte d'Ivoire diversify their crop production. They grow an average of 3 different types of crop. In Figures 2 and 3 we present the percentage of households that reported growing each type of crop to show the diversification of household crop portfolios. The Figure 2 shows that Cocoa is the predominant crop grown. Cocoa farming accounts for 47% in agricultural households' crop portfolio. Root vegetables (yam, cassava, sweet potato, potato, and cocoyam), cereals and beans, and cashew are equally important. They account for 40, 32 and 21 %, respectively, of the crop portfolio. Very few households are specialised in growing food crops[1] or cash crops[2] (Figure 3). Only 23.6% of agricultural households grow food crops only and about 32.2% of agricultural households grow cash crops only.

[1] Food crops include yam, cassava, sweet potato, potato, and cocoyam, legumes, cereals (corn, rice, sorghum) and beans

[2] Cash crops include cocoa, coffee, cotton, rubber, cashew, ground nut, palm oil, pineapple, mango and avocado

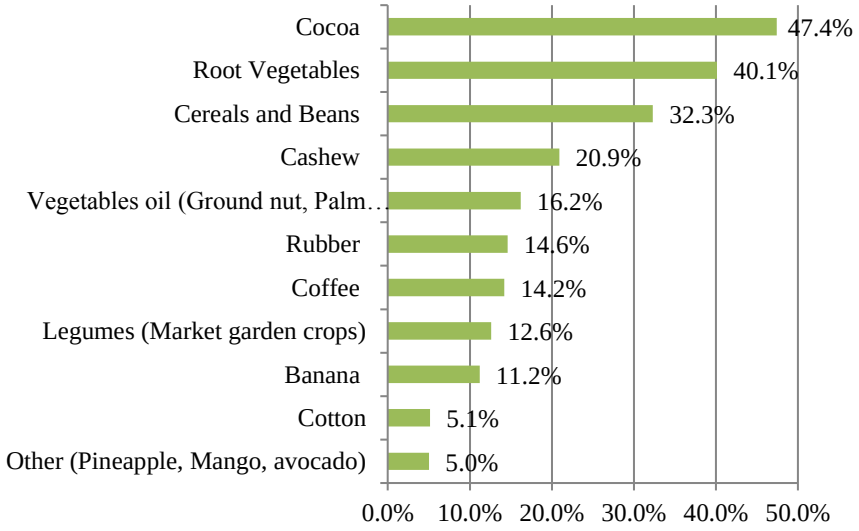

Figure 2. Share of household cultivating each type of crop.

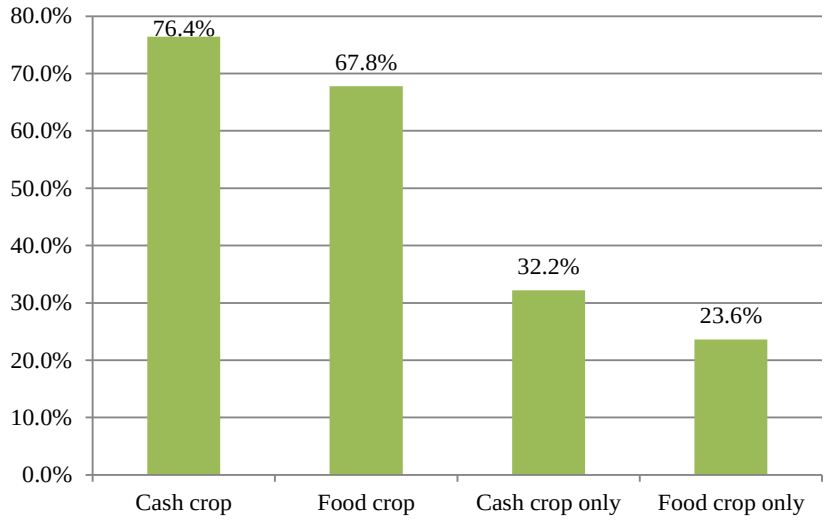

Figure 3. Share of household cultivating each type of crop.

Crop commercialisation

Agricultural households use a large variety of market outlets (Figure 4). The breaking down of the share of households that sold any crop by type of markets they accessed reveals the use of a large variety of market outlet. Approximately, 44% of households reported selling their product to National private operators, while 28% reported having sold in the local market. 19 and 17% of households reported selling respectively to foreign private operators and farmer's cooperatives. National private operators appear to be the main source of access to market accounting for 39% of the overall markets outlets.

Our data show that Cote d'Ivoire is characterised by a high-level of commercialisation. We find that around 80% of households engage in sales (Figure 5). Close to 20% of household reported selling 100% of their agricultural production. This includes the sale of food and cash crops. Indeed, our data suggest that the vast majority of selling households are growing and marketing both cash and food crops while very few of them are specialised in food crops.

As shown in Table 4, the percentage of output actually sold on the market out of the overall harvested production in value terms is around 48.69%, which is very high as compared to the result obtained by Carletto et al. (2015) for Malawi, Uganda and Tanzania, where farming households sold, respectively 17.6, 26.3 and 27.5% of their production. The percentage of output sold is much higher (61.29%) when considering only selling households. Female-headed households appear to commercialise considerably less of their production than male-headed households. The difference of commercialisation index between male- and female-headed households is around 11% points. Even when focusing only on selling households, there is still a large gap between female- and male-headed households. This suggests that female-headed households are less commercially oriented in Côte d'Ivoire.

Not surprisingly, cash crops are more commercialised than food crops. The percentages of output sold are 79.48 and 31.05 respectively for cash and food crops. This suggests that cash crops

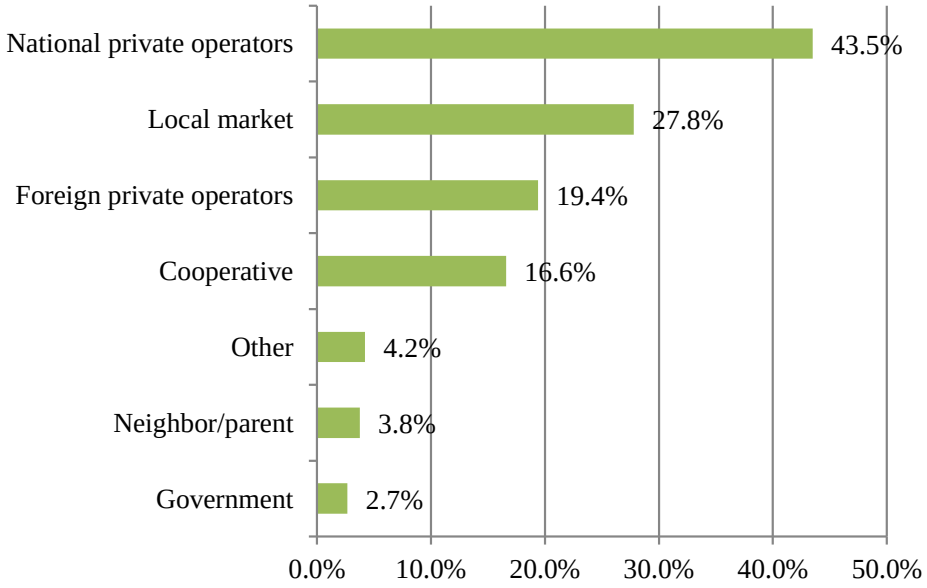

Figure 4. Share of households that sold any crop by type of markets.

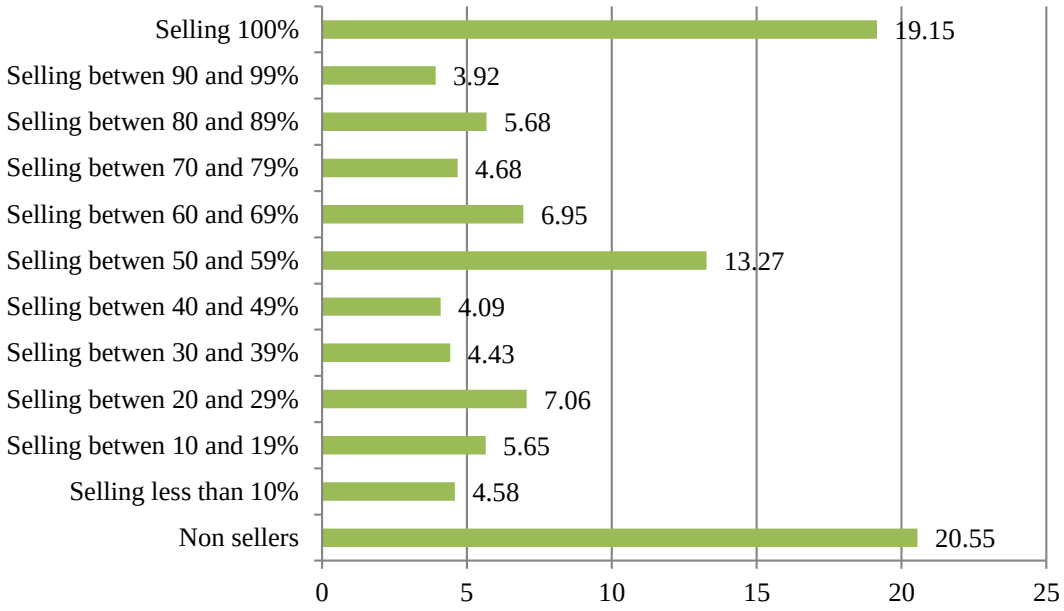

Figure 5. Distribution of households by output commercialisation

adopters are more likely to be market oriented. There is no clear evidence that the degree of commercialisation increases with the farm size (Figures 6 and 7). Compared to the Southern region, smallholder farmers in the other regions and particularly those in Northern and Eastern region are far less likely to sell crop outputs in the market. Of note, the Southern part of Côte d'Ivoire predominantly produces cash crop products while the Northern and the Eastern regions are food producing regions. In addition, national statistics show that poverty is more concentrated in the other regions than in the South with a higher percentage of poverty head count in the Northern and Eastern region. Thus, these regions might be home of subsistence-oriented smallholder farmers.

EMPIRICAL RESULTS

Our estimation results are presented in Table 5. The Wald test has a p-value of 0.0000 and indicates that our model as a whole fits significantly better than an empty model (that is, a model with no predictors). To further check the validity of our model, we perform a likelihood

Table 4. Share of crop output sold by selected characteristics.

Characteristics	Share of crop output sold (%)	Share of crop output sold conditional on sales (%)
Country average	48.69	61.29
Male headed	50.34	61.97
Female headed	39.25	56.69
Cash crops	79.48	
Food crops	31.05	
Head education		
[1] None	46.82	59.72
[2] Primary	51.35	63.64
[3] Secondary	51.05	63.13
[4] Tertiary	58.64	64.10
Land rental market		
Rent in land (No)	50.11	65.85
Rent in land (Yes)	52.46	71.11
Hired labour		
HH uses hired labour (No)	47.95	66.58
HH uses hired labour (Yes)	52.78	65.97
Macro regions		
Southern region	62.92	76.50
Central region	47.47	63.87
Eastern region	39.07	56.80
Western region	52.93	67.30
Northern region	33.22	50.57

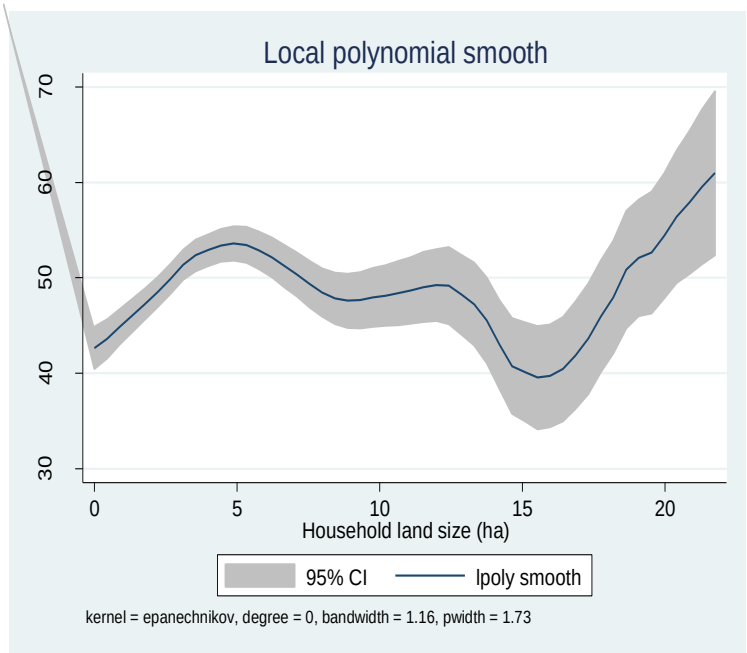

Figure 6. Local linear non-parametric regression of crop commercialisation index by household land-operated size

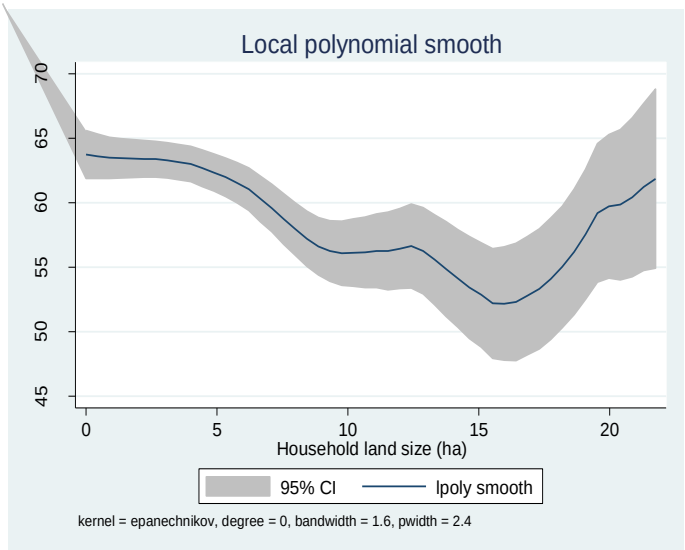

Figure 7. Local linear non-parametric regression of crop commercialisation index (conditional on sales) by household land-operated size.

Table 5. Heckman maximum likelihood estimates (MLE) of the determinants of crop output commercialisation.

Determinant	(1) Probit (1st step)	(2) Benchmark	(3) MLE (2nd step)
Female headed	0.006 (0.135)	-3.437* (1.884)	-3.455* (1.882)
Age of household head (year)	-0.029* (0.016)	-0.173 (0.196)	-0.167 (0.194)
Age of household head squared/100 (year)	0.029*(0.015)	0.236(0.190)	0.232(0.190)
HH head has primary education	0.012(0.109)	0.627(1.439)	0.634(1.439)
HH head has secondary education	0.104(0.141)	0.852(1.872)	0.860(1.872)
HH head has tertiary education	0.246(0.450)	-0.872(5.953)	-0.873(5.953)
HH is married	0.030(0.131)	-3.139*(1.617)	-3.168**(1.610)
Household size	0.009(0.017)	-0.300*(0.250)	-0.324*(0.212)
Household land operated size per adult (ha)	0.019(0.024)	-0.464*(0.277)	-0.467*(0.277)
Land tenure security	-0.187(0.177)	4.270**(2.017)	4.271**(2.017)
Membership of cooperative	0.732***(0.207)	5.283***(1.767)	5.280***(1.767)
HH used hired labor	0.020(0.089)	-1.284(1.181)	-1.280(1.180)
HH used relatives labor	-0.006(0.089)	-2.818**(1.180)	-2.811**(1.179)
HH used organic fertilizer	-0.023(0.131)	-0.380(1.683)	-0.371(1.683)
HH used inorganic fertilizer	0.202(0.135)	0.989(1.738)	0.980(1.737)
HH used pesticide	0.310***(0.105)	0.615(1.405)	0.611(1.405)
Share of off-farm income in HH total income	-2.729***(0.119)	-0.341(3.535)	-0.273(3.513)
# of children under 2 years old	-0.150**(0.072)	0.534(1.144)	
Constant	3.270***(0.537)	78.90***(6.649)	78.74***(6.597)
Village Fixed effects	***YES***	***YES***	***YES***
Athrho		-0.290*(0.182)	-0.293*(0.181)
lnsigma		3.386***(0.014)	3.386***(0.014)
Rho		-0.281(0.167)	-0.284(0.166)
Sigma		29.535(0.419)	29.538(0.419)
Lambda		-8.320(4.996)	-8.414(4.964)
Observations		3393	3393

Standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01; the reference categories are no education for the educational dummies variables.

ratio (LR) test. The latter test has a p-value of 0.0087 implying that the estimated correlation between the errors is significantly different from zero and the hypothesis of absence of sample selection is strongly rejected. To test the validity of the exclusion restriction variable, we ran the Heckman model by including the number of children under two years old as a regressor in both the selection equation and the outcome equation. The result is presented in columns 1 and 2 in Table 5. The coefficient of the restriction exclusion variables is significant in the Probit model (selection equation) and non-significant in the outcome equation. This demonstrates the validity of our exclusion restriction variable. The third column of Table 5 presents the estimation results of our outcome equation.

Our results are presented in Table 5. The first column of Table 5 presents estimates of market participation while the third column represents estimates of market supply. The result in column 1 shows that cooperative membership and the usage of pesticides are positively correlated with household probability to engage in the market. This result confirms our prediction given that cooperatives reduce the transaction costs of members. The age of the household head, the number of children under the age of two years and the share of off-farm in total household income are the factors that negatively affect the probability of households to engage in the market.

As far as commercialisation intensity is concerned, the estimates indicate that the gender of the household head, marital status, household size, labour constraint, land tenure security, membership of cooperative and the share of off-farm in total household income are significantly correlated with the degree of output commercialisation (Table 5). The regression shows that commercialisation index of female headed households is on average 3.4% less than male headed households, everything being equal.

Married household heads sell an average of 3% less output than non-married household heads. The negative and significant coefficient of the household size variable implies that the bigger the household, the less it is oriented toward the market. This applies to situations where the household has more children below working age, who thus do not contribute to farm labour but significantly increase household consumption (Omiti et al., 2009).

The coefficient of the land-operated size per adult is negative and significant at 1% level. Our descriptive statistic shows that smallholder farmers rely heavily on family labour. As a result, the bigger the land operated size per adult, the higher the constraints faced by the household. Thus, the negative coefficient of the land-operated size per adult implies that households who are facing a labour constraint commercialised less output. An increase of one hectare of farmed land per adult decreases the share of output sold by 0.5%. Since the agriculture sector in Côte d'Ivoire is labour intensive, we argue that labour constraint affects household productivity negatively, which has negative impact otheir commercialisation intensity.

Land tenure security is also a factor affecting the degree of output commercialisation. The estimation shows that having a formal land certificate such as land title or sale attestation is associated with higher commercialisation index. Land tenure security raises the level of household commercialisation by 4.3%. Land insecurity affects household crop choice.

Access to market and extension services through cooperatives is an important factor that increases household level of commercialisation.

Household members of a cooperative sold approximatively 5% more than those who are not members of a cooperative. All things being equal, access to off-farm income does not have any impact on the level of commercialisation after correcting for selectivity bias.

In Table 6, the robustness checks for the determinants of crop output commercialisation are presented. More specifically, two alternative methods are applied, the truncated regression and the Tobit regression. The results are similar and close to those found with the Heckman maximum likelihood estimates. However, the standard deviation of all covariates in the Heckman sample selection model are smaller than those obtained with the other methods. This implies that the Heckman sample selection model yields more efficient estimators.

DISCUSSION

Our findings are consistent with similar studies in the literature. Collective actions appear to be very important factors to agricultural commercialisation. This result confirms findings by Holloway et al. (2000) and by Francesconi and Ruben (2007) who found that cooperative farmers outperform non-cooperative farmers in terms of quantity produced and marketed. Land tenure security has also played a significantly influential role in commercialisation of agriculture in Cote d'Ivoire. The positive sign of the coefficient of land tenure security in our study contradicts the findings of Martey et al. (2012). The contradiction could be explained by the fact that Martey et al. (2012) did not correct for selection bias. In addition, in our sample, households with non-secured land property rights are less engaged in perennial cash crops production such as cocoa, coffee, cashew and rubber, which are more market-oriented.

The use of pesticides has also made an equally important contribution to the probability of a farmer engaging in commercialization. As households usually rely on family labour with very limited options for tractors, the use of pesticides could foster market participation for farmers. The extent of agricultural commercialisation by married head of households is 3% lower than those of

Table 6. Robustness checks for the determinants of crop output commercialization.

Determinant	Truncated regression	Tobit regression
Female headed	-4.164*(2.308)	-3.404(2.079)
Age of household head (year)	-0.226(0.231)	-0.434**(0.216)
Age of household head squared/100 (year)	0.307(0.225)	0.499**(0.211)
HH head has primary education	0.777(1.739)	0.589(1.605)
HH head has secondary education	1.086(2.218)	1.482(2.082)
HH head has tertiary education	-0.677(7.011)	1.258(6.671)
HH is married	-3.624*(1.929)	-1.899(1.802)
Household size	-0.400*(0.260)	-0.234(0.235)
Household land operated size per adult (ha)	-0.562*(0.339)	-0.524*(0.312)
Land tenure security	4.512*(2.332)	1.539(2.269)
Membership of cooperative	6.739***(2.063)	8.820***(2.004)
HH used hired labour	-1.446(1.435)	0.153(1.317)
HH used relatives labour	-3.435**(1.440)	-2.494*(1.319)
HH used organic fertiliser	-0.446(2.045)	0.185(1.891)
HH used inorganic fertiliser	1.434(2.092)	2.869(1.944)
HH used pesticide	1.101(1.673)	3.857**(1.558)
Share of off-farm income in HH total income	-6.330***(2.453)	-46.84***(1.895)
Constant	79.22***(7.768)	84.45***(7.410)
Village Fixed effects	***YES***	***YES***
Sigma	37.26***(0.670)	38.55***(0.515)
Observations	2954	3393

Standard errors in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01; the reference categories are no education for the educational dummies variables.

unmarried head of households. This finding is consistent with Martey et al. (2012). Similar to Alene et al. (2008), our results suggest that female-headed households have a greater likelihood of participation in markets than male-headed households but supply less marketable output than male-headed households.

As opposed to Nepal and Thapa (2009) and Martey et al. (2012) which use the farm size (in hectares) as a regressor, we use per adult land operated size to highlight the importance of labour constraints in farm commercialization. We find that labour constraints have a negative and significant effect on farm output commercialisation. We argue that labour constraints negatively affect household productivity, which has a negative impact on household commercialisation intensity. The age and the level of education of the household head appear not to be a significant determinant of farm output commercialisation. This result is consistent with previous studies (Aderemi et al., 2014; Rahut et al., 2015). However, it differs from those of Omiti et al. (2009) in Ghana who found that the age and the year of education of the head of the household have a significant positive impact on the degree of crop output commercialisation. Notably, Omiti et al. (2009) did not correct for selection bias either in their estimates which could explain that divergence.

CONCLUSIONS AND IMPLICATIONS

Agricultural households in Côte d'Ivoire diversify their crop production. They grow on average 3 different types of crop with a mix of cash crop and food crops. Selling households have access to a variety of market outlets with national private operators being the main source of access to the market. A small share of households sold their production through farmer cooperatives. However, Cote d'Ivoire is characterised by a high-level of commercialisation. The vast majority of selling households are growing and marketing both cash and food crops while very few of them are specialized in food crops. Our Heckman maximum likelihood estimates underscore the role of household level characteristics in influencing the extent to which smallholders sell their output on market. It emerges from our study that cooperative membership and land tenure security are the factors that positively and significantly affect the level of crop output commercialisation. Female-headed households sell a lesser share of their crop production while unmarried head of households sell more output than married head of households. Labour and capital constraints are major factors preventing households from being more engaged in the market. There is a regional gap in terms of output commercialisation. Farmers in the Southern region where

the cropping system is dominated by cash crops are more market-oriented.

As to recommendations, we conclude that policies that target the creation of new cooperatives and reinforcement of existing cooperatives could be effective in reducing cost of market access (costs of information seeking, negotiation and monitoring) for smallholder farmers. Another benefit for farmers belonging to a farmer group (when it exists and is functional) is the increase of negotiation power for better prices, secured market outlets and access to technical assistance (Pingali et al., 2005). Smallholder farmers' education should also be an area of attention by policy makers in order to increase technology adoption and crop productivity. Interventions that increase food crop productivity will be beneficial to the poorest farmers, especially those in the Northern part of the country, who are less engaged in cash crop systems. Relaxing capital constraints by providing smallholder farmers with credit will raise their engagement in the market. The promotion of agricultural mechanization will potentially relax labour constraints that are driving down smallholders' level of output commercialisation.

Conflict of Interests

The authors have not declared any conflict of interests.

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