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## Transaction costs and market access in Sub-Saharan Africa: The case of maize

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### Abstract

*Staple crop production in developing countries contributes decisively to food safety. In Sub-Saharan Africa however, the Green Revolution, aiming at sustaining agricultural productivity growth was mostly viewed as not successful, compared to what happened in Asian countries. There is a widespread agreement on the fact that this statement is especially related to the food marketing environment and to transaction costs. Stagnant food crop productivity and poor market performance may then be at stake. The paper aims at identifying the relative importance of marketing and production behaviours. It focuses on the case of maize in Sub-Saharan Africa. The results show that, beyond production choices, two aspects should be taken into account in order to understand commercialisation decisions: the role of intermediation and that of storage.*

**Keywords:** transaction costs, market access, agricultural production, Africa

**JEL:** D13, O13, Q12, P32



## 1. Introduction

Trade has been widely presented as a way for developing countries to alleviate poverty and improve food security, especially for smallholders. Like numerous developing and emerging countries, Sub-Saharan Africa experienced in the 1990s structural adjustment programs aimed at moving to a more liberalized environment and “getting prices right” in order to promote a more efficient allocation of resources. The agricultural sector has been no exception. Policies didn’t only affect external trade: domestic agricultural trade has been targeted after a long period of public intervention. Subsidies were cut down and state parastatal agencies that provided producers with secured outlets (marketing agencies) were shut down (Jayne et al., 2002). However, faced to the difficulties of the agricultural sector, the focus of policy reforms in developing countries has then moved from “getting prices right” to “getting institutions right” and lower transaction costs due to market failures (Fafchamps, 2004). Government participation in the economy has been revisited as to mitigate market imperfections and build institutions governing transactions.

For the empirical analysis, we chose to focus on Sub-Saharan African countries. Since the beginning of the 1990s and the wave of structural adjustment programs, many Sub-Saharan African countries have initiated transitions from controlled food marketing systems to systems where both the government and private operators are involved. Although the patterns of these transitions widely vary across countries, ranging from reliance on markets (Mozambique, Uganda) to more centralized policies (Malawi, Zambia), many governments remain important players in the maize markets: through direct procurement and sales operations as well as through their use of trade policies (Jayne et al., 2006); through research and development in breeding for improved varieties (Smale et al., 2011); extension (Jayne et al., 2010). Maize is nowadays the most-widely grown staple crop in Sub-Saharan Africa and a subsequent source of revenues for rural households in many countries<sup>1</sup> (Smale et al., 2011). Agricultural R&D is involved in producing seeds which are pest-resistant, drought-tolerant and nutrient-rich. Empirical evidence brings however concerns forward. Increase (when observed) is most of the time due to the extension of acreage and not to an increase in productivity; yields remain low compared to those of other parts of the world: 1.5 t/ha per year in East Africa and 1.1 in Southern Africa (excluding South Africa) in 2008 compared to 3.1 in Mexico or 3.9 in

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<sup>1</sup> Maize represents on average 34% of the cereal production in volume and 27% of the cereal area on the period 2005-08 (FAO-stat data, cited in Smale et al, 2011).

Thailand, for instance (Smale et al., 2011). Moreover, for the Sub-Saharan region, the technical literature shows that yields on experimental fields can jump up to 9 tons per hectare (Magorokosho et al., 2010). Moreover, the variation of yields across years is higher than in developing countries that have roughly the same average yields (Byerlee and Heisey, 1997). Last, the empirical studies highlight a low rate of households' participation in the maize markets, especially as sellers. The study by Jayne and al. (2010b, p. 1387) uses panel data gathered from the late 1990s till mid-2000s, conducted nation-wide in Kenya, Malawi, Mozambique and Zambia, and shows that 20 to 35% of the households are sellers in a given year. The authors explain this observation of a low level of market participation by the fact that there is no production surplus to market, even though the consumption patterns of urban areas still relies heavily in maize. Stagnant productivity of maize production is balanced with the increased role of cassava, a drought tolerant crop (Jayne et al., 2006). But low input use is considered as one of the major factors explaining the comparative disadvantage of maize: limited use of irrigation, improved cultivars, for instance. Last, transaction costs incurred by smallholders when marketing their production act as a buffer; thus, market incentives are not transmitted to them and they cannot profit from the potential benefits of trade (Barrett, 2008).

The scarce theoretical literature on marketing behaviours of agricultural households in developing countries emphasizes the role of transaction costs: those costs include crop transportation costs, distance to market, type of marketing structure, costs paid to the intermediary, for instance. The models developed (Key et al., 2000; Barrett, 2008, for the canonical framework) explain why household endowed with different characteristics choose to participate or not in the crop market, and how much they sell. They show that faced to imperfect markets, smallholders are not able to fully benefit from the gains of market participation. However, those models largely overview the endogeneity of the production decisions and take production levels as given. This paper investigates the determinants of commercialisation in relationship to the production decisions of maize producers in Sub-Saharan Africa.

The next section develops a general framework based on the literature on the role of transaction costs in commercialisation decisions. We then present the data and some statistical insights. We last present and apply the empirical econometrical analysis.

## **2. Transaction costs, market participation and the role of institutions**

### *2.1. Market access and production choices*

Barrett (2008) studies the conditions under which the household sells at least part of its production. He shows that transaction costs matter at the individual level because they lower the price paid to the seller and therefore decrease the incentive to sell. By investigating those transaction costs further and distinguishing between variable and fixed transaction costs, Key et al. (2000) aim at measuring the individual and aggregate supply elasticity: transaction costs influence in fact the measure to which market price incentives are transmitted to the producer. Those transactions costs create a wedge due to a combination of factors related to marketing, production, or consumption. Market-related factors include transport costs between the farm household's village and the relevant market, non-competitive behaviour among local traders, poor access to price information, and shallow local markets. Production-related factors include lack of credit to finance key inputs and low food crop productivity, while consumption-related factors include lack of insurance (credit) against household risks of excessive variation in food market prices and availability.

From the empirical point of view, the literature dealing with market participation mostly focused on market-related factors, namely transaction costs: it explores the role of geography and remoteness (e.g. Stifel and Minten, 2008). Insofar, it highlights the importance of public infrastructure investments in rural areas that can lower transport costs (e.g. Renkova et al., 2004). It shows as well that the role of information asymmetries is crucial, especially information on prices (e.g. Muto and Yamano, 2009). In the same line, it investigates the role of intermediation (traders or commission agents) that can provide information and adequately match supply and demand, but can as well enjoy market power, especially in the case of agricultural markets which are often characterized by a high degree of concentration at the traders' level (e.g. Minten and Kyleb, 1999). Moreover, problems of contract enforcement are often mentioned, in countries where the possibility of legal enforcement of contract through courts remains very rare (Fafchamps and Minten, 2001). Last, the role of producers' unions and collective action in marketing was extensively studied (Bernard et al., 2008 for review)

The importance of production-related factors is far less studied. First, from the theoretical point of view, the authors do not attribute the increase in production to an increase of acreage

or an increase in yields. In contexts of land pressure and frontier exhaustion, this distinction seems important as extensive production methods are limited in space. Second, from the empirical point of view, Alene et al. (2007) is, to our knowledge, one of the rare article that highlights the role of technology choice in improving market participation. In the case of maize in Kenya, the authors show that input demand (in this case, fertilizers) is sensitive to the position of the household on the output market. Our proposal is to take into account the effect of production methods and technologies, namely use of inputs and medium and long-term investments in production infrastructures. We draw on this empirical literature and propose to study the joint determinants of production of staples, that may be partly self-consumed, and the amount of sales.

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## *2.2. Modeling the output production and output sales*

Market participation of agricultural households can be modeled as a two-step decision process with first, the decision to participate or not in the market and second, the decision relative to the volume of agricultural goods they are going to sell on the market (Alene et al., 2008; Barrett, 2008; Key et al., 2000).

The modeling especially focuses on the producer problem regarding market participation (Goetz, 1992; de Janvry and Sadoulet, 2005). Indeed, as explained in Key et al. (2000), the input demand and the output supply derived from the model simultaneously considering the producer and the consumer problems are similar to those of two separate models considering each problem in isolation. Accordingly, we only focus on the production side of the household problem that leads to the definition of an output supply equation on which the decision to whether or not participate on the market will be based on. Formally, let us consider a representative farmer with a production technology that can be described by the function  $f$ :

$$y = f(x^v, x^f, t; z^y) \quad (1)$$

where  $y$  is the output,  $x^v$  is a vector of variable inputs and  $x^f$  a vector of inputs that are fixed in the short-run,  $z^y$  are specific observable exogenous characteristics affecting production and  $t$  is

technical change. Regularity conditions associated with  $f(x^v, x^f, t; z^y)$  include that  $f$  is a non-decreasing, twice continuously differentiable and quasi-concave function of  $x^v$ .

Following Alene et al. (2008), the quantity of outputs sold on the market can be defined by a portion of the total amount of output produced on farm as the production surplus not consumed by the household. Thus, the output quantity that can be sold can be written as:

$$s = \theta y \quad 0 \leq \theta \leq 1 \quad (2)$$

with  $s$  the quantity of  $y$  that is sold in the market. The  $\theta$  variable is explained by specific observable exogenous characteristics  $z^h$  describing the household as follows:

$$\theta = h_\theta(z^h) \quad (3)$$

The monetary value of sales is defined as the level of revenues farmers can collect by selling the portion  $s$  of their production in the market at the price  $p^m$ , while supporting variable transaction costs  $t^s$ . Transactions costs include transportation, logistic and marketing costs that are unobservable or cannot be easily recorded in a survey as well as the time spent selling their production and opportunity costs for farmers who transport their crops to the market by their own (Key et al., 2000). Thus, those transactions costs can also be described by specific observable exogenous characteristics  $z^m$  related to the market as well as  $z^h$  related to the household.

$$t^s = h_s(z^m, z^h) \quad (3)$$

Then, the adjusted price can be defined as  $(p^m - t^s)$ . This means that the effect of variable transaction costs has a downward adjustment effect on the output price offered in the market. Based on these definitions, the sales in value can be expressed as follows:

$$S = (p^m - t^s)s \quad (4)$$

where  $s$  are the amount of sales sold by the farmer in the market place and  $S$  are the sales in monetary value using information on the market price  $p^m$  and transactions costs  $t^s$ . Using equation (1) to (3), equation (4) can be rewritten as follows:

$$S = g(p^m, y; z^m, z^h) = g(p^m, x^v, x^f, t; z^y, z^m, z^h) \quad (5)$$

Finally, our model consists in 2 equations, namely equations (1) and (3), to be estimated simultaneously since they are linked together by the following common exogenous variables:

$x^v$ ,  $x^f$ ,  $t$ , and  $z^y$ .

### 3. Presentation of the data and first statistical insights

#### 3.1. The data

The study draws on household surveys conducted in 2002 and 2008 by the program Afrint with the aim to investigate the scope of crop intensification (Jirström et al, 2005 for a description). The number of households<sup>2</sup> is about 3500 for both years (with 3,217 households in 2002 and 3,406 in 2008). Eight countries (approximately 100 villages) were chosen in East Africa in regions endowed with highly different characteristics in terms of agro-ecology and infrastructures to access markets: Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, Tanzania and Zambia<sup>3</sup>. As far as possible the second round kept the same producers as in the first one: if a farmer was not to be found in 2008, he was replaced by the producer installed on the same estate or by a member of his family if any (mostly retired household and one of the descendants). If this could not be done, a producer was randomly selected in the same village. Two types of surveys were conducted: at the household level (including socio-demographic details, production outcomes and methods for various crops and marketing decisions) and at the village level (agro-climatic conditions, infrastructures, population, types of state intervention, farmers' organisation and credit). From these two surveys, we constructed a balanced panel.

#### 3.2. Panel construction

As we have only two points in time, we rely on a balanced panel. This could lead to selection bias and loss inefficiency in the estimation (Baltagi, 2014). The following section explains the construction of the panel and discusses the question of selection bias.

The number of individuals that dropped out of the panel and were not interviewed in 2008 is high (860, namely 26.5% of the 2002 sample) and highly variable across countries (appendix 1.a). But looking closer at the data: villages were dropped (30 out of 115, corresponding to 726 households) more often than households were not tracked. The countries where villages were dropped are those where the number of villages surveyed in the first round is the higher.

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<sup>2</sup> Households are defined by the survey from the consumption viewpoint, namely "people who eat from the same pot and sleep under the same roof/in the same dwelling". Interviewers report a quasi-total (98% of the cases) overlap between consumption and production units so that households can be viewed as farms.

<sup>3</sup> The Afrint Project, Lund University ([www.keg.lu.se](http://www.keg.lu.se)). A precise description can be found at <http://blog.sam.lu.se/afrint/>



Moreover, we analyzed the characteristics of villages that were dropped and run a regression explaining the fact that a village is present in the two rounds. The variables representing the remoteness of the village, its size and agro ecologic conditions turned out not to be significant. When taking into account only the villages present in both waves, attrition rates drop, except for Tanzania (Nigeria: 16%; Tanzania: 34%; Zambia: 18%, Mozambique 0%). Maluccio (2004) highlights the fact that in developing countries, refusals for re-interview are minimal due to the low opportunity cost of time. Field surveys report that drop-outs are mostly due to retirement, however, we will keep in mind that in Tanzania, one of the selected region is located in a migration corridor and that household may have self-select in the balanced panel and check accordingly the robustness of the regression.

In order to test for potential attrition bias, we follow Fitzgerald and al. (1998) as described in appendix 1.b. We run a regression characterizing the individuals that were observed in 2002 but not in 2008 using village level characteristics for identification (Alderman et al., 2001). The prediction power of the estimation is relatively low (pseudo  $R^2$ : 0.15). When controlling for the region of location (sub-country level with two regions selected on purpose per country), most of the variables (individual and farm characteristics) were not significant, except for the fact of be provided with electricity which has a positive effect on the probability to stay in the panel. We should investigate further the attrition bias that may be caused by the individuals not belonging to the two waves in a revised version of the paper and contact the local teams who collected the data to get qualitative information.

We selected farmers that grow maize in both periods (538 observations deleted). Table 1. shows that the percentage of farmers engaged producing maize is high (77% of the farmers) and that two countries concentrate a large part of the non-producers. This fact is due to consumption habits and not to production structures: Teff in the Northern part of Ethiopia, and cassava in the Southern part of Ghana.

Table 1. Percentage of farmers growing maize

country	Farmer producing maize
ethiopia	46,86%
ghana	41,90%
kenya	99,25%
malawi	98,36%
nigeria	98,57%
tanzania	82,13%
zambia	85,10%
mozambique	81,63%
Total	77,11%

We end up with 1777 maize producers that participated in both surveys.

We then corrected the data for outliers for the variables maize area and maize production, two variables which are very sensitive to misreporting. We used the average yields over the seasons 1999/2000-2000/01- 2001/02 (resp. 2005/06-2006/07- 2007/08) to detect misreporting using yields crucial for the empirical model. After checking the influence of various decision methods (Kremp, 1995), we used the decision rule of a positive deviation from the third quantile exceeding 1.5 times the interquantile difference for the upper bound ( $Q3+1.5(Q3-Q1)$ ) and a negative deviation from the first quantile exceeding 1.5 times the interquantile difference ( $Q1-1.5(Q3-Q1)$ ). We checked the level of the thresholds with data from the International Maize and Wheat Improvement Center (CIMMYT) (Magorokosho et al., 2010) in order to detect distortions in the correction, if any. The final sample consists in 1718 observations.

### 3.3. *First statistical insights*

We first had a look at the characteristics of maize producers and changes between 2002 and 2008. Table 2 reports the average total and cultivated land areas. It reflects a relatively stable situation on average, but it hides heterogeneous dynamics across countries (see Appendix 2): a large reduction of the reported cultivated area in Mozambique, a reduction in Tanzania and Ghana, and a large increase in Nigeria.

Table 2: Average total and cultivated areas

	Season 2001/02		Season 2007/08	
	Mean	Std Err	Mean	Std Err
Total land area (acre <sup>4</sup> )	4,03	6,17	4,05	6,08
Total cultivated area (acre)	2,06	2,33	2,17	2,75

Table 3 shows that the average area cultivated with maize<sup>5</sup> increases and that the total maize production increases as well but relatively less. Therefore the average yields are decreasing. However, these observations are not true for all countries (see Appendix 3): yields and their evolution are highly different across countries, and half of the countries exhibit a positive evolution of the yields.

Table 3: Maize area, production and yields

	Average - seasons 1999/2000-2000/01- 2001/02			Average - seasons 2005/06-2006/07- 2007/08		
	Mean	Std Err	Median	Mean	Std Err	Median
Total maize area (acre)	0.98	1.23	0.66	1.14	1.91	0.75
Total maize production (kg)	1249.5	3260.9	600	1390.8	2089.5	745
Yields (kg/acre)	1445.6	1266.2	1053.6	1311	899	1133.3

Table 4 presents the proportion of households selling maize, and the proportion of the total production sold for the subsample of those selling maize. This table highlights the different status of maize production across countries: subsistence crop and/or cash crop. On the one hand, in Ghana, almost every producer is selling maize, and a large proportion of the production is marketed. Abdulai (2000) shows in fact that the Ghanaian maize market is integrated and relates this result to low marketing costs. On the other hand, in Malawi, a small proportion of maize is marketed. It should however be noted that 2001 was a bad year for Malawi due to floods and drought, and therefore the proportion of household selling maize may be unusually low in this period. However, in 2008, the proportion of sellers is still low relatively to other countries and the proportion of the production sold is low too. In fact,

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<sup>5</sup> For some specific variables, we were able to present the average of the last 3 seasons (recall data available in the questionnaire) in order to smooth the random variations.

recent surveys indicate that the average months of food security for rural households from own production in a normal year is between 6 and 7 months, and conclude on the existence of a structural food crop shortage (Chirwa, 2005).

Table 4: Proportion of the households reporting to sell maize, and proportion sold

	Proportion of the production sold (whole sample) 2002	Proportion of the households selling maize 2002	Proportion sold for households selling maize 2002	Proportion of the production sold (whole sample) 2008	Proportion of the household selling maize 2008	Proportion sold for households selling maize 2008
Ethiopia	24,97%	66,17%	37,74%	30,19%	71,53%	42,21%
Ghana	63,20%	97,74%	64,65%	65,85%	99,25%	66,34%
Kenya	10,00%	37,44%	26,72%	16,24%	40,53%	40,06%
Malawi	1,83%	17,20%	10,66%	6,44%	47,67%	13,51%
Nigeria	40,47%	88,78%	45,58%	42,90%	88,56%	48,45%
Tanzania	18,68%	61,40%	30,43%	19,63%	62,38%	31,47%
Zambia	14,04%	53,77%	26,12%	24,55%	68,58%	35,79%
mozambique	13,91%	47,47%	29,31%	9,30%	39,73%	23,40%
Total	19,95%	54,38%	36,96%	23,77%	61,95%	38,38%

#### 4. Empirical analysis

Based on the theoretical framework presented in section 2, we propose to econometrically assess the joint behaviour of production and marketing of maize. We thus estimate, using panel data, a standard equation explaining sales level that depends on the observed production level. To go further, we consider in this estimation the total production level as endogenous and explicit thus the production function using a Cobb-Douglas specification.

We draw on the empirical studies that analyse market participation of smallholders (Heltberg and Tarp, 2002; Alene et al., 2009, among others) and select a set of exogenous variables reflecting:

- Household characteristics: gender and age of the household head, education of the manager of the farm, number of able workers in the family, number of cows as a proxy for capital (household savings are embodied in livestock in Africa).
- Production characteristics: maize production, area planted with maize, total cultivated area, input use (fertilizer, type of seed, pesticides), production techniques (rotation,

intercropping with nitrogen fixing crops – beans, legumes etc -, animal manure), production know-how (extension)

- Variables related to market relationship: average price at the regional level for a given year, membership to a farmer organisation and distance to the most proximate market.

We used a set of instrumental variables and made tests regarding the validity and identification of the model. These variables should explain the level of maize production and be not correlated to the individual level of maize sales. We chose variables related to the use of improved and hybrid seeds at the village level (village questionnaire). In fact, in many countries, governments set up policies for non-traditional seed adoption by introducing “Starter Pack” programmes that provided to food insecure households free inputs (hybrid maize seeds, fertilizers) and extension. This intervention and adoption was thus exogenous to the decision variables we study. Then, we can assume that a diffusion of the adoption of practices takes place (Giné and Yang, 2009) and that the intervention indirectly influences the households.

Then, we chose to add a variable indicating whether or not the village received at any time public food relief caused by local food shortages, and, if this is the case, the date of intervention. In the sample, around 40% of the villages reported an intervention and the intervention date widely differ across villages (from 1958 until the date of interview). Barrett et al. (2002) present the consequences of public food aid in terms of production behavior: first, it can lead to free-riding behaviors and lower the incentives in terms of effort; second, the date of intervention stands is the signal for an important distress in a given year and the resilience of the production system is not instantaneous. The actual production performance can be related to the distance between the year of intervention and the year of the interview.

Last, we introduce the individual’s access to credit for agricultural inputs.

#### 4.1. Selected data and their theoretical counterpart – framework section 2

Labels in section 2	Variable description
<b>Production function</b>	
$y$ production	Maize production
$x^v$ variable inputs	Fertilizer
$x^f$ quasi-fixed inputs	Capital (#Livestock; Total Land-Maize Area), Land(Maize Area), Family Labor(#)
$z^y$ production characteristics	Pesticides, Traditional/Improved/Hybrid Seeds, Rotation, Intercropping, Animal manure, Extension, Agricultural input credit, Improved/hybrid seeds in village
<b>Sales function</b>	
$s$ sales	Maize sales
$p^m$ market price	Regional price levels
$z^m$ market characteristics	Distance to markets, Farmer organization
$z^h$ household characteristics	Gender of the family head, education, number of family members

Descriptive statistics of the data (pooling the two years) are given in Appendix 4. Table 5 reports the final results of the instrumented panel data regression with fixed effects.

#### 4.2. Results

The first range of results is related to the choice to take into account the potential endogeneity of the production level in the explanation of the level of sales. The instrumentation of the variable standing for the production (production level in kg) proved to be the most relevant from the econometric point of view (see tests below). Furthermore, it highly modifies the results. In particular, (i) the coefficient associated to the production of maize in the sales equation is overestimated in the fixed effects panel data regression with no instrumentation: the level of sales is described as more sensitive to the production level when the latter is considered as exogenous, namely the specification that is less efficient. Therefore, we conclude that households adapt their production level (a choice made prior to marketing decisions) to market opportunities; sales are estimated as less elastic to production. Moreover, (ii) many of the variables standing for the production techniques (more precisely, fertilizer use, type of seeds and intercropping) were significantly different from zero in the regression with no instrumentation but turn out not to influence the amount of sales in the IV regression table 5. This would have led to conclude that agricultural practices affect the amount of sales in absolute value whereas the influence is indirect.

Table 5: Market participation and maize production (panel IV regression with fixed effects)

	maize sales (kg)	maize production (kg)
maize production (kg)	0.602*** (0.106)	
maize area (kg)	23.81 (127.6)	1193,8*** (66,40)
total cultivated area (ha)	-17.49 (11.46)	-27,84 (24,88)
gender of family head Ref: female	88.12 (98.08)	-160,83 (215,84)
age of family head	1.504 (2.975)	3,92 (6,66)
education manager (years)	-7.539 (9.580)	22,57 (20,67)
Fertilizer Kg	-0.541 (0.339)	3,09*** (0,19)
Pesticides Ref: No	150.1** (75.58)	-53,63 (169,39)
improved seeds Ref: traditional seeds	110.2 (80.99)	255,87 (176,13)
hybrid seeds Ref: traditional seeds	71.46 (97.90)	647,01*** (154,76)
Rotation Ref: No	65.96 (59.40)	-212,37* (120,41)
Intercropping Ref: No	1.776 (68.61)	-368,92*** (135,16)
animal manure Ref: No	-150.6** (72.29)	290,25** (145,76)
advice from extension: rare Ref: none advice	-42.20 (62.68)	139,92 (135,47)
advice from extension: regular Ref: none advice	10.74 (70.77)	-124,06 (157,55)
regional price level	-2.150 (4.452)	-2,80 (10,69)
livestock (number)	-3.526 (30.25)	251,33*** (28,35)
number of family members	-6.634 (12.67)	50,41** (25,37)
farmer organisation Ref: No	120.7* (61.76)	-48,55 (136,44)
distance to market	-3.471 (3.183)	20,44*** (5,37)
Improved seeds in village		-277,28 (225,68)
Hybrid seeds in village		-499,02 (517,78)
public food relief received Ref: No		-131,79 (174,39)
public food relief date, if any		0,03 (0,38)
agricultural input credit Ref: No		-581,67*** (151,17)
R-squared	0,744	0,555
N=2190, Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1		

The second range of results refers to the estimation reported in table 5.

(i) The production equation (volume produced in kg) shows that maize area is determinant. We find an effect which matches approximately the average yields per hectare that are presented in appendix 3.

The variables related to input use and production techniques turn out to be highly significant, with the expected signs. The use of fertilizers and hybrid seeds and animal manure increases the production everything else equals. However, the use of improved seeds turns out not to differ from that of the traditional seeds. This result may be explained by the fact that hybrid seeds are higher yielding than improved seeds. However, the agricultural practices of smallholders may be at stake as well: agronomic studies point out the misuse of improved seeds. They are recycled by smallholders, this leads to significant yield loss (Denning et al., 2009). Some of the practices introduced in the equation have a negative impact on production (intercropping with plants that regenerate the soil and rotation practices), but those aim more at soil conservation than yields (Scopel et al., 2013).

The fact to receive advices from extension is not significant in any specification we run. This result is in line with studies showing the inadequacy of extension services and advices in developing countries, even though there is no clear-cut conclusion on the topic (Evenson, 2001). The proxy for the capital level (livestock represents a way to save money in the region) has a positive influence on production. The number of able workers in the family has a positive impact as well: the production of maize is, in this region, labor intensive (Smale and Jayne, 2003). This impact may be the result of the agricultural labour market imperfection leading household to heavily rely on family labour. In the survey led in 2002, household were asked about the constraints they face regarding maize production. The first response is the lack of capital to buy inputs (42% of the households) and the second labour shortage (20% of the households). Last, we observe a negative effect of having production credit. Subsidized input credit for maize production has been declining since the 1990s (Smale and Jayne, 2003). Most of the input credit is nowadays obtained through interlinked contracts that mostly concern cash crop production.

(ii) The participation equation (volume marketed in kg) reveals that maize sales are positively related to maize production, and the coefficient shows that, everything else equals, the households are selling 60% of their production. The coefficient associated to the maize area



cultivated is not significant when the production level is instrumented. As regards market-related variables, the members of a producer organization sell more than the non-members. It should be underlined that the variable *farmer organization* reflects the fact to belong to a producer union whether or not the household sells its production through the organization. Distance to the nearest permanent market has no influence on the amount of maize sold, everything else equals. In the 2008 survey, households were asked about the place where they sell their maize production: 32% of them report that they sell their production at the farm-gate, and 27% in the village market. Only 23% report to sell in markets located further away. Some variables reflecting production practices are still significant. In particular, the fact to use pesticides has a positive effect on the amount of sales. Pesticides use allows for better storage conditions and lowers vulnerability to pest attacks in the postharvest handling (Kimenju and De Groote, 2010).

The instruments turned out to be valid, namely uncorrelated with the error term, the model is not over-identified (Sargan test). They were tested as relevant, namely correlated with the endogenous variable, and the model is not under-identified (Anderson canonical correlations test). We furthermore tested the chosen specification of the model against other specifications: instrumented fixed effects versus fixed effects; fixed effects versus random effects; pooled data versus panel data treatment. We used Hausman tests and kept the proposed specification.

For the next steps, we would like to capture environmental effects by introducing regional or country characteristics that are not constant over time. In particular, agricultural policies were implemented in some of the countries with a large increase in public expenditure directed to agriculture in the period (in Malawi, for instance).

## 5. Conclusion

Empirical studies show that the rate and level of participation in staple crop markets is low for smallholders in Sub-Saharan Africa (Jayne et al., 2010a). In order to explain this observation, the literature mostly focused on market-related factors and transaction costs. However, one can suspect that the production surplus at the individual level is a decisive variable to understand the marketing behavior of households.

We use data collected in 2002 and 2008 in seven countries located in Sub-Saharan Africa to understand the production and commercialization decisions. The instrumented regression exhibits different results than that of the non-instrumented one when investigating the determinants of the amount of maize sold in the market. In particular, the coefficients of the variables reflecting the agricultural practices become non-significant except for practices having an impact on the postharvest conditions of storage. Distance to market which was foreseen to be important for marketing decision has no impact. The result may be due to the fact that a lot of smallholders report selling their production at the farm-gate or in their own villages. Therefore, in our view, two dimensions should be kept in mind as results: the importance of safe storage facilities and the role of marketing practices, and especially of intermediaries.

The last question the paper raises is that of the endogeneity of technology adoption to market opportunities. We observe a very high variability of agricultural practices between 2002 and 2008 (even though a relatively small time-span). For instance, the use of hybrid seeds jumped from 0% in 2002 to around 45% of the sample in 2008 in Ethiopia; in Ghana, the use of improved seeds from 30% to more than 70% over the same time period. These evolutions are partly due to policy decisions but to market incentives as well.

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## Appendix 1a. Panel construction, individuals participating in the two surveys

country	obs 2002	Balanced	attrition
ethiopia	323	318	1,55%
ghana	416	358	13,94%
kenya	300	266	11,33%
malawi	400	304	24,00%
nigeria	494	210	57,49%
tanzania	403	263	34,74%
zambia	477	349	26,83%
mozambique	398	283	28,89%
total	3211	2351	26,78%
<i>without Nigeria</i>	<i>2717</i>	<i>2141</i>	<i>21,20%</i>

## Appendix 1b. Testing for attrition

The risk of attrition bias is related to households dropped out the final sample due to non-response, death or residential moves for instance, and to the evolution of sample design that left out some villages. As to test for potential bias induced by the distortion due to non-random patterns of attrition, we draw on Fitzgerald et al. (1998) Moffit et al. (1999). We compare the probability of belonging to the two periods  $t$  and  $t+1$  according to the reference population at period  $t$ . Attrition of the respondent at time  $t$ , denoted  $A_t$ , is then defined as the fact that the respondent belongs to the reference population at time  $t$  but does not participate to the survey at time  $t+1$ . The distinction is made between ignorable selection on observables and non-ignorable selection on observables (Baltagi, 2014, p.254). We study the linear model:

$$y_t = \beta_0 + \beta_1 x_t + \varepsilon_t \quad (1a)$$

$$y_t \text{ observed if } A_t = 0$$

Where  $\varepsilon_t$  random variable with zero mean,  $A_t$  attrition dummy equals to 1 if the observation is missing,  $x_t$  observed for both attritors and non attritors.

The probability of attrition is of the form:

$$A_t^* = \gamma_0 + \gamma_1 x_t + \gamma_2 z_t + \mu_t \quad (2a)$$

$$A_t = 1 \text{ if } A_t^* \geq 0$$

$$A_t = 0 \text{ if } A_t^* < 0$$

Attrition is random if  $\Pr(A_t = 0 | y_t, x_t, z_t)$  can be reduced to  $\Pr(A_t = 0)$ . Otherwise, the selection is non-ignorable if (i)  $\mu_t$  is dependent of  $\varepsilon_t | x_t$  or (ii) attrition depends on  $z_t$ , namely if  $\gamma_2$  is significantly different from zero in equation (2a). Identification relies on the exclusion restriction induced by the existence of variable  $z_t$  that predicts attrition but is independent from  $\varepsilon_t | x_t$ . Following Alderman et al. (2004), we selected variables that are not

under the control of the households so that they do not influence the outcome  $y_i$  and therefore are not relevant in equation (1a). We chose variables related to the village level in the community questionnaire, namely the type of property rights over land. We believe that it may be correlated to non-response as secured property rights promote sedentary behaviours.

The results show that the probability of attrition is independent on  $y_i$ ,  $x_i$  and  $z_i$  so that we cannot reject the hypothesis of random attrition even though attrition rates are relatively high. This conclusion is similar of Alderman et al. (2001) on various developing countries.

## **Appendix 2. Cultivated land area (2002 and 2008)**

	Mean 2002	Std 2002	Mean 2008	Std 2008
Ethiopia	1,81	1,09	1,81	1,41
Ghana	2,80	2,65	2,31	2,07
Kenya	1,07	0,98	1,17	1,01
Malawi	0,93	2,52	1,41	0,90
Nigeria	4,01	4,17	6,86	5,86
Tanzania	2,28	1,94	1,71	1,69
Zambia	3,07	2,53	2,86	2,31
mozambique	2,19	1,40	1,37	1,17
Total	2,06	2,33	2,17	2,75

### Appendix 3. area, production and yields, country-level

Area Maize 2002 and 2008 (acre) (see season in the main text)

	Mean 2002	Std 2002	Median 2002	Mean 2008	Std 2008	Median 2008
ethiopia	1,08	0,84	1,00	0,81	0,57	0,75
ghana	1,22	1,38	0,87	0,72	0,69	0,50
kenya	0,46	0,47	0,30	0,49	0,49	0,35
malawi	0,30	0,16	0,26	0,81	0,45	0,67
nigeria	1,40	2,18	0,80	3,07	4,65	1,70
tanzania	1,14	1,13	0,80	0,94	0,72	0,80
zambia	1,48	1,36	1,07	1,44	1,35	1,08
mozambique	1,00	0,69	0,95	0,76	0,61	0,59

Production per household Maize 2002 and 2008 (kg)

	Mean 2002	Std 2002	Median 2002	Mean 2008	Std 2008	Median 2008
ethiopia	1524,61	1904,39	966,67	1129,94	1590,06	550,00
ghana	765,17	715,79	600,00	854,22	948,00	516,67
kenya	941,65	1620,15	300,00	805,27	1226,82	311,67
malawi	700,64	547,91	516,67	880,58	724,21	700,00
nigeria	3121,34	8389,08	1033,33	2828,43	3183,72	1690,67
tanzania	1081,15	1204,47	753,83	1171,95	1217,18	746,67
zambia	1511,68	1932,80	833,33	2501,62	3148,35	1333,33
mozambique	467,00	530,42	366,67	525,74	528,42	333,33

Yield Maize 2002 and 2008 (kg/ha)

	Mean 2002	Std 2002	Median 2002	Mean 2008	Std 2008	Median 2008
ethiopia	1200,32	808,31	1000,00	1152,82	748,79	946,67
ghana	967,50	811,50	672,22	1274,09	534,50	1250,00
kenya	1763,27	1541,72	1318,75	1524,75	1164,56	1200,00
malawi <sup>6</sup>	2801,79	1556,40	2625,17	1177,26	712,11	1029,17
nigeria	1695,53	1060,88	1333,33	1339,81	899,03	1189,58
tanzania	954,85	614,38	764,76	1350,76	954,58	1130,56
zambia	1133,91	694,52	1019,44	1601,01	889,12	1422,62
mozambique	491,62	314,87	446,43	927,25	839,65	672,27

<sup>6</sup> We suspect a misreporting problem for Malawi in 2002, the whole distribution of yields being translated to the right (therefore the correction for outliers did not fix the problem).



#### Appendix 4. descriptive statistics of the sample (pooled data)

Variable	Obs	Mean	Std. Err	Min	Max
Maize sales (kg)	3416	545,56	1986,62	0	60750
maize production (kg)	3273	1265,76	2743,65	0	70875
maize area (ha)	3273	1,0	1,257	0,033	20
total cultivated area (ha)	3374	2,36	3,021	0,025	60,75
gender of family head (1 if male)	3429	0,818	0,386	0	1
age of family head (years)	3318	48,5	14,708	15	102
education manager (years)	3359	5,28	4,110	0	12
Fertilizer (kg)	3361	76,96	297,354	0	8100
Pesticides use (1 if yes)	3426	0,159	0,366	0	1
traditional seeds use (1 if yes)	3381	0,4634	0,496	0	1
improved seeds use (1 if yes)	3381	0,177	0,382	0	1
hybrid seeds use (1 if yes)	3381	0,358	0,479	0	1
Rotation (1 if yes)	3405	0,454	0,497	0	1
Intercropping (1 if yes)	3388	0,480	0,499	0	1
animal manure (1 if yes)	3386	0,295	0,456	0	1
no advice from extension	3418	0,472	0,499	0	1
advice from extension: rare	3418	0,308	0,462	0	1
advice from extension: regular	3418	0,219	0,413	0	1
regional price level	3337	17,144	6,084	6	30,90
number of cows	3432	0,933	2,615	0	50
number of family members	3405	3,5718	2,593	0	28
farmer organisation (1 if yes)	3414	0,331	0,471	0	1
distance to market	3238	11,001	14,322	0	65
improved seeds in village (1 if yes)	3145	0,659	0,474	0	1
hybrid seeds in village (1 if yes)	3210	0,845	0,363	0	1
public food relief received (1 if yes)	3270	0,697	0,460	0	1
public food relief date, if any	3270	12,912	135,61	0	2008
agricultural input credit (1 if yes)	3406	0,178	0,382	0	1