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Do households that sell their surplus maize reinvest in improved maize seed? Case of southern Africa

R. Lunduka[1]; G. Kassie[2]; A. Tahirou[3]; S. Babu[4]

1: CIMMYT, , Zimbabwe, 2: ICARDA, , Ethiopia, 3: IITA, , Nigeria, 4: IFPRI, , United States of America

Corresponding author email: rodney.lunduka@gmail.com

Abstract:

This study assesses the influence of selling maize grain on re-investing in Improved Maize Varieties (IMV). It uses a unique data set from five southern African countries of Angola, Malawi, Mozambique, Zambia and Zimbabwe where the selling of maize grain in 2011 season was linked to buying of IMV in 2012 season form sample 2,954 households. Using a control function approach to correct for the endogeneity of selling maize grain in 2011 and the accessing IMV through government subsidies, the study employed a double hurdle model and finds that households that sold maize grain in 2011 had the high probability of growing IMV in 2012. This study points to the fact that when households are able to raise income through grain market participation, reinvestment into land productivity-enhancing technologies could be possible and household food security is also addressed. Therefore developing a better agribusiness environment will take care of food security and hence government goals should not stop at being food secure but developing a condition where a household aims at selling its surplus output.

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JEL Codes: Q18, Q12

#1891

1.0 Introduction and motivation of the paper

Maize is life for most of the households in sub-Saharan Africa (SSA) due to its importance to food security and economic well-being. The crop is grown by both smallholder and large estate commercial farmers. Smallholder farmers constitute the largest share of those growing maize generally for food crop (Smale et al. 2011) and may sell surplus while a limited number of estate farms grow maize as a cash crop. Currently, on average, maize constitutes more than 50% of crop area in SSA (Sheahan and Barret 2017). In some countries like Malawi, maize is grown universally by smallholder farmers. It follows then that the consumption of maize in Africa is very high. The highest amounts of maize are consumed in Southern Africa at 85 kg/capita/year as compared to 27 in East Africa and 25 in West and Central Africa. In Lesotho, Malawi, South Africa, Zambia and Zimbabwe, average consumption is over 100 kg/capita/year (Smale et al.,2011). This, therefore, makes maize not just an economic and food security crop but to also highly influence politics to have as it has a direct impact on peoples livelihood and survival. In order to ensure that the millions of households in the southern Africa region have enough food and improved well-being, there has been an increased effort in supporting improved maize productivity. International organizations and the donor community have supported the breeding of improved maize varieties (IMV), while national governments together with donors have supported access to improved seeds. The strategies for improving access to improved seeds have included the re-introduction of input subsidies (Jayne and Rashid, 2013). The most important reason for advocating input subsidies is that rural households are very poor and typically lack sufficient cash resources to buy productive inputs (Holden and Lunduka,2014). In this paper, we show that indeed rural households that have access to cash through participation in maize output markets can purchase and therefore reinvest in improved maize seeds on the market without government assistance or subsidies.

It is now acknowledged that the increased support in IMV, starting from the breeding programs all the way to their access by smallholder farmer has resulted in substantial productivity gains over the past couple of decades (Smale et al. 2011; Sheahan and Barret, 2017). The maize productivity gains have been achieved through mainly smallholder adoption of improved seed and fertilizer, and there is evidence that improved maize varieties have led to significant gains in crop incomes, consumption expenditures, and food security (Khonje et al., (2015). However, the yield levels in SSA are still very low compared to other regions of the world and to research stations within Africa. Average national yields for white maize in the main producing countries of the eastern and southern sub-regions are reported to range between 1.1 tons and 1.8 tons per hectare (Abate et al., 2017), However, they have occasionally surpassed 2 tons per hectare in Zambia, Zimbabwe, and Kenya (Smale et al. 2011). On the other hand, national yields are 0.5 tons per hectare or even lower in Angola and Mozambique. On average, the area for planting modern maize varieties in SSA is estimated at 57% (Abate et al.,2017). Therefore, the potential to increase maize production in this region through IMV is still high. Fisher et al., (2015) found that the major barriers to adoption of IMV include among other issues, lack of resources by farmers and high seed price. Indeed, poverty combined with liquidity constraints may generate high discount rates that can lead to low investment (Holden et al., 1998). Accessing cash before a crop season is therefore important and necessary to ensure that a household can purchase these high productive improved seeds. In this paper, we use unique data sets collected from five southern Africa countries of Angola, Malawi, Mozambique, Zambia, and Zimbabwe to demonstrate that households that sold maize grain in the 2011/12 season had a higher probability of buying IMV in the 2012/13 growing season even without access to government-subsidized seeds. We acknowledge that purchasing of seeds may be financed from many other sources. However, selling maize grain indicates the availability of cash in the household which can be used to purchase IMV from the market in the subsequent year.

The linkage between the output and input markets has not been widely studied. However, it is this link that provides the sustainability of both markets and has potential to improve rural households by increasing productivity on the one hand and provided much-needed cash for reinvesting and purchasing of other household requirements. This study uniquely links the participation of maize output markets to the participation of maize seed input market in southern Africa. It adds to the literature on the importance of participating in output market to the adoption of IMV. It also shows the importance of the linkage between the input and output markets and hence their dependence on each other. We use a wider geographical covered data sets. Most of the studies on IMV have been at national and local level. We show that the findings of the studies can apply at a wider regional level and hence help regional policymaking.

2.0 Smallholder farmers access to markets

2.1 Access to markets

Input and output markets are very critical for improving the livelihood of rural households by turning physical capital into financial capital (Lunduka et al., forthcoming). The financial capital which can be used to purchase consumed goods (Singh, Squire, & Strauss, 1986; de Janvry Fafchamps, & Sadoulet, 1991) has been modeled to be key in rural livelihoods attaining maximum utility. Markets have also been used to increase the efficiency of resources, e.g., in land rental markets and also help in shifting resources from resource-poor to resource-rich households.

Ensuring IMV are bought from efficient producers (seed companies) guarantees that productivity is maintained at a higher level. Atlin et al. (2017) recommend that replacing the seed each season makes sure that yields advantages from hybrids are substantial. However, replacing IMV each season by smallholder farmers will require good access to the input market and having cash on hand to be able to buy the seeds. However, access to input and out put markets is far more restricted for farmers in Sub-Saharan Africa. Smale et al.,(2011) noted that only a quarter of farmers in Sub-Saharan Africa are within two hours of any form of market, and that is if they use motorized transport. Even in South Africa which boasts an extensive and efficient road network and transport infrastructure, the agro-dealer network in rural areas is thin. Mabaya (2016) reported that seed companies estimated that on average, seed is available within an 80km radius for most farmers. This poses a significant constraint and contributes to high transaction costs in accessing agricultural inputs and selling of outputs such that most households end up being in autarky and s subsistent.

2.2 Maize seed markets in Africa.

The supply of IMV has over the past decades has increased due to the efforts of national governments and international partners in supporting the development of the private seed sector (Smale et al., 2011). There has been significant investments made to liberalize maize seed sectors in most African countries (Mabaya 2016). This has seen the rise of a large number of private seed enterprises (both multinational corporations and emerging domestic companies). These private seed companies have been supported by public breeding programs resulting in high numbers of new maize varieties being bred and commercialized by the seed companies. Currently, most of the private players in the maize seed sector are distributors (Ago-dealers) while only a few are large producers. However, even though there has been an increase in the players in the private maize seed sectors, most smallholder farmers in Sub-Saharan African (SSA) countries, obtain maize seeds mainly from their produce, exchange with other farmers and from local markets. Abate et al. 2017 found that in 2013 nearly 43% of the cultivators grown by farmers in southern Africa were hybrids, with OPVs and local cultivars comprising 8% and nearly 50%, respectively. These figures vary across the countries with Zimbabwe having the highest adoption rate of IMV while 60% of Angolan and Mozambican farmers were still using local landraces (Fisher et al.,2015).

To boost the adoption rate, if IMV in SSA some policy strategies have been pursued, the most recent being the reintroduction of input subsidies. Agricultural input subsidies have regained popularity in several African countries (Jayne and Rashid, 2013) after they were cited as a smart subsidy success story in Malawi. In theory, by reducing costs, input subsidies should increase input profitability and reduce farmers' financial capital constraints, thus encouraging adoption of modern inputs to boost production (Fan et al., 2007). This indeed has contributed to the increase in the adoption rate of IMV in some of the SSA countries. For example, Holden and Fisher, (2015), reported that most households using IMV in Malawi have accessed it through subsidy. In Zambia, Smale and Mason (2014) labeled the improved maize seed supply as "the affair of the State." Even though subsidy programs have demonstrated short-term benefits, the sustainability of the seed supply system has been in question. Jayne et al. 2013, indicated that costs of implementing large-scale input subsidy programs might outweigh the benefits in the long run. Current evidence shows that these large subsidy programs crowd out private and commercial inorganic fertilizer (the main subsidized input) suppliers as demonstrated by Xu et al., (2008) in Zambia and Ricker-Gilbert et al., (2012) in Malawi.

It is therefore critical to ensure that policies that promote the private sector in input use are developed and implemented to ensure sustainability of the huge investment already made in the development of the industry and breeding of IMV. The above focusses and addresses issues the supply side of the IMV market. However equally important is the demand side of the seed system. How can farmers sustainably finance the investment in the IMV? Adjognon et al. (2017) pointed out that credit use for fertilizer, pesticide or seed purchases is low in SSA. Therefore, IMVs are primarily financed through cash from nonfarm activities and crop sales instead. This study explores whether access to markets in the previous year has a direct implication on the ability of the household to purchase new improved maize varieties?

2.3 Maize output markets- Income source for smallholder farmers

Rural households in SSA derive about two-thirds of their income from on-farm agriculture (Christensen, 2017). Taking the share of the gross value of crop sales to the gross value of total agricultural production, i.e. the crop commercialization index, as their measure of market participation or agricultural commercialization, Carletto et al. (2017) find that farmers sell on average around 20–25 percent of their crop output (a bit less in Malawi, slightly more in Uganda and Tanzania). Carletto et al. find that these commercialization rates rise with harvest size mainly for food crops like maize. Lunduka et al., (2015) found similar results in Malawi that participation in maize sales is highly positively correlated with the level of production. These findings are contrary to the notion that farmers often sell their maize just to meet immediate short-term cash needs (e.g., Jayne et al. 2010). Farmers' choices to sell maize are rationally based on first meeting their household consumption needs and then later other income. Therefore, increased output from

IMV has higher potential to increase cash available for rural maize growing households. This has also been reported in Zambia by Smale and Mason, (2014) who found that growing higher-yielding hybrid maize contributes to household incomes through annual effects on cash earned through sales of maize or other crops are grown on land re-allocated from maize because of higher yields.

Even though maize output markets have potentials and indeed shown to increase income and cash, where markets are available, maize prices are volatile. This volatility is seasonal. During harvest time in Southern Africa, May, June, and July, prices are low but steady increase up until January and February when maize prices are at their highest. Christiaensen, (2017) found that maize prices in the 193 markets from the seven African countries studied are on average 33 percent higher during the peak months than during the troughs. Due to lack of good storage facilities and technologies, the supply of maize grain is high just after harvest. This has also lead to farmers opting to grow low yielding maize varieties with excellent storage properties. Other attributes other than yield per se contribute to the seed choice of most smallholder farmers (Lunduka et al., 2012; Smale et al., 1995).

Price fluctuations have also been affected by government policies mainly setting price bands and in extreme cases banning the selling of maize grain. Even though policies have legitimate social objectives, the discretionary and unpredictable trade policy controls such as import and export bans, by most governments in Southern Africa, as well as direct state trading operations, have disincentivized farmers at the local level, but also curtailed the potential of regional trade (Chapoto and Jayne 2009). This has been by making maize grain market less lucrative and also denying these farmers access to much-needed cash that they would use in the proceeding year to purchase agricultural input mainly inorganic fertilizer and IMV.

2.4 Investment decisions and resources

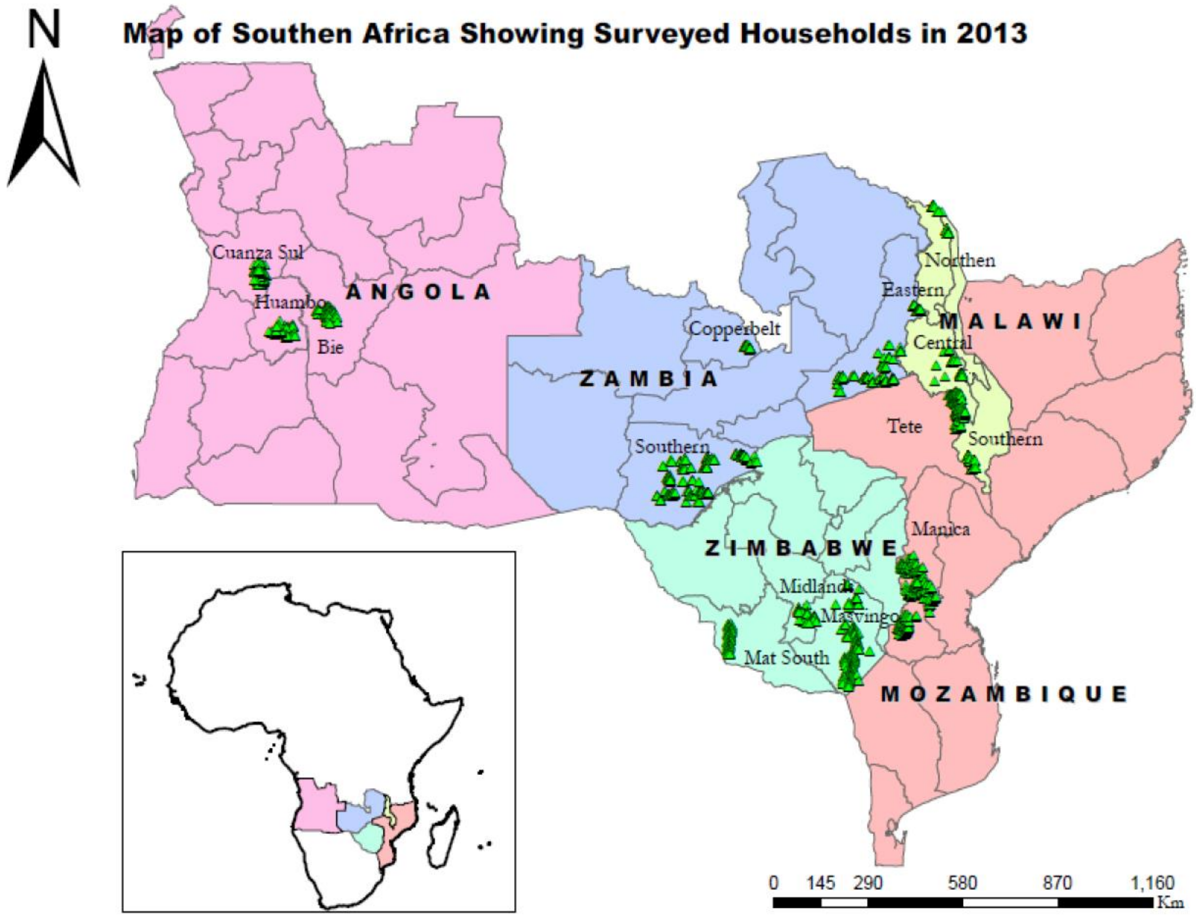
Given that IMV have to be bought from the markets, farmers face the challenge of making sure that they have enough cash to buy the seeds. Input subsidies have given a short-term solution. Accessibility to credit, on the other hand, is very low. A recent article on myths in African agriculture by Christiaensen, (2017) reveals that very few farmers have actual access to credit and that most production investments are made from households own resources. This then points out to the fact that prior participant in output markets is a prerequisite for households to purchase improved inputs like improved maize seeds and inorganics fertilizers. To ensure the sustainability of, the seed sector industry, allowing the fully private sector to dominate the maize seed market may be ideal.

On the other hand, current evidence, however, indicates the price of maize seed is high and deters farmers from investing in IMV. In Kenya, Smale and Olwande (2014) found that that seed to grain price ratio at farm gate has a significant, strong and negative association with farmer's demand hybrids. Therefore limited demand for inputs is not necessarily driven by irrationality. Failure to buy inputs may be the outcome of a rational response to binding cash constraints (Holden and Lunduka, 2013). These two factors, i.e., seed price and availability of cash to smallholder farmers to purchase are influence decisions to demand IMV.

3.0 Methodological approach

3.1 Data sources

We use households' cross-section data collected main crop season of 2013 (except Mozambique, which was done in 2014) data from five Southern African countries of Angola, Malawi, Mozambique, Zambia, and Zimbabwe under the Drought Tolerant Maize for Africa (DTMA) project. Market access variables of 2012 and 2013 evaluate the impact of maize market participation on households' ability to reinvest in subsequent production. Sample sizes for the five surveys approximately 600 farm households per country, and we have a total of 2,954 households that have been used in this study. Sample selection was done in four stages. The first two stages were purposive. First, the main maize growing areas were targeted in each country. Second, six districts were selected within each target area.The next two sampling stages were random. Ten villages were randomly selected in each selected district. Then, ten maize-farming households in each sampled village were randomly selected. Farm interviews, using a five-page questionnaire, were conducted between April and August of 2013 and in July 2014 (Mozambique). The household head was interviewed, with the spouse joining where possible. Information collected concerned household demographics and socioeconomic status, agricultural landholding, agricultural input use for maize production, maize varieties cultivated, and awareness of and demand for DT maize varieties. The short questionnaire, experienced enumerators, and close supervision ensured collection of high-quality data.



3.2 Econometric model specification

Our main question we would like to answer is whether participation in the maize output market in, i.e., selling of maize grain in 2012 enabled a household to purchase Improve Maize Seeds (IMV) in 2013 growing season. Selling of maize grain on the markets indicates household had cash that it was able to buy improved seeds in the markets. We follow farmers that sold maize grain on the market in 2012 and whether they bought improved maize in 2013 growing season and how much.

The common approach in analyzing and modeling market participation of smallholder farmers in SSA has been using two-part model, i.e., the discrete decision of market involvement and the continuous decision of market participation intensity conditional on having decided to participate. This is because not all households participate in the market, be it input or output, there are always households that do not participate. This is the same in our sample of the five countries that participation on both the maize grain market in 2012 and the purchasing of IMV in 2013 was not by all households. A Tobit model and its derivation have been the common workhorse model used in the analysis, e.g., Macharia et al., (2014) used the censored Tobit model; Bellamere and

Barrett, 2006; Alene et al., (2008) used ordered Tobit models to analyze the role of transaction costs on market participation. Specific to input demand studies, a censored regression model using the Tobit procedure has commonly been used to estimate the demand for improving maize adoption (Langyintuo et al. 2006; Mason and Smale, 2013).

A major drawback of the Tobit model is that the choice to participate in the markets and the value of how much to participate, given that a household has decided to participate is determined by the same vector of parameters (Burke, 2009). However, different factors may come to play in the decision to participate and how much to participate, i.e., either sell or buy and when participating, how much to sell or buy. Cragg 1971 proposed a separation in the drivers on the two sides.

$$f\left(\Pr_{imv}, S_{imv} \middle| X_{pr}, X_{imv}\right) = \left\{1-\Phi\left(X_{pr}\beta_{pr}\right)\right\}^{1(\Pr_{imv}=0)} \left[\Phi\left(X_{pr}\beta_{pr}\right)(2\pi)^{-\frac{1}{2\sigma}-1} \exp \frac{\left\{-\frac{\left(S_{imv}-X_{imv}\beta_{imv}\right)^2}{2\sigma^2}\right\}}{\Phi\left(\frac{X_{imv}\beta_{imv}}{\sigma}\right)} \right]^{1(\Pr_{imv}=1)}$$

This is the Cragg Model or Double Hurdle model and integrates the probit model to determine the probability to participate in the market and the truncated normal model for given positive values of households that are participating. Cragg's model, the probability of adopting improved maize varieties ($Pr_{imv} > 0$) and the quantity of IMV for a household S_{imv}, given household has adopted ($Pr_{imv} = 1$), are now determined by different mechanisms (the vectors β_{pr} and β_{imv}, respectively). Furthermore, there are no restrictions on the elements of $\boldsymbol{X_{pr}}$ and $\boldsymbol{X_{imv}}$, implying that each decision may even be determined by a different vector of explanatory variables altogether.

Mathenge et al., (2010) and Mather et al., (2011) have applied a similar model grain market participation of smallholder farmers in eastern and southern Africa. In this study, we allow the decision to use IMV to be different from the how much seeds can be used and we apply the Cragg model using the "craggit" command in Stata 14. The main benefit of using 'craggit' is its ability to facilitate post-estimation analysis and interpretation (Burke 2009). We are interested in estimating the partial effects of participating in a grain market on the amount of IMV bought given that the household bought IMV, i.e., IMV>0 and is given by:

$$\frac{\partial E\left(S_{imv} \middle| S_{imv} > 0, X_{imv}\right)}{\partial Q_{ma}} = \beta_{Q_{ma}} \left[1-\lambda\left(\frac{X_{imv}\beta_{imv}}{\sigma}\right)\left\{\frac{X_{imv}\beta_{imv}}{\sigma}+\lambda\left(\frac{X_{imv}\beta_{imv}}{\sigma}\right)\right\}\right]$$

We, therefore, estimate the model

$$S_{imv} = f\left(Q_{am}, X_{imx}, G_s, X_{pr} \middle| Z, Cl\right)$$

Xpr are factors that include the probability of accessing IMV. Holden and Fisher in Malawi and Mason and Smale in Zambia showed that households access IMV strongly determined by the subsidy programs. We control for endogeneity of the government subsidy programs in the model by using a control function.

We also control for se The is endogenous in the above model and hence the estimate β not consistent. To correct for the endogeneity of the Using the predicted production $\hat{Q}_p$, we calculate the error term $\hat{e}_p$ by $Q_p - \hat{Q}_p = \hat{e}_p$ and we use this in the next stage of the analysis where we estimate. This error term, therefore, controls for the endogeneity of the total production (Q_p) in the quantity of maize sold equation, the control function approach (Wooldridge, 2002). We use this directly in an instrumental variable probit model. This approach was proposed by Rivers-Voung to control for endogeneity in a nonlinear model.

$$\begin{aligned} G_S &= 1(\alpha + X_{subsidy} + Z + e \geq 0) \\ Q_{am} &= X_{mkt} + Z + u \qquad \text{.........................} (9) \\ S_{imv} &= \left(G_S + \hat{e}_S\right) + \left(Q_{ma} + \hat{u}_{ma}\right) + Z_i + X_i + \varepsilon_i \end{aligned}$$

Therefore, the error terms *e* and *u* serve as the instrument that affects the sales of maize and access of government seed but do not influence the purchasing of the IMV in 2012.

4.0 Results

4.1 Determinants of selling maize in 2011 and factors affecting access to Government maize seed programs

We start by looking at how much maize grain was sold by households in 2012 season. Table 1 presented the average amount of grain sold at household level in each of the five countries. Sampled households in Malawi had the lowest grain sold at under 29kg/household. Households in Angola sold on average 61kgs while the highest grain sold per household was from Zambia at 785kg. Mozambique and Zimbabwe households sold 183kg and 146 kg respectively. This amounts of grain sold almost mirrors the percentage of households that were food secure in the five countries. Only 18% of households in Malawi reported having been food secure in 2011/12 season which was the lowest in the region. Zambia households reported the highest percentage of food secure households. This may indicate that households can sell grain when they have met their households needs otherwise they would prefer to keep the grain for household consumption.

Table 1: Summary of key variables

Variable	**Angola**	**Malawi**	**Mozambique**	**Zambia**	**Zimbabwe**
Amount of maize grain sold in 2011 per household (kg)	60.62 (258.44)	28.66 (73.98)	183.25 (498.63)	785.33 (1373.47)	146.36 (682.10)
Percent of households that were food secure in 2011	35 (48)	(18) (39)	37 (48)	56 (50)	33 (47)
Percentage of household that grew IMV in 2012	32 (47)	88 (33)	68 (47)	90 (31)	94 (24)
Quantity of IMV seed by households (kg)	9.15 (25.72)	17.10 (13.68)	24.82 (25.30)	22.24 (19.69)	20.60 (15.26)
Percent households that got seeds from Government	15 (36)	27 (44)	4 (20)	33 (47)	33 (47)
Distance to nearest market in Minute	60.91 (54.52)	78.89 (68.62)	59.65 (63.46)	81.23 (71.83)	66.60 (55.23)
Total land endowment at households (acres)	2.39 (2.02)	2.23 1.47	3.73 (2.67)	3.79 (7.08)	4.16 (2.85)

Source of data: survey data 2013

We now turn to the percentage of households that grew IMV in 2012. We find the percentages of households that grew IMV mirrors documented adopts rates of improved maize in the region. Zimbabwe has the highest percentage of household growing IMV (94%) with Zambia (90%) and Malawi (88%) in second and third. Angola had the lowest percentage of households growing IMV at only 32% of the households. Malawi and Zambia have huge government input subsidy programs that include IMV and inorganic fertilizers. These programs have been attributed to the increased adoption of IMV, e.g., in Malawi (Holden and Fisher, 2015). However, caution is taken here to note that accessing IMV from the cheap government programs may not necessarily mean adoption as households may revert to local varieties once these programs are no longer available. In Zimbabwe; the government is also implementing an input subsidy program called command agriculture that supplies IMV together with chemical fertilizers to smallholder farmers. However, Zimbabwe has had a higher percentage of households growing IMV since the early 90s. Regarding the quantity of IMV seeds, Angola had the lowest amount per household at 9kg while Mozambique registered the highest number at 25kg of IMV seed per household. Even though

Malawi households had a higher adoption rate of IMV than Mozambique household, the amount of IMV used was less at 17 kg/household. Even though households registered to have planted IMV, they do this on a smaller part of their main farm and still plant local verities on the larger part. This could have implications on the total amount maize harvested and sold on the market.

In general, households that sold maize on the market in 2011 bought and planted IMVs in 2012. This is partly shown by the kernel density graph above that shows a positive density at zero for both selling of grain in 2011 and using IMV in 2012. On the right-hand side, we also notice a commutative density for both the log of the amount of grain sold and the log of IMV seed planted in 2012. We regressed the amount of maize grain sold in 2011 on some factors that could influence households to enter the grain market. Table 2 column A presents the results from a Tobit, regression model. The results show that households that were food secure in 2011 had a high probability of selling maize grain and sold even more. This was also common to young and male-headed households. Interestingly accessing maize market was high for households that were able to access markers using vehicles that households that accessed markets on foot. This indicates the importance of infrastructure in improving agricultural productivity (Fan et al. 2005; Fan and Zhang, 2008; Lunduka and Ricker-Gilbert, 2016). We estimate the error term from this model and use it as an instrument in the main IMV seeds demand equation as control function (Wooldridge, 2002).

Table 2: Determinants of selling grain and accessing IMV through government programs

Variables	Tobit Model-Determinates of selling maize grain in 2011 (A)		Probability of accessing IMV through Government seed subsidy (B)	
Household was food secure in 2011	1041.295****	(93.06)	0.041	(0.06)
Gender of household head (Male=1:female=0)	221.613**	(95.17)	-0.179**	(0.08)
Age of household head	-11.402****	(2.71)	0.005**	(0.00)
Education level (number of years in school)	-16.931	(10.38)	0.006	(0.01)
Household size	-18.503	(18.02)	-0.016	(0.01)
Household agricultural labor	73.819**	(30.58)	0.004	
Total livestock units (TLU)	116.871****	(19.58)	0.005	(0.01)
Distance to markets (walking minutes)	0.281	(0.56)	-0.001**	(0.00)
Transport mode- (on foot)	-146.634*	(86.79)		
Transport mode (vehicle)	254.869**	(100.08)		
Income status of the household			0.071****	(0.02)
Total land endowments			0.032***	(0.01)
Extension sources for the households (base Government service)				
Extension farmer to farmer			0.245****	(0.07)
Extension Agro dealers			0.192*	(0.11)
Extension media (Radio, TV, and newspapers)			-0.923*	(0.51)
Country dummies (Angola=base)				
Malawi			0.148	(0.10)
Mozambique			-1.091****	(0.14)
Zambia			0.380****	(0.10)
Zimbabwe			0.208*	(0.11)
Constant	-1387.179****	(268.23)	-0.497**	(0.23)
sigma (σ)	1451.904****	(82.40)		
Prob > chi2	0.000		0.000	
Number of observations (N)	2665.000		2650.000	

Accessing and planting IMV was not always from the markets. We have seen a higher number of farmers accessing seeds from some form of government subsidy be it Input subsidy programs (Malawi and Zambia) or command Agriculture in Zimbabwe. Unfortunately, these programs had shown not to be random either by design as in case of Malawi where the program targets poor households or some political influence. Therefore, accessing IMVs may be correlated with some other household characteristics that also influence normal access to markets (both input and output), e.g., remoteness of the household location, gender or household head and hence endogenous in our model of interest, i.e., accessing IMVs. Regressing the probability of accessing IMV through government program show that older female households with agricultural land had a higher probability of accessed IMVs through the government programs (see table 2, column B). As common with the Government programs, wealthier farmers in less remote location also had a higher probability of accessing the government-sponsored IMVs. Ricker-Gilbert et al. (2011) found that in despite targeting guidelines in the Malawi input subsidy program greater quantities of subsidized fertilizer went to households with higher assets and more land. Similar findings have been reporting in Tanzania (Pan and Christiansen, 2012), and in Zambia Mason and Smale 2013 found evidence of elite capture or preferential targeting of the seed subsidy. We control for these factors by using a control function approach in our IMV seed demand equation.

4.2 Factors affecting the amount of IMV grown

The results from the Craggit analysis are presented in table 3. The first tier results of the probability part of the craggit analysis are presented in Annex 1. The likelihood of growing IMV was positive and significant for households that sold maize grain in 2011 for all countries. We are interested in how much IMV was planted in 2012 by households that sold grain in 2011. The results in Table 3 show that at regional level (Column A) and specific model for each of the five country Column B-F, the log of selling maize grain in 2011 influences the amount of IMV that the farmers grew in 2012. The coefficients are all positive and significant. The largest influence based on the size of the coefficient is Angola followed by Mozambique and Zambia. Malawi has the least coefficient indicating smaller influence as compared to the other countries. This indicates that accessing markets has greater influence in the Angolan smallholders to adopt IMVs. We also note that the error terms from the Tobit model on the amount of grain sold in 2011 for each of the models are significant. This indicates that there is endogeneity in the accessing to markets hence using the control function approach is a better approach to control for that.

On the influence of government program, the results show that the current government programs in the regions have a positive influence on the household probability to grow IMV. However, the second tier results on the how much IMV for households that grew IMV, government programs have a significant negative influence. This indicates that the government programs have increased access to IMV, but their supply is in low quantities. For example, in Malawi, the program only distributes 2kg which is enough for 0.08ha. In Zimbabwe's command agriculture, the distribution of inputs targets mainly semi-commercial farms with land of not less than 5 ha, which was not part of our sampled households in this study. As most programs have a standard small pack of the amount of seed available, the high use of IMV come from elsewhere rather than the government programs.

Cragg's double hurdle model with control function

Tier2	**All countries (A)**	**Angola (B)**	**Malawi (C)**	**Mozambique (D)**	**Zambia (E)**	**Zimbabwe (F)**
	b/se	b/se	b/se	b/se	b/se	b/se
Received Maize seed from Government program (Subsidy)	-62.89****	-3425.87	-318.22**	-247.66	460.20****	-142.05
	(8.07)	(2263.68)	(133.91)	(231.48)	(43.56)	(144.53)

Error term (Subsidy)	67.61****	3496.67	317.23**	247.45	-458.50****	145.07
	(8.41)	(2269.10)	(133.93)	(231.47)	(43.53)	(144.46)
Log of maize sold in 2011	2.71****	12.00***	0.73**	1.34****	1.31****	0.76**
	(0.29)	(4.27)	(0.33)	(0.40)	(0.27)	(0.30)
Errror term (log of maize sold)	-1.37	-61.38**	-4.28**	-0.91	3.18**	-1.01
	(1.30)	(25.79)	(1.69)	(1.80)	(1.53)	(1.07)
Gender of household head	6.07**	21.58	-17.67**	-2.57	30.66****	-6.41
	(2.99)	(141.01)	(8.71)	(6.14)	(4.19)	(9.51)
Age of households head	0.38****	4.81	0.43	0.38**	-0.71****	0.27
	(0.10)	(3.66)	(0.27)	(0.18)	(0.14)	(0.27)
Education of household head	0.25	4.93	0.44	0.25	-0.43	0.04
	(0.33)	(6.34)	(0.44)	(0.48)	(0.38)	(0.41)
Household size	1.43****	-8.38	-2.02**	0.35	4.12****	-0.24
	(0.39)	(11.62)	(0.85)	(0.70)	(0.45)	(0.89)
Household labour supply	1.70***	44.96***	1.54**	0.85	-0.64	0.18
	(0.64)	(14.12)	(0.78)	(1.09)	(0.60)	(0.66)
Total land endowments	1.66****	45.88*	8.05****	4.72****	-1.80****	4.21**
	(0.16)	(24.05)	(1.57)	(0.97)	(0.34)	(1.74)
Household was food secure in 2011/12	12.35*	331.44**	32.31****	1.35	-16.11**	6.10
	(6.51)	(135.19)	(8.45)	(9.12)	(7.72)	(5.79)
Time taken to nearest market (minutes)	-0.01	-0.67	-0.12***	-0.02	0.15****	-0.05
	(0.01)	(0.67)	(0.05)	(0.03)	(0.02)	(0.06)
Number of drought in past 10 years	-0.54	11.29	0.42	-0.70	0.16	-0.86***
	(0.48)	(12.08)	(0.42)	(1.02)	(0.68)	(0.30)
Total Livestock units (TLU)	2.59****	40.27**	2.34**	1.53	-1.68**	2.06***
	(0.73)	(17.72)	(1.17)	(1.04)	(0.82)	(0.65)
Income status of the household	2.83****	60.54	7.31**	1.19	-10.76****	5.61
	(0.62)	(48.30)	(3.21)	(2.14)	(1.30)	(3.80)
Extension Government services	9.19****	234.85	26.95**	10.93*	-46.65****	16.72
	(2.00)	(165.11)	(10.87)	(6.45)	(4.90)	(12.85)
Extension farmer to farmer	8.25***	123.26	19.81**	6.14	-32.44****	14.94
	(2.72)	(122.43)	(9.00)	(5.04)	(5.02)	(10.63)
Extension agro dealers	-1.11	0.00		1.26	123.31****	-33.92
	(8.27)	(.)		(10.21)	(12.69)	(32.68)
Extension media, road tv and news papers	-5.45	0.00	-1.66	-2.28	-3.78	-2.42
	(3.87)	(.)	(3.17)	(6.52)	(2.78)	(4.27)
Constant	-38.48****	-104.53	93.08*	-2.62	-206.50****	55.65
	(9.93)	(633.62)	(49.87)	(19.21)	(22.12)	(56.48)
sigma _cons	25.47****	47.37****	13.18****	20.11****	15.21****	13.32****
	(0.85)	(7.28)	(0.64)	(0.96)	(0.74)	(0.58)
Prob > chi2	0.00	0.00	0.00	0.00	0.00	0.27
Number of observation (N)	2641	361	594	599	499	588

On social-economic characteristics, the results show that IMV are mainly grown by older male-headed household, with relatively more resources. The results indicate that household with more landholding, livestock and savings have a high probability of growing IMV and also grew, even more, quantities of IMV that poorer households. As IMV have to be bought on the market, this is not surprising. Regarding food security, households that grew IMV in 2012 were more food secure in the previous year for the whole all countries and specifically Angola and Malawi. Zambia households had a negative coefficient. However, Zambia had the highest households that were food secure at 56%. Lastly, households that grew more IMV also had more contacts with extension staff that may have encouraged them to increase productivity by growing IMV.

5.0 Discussion

The results in this study point to the fact that maize grain output sales have an impact on subsequent investments in IMV. This could be because the possibility of having cash from the sales motivates the farmers to increase or maintain an increased output through the growing of IMV. Mason et al., (2014) reported that farmers in Zambia have responded to an increase in the Food Reserve Agency (FRA) activities of buying maize grain at harvest by increasing their maize production. Alene et al., (2008) found that output price provides incentives for increased supply by sellers. On the contrary, Malawi had in several years, banned the maize market (e.g., in 2008 Jayne et al. 2010) and price regulation[1] with the aim of protecting smallholder farmers from exploitative private traders. However, this has had a negative impact on the smallholder farmers mainly the productive ones. Jayne et al. 2010 reported that

> *"Maize farmers in surplus areas continue to hold significant maize stocks, which they had hoped to sell at a price above 60 kwacha per kg (U$D0.42). When the price regulations were imposed, many of these farmers were stuck holding maize stocks that decreased significantly in value. This is a group of farmers that is not dependent on fertilizer subsidies but rather buys most of their fertilizer through private channels."*

This has disincentivized most productive farmers in Malawi resulting in low maize production, and the highest incidence of food insecurity that was also reported by Fisher et al. (2015).

In addition to maize grain markets incentivizing farmers to increase their productivity by growing more IMV, the cash obtained from the sales of grain in one year has a direct or indirect injection in purchasing IMV seeds from the market in the subsequent year. The Craggit results show that in Angola, even though the government investment in seed subsidy was the lowest, maize grain sales in 2011 had the strongest influence (size of coefficient) of the adoption of IMV in 2012. Purchasing of marketed products (IMV), demands that cash be available at the household level and

[1] The coefficient of variation (standard deviation / mean price over period) of maize prices in Malawian markets are all above 45% compared to ranges of 20% to 35% for most other markets in the region (Jayne et al.,2010)

selling maize grain ensures that there is cash in the households, enabling it to reinvest in next growing season.

Government input subsidies have been very influential and important in increasing the adoption rate of IMV, e.g., in Malawi Holden and Fisher, (2015) and Zambia, Smale, and Mason (2016). In addition, the government programs have also helped replace old IMV with new varieties (Atlin et al.,2017) with additional traits like drought tolerance (Fisher et al., 2015; Lunduka et al., 2017) or nutritious maize (Bouis and Saltzman, 2017) (Quality protein, zinc, and Provitamin A biofortified). The results of the craggit model show that the current subsidies have increased the probability of households to access IMV but have not influenced the increased amounts of IMV in smallholder farmers-general. Only in Zambia households that accessed Government subsidy had an increased the amount of IMV invested in 2012. In Zambia, the government distributed 10kg pack (enough for 0.4ha of land) of maize seed as compared to Malawi 2kg (enough for 0.08ha), while in Zimbabwe the government program targets semi-commercial farmers with at least 5 ha and other resources, e.g., irrigation. Audet-Bélanger et al., (2016) found that in Malawi where farmers had not received the subsidized seed, only a twelfth of plots were sown with hybrid varieties. This points to the fact that even though we have seen an increase in IMV use is Malawi; this may reduce when the FISP program is stopped. Therefore the majority of the smallholder farmers have to find other sources of accessing IMV to improve their maize productivity. Improving access to grain markets for farmers will increase the probability of increased adoption of these new varieties. Angola and Mozambique households have higher coefficients indicating the importance of maize grain sales on IMV re-investments.

The results of this study show that Zambia households sold the highest amount of maize grain in 2012. High-level government support like the National Food Reserve that has been responsible for mopping excess surplus has helped farmers realize the benefits of growing surplus maize. In addition, Zambia also had the highest food secure households in the region, in addition, to having sold even more maize. Therefore, to ensure that agriculture contributes to the overall development of the country, food security should be considered an intermediary goal for agricultural development. The study shows that development of an agribusiness system where input and output markets are functioning well, food security issues are addressed automatically. This study shows that households will sell their grain when they have met their household food needs. Households sell surplus grain contrary to some finding. Lunduka et al.)2016) found similar results in Malawi where households that sold maize grain on the market had a higher probability of being food secure. Therefore developing a better agribusiness environment will take care of food security and hence government goals should not stop at being food secure but developing a condition where a household aims at selling its surplus output.

Access to markets indicated by the time taken to the market and mode of transport (either by foot or by vehicle) to was high where infrastructure was good. This study has shown that households that sold maize grain had access to markets on vehicles rather than on foot. However, the results in the Craggit model on demand IMV, access to nearest markets was not strongly correlated with the IMV. Chamberlin and Jayne, (2012) indicated that distances to physical infrastructure are often not representative of farmers' access to markets and therefore changes in specific market access conditions may have more to do with the behaviours of marketing agents. In this study access to IMV was also influenced by a government program. However, development of road infrastructure has been showed to have higher and better impact in improving agricultural productivity (Fan et al. 2005 in India; Fan and Zhang, 2008 in Uganda; Lunduka and Ricker-Gilbert, 2016 in Malawi).

6.0 Conclusion

This study assesses the influence of selling maize grain on re-investing in IMV. It uses a unique data set from five southern African countries of Angola, Malawi, Mozambique, Zambia and Zimbabwe where the selling of maize grain in 2011 season was linked to buying of IMV in 2012 season form sample 2,954 households. Using a control function approach to correct for the endogeneity of selling maize grain in 2011 and the accessing IMV through government subsidies, the study employs a double hurdle model and finds that households that sold maize grain in 2011 had the high probability of growing IMV in 2012. These households also grew more IMV after controlling for Government seed subsidies. This point to the need to encourage policies that are believed to promote market stability and small farm incentives to sustainably use improved seed and inputs (Benin, 2017). Governments in the region may need to be clear on their goals. For example, if providing cheap food for the urban poor is the issue, then raising yields may be what matters most (Benin, 2017) which can be done by increasing land productivity through improved agricultural technologies like IMV. However, if the goal is to reduce poverty among the rural households, then raising labor productivity through increased income should also be highly supported. Mather et al., (2013) showed that investments that raise farm-level productivity are an essential complement to investments that improve market access. Benin (2017) indicated that because of the majority of Africa's poor lives in rural areas and depends on agriculture for their livelihoods, raising labour productivity, which in turn raises rural incomes, is a key strategy to reduce rural poverty. This could be done by promoting and supporting strategies that increase output market participation to ensure that rural households can earn income from their agricultural activities. This study points to the fact that when households are able to raise income through grain market participation, reinvestment into land productivity-enhancing technologies could be possible and household food security is also addressed.

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