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Zambia Buy-in

# SMALLHOLDER MAIZE MARKET PARTICIPATION AND CHOICE OF MARKETING CHANNEL IN THE PRESENCE OF LIQUIDITY CONSTRAINTS: EVIDENCE FROM ZAMBIA

By

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# EXECUTIVE SUMMARY

Smallholder participation in agricultural output markets holds potential to move farmers out of subsistence farming to more commercial and profitable agricultural enterprise (Heltberg and Tarp 2002; Barrett 2008; Von Braun et al. 1994; Timmer 1988). Yet, a relatively low portion of smallholder farmers participate in food markets as net sellers in many sub-Saharan African (SSA) countries (Barrett 2008; Mather, Boughton, and Jayne 2013). Most studies that empirically study the reasons behind this low participation have focused on transaction costs of accessing output markets such as poor roads, infrastructure, and/or insufficient endowments of public and private assets. However, constraints that limit a household's capacity to produce a surplus beyond meeting its consumption needs could also limit a household's capacity to be a part of commercial agriculture. One such constraint is the inability to invest in productivity enhancing agricultural inputs such as inorganic fertilizer and improved seed due to lack of liquidity (i.e. cash from income or credit) at time of planting. There is clear evidence that liquidity constraints at planting time lead to lower agricultural output (Winter-Nelson and Temu 2005; Foltz 2004; Feder et al. 1990). This paper extends this literature to assess the extent to which liquidity constraints that constrain agricultural output can subsequently also limit the household's capacity to sell agricultural output.

Liquidity constraints are also known to make agricultural households "sell low, buy high", i.e. they sell their grain output immediately after harvest (when prices are lowest) to meet cash needs, and then they end up buying grain later in the lean season when prices rise. This behavior could also potentially have an impact on the marketing channel that is chosen by the participants of agricultural output markets, particularly if a channel is characterized by uncertainty of the time of purchase, purchase price, and delays in payment.

We base this study on the maize markets of Zambia. Maize is the staple food grain of Zambia, is grown by almost all farm households and is an important source of cash for many of them (Chapoto et al 2015). Using data from the Rural Agricultural Livelihood Survey (RALS), a nationally representative two-wave panel dataset of smallholder farm households in Zambia for 2012 and 2015, we study the following questions for maize smallholders in Zambia:

1) First, we assess whether liquidity constraints during the maize production period affect a farm household's decision to participate as a net seller of maize.
2) We then study whether liquidity constrained households are less responsive to changes in maize prices with respect to this decision.
3) Finally, we explore whether liquidity constraints have an effect on the choice of marketing channels for net sellers of maize.

This third question is of particular interest in the case of Zambia given the significant role played by the Food Reserve Agency (FRA) in both its domestic maize market and in agricultural policy in general. The role of the FRA is particularly relevant to our interest in the effect of liquidity constraints on a smallholder's choice of maize marketing channel because, although the FRA typically purchases maize from farmers at a price that is higher than the prevailing producer sale price, the timing of FRA maize purchases each marketing season is uncertain. More significantly, there is typically a relatively long and unpredictable delay in FRA's payment to farmers for the maize they purchase from them. We define a household as liquidity constrained in the maize production period if one or both of the following conditions are met (following the approach similar to Winter-Nelson and Temu (2005)): (1) The household claims to not have acquired fertilizer from market due to lack of cash, and/or (2) the household claims to not have obtained fertilizer from the Farm Input Subsidy Program (FISP) due to: a) not being able to afford the down payment for obtaining fertilizer through FISP and/or b) lack of cash for the mandatory cooperative membership payment required for participation in the program.

We find that more than half of all smallholders in the sample were liquidity constrained in 2012 and 2015. Being liquidity constrained is found to be associated with lower input use, smaller maize productivity and output per capita, less ownership of land-holding and livestock among other factors. The three main maize marketing channels in Zambia were identified as the FRA, private traders and other households, which were chosen by 47, 42 and 11 percent of maize net sellers for their largest maize transactions, respectively.

We have five main findings from our regression analysis. First, we find that liquidity constraints during the production period is associated with an 11 percent reduction in the probability that a liquidity-constrained household is a net seller of maize. Although we are not able to establish causality in this relationship, it appears that because liquidity constrained households are not able to adequately invest in productivity-enhancing inputs, this limits their capacity to produce a marketable surplus, thereby decreasing their probability of being a net seller of maize.

Second, we find that while households without liquidity constraints have a statistically significant positive response to higher maize prices, liquidity-constrained households do not respond to changes in maize prices. This suggests that because LC households are less likely to acquire productivity-enhancing inputs, this mutes their responsiveness to changes in the maize price. Third, we find that measures of market access based on the distance from the household or village to the nearest agricultural market or main district town (boma) do not have a large effect on the probability of being a net seller, for either liquidity-constrained or unconstrained households. While this result may seem counterintuitive, it is important to note that it does not imply that "market access" or road and market infrastructure do not play an important role in promoting and facilitating market participation by smallholders. What it does imply is that our use of maize prices adjusted for transportation costs to and from each village appear to be capturing an important part of differences in farmgate maize prices between more and less remote villages. In addition, these results suggest that transaction costs of searching for price information and buyers appear to be relatively low – perhaps due to relative proximity to FRA depots, good access to private traders (who visit 75 percent of villages), and the fact that nearly all villages have cell network access -- and/or that these transaction costs are being captured by other explanatory variables such as ownership of a cell phone. These results suggest that market access and competitiveness in output market in Zambia may not be as poor as is often assumed in literature.

Fourth, we find that an additional expected moisture stress period during the growing season reduces the probability that a liquidity-constrained household is a net seller by 16 percent. This highlights the vulnerability of smallholder maize production in Zambia to drought and the potential benefit of the adoption of soil management practices and drought-tolerant maize varieties that can help to mitigate the negative effects of drought on crop productivity (Ajayi et al 2007; Haggblade, Tembo, and Donovan 2004). Finally, we find that liquidity-constrained households are 18 percent less likely to sell to the FRA, and are thereby unable to enjoy the benefits of higher FRA maize purchase prices. Although we are not able to discern the specific reason for this result based on our research to date, we expect that this may be due to uncertainty regarding the timing of FRA maize purchases each year as well as the typically long delay in payment by the FRA to farmers.

Our results demonstrate that liquidity constraints can limit smallholder participation in food grain markets as net sellers, reduce their responsiveness to changes in maize prices, and limit their access to relatively high FRA maize purchase prices. They also provide additional evidence that relatively well-off farmers (those that are not liquidity constrained) are best able to access the benefits of FRA maize purchase prices that are higher than those offered by the private sector. Further research is needed to explore policies that can reduce liquidity constraints at time of planting and incorporate mechanisms for productivity enhancement as a measure for encouraging commercial agriculture.

# CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

## ACRONYMS

| | |
|---|---|
| AIC | Akaike Information Criterion |
| CRE | Correlated Random Effects |
| CSO | Central Statistical Office |
| CV | Coefficient of Variation |
| FISP | Farmer Input Support Programme |
| FRA | Food Reserve Agency |
| FTC | Fixed Transaction Costs |
| HH | Household |
| IAPRI | Indaba Agricultural Policy Research Institute |
| IIA | Independence of Irrelevant Alternatives |
| IMR | Inverse Mills Ratio |
| LC | Liquidity Constrained |
| MoA | Ministry of Agriculture |
| MNL | Multinomial Logit |
| MSU | Michigan State University |
| PTC | Proportional Transaction Costs |
| RALS | Rural Agricultural Livelihoods Survey |
| SIDA | Swedish International Development Agency |
| SSA | Sub-Saharan Africa |
| TAMSAT | Tropical Applications of Meteorology using Satellite Data and Ground-based Observations |
| TLU | Tropical Livestock Units |
| UC | Liquidity Unconstrained |
| USAID | United States Agency for International Development |
| USDA | United States Department of Agriculture |
| WRS | Warehouse Receipt System |
| ZMW | Zambian Kwacha |

# INTRODUCTION

Increased participation of smallholder farmers in agricultural output markets holds the potential to lift farmers out of high-risk and low-productivity subsistence farming to more commercial and profitable agriculture (Heltberg and Tarp 2002; Barrett 2008; Von Braun et al. 1994; Timmer 1988). Yet, a relatively low portion of smallholder farmers participate in food markets as net sellers in many sub-Saharan African (SSA) countries. For example, in a survey of literature of smallholder participation in food grain markets covering six countries in east and southern Africa, Barrett (2008) finds that the percent of net-sellers[1] ranged between 25 percent (Ethiopia, 1996) to 39 percent (Kenya, 1998). Mather et al. (2013) also find that the percentage of net-sellers of food grains in Mozambique (2005) and Zambia (2008) were as low as 15 and 27 percent, respectively. In this paper, we revisit the question of why smallholders do not participate in food grain markets as net-sellers despite the apparent benefits of participation.

The pioneering work by De Janvry et al. (1991) explains low food market participation of smallholder farmers in developing countries as a household and not a commodity-specific market failure, and is a result of various factors that raise transaction costs of accessing markets. Subsequent literature in this field has focused on the impact of transaction costs arising from poor infrastructure such as roads and inadequate market information on market participation (Goetz 1992; Key et al. 2000; Heltberg and Tarp 2002). More recent literature has explored the importance of a combination of both public (roads, extension and communication services) and private assets (land, labor, animal traction) in facilitating market participation (Barrett 2008; Boughton et al. 2007; Cadot et al. 2006; Renkow et al. 2004). However, market imperfections also exist in input markets and can undermine the capacity of a household to generate a marketable surplus. Very few studies attempt to understand the effect of production bottlenecks on the capacity of a household to produce a marketable surplus and subsequently on market participation (Mather et al. 2013; Alene et al. 2008).

One of the limits to production of a marketable surplus is liquidity constraints at planting time. Liquidity constraints can limit farmers' ability to invest in area- or productivity-enhancing inputs into crop production activities and therefore constrain the production of a marketable surplus. Prior literature shows that liquidity constraints lead to lower agricultural production (Winter-Nelson and Temu 2005; Foltz 2004; Feder et al. 1990). Extant literature on smallholder grain market participation has only investigated the influence of liquidity constraints in the marketing period (i.e. after the marketing surplus has been realized) and has often been used to explain the "sell low, buy high" phenomenon[2] (Burke et al. 2018; Dillon 2017; Stephens and Barrett 2011). However, there is a gap in the grain market participation literature regarding links between liquidity constraints at planting time and grain market participation[3].

[1] A household is referred as a net-seller of an agricultural good if the value of its sale of that good is more than the value of purchase

[2] This refers to the typical situation of smallholder farmers in developing countries who often sell food grains relatively soon after harvest due to cash constraints and/or lack of quality storage facilities. At this time of the year, food grain prices tend to be at their lowest (i.e. "sell low"). Many of these households then purchase grain from local retailers later in the marketing year, when grain prices tend to be higher (i.e. "buy high").

[3] While growers of crops such as coffee, tobacco, cotton, or certain horticultural crops may receive inputs on credit through an "interlinked credit" arrangement with an outgrower scheme, such arrangements have been found to be very difficult to implement successfully with food grains for a variety of reasons (Poulton et al, 1998). One main reason for this is that unlike a crop like cotton, the producer of a food grain does not have only one use for their crop (i.e. to sell it) and only one buyer (Poulton et al, 1998), thus it can be difficult for a company/firm that lends inputs to a food grain grower to enforce an agreement for that grower to repay their input loan by selling their surplus grain to the firm.

Another less explored aspect of smallholder market participation in the developing country context is the choice of marketing channel that households make when faced with several buyer types, such as, private traders of various scales, government agencies, and other households in the village. Most studies in the literature on choice of marketing channel for agricultural output are limited in their analysis to the choice between selling at a distant market versus at the farmgate. In addition, they typically abstract away from the potential constraint of imperfect input markets by focusing on commercial crops and/or small samples of commercial farmers (Zanello et al. 2014; Shilpi and Umali-Deininger 2008; Fafchamps and Hill 2005). Further, the conclusion emanating from this literature is mixed: Fafchamps and Hill (2005) and Shilpi and Umali-Deininger (2008) find that wealthier farmers with better access to infrastructure and information are more likely to sell at a market rather than at the farm gate. In contrast, Jagwe and Machethe (2011) and Zanello et al. (2014) find that possessing smaller landholdings and residing in remote areas led to higher probability of sale of agricultural produce in the market. Muamba (2011) and Takeshima and Winter-Nelson (2012) are the few papers that have studied choice between selling at the farmgate versus in a distant market in the presence of market imperfections. A few studies look beyond the binary choice of selling at the farmgate versus at a distant market (Negi et al. 2018; Bardhan et al. 2012), but they do not consider input market imperfections either.

In this paper, we address the literature gaps noted above by using descriptive and econometric analysis of panel household survey data from Zambia. We choose the maize markets of Zambia as a relevant context because maize is the staple food grain of Zambia, is grown by almost all farm households, and is an important source of cash for many of them. (Chapoto et al. 2015). We first assess whether liquidity constraints during the maize production period affect a farm household's decision to participate as a net seller of maize. We then assess whether liquidity constrained households are less responsive to changes in maize prices with respect to this decision. Finally, we explore whether liquidity constraints have an effect on the choice of marketing channels for net sellers of maize, especially when some channels are characterized by uncertainty of the time of purchase as well as the length of payment delays.

This third question is of particular interest in the case of Zambia given the significant role played by the Food Reserve Agency (FRA) in both its domestic maize market and in agricultural policy in general. The FRA is a government parastatal that serves as a strategic food reserve and maize marketing board, and it seeks to raise and stabilize maize market prices as a means of improving national food security. Since 2002/03, the agency has significantly expanded its share in the market and has become a major player in the Zambian maize market (Mason and Myers 2013). The extent of FRA's intervention in the market has attracted a lot of attention among researchers, who have found both positive and negative effects of FRA on Zambia's agricultural sector.[4]

The role of the FRA is particularly relevant to our interest in the effect of liquidity constraints on a smallholder's choice of maize marketing channel because although the FRA typically purchases maize from farmers at a price that is higher than the prevailing producer sale price, the timing of FRA maize purchases each marketing season is uncertain. More significantly, there is typically a

[4] For example, studies have shown that its purchases and sales of maize have raised maize prices and achieved price stabilization (Mason and Myers 2013), which has induced farmers to bring more land under maize cultivation (Mason et al. 2015). FRA activities have also had positive welfare effects for the minority of smallholders that sold to FRA during the period of the study (Fung et al. 2015). However, the FRA has also been accused of benefiting large farmers disproportionately more than smallholders, threatening the status of private maize traders, creating uncertainty based on its ad-hoc maize marketing activities, and accounting for a large share of the scarce government expenditures on the agricultural sector (Sitko and Jayne 2014; Jayne et al. 2011).

relatively long and unpredictable delay in FRA's payment to farmers for the maize they purchase from them. In addition, given that relatively poorer smallholders are more likely to face liquidity constraints in maize production and marketing periods, the answer to our third research question is not only relevant for academic reasons but also for Zambia's maize marketing policy.

The remainder of our paper is organized as follows. We present a conceptual framework in section two, describe our data sources in section three, and our empirical methods in section four. In section five and six we present descriptive and econometric results respectively before providing conclusions in section seven.

## CONCEPTUAL FRAMEWORK

Our theoretical framework is guided by the seminal work of Key et al. (2000) but with some important modifications. Firstly, while we employ a non-separable household model and thus assume that the production, consumption, and market participation decisions are made simultaneously at time of planting (Singh, Squire, and Strauss 1986), we allow the agents to update their market participation expectations after harvest, by which point in time they can observe both actual market conditions and harvested quantity. Secondly, we relax the assumption of no liquidity constraint in the production period. Specifically, we include an additional constraint in the optimization problem of households that face cash constraints during the time of planting of maize. We show that this additional constraint will lead to a marked-up price of agricultural inputs for the liquidity constrained households (De Janvry et al. 1992). This then affects their decisions regarding input use, which can subsequently affect their level of maize output.

We begin by assuming that a risk-averse agricultural household maximizes its expected utility (1a) of consumption of maize ($c_{mz}$), leisure ($c_l$), and market-purchased goods ($\mathbf{c_{mk}}$) given household level characteristics ($\mathbf{z_h}$) that affect consumption tastes and preferences and are subject to several constraints as described by the equations 1(b) to 1(e) below. For simplicity, we assume maize to be the only agricultural product produced by the household and labor and non-labor input markets to be functioning perfectly. We explicitly model the liquidity constraints but maintain that the liquidity constraints apply only to the variable production inputs, here, labor (l) and non-labor (x) variable inputs.

The household's problem is summarized below:

$$\max_{c_{mz}, c_l, \mathbf{c_{mk}}, x, l, m, q_{mz}} \quad EU(c_{mz}, c_l, \mathbf{c_{mk}}; \mathbf{z^h}) \qquad (1a)$$

s.t.

$$q_{mz} = g(l, x; \mathbf{z^q}) + \epsilon, \qquad (1b)$$

$$q_{mz} - m - c_{mz} = 0, \qquad (1c)$$

$$\eta(wl + p_x x - K) \geq 0 \quad \text{,where}\, \eta = 0 \,\text{if constraint binds,} \qquad (1d)$$

$$M + wT - wl - p_x x - wc_l - \mathbf{p_{mk} c_{mk}} \geq 0 \qquad (1e)$$

The production constraint (1b) represents the production technology that transforms farm labor (l) (consisting of hired and/or family labor) and non-labor inputs (x) into maize crop ($\mathbf{q_{mz}}$) given the fixed and quasi-fixed factors ($\mathbf{z_q}$) and random shocks ($\varepsilon$) such as weather, that can shift the output supply. The resource constraint (1c) implies that the net maize sold or bought (m) and consumed ($c_{mz}$) equals the quantity of maize produced by the household. Let w and $p_x$ stand for the price of labor and the non-labor input, respectively, assumed to be known at planting time. Following De Janvry et al. (1992), the liquidity constraint (1d) states that if liquidity is binding ($\eta = 0$), then the amount of agricultural inputs used (l and x) will be limited by some upper limit K that represents the available cash with the household. Finally, the income constraint (1e) balances the income and expenditure of the household. Here, M is the net revenue or expenditure of the household evaluated at the household's expected price of maize ($= p_e m - t^i_f$), where $p_e$ is the expected maize price, $m = (q_{mz} - c_{mz})$ is the marketable surplus, and $t^i_f$ is the fixed transaction cost (FTC) that takes up the value $t^s_f$ for sellers and $t^b_f$ for buyers. The FTCs do not vary with the amount of maize transacted and can constitute costs such as those incurred in obtaining price information, negotiating prices and arranging the transaction of maize. Details about the expected price are described below. $\mathbf{p_{mk}}$ is the vector of prices for other market purchased consumption goods and T is the total time endowment available with the household. Combining the cash and liquidity constraints, and assuming the shadow price of income to be λ, gives us the full income constraint as follows:

$$\begin{aligned} y^* &= M + wT - wc_l - \mathbf{p_{mk}c_{mk}} - wl - p_x x + \frac{\eta}{\lambda}(K - wl - p_x x) \geq 0 \\ &= M + wT - wc_l - \mathbf{p_{mk}c_{mk}} - wl - p_x x + \lambda_c(K - wl - p_x x) \geq 0 \qquad (2) \\ &= M + wT - wc_l - \mathbf{p_{mk}c_{mk}} - w^* l - p_x^* x + \lambda_c K \geq 0 \end{aligned}$$

As explained by De Janvry et al. (1992), the term $\lambda_c$ represents the shadow price of liquidity and $w^*$ and $p_x^*$ the marked-up prices of labor and non-labor inputs respectively.

Now we follow the approach used by Key et al. (2000) to determine the household's decision of market position at planting time (i.e. net-seller, net-buyer, and autarkic). Let $p^*$ be the household's endogenous price of maize and $p_{s,t+1} - t_{s,t+1}$ and $p_{b,t+1} + t_{b,t+1}$ be the price of maize net of proportional transaction costs (PTC) in the next maize marketing season for maize sellers and buyers respectively. Note that the PTCs vary with the amount of maize bought or sold and are positive for sellers of maize and negative for buyers of maize. Further, the household cannot observe these prices at planting time but has some expectations about them ($E_t[p_{s,t+1} - t_{s,t+1}]$ and $E_t[p_{b,t+1} + t_{b,t+1}]$). The household then determines its maize market position according to the following decision rule:

$$\text{If } p^* \leq E(p_s - t_p^s),\ m > 0 \qquad \text{(household is a net seller)}, \qquad (3)$$

$$\text{If } p^* \geq p_b + t_p^b,\ m < 0 \qquad \text{(household is a net buyer)}, \qquad (4)$$

$$\text{If } E(p_s - t_p^s) < p^* < p_b + t_p^b,\ m = 0 \qquad \text{(household is autarkic)} \qquad (5)$$

For tractability, we assume that these states are mutually-exclusive and the household can choose only one of them.[5] Since the liquidity-constrained and unconstrained households face different income constraints, their respective optimization problems therefore lead to different factor demand and output supply functions.

[5] In our data for the marketing year 2014/15, only 6.4 percent of maize producers were found to be both sellers and buyers of maize.

$$\mathbf{s} = \mathbf{s}^{\mathbf{C}}(p^*,\, \mathbf{p_{mk}},\, w,\, p_x,\, K,\, \mathbf{z^h},\, \mathbf{z^q}) \qquad \ldots \text{if liquidity constrained} \qquad (6)$$

$$\mathbf{s} = \mathbf{s}^{\mathbf{UC}}(p^*,\, \mathbf{p_{mk}},\, w,\, p_x,\, \mathbf{z^h},\, \mathbf{z^q}) \qquad \ldots \text{if liquidity unconstrained} \qquad (7)$$

While we assume that a household makes an *ex ante* decision about its state of market position, we also acknowledge that the households may revise their decision regarding market participation based on the realized production level and observed harvest-period market prices of maize. Thus, while factor demand and thus production decisions are influenced by the household's expectations about maize prices and proportional transaction costs, the household's final decision regarding their participation in the maize market are expected to be influenced by both realized maize output and actual maize prices. Let pm be the realized market price of maize (assumed to be the same for buyers and sellers) and psi and $p_{bi}$ the selling and buying price of each household net of household specific PTCs. Let $y^* = y(p_{ij}, w, p_x, \mathbf{p_{mk}}, t^f_{ij}, T)$ be the income realized by the household i by choosing the market position j (net seller, net buyer, autarkic). Thus, the decision to be made by the household can be represented as:

$$\text{If } V_i(p_{si}, y^*, z_u) \geq V_i(p_m, y^*, z_u) \qquad \Longrightarrow \qquad \text{net-seller}$$

$$\text{If } V_i(p_{bi}, y^*, z_u) \geq V_i(p_m, y^*, z_u) \qquad \Longrightarrow \qquad \text{net-buyer}$$

$$\text{If } V_i(p_{si}, y^*, z_u) < V_i(p_m, y^*, z_u) < V_i(p_{bi}, y^*, z_u) \qquad \Longrightarrow \qquad \text{autarkic}$$

In the second part of the paper, we study the choice of maize marketing channel for the net-sellers. We maintain the assumption that decision of marketing channel is taken sequentially, and is conditional on the decision to participate in the market. Liquidity constraints at time of marketing can be relaxed by a flow of income from other sources in the marketing season (I). The presence of this external source of income relieves the urgent cash needs of the household and thus creates an opportunity for price arbitrage (i.e. wait to sell their maize until later in the marketing year when maize prices are higher). On the other hand, a household without any such source of outside income would forego the price arbitrage and sell maize early in the season to meet its urgent cash needs (Burke et al. 2018; Stephens and Barrett 2011). To make this clearer, we define an effective price that the household uses to make the choice between the different marketing channels. This effective price incorporates not only the transaction costs incurred in transporting and handling maize, but also the discounted value of income from a sale of maize that faces delays in the timing of the sale (such as when the FRA decides to begin purchases of maize) or payments by the chosen marketing channel. Thus, the price received from some channel A early in the marketing season would have a higher effective price compared to that same price received from channel B later in the season. Let the effective price received from selling to channel j be $p^j_s$. Let the realized income of the household along with the outside income be $y^* + I$. Then a household will choose a marketing channel such that:

$$V_j(p_s^j, y^* + I, \mathbf{z^q}, \mathbf{z^h}) > V_k(p_s^k, y^* + I, \mathbf{z^q}, \mathbf{z^h}) \quad \ldots \forall j \neq k \qquad (8)$$

With this background, we hypothesize that:

1) Households limited by liquidity constraints in the production period are less likely to be net-sellers of maize as compared to those unconstrained by liquidity-constraints.

2) When choosing their maize market position, liquidity-constrained households are less responsive to higher maize prices than liquidity-unconstrained households.
3) Households facing liquidity constraints in the maize production and marketing season are less likely to sell to a channel such as FRA for whom the timing of maize purchases from farmers is unpredictable and which typically provides payment to farmers only after a delay of uncertain length.

# DATA

### HOUSEHOLD-LEVEL DATA

The first data source we use in this analysis is the Rural Agricultural Livelihood Survey (RALS), a nationally representative two-wave panel dataset of smallholder farm households in Zambia. The RALS was implemented in June-July of 2012 and 2015 by the Indaba Agricultural Policy and Research Institute (IAPRI) in collaboration with the Zambia Central Statistical Office (CSO) and the Ministry of Agriculture (MoA). See CSO (2012) for details on the RALS sample design.

In both panel waves, the RALS collected detailed information on household demographics, crop and livestock production and marketing, off-farm employment and own business activity, and distances to roads, markets, and public services such as agricultural extension. It also included information on households' participation in maize markets as sellers and/or buyers of maize, and details about their maize sales or purchases within the past year. The 2012 survey covered the 2010/11 agricultural year (October 2010–September 2011) and the associated crop marketing year (May 2011–April 2012). The 2015 survey covered the 2013/14 agricultural year and the 2014/15 crop marketing year.

A total of 8,839 households were interviewed in the 2012 RALS. Of these, 7,254 (82.1%) were successfully re-interviewed in 2015. Our sample for this study consists of a balanced panel of RALS households that grew maize in both 2012 and 2015, which amounts to 84% of the households in that balanced sample. Our analysis thus uses a sub-sample of 6,063 households in each year leading to a total of 12,126 observations. While it is possible that our results could be affected by attrition bias, testing and potentially correcting for such bias is beyond the scope of this paper.

### DISTRICT LEVEL PRICE DATA

We use district-level data on mean retail maize prices as recorded by the CSO in relevant months (CSO 2018), as a proxy for expected and actual producer prices for maize. This data is collected monthly by the CSO for all major consumer goods and at all major markets in Zambia with the primary purpose of computing the Consumer Price Index. Further detail about use of this data is included in section 4.3

### GEOSPATIAL DATA

We also use geospatial time-series data on rainfall from (TAMSAT) (Tarnavsky et al. 2014; Maidment et al. 2014; Maidment et al. 2017), which is based upon a combination of satellite data and ground-based observations. Snyder et al (2019) matched the TAMSAT data to GPS locations of RALS households and created rainfall estimates using the Raster Calculator tool in ArcGIS Model Builder. Estimates of seasonal moisture stress were derived using decadal (10-day) rainfall data and other rainfall measures using monthly data. The TAMSAT data has a spatial resolution of approximately 0.0375 x 0.0375 degrees, which is approximately 4 x 4 kilometers, or 16 square kilometers (ibid, 2019). In practical terms, these rainfall estimates are therefore village-level measures.

# EMPIRICAL METHODOLOGY

## INTRODUCTION

In this section we will present the description of variables used in the analysis and the econometric tools employed to test the hypothesis. We begin by describing two variables that are an integral part of our analysis: liquidity status and maize market position of the household. A household is defined as liquidity constrained in maize production period if one or both of the following conditions are met (following the approach similar to Winter-Nelson and Temu (2005)): (1) The household claims to not have acquired fertilizer from market due to lack of cash, and/or (2) the household claims to not have obtained fertilizer from the Farm Input Subsidy Program (FISP) (A government-initiated program to enable farmers to obtain farm inputs at lower prices) due to – a) not being able to afford the down payment for obtaining fertilizer through FISP and/or b) lack of cash for the mandatory cooperative membership payment required for participation in the program.

We define a household's market position by comparing the value of its maize sales with the value of its maize and maize meal purchases. A household is defined to be a *net seller of maize* if the value of its maize sales is greater than the value of its maize and maize meal purchases; *autarkic*[6] if the household either has no maize sales or purchases, or if value of its maize sales equals the value of its maize and maize meal purchase; and a *net-buyer* if the value of its maize sales is less than the value of its maize and maize meal purchases.

In order to test the hypotheses, our econometric analysis consists of the following main steps. To test the first and second hypotheses, we estimate an ordered probit regression of household maize market position, in which household liquidity status is either used to separate the sample into two sub-groups (those who are liquidity constrained and those who are not), or included as an explanatory variable. To test our third hypothesis, we use the sub-sample of maize net seller households to estimate a multinomial logit (MNL) regression of the household's choice of maize marketing channel dependent on liquidity status in the production and marketing periods.

## HOUSEHOLD CHOICE OF MAIZE MARKET POSITION

In order to test our first hypothesis, we use an ordered probit of household maize market position to estimate the probability of being a net-seller conditional on being liquidity constrained or unconstrained in the production period. Let Pr(Y=j | **X**, I), be the probability to choose the market position 'j' conditional on the vector of explanatory variables **X** and the liquidity status I (which takes on value 1 if household is liquidity constrained and 0 otherwise). The maize market position (j) can take on values 1, 2, or 3 depending on whether the household is a net-buyer, autarkic, or net-seller of maize, respectively. The probability of being a net seller can be represented as:

$$\Pr(Y_{it}=3 \mid \boldsymbol{X}_{it}, I_{it}=1) = \Phi(\boldsymbol{X}_{it}\boldsymbol{\beta}_{0i} + \boldsymbol{X}_{it} * I_{it} * \boldsymbol{\beta}_{1i} + c_i + v_t + \epsilon_{it})$$

$$\Pr(Y_{it}=3 \mid \boldsymbol{X}_{it}, I_{it}=0) = \Phi(\boldsymbol{X}_{it}\boldsymbol{\beta}_{0i} + c_i + v_t + \epsilon_{it})$$

Here, $Y_{it}$ is the market position, $\boldsymbol{X}_{it}$ is the vector of explanatory variables, $I_{it}$ is the liquidity status for household i at time t. $\boldsymbol{\beta}_{0i}$ is the vector of parameter values for unconstrained household i and $\boldsymbol{\beta}_{0i} + \boldsymbol{\beta}_{1i}$ is the vector of parameters for constrained household i. $c_i$ is the household specific unobserved heterogeneity and $v_t$ is the year fixed effect. $\epsilon_{it}$ are the idiosyncratic error terms specific to each household and time period. The availability of panel data enables us to use an econometric

[6] Autarky is also a term used to describe a household that does not participate in a particular market as either a buyer or a seller.

technique to address the potential problem of omitted variable bias due to unobserved time-invariant household-level heterogeneity. Given the non-linear nature of our estimators, we use a correlated random effects (CRE) approach as recommended by Mundlak (1978) and Chamberlain (1984). The CRE approach requires us to assume strict exogeneity conditional on all exogenous variables as well as a linear relationship between unobserved household-level time constant heterogeneity and our explanatory variables.

*Use of switching regressions:* Our first two research questions require that we model a household's maize market position under binding and non-binding liquidity constraints, which suggests three potential specifications of our ordered probit. The first is an endogenous switching model, which allows the equations under the regimes of binding and non-binding liquidity constraints to differ in parameters while also controlling for any potential bias created by selection into each regime. This model imposes an assumption of joint normality of the error terms of equations in the two regimes and the equation determining the selection into a regime. It also assumes non-zero covariance between error terms from the two equations. Identification of the endogenous switching regression hinges on the availability of a strong exclusion restriction variable that has a statistically significant effect on the household's selection into one of the two regimes, yet which we can confidently assume is not correlated with the household's market position. Unfortunately, we are not able to find a sufficiently strong exclusion restriction variable, and hence we do not proceed with an endogenous switching regression. The reason for this is because use of a weak exclusion restriction has been known to compound the problem of inconsistent parameters (Bound, Jaeger, and Baker 1995).

The second option is an exogenous switching model, which is similar to the endogenous switching model, except we now relax the assumption of non-zero covariance of the error terms. This is a strong assumption, yet we argue that it is justifiable given that our specification includes a rich set of controls as well as CRE terms that control for time-invariant household-level unobserved heterogeneity. Our third option is to relax the assumptions imposed by switching models on the data and parameters to be estimated, by estimating a model with the pooled sample of liquidity constrained and unconstrained households together, while introducing household liquidity status as an explanatory variable in the estimation. To test whether a switching regression or the pooled regression is a better fit for the ordered probit model, we use a Likelihood Ratio test and find that the (exogenous) switching regression provides a statistically significant better fit of the model (LR-ratio= 109.62, p>chi2=0.0000) compared to the pooled regression.[7]

**CHOICE OF MAIZE MARKETING CHANNEL**

To address our third research question, we use a Multinomial Logit (MNL) regression to determine the relationship between a household's discrete unordered choice of maize marketing channel and the explanatory variables of interest. The choice of marketing channel can be represented as:

$$\Pr(Y_{it} = j \mid \boldsymbol{X}_{it}, I_{it}=1) = \frac{\exp(X_{it}\,\beta_{ij})}{1 + \exp(X_{it}\,\beta_{i1}) + \exp(X_{it}\,\beta_{i2}) + \exp(X_{it}\,\beta_{i3})}$$

Here j is the choice of marketing channel for largest maize transaction that can take one of the three values: 1-Private traders of maize (including small-scale traders, large-scale traders, wholesalers, and retailers); 2- Direct and indirect (through farmer cooperative) sale to the FRA; 3- Other households (includes sale made to community church, school and hospital). For simplicity, we limit the analysis

[7] Results of the pooled ordered probit are presented in the Appendix B.

to the largest maize sale made by the household in the marketing year.[8] Thus, the choice of marketing channel for each net seller is mutually exclusive. Estimating the MNL regression requires the Independence of Irrelevant Alternatives (IIA) assumption. IIA assumes that net sellers would make the same choice whether they had options A, B and C, or just A and B. In our context, this means that a maize net seller's choice of maize marketing channel between, say, selling to a private trader and selling to other household should not be affected by whether or not a third choice (selling to FRA) is available or not. This assumption may not be very realistic and may not represent the actual behavior very accurately. However, we proceed with MNL given the computational challenges of estimating either a mixed logit or a multinomial probit.

It is important to note that because we are only using maize net sellers in our MNL regression of maize marketing channels, this could potentially introduce a self-selection bias in that MNL analysis. This could occur if that subsample of farmers is non-random in terms of observable or unobservable characteristics. We therefore use the Heckman two-step approach to test and control for potential self-selection bias within the MNL.

In practice, we implement this by first computing the Inverse Mills Ratio (IMR) from the linear prediction of the ordered probit regression. We then include this term as a regressor in the MNL of maize marketing channel. For consistency of the two-step approach, we require at least one exclusion restriction - a variable that is strongly correlated with the household's maize market position, but can be confidently assumed to not have a significant effect on its choice of marketing channel. We argue that the household's observed maize production in each year of the panel is an appropriate exclusion restriction here. As mentioned before, the maize output affects the capacity of the household to produce a marketable surplus and thus, act as a net-seller of maize. However, conditional on being a net-seller, the choice of marketing channel is expected to be determined by the price incentives and the ease of access to each channel, rather than the amount of maize produced We find that household maize production is a strong instrumental variable with $F(1, 366) = 109.24$.

### EXPLANATORY VARIABLES

*Post-harvest market price of maize*

We use two sets of maize sale prices -- those farmers receive from FRA and those from non-FRA channels. The FRA prices are pan-territorial and typically are not modified within a given year. However, in practice, there is heterogeneity in FRA prices given that each farmer selling to FRA must pay the cost of transporting their maize from their farmgate to the nearest FRA depot. To incorporate this heterogeneity, we compute what we refer to as the "farmgate FRA price". This is defined as the pan-territorial FRA price less the costs of transporting maize from the household to the nearest feeder road. Please see Appendix A for details on computation of farmgate prices.

Although RALS records information on the sale price of the largest maize sale of each household, we refrain from using this data in our analysis due to potential endogeneity of these maize prices with determinants of the dependent variable. This potential endogeneity is expected to arise from two sources: (a) the procedure followed to construct the dependent variable uses the household level prices, thus empirically the dependent variable has the same drivers as the household level prices themselves; and (b) the presence of a large number of autarkic households in the sample implies that

[8] In our sample for the year 2015, 88 percent of maize net-seller households made a single transaction of maize.

households may not be price-takers in the maize output market (Singh et al. 1986). A potential approach to navigate this problem is to use maize market prices from some other source than the household data used within our regression analysis. The most suitable prices available to us are district level average maize retail prices collected by the Central Statistical Office of Zambia every month at major markets across the country. We thus use the district level mean maize retail price as of August of the relevant marketing year as proxies for the producer price of maize. [9] Because each village in a district is likely not the same distance from the boma, the actual private trader maize purchase price faced by smallholders likely varies across villages. Theoretically, the difference between the maize price in the boma and that in the village would be the maize price in the boma less transport costs to the village.  In practice, we adjust the retail maize price in each district by subtracting an estimate of the cost to transport maize from the village to the nearest feeder road (please see Appendix A for details). This adjustment also has the practical advantage of adding meaningful inter-district variation in maize prices. We refer to this price as "village retail maize price".  Finally, because we observe prices of maize in two different years, we use a consumer price index from World Bank (2019) to convert these prices to real terms. In addition, we take the natural logarithms of each price in order to simplify interpretation of the regression results.

*Proxies for transaction costs and market access*

We use the cluster medians of distance to important points of market access such as the nearest boma (administrative town), feeder road (unpaved roads that link to larger roads), tarmac road (paved roads), and local agricultural market. We also include cluster medians of the number of maize traders that arrived in the village during the peak maize marketing season (May-October) to capture the competitiveness of the maize markets within the village. Dummy variables that indicate the household's ownership of bicycle, radio, and cell-phone are included to represent the household's capacity to reduce fixed transaction costs such as those associated with obtaining price and buyer information.

*Indicators of agro-ecological potential*

Agro-ecological factors are particularly important determinants of agricultural production in the context of Zambia where agriculture is predominantly rainfed. We include a number of seasonal rainfall measures created by Snyder et al (2019), which use geospatial coordinates of each household and spatial data of 10-day rainfall estimates to construct several measures of expected and actual rainfall conditions during or prior to each of our two panel waves. The first measure is the cumulative amount of rainfall received during the main growing season of 2010/11 and 2013/14. The second is the number of "moisture stress periods", which we define as the number of overlapping 20-day periods with less than 40 mm of rainfall. We also include variables for "expected seasonal rainfall" and "expected number of moisture stress periods", which are computed as the 16-year moving averages of the two rainfall variables noted above. To measure expected variation in rainfall over time, we also include the 16-year moving average of the coefficient of variation of rainfall.

[9] The period relevant to the study is the maize marketing period of 2012 and 2015 waves (May 2011- April 2012 and May 2014-April 2015). However, we use prices as of August because we observe that the highest percentage of maize transactions occur in the August month across the country. In our sample we observe that 48 percent of maize sales in 2015 occur in the month of August.

*Other control variables*

We also include potential measures of household access to cash, including the income earned by the household through non-farm sources during the peak maize marketing season (May-October) and the household ownership of livestock, which we convert to Tropical Livestock Units[10] (TLU). Other controls include household-level demographic variables, including household size (the number of full-time equivalent household members) and various characteristics of the household head (age, years of education, gender), and measures of household agricultural assets (total household landholding, number of plows, number of harrows, number of ox-carts). Finally, we include provincial dummies and a dummy for the second of our two years of panel data.

[10] TLU's were calculated with the following FAO formula: cattle = 0.70, sheep and goats = 0.10, pigs = 0.20 and chickens = 0.01 (FAO 2007).

# DESCRIPTIVE RESULTS

## LIQUIDITY CONSTRAINTS

In this section we present some descriptive analysis of our household survey data to provide additional context to the subsequent regression analysis of household maize market position and choice of maize marketing channel between liquidity constrained (LC) and unconstrained (UC) households. We apply survey sampling weights in Stata to all descriptive and econometric analysis in this paper to account for the sampling design used in data collection (which includes clustering and stratification).

More than half of all smallholders in the sample were liquidity constrained in 2012 and 2015 with respect to maize production (65 percent in 2012 and 55 percent in 2015) (Table 1). Given the definition of liquidity constraints in the context of this study, we expect that LC households would be less likely to use productivity-enhancing inputs and/or to use them at lower application rates relative to UC households. This is in fact what we find as only 52 percent LC households use improved seeds compared to 84 percent UC households in the year 2015 (Table 2). Similarly, only 51 percent LC households use some form of inorganic fertilizer compared to 90 percent of UC households. Among the households that use inorganic fertilizer, the average rate of application in UC households is higher than that of LC households by 49 kg/ha.

**Table 1. Liquidity status of household (%) by year**

| Liquidity status | *2012* | *2015* | *Overall* |
|---|---|---|---|
| Constrained | 65 | 55 | 60 |
| Unconstrained | 35 | 45 | 40 |
| Total | 100 | 100 | 100 |

Source: All tables in this document are from authors' computations using RALS 2012 and 2015 data unless otherwise noted.

**Table 2. Household input use in maize production by liquidity status, 2015**

| | *Unconstrained* | *Constrained* |
|---|---|---|
| HH used improved seed (%) | 84 | 52 |
| HH used inorganic fertilizer on maize field (%) | 90 | 51 |
| Average quantity of inorganic fertilizer applied (by users only) (kg/ha) | 177 | 128 |

We next compare other characteristics of LC and UC households and find that they differ fundamentally in several aspects. For example, UC households own 1.5 ha more land and produce, on average, 4,156 kg more maize than the UC households (Table 3). They are also more likely to own a draft animal and a plow as they are twice as likely to own a plow and own on average 2.3 more Tropical Livestock Units (TLU). In addition, UC households are 4.6 km closer to the nearest agricultural market than LC households on average, as well as 3.5 km closer to the boma and 6.8 km closer to a tarmac road. In addition to being closer to markets, UC households are also more likely to own assets that can improve access to market information and buyers. For example, there are 25 percent more UC households that own a cell-phone compared to LC households and 18 percent more households that own a bicycle.

**Table 3. Difference in average values of explanatory variables by liquidity constraint status, 2015**

| | Mean values for liquidity unconstrained (A) | Mean values for liquidity constrained (B) | Difference (A-B) | p-value |
|---|---|---|---|---|
| Maize production in kg | 5871 | 1715 | 4156*** | 0.000 |
| Village retail maize price (ZMW/kg, 2017=100) | 1.88 | 1.90 | -0.02 | 0.061 |
| Farmgate FRA price (ZMW/kg, 2017=100) | 1.86 | 1.86 | 0.00 | 0.949 |
| Distance to boma (km) | 35.33 | 38.89 | -3.57*** | 0.000 |
| Distance to feeder road (km) | 1.03 | 1.00 | 0.03 | 0.641 |
| Distance to tarmac road (km) | 21.53 | 28.32 | -6.79*** | 0.000 |
| Distance to ag market (km) | 20.84 | 25.45 | -4.62*** | 0.000 |
| Distance to nearest FRA depot (km) | 3.68 | 3.48 | 0.21** | 0.002 |
| No. of maize traders visiting cluster, post-harv | 9.07 | 11.11 | -2.04*** | 0.000 |
| HH owns a bicycle (=1) | 0.79 | 0.61 | 0.18*** | 0.000 |
| HH owns a radio (=1) | 0.75 | 0.53 | 0.21*** | 0.000 |
| HH owns a cellphone (=1) | 0.78 | 0.52 | 0.26*** | 0.000 |
| Expected seasonal rainfall (mm) | 804.66 | 809.31 | -4.64** | 0.008 |
| CV of expected seasonal rainfall | 11.35 | 11.20 | 0.16* | 0.038 |
| Expected no. of seasonal moisture stress periods | 0.87 | 0.82 | 0.05*** | 0.000 |
| Growing season rainfall (mm) | 826.65 | 841.55 | -14.90*** | 0.000 |
| Number of moisture stress periods | 1.70 | 1.46 | 0.24*** | 0.000 |
| Age of the HH head (years) | 48.41 | 49.90 | -1.49*** | 0.000 |
| Education of household head (years) | 6.87 | 5.22 | 1.65*** | 0.000 |
| Male-headed household (=1) | 0.85 | 0.75 | 0.11*** | 0.000 |
| No. of full-time equivalent household members | 6.48 | 5.80 | 0.68*** | 0.000 |
| HH landholding (ha) | 4.04 | 2.52 | 1.52*** | 0.000 |
| HH number of plows | 0.67 | 0.32 | 0.35*** | 0.000 |
| HH number of harrows | 0.12 | 0.03 | 0.09*** | 0.000 |
| HH number of ox-carts | 0.26 | 0.10 | 0.16*** | 0.000 |
| Tropical Livestock Units (TLU) | 3.92 | 1.64 | 2.28*** | 0.000 |
| Non -farm income earned between May-Oct | 8458 | 2885 | 5573*** | 0.000 |
| Observations | 3093 | 2970 | 6063 | 6063 |

On the other hand, the long run growing season rainfall (an indicator of the agro-ecological potential) is only different by a practically insignificant value of 4.6 mm between the two sub-samples. Further, the households in the two samples do not differ in their distance to a feeder road (statistically or practically). The difference between the number of maize traders visiting the village is also practically insignificant (0.2 more maize traders visited the villages of the liquidity unconstrained households). Thus, the liquidity status of a household can be an approximate indicator of the household's production capability but does not appear to be correlated with either agro-ecological potential or market access. The liquidity constraints could however be linked to presence of other opportunities for income generation (due to the nearness to boma and tarmac road).

### HOUSEHOLD MAIZE MARKET POSITION

Between 40 to 50 percent of maize-growing households in Zambia are net sellers of maize, depending on the year (Table 4). Between 23 to 34 percent of households are net buyers, while 25 percent are autarkic. Thus, 75 percent of maize-growing households participate in maize markets as buyers and/or sellers. As we would expect, households that are liquidity constrained are considerably less likely to be a maize net seller (i.e. 31 percent in 2015 and 44 percent in 2012) relative to those who are not (68 and 56 percent, respectively) (Table 5). Likewise, LC households are more likely to be net buyers of maize (26 percent in 2012 and 39 percent in 2015) relative to those who are not LC (16 and 29 percent, respectively). The main reason for these differences in maize market position by liquidity status is likely the fact that maize producers who are not LC have considerably higher maize productivity (median yield of 2,515 kg/ha for UC households, relative to 1,495 kg/ha for LC) and maize production per capita (median of 479 kg/capita for UC relative to 205 kg/capita for LC).

**Table 4. Household maize market position by year (%)**

| HH maize market position | 2012 | 2015 | Total |
|---|---|---|---|
| Net seller | 52 | 42 | 47 |
| Autarkic | 25 | 24 | 24 |
| Net buyer | 23 | 34 | 28 |
| Total | 100 | 100 | 100 |

**Table 5. Household maize marketing position by liquidity status and year (%)**

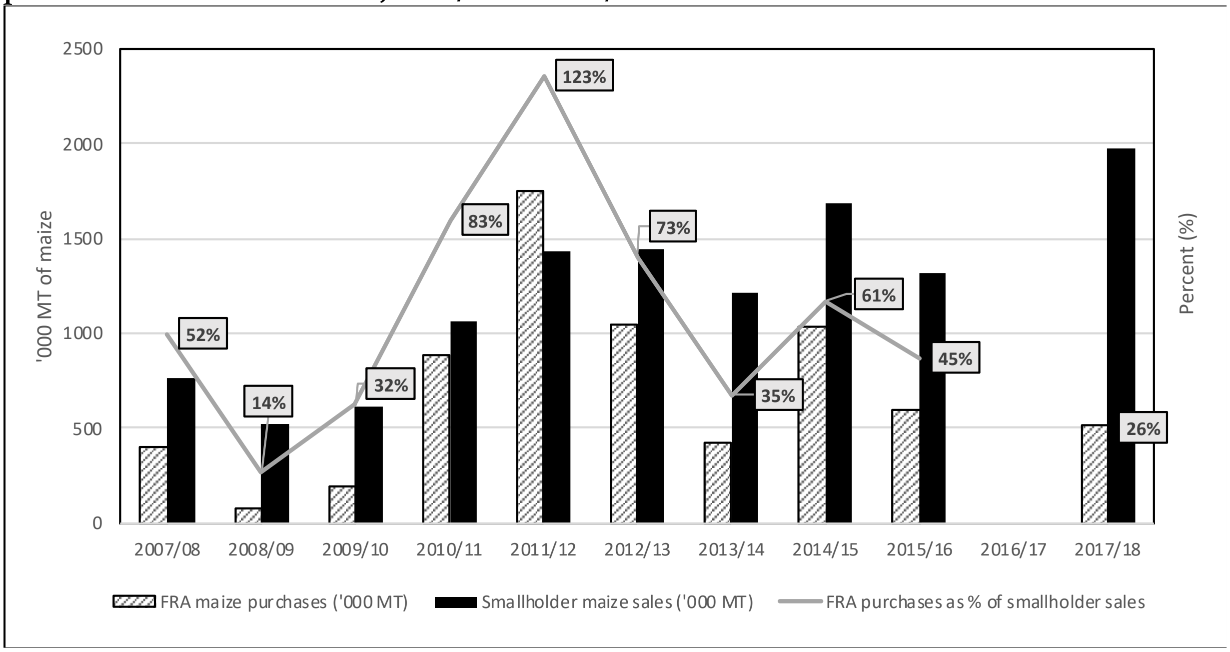
| HH maize market position | 2012 | | 2015 | |
|---|---|---|---|---|
| | Household is liquidity constrained | | | |
| | No | Yes | No | Yes |
| Net seller | 68 | 44 | 56 | 31 |
| Autarkic | 15 | 30 | 16 | 31 |
| Net buyer | 16 | 26 | 29 | 39 |
| Total | 100 | 100 | 100 | 100 |

### HOUSEHOLD CHOICE OF MAIZE MARKETING CHANNEL

Smallholder maize producers in Zambia have three main buyers for their maize, including the FRA, private traders of various sizes, and other households. Each of these marketing channels represents a different type of output market, and we expect that household characteristics will shape the constraints and opportunities that each maize grower will face in making maize production and marketing decisions. Specifically, we want to investigate the potential effect of liquidity constraints in the production and marketing periods on the probability that a net seller of maize decides to sell to the FRA.

During the period covered by our survey data (RALS), FRA has played a major role in maize marketing in Zambia, though the extent of its intervention in the market has varied drastically from year to year depending on the availability of budget with the government and the total maize production in the country. For example, between 2007/08 and 2017/18, FRA purchased significant quantities of maize from large, medium and small-scale Zambian farmers, though their volumes purchased vary considerably from year to year (Figure 1). In general, there is strong correlation (0.75) between smallholder maize production levels and FRA maize purchase levels, as FRA maize purchases increase or decrease as national maize production (and thus sales) increases or decreases. Between 2007/08 to 2017/18, the volume of maize purchased by FRA averaged approximately 54 percent of the total volume of smallholder maize sales, ranging from a low of 14 percent in 2007/08 to a high of 122 percent in 2010/11.[11] During the years immediately preceding RALS survey wave 1 (2011/12) and wave 2 (2014/15), FRA purchased approximately 83 and 35 percent of the total volume of smallholder maize sales respectively.

**Figure 1. Trends in FRA maize purchase, smallholder maize sales, and FRA purchase as percent of smallholder sales, 2007/08 to 2017/18**




Source: Mason and Myers (2011), from FRA, CSO: Crop Forecast, Post-Harvest, and Supplemental Surveys for years 2007/08 to 2010/11; FRA, CSO: Crop Forecast Surveys, Various issues for years 2011/12 to 2017/18.

Given these relatively large changes in the percentage of maize sold that is purchased in any given year by the FRA, it is perhaps not surprising that the relative share of each of the three marketing channels vary considerably from year to year among net sellers of maize. For example, the FRA was the maize marketing channel for 62 percent of net sellers in 2012 but 47 percent in 2015 (Table 6). Subsequently, the share of net sellers whose main sale was to private traders was considerably higher in 2015 (42 percent) relative to 2012 (27 percent). Only around 11 or 12 percent of net sellers make their largest maize sale to another household in their village.

[11] FRA sales as percent of total smallholder sales exceeded 100 percent because FRA buys a significant amount of maize from large farmers. The data for the sales from large farmers was not available.

**Table 6. Choice of marketing channel for largest maize transaction chosen by net sellers (%)**

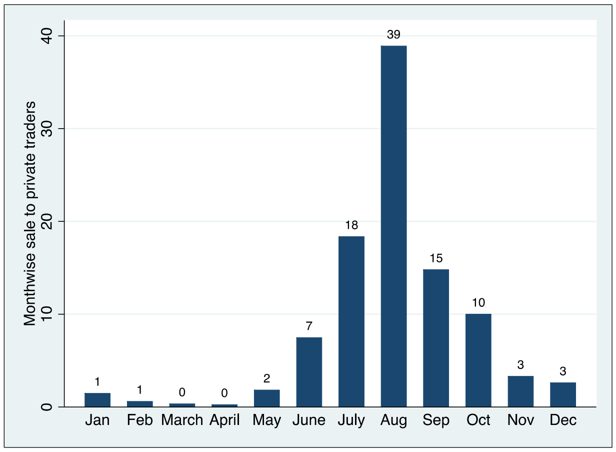
| Marketing channel | 2012 | 2015 |
|---|---|---|
| *Private traders* | 27 | 42 |
| *FRA* | 62 | 46 |
| *Households* | 11 | 12 |
| *Total* | 100 | 100 |

Note: Private traders includes small scale traders (55%), large scale traders/wholesalers (18%), retailers (12%), millers (11%), and others (4%).

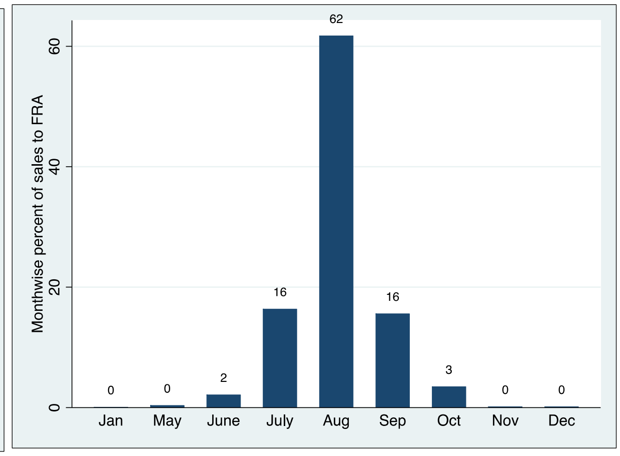
Because the timing of FRA's entry into the maize market as a buyer is uncertain each year, we next consider the specific timing (by month) of sales to the different maize marketing channels. Among all net sellers, their main maize sale was most frequently made between July to September (with August having the most) (Figure 2). By contrast, very few transactions occur between November to May. This timing is as expected as most smallholder maize producers do not own high quality grain storage facilities, thus most of their maize sales are made relatively soon after harvest (which generally begins in April/May).

Among sales made to private traders, by far the most (39 percent) are made in August and the average for July, September, and October was 14 percent (Figure 2). While private traders also buy maize from smallholder net-sellers in every other month of the year, the volumes purchased then are considerably smaller. The proportion of sales occurring in August as compared to other months is much higher for FRA (62 percent), while sales between November to May are zero or negligible. This is also not surprising as FRA only purchases maize from farmers during a certain period of the year (typically between July and September). Sales made to other households are predominantly made from July to November, with a high in August (18 %). That said, the percentage of transactions to other households are in general more uniformly spread throughout the year as compared with the other two channels.

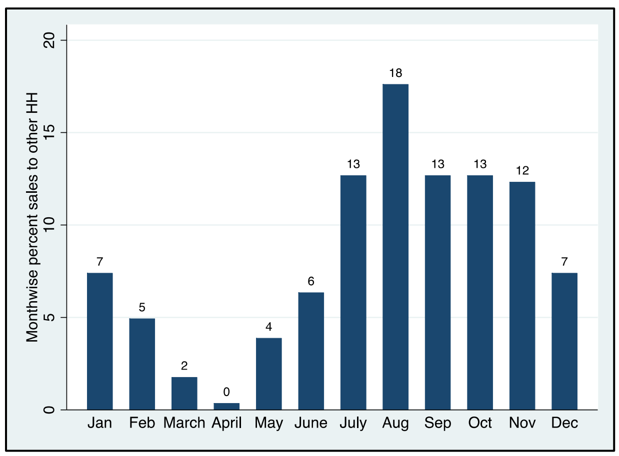
**Figure 2. Monthly distribution of maize sales by marketing channel, 2015**




Panel A: Private traders




Panel B:




Panel C: Other

Because FRA payments for their maize purchases are often delayed, we next consider the time between sale to FRA and receipt of payment. Almost 50% of farmers who sold to FRA in the marketing season 2013/14 had to wait for 3 months or longer to receive payment for their sale (Figure 3). By contrast, more than 90% of those who sold to a private trader or other household during the same time period received payment at the time of the sale. Another key difference between selling maize to the FRA relative to other buyers is the location of the point of sale. For example, 93 percent of those who sold to FRA travelled at least some distance to sell it, with a median distance travelled of 5 km (Table 7). By contrast, among those who sold to private traders, about half sold their maize at the farmgate. However, among the half who chose to transport their maize to the point of sale to a private trader, they travelled a median of 15 km, which therefore would entail considerably higher transport costs relative to selling to FRA, on average. Among those who sold to other households, only 13% travelled to sell this maize. Among those who did travel, the median distance to the point of sale was 4.5 km.

**Figure 3. Delay in payment made to farmers for their largest maize sale (months)**

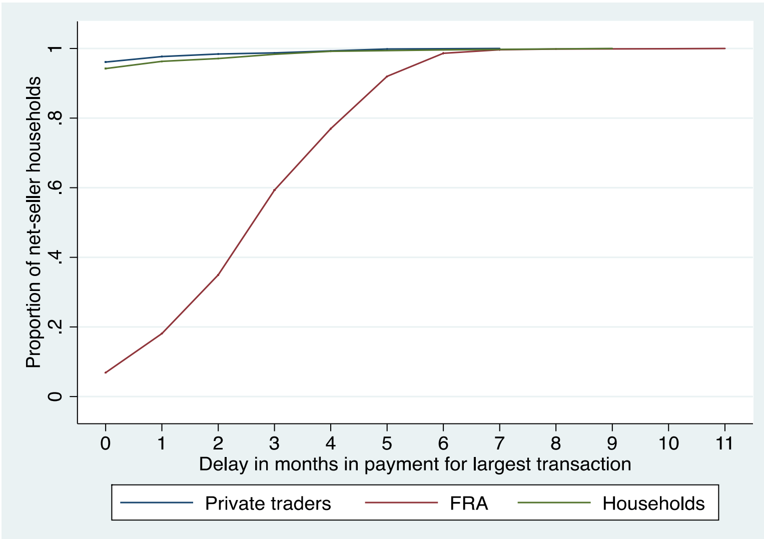



**Table 7. Percentage of maize net sellers and distance traveled to sell maize by choice of maize marketing channel, 2015**

| *Marketing channels* | *Percent of net-seller HH that sold to channel* | *Among these, No. (%) of HH that* | | *Median distance travelled by those who travelled to sell maize (km)* |
|---|---|---|---|---|
| | | *travelled to sell maize* | *sold maize at the farmgate* | |
| FRA | 46 | 93 | 7 | 5.0 |
| Private trader | 43 | 48 | 52 | 15.0 |
| Other HH | 11 | 13 | 87 | 4.5 |
| Total | 100 | | | |

# ECONOMETRIC RESULTS

### HOUSEHOLD MAIZE MARKET POSITION

In table 8 we present means and standard deviations of most of the explanatory variables used in the regression analysis in this section of the paper. In this section we present the results of our regression analysis.

**Table 8. Summary statistics of variables used in regression analysis**

| Variables | Mean | Standard deviation |
|---|---|---|
| Maize production in kg | 2847 | 5197 |
| Age of the household head (years) | 48.25 | 15.10 |
| Education of household head (years) | 5.77 | 3.62 |
| HH landholding (ha) | 2.83 | 2.99 |
| No. of full-time equivalent household members | 5.83 | 2.56 |
| Distance to feeder road (km) | 1.05 | 2.44 |
| Distance to tarmac road (km) | 26.35 | 31.09 |
| Distance to ag market (km) | 24.37 | 24.60 |
| Distance to boma (km) | 38.87 | 28.86 |
| Distance to nearest FRA depot (km) | 10.20 | 15.78 |
| No. of maize traders visiting cluster, post-harvest | 3.55 | 2.50 |
| Village retail maize price, ZMW/kg, 2017=100 | 1.89 | 0.48 |
| Farmgate FRA maize price, ZMW/kg, 2017=100 | 1.86 | 0.04 |
| Price of basal fertilizer, ZMW/kg, 2017=100 | 5.64 | 0.72 |
| Wage to weed 0.25 ha, ZMW/kg, 2017=100 | 89.44 | 34.81 |
| Expected seasonal rainfall (mm) | 803.4 | 68.34 |
| No. of seasonal moisture stress periods | 0.85 | 0.47 |
| CV of expected seasonal rainfall | 11.38 | 3.01 |
| HH number of plows | 0.38 | 0.79 |
| HH number of harrows | 0.06 | 0.26 |
| HH number of ox-carts | 0.12 | 0.35 |
| Tropical Livestock Units (TLU) | 1.94 | 5.62 |
| Non-farm income earned between May-Oct | 4572 | 14008 |
| HH is liquidity constrained (=1) | 0.55 | 0.50 |
| Male-headed household (=1) | 0.76 | 0.43 |
| HH owns a bicycle (=1) | 0.65 | 0.48 |
| HH owns a radio (=1) | 0.58 | 0.49 |
| HH owns a cellphone (=1) | 0.58 | 0.49 |

Note: Does not include all explanatory variables in our regressions, such as time-average terms.

We begin our regression analysis by estimating an exogenous switching Ordered Probit that includes CRE terms. We find that liquidity constrained (LC) maize-growing households are 4 percentage points less likely to be net-sellers of maize compared to unconstrained (UC) households (Table 9). Because 38 percent of LC households are net sellers, this implies that liquidity constraints result in an 11 percent reduction in the probability that a LC household is a net seller. This finding is consistent with our first hypothesis: that LC households are less likely to be net sellers of maize compared with UC households.

The sign of the APE on the village retail price of maize (i.e. a proxy for the private trader maize price in each village) is positive for both categories of households, but the APE is only statistically significant for UC households. This finding is consistent with our second hypothesis: that LC households are less responsive to changes in maize prices than UC households. This is also consistent with our expectation that a household facing liquidity constraints would find it more difficult to purchase yield-enhancing inputs such as inorganic fertilizer and improved seed, and thus would produce less maize. Therefore, our expectation that LC households would have less capacity to respond to the incentive of higher maize prices is seen in both lower input use and lower maize production (as noted above) and in a muted response to changes in maize sale prices.

The APE of the farmgate FRA price is not significant, which may be due to the fact that there is relatively less variation in the farmgate FRA price data across households and from one survey year to another than in the village retail market price of maize (Table 9). We also find that a one percent increase in maize production increases the probability of being a net seller of maize by 0.2 percent points for UC households, compared to 0.14 percent points for LC households. Thus, a ten percent increase in maize production will increase the probability of being a net seller by 2 percentage points for UC households, and 1.4 percent points for LC households.

With respect to our measures of market access, we find that an increase of one maize trader coming to the village increases the probability of a LC household being a net seller by 0.9 percentage points (Table 9). This is a relatively small effect as it amounts to an increase in the probability of being a net seller of only about 2 percent. It is important to note that a one-unit increase in the number of maize traders implies a 30 percent increase in that number (based on the mean number of traders of 3.6 in the sample), and is thus a relatively large marginal change in that explanatory variable.

That said, this does not imply that the presence of private traders in the village during the post-harvest period is not beneficial to smallholders seeking to sell surplus maize – just that because most villages (75 percent) receive one or more such traders each year, the marginal effect of additional traders on the probability of being a net seller is not large.[12] Likewise, although we find that the APEs of distance from the boma and tarmac roads are both positive and statistically significant among LC households, the magnitude of these effects are quite small. For example, an increase of ten kilometers in the distance from the boma results in only an increase of one percentage point in the probability that an LC household is a net seller. This result could also reflect the fact that there is relatively poor access to non-farm sources of income in more remote villages, thus farmers there are likely to be specialized in farm production activities.

[12] For example, if we replace the continuous measure of number of traders visiting the village with a binary indicator that =1 if any trader visited the village, we find that the presence of one or more traders increases the probability of being a net seller by 5 percent.

**Table 9. Average partial effects of key variables on the probability that a household is a net-seller of maize: Exogenous switching CRE-Ordered Probit model**

| ***Explanatory variables*** | ***Not Liquidity constrained*** | | ***Liquidity constrained*** | |
|---|---|---|---|---|
| | *APE* | *p-value* | *APE* | *p-value* |
| HH is liquidity constrained (=1) | | | -0.0421*** | 0.000 |
| ln(Maize production in kg) | 0.2074*** | 0.000 | 0.1415*** | 0.000 |
| ln(Village retail maize price) | 0.1059*** | 0.006 | 0.0486 | 0.210 |
| ln(Farmgate FRA price) | 0.2483 | 0.761 | -0.8051 | 0.299 |
| Distance to boma (km) | 0.0002 | 0.574 | 0.0011*** | 0.000 |
| Distance to feeder road (km) | 0.0112 | 0.134 | -0.0074 | 0.362 |
| Distance to tarmac road (km) | 0.0005 | 0.130 | 0.0003** | 0.040 |
| Distance to ag market (km) | 0.0011** | 0.012 | 0.0004 | 0.175 |
| Distance to nearest FRA depot (km) | 0.0000 | 0.971 | -0.0003 | 0.408 |
| No. of maize traders visiting village, post-harvest | 0.0014 | 0.693 | 0.0095*** | 0.000 |
| ln(Non -farm income earned between May-Oct) | -0.0057* | 0.058 | -0.0050** | 0.045 |
| HH owns a bicycle (=1) | 0.0412 | 0.137 | 0.0118 | 0.575 |
| HH owns a radio (=1) | -0.0109 | 0.651 | 0.0278 | 0.149 |
| HH owns a cellphone (=1) | -0.0149 | 0.561 | 0.0135 | 0.520 |
| Tropical Livestock Units (TLU) | 0.0012 | 0.547 | -0.0027 | 0.469 |
| HH landholding (ha) | -0.0066 | 0.101 | 0.0041 | 0.359 |
| Expected seasonal rainfall (mm) | -0.0003 | 0.253 | 0.0004** | 0.041 |
| Expected no. of seasonal moisture stress periods | -0.0323 | 0.389 | -0.0625** | 0.022 |
| CV of expected seasonal rainfall | -0.0022 | 0.700 | 0.0047 | 0.171 |
| Year FE | Yes | | Yes | |
| Provincial FE | Yes | | Yes | |
| Time average terms (CRE) | Yes | | Yes | |
| Observations | 12,126 | | 12,126 | |

Source: All tables in this document are from authors' computations using RALS 2012 and 2015 data unless otherwise noted. See Appendix B for full results.

These results suggest that measures of market access based on the distance from the household or village to the nearest agricultural market or boma do not have a large effect on the probability of being a net seller for either UC or LC households. While this result may seem counterintuitive, it is important to note that it does not imply that "market access" and "transaction costs" do not play an important role in promoting and facilitating market participation by smallholders. That is, theoretically we would expect that farmers in more remote villages would face lower maize sale prices due to the relatively higher transport costs from those villages to and from the nearest town or agricultural market. However, if regression analysis of the determinants of market participation includes maize prices that either embody or net out transportation costs from each village to the nearest agricultural market (or maize buyer type, as we do in this paper), then theoretically we should not necessarily expect that a measure of market access such as "distance to the nearest agricultural market" (or town/boma) would have a statistically significant and relatively large negative effect on the probability of being a net seller (at least not on the basis of differences in transportation costs). Remoteness could also increase the transaction costs of obtaining information on maize buyers and the maize price that they offer. Yet, smallholders in Zambia in 2012 and 2015 appear to have enjoyed relatively good access to potential maize buyers (and thus information on market prices), as 75 percent of villages are visited by one or more private traders during the marketing season, nearly all households live in a village with cellular network access, a majority of villages have a feeder road that runs directly to the village, and the median distance to the nearest FRA depot is only 5 km. Our results with regard to "distance to market" measures are also consistent with grain market participation research from Kenya, Mozambique and Zambia (Mather et al 2013) and an empirical study of market access measures in Kenya (Chamberlain and Jayne 2013).

Besides liquidity constraints, the other statistically significant factor with relatively large effects on maize market position is expected moisture stress during the growing season. For example, we find that an additional expected moisture stress period during the growing season reduces the probability that a LC household is a net seller by 6 percentage points, which is equivalent to about a 16 percent decrease in this probability (Table 9). Finally, while we find that non-farm income has a statistically significant negative effect on the probability of being a net seller for both UC and LC households, the magnitude of this effect is quite small.

#### CHOICE OF MAIZE MARKETING CHANNEL FOR NET SELLERS

We next consider the results from our CRE-multinomial logit regression of household choice of maize marketing channel, which uses only the subsample of net sellers of maize. First, we find that the Inverse Mills Ratio term is large but statistically insignificant for all three choices. This implies that the result from the MNL are not biased by the self-selection of net sellers of maize and our use of only those households in the MNL. Second, we find that LC households are 7 percentage points less likely to sell to FRA. This is equivalent to reducing the probability of selling to FRA by 18 percent. This finding is consistent with our third hypothesis: that households facing liquidity constraints are less likely to sell to the FRA. Although we are not able to test the reason behind this result, we expect that it is due to the relatively long average delay in payment by the FRA to farmers. LC households are also 3.6 percentage points more likely to sell to either private traders or other households.

Third, the village retail market price of maize does not have a statistically significant effect on the choice of maize marketing channel. The APE of the farmgate FRA maize purchase price on probability to sell to private traders is negative and not far from being statistically significant ($p=0.16$) and suggests that an increase in the FRA price of 5 (10) percent would decrease the probability of selling to a private trader by 5 (10.2) percentage points. This implies a decrease of 16 (31) percent in the probability of selling to a private trader, and suggests that among net sellers, the relatively high price offered by FRA may result in FRA crowding out a fairly significant amount of private sector trader purchases of maize.

**Table 10. Average partial effects of key explanatory variables on the probability of choosing each marketing channel for largest maize transaction: CRE-Multinomial Logit model**

| ***Explanatory variables*** | ***Private Traders*** | | ***FRA*** | | ***Other HH*** | |
|---|---|---|---|---|---|---|
| | *APE* | *p-value* | *APE* | *p-value* | *APE* | *p-value* |
| HH is liquidity constrained (=1) | 0.036* | 0.052 | -0.071*** | 0.000 | 0.035*** | 0.001 |
| ln(Village retail maize price) | 0.034 | 0.510 | -0.060 | 0.241 | 0.026 | 0.427 |
| ln(Farmgate FRA price) | -1.589 | 0.169 | 0.472 | 0.641 | 1.117 | 0.118 |
| Distance to boma (km) | 0.000 | 0.386 | 0.000 | 0.643 | 0.000 | 0.502 |
| Distance to feeder road (km) | -0.007 | 0.539 | 0.002 | 0.833 | 0.005 | 0.428 |
| Distance to tarmac road (km) | 0.000 | 0.457 | -0.001* | 0.068 | 0.000** | 0.043 |
| Distance to ag market (km) | -0.001** | 0.023 | 0.002*** | 0.001 | -0.001** | 0.024 |
| Distance to nearest FRA depot (km) | 0.005*** | 0.000 | -0.006*** | 0.000 | 0.002*** | 0.000 |
| No. of maize traders visiting cluster, post-harvest | 0.009** | 0.029 | -0.004 | 0.277 | -0.005** | 0.035 |
| ln(Non -farm income earned between May-Oct) | 0.005* | 0.095 | -0.005* | 0.065 | 0.000 | 0.946 |
| HH number of plows | 0.011 | 0.582 | -0.021 | 0.287 | 0.010 | 0.618 |
| HH number of harrows | 0.057 | 0.288 | -0.013 | 0.771 | -0.044 | 0.282 |
| HH number of ox-carts | 0.003 | 0.948 | -0.016 | 0.679 | 0.013 | 0.636 |
| HH owns a bicycle (=1) | 0.021 | 0.410 | 0.000 | 0.991 | -0.021 | 0.261 |
| HH owns a radio (=1) | -0.004 | 0.885 | 0.009 | 0.729 | -0.005 | 0.761 |
| HH owns a cellphone (=1) | 0.013 | 0.653 | -0.018 | 0.513 | 0.005 | 0.799 |
| Tropical Livestock Units (TLU) | -0.001 | 0.620 | 0.001 | 0.599 | 0.000 | 0.988 |
| HH landholding (ha) | -0.002 | 0.748 | 0.001 | 0.794 | 0.000 | 0.948 |
| Expected seasonal rainfall (mm) | -0.001** | 0.018 | 0.001*** | 0.002 | -0.000* | 0.082 |
| Expected no. of seasonal moisture stress periods | -0.079 | 0.117 | 0.123** | 0.020 | -0.044 | 0.110 |
| CV of expected seasonal rainfall | 0.005 | 0.460 | -0.005 | 0.420 | 0.000 | 0.926 |
| IMR from ordered probit | 605 | 0.772 | -933 | 0.732 | 328 | 0.608 |
| Provincial dummies | Yes | | Yes | | Yes | |
| Time average terms (CRE) | Yes | | Yes | | Yes | |
| Observations | 6,485 | | 6,485 | | 6,485 | |

Notes: See appendix B for full results.

We also find that transaction costs as measured by distances from markets have a statistically significant effect on the choice of marketing channel. For example, an increase of one kilometer in the distance from the nearest agricultural market decreases the probability of selling to private traders by 0.1 percentage points and increases the probability of selling to FRA by 0.2 percentage points. Likewise, an increase of one kilometer in a household's distance from an FRA depot reduces their probability of selling to FRA by 0.6 percentage points, while increasing the probability of selling to private traders by 0.5 percentage points and other households by 0.2 percentage points. Similarly, we find that a one-unit increase in the number of maize traders visiting the village (cluster) increases the probability of selling to private traders by 0.9 percentage points (and thus the probability of selling to private traders by 2 percent).

Each of these results have the expected signs yet the magnitude of their effects on the probability of selling to a specific marketing channel are quite small. As noted in our results from the ordered probit, this does not imply that "market access" or road and market infrastructure does not play an important role in promoting and facilitating market participation by smallholders. What it does imply is that our use of maize prices adjusted for transportation costs to and from each village appear to be capturing an important part of differences in farmgate maize prices between more and less remote villages. In addition, these results suggest that transaction costs of searching for price information and buyers appear to be relatively low, as noted above, and/or are being captured by other explanatory variables such as ownership of a cell phone.

We had expected that households with relatively lower levels of non-farm income would be less likely to sell to FRA, given the typical delay of payment by FRA and subsequent effects on household liquidity. However, while there is a statistically significant relationship between non-farm income earned during the maize marketing period of the year and choice of FRA as a marketing channel, the direction of this effect is opposite of our expectation. We find that an increase in non-farm income is associated with a decrease in the probability of selling maize to FRA. One potential explanation for this result is that households with higher levels of non-farm income may be less likely to depend heavily upon income from crop production. Related to this is the fact that since we are only including net sellers in this regression, this could imply that such households may have ways other than non-farm income to meet liquidity needs. Further research is warranted to investigate this relationship in more depth as well as other potential household sources of liquidity.

## CONCLUSIONS

In this paper, we use descriptive and econometric analysis of panel household survey data from Zambia to first assess whether liquidity constraints during the maize production period affect a farm household's decision to participate as a net seller of maize. We then assess whether liquidity-constrained households are less responsive to changes in maize prices with respect to this decision. Finally, we explore whether liquidity constraints have an effect on the choice of marketing channels for net sellers of maize, especially when some channels are characterized by uncertainty of the time of purchase as well as the length of payment delays. We have five main findings from our analysis.

First, we find that liquidity constraints during the production period is associated with an 11 percent reduction in the probability that a liquidity-constrained household is a net seller of maize, though we are not able to establish causality in this relationship. It appears that because liquidity constrained households are not able to adequately invest in productivity-enhancing inputs, this limits their capacity to produce a marketable surplus, thereby decreasing their probability of being a net seller of maize. These results are consistent with research from Mather et al. (2013), Alene et al. (2007), and Boughton et al. (2007), which found that insufficient access to public and private assets can limit a smallholder from producing a marketable surplus of a food crop and thus reduce their participation in food grain output markets.

Second, we find that while households without liquidity constraints have a statistically significant positive response to higher maize prices, liquidity-constrained (LC) households do not respond to changes in maize prices. This suggests that because LC households are less able to acquire productivity-enhancing inputs, this mutes their responsiveness to changes in the maize price. This is consistent with the suggestion made by Barrett (2008) that price policies may have minimal effect on smallholders' food production and marketing responses if they lack access to productive assets and inputs needed to expand production.

Third, we find that measures of market access based on the distance from the household or village to the nearest agricultural market or main district town (boma) do not have a large effect on the probability of being a net seller, for either liquidity-constrained or unconstrained households. While this result may seem counterintuitive, it is important to note that it does not imply that "market access" or road and market infrastructure do not play an important role in promoting and facilitating market participation by smallholders. What it does imply is that our use of maize prices adjusted for transportation costs to and from each village appear to be capturing an important part of differences in farmgate maize prices between more and less remote villages. In addition, these results suggest that transaction costs of searching for price information and buyers appear to be relatively low – perhaps due to relative proximity to FRA depots, good access to private traders (who visit 75 percent of villages), and the fact that nearly all villages have cell network access -- and/or that these transaction costs are being captured by other explanatory variables such as ownership of a cell phone. These results suggest that market access and competitiveness in output market in Zambia may not be as poor as is often assumed in literature (Sitko and Jayne, 2014).

Fourth, we find that an additional expected moisture stress period during the growing season reduces the probability that a liquidity-constrained household is a net seller 16 percent. This highlights the vulnerability of smallholder maize production in Zambia to drought and the potential benefit of the adoption of soil management practices and drought-tolerant maize varieties that can help to mitigate the negative effects of drought on crop productivity (Ajayi et al 2007; Haggblade, Tembo, and Donovan 2004).

Fifth, we find that liquidity-constrained households are 18 percent less likely to sell to the FRA, and thereby unable to enjoy the benefits of higher FRA maize purchase prices. Although we are not able to discern the specific reason for this result at this point in our research, we expect that this may be due to uncertainty regarding the timing of FRA maize purchases each year as well as the typically long delay in payment by the FRA to farmers.

Taken together, our results demonstrate that liquidity constraints can limit smallholder participation of in food grain markets as net sellers, reduce their responsiveness to changes in maize prices, and limit their access to relatively high FRA maize purchase prices. These results provide additional evidence that relatively well-off farmers (those that are not liquidity constrained) are best able to access the benefits of higher FRA maize purchase prices. They also suggest a need to investigate ways to reduce smallholder's liquidity constraints in Zambia as related to maize production. This is not a new challenge, and unfortunately there seem to be more examples of ineffective efforts to address this constraint in SSA than successful ones. For example, the history of state-subsidized agricultural credit for staple crop growers in many SSA countries during the 1970s/80s is that farmer default on seasonal agricultural input loans was often widespread (Poulton et al, 1998). While there has been success in the development of micro-finance institutions in rural areas, these are typically incapable of providing seasonal credit for agricultural inputs given the size and lumpiness of such loans as well as the fact that they cannot be repaid for many months (Poulton et al, 2006). A potential remedy to facilitate credit for smallholder grain producers is a Warehouse Receipt System, though the requirements to successfully develop and sustain a WRS are challenging and are not easily met by small farmer associations or cooperatives without considerable outside support (Meyer, 2015).

## REFERENCES


Alene, A.D., V. Manyong, G. Omanya, H. Mignouna, M. Bokanga, and G. Odhiambo. 2008. “Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya.” *Food policy* 33:318–328.

Ajayi, O. C., Akinnifesi, F. K., Sileshi, G., and Chakeredza, S. 2007. “Adoption of renewable soil fertility replenishment technologies in the southern African region: Lessons learnt and the way forward”. *Natural resources forum*, 31(4): 306-317

Bardhan, D., M. Sharma, and R. Saxena. 2012. “Market participation behaviour of smallholder dairy farmers in Uttarakhand: A disaggregated analysis.” *Agricultural Economics Research Review* 25:243.

Barrett, C.B. 2008. “Smallholder market participation: Concepts and evidence from eastern and southern Africa.” *Food policy* 33:299–317.

Bellemare, M.F., and C.B. Barrett. 2006. “An ordered Tobit model of market participation: Evidence from Kenya and Ethiopia.” *American Journal of Agricultural Economics* 88:324–337.

Boughton, D., D. Mather, C.B. Barrett, R.S. Benfica, D. Abdula, D. Tschirley, and B. Cunguara. 2007. “Market participation by rural households in a low-income country: An asset based approach applied to Mozambique.” *Faith and economics* 50:64–101.

Bound, J., Jaeger, D. A., & Baker, R. M. 1995. “Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak”. *Journal of the American statistical association*, *90*(430), 443-450.

Burke, M., L.F. Bergquist, and E.Miguel. 2018. “Sell low and buy high: arbitrage and local price effects in Kenyan markets.” *The Quarterly Journal of Economics* 134:785–842.

Cadot, O., M. Olarreaga, and L. Dutoit. 2006. “How costly is it for poor farmers to lift themselves out of poverty?” World Bank Policy Research Working Paper 3661, World Bank, Washington, D.C.

Chamberlain, G. 1984. “Panel data.” Handbook of Econometrics 2:1247–1318.

Chamberlin, J. and T.S. Jayne. 2013. "Unpacking the Meaning of ‘Market Access’: Evidence from Rural Kenya," *World Development*, 41(C): 245-264.

Chapoto, A., O. Zulu-Mbata, B.D. Hoffman, C. Kabaghe, N. Sitko, A. Kuteya, and B. Zulu. 2015. “The Politics of Maize in Zambia: Who holds the keys to change the status quo.” Working paper No. 99, Indaba Agricultural Policy Research Institute, IAPRI, Lusaka, Zambia.

Central Statistical Office (CSO). 2012. RALS 2012: Instruction manual for listing, sample selection, and largest maize field data collection, Lusaka, Zambia.

Central Statistical Office (CSO). 2018. Administrative data obtained from the Central Statistical Office, Lusaka, Zambia.

De Janvry, A., M. Fafchamps, and E. Sadoulet. 1991. "Peasant Household Behavior with Missing Markets: Some Paradoxes Explain." *Economic Journal* 101:1400–1417.

De Janvry, A., E. Sadoulet, M. Fafchamps, and M. Raki. 1992. "Structural adjustment and the peasantry in Morocco: A computable household model." *European Review of Agricultural Economics* 19:427–453.

Dillon, B. 2017. "Selling crops early to pay for school: A large-scale natural experiment in Malawi." Available at SSRN 2848003.

Fafchamps, M., and R.V. Hill. 2005. "Selling at the farmgate or traveling to market." *American Journal of Agricultural Economics* 87:717–734.

FAO. 2007. *Compendium of Agricultural - Environmental Indicators (1989-91 to 2000): Annex 2 Definitions*. Rome: FAO.

Feder, G., L.J. Lau, J.Y. Lin, and X. Luo. 1990. "The relationship between credit and productivity in Chinese agriculture: A microeconomic model of disequilibrium." *American Journal of Agricultural Economics* 72:1151–1157.

Foltz, J.D. 2004. "Credit market access and profitability in Tunisian agriculture." *Agricultural Economics* 30:229–240.

Food Reserve Agency (FRA). n.d. Administrative data obtained from FRA, Lusaka, Zambia.

Fung, W., L.S.O. Liverpool-Tasie, N. Mason, and R. Uwaifo Oyelere. 2015. "Can Crop Purchase Programs Reduce Poverty and Improve Welfare in Rural Communities? Evidence from the Food Reserve Agency in Zambia." IZA Discussion Paper.

Goetz, S.J. 1992. "A selectivity model of household food marketing behavior in sub-Saharan Africa." *American Journal of Agricultural Economics* 74:444–452.

Grossman, J. and M. Tarazi. 2014. "Serving Smallholder Farmers: Recent Developments in Digital Finance." Focus Note 94. CGAP: Washington, D.C.

Haggblade, S., Tembo, G., and Donovan, C. 2004. "Household level financial incentives to adoption of conservation agricultural technologies in Africa", FSRP Working paper no. 9, Department of Agriculture, Food, and Natural Resources, Michigan State University, East Lansing.

Heltberg, R., and F. Tarp. 2002. "Agricultural supply response and poverty in Mozambique." *Food Policy* 27:103–124.

IAPRI. 2017. "Achieving more with less: Reform and scaling down of FRA and FISP and boosting social protection" Policy Advisory Paper, Indaba Agricultural Policy Research Institute (IAPRI), Lusaka: Zambia.

Jagwe, J.N., and C. Machethe. 2011. "Effects of transaction costs on choice of selling point: a case of smallholder banana growers in the Great Lakes region of Central Africa." *Agrekon* 50:109–123.

Jayne, T.S., N.M. Mason, W.J. Burke, A.M. Shipekesa, A. Chapoto, and C. Kabaghe. 2011. "Mountains of maize, persistent poverty." Working paper No. 48, Indaba Agricultural Policy Research Institute, IAPRI, Lusaka, Zambia.

Key, N., E. Sadoulet, and A.D. Janvry. 2000. "Transactions costs and agricultural household supply response." *American Journal of Agricultural Economics* 82:245–259.

Maidment, R.I., D. Grimes, R.P. Allan, E. Tarnavsky, M. Stringer, T. Hewison, R. Roebeling, and E. Black. 2014. "The 30 Year TAMSAT African Rainfall Climatology and Time Series (TARCAT) Data Set". *Journal of Geophysical Research: Atmospheres* 119.18: 610-619.

Maidment, R.I., D. Grimes, E. Black, E. Tarnavsky, M. Young, H. Greatrex, R.P. Allan et al. 2017. "A New, Long-Term Daily Satellite-Based Rainfall Dataset for Operational Monitoring". Scientific Data Volume 4, Article number: 170063. DOI:10.1038/sdata.2017.63.

Mason, N.M., T.S. Jayne, and R.J. Myers. 2015. "Smallholder supply response to marketing board activities in a dual channel marketing system: The case of Zambia." *Journal of Agricultural Economics* 66:36–65.

Mason, N.M., and R.J. Myers. 2013. "The effects of the Food Reserve Agency on maize market prices in Zambia." *Agricultural Economics* 44:203–216.

Mather, D., D. Boughton, and T. Jayne. 2013. "Explaining smallholder maize marketing in southern and eastern Africa: The roles of market access, technology and household resource endowments." *Food Policy* 43:248–266.

Meyer, R.L. 2015. "Financing Agriculture and Rural Areas in Sub-Saharan Africa: Progress, challenges and the way forward." International Institute for Environment and Development (IIED) Working Paper. IIED, London.

Muamba, F.M. 2011. "Selling at the farmgate or traveling to the market: A conditional farm-level model." *The Journal of Developing Areas*, pp. 95–107.

Mundlak, Y. 1978. "On the pooling of time series and cross section data." *Econometrica: Journal of the Econometric Society*, pp. 69–85.

Negi, D.S., P.S. Birthal, D. Roy, and M.T. Khan. 2018. "Farmers a choice of market channels and producer prices in India: Role of transportation and communication networks." *Food Policy* 81:106–121.

Poulton, C., A. Dorward, and J. Kydd. 1998. "The Revival of Smallholder Cash Crops in Africa: Public and Private Roles in the Provision of Finance." *Journal of International Development* 10(1): 85-103.

Poulton, C., J. Kydd, and A. Dorward. 2006. "Overcoming Market Constraints on Pro-Poor Agricultural Growth in Sub-Saharan Africa." *Development Policy Review* 24(3): 243-277.

Renkow, M., D.G. Hallstrom, and D.D. Karanja. 2004. "Rural infrastructure, transactions costs and market participation in Kenya." *Journal of Development Economics* 73:349–367.

Samboko, P., Chapoto, A., Banda, A., and Chisanga, B. 2019. "Agricultural sector in peril: Is Zambia killing the goose that lays the golden egg?" Policy brief No. 98, Indaba Agricultural Policy Research Institute (IAPRI), Lusaka, Zambia.

Shilpi, F., and D. Umali-Deininger. 2008. "Market facilities and agricultural marketing: evidence from Tamil Nadu, India." *Agricultural Economics* 39:281–294.

Singh, I., L. Squire, and J. Strauss. 1986. "A survey of agricultural household models: Recent findings and policy implications." *The World Bank Economic Review* 1:149–179.

Sitko, N.J., and T. Jayne. 2014. "Exploitative briefcase businessmen, parasites, and other myths and legends: assembly traders and the performance of maize markets in eastern and southern Africa." *World Development* 54:56–67.

Snyder, J., T.S. Jayne, N. Mason, P. Samboko. 2019. "Agricultural Productivity and rural household incomes: Micro-level evidence from Zambia". Feed the Future Innovation Lab for Food Security Policy Research Paper 151. East Lansing, Michigan.

Stephens, E.C., and C.B. Barrett. 2011. "Incomplete credit markets and commodity marketing behaviour." *Journal of Agricultural Economics* 62:1–24.

Takeshima, H., and A. Winter-Nelson. 2012. "Sales location among semi-subsistence cassava farmers in Benin: A heteroskedastic double selection model." *Agricultural Economics* 43:655–670.

Tarnavsky, E., D. Grimes, R. Maidment, E. Black, R.P. Allan, M. Stringer, R. Chadwick, and F. Kayitakire. 2014. "Extension of the TAMSAT Satellite-Based Rainfall Monitoring over Africa and from 1983 to Present". *Journal of Applied Meteorology and Climatology* 53.12: 2805-2822.

Timmer, C.P. 1988. "The agricultural transformation." Handbook of Development Economics 1:275–331.

Von Braun, J., and Kennedy, E. T. (1994). "*Agricultural commercialization, economic development, and nutrition"*. Published for the International Food Policy Research Institute (IFPRI), Washington D.C.

Winter-Nelson, A., and A.A. Temu. 2005. "Liquidity constraints, access to credit and pro-poor growth in rural Tanzania." *Journal of International Development* 17:867–882.

World Bank. 2019. World Development Indicators: Consumer Price Index. [Datafile]. retrieved from: https://databank.worldbank.org/indicator/FP.CPI.TOTL.ZG/1ff4a498/Popular-Indicators

Wooldridge, J.M. 2015. "Control function methods in applied econometrics." *Journal of Human Resources* 50:420–445.

—. 2014. "Quasi-maximum likelihood estimation and testing for nonlinear models with endogenous explanatory variables." *Journal of Econometrics* 182:226–234.

Zanello, G., C.S. Srinivasan, and B. Shankar. 2014. "Transaction costs, information technologies, and the choice of marketplace among farmers in Northern Ghana." *The Journal of Development Studies* 50:1226–1239.

# APPENDIX A. ADJUSTING FRA AND RETAIL MAIZE PRICES BY TRANSPORT COSTS TO THE VILLAGE

There are two significant limitations of using a district-level mean maize price at the retail level as a proxy measure of the maize purchase price offered by private traders to smallholder farmers within a given village – a farmgate price. The first is that margins between farmgate and retail maize prices may not be the same from one village to the next, even within the same district. However, due to data limitations, we have to make that assumption. The second is that within each district, the farmgate price of maize in village A (at a given point in time) is unlikely to be the same as the farmgate price of maize in village B, given that transportation costs from the boma[13] to the two villages are not likely to be equal. Fortunately, for farmers whose largest maize sale was made somewhere away from their homestead, RALS records their transport costs (per kilogram and per kilometer) to that point of sale. We then adjust the district mean retail maize price (per kg) in August of a given year for each village by subtracting an estimate of the transport cost from each village to the nearest feeder road. This estimate is the village median cost (per kg per km) of transporting maize[14], multiplied by the distance from the village to the nearest feeder road. We make two assumptions in computing the transport costs in this way. The first is that the cost of transport to the feeder road is typically the largest source of transport cost incurred by the farmer who sells maize somewhere outside his/her village[15]. The second assumption is that most farmers who sell maize somewhere outside of the village are not traveling further than the nearest feeder road to make their sale. In fact, when we look at RALS data on distance to maize sale (for those who do not sell from their homestead or in the village), we find that most of those sellers are in fact traveling further than the nearest feeder road to sell their maize. This implies that our estimate of transport costs to/from the village are an underestimate.

We do not net out the costs of transport from the household all the way to the nearest FRA depot because as noted above, the maize transport costs observed in RALS are very likely only the (relatively high) costs of transporting maize from the village to the nearest feeder road. Thus, were we to apply those transport costs per kg per km to the distance between the nearest feeder road and the nearest FRA depot, this would very likely overestimate the actual transport costs on feeder or higher-quality roads.

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[13] The boma is the spatial location for at least some of the observations of retail maize price that are used to construct the mean maize retail price in a given district.

[14] The use of cluster level medians serves two purposes. Firstly, it ensures that farmer level transport costs do not introduce endogeneity in the expected prices. Secondly, it allows us to compute the transport costs for households that did not sell maize and thus did not report cost of transport. The rule of thumb used while computing the cluster median was that there are at least 10 observations per cluster to obtain a median. Wherever, this rule was not followed, we used the district or the provincial median, whichever permitted at least 10 observations. While this cost is only observed for the marketing season of maize in both years, we do not expect the costs of transport and distance to feeder road to vary significantly within the time period of a year.

[15] While this cost is only observed for the marketing season of maize in both years, we do not expect the costs of transport and distance to feeder road to vary significantly within the time period of a year.

## APPENDIX B. COMPLETE RESULTS FROM REGRESSION ANALYSIS

**Table B1. Average partial effects of explanatory variables from exogenous switching ordered probit of maize market position, probability of being a net seller**

| | Ordered probit of HH maize market position | | | |
|---|---|---|---|---|
| ***Explanatory variables*** | ***Net sellers: Not Liquidity constrained*** | | ***Net sellers: Liquidity constrained*** | |
| | *APE* | *p-value* | *APE* | *p-value* |
| HH is liquidity constrained (=1) | | | -0.0421*** | 0.0000 |
| ln(Village retail maize price) | 0.1059*** | 0.0060 | 0.0486 | 0.2097 |
| ln(Farmgate FRA price) | 0.2483 | 0.7607 | -0.8051 | 0.2987 |
| ln(Maize production in kg) | 0.2074*** | 0.0000 | 0.1415*** | 0.0000 |
| Distance to boma (km) | 0.0002 | 0.5737 | 0.0011*** | 0.0000 |
| Distance to feeder road (km) | 0.0112 | 0.1340 | -0.0074 | 0.3622 |
| Distance to tarmac road (km) | 0.0005 | 0.1302 | 0.0003** | 0.0401 |
| Distance to ag market (km) | 0.0011** | 0.0116 | 0.0004 | 0.1747 |
| Distance to nearest FRA depot (km) | 0.0000 | 0.9712 | -0.0003 | 0.4080 |
| No. of maize traders visiting cluster, post-harv | 0.0014 | 0.6933 | 0.0095*** | 0.0001 |
| ln(Non -farm income earned between May-Oct) | -0.0057* | 0.0579 | -0.0050** | 0.0447 |
| HH number of plows | -0.0190 | 0.4662 | 0.0110 | 0.5820 |
| HH number of harrows | -0.0369 | 0.5498 | 0.0568 | 0.4314 |
| HH number of ox-carts | 0.0319 | 0.3498 | 0.0864** | 0.0298 |
| HH owns a bicycle (=1) | 0.0412 | 0.1370 | 0.0118 | 0.5747 |
| HH owns a radio (=1) | -0.0109 | 0.6512 | 0.0278 | 0.1493 |
| HH owns a cellphone (=1) | -0.0149 | 0.5606 | 0.0135 | 0.5197 |
| Tropical Livestock Units (TLU) | 0.0012 | 0.5472 | -0.0027 | 0.4685 |
| HH landholding (ha) | -0.0066 | 0.1014 | 0.0041 | 0.3594 |
| Expected seasonal rainfall (mm) | -0.0003 | 0.2534 | 0.0004** | 0.0406 |
| Expected no. of seasonal moisture stress periods | -0.0323 | 0.3886 | -0.0625** | 0.0222 |
| CV of expected seasonal rainfall | -0.0022 | 0.7000 | 0.0047 | 0.1708 |
| Age of the household head (years) | -0.0015*** | 0.0054 | 0.0000 | 0.9001 |
| Education of household head (years) | -0.0050** | 0.0350 | -0.0013 | 0.4584 |
| Male-headed household (=1) | -0.0427** | 0.0407 | -0.0294** | 0.0290 |
| No. of full-time equivalent household members | -0.0134*** | 0.0000 | -0.0182*** | 0.0000 |
| Agricultural year 2013/14 (=1) | -0.1598 | 0.1804 | -0.2370** | 0.0161 |
| Copperbelt (=1) | -0.0574 | 0.1683 | -0.1053*** | 0.0035 |
| Eastern (=1) | -0.0592** | 0.0409 | -0.0957*** | 0.0010 |
| Luapula (=1) | 0.1690*** | 0.0012 | 0.0718* | 0.0908 |
| Lusaka (=1) | -0.0175 | 0.6859 | 0.0092 | 0.8170 |
| Muchinga (=1) | -0.0042 | 0.9120 | 0.0538 | 0.1076 |
| Northern (=1) | 0.1510*** | 0.0015 | 0.1916*** | 0.0000 |

| Explanatory variables | Ordered probit of HH maize market position | | | |
|---|---|---|---|---|
| | ***Net sellers: Not Liquidity constrained*** | | ***Net sellers: Liquidity constrained*** | |
| | *APE* | *p-value* | *APE* | *p-value* |
| Northwestern (=1) | 0.1222** | 0.0151 | 0.0601 | 0.1583 |
| Southern (=1) | -0.0650 | 0.1469 | -0.0891** | 0.0119 |
| Western (=1) | 0.0035 | 0.9416 | -0.0640* | 0.0687 |
| Time-average (TA) of ln(Maize production in kg) | 0.0326** | 0.0358 | 0.0454*** | 0.0004 |
| TA of ln(Village retail maize price) | -0.0892 | 0.1901 | -0.0504 | 0.3906 |
| TA of ln(Farmgate FRA price) | 0.1161 | 0.8986 | 0.3975 | 0.7237 |
| TA of HH number of plows | 0.0266 | 0.3409 | -0.0238 | 0.3285 |
| TA of HH number of harrows | 0.0315 | 0.6424 | 0.0305 | 0.6936 |
| TA of HH number of ox-carts | -0.0348 | 0.3901 | -0.0320 | 0.5011 |
| TA of HH landholding (ha) | 0.0023 | 0.6508 | 0.0015 | 0.7838 |
| TA of HH Tropical Livestock Units (TLU) | 0.0001 | 0.9761 | 0.0037 | 0.2557 |
| TA of Distance to feeder road (km) | -0.0256** | 0.0114 | 0.0006 | 0.9569 |
| TA of HH owns a bicycle (=1) | -0.0050 | 0.8807 | 0.0523** | 0.0428 |
| TA of HH owns a radio (=1) | 0.0522* | 0.0978 | -0.0500** | 0.0424 |
| TA of HH owns a cellphone (=1) | -0.0167 | 0.5913 | -0.0226 | 0.3703 |
| TA of ln(Non -farm income earned between May-Oct) | -0.0079** | 0.0374 | -0.0036 | 0.2408 |
| Provincial dummies | Yes | | Yes | |
| Time average terms (CRE) | Yes | | Yes | |
| Observations | 12,126 | | 12126 | |

**Table B2. Average partial effects of explanatory variables from pooled ordered probit of maize market position, probability of being a net-seller**

| ***Explanatory variables*** | *APE* | *p-value* |
|---|---|---|
| HH is liquidity constrained (=1) | -0.0348*** | 0.0008 |
| ln(Village retail maize price) | 0.0798*** | 0.0051 |
| ln(Farmgate FRA price) | -0.2972 | 0.6012 |
| ln(Maize production in kg) | 0.1596*** | 0.0000 |
| Distance to boma (km) | 0.0009*** | 0.0006 |
| Distance to feeder road (km) | -0.0017 | 0.7777 |
| Distance to tarmac road (km) | 0.0003** | 0.0163 |
| Distance to ag market (km) | 0.0006** | 0.0252 |
| Distance to nearest FRA depot (km) | -0.0002 | 0.4897 |
| No. of maize traders visiting cluster, post-harv | 0.0066*** | 0.0036 |
| ln(Non -farm income earned between May-Oct) | -0.0055*** | 0.0043 |
| HH number of plows | -0.0016 | 0.9246 |
| HH number of harrows | -0.0105 | 0.8032 |

| *Explanatory variables* | *APE* | *p-value* |
|---|---|---|
| HH number of ox-carts | 0.0636** | 0.0169 |
| HH owns a bicycle (=1) | 0.0190 | 0.2622 |
| HH owns a radio (=1) | 0.0171 | 0.2834 |
| HH owns a cellphone (=1) | 0.0047 | 0.7819 |
| Tropical Livestock Units (TLU) | -0.0007 | 0.7844 |
| HH landholding (ha) | -0.0004 | 0.9064 |
| Expected seasonal rainfall (mm) | 0.0002 | 0.3157 |
| Expected no. of seasonal moisture stress periods | -0.0531** | 0.0276 |
| CV of expected seasonal rainfall | 0.0017 | 0.5729 |
| Age of the household head (years) | -0.0005 | 0.1418 |
| Education of household head (years) | -0.0032** | 0.0266 |
| Male-headed household (=1) | -0.0327*** | 0.0030 |
| No. of full-time equivalent household members | -0.0163*** | 0.0000 |
| Agricultural year 2013/14 (=1) | -0.1895** | 0.0134 |
| Copperbelt (=1) | -0.0846*** | 0.0039 |
| Eastern (=1) | -0.0738*** | 0.0014 |
| Luapula (=1) | 0.1177*** | 0.0013 |
| Lusaka (=1) | 0.0170 | 0.6168 |
| Muchinga (=1) | 0.0482* | 0.0656 |
| Northern (=1) | 0.1931*** | 0.0000 |
| Northwestern (=1) | 0.0916** | 0.0137 |
| Southern (=1) | -0.0691** | 0.0204 |
| Western (=1) | -0.0235 | 0.4590 |
| TA of ln(Maize production in kg) | 0.0452*** | 0.0000 |
| TA of ln(Village retail maize price) | -0.0569 | 0.1977 |
| TA of ln(Farmgate FRA price) | 0.2393 | 0.7578 |
| TA of HH number of plows | -0.0004 | 0.9828 |
| TA of HH number of harrows | 0.0478 | 0.3090 |
| TA of HH number of ox-carts | -0.0315 | 0.3433 |
| TA of HH landholding (ha) | 0.0020 | 0.6142 |
| TA of HH Tropical Livestock Units (TLU) | 0.0021 | 0.3614 |
| TA of Distance to feeder road (km) | -0.0044 | 0.6056 |
| TA of HH owns a bicycle (=1) | 0.0380* | 0.0626 |
| TA of HH owns a radio (=1) | -0.0226 | 0.2754 |
| TA of HH owns a cellphone (=1) | -0.0191 | 0.3268 |
| TA of ln(Non -farm income earned between May-Oct) | -0.0050** | 0.0334 |
| Provincial dummies | Yes | |
| Time average terms (CRE) | Yes | |
| Observations | 12,126 | |

**Table B3. Average partial effects of explanatory variables on the choice of each marketing channel: CRE-Multinomial Logit**

| ***Explanatory variables*** | ***Private Traders*** | | ***FRA*** | | ***Other HH*** | |
|---|---|---|---|---|---|---|
| | *APE* | *p-value* | *APE* | *p-value* | *APE* | *p-value* |
| HH is liquidity constrained (=1) | 0.0358* | 0.0515 | -0.070*** | 0.0001 | 0.034*** | 0.0010 |
| ln(Village retail maize price) | 0.0343 | 0.5095 | -0.0601 | 0.2406 | 0.0258 | 0.4267 |
| ln(Farmgate FRA price) | -1.5888 | 0.1686 | 0.4720 | 0.6410 | 1.1168 | 0.1176 |
| Distance to boma (km) | 0.0004 | 0.3862 | -0.0002 | 0.6434 | -0.0002 | 0.5018 |
| Distance to feeder road (km) | -0.0072 | 0.5394 | 0.0020 | 0.8327 | 0.0052 | 0.4279 |
| Distance to tarmac road (km) | 0.0003 | 0.4567 | -0.0007* | 0.0684 | 0.0004** | 0.0428 |
| Distance to ag market (km) | -0.0011** | 0.0231 | 0.0018*** | 0.0006 | -0.001** | 0.0240 |
| Distance to nearest FRA depot (km) | 0.0046*** | 0.0000 | -0.006*** | 0.0000 | 0.001*** | 0.0001 |
| No. of maize traders visiting cluster, post-harv | 0.0089** | 0.0286 | -0.0043 | 0.2770 | -0.004** | 0.0349 |
| ln(Non -farm income earned between May-Oct) | 0.0049* | 0.0950 | -0.0050* | 0.0651 | 0.0001 | 0.9457 |
| HH number of plows | 0.0111 | 0.5821 | -0.0212 | 0.2873 | 0.0101 | 0.6176 |
| HH number of harrows | 0.0571 | 0.2880 | -0.0133 | 0.7707 | -0.0438 | 0.2820 |
| HH number of ox-carts | 0.0025 | 0.9475 | -0.0158 | 0.6786 | 0.0133 | 0.6364 |
| HH owns a bicycle (=1) | 0.0211 | 0.4095 | -0.0003 | 0.9911 | -0.0209 | 0.2614 |
| HH owns a radio (=1) | -0.0037 | 0.8850 | 0.0089 | 0.7292 | -0.0052 | 0.7608 |
| HH owns a cellphone (=1) | 0.0130 | 0.6526 | -0.0175 | 0.5132 | 0.0045 | 0.7986 |
| Tropical Livestock Units (TLU) | -0.0013 | 0.6200 | 0.0013 | 0.5989 | 0.0000 | 0.9883 |
| HH landholding (ha) | -0.0016 | 0.7480 | 0.0013 | 0.7935 | 0.0003 | 0.9477 |
| Expected seasonal rainfall (mm) | -0.0007** | 0.0179 | 0.0009*** | 0.0018 | -0.0003* | 0.0818 |
| Expected no. of seasonal moisture stress periods | -0.0789 | 0.1172 | 0.1228** | 0.0196 | -0.0439 | 0.1100 |
| CV of expected seasonal rainfall | 0.0048 | 0.4598 | -0.0052 | 0.4197 | 0.0004 | 0.9260 |
| Age of the household head (years) | -0.0014** | 0.0324 | 0.0009 | 0.1746 | 0.0005 | 0.1662 |
| Education of household head (years) | -0.0057** | 0.0224 | 0.0070*** | 0.0066 | -0.0013 | 0.3827 |
| Male-headed household (=1) | 0.0274 | 0.2496 | -0.0327 | 0.1920 | 0.0054 | 0.6698 |
| No. of full-time equivalent household members | -0.0062** | 0.0483 | 0.0023 | 0.5000 | 0.0039* | 0.0656 |
| Agricultural year 2013/14 (=1) | -0.0901 | 0.5370 | -0.1002 | 0.5059 | 0.1902 | 0.1767 |
| Copperbelt (=1) | -0.0457 | 0.3445 | 0.0217 | 0.6645 | 0.0240 | 0.3753 |
| Eastern (=1) | -0.0790** | 0.0400 | 0.0775** | 0.0444 | 0.0015 | 0.9376 |
| Luapula (=1) | -0.282*** | 0.0000 | 0.2467*** | 0.0000 | 0.0360 | 0.2966 |
| Lusaka (=1) | -0.185*** | 0.0003 | 0.1015 | 0.1438 | 0.0840* | 0.0986 |
| Muchinga (=1) | -0.306*** | 0.0000 | 0.3448*** | 0.0000 | -0.038** | 0.0305 |
| Northern (=1) | -0.321*** | 0.0000 | 0.3741*** | 0.0000 | -0.05*** | 0.0022 |
| Northwestern (=1) | -0.165*** | 0.0032 | 0.1754*** | 0.0030 | -0.0099 | 0.6760 |
| Southern (=1) | -0.123** | 0.0237 | -0.0019 | 0.9724 | 0.124*** | 0.0053 |
| Western (=1) | -0.1057 | 0.1370 | 0.0439 | 0.5670 | 0.0618 | 0.1496 |

| ***Explanatory variables*** | ***Private Traders*** | | ***FRA*** | | ***Other HH*** | |
|---|---|---|---|---|---|---|
| | *APE* | *p-value* | *APE* | *p-value* | *APE* | *p-value* |
| TA of ln(Village retail maize price) | 0.0745 | 0.3759 | -0.0811 | 0.3980 | 0.0066 | 0.8644 |
| TA of ln(Farmgate FRA price) | 0.8960 | 0.5123 | -1.1989 | 0.3653 | 0.3029 | 0.7430 |
| TA of HH number of plows | 0.0086 | 0.7557 | 0.0308 | 0.2691 | -0.0394 | 0.1104 |
| TA of HH number of harrows | 0.0025 | 0.9692 | -0.0078 | 0.9034 | 0.0053 | 0.9097 |
| TA of HH number of ox-carts | -0.0742 | 0.1439 | 0.1109** | 0.0302 | -0.0367 | 0.4116 |
| TA of HH landholding (ha) | -0.0029 | 0.6210 | 0.0151** | 0.0152 | -0.012** | 0.0293 |
| TA of HH Tropical Livestock Units (TLU) | -0.0006 | 0.8581 | 0.0008 | 0.8059 | -0.0002 | 0.9338 |
| TA of Distance to feeder road (km) | 0.0026 | 0.8593 | -0.0066 | 0.6495 | 0.0040 | 0.6276 |
| TA of HH owns a bicycle (=1) | -0.0860** | 0.0222 | 0.0940** | 0.0170 | -0.0080 | 0.7206 |
| TA of HH owns a radio (=1) | -0.0032 | 0.9302 | 0.0062 | 0.8623 | -0.0031 | 0.8908 |
| TA of HH owns a cellphone (=1) | -0.0721* | 0.0638 | 0.1034*** | 0.0056 | -0.0312 | 0.2046 |
| TA of ln(Non -farm income earned between May-Oct) | 0.0013 | 0.7354 | -0.0025 | 0.5253 | 0.0012 | 0.6112 |
| IMR from ordered probit | 605.1241 | 0.7720 | -933.2131 | 0.7320 | 328.0891 | 0.6077 |
| Observations | 6,485 | | 6,485 | | 6,485 | |