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Storage losses, liquidity constraints, and maize storage decisions in Benin

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Abstract

This article estimates how storage losses from mold, insects, and other pests, combined with liquidity constraints, influence a smallholder farm household's decision to store maize on farm after harvest. We analyze panel data from 309 smallholders in Benin covering the 2011 and 2013 harvest seasons. Results suggest that smallholders are driven to sell at harvest time for different reasons, depending on their motivation for storing. In households that report direct consumption as their primary goal for storing maize, liquidity constraints, not storage losses, reduce the amount they store. In contrast, households that store maize with the intention of selling it later in the year appear unaffected by liquidity constraints. Instead, these households store less when they expect to lose more during storage. These results suggest that policies to provide liquidity will be more helpful in motivating storage among consumption-oriented households. Households motivated to store for later sale will benefit from modern storage technologies that mitigate the operational costs associated with storage losses.

JEL classifications: C13, C23, D13, O12, O13

Keywords: Liquidity constraints; Storage losses; Benin; Sub-Saharan Africa

1. Introduction

Smallholder farm households throughout the developing world often sell substantial portions of their staple crop output immediately after harvest, a time when prices are low, only to repurchase the same staples later in the year at higher prices. That this behavior occurs, despite seemingly clear evidence that households could benefit from holding grain into the lean period, constitutes an important economic and food security challenge. The stylized pattern points to several major constraints facing smallholder households.

In this regard, economic research focuses on liquidity constraints as a major impediment to storage. Many smallholder farm households face substantial financial outlays at harvest time, including loan repayments from planting time and school fees. In the absence of credit or sufficient off-farm income, a household's only option may be to generate cash by selling a portion of newly harvested crops (Abdoulaye and Sanders, 2005, 2006). For example, Stephens and Barrett (2011) show that asset-poor Kenyan households are more likely to "sell low" and "buy high" than better-off households. Burke (2014) also finds that access to credit at the time of harvest allows Kenyan households to hold a larger proportion of their maize harvest to sell later in the year.[1] Therefore, liquidity constraints can lead to a suboptimal outcome when households cannot take the advantage of temporal price arbitrage opportunities that often occur when grain is stored for sale later in the year.

In contrast, the entomology literature focuses on quantity losses in storage due to mold, insects, and other pests as the reason smallholders do not store more grain at harvest. Insects such as the larger grain borer (LGB) are prevalent across much of Africa and Asia and can reportedly cause losses of up to

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[1] Basu and Wong (2015) report findings from a randomized evaluation of two seasonal programs in West Timor, Indonesia that included access to food storage equipment at zero cost, and access to credit. They find that the credit program improves the low harvest-to-lean period of rice marginal rate of transformation by allowing households to borrow against future harvests. In a recent study, Michler and Balagtas (2016) use consumption and net income data from rural households in Bangladesh to find that precautionary rice storage levels vary little across income quartiles.

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30% in maize after six months of storage (Affognon et al., 2015; Boxall, 2002; Golob, 2002). Faced with high rates of potential losses, selling maize at harvest may be an optimal strategy to avoid losses due to pest damage. Although some empirical evidence from Kenya, South America, and Ethiopia indicates that modern storage technologies such as hermetic (airtight) bags, metal silos, and/or chemical protectants may reduce losses from insect damage and thereby improve households' food and income security, access to these technologies is severely limited, particularly in sub-Saharan Africa (SSA; Bokusheva et al., 2012; Gitonga et al., 2013, Tesfaye and Tirivavi, 2018). Lack of access to effective storage technologies may prevent smallholder households from storing grain at harvest for consumption or sale later in the year. Yet, Kaminski and Christiaensen (2014) use nationally representative data from smallholder households in three countries in SSA (Malawi, Uganda, and Tanzania) and find that many smallholder farmers believe their postharvest losses (PHLs) are small (between 1.4% and 5.9% of self-reported quantity produced is reportedly lost in storage). Thus, these findings contrast with the entomology literature and therefore beg the question of how large these quantity losses actually are, and to what extent do expectations about these losses influence a smallholder household's grain management decisions?

The objective of the present article is to estimate the extent to which storage concerns and liquidity constraints affect the quantity of maize that a household decides to store at harvest for sale or consumption later in the year. We use two waves of household-level panel data from 309 smallholder households that cultivate maize in Benin. We specifically test two hypotheses: (1) whether the amount of maize that a household expects to lose due to pests has a statistically significant effect on the quantity of maize stored after harvest; and (2) whether liquidity constraints exert an influence over the quantity of maize stored after harvest. In the case of storage, we focus on a household's expectation of storage losses. We use information collected at the time of harvest about how much maize farmers expected to lose during subsequent storage due to mold, insects, and other pests. We measure a household's liquidity constraint as the amount of cash savings on hand at the beginning of the harvest. We also use the number of children in school during the current year for whom school expenses would need to be paid, as an additional proxy for liquidity constraints.

Despite a recognition of the economic importance of storage losses, the economics literature tends to embed storage loss and storage technology as components of overall storage costs rather than modeling them separately (see Brennan, 1958; Fuglie 1995; Park, 2006, Renkow, 1990; Saha and Stroud, 1994).[2] We contribute to the applied economics and food security literature by explicitly taking into account storage losses as a measure of the technology constraint that smallholders face, while simultaneously considering liquidity constraints in a household's maize allocation decision at harvest. Moreover, we measure the effects of these constraints by classifying households by what they say their goal was for their stored maize at the end of the harvest period.[3] Households may store maize for sale, consumption, future use as seed or some combination thereof. For the purpose of our analysis, we group households into two categories: market-oriented households and consumption-oriented households. The former includes those who store all or a share of their maize for sale during the postharvest season. The latter includes those who store maize for consumption or future use as seed, with no intention of selling it.

We address potential issues of endogeneity using a household-level fixed effect (FE) estimator to control for time-constant unobserved heterogeneity. Although households' risk aversion may be accounted for by households' unobserved heterogeneity, accounting for what households say their goal was for their stored maize may also reflect time-varying risk aversion and food consumption preferences for maize. By including this goal in the model, we can at least partially control for this issue. Although we strive to obtain unbiased estimates for the tested covariates, we recognize that we cannot make strong causal inference in the context of observational data. Nevertheless, this article highlights important associations between the tested covariates and households' decisions to store at harvest. Our results indicate that if a household stores maize with the intention of selling it later in the year, it will store less maize when it expects storage losses to be higher *ceteris paribus*. Conversely, when a household stores maize with the goal of consuming it, expected losses have no statistically significant effect on how much maize it stores. Having access to cash savings at harvest has the opposite effect: it does not affect the quantity of maize stored by households that store with the intention of selling it later in the year. However, having access to cash increases the quantity of maize stored by those who store with the intention of consuming it later in the year. Based on these findings, we conclude that consumption-oriented households and market-oriented households both tend to "sell low" at harvest time. However, the reasons differ. For the former, liquidity constraints appear to motivate sales; for the latter, storage constraints are the driver. This implies that a single policy intervention to encourage households to hold grain after harvest is unlikely to work for all smallholders. In the next section, we motivate our analysis by discussing the overall context of storage losses and maize marketing in Benin. We offer a brief conceptual framework that accommodates multiple motivations and multiple constraints on smallholder stockholding behavior. We then describe our data, empirical approach, and estimation

[2] A third strand of literature indicates that price risk affects the household's storage decision (see Park, 2006; Renkow, 1990; Saha and Stroud, 1994). However, these studies focus in South Asia, where the prevalence of multiple cropping seasons in a calendar year make intraseasonal price fluctuations much less severe, compared to the unimodal production systems in most parts of SSA where intraseasonal price fluctuations are much more pronounced. Since we have limited data for price series at the community level, we control for farmers' expectation about price increases in our empirical model, but do not make it a central part of the article.

[3] Food allocation decisions in rural areas of SSA are likely to reflect, at least partially, households' goals (Berkhout et al., 2010).

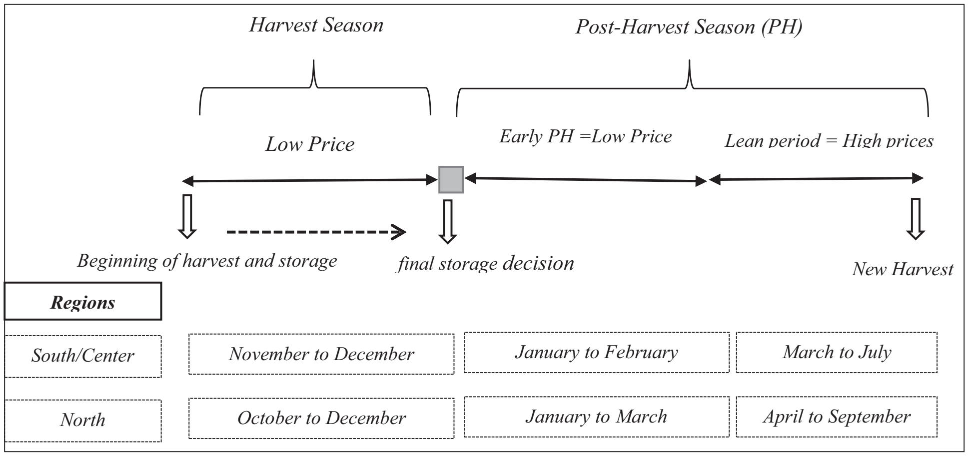

Fig. 1. Maize consumption and production cycle.
Notes: Fig. 1 presents the second harvest season in the South and Center; the first harvest season in these regions starts around July/August.

strategy. The final sections report econometric results and our conclusions.

2. Storage losses and maize marketing in Benin

2.1. Storage losses

Maize is the main staple crop for most people in Benin. Maize production and storage practices differ among regions due to local consumption patterns and maize's comparative advantages compared to other crops. Maize is largely produced for consumption in the south whereas in many regions from the center and north it is also an important cash crop.

PHL, especially storage losses, due to insect pests attacking stored maize continues to be a major threat to food and income security in Benin. The National Institute of Statistics in Benin estimates maize production to have been 1,165 million tons in 2011/2012. Data from our surveys suggest that total storage losses were about 8% on average in 2011/2012. Other studies estimate storage losses between 15% and 30% for maize in Benin depending on location (ADA, 2010). The dryer Sudan Savannah in the North records storage losses of 2.5%, while in the Guinea Savannah in the center of the country average storage losses can reach 10% (Adda et al., 2002). In contrast, higher average losses are observed in more humid areas such as southern Benin where insect pressure is also greater due to high air moisture and high temperatures that are both favorable for insect propagation. Storage losses in the south can reportedly reach 20–50% after six months of storage with traditional structures (Maboudou et al., 2004).[4]

Despite efforts to reduce storage losses through introduction of improved storage technologies in the late 1990s, storage practices remain largely traditional and thus create substantial risk of storage loss. More recent storage technologies, such as hermetic bags and metal silos, have had limited promotion in Benin. Application of chemical insecticides to stored maize remains the only modern technology that is widely used by households to prevent insect pest damage. Recommended insecticides such as Sophagrain and Actellic were promoted by projects that facilitated credit access and supplied these protectants (Adegbola, 2010). Unfortunately, the implementation of these projects did not address other long-term constraints to adoption of these new technologies such as high costs and availability of products (Adegbola, 2010). Thus, many households do not have access to appropriate storage technologies to store maize over an extended period. They still use traditional conservation measures or farm pesticides, especially chemicals intended for cotton, or other chemicals believed to be appropriate to deal with pest damage (Adegbola, 2010; Hell et al., 2008; PAN, 2010). Even though these inappropriate pesticides may preserve maize stock from pest damage, their common use among households raises serious health concerns. Unfortunately, there is no formal quality control mechanism in informal markets, which creates an information asymmetry between consumers and households that apply chemicals on maize.

2.2. Maize marketing

Maize price varies sharply within the marketing season in Benin. Even though the national food agency releases stocks to attempt to smooth out market supplies and limit price surges, our data indicate that average annual price increases within the season are 80% and can even reach 200% from harvest to lean period in some areas. Although the differences in the timing of harvest periods among the different regions of Benin contributes to reducing the imbalance of maize availability across the country, it does not come close to eliminating intra-seasonal price variability (Fig. 1).

Regardless, few smallholder households in Benin are likely to benefit from intra-seasonal price variability when they sell their

[4] Kaminski and Christiansen (2014) describe and estimate how postharvest losses could evolve over time and depending on climatic conditions.

maize. Most of them sell immediately after harvest or during the early postharvest period to pay prior-year debts for which payments are often due during this period or to face seasonal expenses.[5] As in many other West African countries, the harvest season in Benin coincides with religious and traditional celebrations and the beginning of the nine-month academic year. Primary and secondary schools start around September/October, which corresponds to the harvest seasons in many regions of Benin. Therefore, many liquidity-constrained households may be obligated to sell their maize at harvest to pay school expenses or other fees.[6] As such, they tend to be locked into the "sell-low," "buy-high" phenomenon. The ubiquity of this pattern makes Benin an ideal setting to study the factors associated with maize storage decisions.

3. Conceptual framework

The conceptual framework used in this article is a two-season additively separable utility maximization model adapted from Saha and Stroud (1994). The model encompasses one consumption cycle, starting with harvest and extending through the postharvest season, ending before the subsequent harvest. To evaluate households' grain storage, the harvest season is broadly understood as the beginning of maize harvest on farm until the end of harvest when all grain has been removed from the field and stored. Postharvest season starts when the household starts sourcing its grain from its stock or from market. This season ends at the beginning of the new harvest (see Fig. 1). We assume the household produces one main staple crop, maize. Production occurs prior to harvest and the start of the consumption cycle.

In each season (harvest and postharvest), the household obtains utility from consuming the main staple grain *M* and a composite nonfood good *Y*. The household's decision during the consumption cycle is then a utility maximization problem over the harvest season (subscript *H*) and the postharvest season (subscript *L*), as seen in Eq. (1).

$$\text{Max V} = U_H(M_H, Y_H) + \gamma\, E_H U_L(M_L,\ Y_L). \tag{1}$$

We assume the utility function *U* is twice differentiable; the term $E_H U_L$ represents the household's expectation at harvest time (when the storage decision is made) of utility in the postharvest season. The term γ is a scalar discount factor.

We build on Saha and Stroud by adding storage loss uncertainty to the interseasonal household model. If a household decides to store maize, access to effective storage technology is a precondition for successfully transferring grain from one season to another. Because there is no production during the postharvest season, grain available during that period depends on how effectively the storage technology can preserve maize stored at the end of the harvest season. Thus, the maize stock at the time of harvest can be viewed as an input into a transformation function via which the storage technology imperfectly converts harvested maize into postharvest supply. This storage constraint is defined as

$$\tilde{Q}_L = (1 - \tilde{\delta}_L(T))S_H \tag{2}$$

where the random variable $\tilde{Q}_L$ is the amount of maize available in the postharvest season following storage, *T* is the storage technology that the household uses to transfer grain between periods, and S_H is maize placed into storage at harvest time. The random parameter $\tilde{\delta}_L$ is the proportion of stored maize that is lost during storage. *Ex ante*, the distribution of $\tilde{\delta}_L$ depends on the storage technology. The actual storage loss is therefore not a strictly exogenous constant, as in standard models of household interseasonal decision making, but instead depends on a household's use of a storage technology. A central feature of the model is that the stochastic portion of maize losses may be important, which is especially germane in many developing countries where smallholders have limited access to improved storage technologies.

Limited access to effective technologies with low values of $\tilde{\delta}_L$ therefore exacerbates consumption and income risk for the household during the postharvest season. As a result, the household faces two identical constraints during the harvest and the postharvest seasons: a technology "grain balance" constraint and a liquidity constraint.

$$Q_H - S_H - I_H = M_H \tag{3a}$$

$$P_H I_H + B_{H-1} - B_H = Y_H \tag{3b}$$

$$\left(1 - \tilde{\delta}_L\right) S_H + A_L - S_L - I_L = M_L \tag{4a}$$

$$P_L\left[\left(1-\tilde{\delta}_L\right) S_H + A_L - S_L - M_L\right] + (1+r)B_H - P_L A_L = Y_L. \tag{4b}$$

Eq. (3a) defines grain balance at harvest. The household allocates the quantity produced (Q_H) among consumption (M_H) storage (S_H) and sale (I_H) during the harvest season. In Eq. (3b) liquidity during the harvest season comes from savings at the beginning of harvest season (B_{H-1}) and from maize sold (I_H) during harvest at the market price (P_H). The household can use its previous season savings (B_{H-1}) and sale revenues ($P_H I_H$) available at harvest to spend on other composite goods

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[5] In our sample, approximately 20% of total sales occur during the harvest season and 80% during the postharvest season. Data show that 80% of the most important sale transactions during the postharvest season occur during the early postharvest period and 20% during the lean period. Data also show that approximately 19% of households are net buyers, 17% autarkic, and 64% net sellers during the postharvest season. Fig. 1 explains in which period a household may sell maize in an agricultural cycle.

[6] Grimm (2011) uses evidence from Burkina Faso to show that households' income matters for school enrolment in settings where households face tight liquidity constraints caused by the lack of insurance and limited possibilities to smooth consumption through credit and savings.

(Y_H).[7] The household may also save money (B_H) at the end the harvest season, which earns interest at the rate r.

Eqs. (4a) and (4b) are defined in a similar fashion as Eqs. (3a) and (3b) with the subscript (L) representing the postharvest season. Eq. (4a) states that grain available during the postharvest season ($\tilde{Q}_L$) is obtained through the storage transformation function (Eq. (2)). The household can also source grain from the market (A_L) at postharvest season price (P_L). In Eq.(4a), S_L is the leftover from storage after all grain uses during the postharvest season. Eq. (4b) states that the household may sell maize (I_L) at price (P_L) and spend income and savings on nonfood goods (Y_L), while maintaining the liquidity balance.

After substituting Eqs. (3) and (4) into Eq. (1), we obtain a new objective function where we can derive the first-order condition (FOC) with respect to the storage decision at harvest.[8] Eq. (5) defines this FOC:

$$\frac{\partial V}{\partial S_H} \equiv \frac{\left(1 - E_H\tilde{\delta}_L\right)}{(1+r)} E_H P_L - P_H + \frac{\left(1 - E_H\tilde{\delta}_L\right)}{(1+r)} \times \frac{\text{cov}\left(U_{Y_L},\ P_L\right)}{E_H\ U_{Y_L}} - \frac{\text{cov}\left(U_{Y_L} P_L,\ \tilde{\delta}_L\right)}{(1+r)E_H\ U_{Y_L}}. \quad (5)$$

The above equilibrium can be written more compactly as

$$\frac{\partial V}{\partial S_H} \equiv \Delta P + \left(1 - E_H\tilde{\delta}_L\right)\Omega_0 - \Omega_1 = 0 \quad (6)$$

where $\Delta P = \frac{(1-E_H\tilde{\delta}_L)}{(1+r)} E_H P_L - P_H$ and $(1 - E_H\tilde{\delta}_L)\Omega_0 = \frac{(1-E_H\tilde{\delta}_L)}{(1+r)} \times \frac{\text{cov}(U_{Y_L},\ P_L)}{E_H\ U_{Y_L}}$ and $\Omega_1 = \frac{\text{cov}(U_{Y_L} P_L,\ \tilde{\delta}_L)}{(1+r)E_H\ U_{Y_L}}$.

Saha and Stroud define the parameter Ω_0 as the strength of the food security and price arbitrage motive. They underscore that under risk aversion, the coefficient of risk aversion is greater than income elasticity with respect to the demand for food consumption so that $\Omega_0 > 0$. Therefore, it is possible to have storage even if price change between seasons (ΔP) is less than or equals to zero. We build on Saha and Stroud by defining a parameter, Ω_1, as the strength of the storage technology risk, price risk, and the food security objective. This parameter does not appear in their original model, implying an assumed value of zero.[9] We instead postulate that Ω_1 might frequently differ from zero. For instance, if food security motives are stronger than cash needs, an increase in storage losses may decrease the marginal value assigned to other goods. This could reflect a situation in which a household must secure maize consumption by reducing consumption of other goods. However, the scale of the parameter Ω_1 depends on how strongly farmers value nonfood goods relative to maize. A household that stores maize with the intention to sell some or all of it might have a higher marginal value for other goods than a household that stores for consumption only. By contrast, a household that stores for consumption only might place a higher marginal value on maize than one intending to sell. For these reasons, a proper understanding of grain storage decisions as characterized in Eq. (6) must account not only for price change and risk but also for risks associated with storage, and must do so while considering a household's food security motive.

4. Data

4.1. Data collection

This study uses data from a survey conducted in 6 of the 12 departments in Benin. We first considered the three regions in Benin: North, Center, and South. In each region, we used reported maize yield to select the 50th percentile of the most productive areas among the departments. However, we retained one department, Toucoutouna in the North, because of the prevalence of food insecurity, even though it was not among the most productive areas. The other steps of the survey to identify the households were random. Two districts were randomly chosen within a given department. Counties, called "Commune," were also randomly selected in the district, followed by a random choice of villages. In the first stage, survey enumerators conducted a census of maize households in each of the 12 villages to identify the pool of households that produced maize. In the second stage, 30 households were randomly chosen among these households. Each household interviewed was the head of the household.

The survey covered a consumption cycle for each household (see Fig. 1) for the two waves of data collection, namely 2011/2012 and 2013/2014 harvest seasons. The first wave data cover 360 households, but only 309 of these households were successfully interviewed during the second wave or have data complete set of information.[10] We end up with a balanced sample of 309 households and 618 individual observations in the balanced panel. Unfortunately, there is no regression-based test for attrition bias when FE is used with only two time periods, as three periods of data are needed for such tests (Wooldridge, 2010). The regression models in our analysis control for attrition bias to the extent that any attrition is related to the observed covariates and/or time-constant, unobserved effects (Mason and Ricker-Gilbert, 2013; Mason and Smale, 2013). We also find few observable characteristics that explain a household's probability to be reinterviewed during the second wave

[7] The household may also spend on storage technologies and/or chemical protectant. To simplify our model, we consider that storage cost is negligible in our context, since many farmers have limited access to appropriate storage technologies and use traditional methods. We also consider that there is no maize purchase during the harvest season because there is plentiful grain in the household. But the household might purchase maize during the post-harvest season.

[8] The full derivation is presented in Appendix A.

[9] Saha and Stroud (1994) include the parameter (δ_l) in the storage cost, and therefore in ΔP. They also include the marginal cost of storage in ΔP.

[10] We drop one household that reported a cultivated area more than 51 times the sample average because it cannot be considered as a smallholder household.

Table 1
Descriptive statistics of continuous variables

Variables	Full sample Mean	2011 Mean	2013 Mean	=1 If HH's storage goal is consumption only Mean	=1 If HH's storage goal includes sales Mean	P-value[a]
Maize stored at harvest (kg)	2,555	2,343	2,768	1,643***	3,046***	(0.00)
	(4,4430)	(4,505)	(4,350)	(5,313)	(3,790)	
Quantity sold at harvest (kg)	208	285	130	178	223	(0.46)
	(773)	(1002)	(427)	(667)	(825)	
Expected storage losses[b] (%)	7.8	8.0	7.7	7.6	7.9	(0.75)
	(10.8)	(10.8)	(10.9)	(11.9)	(10.2)	
Savings (×1,000 F CFA)	131	87	175	82***	158***	(0.00)
	(298)	(247)	(335)	(155)	(348)	
Number of children in school	4	4	4	3*	4*	(0.07)
	(3)	(3)	(4)	(3)	(4)	
Harvest price (F CFA)	113	116	110	118**	110**	(0.03)
	(39)	(46)	(29)	(42)	(36)	
Expected price change between seasons % (F CFA)	84	82	86	87	82	(0.27)
	(45)	(54)	(41)	(48)	(44)	
Quantity available at harvest (kg)	3,014	2,848	3,187	2,013***	3,552***	(0.00)
	(4,760)	(4,953)	(4,560)	(5,500)	(4,220)	
Quantity produced at harvest (kg)	2,674	2,440	2,908	1,666***	3,221***	(0.00)
	(3,981)	(3,605)	(4,317)	(3,806)	(3,976)	
Farm size (ha)	4	4	5	3***	5***	(0.00)
	(5)	(4)	(6)	(3)	(6)	
Age	44	43	45	46***	43***	(0.01)
	(13)	(13)	(13)	(14)	(13)	
Household size (#)	11	11	11	10	11	(0.20)
	(6.1)	(6.3)	(5.9)	(7)	(6)	
Number of years in the association	4	3	4	3	4	(0.20)
	(6)	(6)	(7)	(6)	(6)	
Distance from main market (km)	6	6	6	6.4**	5.6**	(0.04)
	(5)	(5)	(5)	(5)	(5)	

Notes: Standard deviation in parentheses.
[a] *P*-value for *t*-test for mean difference between storage goal; $^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$.
[b] As measured in percentage of maize quantity stored from grain managements of previous years; U.S.$ 1.00 = 512 CFA Francs at the time of the survey.

(see Appendix B). In addition, we weight our sample by the inverse probability of selection to account for the probability that the household was randomly sampled for interview. Nevertheless, given our relatively small sample, we cannot make a strong claim that it is fully representative of all maize growers in Benin.

The survey focused on household grain management over different time periods owing to different geographic locations. The survey started in July when most households from the South were at the end of the small harvest season. Households in the North were interviewed in August, the lean period or the early beginning of the new harvest season.

4.2. Descriptive statistics for the main variables

When investigating the reason why households in our sample store maize, we find that 35% of them do so with the single goal of consuming it, while 60% do so with the goal of consuming and selling it. Only 5% of respondents store maize with the goal of only selling it. We group the two latter types of households under the category market-oriented households. By contrast, we define the former as a category of consumption-oriented households. We find that 79% of the households that were consumption-oriented households in 2011/2012 remain so in 2013/2014. Likewise, data show that 88% of market-oriented households do not change their status in the second wave of data collection. This pattern could suggest that households' storage goal reflect their long-term market participation status, and is thus quasi-fixed and less likely to be influenced by unobservable, time-varying factors.

We use the quantity (in kilograms) of maize stored at the end of the harvest season as the dependent variable in our estimation.[11] Table 1 shows that the average quantity of maize stored by consumption-oriented households is about 1,643 kg, whereas it is about 3,046 kg market-oriented households. Households store 82% and 86 % of the quantity available at harvest (i.e., the quantity produced plus carryover stock) in consumption-oriented and market-oriented households respectively. Because the distribution of quantity stored is skewed, we use its

[11] Only six observations have quantity stored at harvest that is greater than the quantity available at harvest (i.e., quantity produced plus carryover stock) because they received gifts from friends or purchased maize from markets.

Table 2
Descriptive statistic of discrete variables

Variables	Full	2011	2013	=1 If HH's storage goal is consumption only	=1 if HH's storage goal includes sales	P-value[a]
=1 if savings > 0	0.61	0.45	0.77	0.57*	0.64*	0.10
=1 if HH has access to credit	0.16	0.15	0.18	0.09***	0.20***	0.00
=1 if household uses chemical protectant	0.25	0.24	0.26	0.22	0.27	0.18
=1 if presence of input dealer in village	0.13	0.17	0.09	0.16	0.12	0.18
=1 if presence of extension agent in village	0.42	0.58	0.26	0.33***	0.47***	0.00
=1 if household (HH)'s head is male	0.91	0.91	0.91	0.90	0.91	0.83
=1 if HH's head attended school	0.37	0.37	0.37	0.43**	0.33**	0.02
=1 if household owns cell phone	0.57	0.38	0.75	0.56	0.57	0.69
Covariates for wealth index[b]						
=1 if household owns bike	0.52	0.47	0.57	0.47*	0.55*	0.06
=1 if household owns motorbike	0.55	0.44	0.66	0.51	0.57	0.15
=1 if household owns TV	0.22	0.17	0.27	0.22	0.22	0.98
=1 if household owns radio	0.62	0.48	0.77	0.59	0.64	0.28
=1 if household owns metallic roof	0.45	0.36	0.54	0.43	0.46	0.38
=1 if HHs stores for consumption only	0.35	0.34	0.36	1	0	n/a
=1 if HH stores for sale only	0.05	0.04	0.05	0	0.07	n/a
=1 if HH stores for both consumption and sale	0.60	0.62	0.59	0	0.83	n/a

Notes: The number of observation = 618 of which 35% are households that store for consumption only and 65% are households whose storage goal include sale.
[a] P-value for Chi^2 test for frequency difference between storage goal.
[b] Covariates used to construct an index from a principal component analysis.
$^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$; n/a = not applicable.

logarithm transformation as the final form of the dependent variable, quantity of maize stored.

The mean value for naïve expected storage loss is about 8% in each wave of data collection (see Table 1).[12] Thus, there is little change in the value of storage losses between survey waves, most likely because households follow the same storage practices across agricultural seasons. For instance, only 10% of households that do not use chemical protectant in the first year use it in the second year. In addition, we do not find a statistically significant difference for expected storage losses between households that store for sale and those who store for consumption only.

Given the limited access to credit in our sample, we prefer to use the amount of savings that the household owns at the beginning of harvest and the number of children in school as the key variables for liquidity constraints. We also adopt a log transformation for the savings variable to measure an elasticity of the liquidity effect on the storage supply in the households depending on this future uses of maize.[13] In Table 1, the average savings is about 131,000 F CFA (about U.S.$ 256) for the whole sample. Market-oriented households have twice as much money in savings as consumption-oriented households have. We find that the difference in savings between these two groups is statistically significant. The number of children enrolled in schools is about four on average. This enrolment rate has not substantially changed over the two years of the data collection whereas savings has increased on average. Likewise, market-oriented households enroll one more child than consumption-oriented households do on average, and the difference is statistically significant. Overall, we find that few households have recourse to formal or informal source of credits in our sample, as less than 16% of them have access to credit during the harvest period. By contrast, 61% of households in our sample have savings at the beginning of the harvest season (see Table 2).

5. Empirical model

The empirical specification for the maize storage decision after harvest of household (i) at time (t) is based on the following:

$$S_{it} = \alpha_1 \delta_{it}^{e} + \boldsymbol{L}_{it}\boldsymbol{\alpha}_2 + \mu_i + \varepsilon_{it}, \quad (7)$$

where S_{it} represents the log transformation of the kilograms of maize that the household stores at the end of the harvest for consumption, and/sales during the postharvest season. As explained in the conceptual framework, the variable ${\delta_l}_{it}^{e}$ represents the percentage of maize that a household expects to lose in storage (during the postharvest season) at the time it makes its storage decisions during harvest, and α_1 is the corresponding parameter to be estimated. Time-constant, unobservable household-level factors that affect S are represented by μ_i, and ε_{it} denotes the idiosyncratic time-varying error. We discuss our

[12] Actual storage losses (losses/quantity stored) were 6.6% for the entire sample, 7.7% in 2011 and 5.5% in 2013. The figures are 7.5% and 6.1% for consumption-oriented and market-oriented households, respectively. The difference between the two groups is statistically significant with P-value = 0.06.

[13] We use a log hyperbolic sine transformation function. We also use a binary indicator equals to one when a household has savings at the beginning of the harvest season and zero otherwise. Point estimates for the savings variable are similar in sign and statistical significance under this alternative specification in Appendix C.

approach for dealing with potential correlation between the error terms and the right-hand side variable in Eq. (7) in the identification strategy section.

We record information about expected storage losses by asking households the amount of maize that they expected to lose in a maize bag (mostly equivalent to 100 kg in capacity) at the time they were about to store maize.[14] We use this measure of a household's naïve expectation to measure expected storage losses, and test our first hypothesis, namely that expected storage losses have no statistically significant effect on the quantity of maize that a household stores. This is simply the one-sided test that $\alpha_1 < 0$ against the null hypothesis that the coefficient equals zero.

The vector $\boldsymbol{L}_{it}$ denotes liquidity constraints and $\boldsymbol{\alpha}_2$ represents the corresponding vector of parameters to be estimated. We test a second hypothesis, namely that the liquidity constraint has no statically significant effect on quantity stored. We conduct this test using the estimated coefficients for variables that proxy for the liquidity constraint: savings at the start of the harvest season (for which we expect the coefficient to be positive) and the number of children in school (for which we expect the point estimate to be negative). Many studies cite school expenses as major nonfood expenditure during the harvest season in Benin and elsewhere in SSA (Adegbola 2010; Burke, 2014; Grimm, 2011). To avoid potential simultaneity bias, we collected information on the number of children who were in school during the previous academic year, since the academic season coincides with the harvest season in Benin, as in many other West African countries.

To the parsimonious version of the regression represented by (7) we add a number of additional variables and interactions to control for and infer their correlation with the tested covariates. We include a binary indicator of the household's storage goal for its maize. The theoretical framework provides the economic rationale to include the storage goal (as a proxy for maize preference). Specifically, the variable takes the value one when the household stores for sale only or for both consumption and sales, and the variable equals zero if the maize storage goal is consumption only. As mentioned earlier, we refer to the first group as market-oriented households, and the second group as consumption-oriented households. We obtain this measure of storage goal from the response given by household heads by asking them their goals for storing maize at the point of decision to store. We also add interaction variables between the storage goal group variable and the tested covariates to account for the fact that the effect of expected storage losses and liquidity constraints might depend on households' storage goal as suggested in the conceptual framework. In so doing, we suggest that the effect of the tested covariates on the storage decision in consumption-oriented households might be different from the one in market-oriented households.

Other factors that likely condition the household's storage decision include the value of a household's durable assets, maize quantity available at harvest, harvest price and expected price difference between harvest and postharvest seasons (see Tables 1 and 2 for the full set of variables we include).[15]

6. Identification strategy

6.1. Omitted variable bias

Our first econometric challenge is to control for unobserved heterogeneity that could affect the tested covariates. Some households may be more aware of pest risk or some could be more talented and know how to manage pests without using chemical protectants on their stored maize (Ricker-Gilbert and Jones, 2015). In addition, each household's expectation of maize storage losses is potentially endogeneous because unobserved characteristics of individuals could determine both their expectation and their storage behavior (Attanasio, 2009; Delavande et al. 2011). The use of a household-level FE estimator in panel data allows us to address the issue of unobserved heterogeneity. The FE estimator demeans the data and in doing so removes unobserved heterogeneity, (μ_i) in Eq. (7) from the model.

In addition to using an FE estimator, we take the additional step of adding control variables to account for any remaining correlation between key covariates and time-varying unobservable factors. First, if expected storage losses depend on a household's past grain management experience, there could be a correlation between expected storage losses and the use of chemical storage protectant. Chemical protectant is an indirect input in a household's storage decision. Indeed, the decision to use chemical protectants mostly occurs during the planting season since most households use field pesticides to prevent maize stocks from pest damage. Some households may also want to recover their outlay on pesticides by storing maize and then selling it near to the next planting season. Nevertheless, controlling for chemical use in the model does not substantially

[14] Recall that the household reports its expected storage losses for the entire postharvest season based on its experiences from grain allocation, storage practices, and grain decay over time. We are confident in this measure because the accuracy of a respondent's expectations has been found to be high for reasonably common, regular occurring events and when expectation is obtained on short time horizon (Delavande et al., 2011). Whether bags of maize last one, two, three months or more, the household still reports its expectation based on the total amount usually lost during the storage period. Variables such as quantity of maize available at harvest and storage goal can also reflect how long a household may store grain and therefore control for duration of storage.

[15] Although a binary indicator for year may account for inflation and other time-trend effects, it does not substantially change the estimates and the statistical significance of our estimates (Appendix D). Since there is no price series available in all the 12 communities of our sample, we obtain naïve price expectation by asking households their expectation about postharvest season price at the time they were about to store maize. Their naïve price expectation could also indicate their transactions costs and bargaining powers that are not necessary reflected in aggregate price time series at the village level. We use the village-level price as the most realistic prices for farmers who do not sell at harvest. We also use the mean average of expected prices at the village level for farmers who do not intend to sell during the postharvest season.

change the estimate and the statistical significance of the tested covariates (Columns 1 and 2, Appendix D). We also account for the presence of an input dealer in the village. This covariate might be an implicit indicator of the level of pest infestation and rural market development in the community. Similarly, we consider the presence of an extension agent who resides in the village to suggest how easily a household may have access to information about storage practices as well as markets. We also ensure that the tested covariates for liquidity constraints are exogenous, by controlling for whether a household can access to credit (formal and/or informal) in the community during the harvest season. Access to credit does not substantially modify the estimates and the statistical significance of the tested covariates (Columns 1 and 3, Appendix D). The time-varying error term in Eq. (7) is assumed to be i.i.d. normally distributed, after using FE and adding the additional time-varying controls mentioned above.

6.2. *Potential endogeneity of a household's storage goal*

Omitted variable bias could also potentially arise if a household's storage goal is not accounted for. As postulated in the conceptual framework, a household's storage goal is important because it accounts for the food security motive and level of risk aversion. However, the storage goal is a choice variable. Some unobserved characteristics that influence the probability that a household chooses a storage goal could also influence the quantity stored once the household decides to store for future sales or consumption in the postharvest season. Nevertheless, evidence shows that there is no substantial change in the estimate and the statistical significance of the tested covariates whether storage goal is included in or omitted from the model (Columns 2 and 3, Appendix E1).[16] Such a result is also consistent with past studies that find that accounting for households' goal with respect to market participation does not create large endogeneity bias in food allocation decisions (Berkhout et al., 2010). It could be that a household's storage goal reflects long-term maize preference and market participation status. In addition, it could be that the storage goal is correlated with time-constant unobservable factors, and/or production decisions that occur before storage, and as a result using a household-level FE estimator and accounting for maize production may take care of this potential endogeneity issue.

6.3. *Reverse causality and simultaneity bias*

We use the household's expectation about storage losses as the main covariate for the storage technology constraint. Expectations are indeed useful predictors of economic behavior, but their validity depends on the different methods used for eliciting such information (Delavande et al., 2011). That we obtain expected storage losses from the respondent household head's direct elicitation at the time when storage losses have already occurred may raise concerns of possible reverse causality. However, we model maize prices and storage losses naïvely, based on prior experience with storage losses and grain management. In fact, a household's storage practices and expectation about storage losses change little across agricultural seasons. As such, we remain confident that respondents state their expectation about storage losses based on their experience in grain management from the previous year. Simultaneity bias is unlikely to be an issue for the same reasons. Likewise, the variables for savings and the number of children in school are both determined prior to the storage decision. Households report their savings at the beginning of the harvest season. They also indicate the number of children in school during the academic year preceding the survey. Thus, we can also likely rule out any reverse causality and simultaneity bias concerning these variables.

7. Econometric results

Table 3 presents the results for factors affecting the amount of maize that the household stores at the end of the harvest season for use later in the year. Results are obtained using a household-level FE estimator.[17] Model (1) presents the results of the parsimonious regression that includes only the covariates related to our main research objectives, and a constant, while model (2) adds additional controls to the model. In model (3) we consider the parsimonious regression along with an interaction term between the tested covariates and households' storage goals, where the variable store for sale equals one if the household's storage goal for maize includes selling it in the postharvest season (i.e., market-oriented households). We estimate a model (4) that represents the full specification of the model (3).

In models (1) and (2), we find that the estimate for expected storage losses has a negative effect on the amount of maize a household stores at harvest. Although the sign of the estimate makes economic sense, it is only statistically significant in model (1), and loses statistical significance when additional controls are added in model (2). However, models (3) and (4) show that the effect of expected storage losses on the storage

[16] We also test for the potential endogeneity of storage goal by following a control function approach, where we first estimate the factors that affect storage goal and then control for omitted variable bias with the generalized residual derived obtain from the probit equation. We do not find that farmers' goal is endogenous (Columns 1–1 and 1–2, Appendix E1). We allow different coefficients across two storage goals and follow an approach recently proposed by Murtazashivili and Wooldridge (2016). We do not find evidence of selection bias (Columns 1–1 and 1–2, Appendix E2). Note that we obtain results in Appendices E1 (Columns 1–1 and 1–2) and E2 (Columns 1–1 and 1–2) using a CRE (correlated random effect [RE]) estimator. The CRE controls for a household's unobserved heterogeneity by modeling it as a linear function of the time average of all time-varying covariates. The CRE provides estimates analogous to the FE. Our main results for the full sample remain also valid when the sample is separated in two groups of households depending on their storage goal (see Appendix E3).

[17] We carried out a Haussmann test to find that the null hypothesis of efficient and consistent estimator of the RE is rejected against the FE estimator with P-value < 0.01. Our results are also unchanged when we cluster the standard errors at the village level. Appendix F also presents the FE results benchmarked against the OLS estimations (as requested by a referee).

Table 3
Factors that affect the amount of maize stored at harvest (fixed-effect estimator used)

Dependent variable = Log(Quantity Stored)	(1) Parsimonious	(2) Full	(3) Parsimonious + Interaction term[a]	(4) Full + Interaction term[a]
Expected losses (×100)	−0.0148*	−0.0085	−0.0013	0.0013
	(0.0078)	(0.0062)	(0.0057)	(0.0055)
Log (Savings)	0.0097**	0.0035	0.0246**	0.0105*
	(0.0046)	(0.0035)	(0.0101)	(0.0060)
No. of children in school	0.0335	−0.0156	0.0049	−0.0619
	(0.0490)	(0.0344)	(0.0597)	(0.0400)
Store for sale[b] × Expected Losses (×100)			−0.0383***	−0.0275***
			(0.0109)	(0.0092)
Store for sale × Log (Savings)			−0.0218*	−0.0088
			(0.0111)	(0.0067)
Store for sale × No. of children in School			0.0328	0.0617**
			(0.0444)	(0.0310)
Store for sale		0.4198***	0.9992***	0.6190***
		(0.1157)	(0.2627)	(0.1962)
Harvest price (F CFA/kg)		−0.0030***		−0.0035***
		(0.0011)		(0.0011)
Expect. price change (F CFA/kg)		−0.0006		−0.0005
		(0.0010)		(0.0010)
Quantity available at harvest (kg)		0.0002***		0.0002***
		(2.2E-05)		(2.2E-05)
Household size		0.0092		0.0114
		(0.0113)		(0.0113)
Total farm size (ha)		0.0092		0.0093
		(0.0157)		(0.0148)
Wealth index		0.0941**		0.0870*
		(0.0475)		(0.0461)
=1 if HH owns a cell phone		0.1671		0.1427
		(0.1022)		(0.0990)
=1 if input dealer in village		0.1023		0.0757
		(0.1337)		(0.1355)
=1 if extension agent in village		0.1085		0.1367
		(0.0938)		(0.0951)
Constant	7.0826***	6.4689***	6.4928***	6.4289***
	(0.1895)	(0.2734)	(0.2532)	(0.2737)
Observations	618	618	618	618
Adjusted R^2	0.0365	0.4820	0.1145	0.5010

Notes: Robust standard errors in parentheses with cluster at the household level; data are weighted by the inverse probability of selection.
*** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.
[a]Interaction term between household's storage goal and the tested covariates (expected storage losses, savings, and number of children in school); U.S.$ 1.00 = 512 CFA Francs at the time of the survey.
[b]Store for sale = 1 if household's storage goal for maize includes selling it later in the agricultural season and zero otherwise.

decision could be better understood by accounting for the interaction term between the tested covariates and a household's storage goal. In these specifications, we find that the coefficient estimate on expected storage losses has a statistically significant and negative effect on the quantity of maize stored for market-oriented households only. In model (4), the joint *t*-test for the statistical significance of expected storage losses and its interaction with the variable store for sale equals one (market-oriented households) has a *P*-value equals (0.00). The joint estimate suggests that a 1% point increase in expected storage losses results in about 2.6 % decrease in the quantity of maize store at harvest in market-oriented households. Therefore, for market-oriented households that store maize at harvest for sale later in the year, we can reject hypothesis (1) that the amount of maize that a household expects to lose due to pests has no statistically significant effect on the quantity of maize that a household stores after harvest. This result makes sense as the covariate expected storage losses could represent an important operational cost that market-oriented households do not want to bear because it has a negative effect on their income. Instead, the fact that we find no statistically significant effect of expected storage losses on quantity of maize stored for consumption-oriented households is likely because they have no other option but to bear the cost of losing maize to insect pests in storage.

The estimate for liquidity constraint, first measured as the value of savings at harvest, affects maize storage is also quite robust across specifications in Table 3. In model (1) where there is a parsimonious estimation with no interaction term, we find that a 1% increase in savings increases the quantity of maize stored at harvest by nearly 0.01%. This result seems to suggest that households that have greater liquidity before the harvest season store more maize on average. Yet the coefficient loses statistical significance in the full estimation in model (2). As we might expect by relying on the theoretical framework, we obtain insights from differentiating the effect of savings by households' storage goal. Results in models (3) and (4) suggest that consumption-oriented households store more maize when they have more savings at the beginning of the harvest season. These results are therefore consistent with one strand of the literature underscoring that access to credit improves interseasonal household decision (Burke 2014; Stephens and Barrett, 2011). Model (4) suggests that a 1% increase in savings for consumption-oriented households increases the quantity of maize stored by 0.01% for this group on average. Therefore, for consumption-oriented households, we can reject the hypothesis (2) that the liquidity constraint has no statically significant effect on quantity stored. Although the estimate is not large, the joint *t*-test for savings and its interaction with households' storage goal shows, on the contrary, that in market-oriented households, the elasticity of the savings effect on the storage decision is almost zero in economic magnitude in model (3) (2.8E − 03) and not statistically significant in model (4). Likewise, the effect of the number of children in school is not statistically significant in market-oriented households. The coefficient estimate on this variable has the expected negative effect in consumption-oriented households, but it is also not statistically significant.[18]

These results reveal that consumption-oriented households need liquidity at the beginning of the harvest seasons more than market-oriented households do. This result is logical since it is easier for consumption-oriented households to meet food consumption needs at harvest than it is for them to purchase nonfood items. On the contrary, our results could suggest that market-oriented households are less reliant on short-term liquidity constraints to make interseasonal household decisions about storage. One could imagine that even if these households have no access to credit markets at all, they may still achieve a high degree of intertemporal consumption smoothing through the use of assets as buffers (Deaton, 1991). Indeed, we find that households' assets have a positive and statistical effect on the amount of maize stored at harvest, which is consistent with earlier research from elsewhere in SSA (Stephens and Barrett, 2011).

7.1. Study limitations

Several caveats should be kept in mind when considering our results. First, it is possible that our estimates could gain efficiency by modeling household storage decisions jointly with other decision variables during the harvest period such as consumption or sales. However, we believe that broader economic incentives of storage, food consumption, labor, and chemical use are not necessary for our estimation. Because our main interest is to obtain consistent coefficient estimates for the tested covariates, we sacrifice some possible efficiency for consistency in a well-specified and estimated single equation. Second, food consumption varies little during the harvest season when maize is plentiful, so the consumption decision is already accounted for with the observable covariates including the household's storage goals and size, along with using an FE estimator to control for unobserved heterogeneity. Third, any harvest and input decision has mainly a recursive effect on storage through the quantity of maize available at harvest and/or the tested covariates, and this has already been addressed in our analysis.

8. Conclusion

In this article, we extend previous models of a smallholder farm household's decisions about grain storage. We account for technology and liquidity constraints, while controlling for whether households store maize with the main goal of consumption or sale. Specifically, we test how a household's expectation about storage losses along with its liquidity at harvest, proxied by its savings and the number of children in school affect its decision to store maize at harvest. In doing so, this article helps explain important postharvest decision-making factors faced by smallholder farm households in the developing world. This is extremely relevant to policy actions amidst the growing interests for reducing PHLs and improving grain management in SSA (Affognon et al., 2015; Kaminski and Christiaensen, 2014; World Bank, 2011).

Although we refrain from making strong causal inferences from observational data, our results are consistent with previous findings. In addition, they extend the literature by providing insights based on a household's goals of storing maize for home consumption and/or for selling. Our key findings are as follows. First, we find that expected storage losses deter households whose storage goal for maize includes storing it for sale later in the year from storing more maize at harvest. This may occur because these more market-oriented households likely view storage losses as an operational cost that they want to minimize. Second, we suggest that liquidity matters more in households that mainly store maize for food consumption than in households whose storage goal includes sale during the postharvest season. Therefore, we conclude that liquidity constraints cause consumption-oriented households to sell maize for a low price at harvest, whereas storage technology constraints drive market-oriented households to "sell low" as well.

These results show that PHLs cannot be neglected in rural households' decisions about grain management. Lower losses reported in some recent studies, such as Kaminski and Christiaensen (2014) could, in fact, come from concerns that

[18] In model 4, the coefficient estimate for number of children in school shows that one additional child in school reduces the quantity stored by 6% in consumption-oriented households, but with *P*-value = 0.12. This coefficient is about zero in economic magnitude (0.02%) in market-oriented households, and the *P*-value of the joint *t*-test is also about 0.12.

smallholders have about storage losses given the current ineffective technologies available to them. Our results suggest that concerns about storage losses cause some households to store less at harvest and sell early in the postharvest season for a lower price rather than storing in hopes of obtaining a higher price later in the year.

Overall, evidence underscore the importance of policies that seek to improve grain management for smallholders in SSA. Our findings call for policies that promote modern storage technology alongside liquidity access, but with different targeting mechanisms depending on a household's current goal for storing its maize. For example, in areas where smallholders are more consumption-oriented, the main constraint appears to be the limited access to liquidity that could trap these households in a cycle of food insecurity. Yet many consumption-oriented households are hardly viable borrowers because they are relatively costly to serve (Hardaker et al., 1998). In this case, short-term cash transfers, assistance in organizing households into village savings groups, or providing linkages to microfinance institutions could help relieve these constraints. In contrast, policies that promote better access to modern storage technologies could contribute to reducing the quantity of maize that smallholders lose in storage. This would seem to be particularly beneficial to market-oriented households that view storage losses as a cost that they want to reduce.

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Appendix A: An interseasonal household model with storage technology constraint adapted from Saha and Stroud (1994)

Objective function

$$\text{Max V} = U_H(M_H,\ Y_H) + \gamma\ E_H U_L(M_L,\ Y_L). \tag{A.1}$$

Technology constraint in interseasonal decision

$$\tilde{Q}_L = \left(1 - \tilde{\delta}_L(T)\right) S_H \tag{A.2}$$

Other constraints

$$Q_H - S_H - I_H = \boldsymbol{M_H} \quad (\textit{Quantity balance during harvest season}) \tag{A.3a}$$

$$P_H I_H + B_{H-1} - B_H = Y_H \quad (\textit{Liquidity balance during harvest season}) \tag{A.3b}$$

Accounting for (A.3a) we can rewrite Eq. (A.3b) as follows:

$$\boldsymbol{P_H}\left(\boldsymbol{Q_H} - \boldsymbol{S_H} - \ \boldsymbol{M_H}\right) + \boldsymbol{B}_{\boldsymbol{H}-1} - \boldsymbol{B_H} = Y_H \tag{A.3c}$$

$$\tilde{Q}_L + A_L - S_l - I_l = M_L \quad (\textit{Quantity balance during post} - \textit{harvest season}) \tag{A.4a}$$

Accounting for Eq. (A.2) we can rewrite Eq. (A.4a) as follows:

$$\left(1 - \tilde{\delta}_L\right) S_H + A_L - S_l - I_l \ = \boldsymbol{M_L} \tag{A.4b}$$

$$P_L I_L + (1+r)B_H - P_L A_L = Y_L \quad (\textit{Liquidity balance during post} - \textit{harvest season}) \tag{A.4c}$$

Accounting for Eq. (A.4b) we can rewrite Eq. (A.4c) as follows:

$$P_L\left[\left(1-\tilde{\delta}_L\right) S_H + A_L - S_l - M_L\right] + (1+r)B_H - P_L A_L = Y_L \tag{A.4d}$$

$$\boldsymbol{P_L}\left[\left(1 - \tilde{\boldsymbol{\delta}}_{\boldsymbol{L}}\right) \boldsymbol{S_H} - \boldsymbol{S_l} - \boldsymbol{M_L}\right] + (1 + \boldsymbol{r})\, \boldsymbol{B_H} = Y_L \tag{A.4e}$$

Objective function modified when sales are residual

$$\begin{aligned} Max\ V = &\ U_H\{\ M_H,\ P_H\,(Q_H - S_H - M_H) + B_{H-1} - B_H\} \\ &+ \gamma\, E_H U_L\{\ M_l,\ \ P_l[\left(1 - \tilde{\delta}_L\ \right) S_H - S_l - M_L] \\ &+ (1+r)\, B_H\ \} \end{aligned} \tag{A.5}$$

FOCs with respect to three endogenous variables (consumption, savings, & storage)

$$\frac{\partial V}{\partial M_H} \equiv U_{M_H} - P_H\ U_{Y_H} = 0 \tag{A.6}$$

$$\frac{\partial V}{\partial B_H} \equiv -U_{Y_H} + \gamma\,(1+r)\,E_H\; U_{Y_L} = 0 \tag{A.7a}$$

Eq. (A.7a) implies:

$$U_{Y_H} = \gamma\,(1+r)\,E_H\; U_{Y_L} \tag{A.7b}$$

$$\frac{\partial V}{\partial S_H} \equiv -P_H\,U_{Y_H} + \gamma\; E_H\left\{U_{Y_L}\,P_L\left(1-\tilde{\delta}_L\right)\right\} = 0 \tag{A.8a}$$

$$\frac{\partial V}{\partial S_H} \equiv -P_H U_{Y_H} + \gamma\; E_H(U_{Y_L}P_L) - \gamma\; E_H\left(U_{Y_l}P_L\tilde{\delta}_L\right) = 0 \tag{A.8b}$$

$$\frac{\partial V}{\partial S_H} \equiv -P_H U_{Y_H} + \;\gamma(1-E_H\tilde{\delta}_L)\;E_H\left(\;U_{Y_L}P_L\right) - \gamma\; cov\left(U_{Y_L}P_L,\;\tilde{\delta}_L\right) \;= 0 \tag{A.8c}$$

$$\frac{\partial V}{\partial S_H} \equiv -P_H U_{Y_H} + \;\gamma\left(1-E_H\tilde{\delta}_L\right)\left[\;E_H\left(\;U_{Y_L}\right)\;E_H(P_L) + \;cov\left(U_{Y_L},P_L\right)\right] - \gamma\; cov\left(U_{Y_L}P_L,\;\tilde{\delta}_L\right) \;= 0 \tag{A.8d}$$

Accounting for Eq. (A.7b), we can rewrite Eq. (A.8d) as follows:

$$-\;P_H\;\gamma\,(1+r)\,E_H\;U_{Y_L} + \;\gamma\left(1-E_H\tilde{\delta}_L\right)\left[\;E_H\;(U_{Y_L})\;\;E_H(P_L) + \;cov\left(U_{Y_L},P_L\right)\right] - \gamma\; cov\left(U_{Y_L}P_L,\;\tilde{\delta}_L\right) = 0 \tag{A.9a}$$

Diving Eq. (A.9a) by $\gamma(1+r)E_H\;U_{Y_L}$

$$-\;P_H + \;\left(1-E_H\tilde{\delta}_L\right)\frac{E_H P_L}{1+r} + \frac{\left(1-E_H\tilde{\delta}_L\right)\;cov\left(U_{Y_L},P_L\right)}{(1+r)\,E_H\;U_{Y_L}} - \;\frac{cov\left(U_{Y_L}P_L,\;\tilde{\delta}_L\right)}{(1+r)\,E_H\;U_{Y_L}} = 0 \tag{A.9b}$$

Arranging the terms, we obtain

$$\frac{\partial V}{\partial S_H} \;\equiv \frac{\left(1-E_H\tilde{\delta}_L\right)}{(1+r)}\;E_H P_L - P_H + \frac{\left(1-E_H\tilde{\delta}_L\right)}{(1+r)}\frac{cov\left(U_{Y_L},\;P_L\right)}{E_H\;U_{Y_L}} - \frac{cov\left(U_{Y_L}P_L,\;\tilde{\delta}_L\right)}{(1+r)\,E_H\;U_{Y_L}} \tag{A.9c}$$

More compactly

$$\frac{\partial V}{\partial S_H} \;\equiv \Delta P + \left(1-E_H\tilde{\delta}_L\right)\;\Omega_0 - \Omega_1 = 0 \tag{A.9d}$$

Where $\Delta P = \frac{(1-E_H\tilde{\delta}_L)}{(1+r)}\;E_H P_L - P_H$

$$\left(1-E_H\tilde{\delta}_L\right)\Omega_0 = \frac{\left(1-E_H\tilde{\delta}_L\right)}{(1+r)}\;\frac{cov\left(U_{Y_L},\;P_L\right)}{E_H\;U_{Y_L}}\;\textit{and}$$

$$\Omega_1 = \frac{cov\left(U_{Y_L}P_L,\;\tilde{\delta}_L\right)}{(1+r)\,E_H\;U_{Y_L}}$$

Appendix B: Probability for a household to be re-interviewed in the wave 2 (Attrition bias)

Dependent Var. = 1 if HH Head is interviewed twice (Wave 1 & 2)	Average partial effect (APE)
Expected Losses (%)	2.37E-03
	(1.97E-03)
Log(Savings)	1.01E-03
	(2.1E-03)
Harvest prices (F CFA/kg)	9.93E-04
	(8.98E-04)
Expected price change (F CFA/kg)	4.30E-04
	(4.68E-04)
Quantity available at harvest (kg)	−7.19E-06
	(5.41E-06)
=1 if HH's head attended school	7.84E-04
	(0.0490)
=1 if HH head is male	−0.0250
	(0.0666)
Age	−4.54E-04
	(0.00248)
# Years in the village	0.00255
	(0.00188)
Total farm size (Ha)	0.0234*
	(0.0134)
Distance from market (Km)	0.00155
	(0.00527)
=1 if Input dealer in village	−0.0447
	(0.0937)
=1 if extension agent in village	−0.0274
	(0.0530)
Constant	−0.6288
	(0.8303)
Department dummies included	Yes
Observations	354
Pseudo R-squared	0.070

Notes: Standard errors in parentheses$^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$; 1 household was an outlier for production size, 5 observations were dropped because of missing or inconsistent information during the second wave of data collection; the number of children in school for wave 1 was obtained as a recall variable during the second wave, and therefore could not be collected for dropped households; US$ 1.00 = 512 CFA Francs at the time of the survey.

Appendix C: Factors that affect the amount of maize stored at harvest – Alternative measure for savings (Fixed Effect estimator used)

Dependent variable = Log(Quantity Stored)	Main results
Expected losses (%)	0.0010
	(0.0054)
=1 if Savings > 0	0.2275*
	(0.1285)
# of children in school	−0.0614
	(0.0399)
Store for sale[a] x Exp. Losses	−0.0272***
	(0.0092)
Store for sale x (= 1 if Savings > 0)	−0.1956
	(0.1496)
Store for sale x (# of children in school)	0.0609**
	(0.0309)
Store for sale	0.6279***
	(0.1971)
Harvest price (F CFA/kg)	−0.0035***
	(0.0011)
Expected price change (F CFA/kg)	−0.0005
	(0.0010)
Qty. available at harvest (kg)	0.0002***
	(2.2E-05)
Household size	0.0110
	(0.0113)
Total farm size (Ha)	0.0095
	(0.0148)
Wealth index	0.0879*
	(0.0463)
=1 if HH owns a cell phone	0.1473
	(0.0983)
=1 if Input dealer in village	0.0765
	(0.1360)
=1 if extension agent in village	0.1347
	(0.0948)
Constant	6.4265***
	(0.2731)
Observations	618
Adjusted R^2	0.5005

Notes: Robust standard errors in parentheses; *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.
[a]Store for sale = 1 if household's storage goal for maize includes selling it later in the year, otherwise it takes the value zero; US$ 1.00 = 512 CFA Francs at the time of the survey.

Appendix D: Factors that affect the amount of maize stored at harvest – Additional covariates (Fixed Effect estimator used)

Dependent variable = Log(Quantity Stored)	(1) Main regression	(2) Main + Chemical protectant	(3) Main + Access to credit	(4) Main + Time dummy
Expected losses (%)	0.0013	0.00210	0.0012	0.0011
	(0.0055)	(0.0055)	(0.0056)	(0.0056)
Log (Savings)	0.0105*	0.0102*	0.0104*	0.0111*
	(0.0060)	(0.0059)	(0.0060)	(0.0061)
Number of children in school	−0.0619	−0.0597	−0.06112	−0.0618
	(0.0400)	(0.0408)	(0.04032)	(0.0399)
Store for sale[a] x Exp. Losses	−0.0275***	−0.0275***	−0.02687***	−0.0274***
	(0.0092)	(0.0091)	(0.00932)	(0.0091)
Store for sale x Log(Savings)	−0.0088	−0.0084	−0.0089	−0.0089
	(0.0067)	(0.0067)	(0.0067)	(0.0067)
Store for sale x (# of child. in school)	0.0617**	0.0622**	0.0626**	0.0660**
	(0.0310)	(0.0310)	(0.0315)	(0.0311)
Store for sale	0.6190***	0.6161***	0.6253***	0.6030***
	(0.1962)	(0.1989)	(0.1963)	(0.1968)
=1 if HH uses chemical protectant		0.1090		
		(0.1422)		
=1 if HH has access to credit			−0.0811	
			(0.0818)	
=1 if panel is second wave				−0.0628
				(0.0745)
Harvest price (F CFA/kg)	−0.0035***	−0.0033***	−0.0035***	−0.0035***
	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Expected price change (F CFA/kg)	−0.0005	−0.0006	−0.0005	−0.0005
	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Qty. available at harvest (kg)	0.0002***	0.0002***	0.0002***	0.0002***
	(2.1E-05)	(2.1E-05)	(2.1E-05)	(2.2E-05)
Household size	0.0114	0.01292	0.0111	0.0120
	(0.0113)	(0.01135)	(0.0113)	(0.0115)
Total farm size (Ha)	0.0093	0.0098	0.0101	0.0104
	(0.0148)	(0.0148)	(0.0149)	(0.0147)
Wealth index	0.0870*	0.0874*	0.0865*	0.0982*
	(0.0461)	(0.0469)	(0.0460)	(0.0506)
=1 if HH owns a cell phone	0.1427	0.1456	0.1494	0.1561
	(0.0990)	(0.0992)	(0.0995)	(0.1037)
=1 if Input dealer in village	0.0757	0.0608	0.0555	0.0483
	(0.1355)	(0.1377)	(0.1333)	(0.1318)
=1 if extension agent in village	0.1367	0.1362	0.1345	0.1017
	(0.0951)	(0.0955)	(0.0953)	(0.0865)
Constant	6.4289***	6.3822***	6.4353***	6.4621***
	(0.2737)	(0.2848)	(0.2743)	(0.2702)
Observations	618	618	618	618
Adjusted R-squared	0.5010	0.5018	0.5015	0.5011

Notes: Robust standard errors in parentheses; $^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$.
[a]Store for sale = 1 if household's storage goal for maize includes selling it later in the year, otherwise it takes the value zero; US$ 1.00 = 512 CFA Francs at the time of the survey.

Appendix E1: Test of endogeneity for storage goal (Intercept effect)

	(1–1) Store for sale[a] Probit-CRE	(1–2) Log (Qty stored) OLS-CRE	(2) Log (Qty stored) FE	(3) Log (Qty stored) FE
Nb. years in associations/groups	0.0052*			
	(0.0028)			
Residuals		0.1190		
		(0.3608)		
Store for sale[a]		0.2449	0.4198***	
		(0.5969)	(0.1157)	
Expected losses (%)	−0.0026	−0.0090	−0.0085	−0.0096
	(0.0040)	(0.0076)	(0.0062)	(0.0065)
Log (Savings)	0.0011	0.0038	0.0035	0.0041
	(0.0019)	(0.0037)	(0.0035)	(0.0036)
Number of children in school	0.0270	−0.0101	−0.0156	−0.0034
	(0.0172)	(0.0410)	(0.0344)	(0.0361)
Harvest price (F CFA/kg)	−0.0007	−0.0032**	−0.0030***	−0.0034***
	(0.0007)	(0.0014)	(0.0011)	(0.0012)
Exp. price change (F CFA/kg)	−0.0003	−0.0007	−0.0006	−0.0008
	(0.0004)	(0.0012)	(0.0010)	(0.0011)
Qty. available at harvest (kg)	7.4E-04	0.0002***	0.0002***	0.0002***
	(4.8E-06)	(2.3E-05)	(2.2E-05)	(2.2E-05)
Household size	−0.0030	0.0088	0.0092	0.0081
	(0.0041)	(0.0124)	(0.0113)	(0.0115)
Total farm size (Ha)	−0.0078	0.0088	0.0092	0.0079
	(0.0100)	(0.0161)	(0.0157)	(0.0167)
Wealth index	0.0058	0.0957*	0.0941**	0.0949*
	(0.0257)	(0.0499)	(0.0475)	(0.0500)
=1 if HH owns a cell phone	−0.0890	0.1522	0.1671	0.1272
	(0.0560)	(0.1231)	(0.1022)	(0.1020)
=1 if input dealer in village	−0.0089	0.0980	0.1023	0.0995
	(0.0428)	(0.1508)	(0.1337)	(0.1341)
=1 if extension agent in village	−0.0182	0.1027	0.1085	0.1045
	(0.0480)	(0.1019)	(0.0938)	(0.0982)
Age	0.0003	−0.0036		
	(0.0020)	(0.0031)		
=1 if HH's head attended school	−0.0498	−0.0806		
	(0.0524)	(0.1020)		
=1 if HH is male	0.0413	0.2333*		
	(0.0868)	(0.1398)		
Distance from main mark. (Km)	0.0048	0.0068		
	(0.0061)	(0.0134)		
Department dummies	Yes	Yes		
Time Average	Yes	Yes		
Constant	−1.0300	5.2345***	6.4689***	6.8156***
	(0.8832)	(0.3973)	(0.2734)	(0.2488)
Observations	618	618	618	618
Pseudo/Adjusted R^2	0.1887	0.7526	0.4820	0.4550

Notes: [a]Store for sale = 1 if household's storage goal for maize includes selling it later in the year; Robust standard errors in parentheses and bootstrapped in column 1–2; $^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$; US$ 1.00 = 512 CFA Francs at the time of the survey.

Appendix E2: Test of endogeneity switching effect for storage goal (Slope effect)

	Endogenous switching regression 1–1 Store for sale[a] Probit-CRE	1–2 Log(Qty. stored) FE-Coef.	Without endogenous 2-Log (Quantity Stored) FE-Coef.
# Years in associations/groups	0.0052*		
	(0.0028)		
Residuals		0.3297	
		(0.6145)	
Residuals x Store for sale[a]		0.2200	
		(0.4802)	
Expected losses (%)	−0.0026	−0.0018	0.0013
	(0.0040)	(0.0114)	(0.0055)
Log (Savings)	0.0011	0.0121	0.0105*
	(0.0019)	(0.0084)	(0.0060)
Number of children in school	0.0270	−0.0365	−0.0619
	(0.0172)	(0.0572)	(0.0400)
Store for sale[a] x Exp. Losses		−0.0249**	−0.0275***
		(0.0113)	(0.0092)
Store for sale[a] x Log(Savings)		0.0590	−0.0088
		(0.0380)	(0.0067)
Store for sale[a] x # of child. in school		−0.0095	0.0617**
		(0.0087)	(0.0310)
Store for sale[a]		0.0421	0.6190***
		(1.2455)	(0.1962)
Harvest price (F CFA/kg)	−0.0007	−0.0043*	−0.0035***
	(0.0007)	(0.0023)	(0.0011)
Exp. Price Change (F CFA/kg)	−0.0003	−0.0001	−0.0005
	(0.0004)	(0.0022)	(0.0010)
Qty. available at harvest (kg)	0.0000	0.0002***	0.0002***
	(0.0000)	(0.0001)	(0.0000)
Household size	−0.0030	0.0142	0.0114
	(0.0041)	(0.0213)	(0.0113)
Total farm size (Ha)	−0.0078	−0.0527	0.0093
	(0.0100)	(0.0665)	(0.0148)
Wealth index	0.0058	0.1053	0.0870*
	(0.0257)	(0.0831)	(0.0461)
=1 if HH owns a cell phone	−0.0890	0.1947	0.1427
	(0.0560)	(0.1797)	(0.0990)
=1 if input dealer in village	−0.0089	0.0616	0.0757
	(0.0428)	(0.4833)	(0.1355)
=1 if extension agent in village	−0.0182	0.1052	0.1367
	(0.0480)	(0.1606)	(0.0951)
Department dummies	Yes		
Time Average	Yes		
Constant	−1.0300	6.9748***	6.4289***
	(0.8832)	(0.9814)	(0.2737)
Observations	618	618	618
Pseudo R-square/Adjusted R^2	0.1887	0.5027	0.5010

Notes: [a]Store for sale = 1 if household's storage goal for maize includes selling it later in the year; Robust standard errors in parentheses and bootstrapped in column 1–2; $^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$; US$ 1.00 = 512 CFA Francs at the time of the survey; Results in Column 1–1 are identical to those in Column 1–1 (Appendix E-1)—some covariates are not shown; Column 1–2 includes full interaction terms, and covariates without interactions are interpreted as for Store for sale = 0.

Appendix E3: Factors that affect the amount of maize stored at harvest- Separated sample (Fixed Effect estimator used)

Dependent Variable: Log(Quantity Stored)	(1) Market-oriented HHs	(2) Market-oriented HHs	(3) Consumption-oriented HHs	(4) Consumption-oriented HHs
Expected losses (%)	−0.0247**	−0.0299**	−0.0078	−0.0069
	(0.0106)	(0.0147)	(0.0112)	(0.0178)
Log (Savings)	−0.0021	−0.0004	0.0103*	0.0097
	(0.0034)	(0.0050)	(0.0063)	(0.0115)
Number of children in school	−0.0016	0.0394	−0.0610	−0.0727
	(0.0424)	(0.0604)	(0.0830)	(0.1181)
Harvest price (F CFA/kg)	−0.0025	−0.0036*	−0.0030	−0.0026
	(0.0017)	(0.0022)	(0.0019)	(0.0043)
Expected price change (F CFA/kg)	−0.0022*	−0.0028*	−0.0008	−0.0006
	(0.0011)	(0.0016)	(0.0021)	(0.0029)
Qty available at harvest (kg)	0.0002***	0.0002***	0.0001**	0.0001
	(3E-05)	(3E-05)	(5E-05)	(0.0001)
Household size	0.0201*	0.0164	−0.0003	0.0005
	(0.0107)	(0.0152)	(0.0213)	(0.0286)
Total Farm size (Ha)	0.0037	0.0010	0.1385*	0.1434
	(0.0088)	(0.0123)	(0.0768)	(0.1142)
Wealth index	0.0800	0.0875	0.1350	0.1330
	(0.0489)	(0.0621)	(0.1321)	(0.1443)
=1 if HH owns a cell phone	−0.0083	−0.1280	−0.1675	−0.1341
	(0.0989)	(0.1440)	(0.2283)	(0.2735)
=1 if Input dealer in village	−0.0831	−0.0849	0.1300	0.1328
	(0.1468)	(0.1796)	(0.5921)	(1.7440)
=1 if Input extension agent in village	0.0926	0.0439	0.0189	0.0234
	(0.1004)	(0.1213)	(0.1519)	(0.2386)
Inverse Mill ratio for selection bias		1.0722		−0.1927
		(0.9989)		(1.2816)
Constant	7.2640***	6.9624***	6.4112***	6.1792***
	(0.3032)	(0.4564)	(0.5200)	(1.5095)
Observations	402	402	216	216
Adjusted R^2	0.5039	0,5123	0.3840	0.3813

Notes: Robust standard errors in parentheses and bootstrapped in columns 2 & 4; $^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$; *P*-value associated with log(Savings) is 0.106 in columns 3; US$ 1.00 = 512 CFA Francs at the time of the survey; because the sample size in columns 3 & 4 is small, the statistical significance of the tested variable (Savings) is lower than it is in the full sample.

Appendix F: Factors that affect the amount of maize stored at harvest (FE vs OLS estimations)

Dependent variable: log(Quantity Stored)	(1) FE	(2) OLS full sample	(3) OLS = 1 if panel is 2011	(4) OLS = 1 if panel is 2013
Expected losses (%)	0.0013	−0.0018	−0.0038	−1.1E-05
	(0.0055)	(0.0044)	(0.0066)	(0.0051)
Log(savings)	0.0105*	0.0111**	0.0010	0.0177**
	(0.0060)	(0.0049)	(0.0086)	(0.0072)
Number of children in school	−0.0619	0.0047	−0.0073	0.0207
	(0.0400)	(0.0297)	(0.0397)	(0.0263)
Store for sale x Expected Losses	−0.02.75***	−0.0077	−0.0026	−0.0079
	(0.0092)	(0.0064)	(0.0094)	(0.0077)
Store for sale x Log(savings)	−0.0088	−0.0065	0.0103	−0.0241***
	(0.0067)	(0.0059)	(0.0098)	(0.0086)
Store for sale x Nb. of child. in school	0.0617**	−0.0123	0.0023	−0.0233
	(0.0310)	(0.0304)	(0.0420)	(0.0298)
=1 if store for sale	0.6190***	0.7250***	0.5312***	0.9866***
	(0.1962)	(0.1432)	(0.1828)	(0.1982)
Harvest price (F CFA/kg)	−0.0035***	−0.0056***	−0.0050***	−0.0047***
	(0.0011)	(0.0012)	(0.0012)	(0.0018)
Expected price change (F CFA/kg)	−0.0005	−0.0008	−0.0005	−0.0005
	(0.0010)	(0.0008)	(0.0010)	(0.0015)
Quantity available at harvest (kg)	0.0002***	0.0002***	0.0001***	0.0002***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Household size	0.0114	0.0315***	0.0326***	0.0256**
	(0.0113)	(0.0075)	(0.0094)	(0.0099)
Total farm size (Ha)	0.0093	0.0190*	0.0428**	0.0081
	(0.0148)	(0.0106)	(0.0205)	(0.0117)
Wealth index	0.0870*	−0.0223	0.0087	−0.0232
	(0.0461)	(0.0342)	(0.0402)	(0.0431)
=1 if HH owns a cell phone	0.1427	0.2582***	0.1289	0.2637**
	(0.0990)	(0.0818)	(0.0934)	(0.1228)
=1 if input dealer in village	0.0757	0.1469	0.3406**	−0.0102
	(0.1355)	(0.0991)	(0.1386)	(0.1548)
=1 if extension agent in village	0.1367	0.1478*	−0.0788	0.3885***
	(0.0951)	(0.0752)	(0.1064)	(0.1445)
Constant	6.4289***	6.1506***	6.2949***	5.9566***
	(0.2737)	(0.1841)	(0.2380)	(0.3053)
Observations	618	618	309	309
Adjusted R-squared	0.5010	0.7110	0.6690	0.7596

Notes: Robust standard errors in parentheses; $^{***}P < 0.01$, $^{**}P < 0.05$, $^{*}P < 0.1$; [1]Store for sale = 1 if household's storage goal for maize includes selling it later in the year, otherwise it takes the value zero; US$ 1.00 = 512 CFA Francs at the time of the survey.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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