African Journal of Agricultural and Resource Economics Volume 13 Number 2 pages 169-181

Does linking farmers to markets work? Evidence from the World Food Programme's Purchase for Progress satellite collection points initiative in Uganda

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Abstract

Using a non-experimental cross-sectional dataset of 471 households, we evaluate the impacts of satellite collection points (SCPs) under the Purchase for Progress (P4P) initiative implemented by the World Food Programme (WFP) on storage decisions and crop income from maize sales among smallholder farmers in Uganda. We find strong evidence that storage users had significantly more maize sales due to significantly larger inventories and received higher maize prices than the non-storage users. This evidence is robust across the two econometric estimators, consisting of the ordinary least squares (OLS) and two-stage instrumental variable approaches. These results demonstrate that the SCPs are successful in linking farmers to markets and result in improved welfare of the users, suggesting that they should be scaled up and scaled out as a poverty-reducing development intervention and strategy in rural areas with storable agricultural products.

Key words: Purchase for Progress; storage decisions; linking farmers to markets; crop income; instrumental variable

1. Introduction

Development partners have implemented several initiatives to improve agricultural production and marketing in developing countries, where low agricultural productivity and poverty are still immense challenges. Empirical evidence on how effectively these initiatives have linked smallholder farmers to markets and improved their welfare is still limited. Limited market participation is a well-recognised problem that has kept a large section of smallholder farmers in abject poverty. Many studies have presented conditions under which African farmers may increasingly participate in markets to improve household welfare and food security, and to reduce poverty. Some of these conditions include improved smallholder organisation, reducing costs of intermarket commerce, access to improved technologies and productive assets, improved macroeconomic and trade policies, and promoting institutional demand (Key *et al*. 2000; Shepherd 2007; Barrett 2008; Kaganzi *et al*. 2009; Fischer & Qaim 2012, 2014; Nehring *et al*. 2017). There have been studies on how the Local and Regional Procurement (LRP) activities of the World Food Programme (WFP) have benefited farmers in Uganda by providing markets and empowering them (Ferguson & Kepe 2011), and through offering relatively higher prices, leading to additional incomes, greater access to food and increased production (Bronkhorst 2011; Zavale *et al*. 2015). Other studies have shown how storage technology (protectants) and insect damage during storage

affect smallholders' decisions to adopt improved maize varieties, area planted, and trader price discounts (Ricker-Gilbert & Jones 2015; Jones *et al*. 2016; Kadjo *et al*. 2016). However, there has been no investigation, to our knowledge, of how investments in storage facilities – viewed as investment in physical marketing infrastructure – and participation in storage activities by smallholder farmers affect market participation. Therefore, the policy and scholarly contribution of this paper is on how investments in storage facilities and participation in storage activities by smallholder farmers affect market participation and farmer welfare.

This paper is organised as follows. Section 1 presents an introduction to and motivation for the study. Section 2 describes the implementation context of World Food Programme storage facilities project in Uganda. Section 3 details the methods, theoretical framework and estimation approach. Section 4 shows and discusses both the descriptive and econometric results, and section 5 gives the conclusions.

2. Context: P4P and satellite collection points (SCPs)

Purchase for Progress (P4P) is an initiative that has been piloted in 20 countries under the WFP in terms of which low-income farmers supply locally grown staple commodities to the WFP and other market actors. P4P aims at creating incentives for smallholder farmers to increase their production and links them to buyers who can offer competitive prices. One of the components of the P4P strategy in Uganda includes the construction of stores, referred to as SCPs, in rural areas whose storage capacity ranges between 100 and 300 metric tonnes.

Individual farmers or groups of farmers deliver maize to the SCPs. Upon delivery, the produce is checked for quality against parameters such as moisture content, cleanliness and foreign matter. If the produce has a high moisture or foreign matter content, the farmers are advised to dry the produce further or clean it. Clean produce is packed in 100 kilogram bags and stored on pallets in the store, and farmers are issued with a stamped receipt detailing the type and quantity of produce stored. Fumigation is done regularly or when pests are seen, and the stores are cleaned whenever necessary.

Farmers are told to wait for prices to increase, as the store management committee continuously monitors for a "good price" or "good market". The store management committee looks for buyers, usually through the district production offices, schools, radio and non-governmental organisations, and by directly contacting traders. Once a buyer offering a "good price" is obtained, members are consulted to seek their consent to sell. If the farmers accept the price, the management committee calls the traders to buy the produce. The money is received by the treasurer, chairperson and store manager and is given to the farmers or representatives after deducting storage costs.

This article seeks to address the following key questions: (1) Under what conditions were the farmers likely to utilise the WFP's P4P SCPs? What were the effects of participation in WFP/ P4P SCPs on maize (2) crop income, (3) storage demand, and (4) prices received by farmers?

3. Methods

3.1 Study sites, sample and sampling design, and data

This study was conducted in 11 districts spread across three regions of Uganda where P4P pilot activities were conducted. The districts were Bugiri, Amuria, Soroti and Kaberamaido in eastern Uganda; Lira, Oyam, Gulu, Nwoya, Agago and Kitgum in northern Uganda; and Kamwenge in western Uganda. The study collected primary data from a sample of 471 households using a structured questionnaire administered by enumerators. Interviews were conducted in July 2013 for

season A, which ran from January to July 2012, and season B, which ran from August 2012 to January 2013.

Using a two-stage sampling design, we randomly selected survey participants. First, the primary sampling units (SCPs) were stratified into non-overlapping regions (i.e. northern, eastern and western Uganda). The number of SCPs selected from each stratum was determined by stratified sampling, with proportional allocation within the regions. In the first stage, a random sample of SCPs was selected from each of the three strata using simple random sampling without replacement. In the second stage, a random sample of 30 households from each of the sampled SCPs was selected using simple random sampling without replacement. An assumption of this sampling design is that a random sample of 30 households properly accounts for the differences in the population densities of the SCP catchment areas selected in the study.

The variables used in the analysis are included in Table 1. They comprise households that stored maize at the SCPs and those that did not, sex and age of household head, and distance from household to the district headquarters. The endowments consist of the value of household farmland in thousands of Uganda shillings; the education of the household head; and the number of adult males and females in the household. Marketing and transaction cost variables include transport cost, duration of transporting a 100 kg bag of maize to the trading centre on a *boda-boda* (motor cycle) in minutes, membership of a credit and savings group, and variance of maize price in the SCP catchment area. Market indicators entail quantity of maize sold in kilograms, price of maize per kilogram for the largest transaction, quantity of maize stored for sale in kilograms, cost of storage per month for each 100 kg bag of maize, and income (quantity x price) from the sale of maize. The last category consists of regional dummies for eastern, northern and western Uganda.

There were concerns that the interviewed households could not accurately report some of the information, including value of land (Carletto *et al*. 2013), distance to district headquarters, transport costs, and duration of transport (Escobal & Laszlo 2008). All the variables used in this study were self-reported and not measured with any special equipment, such as GPS, tape recorders and navigation campuses, which implies that there are both sampling and non-sampling errors in the variables, and the latter were systematic and minimised due to the use of highly trained enumerators. Regarding land costs, individual agricultural land sales in Uganda are common in all regions under different land tenure systems, such as *mailo* (Buganda private freehold), freehold, leasehold, *Kibanja* (traditional lease with nominal rent), and customary; this implies that Ugandan farmers can accurately estimate the value of their land.

3.2 Theoretical framework

The theoretical framework used in this study is based on the agricultural household model (Singh *et al*. 1986) and on the seminal *speculative demand* and *convenience yield* theory of storage demand (Saha & Stroud 1994; Gardner & López 1996). Speculative demand refers to the pure profit motive for holding stocks in anticipation of the appreciation of commodity prices. Convenience yield refers to certain agents (e.g. farmers, processors and traders) whose stocks can generate utility by providing: (1) insurance against production delays; (2) insurance against loss of customer goodwill in case they fail to deliver as promised; (3) opportunities to make extra profit or reduce losses (on the production side); and (4) food security by storing food until the next harvest as insurance against hunger. For these reasons, agents store even when they know or expect prices to be lower in the future than the current prices after adjusting for storage costs and the interest foregone on funds invested in stocks. From this theoretical background, we can model quantity stored, income from maize sales, and prices received as:

Quantity stored: $$s_i = S(q_i, p_i, w_i, Z_i) \quad (1)$$

Income from maize sales: $$\pi_i = \Pi(p_i, w_i, Z_i) \quad (2)$$

Prices received: $$p_i = P(q_i, s_i, w_i, Z_i) \quad (3)$$

S, Π, P are storage demand, profit and inverse of output supply functions. Equation (1) is used to model quantity stored (s_i), which depends on quantity sold (q_i); price of maize (p_i); input costs, such as transport, time and storage (w_i); and other exogenous factors (Z_i), such as proximity to markets and education. Equation (2) is the profit function and states that profits (π_i) – a proxy for crop income – depend on output price, input costs, and other exogenous factors. We assumed that farmers are maximising profits, although in reality some farmers may aim at producing enough food for subsistence or food security, which is the convenience yield part of the storage demand theory. Equation (3) is used to model prices received (p_i), which depends on quantity sold, quantity stored, input costs and exogenous factors. Ideally, future or lagged prices should be used for quantities stored by each household (Saha & Stroud 1994), but this is not possible in Uganda, where market information systems do not provide them, and due to the cross-sectional nature of this study.

3.3 Estimation approach

We estimated the determinants of the decisions to store using a multivariate probit regression, since the outcome variable of the use or non-use of SCPs is dichotomous. We estimated the impacts of SCPs on three continuous outcomes: maize sales, maize stored and maize price. The study used a cross-sectional multivariate regression framework in which other confounding factors that may be affecting the same outcomes at the same time were controlled. We accounted for differences in individual farmer characteristics (sex, age and education), locational differences (market access proxies and regional dummies) and price uncertainty effects. We hypothesised that the use or non-use of SCPs was likely to be endogenous, which, if not corrected, would lead to biased and inconsistent estimates of the OLS estimator. To correct this problem, we estimated the instrumental variable (IV) versions of each outcome of the OLS model using generalised method of moments–instrumental variables estimation (GMM-IV), which is efficient under heteroskedasticity (Davidson & MacKinnon 2004). The GMM-IV approach requires that valid instruments be used (Deaton 1997). Instrument validity relies more on persuasive argument, economic theory and norms established in prior, related empirical studies (Cameron & Trivedi 2010).

The IVs used for quantity of maize sales were the natural logarithm of the cost of storage, distance to district headquarters, and being a member of a credit and savings group. The IVs for quantity of maize stored were the natural logarithm of the cost of storage, age of household head, and being a member of a credit and savings group. The IVs for model of prices received were the natural logarithm of the duration of transportation time, age of household head, and being a member of a credit and savings group. First, we ensured that the estimated OLS coefficients of the instruments were statistically significant – suggesting high correlated with the error term – in the binary model of storage. We ensured that the estimated OLS coefficients of the instruments were not statistically significant – suggesting no correlation with the error – thus excluded in the impact models of maize sales, maize stored, and prices received. We then tested for the validity of the excluded instruments using the Hansen J statistic for over-identifying restrictions. For all three outcomes, we failed to reject the null hypothesis that the instruments were uncorrelated with the error terms in the respective models, and that the excluded instruments were correctly excluded from the estimated equations. Having passed the over-identification conditions, we then had confidence to apply the equivalent of the Durbin-Wu-Hausman test (i.e. the C statistics) (Baum *et al*. 2003) to test for the

endogeneity of SCP use. We failed to reject the null hypothesis of the exogeneity of SCP use in all the three outcomes (maize sales, maize stored, and maize price). This implied that OLS was our preferred model of choice for all outcomes. However, we present the results of both the OLS and IV to demonstrate the robustness of our findings. Both models use weights to account for the first- and second-stage selection of the two-stage sampling design used.

We also tested for multicollinearity, which tends to reduce statistical power, and found that it was not a serious problem, as shown by the low variance inflation factors (maximum VIF < 1.45). We accommodated heteroskedasticity of an unknown form by estimating standard errors using the Huber-White estimator of robust standard errors in the regression models (Greene 2003). Some continuous variables were transformed to better suit the data-generating mechanism.

4. Empirical results

4.1 Descriptive and econometric results

Table 1 presents the means and t-tests for the equality of means of key exogenous characteristics between participants and non-participants in the SCPs. We found that the majority of farmers who stored at the SCPs were females. Farmers who stored with the SCPs were statistically significantly older (44 years) than those who did not (41 years). The distance from home to the district headquarters in kilometres was significantly higher among participants (21 km) than among non-participants (14 km), suggesting that the participants appear to be more rural than the non-participants.

The physical asset endowments in terms of value of land of the participants and non-participants in shillings were not significantly different. The percentage of farmers without formal education who stored at the SCPs (37%) was significantly higher than those who did not store (22%). The majority of non-participants (56%) and 46% of the participants had attained primary education. There was no significant difference in the education levels of the participants and non-participants. Regarding labour endowments, the participating and non-participating households had the same household structure on average, consisting of an average of two adult females and two adult males.

Significantly higher percentages (79%) of farmers were members of a credit and savings group among households that stored at the SCPs compared to those who did not (60%). No significant differences were observed in transport costs and duration of transporting a 100 kilogram bag of maize from home to the nearest trading centre on a *boda-boda* between farmers who stored at the SCPs and those who did not. Non-participants faced significantly higher price uncertainty than participants, indicated by the variance in the prices of maize in the SCP catchment areas.

Regarding market indicators, Table 1 shows that maize farmers who stored at the SCPs sold significantly more (i.e. were more commercialised) at higher prices, stored a greater quantity, incurred higher storage costs, and earned more crop income compared to those who did not.

The next section analyses the conditions under which farmers were likely to store with the SCPs.

Table 1: Characteristics of users and non-users of SCPs

	Did not store at SCP (N = 258)	Stored at SCP (N = 213)	t-test for equality of means	
Variable	Mean	Mean	t-statistic	p-value
Sex of household head (0 = Male, 1 = Female)	0.590	0.606	0.34	0.731
Age of household head	40.566	43.817	2.73	0.007
Distance to district headquarters (km)	14.225	20.618	5.80	0.000
Value of your farm land ('000 UGX[1])	15 957	12 910	-1.20	0.230
No education of household head (1 = Yes, 0 = No)	0.218	0.370	3.20	0.001
Primary education of household head (1 = Yes, 0 = No)	0.557	0.461	-1.95	0.052
Secondary and tertiary education (1 = Yes, 0 = No)	0.207	0.148	-1.73	0.084
Junior and vocational education (1 = Yes, 0 = No)	0.018	0.021	0.21	0.831
Adult males in household	2.102	1.995	-0.67	0.500
Adult females in household	1.999	1.882	-0.87	0.384
Member of credit and savings group (1 = Yes, 0 = No)	0.595	0.792	4.62	0.000
Ln of transport cost (UGX)	8.015	7.934	-0.84	0.402
Ln of duration of transporting (minutes)	3.044	3.180	1.57	0.116
Variance of maize price in SCP catchment	51 793	38 607	-3.16	0.002
Quantity of maize sold (kg)	598	1 307	4.25	0.000
Maize price per kilogram (UGX / kg)	576	665	3.39	0.001
Quantity stored for sale (kg)	426	864	4.98	0.000
Cost of storage (UGX / 100 kg)	120	531	6.21	0.000
Maize crop income (UGX)	346 928	810 136	5.12	0.000
Eastern Uganda (1 = Yes, 0 = No)	0.266	0.261	-0.09	0.928
Northern Uganda (1 = Yes, 0 = No)	0.642	0.632	-0.21	0.834
Western Uganda (1 = Yes, 0 = No)	0.092	0.106	0.56	0.574

Note: Estimates corrected for sampling weights. [1] UGX = Uganda Shillings

4.2 Determinants of the decision to store at SCPs

To identify the contribution of each hypothesised factor, we used a multivariate regression analysis involving the estimation of a probit regression, since the outcome variable of use or non-use is dichotomous (Greene 2003; Wooldridge 2009). We estimated a reduced form specification that is strictly exogenous to avoid simultaneous bias problems in the decision to use or not to use the SCPs. We controlled for several confounding factors that are commonly used in the adoption literature to explain decisions on using agricultural technologies, such as demographic and market access factors; physical, human capital, and labour endowments; marketing and transaction costs; and risk factors (Just & Zilberman 1983; Gershon *et al*. 1985; Shakya & Flinn 1985; Polson & Spencer 1991; Feder & Umali 1993; Staal *et al*. 2002; Marenya & Barrett 2007; Foster & Rosenzweig 2010).

The results on the demographic factors in Table 2 indicate that older farmers were significantly more likely to store their produce at the SCPs than young ones, suggesting that the use of SCPs should be promoted among the youth. With regard to access factors, farmers far away from the district headquarters were significantly more likely to store with WFP SCPs than those who were closer. This implies that SCPs were located in the rural areas of Uganda, suggesting that WFP investments target rural areas. Another implication is that, subject to resource availability, investing in storage facilities in more rural areas is likely to link more farmers to markets through access to storage facilities.

Furthermore, the high transport costs significantly reduced the chance of farmers storing at the SCPs, because the demand for most services declines as costs increase. When transport costs are high, farmers sell at the farm or near their households. This suggests that it is important to implement policies that can reduce transport costs, such as investing in feeder roads and reducing

import taxes for motorcycles and gasoline. In addition, farmers with longer transport duration from home to the trading centre had a significantly higher chance of storing at the SCPs. This implies that SCPs are located in rural areas where the duration of transporting produce to markets is longer, or where the infrastructure is poor, resulting in longer duration of transportation. Therefore, it is an optimal strategy for farmers at distant locations in terms of distance to take the produce to the SCP, from where they can obtain better prices from buyers, leading to increased crop incomes and profits resulting from reduced transport costs.

The results also indicate that price uncertainty significantly reduced the decision of farmers to store at the SCPs, which is counterintuitive, since the theory suggests that uncertainty encourages storage as speculators seek to benefit from future price movements. This could be attributed to the farmers' preference to store at home for convenience yield, such as food security.

Finally, farmers who were members of a credit and savings group had significantly higher chances of storing produce with the SCPs. Therefore, farmers who have access to savings and credit are more likely to indulge in temporal arbitrage by storing and then selling in off-peak marketing months, thus receiving higher prices. Conversely, farmers who do not have access to savings and credit do not engage in temporal arbitrage; they sell their entire surplus output during the peak marketing months soon after harvesting.

Table 2: Determinants of the decision to store at SCPs (N = 471)

	Marginal effects	Delta method		
		Standard error	z-statistic	p-value
Sex of household head (0 = Male, 1 = Female)	-0.057862	0.041724	-1.39	0.166
Age of household head	0.0034614*	0.001468	2.36	0.018
Distance to district headquarters (km)	0.0056331***	0.001515	3.72	0.000
Ln of value of your farm land ('000 UGX)	0.0059318	0.017791	0.33	0.739
Primary (omitted = no education) of household head (1 = Yes, 0 = No)	-0.095344	0.049515	-1.93	0.054
Secondary and tertiary education (1 = Yes, 0 = No)	-0.117275	0.061146	-1.92	0.055
Junior and vocational education (1 = Yes, 0 = No)	-0.041468	0.126491	-0.33	0.743
Adult men in household	-0.0077	0.011856	-0.65	0.516
Adult females in household	-0.01393	0.014417	-0.97	0.334
Ln of transport cost (UGX/100 kg/trip to market)	-0.045577*	0.0207	-2.20	0.028
Ln of duration of transporting (minutes)	0.0884262***	0.025313	3.49	0.000
Variance in maize price in SCP catchment	-0.0000012**	0.0000004	-2.70	0.007
Cost of storage (UGX/100 kg/month)	0.0610888	0.004499	13.58	0.000
Member of credit and savings group (1 = Yes, 0 = No)	0.1200965**	0.041069	2.92	0.003
Northern Uganda (1 = Yes, 0 = No)	0.0110257	0.04877	0.23	0.821
Western Uganda (1 = Yes, 0 = No)	0.0109255	0.078636	0.14	0.889

Note: Marginal effects for factor levels refer to the discrete change from the base level. *, ** and *** denote significance at 5%, 1% and 0.1% respectively. Estimates corrected for sampling weights.

4.3 Impacts of storage at SCP on maize sales

This section addresses the second objective of this study, which was to investigate the effects of participation in WFP/P4P SCPs on the crop income of the farmers. We used a linear regression model of maize sales on factors hypothesised to affect sales, and the results are included in The results relating to physical endowments indicate that households with farmlands of higher value sold significantly more maize, suggesting that farmers who have a lot of land also have the capacity to produce more maize, since land is a very important input factor in maize production.

Table 3. The storage decision model involved 471 households, while the impact of SCPs on maize sales, maize stored and maize price models involved 341 households because some households, although they stored, did not sell maize. The estimated coefficients of the models in Table 3, and

the subsequent ones, have similar signs and are close in magnitude, suggesting stability and consistency.

We found a very statistically significant positive effect on maize sales among those who stored with SCPs, who earned UGX 371 179 (about 149 United States dollars (USD) at the time of the survey) more compared to those who did not, which was almost 29% of the annual national per capita income of Ugandans in 2012. This finding shows the profound poverty-alleviating and income-enhancing effects that the WFP SCP storage investments had on the users.

The results from the demographic factors indicate that females sold significantly less maize – on average UGX 212 102 (approximately USD 85 at the time of survey) less than that sold by men. In addition, sales significantly reduce as farmers become older, suggesting that, although older farmers participated in the SCPs more than younger ones, younger farmers benefited more from the SCPs in terms of sales. It is possible that young and male farmers engaged more in speculative demand than older and female farmers, who might have preferred convenience yield to ensure food security by storing food until the next harvest as insurance against hunger.

The results relating to physical endowments indicate that households with farmlands of higher value sold significantly more maize, suggesting that farmers who have a lot of land also have the capacity to produce more maize, since land is a very important input factor in maize production.

Table 3: Impacts of storage at SCPs on maize sales

	OLS		IV-2SLS	
	Coefficient	**Robust std. error**	**Coefficient**	**Robust std. error**
Storage at SCP (1 = Yes, 0 = No)	371 179.10***	76 309.95	373 703.20***	71 016.77
Sex of household head (0 = Male, 1 = Female)	-212 102.40*	83 539.22	-220 382.40**	79 257.61
Age of household head	-10 065.45**	3 069.27	-10 217.18***	2 849.39
Ln of value of your farm land (‘000 UGX)	132 783.50**	40 685.02	131 631.20***	39 482.98
Primary education (omitted = no education) of household head (1 = Yes, 0 = No)	-282 299.00**	93 266.90	-286 562.30***	86 422.07
Secondary and tertiary education (1 = Yes, 0 = No)	-173 399.80	111 738.70	-184 307.40	105 587.70
Junior and vocational training (1 = Yes, 0 = No)	-463 480.40**	142 723.70	-472 193.30***	137 743.80
Adult men in household	16 943.79	22 171.28	16 769.19	21 330.12
Adult females in household	19 697.14	33 247.09	19 751.38	31 864.82
Ln of transport cost	-105 335.60	55 146.79	-109 793.30*	52 201.10
Ln of duration of transporting	22 197.08	49 580.01	21 973.65	47 259.30
Price of maize	662.91***	151.32	663.98***	146.55
Uncertainty (variance in maize price)	-2.18**	0.72	-2.20**	0.69
Northern Uganda (1 = Yes, 0 = No)	-352 541.50**	113 512.10	-359 463.80**	109 402.80
Western Uganda (1 = Yes, 0 = No)	366 340.40*	163 916.10	356 299.90*	156 549.90
Constant	477 537.10	578 451.10	546 202.30	539 560.80
N	341		341	
R^2, centred	0.3736		0.3735	
Hansen J statistic			0.230	
J Hansen p-value			0.9726	
C statistic (endogeneity test stat)			0.009	
C statistic – p-value			0.9245	

Note: *, ** and *** denote variables significant at 5%, 1% and 0.1% respectively. Estimates corrected for sampling weights.

The results regarding human capital endowments show that famers who had formal education (primary, junior and vocational training) actually received significantly lower crop incomes than those without formal education. Farmers with formal education have alternative occupations and activities, besides maize farming, which generate non-farm income compared to those without formal education – thus the need to promote the use of SCPs among farmers with formal education.

A higher price of maize significantly increases maize sales, which is intuitive: an increase in the price of a kilogram of maize will lead to an increase in sales, holding other factors constant. Price uncertainty also significantly reduces maize sales. Farmers who are uncertain of the price of maize are likely to make fewer sales, suggesting the need to provide complementary services to storage, such as market information services.

Regional dummies were significant. Farmers from northern Uganda made fewer sales compared to their counterparts in eastern Uganda, while those from western Uganda made more sales. It is not clear why this is the case. Although northern Uganda is relatively far from the good export markets in Kenya and Tanzania via Busia compared to eastern Uganda, it is close to the South Sudan market, which was booming at the time of the study. Western Uganda is close to good export markets in Rwanda and the Democratic Republic of Congo, in addition to its good road networks, which link it easily to the massive institutional and household-based markets in central Uganda.

4.4 Impacts of storage at SCPs on quantity stored

In this section, we use an OLS specification of the demand for storage model and control for several confounding factors that are likely to explain demand for storage. The results in 4.5 Impacts **of storage at SCPs on prices received**

In this section, we use an OLS specification of the inverse of the output supply model for maize prices and control for several confounding factors that are likely to explain the prices received. Table 5 shows that farmers who stored at the SCPs received significantly higher prices for maize (UGX 72, or about 0.03 US cents, per kilogram) than those who did not. This implies that one of the mechanisms that led to higher crop incomes among the participating farmers than the non-participating ones was the higher prices received by the former group. Farmers who were far away from the district headquarters received significantly lower prices for the sale of their maize than those near the district headquarters. The cost of storage is also significantly associated with the higher prices for maize received by the farmers.

Table 4 show that the quantities stored by farmers who stored at the SCPs were 390 kilograms more than that of non-participating farmers. This implies that one of the mechanisms that led to higher crop incomes among participating farmers compared to non-participating farmers was the higher quantities stored by the former group.

In terms of physical endowments, we find that farmers with higher value of farmland stored significantly more maize than those with a lower value. This is intuitive because value of farm land consists of two components: the quantity of land and the per-unit price of land. Farmers with more land are likely to grow and store more maize than those with less land.

Farmers from western Uganda stored more maize compared to their counterparts in eastern Uganda. During the field visits, we observed that farmers from western Uganda were more organised as groups, emancipated, and eager to utilise the stores. Higher price uncertainties significantly reduced the quantity of maize stored. The provision of specialised and customised market information with price forecasts would reduce this price uncertainty, and thus contribute to increased temporal arbitrage.

4.5 Impacts of storage at SCPs on prices received

In this section, we use an OLS specification of the inverse of the output supply model for maize prices and control for several confounding factors that are likely to explain the prices received. Table 5 shows that farmers who stored at the SCPs received significantly higher prices for maize (UGX 72, or about 0.03 US cents, per kilogram) than those who did not. This implies that one of the mechanisms that led to higher crop incomes among the participating farmers than the non-participating ones was the higher prices received by the former group. Farmers who were far away from the district headquarters received significantly lower prices for the sale of their maize than those near the district headquarters. The cost of storage is also significantly associated with the higher prices for maize received by the farmers.

Table 4: Impacts of storage at SCPs on quantity stored

	OLS		IV-2SLS	
	Coefficient	**Robust std. error**	**Coefficient**	**Robust std. error**
Storage at SCP (1 = Yes, 0 = No)	389.65***	91.39	412.36***	80.48
Sex of household head (0 = Male, 1 = Female)	-85.00	92.04	-65.98	83.92
Distance to district headquarters	2.22	3.23	2.00	3.12
Ln of value of your farm land ('000 UGX)	160.14**	48.96	174.21***	41.00
Primary education (omitted = no education) of household head (1 = Yes, 0 = No)	-2.62	102.04	30.35	79.13
Secondary and tertiary training (1 = Yes, 0 = No)	74.16	103.43	92.84	94.64
Junior and vocational training (1 = Yes, 0 = No)	-277.37	149.63	-257.55	141.17
Adult men in household	-28.17	28.26	-38.53	20.79
Adult females in household	26.38	37.13	35.99	29.25
Ln of transport cost	-95.17	64.13	-111.00*	52.43
Ln of duration of transporting	51.34	51.04	65.71	42.15
Northern Uganda (1 = Yes, 0 = No)	-178.19	112.05	-148.39	94.14
Western Uganda (1 = Yes, 0 = No)	557.67***	165.50	564.45***	158.28
Price of maize	0.12	0.14	0.09	0.13
Uncertainty (variance in maize price)	-0.002**	0.001	-0.002**	0.001
Constant	-317.32	573.95	-395.64	535.87
N	341		341	
R^2, centred	0.2472		0.2459	
Hansen J statistic			0.364	
J Hansen p-value			0.9477	
C statistic (endogeneity test stat)			0.001	
C statistic - p-value			0.9788	

Note: *, **, and *** denote variables significant at 5%, 1% and 0.1% respectively. Estimates corrected for sampling weights.

Table 5: Impacts of storage at SCP on prices received

	OLS I		OLS II Parsimonious		IV-2SLS	
	Coefficient	**Robust std. error**	**Coefficient**	**Robust std. error**	**Coefficient**	**Robust std. error**
Storage at SCP (1 = Yes, 0 = No)	71.500**	26.916	60.549*	26.721	72.826**	26.129
Sex of household head (0 = M, 1 = F)	-37.094	26.398			-38.464	25.377
Quantity of maize produced	0.006	0.006	0.005	0.005	0.005	0.005
Distance to district headquarters (km)	-2.388**	0.815	-2.392**	0.773	-2.481**	0.756
Value of your farm land	25.320	19.882			25.572	18.322
Primary (omitted = no education)	-27.081	33.117			-30.736	32.125
Secondary and tertiary (1 = Y, 0 = N)	-22.816	42.265			-23.772	40.581
Education other (1 = Yes, 0 = No)	103.387	94.263			101.850	91.826
Adult men in household	0.993	8.483			0.802	7.998
Adult females in household	-7.813	11.282			-9.258	10.951
Ln of transport cost of a 100 kg bag to TC on boda-boda	-14.625	17.917			-15.317	17.346
Cost of storage for 100 kg bag produce	10.376*	4.697	10.841**	4.166	11.087*	4.499
Uncertainty (variance in price at SCL level)	0.001	0.001			0.001	0.001
Northern Uganda (1 = Yes, 0 = No)	34.821	37.208			36.475	35.980
Western Uganda (1 = Yes, 0 = No)	12.039	33.274			16.826	32.233
Constant	467.750*	193.346	599.822***	25.442	475.971**	183.241
N	341		341		341	
R^2, centred					0.1384	
Hansen J statistic					1.567	
J Hansen p-value					0.6669	
C statistic (endogeneity test stat)					0.138	
C statistic - p-value					0.7105	

Note: *, ** and *** denote variables significant at 5%, 1% and 0.1%, respectively. Estimates corrected for sampling weights.

Most of the explanatory variables were not significant in explaining prices received, probably indicating that prices were determined largely by the market forces of demand and supply. For consistency purposes, a parsimonious price model was estimated that included quantity supplied, distance to the district headquarters, and cost of storage for a 100 kg bag of produce. The treatment impact reduced from 72 to 61 shillings per kilogram.

5. Conclusions, implications and areas for further research

5.1 Conclusions

Using data collected from a random sample of 471 households, this article sought to address the following key empirical research questions: (1) Under what conditions were the farmers likely to utilise the P4P satellite collection points? What were the effects of participation in SCPs on maize (2) sales, (3) quantity stored, and (4) prices received by farmers?

The results show that older and remotely located smallholder famers and those with longer transport duration were more likely to use the SCP storage facilities, while farmers with poor market access in terms of high transport costs and those who face higher price uncertainties were less likely to store at the SCPs. Therefore, there was no elite capture and the investments were pro-poor. With respect to the second objective, households that stored at SCP facilities had significantly higher incomes or sales than those that did not; therefore, investments in storage enhanced the wellbeing of

the participants. For the third objective, the results robustly show that farmers who used SCP storage facilities stored significantly more quantities of maize than their counterparts who did not use these facilities. Finally, those who used the SCP storage facilities received significantly higher maize prices than those who did not.

5.2 Implications

Overall, these empirical results based on an ex-post econometric analysis demonstrate that SCP storage facilities were successful in linking farmers to markets, and significantly enhanced farmers' welfare through their positive, strong impacts on maize sales, quantities stored, and prices received. Therefore, SCPs should be scaled up and scaled out. This storage innovation and approach by the WFP is pro-poor and could be replicated by both public and private sector actors elsewhere in Uganda, and in other, similar settings in sub-Saharan Africa. Furthermore, some of the options that would increase the likelihood that more farmers would use the SCP facilities – subject to the availability of resources – include improving feeder roads and providing improved agricultural market information, such as price forecasts, to reduce price uncertainties among farmers. It is also important to promote the usage of SCPs among the youth and household heads with formal education.

5.3 Areas for further research

This was a cross-sectional study and limited to short-term impacts; we recommend that more rounds of data could be collected in the future from the same respondents to assess whether our observed impacts are sustainable in the long run, and to improve the precision of attributing the impacts of SCPs using the conventional panel data estimators, such as the difference-in-difference method.

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