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The effects of grain storage technologies on maize marketing behaviour of smallholder farmers in Zimbabwe

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Abstract

This study investigated the effects of grain storage practices on smallholder farmers' maize marketing behaviour using primary data collected from 413 random households in Makoni and Shamva Districts of Zimbabwe. The data was analysed using the ordered probit model and the study results revealed that storage practices had significant effects on the maize marketing behaviour of smallholder farmers. Storage using insecticide and traditional granary increased the chances of farmers to become net sellers of maize. Using insecticide in storage reduces the amount of grain that is lost in storage hence farmers are able to preserve the amount of grain available for consumption and also for sale. This implies that safe storage of maize may increase household incomes thus reducing poverty. This also contributes to improved food security. Investment in safe grain storage technologies is thus a fundamental key policy issue in developing countries. Quantity harvested, market location, household head's sex and other household factors influenced maize marketing behaviour of smallholder farmers in Zimbabwe.

Keywords: Smallholder farmers, net buyer, net seller, maize, ordered probit regression

1 Introduction

Storage of staple crops such as maize (*Zea mays*) remains important in developing countries for smoothening variable supply against constant demand. Maize production in southern Africa is seasonal as it largely depends on rain-fed agriculture, thus making storage a vital component of the production chain. Maize is the staple crop for the majority of people in the region (Smale *et al*., 2011; Tesfaye *et al*., 2017; Ekpa *et al*., 2018) and smallholder farmers are the bulky producers of the crop. In Zimbabwe, at least 70 % of the population directly depend on agriculture for their livelihood (Kassie *et al*., 2017; Makuvaro *et al*., 2017) and smallholder farmers contribute about 50 % to the national maize production (Rukuni *et al*., 2006; Makuvaro *et al*., 2017). About 70 % of the maize produced is stored on the farm for household consumption as well as marketing (Mhiko *et al*., 2014). Hence, storage of maize grain allows farmers not to market their produce immediately after harvest when prices are low and release it back into the market when prices are favourable (Proctor, 1994). This behaviour can impact smallholder farmers' incomes, food security and livelihoods.

Nevertheless, 20 % to 30 % of their stored maize grain using traditional technologies is lost and cereal losses can be as high as 50 % (Nukeine, 2010; Tefera & Abass, 2012; World Bank, 2011). Poor post-harvest management of cereals is one of the major challenges of food security in southern Africa (Tefera, 2012). According to World Bank (2011) post-harvest losses in developing countries are high due to, among other factors, inadequate and ineffective storage structures and poor handling practices. In sub-Sahara Africa, Zimbabwe included, common storage of grains on smallholder farms include the use of jute bags, plastic containers, polypropylene bags, woven bags, and traditional granaries largely made of wooden walls and grass thatched roofs (Midega *et al*., 2016). Moreover, smallholder farmers apply synthetic and botanical pesticides on stored grains for pest control (Manandhar *et al*., 2018). Recent storage technology developments have witnessed the promotion of hermetic technologies in Africa as safer and more effective methods of grain storage among smallholder farmers (Mutambuki *et al*., 2019). However, while a number of studies

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have focused on evaluating effectiveness of different storage technologies on storage pests (De Groote *et al*., 2013; Likhayo *et al*., 2016; Mutambuki, 2019) little attention has been paid to the economics of post-harvest losses (PHL) and storage technology in studies on household grain management; in particular, their effect on market participation.

Market participation of smallholder farmers has been considered an important part of the agrarian transformation in developing, low-income countries as agricultural markets provide the opportunity for farm production to contribute to poverty reduction through the cash income realised from sales of farm produce (Eleni, 2009; Obi *et al*., 2012). It is also a means of ensuring food security, enhanced nutrition and incomes (Eleni, 2009). According to Bellemare & Barret (2006), the literature on market participation remains thin in developing countries. While a substantial amount of effort has been directed to understanding determinants of smallholder farmers participation in markets as sellers, there is limited attention to why they participate in markets (Muricho *et al*., 2015). The majority of studies analysed the discrete market participation decision together with market participation intensity (Goetz, 1992; Alene *et al*., 2008; Bellemare & Barrett, 2006; Mathenge *et al*., 2010), while other studies only analysed the continuous decision of market participation intensity (Omiti *et al*., 2009; Macharia *et al*., 2014). Hlongwane *et al*. (2014) found that gender, farmer's access to credit, marital status, market information and infrastructure are positively significant in affecting the market participation decision of maize farmers in the Limpopo province, South Africa. According to Egbetokun & Omonona (2012), age, marital status, source of labour, farming experience, and farm size are the major determinants of farmers' participation in the markets, whereas the probability of participating in output markets depends on household size, distance to the nearest marketing channel, price of commodity and sex of the farmer (Onoja *et al*., 2012).

To the best of our knowledge, few studies in Zimbabwe have looked at factors that influence smallholder farmers' maize market participation behaviour (Zamasiya *et al*., 2014). There is no evidence available in the country on how storage technology or practices affect smallholder farmers' market participation behaviour, particularly in the maize sector. Analysing storage technology and smallholder farmers' participation in different market regimes is critical in designing carefully targeted policy interventions. This study therefore seeks to address this information gap. The study hypothesizes that storage technologies have a significant effect on grain sales and purchasing behaviour or patterns of smallholder farmers in Zimbabwe.

2 Materials and methods

2.1 Study area

The study was conducted in Makoni and Shamva Districts of Manicaland and Mashonaland Central provinces, respectively. Both districts are major maize growing areas in Zimbabwe. Agriculture is the main occupation of people living in these areas and maize production is rain-fed. Both districts lie in Natural Region II, whose mean annual rainfall of 800-1000 mm is suitable for intensive crop production (WFP, 2014). Based on the census results of 2012, Makoni District has a total population of 272 340 while Shamva district has a total population of 123 650 (Zimbabwe National Statistics Agency (ZIMSTAT), 2014). These districts were purposively chosen for the study based on the fact that maize production is dominant, farmers often produce a marketable surplus of maize and storage is a critical component of the maize value chain.

2.2 Data

A multi-stage sampling procedure was followed for the selection of maize producing smallholder households. This was done in consultation with the district agricultural extension officers of the Department of Agriculture, Extension and Technical Services (AGRITEX). First stage: purposive selection of six administrative wards in both Makoni and Shamva Districts. High maize yields characterised these wards to ensure that there were adequate market participation activities. Second stage: random selection of two enumeration areas out of eight enumeration areas (EAs) in each ward. An EA is a census-defined geographical area consisting of between 80 and 120 households. Twenty-four EAs were randomly selected, twelve from each district. Our sampling frame was derived from the International Maize and Wheat Improvement Centre (CIMMYT), Effective Grain Storage Project (EGSP)'s household listing survey that captured farmers' maize production, storage capacity, storage losses, and income sources among other socioeconomic attributes in March and April of 2013. Eligible farmers included those farmers that planted maize and had surplus maize from the previous 2011/2012 season, had access to income from non-maize production sources, and reported physical loss of grain in the previous storage season. Using the selection criteria, the lists of eligible population of farmers for each targeted EA were developed accordingly. The proportionate random sampling method, without replacement, was used to select 413 households for the study. The selection was done at a public gathering in the presence of local leadership, farmers, agricultural extension and the research teams. The proportionate random sampling method

was used in order to distribute households fairly across EAs and also to get local leadership support. The survey results were also going to inform the distribution of hermetic metal silos in the study areas, through the CIMMYT EGSP led project, thus a fair distribution of participants was paramount in order to balance local leadership interests and influence for the project. Households chosen for the survey were maize farmers, with capacity to produce surplus maize for storage and for sale. Primary data was collected using a structured household questionnaire in face-to-face interviews. Data collected included household demographics; equipment, implements and gadgets; land ownership, access and use; cropping and harvest; investments and ownership of grain handling structures; maize storage patterns and loss assessment; sufficiency of own maize harvest for household consumption; household maize selling behaviour; household maize purchasing behaviour; insecticide use; training and information sources; formal and informal business activities.

2.3 Analytical framework and selection of variables

The random utility framework (McFadden, 1974) and the theory of farm household decision making under imperfect markets (De Janvry *et al*., 1991) informed the study of the household's decision on whether to participate in the maize market as net seller, autarkic, or net buyer. According to the random utility framework, smallholder farmers will decide to participate in the market if the perceived utility or net benefit of participating as a net seller, net buyer or autarkic is highest relative to the other participation options. Household market participation, according to the theory of farm household decision making, is mainly a function of market transaction costs. Households who participate in the market are those with market gains that are higher than the transaction costs, while the opposite holds true (De Janvry *et al*., 1991). As expounded in De Janvry *et al*. (1991) and other studies (for example, Alene *et al*., 2008; Mather *et al*., 2013) the household's market participation is influenced by its institutional environment and economic position. In this study, it is assumed that smallholder farmers choose to participate in the maize market as net buyers, autarkic, or net sellers.

2.3.1 Model choice and specification

This study assumes that market participation is "trichotomous" in nature. The continuous market participation outcome can be partitioned into three distinct categories: net buyers (households whose net sales are negative, that is household sells less maize than what it buys from the market), autarkic (households whose net sales are equal to zero, that is household sells the same amount of maize as it buys) and net seller households (those whose net sales are positive, that is household sells more maize than it buys from the market). There is a natural ordering of the categories with the lowest category being net buyers of maize. The dependent variable is, therefore, categorical and qualitative in nature. Following Greene (2011) and Muricho *et al*. (2015) ordered probit model is the appropriate analytical model in such a situation. According to Muricho *et al*. (2015), the participation decision can be represented by the following latent model Y^*_{ji} which describes the i^{th} household's behaviour of participating in market regime j revealed in an ordinal scale (1, 2,. . . , k):

$$Y^*_{ji} = \beta_j X_{ji} + \varepsilon_{ji} \tag{1}$$

Where X's are a vector of covariates influencing the j^{th} market participation regime and β's are associated vector of parameters, and ε is the error term that has a standard normal distribution. The household's utility from participating in a given market regime is not observable but the decision to participate is observable. Therefore, household's choice of market regime j can be represented as follows:

$$Y^*_{ji} = \begin{cases} 1 \quad if \quad Y^*_{ji} \leq \partial_1 \\ 2 \quad if \quad \partial_1 < Y^*_{ji} \leq \partial_2 \\ 3 \quad if \quad \partial_2 < Y^*_{ji} \leq \partial_3 \end{cases} \tag{2}$$

where ∂_1, ∂_2 and ∂_3 are unknown net buying, autarkic and net selling threshold parameters, respectively, for estimation in the model. Including an intercept coefficient in the model normalizes Y^*_{ji} to zero value (Greene, 2011), allowing only $k-1$ additional parameters to be estimated with X's (Okoye *et al*., 2010). Following Okoye *et al*. (2010), like the models for binary data, the probabilities for each of the observed ordinal responses are given as:

$$Prob\,(Y=1) = P\,(Y^*_{ji} \leq 1) = P\,(\beta^{'} X + \varepsilon_I) = \phi\,(-\beta^{'} X) \tag{3}$$

$$Prob\,(Y=2) = \phi\,(\partial_2 - \beta^{'} X) - \phi\,(-\beta^{'} X) \tag{4}$$

$$Prob\,(Y=3) = 1 - \phi\,(\partial_2 - \beta^{'} X) \tag{5}$$

Thus, the marginal probabilities could be calculated as:

$$\frac{\partial prob(Y_i)}{\partial X_j} = [\phi\,(\delta_{j-1} - \beta X_j) - \phi\,(\delta_j - \beta^{'} X_j)]\beta \tag{6}$$

Where ϕ is the normal density function, j is the threshold parameter and X_j is the j explanatory variable.

2.3.2 Determinants of market participation

Determinants of market participation are derived from literature, theory and the nature of data available for analysis.

Table 1 displays the explanatory variables, their measurement, definition and *a priori* expectations.

Dependent variable

Market participation: The market participation outcome is categorized into three distinct groups: net buyer, autarkic, and net seller, taking values 1, 2, 3, respectively

Independent variables

The study considered type of storage methods and forms of preservative measures used on stored grain to determine the effects of grain storage practices on market participation behaviour. These include improved granaries, room in a house, traditional granary and poly grain bags. Dummy variables were created for each storage method. Storing using poly grain bags is the commonest storage practice in Zimbabwe, and hence was used as the reference category. Improved granary was expected to positively influence market participation while the effects of room in a house and traditional granary were considered to either increase net selling or net buying than being autarkic. Farmers who stored grain in improved granaries were more likely to be net sellers than autarkic and more likely to be autarkic than net buyers of maize grain. Grain stored in improved granaries is less at risk from negative factors such as rodents, theft, and rain than stored in other storage methods particularly, traditional granaries. The study also hypothesized the use of insecticides, non-use of any preservation chemicals and use of biological preservation methods to influence market participation of households. Farmers who did not use insecticide in storage were considered to belong to the "no insecticide treatment" storage technology. This was identified as the base outcome category and was left out of analysis so as to avoid the dummy variable trap. Farmers who used insecticide formed the "insecticide treatment". Thus the rest of the farmers who used eucalyptus method, trap and kill, and smoking were categorized as the "other storage" group. Storage practices were hypothesized to be the major determinants of market participation in the study. Insecticide treatment was expected to positively influence market participation of households while the effect of other storage on participation was considered to be either positive or negative. Insecticides help to fight against common storage pests such as the maize weevil, which cause storage losses (Stathers *et al*., 2002; Mutambuki *et al*., 2019).

Storage loss (percent loss): Storage loss is measured as the physical grain lost while in storage due to microbial activities and other factors. Farmers reported the amount of storage loss they incurred after the last harvest. This was then expressed as a percentage of the total grain stored in the year. Storage loss directly determines the amount of grain left for both consumption and consequently for market purposes. Hence, farmers that incur huge losses are more likely to be autarkic than net sellers and more likely to be net buyers than autarkic.

The diversity of smallholder farming sector in the different wards was considered a critical factor in influencing market participation. Smallholder farming households in Zimbabwe are comprised of the old resettlement farmers, communal farmers, model A1 farmers (recently resettled farmers through land reform) and small-scale commercial farmers. The different farming sectors depict a diversity of agricultural production systems and resource endowments of the smallholder farmers (Ndakaza *et al*., 2016) as determined by agro-ecological factors, tenure systems, farm sizes, crop and livestock production systems, levels of technology use, management and income levels. Communal farmers are the least endowed in terms of resources. The small-scale commercial farming sector was used as a benchmark and was left out of the analysis. All the three farming sectors represent the major maize producing households and it was expected that households from these areas would more likely to be autarkic than net buyers and more likely to be net sellers than autarkic.

To control for regional differences, a district dummy was included. Other household and institutional variables such as quantity of maize harvested, land size, market location, ownership of cell phone, access to extension services, sex, marital status, age, household size and education years of household head were also included as guided by theory and literature. Table 1 provides full description, and *a priori* expectations of the variables.

3 Results

3.1 Household characteristics and market decisions of smallholder farmers

Results of chi-square are presented in Tables 2 and 3 and those for one-way analysis of variance (ANOVA) are in Table 4. Table 2 shows that majority (55 %) of households applied insecticide in storage while a minority used other storage preservatives (15 %). In terms of storage facility, poly grain bags were the predominant (40 %) storage method among farming households compared to room in house (38 %), improved granary (11 %) and traditional granary (11 %). Use of no treatment and use of room in a house, traditional granary and poly bags and other storage differed statistically significantly across farming sectors. Use of other storage methods such as eucalyptus leaves, trap and kill, smoking was commonly practised in the communal

Table 1: *Independent variables.*

Variable	*Definition*	*Sign*
Insecticide	Insecticide = 1 if insecticide treatment was used; 0 otherwise	+
Other storage	Other storage = 1 if other preservatives were used; 0 otherwise	+/−
No treatment*	No treatment = 1 if stored grain was never treated; 0 otherwise	−
Improved	Improved granary = 1 if brick granary was used; 0 otherwise	+
Room	Room in a house = 1 if room in a house was used; 0 otherwise	+/−
Traditional	Traditional granary = 1 if pole & mud plastered; 0 otherwise	+/−
Poly bag*	Poly bag = 1 if polypropylene bags; 0 otherwise	+/−
Storage loss	Total storage grain loss as a ratio	−
Qharvested	Total quantity of grain harvested (kg)	+
Land size	Land size in hectares	+
Market	Market location: 1 = local ; 0 = otherwise	+
Cell phone	Ownership of a cell phone of household head : 1 = yes; 0 = no	+
Extension	Extension access of household head : 1 = yes; 0 = no	+
District	District: 1 = Shamva ; 0 = Makoni	+/−
Model A1	Model A1 newly resettled farmers; 1 = yes; 0 = Otherwise	+
Communal	Communal farming sector; 1 = yes; 0 = Otherwise	+
OR	Old resettlement farming sector; 1 = yes; 0 = Otherwise	+
Small scale*	Small scale commercial sector; 1 = yes; 0 = otherwise	+
Sex	Sex of household head: 1 = male; 0 = female	+
Marital status	Marital status of household head :1= married;0 = otherwise	+/−
Age	Age of household head in years	+/−
HHsize	Household size (number)	−
Education	Education of household head in years	+

*Reference category in the ordered probit model regression.

Table 2: *Storage methods and storage practices by farming sector.*

	Farming sector (%)					
Variable	*Sample*	*Model A1*	*Communal*	*Old resettlement*	*Small scale*	*p-value*
Insecticide	55	16	44	31	8	0.349
Other storage	15	29	35	27	9	0.009
No treatment	30	5	41	44	10	0.001
Improved granary	11	7	35	49	9	0.144
Room in house	38	8	49	33	10	0.013
Traditional	11	0	34	64	2	0.000
Poly bag	40	27	39	23	11	0.000

Source: own study

farming sector, while use of no chemicals or insecticides on stored grain was prevalent in the old resettlement sector. Room in house storage and poly grain bags were common in the communal sector, while traditional granary was commonly used in the old resettlement farming sectors.

The chi-square results indicate that no-treatment storage practice, improved granary and poly bag storage methods, market location, access to extension, district of location, and old resettlement and communal farming sectors were statistically significant (Table 3). About 30 % of the farmers did not use any chemicals on their stored grain whilst the ma-

Table 3: *Dummy household characteristics by farmer group status.*

	Farming group (%)				
Variable	*Sample*	*Net buyer*	*Autarkic*	*Net seller*	*p-value*
Insecticide	55	7	24	69	0.194
Other storage	15	6	26	68	0.729
No treatment	30	14	28	58	0.039**
Improved granary	11	2	16	81	0.060*
Room in house	38	9	23	68	0.700
Traditional	11	2	26	72	0.212
Poly bag	40	13	29	58	0.011**
Market location	55	0	0	100	0.000***
Own cell phone	87	9	25	66	0.853
Extension access	36	4	19	77	0.001***
Male	61	7	26	67	0.134
Married	72	9	24	66	0.717
District	45	6	21	73	0.002***
Model A1	15	10	20	70	0.561
Old resettlement	34	5	20	75	0.015**
Communal	59	12	29	59	0.035**
Small scale	9	8	37	55	0.220

*, **, ***, signify 10%, 5%, 1% statistical significance levels, respectively.
Source: own study

jority applied either insecticide (55 %) or other storage preservatives (15 %). Although insecticide treatment was not statistically significant, the majority of net maize sellers used insecticides (69 %) in stored grain. Untreated grain is at high risk of pest attacks and thus farmers who engage such storage practices may risk losing much of their stored grain thus reducing the amount of grain available for consumption and sale.

While the majority of farmers stored grain in poly grain bags (40 %), only a few stored grain in improved granaries (11 %). Storing grain in poly bags and improved granaries were typical among net grain sellers (58 % and 81 %, respectively). Use of improved storage methods can reduce farmer storage losses thus increase the quantity of grain available. In terms of market location for selling and purchasing grain, 55 % of the farmers used local markets for their transactions. However, only the net maize sellers (100 %) dominated in these markets. Availability of well-developed local markets can boost smallholder farmers' market participation in developing countries. On the other hand, one of the means to increase production and productivity in Zimbabwe is through farmers' access to extension services. However, only 36 % of the farmers in this study had access to extension services. Nevertheless, a higher percentage of net sellers had access to extension services (77 %) compared to net buyers (4 %). Considering location, Shamva District represented 45 % of the sampled farmers in the study with net buyers being the majority, followed by the autarkic group and lastly, net sellers. In terms of farming sector, communal farmers constituted the highest proportion of farmers in the study areas (42 %), while old resettlement, A1 model and small scale constituted 34 %, 15 % and 9 % of the sampled farmers. Furthermore, most of the farmers who were net sellers came from old resettlement (75 %) and communal (59 %) farming sectors, while the majority of net buyers (12 %) and autarkic farmers (37 %) were found in the communal areas and small-scale commercial sectors.

Table 4 shows that out of the sampled farmers, the majority were net sellers (65 %) while net buyers were the minority (9 %). The ANOVA results of quantity harvested, land size, household head's age and education years, indicated a statistically significant difference across the three options of farmers' market decision. The quantity of maize grain harvested showed statistically significant differences ($p < 0.05$), and the *post-hoc* test showed that this difference was between the net sellers and net buyers; and the net sellers and autarkic farmers ($p < 0.01$). Net sellers had the biggest volumes of maize grain harvested, compared to their counterparts.

Table 4: *Description of continuous household characteristics by farmer group status.*

	Farmer group (mean)					
Variable	*Net buyer*	*Autarkic*	*Net seller*	*Sample (mean)*	*F-sign*	*Post-Hoc test* (Tukey)*
n	37	104	272	413		
Percent loss	8.0	9.2	7.5	8.0		
Quantity harvested	1,282	1,780	2,854	2,443	**	NS/NB*, NS/A*
Land size	2.2	3.5	3.7	3.5	**	A/NB*, NS/NB**
Age	52	54	48	50	***	NS/A***
Education years	7	7	8	7	*	
Household size	6.3	5.9	5.8	5.8		

*, **, ***, ns, signify 10%, 5%, 1% statistical significance levels and not statistically significant, respectively.
* Tukey test is a post hoc test that is run to confirm where differences occurred between groups and is run only when one-way ANOVA result is statistically significant. ANOVA does not tell which specific groups differ, Tukey test does.
NS, NB, A mean Net Seller, Net Buyer, and Autarkic.

Results further indicate that land size was statistically significantly different ($p < 0.05$) across the three farmer market decision groups. The net buyers of maize grain were the least land endowed, compared to the autarkic and net sellers. However, significant differences in land owned were observed between the autarkic and the net buyers, and between the net sellers and net buyers More so, the age of farmers was statistically significant($p < 0.05$). A significant difference ($p < 0.01$) was observed between the net sellers, who are the youngest, and the autarkic farmers, who are the oldest. However, the years of schooling of the household heads was only slightly significantly different ($p < 0.1$) across the three farmer market decision options.

3.2 Smallholder farmers' decisions on market participation

The ordered probit model results with marginal effects are shown in Table 5. The chi-square statistics was highly significant ($p \leq 0.000$) indicating that the choice of explanatory variables included in the model explained the variation in market decisions of farmers. No serious problem of multicollinearity among explanatory variables was observed. The discussion of results is focused on marginal effects of the ordered probit model.

The results showed that insecticide storage, traditional granary, the quantity of maize harvested, market location, sex, marital status, district of location (Shamva), A1 model, old resettlement and communal farming sectors had significant influence on market participation decisions of farmers. Insecticide treatment storage showed a positive and significant ($p = 0.05$) effect on the market participation decisions of farmers. The marginal effects showed that insecticide storage increased the probability of farming households to be net maize sellers by 10.1 % while reducing the probability of being a net maize buyer by 0.3 % and of being autarkic in the maize market by 9.8 %.

In terms of grain storage method, traditional granary had a positive and statistically significant ($p < 0.001$) effect on farmers' market participation decisions. The marginal effects indicated that storing maize grain in a traditional granary increases the probability of being a net maize seller by 10.7 %, while it reduces the probability of being autarkic by 10.5 % and of being a net maize buyer by 0.2 %.

The coefficient of the quantity of maize harvested was positive and statistically significant ($p < 0.1$). However, the marginal effects suggests that a unit increase in the amount of maize harvested is likely to increase the probability of a household being a net seller by a margin close to zero while reducing the probability of being a net buyer and autarkic by a similar margin.

Market location coefficient was positive and its influence on market participation decisions was statistically significant ($p = 0.001$). The marginal effects indicated that local markets increase the probability of being net seller by 74.4 % while reducing the probability of being autarkic by 61.3 % and of being net buyers of maize by 13.1 %.

The coefficient of sex of household head was positive and statistically significant ($p = 0.05$). The marginal effects indicated that being a male-headed household increased the probability of being a net maize seller by 10.3 % while it reduces the probability of being autarkic by 10.0 % and of being a net maize buyer by 0.3 %.

On the other hand, marital status of the household head was statistically significant but had a negative influence on market participation ($p = 0.05$). This implies that being married reduces the probability of being a net seller by 10.3 %

Table 5: *Ordered probit results with marginal effects.*

Variable	*Coefficient*	*Standard error*	*Net buyer*	*Autarkic*	*Net seller*
Insecticide	0.490**	0.200	−0.003	−0.098**	0.101**
Other storage	0.300	0.224	−0.001	−0.051	0.053
Improved granary	0.272	0.356	−0.001	−0.047	0.047
Room in house	−0.084	0.208	0.000	0.017	−0.017
Traditional	0.772***	0.274	−0.002	−0.105***	0.107***
Percent loss	−0.003	0.005	0.000	0.001	−0.001
Quantity harvested	0.000*	0.000	0.000	0.000*	0.000*
Land size	0.008	0.026	0.000	−0.002	0.002
Market location	3.342***	0.454	−0.131***	−0.613***	0.744***
Own cell	−0.210	0.241	0.001	0.037	−0.038
Extension access	0.217	0.186	−0.001	−0.041	0.042
Age	−0.004	0.006	0.000	0.001	−0.001
Education years	0.050	0.032	0.000	−0.010	0.010
Sex	0.484**	0.21	−0.003	−0.100**	0.103**
Marital status	−0.173**	0.291	0.003	0.119***	−0.121***
Household size	0.003	0.032	0.000	−0.001	0.006
District	−0.008***	0.002	0.000	0.001***	−0.002***
Model A1	0.926**	0.36	−0.002	−0.122***	0.124***
Old resettlement	0.784***	0.284	−0.003	−0.133***	0.137***
Communal	0.740**	0.302	−0.004	−0.135***	0.138**

*, **, ***, signify 10%, 5%, 1% statistical significance levels, respectively.
Source: own study.

while increasing the probability of participating in the market as a net buyer by 0.3 % and as autarkic by 11.9 %.

The district of location was negative and statistically significant (p=0.001). The marginal effects showed that being a farming household from Shamva District reduces the probability of becoming a net seller by 0.2 % while increasing the probability of being autarkic by 0.1 % and of being a net buyer of maize by 0.0 %.

All the three types of farming sector were positive and significantly influenced farmers' market participation decisions; A1 model ($p = 0.05$), communal ($p = 0.05$), and old resettlement ($p = 0.001$). The marginal effects show that farms located in the A1 model farming sector increase the probability of farming households to be net maize sellers by 12.4 % while reducing the probability of farming households to be autarkic by 12.2 % and to be net buyers by 0.2 %. Being a communal farming household reduces the probability of being a net maize buyer by 0.4 % and of being autarkic by 13.5 % while increasing the probability of being a net maize seller by 13.8 %. Being an old resettlement farming household also increases the probability of being a net maize seller by 13.7 % while reducing the probability of being autarkic by 13.3 % and of being a net maize buyer by 0.3 %.

4 Discussion

Preserving maize grain in storage with insecticides influenced farming households to be net maize sellers than to be autarkic or net maize buyers. Insecticides reduce microbial activity in stored grain that causes grain loss, thereby preserving the available grain. According to Midega *et al.* (2016), judicious use of insecticides provides effective pest control. Furthermore, use of traditional storage granaries promoted net maize selling behaviour in this study. Although the result was not expected, the finding corresponds with the findings of Persson (2009) in a study on market participation and poverty of the smallholders in Uganda, where access to storage facilities was correlated with a high probability of market participation. This result could also imply that farmers who stored grain in traditional granaries had better grain storage management skills that enhanced the safety of maize, such as the judicious use of insecticides and other preservative methods and thus promoted net selling behaviour. Gitonga *et al.* (2015) noted that farmers who adopt better storage technologies such as hermetic metal silos had better chances of selling their maize when prices became favourable. Thus storage technology plays a crucial role in in-

fluencing farmers' market participation behaviour (Moussa *et al*., 2014).

Farming households with higher quantities of maize grain were more likely to participate in the maize market as net sellers than as autarkic or net buyers, *ceteris paribus*. Amount of harvest directly determines the amount of grain available for household consumption as well as a marketable surplus (Geoffrey *et al*., 2013). A similar observation was noted in other studies (Omiti *et al*., 2009; Astewel, 2010; Geoffrey *et al*., 2013; Muricho *et al*., 2015). Pender & Alemu (2007), Ele *et al*. (2013) and Mbitsemunda & Karangwa (2017) found that quantity of crop produced had a significant and positive effect on the household's decision to participate in the output market. Policies that boost production of maize at the household and household head levels are thus key to promoting participation of smallholder households in maize markets.

Market location had a positive influence on market participation decisions. The availability of local markets promoted net maize selling behaviour of smallholder farmers in the area. This could be explained by the fact that farmers find it more costly to participate in distant markets than local ones. Other studies (Musah *et al*., 2014; Martey *et al*., 2012; Omiti *et al*., 2009) attested to this. Distant markets have higher transaction costs in terms of both travel time and cost of travelling than local markets (*ibid*.). This result is in line with other empirical studies on transaction costs which established that distance is inversely related to the decision to participate in the output markets (Key *et al*., 2000; Alene *et al*., 2008). Policies that promote the development of local markets are highly recommended.

The positive influence of sex on market participation decisions suggests that male households were more likely to be net sellers or autarkic compared to being net maize buyers. This is expected as male-headed households are likely to be more market-oriented than female-headed households due to their potential crop production efficiency advantages over their female counterparts (Omiti *et al*., 2009; Gebremedhin & Jaleta, 2010). This result corresponds with the findings of Hlongwane *et al*. (2014) who found a positive and significant effect of gender on market participation of maize farmers in South Africa. However, in contrast to this, Egbetokun *et al*. (2017) found that gender had a significant but negative influence on market participation of maize farmers in Nigeria. Therefore, gender is an important determinant of smallholder participation in output markets (Rahut *et al*., 2010; Quisumbing *et al*., 2014). Hence, policies that promote smallholder farmers market participation should include both men's and women's needs for equitable participation of farmers in output markets as markets provide farmers with an opportunity to improve their livelihoods through grain sales.

Influence of marital status on market participation decisions was positive. This implies that married farmers were more likely to be net maize buyers compared to being autarkic or net maize sellers. Married farmers are more concerned about being self-sufficient and feeding their households than their counterparts. More so, intra-household decision making is relevant for market participation decision making, henceforth, the positive influence on market participation. Egbetokun *et al*. (2017) found a similar result in a study on determinants of market participation among maize farmers in Nigeria. Policies that promote the household production of maize should support married farmers to access both input and output markets of staple crops so as to increase their production levels and thus participate in the market as net sellers of maize.

The negative and positive influence of district of location and farming sectors (Model A1, old resettlement, communal), respectively, on market participation decisions implied that farmers from Shamva District and small scale commercial sector were more likely to be autarkic than net sellers and were more likely to be net buyers than autarkic compared to their counterparts. Location-specific characteristics such as population related factors and industrial state of development that affect demand for the maize crop could have contributed to this difference. The higher population density of Makoni District and a relatively booming business sector which boost demand for maize meant that households in the district were likely much more willing to participate in the market as net sellers than in Shamva District. On the other hand, small scale commercial farmers in Zimbabwe have increased the acreage grown under tobacco at the expense of maize (ZIMVAC, 2011), thus their negative net selling behaviour. The findings connote with that of Muricho *et al*. (2015) and Mignouna *et al*. (2016) who found district of location to be a significant determinant of maize market participation in Kenya and maize and cowpea farmers in northern Nigeria, respectively. Understanding the location-specific characteristics of households is therefore important to design targeted policies for the promotion of market participation so as to improve their livelihoods.

5 Conclusions

Overall, farmers participate in staple food crop markets either as net sellers, autarkic or net buyers. This contributes to poverty reduction through income realised from sales, improved food security and enhanced nutrition as farmers buy from the market for household consumption. While a sub-

stantial amount of effort has been directed at understanding determinants of smallholder farmers' participation in markets analysing the discrete and continuous decision of market participation, there is still limited information as to how storage practices affect these decisions in developing countries. Storage is a critical component of the value chain among smallholder farmers in developing countries and has potential to contribute to farm incomes and food security. Hence, this study looked at the effects of grain storage technologies on smallholder farmers' market participation behaviour. Using primary data collected from a random sample of 413 farming households in Shamva and Makoni Districts of Zimbabwe, the ordered probit regression results showed the importance of storage technologies in influencing marketing decisions. Use of grain storage preservatives such as insecticides and storing grain using traditional granary promote a positive net maize selling behaviour, suggesting that safe storage of grain and type of storage method or facility are critical to enhance market participation of smallholder farmers. Thus, policies that encourage investment in safe storage technologies are highly recommended. Government should also design policies and develop programs to increase farmers' awareness of the use and benefits of insecticides on stored grain.

In addition, study results indicated the importance of other household socioeconomic characteristics such as quantity harvested, market location, sex and marital status of household head, district of location and farming sectors in influencing smallholder farmers' maize marketing decisions in Zimbabwe. Overall, policies that promote the development of local markets, that boost maize production are recommended for increased marketable surplus.

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Conflict of interest

The authors declare that they have no conflict of interest.

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