REGULAR ARTICLE

WHAT DRIVES THE CHOICE OF SEED STORAGE STRUCTURES? EVIDENCE FROM CERTIFIED MAIZE TRADERS IN GHANA

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ABSTRACT

Research background: Quality maize seed is a necessity to meet the ever-increasing demand for maize production for domestic and commercial uses in Ghana. The need for appropriate storage structures to maintain quality seeds is essential to attain food security and poverty reduction. Proper storage ensures that the gains of seed breeding programmes are maintained. It also maximizes profits through an increase in the quantity, quality, and a reduction in the commercial loss of seeds
Purpose of the article: Research in the seed value chain in Ghana has concentrated on farmers with lesser emphasis on the activities of seed traders although they are a critical link between seed producers and farmers. The infrastructure available for their trade has a telling effect on the seeds they offer for sale. This study investigates the type of seed storage structures used by maize seed traders in the Brong Ahafo Region. Factors that affected their choice were also examined.
Methods: We made a total population sampling of 82 certified maize seed traders across 8 districts in the region. A discrete choice model is used to examine the traders' choice of storage structures, as well as the determinants influencing their choice.
Findings & Value added: We find that traders predominantly store seeds in concrete and metal structures. While we find traders with more years of trading maize seeds tending to store their seeds in concrete structures, older farmers tend to use metal structures. Storage duration, age and perception of affordability of rent charges tend to decrease the likelihood of using metal as the storage structure. From a policy perspective, given the marked heterogeneity in characteristics influencing traders' choice of storage technology, it is relevant to critically consider these differences in policy design.

Keywords: *certified seeds; binary logistic regression; concrete; metal*.
JEL Codes: C25; Q13; Q16;013

INTRODUCTION

Seed storage is extremely relevant in the agricultural production system given the time widening period between harvesting and the next planting seasons. According to **Wambugu et al. (2009),** Sustainably storing seeds for uninterrupted and continuous production is crucial for the dual goals of poverty and food insecurity reduction. In addition to the good agronomic practices to preserve the vigour and vitality of seeds, storage structures certainly play an important role. Seed storage structures are facilities used to hold seeds during the storage period (**FAO, 2018a**). Appropriate storage structures and mechanisms are essential requirements for every seed business. Through an efficient intermediating role of traders, farmers can harness the potential benefits of seed breeding programs. Thus, proper storage also ensures profit maximization through a reduction in qualitative, quantitative and commercial losses **(Yousaf *et al.*, 2016)**. Seed storage further guarantees the stabilization in price by minimizing seed demand and supply shocks **(Pichop and Mndiga, 2007a)**. **Wambugu *et al.* (2009)** described poor seed storage infrastructure or facility as a major threat to seed security in Africa.
Different materials have been used for the construction of storage structures, including concrete, brick, wood and metal **(Semple *et al.*, 1992a)**. The different materials used in construction have varying attributes. Concrete storage structures, for instance, can provide insulation from heat, and are considered impervious. However, they tend to be considerably more expensive **(FAO, 2011a)**. When cracked, concrete structures tend to provide conducive conditions for insects, which could potentially attack the stored seeds **(FAO, 2011b, 2018b)**. Metal structures, on the other hand, are good conductors of heat and therefore allow for a rapid rise in temperatures **(Blight, 2006)**. At low temperatures, the problem of condensation also arises, leading to an increased moisture content of seeds and hastened deterioration **(Befikadu, 2014; Mijinyawa *et al.*, 2006)**. However, metal structures such as metal silos have the advantage of protecting seeds

from rodent attacks. It can also be made air-tight in which case it prevents insect proliferation by inhibiting respiration **(Tefera *et al.*, 2011)**. However, the high cost of construction may deter actors in the seed value chain from using them **(Nduku *et al.*, 2013)**.

Brong Ahafo region has a comparative advantage in maize production and maize seed multiplication due to its' conducive climate. However, the region lacks adequate modern storage facilities to support maize seed traders **(Amanor, 2013a)**. Farmers and traders often improvise on rather less effective traditional methods for storage. Even though these methods may offer partial effectiveness, they can lead to varying issues including low farmer confidence in certified seeds due to poor seed quality **(Pichop and Mndiga, 2007b)**. This may lead to low sales and profitability of the seed business. Furthermore, the low trust in certified seeds may incentivize farmers to use seeds stored from their previous harvest and may lead to lower yields due to a lack of guaranteed seed quality and a mix-up of varieties leading to loss of desirable traits after repeated use **(Aidoo *et al.*, 2012)**.

There is a growing body of evidence on the seed sector in Ghana. However, most of these studies have largely concentrated on seed delivery systems **(AGRA-SSTP, 2016; Aidoo *et al.*, 2012, 2013, 2014a; Almekinders and Louwaars, 2008; Amanor, 2013b; Etwire *et al.*, 2016, 2013; Krausova and Banful, 2010; Lyon and Afikorah-Danquah, 1998; Tripp and Mensah-Bonsu, 2013; Tripp and Ragasa, 2015)**, as well as seed policies in Ghana **(Amanor, 2012; Poku *et al.*, 2018; Zhou and Kuhlmann, 2016)**. Other studies conducted regarding maize storage also focused mainly on grains and farmer-saved seeds **(Aggrey, 2015; Peprah, 2004; Ragasa *et al.*, 2014)**. It appears most of these studies have generally concentrated on farmers, with less research on maize seed traders. Given the crucial role of traders in facilitating the seed business, it is relevant to undertake the study, to gain more insights into traders' activities in the value chain. The study contributes to the growing body of evidence by assessing the factors that influence the choice of maize seed storage structure among maize traders in the Brong Ahafo region of Ghana. Specifically, the study seeks to identify the storage structures used by seed traders and the determinants of their choice.

LITERATURE REVIEW

The Food and Agriculture Organisation of the United Nations establishes that "seed security exists when men and women within the household have sufficient access to quantities of available good quality seed and planting materials of preferred crop varieties at all times in both good and bad cropping seasons" **(FAO, 2015)**. Interactions between climate change and other factors such as household wealth, access to credit and ethnic conflicts among marginalised groups and their superior counterparts have also led to situations of seed insecurity in Sub-Saharan Africa **(Madin *et al.*, 2022; Mcguire and Sperling, 2016)**.

Different strategies have been employed in times of drought, late onset of rains and conflicts in acquiring seeds when planted seeds are lost or destroyed and seed stocks are depleted. These include switching to other more resilient or shorter-duration crops or varieties. Another strategy is to seek seeds from kinsmen in other communities. However, there are likelihoods of refusal or not getting the desired quantities in some instances. Some cultural norms also frown upon seeking seeds from the same social network year after year **(Violon *et al.*, 2016)**. Wealthier households construct seed stores close to their homes to prevent losses from livestock, bushfires or destructions during conflicts **(Madin *et al.*, 2022)**.

The impact of seed security on food security cannot be overemphasised. This has led to interventions and investments in crop improvement to mitigate the impact of climate change **(Poku *et al.*, 2018)**. Governmental support to address the shortcomings of the traditional seed acquisitions has been the creation of a more formalised seed system through the supply of subsidised seeds **(Tripp and Mensah-Bonsu, 2013)** has been one of the adaptation strategies to curb the impact of climate change.

Ghana's formal seed sector has had a long and checkered history. The first formal seed unit was the Hybrid Maize Unit set up in 1958 **(Etwire *et al.*, 2013)**. A new seed company called the Ghana Seed Company was established in 1979. This company had the mandate to produce certified seeds until it was privatised in 1989 as part of reforms implemented during the Structural Adjustment Program of the Government of Ghana **(Lyon and Afikorah-Danquah, 1998)**. Currently, governmental agencies play regulatory roles whiles commercial seed production is done by the private sector. The Ghana Seed Inspection Division (GSID) has the mandate of regulating the seed sector through the certification of seed producers and retailers and conducting field inspections for adherence to seed production protocols **(Zhou and Kuhlmann, 2016)**. They also carry out inspections at storage and sales facilities. Laboratory tests for purity and germinability are done before seeds are certified for packaging and sale to farmers by GSID **(Poku *et al.*, 2018)**. Varietal development is done mainly by public research institutions and universities **(Etwire *et al.*, 2013)**.

Production of certified seeds is done by private seed producers and a majority are members of the Seed Producers Association of Ghana (SEEDPAG) **(Etwire *et al.*, 2013)** or National Seed Trade Association of Ghana (NASTAG) **(AGRA-SSTP, 2016; Zhou and Kuhlmann, 2016)**.

The sale of certified seeds in Ghana is done by dealers who also sell other inputs like fertilizer and pesticides. Some seed traders are in an association by the name Ghana Agri-Input Dealers Association (GAIDA). According to **Tahirou *et al.* (2009)** and **Etwire *et al.* (2013)**, seed distribution is done through direct sales to farmers, NGOs and governmental organizations.

Seed traders have used different facilities to hold seeds until distribution or their final use. There is a wide range of materials or options to select from when constructing storage structures. They include; concrete or brick, wood or metals **(Semple *et al.*, 1992b)**.

Seeds are living; therefore, they respire during storage and release heat and moisture during the process. So, poorly ventilated seed storage rooms enhance temperature and moisture accumulation in the seed lot resulting in rapid loss of seed viability and health **(Bewley *et al.*, 2013; McDonald and Copeland, 1997)**.

According to **FAO (2011a)**, factors such as the type and purpose of the structure and the economics of constructing and maintaining the structure should be a guide when making a choice. Other factors to consider are the availability of raw materials and labour to construct the structure, comparison of quality and durability of alternatives, cost of transporting the construction materials, compatibility of construction materials and individual preference.

Various studies have been conducted to ascertain the factors that affect the adoption of technologies by farmers **(Maboudou *et al.*, 2004a; Maonga *et al.*, 2013a; Owach *et al.*, 2017a)**. The review of factors that affect adoption will be categorised as; socioeconomic, technical or institutional factors and perceptions.

Socioeconomic Characteristics Influencing Adoption

Age has often been associated with the accumulation of wealth thereby increasing the potential of acquiring more durable and comparatively expensive storage facilities **(Owach *et al.*, 2017a; Thamaga-Chitja *et al.*, 2004)**. In other studies, an increase in age has been linked to an aversion to new technologies **(Bokusheva *et al.*, 2012a; Maonga *et al.*, 2013a)**. Thus, the effect of age on the choice of storage structures has been mixed.

The positive impact of experience stems from the fact that more informed choices are likely to be made when a person remains in that field for an appreciable number of years **(Okoruwa *et al.*, 2009a)**. This was corroborated by **Adetunji (2007a)** in a study on grain storage technologies used by farmers in Nigeria. In their study, additional years of experience in maize storage increased farmers' adoption of modern structures compared to local and semi-modern options. Contrary to the above, **Ainembabazi and Mugisha (2014)** reported that experience influenced choice at the introductory phase of a product or technology, but after testing they will either adopt or discontinue use based on the performance of the technology or system.

Education: Education has been known to increase exposure and the ability to access and adopt modern technologies **(Maonga *et al.*, 2013b; Uaiene *et al.*, 2009a)**. Some empirical studies have shown the positive effect education has on farmer choice. Adetunji and **Okoruwa *et al.* (2007b; 2009b)** found that increased years in formal education enhanced the use of modern storage methods in different states in Nigeria. An increase in years spent in formal education and experience was likely to enable farmers to make more informed choices. Education also afforded a person the ability to keep records **(Djokoto *et al.*, 2016)** and thus be able to compare the performance of different systems. Increased years of formal education of household heads were also found to increase the adoption of modern storage and agricultural technology in Agrarian communities in Northern Uganda and Mozambique **(Owach *et al.*, 2017b; Uaiene *et al.*, 2009a)**. Additional years of education also enhanced the adoption of small metal silos by farmers in Mwingi Central Sub-County in Kenya and Malawi **(Kimani, 2016a; Maonga *et al.*, 2013b)**.

Income levels, land ownership and Farm size

Bokusheva *et al.* (2012b) reported a positive influence on land ownership and adoption of metal silos. Farmers who own lands were seen as wealthier and thus their ability to purchase metal silos which were relatively more expensive compared to their substitutes in Nicaragua, El-Salvador, Guatemala and Honduras. Such farmers were also willing to invest more in their lands and business since they would not have tenancy renewal issues compared to farmers who rented lands. They would be willing to put up permanent structures like metal silos. This was confirmed by **Conteh *et al.* (2015)** who investigated the determinants of post-harvest technologies in Sierra Leone. Farm size has affected choice either positively or negatively in various research. Some studies used larger farm sizes as a proxy for wealth and the ability to buy inputs and pay for labour **(Kimani, 2016b; Maboudou *et al.*, 2004b; Maonga *et al.*, 2013c)**. **Owach *et al.* (2017c)** explained that there is a possibility of increased yield when farm size was expanded and thus the need for better storage spaces to protect produce. A divergent effect was recorded in another empirical study by **Makana and Thebulo (2018)**. They reported that cheaper traditional storage structures were sought after to reduce the cost of storing larger harvests resulting from an increase in farm size.

Technical or Institutional Factors

Extension improved awareness of modern or more efficient technologies **(Maonga *et al.*, 2013a; Uaiene *et al.*, 2009b)**. The importance of extension in decision-making was corroborated by **Aidoo *et al.* (2014b)**, **Lwala *et al.* (2016)** and **Okorley and Bosompem (2014)**. Farmers with access to extension services adopted metal silos more than farmers who had limited extension contact in research in Malawi **(Maonga *et al.*, 2013a)**.

Membership of an association affected farmers' choice of modern food storage structures positively in a study by **Owach *et al.* (2017a)**. Some reasons given for the positive influence were that farmers were more organised and likely to have access to information about new technologies. Association membership is also likely to boost bargaining power through the collective acquisition of modern structures **(Owach *et al.*, 2017a)**. The associations become the mouthpiece of their members and can influence policy decisions **(Asante *et al.*, 2011)**. Membership in an association may lead to peer pressure, that is members would acquire modern structures to keep up with other members of the group **(Owach *et al.*, 2017a)**.

Credit increased the purchasing power of farmers or traders in acquiring new food storage technologies and hiring labour during construction **(Owach *et al.*, 2017a)**. Some research has shown a high correlation between credit access and productivity **(Awotide *et al.*, 2015; Diagne and Zeller, 2001; Foltz, 2004)**. Households with access to credit were able to acquire modern structures in research conducted in Uganda and Mozambique **(Gbénou-Sissinto *et al.*, 2018; Owach *et al.*, 2017a; Uaiene *et al.*, 2009b)**.

Perceptions About Storage Facility

The adoption perception paradigm states that the perceived characteristics of a technology influences adoption **(Uaiene *et al.*, 2009b)**. **Gbénou-Sissinto *et al.* (2018)** were of the view that user perceptions of the effectiveness of structure influenced their choice positively or negatively. A storage structure which was considered to provide the greatest protection against pests, fire and theft was selected. Thus, knowledge of end-user perception and preferences should inform product development and dissemination.

DATA AND METHODS

Data source and sampling procedure

The study was conducted in the Brong Ahafo region of Ghana, a region known to be the food basket of Ghana. Brong Ahafo is the largest maize-producing region in Ghana accounting for 24.23% of the overall national production in 2016 **(Ministry of Food and Agriculture, 2017)**.

A purposive sampling of eight districts/municipalities where maize seed sales were predominant in the Brong Ahafo region was made. The districts/municipalities selected were Atebubu Amantin, Kintampo South, Kintampo Municipal, Nkoranza North, Nkoranza Municipal, Techiman North, Techiman Municipal and Wenchi Municipal There were hundred (100) operational and duly licenced Agro-input dealers in the study area according to the records of the Plant Protection and Regulatory Services Directorate (PPRSD) in 2018. A total population sampling of the 100 agro-input dealers was done of which 82 of them were found to have sold certified maize seed during the planting season and hence these were interviewed.

Conceptual framework

Consider a risk-averse trader who purchases and sells a kilogram of maize seeds, Q, with options to utilize storage structures $S_c = (S_1, S_2, \dots, S_K)$, with their associated initial investment costs $N_c = (N_1, N_2, \dots, N_K)$ and operational and maintenance costs, $C_c = (C_1, C_2, \dots, C_K)$. Using the storage structure preserves the vigour and vitality of seeds, increases the quality and improves the storage duration. Let $q_s = (q_1, q_2, \dots, q_k)$ represent the improvements in the seed quality for using the respective structure, S_c. Thus, the quantity of seed traded, Q, is a function of the type of storage, expressed as $Q = f(S_c, e)$ where e captures all other factors that influence the quantity of seeds at any particular point in time. Given that seed buyers are willing to pay a premium price, P_q over and above the standard price $\bar{P}$, the premium P_q is ordered from 0, in which case the buyer pays the standard price, to P_{q_max}, the maximum the buyer is willing to pay above the standard price. Thus, the premium captures the value associated with quality, q_s.The total cost associated with seed storage structure, S_c, is given by the sum of the initial investment cost and the discounted operational costs, $N_c + \sum_{t=1}^{T} \frac{C_s}{(1+r)^T}$ Different seed storage structures are capable of safely storing seeds to different extents over time T, because of their varying duration of storage. The associated revenues from seed sale from storage structure are given by $Q\left(\bar{P} + \sum_{t=1}^{T} \frac{P_q}{(1+r)^T}\right)$ We assume that the trader maximizes her expected utility of the discounted profits, $E[U(\pi_c)]$, in the expression:

$$MaxE\left[U(\pi_s)\right] = \underset{s}{Max}\, E\left\{U\left[Q\left(\bar{P} + \sum \frac{P_q}{(1+r)^T}\right) - N_s + \sum \frac{C_s}{(1+r)^T}\right]\right\} \quad (1)$$

Where the expression $U(\cdot)$ represents the von Neumann-Morgenstern utility, with a positive marginal utility, $\frac{\partial U(\cdot)}{\partial(\pi_c)} > 0$, and a decreasing marginal utility, $\frac{\partial^2 U(\cdot)}{\partial^2(\pi_c)} < 0$.

The expectation operator is denoted by E and π_c represents the profit a trader obtains from her choice of the storage structure. The trader's profit is maximized when:

$$\overline{P}\frac{\partial Q}{\partial S}+P_q\frac{\partial Q}{\partial S}-\frac{\partial Q}{\partial S}=0 \tag{2}$$

As previously indicated, a rational risk-averse trader will choose the storage structure that maximizes her expected utility, $E\left[U\left(\pi^{s^*}\right)\right]-E\left[U\left(\pi^{s}\right)\right]>0$, which S^* denotes the alternative chosen by the trader, i over all others S. Given that the net utility of profit, y_i^*, associated with the choice of storage structure, is latent, we can express it as a function of some observables:

$$y_i^*=Z_i\beta_i+\varepsilon_i,\ \ y_i=1\ \text{ if }\ y_i^*>0 \tag{3}$$

Where y_i is a binary indicator variable representing the household i, and is equal to 1, if a trader uses a concrete storage structure, and zero otherwise. Also, Z_i is a vector of explanatory variables, including age, years of experience in trading in maize seed, membership of trader association, and duration of seed storage, among others.
Likewise, β_i is a vector of parameters to be estimated, and ε_i is the error term assumed to be normally distributed with zero mean and constant variance.

Empirical specification

As previously indicated, seed traders are assumed rational and will make choices on the type of storage structure that maximizes profit. However, the utility associated with the choice of storage structure cannot be observed. In expressing the function of the latent variable of storage choice on some observables, several distributional assumptions are made. When the Bernoulli event of choosing either a concrete or a metal container to store seeds is repeated many times, its distribution may be approximated by a more manageable and easily estimated function. In particular, when we approximate this seed storage structure choice conditional on a normally distributed disturbance term, then a Probit model is estimated. On the other hand, conditioning on a logistic disturbance term calls for the use of the logistic model. The tendency for the logit model to conveniently handle extreme values makes it a preferred option **(Gujarati, 2004)**. In addition, the logistic model has the advantage of flexibility and ease of interpretation of dichotomous outcome variables **(Hosmer and Lemeshow, 1989)**.
The Logit probability is represented mathematically as:

$$P_i=\frac{1}{1+e^{-z_i}}=\frac{e^{z}}{1+e^{z_i}} \tag{4}$$

$f(z_i)$ is the weight of the density function with respect to z_i.
The logit model takes the form;

$$\log\left[\frac{P_i}{1-P_i}\right]=\beta_0+\sum_{j=1}^{n}\beta_{in}Z_i+\varepsilon_i \tag{5}$$

Where
P_i =probability of a trader using a concrete storage structure
B_0 = constant
$\sum_{j=1}^{n}\beta_{in}Z_i$ = vector of the independent variables and their associated coefficients
ε_i= disturbance term
Specifically, the model is expressed as:

$$\begin{aligned}STORAGE_i=\beta_0&+\underset{+/-}{\beta_1\left(AGE\right)_i}+\underset{+/-}{\beta_1\left(Experience\right)_i}+\underset{+}{\beta_3\left(TradeAssoc\right)_i}+\underset{-}{\beta_4\left(StoreDuration\right)_i}\\&+\underset{-}{\beta_5\left(AffordPerceptn\right)_i}+\underset{+}{\beta_6\left(QtyDiscard\right)_i}+\varepsilon_i\end{aligned} \tag{6}$$

Where $STORAGE_i$ is the storage structure used by seed traders with 1 = concrete structure, and 0 = metal, (wooden was excluded because of limited usage of this structure by respondents $\beta_0,...,\beta_5$ are parameters to be estimated whiles capturing the disturbance term, ε_i .

RESULTS AND DISCUSSION

Descriptive statistics of maize seed traders

A typical maize seed trader is about 37 years old and has been trading in the commodity for about six years. About one in three of the interviewed traders belonged to a trader's association. Traders purchased and stored their maize stock for about four weeks before they sell. On their perception of the cost of rent, the results show that traders appear to be indifferent to the cost of rent for their storage structures. This, perhaps, could be indicative of their general satisfaction with the cost of renting the storage structures. In particular, neither do they perceive the cost to be exorbitant nor cheap. We present the descriptive statistics of the sampled traders in Table 1 below.

Table 1 Descriptive statistics on sampled seed traders

Dependent variable for Binary Model: Seed storage structure (1= Concrete, 0=Metal)			
Independent Variables	Definition	Mean	Std
Traders Characteristics:			
Age	Age of trader in years	36.98	11.23
Experience	Number of years selling maize seeds	6.11	6.11
Technical/Institutional			
Membership of Trader's Association	1=Member of Trader's Assoc. 0= Otherwise	0.29	0.46
Storage Duration	In weeks	4.16	2.86
Perception of Traders			
Perception of affordability of Cost of Rent	1= Very low, 2=Low, 3 =Average 4= High and 5= Very high	3.78	0.88
Perception of reduction in Quantity Discarded	1= Very low, 2=Low, 3 =Average 4= High and 5= Very high	4.94	0.29

Seed Storage Structures used by Maize Seed Traders

Eight different seed storage structure and container combinations categorised as concrete, metal and wooden were identified as being used by traders as shown in Table 2.

Concrete building refers to stores in the market centers, commercial warehouses or rooms in the dwellings of the trader. Concrete + Plastic sacks (68.30%) was the widely used seed storage structure-container combination. However, three traders (3.7%) emptied their packaged maize seeds into hermetic sacks during storage and sales. Four other traders stored theirs in boxes, metal drums and plastic receptacles during seed storage and sales. Their motive for storing seeds this way was to prevent rodents from destroying seeds. Structures built from metallic sheets or recycled shipping containers were also used by approximately 18% of those who stored in the generic plastic sack issued by Ghana Seed Inspection Division (GSID). Only one trader was found to use a wooden structure and so was treated as an outlier and removed from the model so further discussions focused on the usage of concrete or metal storage structures.

Table 2 Seed storage structure and container combinations used by traders

Type of seed storage structure	Frequency	Percentage
Concrete building + Hermetic sacks	3	3.7
Concrete building + Paper box	1	1.2
Concrete building + Metal drum	1	1.2
Concrete building + Plastic sacks	56	68.3
Concrete building + Plastic container	2	2.4
Metal container + Hermetic sacks	3	3.7
Metal container + Plastic sacks	15	18.3

Wooden structure + Plastic sacks	1	1.2
Total	82	100

Source: Field survey, 2019

A general observation of all the storage structures was that they were not solely used for seed storage. Traders who had separated structures for both vending and storing also stored other agro-inputs and equipment in the same structure. Ventilation in these stores was very poor whilst the main entrances to the stores and metal structures were shut at night. Ventilation is essential in seed storage stores as it is a requisite for effective convectional airflow that would enhance heat dissipation which would lead to a significant reduction in moisture content in the storage facility generated from seed respiration. Poor ventilation could lead to hot spots, caking or sprouting of seeds resulting in the eventual loss of seed viability **(McDonald and Copeland, 1997)**.

Relationship between socio-economic variables and seed storage structures

Table 3 summarises the socio-demographics of seed traders with respect to the type of storage structure used. There was no significant difference in age, years spent in formal education, household size, association membership, cost of storage as well as storage duration between users of concrete and metal seed storage structures. Conversely, differences in experience (years) and quantity sold were significant at 1%. Users of concrete storage structures were more experienced with a mean of 6.82 years compared to metal storage structure users with mean years of experience of 3.53 years.

Users of concrete storage structures sold significantly higher quantities than metal structure users, hence, are classified as large-scale operators. The average amount of seeds sold by concrete structure users was 748.96 kg whiles an average of 252.48 kg was sold by metal structure patrons. Concrete structure users also had greater access to credit. Differences in access to credit were significant at 10%. This can be attributed to the fact that financial institutions consider the type of infrastructure used by the business before granting loans to them (Fufa, 2016). Thus, fixed assets are a requisite for creditworthiness.

Table 3 Demographics of maize seed traders based on storage structure type utilised

	Concrete		Metal			
	Mean	Std	Mean	Std	Mean Diff.	T-test
Age (years)	37.02	12.07	36.41	9.42	0.61	0.22
Education (years)	11.36	3.26	10.5	1.97	0.86	1.31
Household Size	4.64	2.87	4.29	2.97	0.35	0.43
Experience (years)	6.82	4.84	3.53	2.12	3.29***	3.98
Number of Training	2.05	1.49	1.44	1.42	0.61	1.56
Access to Credit	0.64	0.48	0.39	0.5	0.25*	1.87
Association Membership	0.34	0.47	0.17	0.38	0.17	1.26
Quantity Sold (kg)	748.96	14.73	252.48	7.02	496.48***	3.74
Storage Cost/kg	0.27	0.29	0.26	0.23	0.01	0.13
Storage duration (weeks)	3.54	1.93	4.47	3.18	0.93	-1.43

Significance level: * p<0.05 ** p<0.01 *** p<0.001

Factors Affecting the Choice of Seed Storage Structures

The explanatory power of the model was determined by the Likelihood ratio (LR). The LR was statistically significant (p<0.001) and confirms that the model follows a Chi-square distribution. Therefore, this data is adequately explained by the logit model as presented in Table 4.

Table 4 Binary logit estimates of factors affecting the choice of seed storage structures

Variables	Coefficient	Marginal Effects
Age	-0.07*	-0.01*
	(-0.04)	-0.004
Experience	0.38***	0.04***
	(-0.16)	-0.014

Storage Duration	-0.33**	-0.03**
	(-0.16)	-0.017
Trader Association Membership	1.3	0.11
	(-1.05)	-0.073
Reduction in Quantity Discarded	1.11	1.11
	(-0.18)	-0.1
Affordability of Cost of Rent	-1.01*	-0.1*
	(-0.53)	-0.057
Constant	1.77	
	(-5.06)	
LR Chi^2	25.66***	
Pseudo R^2	0.302	
Log-likelihood	-29.56	

Significance level: * $p<0.05$ ** $p<0.01$ *** $p<0.001$.

The variable representing age was negative and statistically significant. This means that an increase in age decreases the probability of using concrete storage structures by one per cent. Which may be attributed to risk aversion associated with an increase in age **(Bokusheva *et al.*, 2012a; Maonga *et al.*, 2013a)**. Contrary to the findings of this research, **Thamaga-Chitja *et al.* (2004)**, **Adetunji (2007a)** and **Owach et al. (2017)** reported age to increase the probability of adoption of modern technologies. They further associated increased age with the likelihood of greater wealth accumulation to afford better technologies.

Experience or number of years for selling maize seeds influenced the choice of concrete storage structure positively and was significant at 1%. An additional year of experience in selling maize seeds increased the probability of using concrete storage structures by about four per cent. With an increase in years of experience, maize seed traders are better placed to appreciate the merits and demerits of the various storage structure options. This finding agrees with Maboudou *et al.* **(Maboudou *et al.*, 2004a)** on the use of improved clay storage facilities in Benin where a higher level of experience affected adoption. It also corroborates **Adetunji (2007)** who researched the economics of storage among farmers in Kwara State, Nigeria. With increased experience, it is also possible to acquire additional wealth to construct or rent more expensive seed storage structures **(Owach *et al.*, 2017a)**.

Another factor that significantly affected the choice of concrete seed storage structure negatively was the duration of storage which was significant at 5%. There was a negative marginal effect of 0.03 in using concrete structures as storage duration increased. An increase in seed storage duration is not compensated with price increases due to the relative stability of the price of maize seeds. Maize seed traders in the study area tend to use metal storage structures as storage duration increases and the cost of storage accumulates. These findings were underscored by **Ayedun (2018)** who also reported a negative impact on the use of PICS bags with increasing storage period. This was due to the relatively high cost of PICS bags so farmers resulted to cheaper options like chemicals to protect their stocks when storage duration increased. The findings however contradict the assertions made by **Gbénou-Sissinto *et al.* (2018)** in their research in Benin after investigating the relationship between the period of maize storage and storage alternatives.

Traders' perception of the affordability of rent charges for a storage structure affected their choice of concrete storage structures. There was a significant negative effect of trader perception of the cost of rent on the choice of concrete structures. An additional increase in the perception of the cost of rent will reduce the use of concrete storage structures by 10%. This is in line with the findings of **Maonga et al. (2013)**. In their study, farmer perception of the cost of metal silos was a deterrent to adoption although the farmers agreed it was more effective in reducing losses. Contrary to the finding of this study, **Gitonga *et al.* (2015)** found farmers' perceptions of the high cost of metal silos in Kenya to influence adoption positively. This was because the farmers linked higher costs to the effectiveness of storage facilities to protect their grains. They were of the view that they could recoup their investment in the long run when well-protected grains were sold. **Gbénou-Sissinto *et al.* (2018)** on the other hand reported a mixed effect on the perception of the cost of the storage structure. The positive or negative impact of the perception of cost on adoption was based on the segment of society they belonged to.

CONCLUSION AND RECOMMENDATIONS

The study investigated the types of seed storage structures used by maize seed traders in the Brong-Ahafo region of Ghana and the factors that determined their choice. A census of the population was taken and data from the survey was fitted using a logistic model. About 78% of the traders sampled stored their seeds in concrete structures with the remaining stored mainly in metal structures. Traders who stored in concrete facilities were more experienced and also sold larger quantities of maize seed than those who stored in metal structures. Additionally, concrete structure users had greater access to credit facilities than metal storage users.

The empirical logit results show that, with the increasing age of maize seed traders, metal structures were preferred whiles an increase in years of trading in maize seed led to the use of concrete structures. Also, storage duration and perception of higher rent cost of concrete structures negatively influenced its usage.
The study recommends that, in generating and disseminating seed storage technologies to seed traders, factors such as age, experience, storage duration and perception of rent charges are important factors to consider to promote adoption. Therefore, any strategies aimed at improving or introducing storage structures to traders should consider these factors in their implementation. To ensure that seed traders can obtain loans to support their business thereby enhancing seed availability, accessibility and seed security the promotion of concrete storage structures is required as users had greater access to credit.

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REFERENCES

ADETUNJI, M. O. (2007). Economics of maize storage techniques by farmers in Kwara state, Nigeria. Pakistan Journal of Social Sciences, 4(3), 442–50. https://medwelljournals.com/abstract/?doi=pjssci.2007.442.450

AGRA-SSTP. (2016). Ghana Early Generation Seed Study. United State Agency for International Development, Ghana. pp. 24-112. Date Accessed: 19-06-2019. https://www.agrilinks.org/sites/default/files/resource/files/ghana_early_generation_seed_report.pdf

AIDOO, R., MENSAH, J. O., OMONO, B. F. AND ABANKWAH, V. (2014). Factors determining the use of certified maize seeds by farmers in Ejura-Sekyedumasi Municipality in Ghana. World Journal of Agricultural Sciences, 2 (5) (July), 84–90. https://api.semanticscholar.org/CorpusID:54804166

AIDOO, R., QUANSAH, C., AKROMAH, R., OBENG-ANTWI, K., ADU-GYAMFI, K., LAMPOH, J. AND SUBEDI, A. (2012). Ghana Seed Sector Assessment. Integrated Seed Sector Development, Africa. pp. 1-5. https://www.researchgate.net/publication/283070048_ISSD_Briefing_Note_-_September_2012_Ghana_Seed_Sector_Assessment

AIDOO, R., QUANSAH, C., AKROMAH, R., OBENG-ANTWI, K., ADU-GYAMFI, K., LAMPOH, J. AND SUBEDI, A. (2013). ISSD Briefing Note – April 2013 Ghana Seed Entrepreneurship Assessment. Date Assessed: 10-10-2018. https://www.wur.nl/web/file?uuid=a5a342f3-b6d4-4762-972e-be3195086d9f&owner=1a616bd7-d3c1-493f-9533-d5d61aa53e4a

AINEMBABAZI, J. H. AND MUGISHA, J. (2014). The Role of Farming Experience on the Adoption of Agricultural Technologies: Evidence from Smallholder Farmers in Uganda. The Journal of Development Studies, 50(5), 667–679. Uganda. http://dx.doi.org/10.1080/00220388.2013.874556

ALMEKINDERS, J. M. C. AND LOUWAARS, P. N. (2008). The Importance of the Farmers' seed systems in a functional national seed sector. Journal of New Seeds, 4, 15–33. https://doi.org/10.1300/J153v04n01_02

AMANOR, K. S. (2012). From Farmer Participation to Pro-Poor Seed Markets: The Political Economy of Commercial Cereal Seed Networks in Ghana. Policy Brief (Vol. 047). Future Agricultures Consortium. pp. 48-58. https://doi.org/10.1111/j.1759-5436.2011.00235.x

AMANOR, K. S. (2013). Dynamics of Maize Seed Production Systems in the Brong Ahafo Region of Ghana: Agricultural Modernisation, Farmer Adaptive Experimentation and Domestic Food Markets. Future Agricultures Consortium. Working Paper, pp. 2-18. https://assets.publishing.service.gov.uk/media/57a08a3ded915d3cfd000670/FAC_Working_Paper_061.pdf

ASANTE, B. O., SEFA, V. A. AND SARPONG, D. B. (2011). Determinants of small-scale farmers' decision to join farmer-based organizations in Ghana. African Journal of Agricultural Research, 6(10), 2272–2279. Ghana. https://doi.org/10.5897/AJAR10.979

AWOTIDE, B. A., ABDOULAYE, T., ALENE, A. AND MANYONG, V. M. (2015). Impact of Access to Credit on Agricultural Productivity: Evidence from Smallholder Cassava Farmers in Nigeria (pp. 1–34). Milan: International Conference of Agricultural Economics, August, 9-14 2015. https://ageconsearch.umn.edu/record/210969/?ln=en

AYEDUN, B. (2018). Studies on Effects of Purdue Improved Crop Storage Bags in Reducing Post-Harvest Loss in Maize Storage in Nigeria. Acta Scientific Nutritional Health, 2(7), 25–41. Nigeria. https://actascientific.com/ASNH/pdf/ASNH-02-0098.pdf

BEFIKADU, D. (2014). Factors Affecting Quality of Grain Stored in Ethiopian Traditional Storage Structures and Opportunities for Improvement. International Journal of Sciences: Basic and Applied Research, 18(1), 235–257. Ethiopia. https://api.semanticscholar.org/CorpusID:54671479

BLIGHT, G. (2006). Assessing Loads on Silos and other Bulk Storage Structures. Taylor and Francis (CRC Press/Balkema), Florida, pp 139-142. https://www.amazon.com/Assessing-Loads-Silos-Storage-Structures/dp/0415392373

BOKUSHEVA, R., FINGER, R., FISCHLER, M., BERLIN, R., MARÍN, Y., PÉREZ, F. AND PAIZ, F. (2012). Factors determining the adoption and impact of postharvest storage technology. Springer, 4, 279–293. https://doi.org/10.1007/s12571-012-0184-1

DIAGNE, A. AND ZELLER, M. (2001). Access to Credit and Its Impact on Welfare in and Its Impact on Welfare in Malawi. International Food Policy Research Institute Washington, D.C. Research Report 116, p. 2. https://ideas.repec.org/p/fpr/resrep/116.html

ETWIRE, E., ARIYAWARDANA, A. AND MORTLOCK, M. Y. (2016). Seed Delivery Systems and Farm Characteristics Influencing the Improved Seed Uptake by Smallholders in Northern Ghana. Sustainable Agricultural Research, 5(2), 27–40. Ghana. https://doi.org/10.5539/sar.v5n2p27

ETWIRE, P. M., ATOKPLE, I. D. K., BUAH, S. S. J., ABDULAI, A. L., KARIKARI, A. S. AND ASUNGRE, P. (2013). Analysis of the Seed System in Ghana. International Journal of Advance Agricultural Research, 1, 7–13. https://api.semanticscholar.org/CorpusID:55444941

FAO. (2011). Grain Crop Drying, Handling and Storage. Rural Structures in the Tropics: Design and Development (pp. 363–385). Food and Agriculture Organisation, Rome. pp. 363-385. https://www.fao.org/3/i2433e/i2433e10.pdf

FAO. (2015). *Household seed security concepts and indicators*. Retrieved from http://www.fao.org/fileadmin/user_upload/food-security-capacity-building/docs/Seeds/SSCF/Seed_security_concepts_and_indicators_FINAL.pdf

FAO. (2018). Seeds Toolkit- Module 6: Seed Storage. Food and Agriculture Organisation, Rome. pp. 3-100. https://www.fao.org/publications/card/en/c/CA1495EN/

FOLTZ, J. D. (2004). Credit market access and profitability in Tunisian agriculture. Agricultural Economics, 30, 229–240. https://doi.org/10.1111/j.1574-0862.2004.tb00191.x

FUFA, F. G. (2016). Determinants of Access to Credit and Credit Source Choice by Micro, Small and Medium Enterprises in Nekemte, Ethiopia. International Journal of African and Asian Studies, 28, 11–27. Ethiopia. https://api.semanticscholar.org/CorpusID:53991885

GBÉNOU-SISSINTO, E., ADEGBOLA, Y. P., BIAOU, G. AND ZOSSOU, R. C. (2018). Farmers' Willingness to Pay for New Storage Technologies for Maize in Northern and Central Benin. Sustainability, 10(2925), 1–21. https://doi.org/10.3390/su10082925

GITONGA, Z., GROOTE, H. DE AND TEFERA, T. (2015). Metal silo grain storage technology and household food security in Kenya. Journal of Development and Agricultural Economics, 7(6). Kenya. https://doi.org/10.5897/JDAE2015.0648

GUJARATI, D. N. (2004). Basic Econometrics (4th Edn.). The McGraw-Hill Companies, New York, pp. 616-615. https://www.amazon.com/Basic-Econometrics-4th-Damodar-Gujarati/dp/0070597936

HOSMER, D. W. AND LEMESHOW, S. (1989). Applied Logistic Regression Second Edition (2nd Edn.). John Wiley & Sons, Inc., U.S.A. pp. 1-30, 147-150. https://doi.org/10.1002/0471722146

KRAUSOVA, M. AND BANFUL, A. B. (2010). Overview of the Agricultural Input Sector in Ghana. International Food Policy Research Institute (IFPRI), Development Strategy and Governance Division. Discussion Paper pp. 1-28. https://www.ifpri.org/publication/overview-agricultural-input-sector-ghana

LWALA, R. J., ELEPU, G. AND HYUHA, T. S. (2016). Effect of Farmer Field School on Adoption of Improved Cotton Production Technologies in Eastern Uganda. Journal of Agricultural Economics, Extension and Rural Development, 4, 419–428. Uganda. http://www.springjournals.net/full-articles/springjournals.netjaeerdarticlesindex=9lwalaetal.pdf?view=inline

LYON, F. AND AFIKORAH-DANQUAH, S. (1998). Small-scale seed provision in Ghana: social relations, contracts and institutions for micro-enterprise development. Agricultural Research and Extension Network (AgREN), NO. 84 pp. 1-9. https://api.semanticscholar.org/CorpusID:55831143

MABOUDOU, A. G., ADEGBOLA, P. Y., COULIBALY, O., HELL, K. AND AMOUZOU, E. (2004). Factors Affecting the Use of Clay Stores for Maize in Central and Northern Benin. New Directions for a Diverse Planet, Proceedings of the 4th International Crop Science Congress, Brisbane, Australia, 26 September–1 October (pp. 1–6). http://www.regional.org.au/au/asa/2004/poster/4/1/2/1233_maboudou.htm

MAONGA, B. B., ASSA, M. M. AND HARAMAN, E. M. K. (2013). Adoption of small metallic grain silos in Malawi: A farm level cross-sectional study. International Journal of Development and Sustainability, 2(2), 1534–1548. Malawi. http://www.regional.org.au/au/asa/2004/poster/4/1/2/1233_maboudou.htm

MCDONALD, M. B. AND COPELAND, L. O. (1997). Seed Production: Principles and Practices. Springer Science+Business Media, B. V., Dordrecht. pp. 127-132. https://doi.org/10.1007/978-1-4615-4074-8

MIJINYAWA, Y., MWINJILO, M. L. AND DLAMINI, P. (2006). Assessment of Crop Storage Structures in Swaziland. Agricultural Engineering International: the CIGR Ejournal, 8(22), 1–18. Swaziland. https://doi.org/10.1007/978-1-4615-4074-8

MADIN, M. B., NYANTAKYI-FRIMPONG, H. AND INKOOM, D. K. B. (2022). Seed security among smallholder farmers in semi-arid Ghana. Environmental Challenges, 6. Elsevier B.V. https://doi.org/10.1016/j.envc.2021.100438

MCGUIRE, S. AND SPERLING, L. (2016). Seed systems smallholder farmers use. *Springer*, 179–195. DOI: https://doi.org/10.1007/s12571-015-0528-8

MoFA (2017). Agriculture in Ghana, Facts and Figures (25th Edn.). Accra, Ghana: Ministry of Food and Agriculture; Statistics, Research and Information Directorate (SRID), pp. 6, 104. https://mofa.gov.gh/site/images/pdf/AGRICULTURE-IN-GHANA-Facts-and-Figures-2015.pdf

NDUKU, T. M., DE GROOTE, H. AND NZUMA, J. M. (2013). Comparative Analysis of Maize Storage Structures in Kenya. 4th Conference of the African Association of Agricultural Economists (AAAE), 22-25 September 2013, Tunisia (pp. 2–16). https://ageconsearch.umn.edu/record/161519/?ln=en

OKORLEY, E. L. AND BOSOMPEM, M. (2014). The potential of farmer field school in cocoa extension delivery: A Ghanaian case study. Journal of International Agricultural and Extension Education, 21(2). DOI: 10.5191/jiaee.2014.20203

OKORUWA, V. O., OJO, O. A., AKINTOLA, C. M., OLOGHOBO, A. D. AND EWETE, F. K. (2009). Post-Harvest Grain Management Storage Techniques and Pesticides Use by Farmers in South-West Nigeria. Journal of Economics and Rural Development, 18(1), 53–72. https://ideas.repec.org/a/ags/ngjred/147906.html

OWACH, C., BAHIIGWA, G. AND ELEPU, G. (2017). Factors influencing the use of food storage structures by agrarian communities in Northern Uganda. Journal of Agriculture, Food Systems, and Community Development, 7(2), 127–144. Uganda. http://dx.doi.org/10.5304/jafscd.2017.072.003

PICHOP, G. AND MNDIGA, S. H. (2007). Essentials of modern marketing management & supply chain systems for vegetable seed companies, AVRDC-The World Vegetable Center. Shanhua, Taiwan. Technical Bulletin No. 39. pp. 1-10. https://worldveg.tind.io/record/7482?ln=en

POKU, A. G., BIRNER, R. AND GUPTA, S. (2018). Why do maize farmers in Ghana have a limited choice of improved seed varieties? An assessment of the governance challenges in seed supply. Food Security, 10(1), 27–46. Food Security. https://doi.org/10.1007/s12571-017-0749-0

RAGASA, C., CHAPOTO, A. AND KOLAVALLI, S. (2014). Maize Productivity in Ghana. Accra, Ghana: International Food Policy Research Institute (IFPRI), Ghana Strategy Support Program. Policy Note NO. 5, pp. 1-4. https://www.ifpri.org/publication/maize-productivity-ghana

SEMPLE, R. L., HICKS, P. A., LOZARE, J. V. AND CASTERMANS, A. (1992). Towards Integrated Commodity and Pest Management in Grain Storage. National Post-Harvest Institute for Research and Extension (NAPHIRE), (pp. 85–105). Rome: REGNET, FAO, Rome. https://www.fao.org/3/x5048e/x5048E00.htm

SPERLING, L., OSBORN, T. AND COOPER, H. D. (2003). Towards effective and sustainable seed relief activities: Report of the Workshop on Effective and Sustainable Seed Relief Activities. Rome, 26-28 May: FAO Plant Production and Protection Paper 181. https://www.fao.org/3/y5703e/y5703e00.htm

TEFERA, T., KANAMPIU, F., GROOTE, H. DE, HELLIN, J., MUGO, S., KIMENJU, S., BEYENE, Y., BODDUPALLI, P. M., SHIFERAW, B. AND BANZIGER, M. (2011). The metal silo: An effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries. Crop Protection, 30(3), 240–245. https://doi.org/10.1016/j.cropro.2010.11.015

THAMAGA-CHITJA, J. M., HENDRIKS, S. L., ORTMANN, G. F. AND GREEN, M. (2004). Impact of maize storage on rural household food. Tydskrif vir Gesinsekologie en Verbruikerswetenskappe, 32. South Africa. https://api.semanticscholar.org/CorpusID:55864752

TRIPP, R. AND MENSAH-BONSU, A. (2013). Ghana's Commercial Seed Sector: New Incentives or Continued Complacency? Accra, Ghana: International Food Policy Research Institute (IFPRI). No. 32 pp. 1-13. https://www.ifpri.org/publication/ghanas-commercial-seed-sector-new-incentives-or-continued-complacency

TRIPP, R. AND RAGASA, C. (2015). Hybrid Maize Seed Supply in Ghana. International Food Policy Research Institute (IFPRI), Ghana Strategy Support Program. NO. 40, pp. 1-19. https://www.ifpri.org/publication/hybrid-maize-seed-supply-ghana

UAIENE, R. N., ARNDT, C. AND MASTERS, W. A. (2009). Determinants of Agricultural Technology Adoption in Mozambique. Mozambique: National Directorate of Studies and Policy Analysis, Ministry of Planning and Development. Discussion Papers No. 67E, pp. 9-26. https://www.acismoz.com/wp-content/uploads/2017/06/Adopcao%20Tecnologias%20ENG.pdf

VIOLON, C., THOMAS, M. AND GARINE, E. (2016). Good year, bad year: Changing strategies, changing networks? A two-year study on seed acquisition in northern Cameroon. Ecology and Society, 21(2). Resilience Alliance. DOI: https://doi.org/10.5751/ES-08376-210234

WAMBUGU, P. W., MATHENGE, P. W., AUMA, E. O. AND VAN RHEENEN, H. (2009). Efficacy of traditional maize storage methods in western Kenya. African Journal of Food Agriculture Nutrition and Development, 9(4), 1110–1128. https://doi.org/10.4314/AJFAND.V9I4.43882

YOUSAF, Z., SALEH, N., RAMAZAN, A. AND AFTAB, A. (2016). Post-Harvest Techniques and Maintenance of Seed Quality. New Challenges in Seed Biology - Basic and Translational Research Driving Seed Technology (pp. 118–131). https://doi.org/10.5772/64994

ZHOU, Y. AND KUHLMANN, K. (2016). Seed Policy Harmonization in ECOWAS: The Case of Ghana. Syngenta Foundation for Sustainable Agriculture. pp. 1-27. https://www.syngentafoundation.org/sites/g/files/zhg576/f/seeds_policy_ghana_seed_case_study_jan16_0_1.pdf
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