Research Article

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How does Farmer Preference matter in Crop variety Adoption? The case of Improved Cassava varieties' Adoption in Ghana

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Abstract: Ghana's National Agricultural Research Systems have officially released 24 improved cassava varieties, which are high yielding, disease and pest resistant and early maturing. However, adoption of these varieties by mainly smallholder farmers is very low, leading to low yields and incomes. The purpose of this study was to contribute to the development and adoption of improved cassava varieties by assessing the preferences of farmers for cassava variety traits. The study explored Ghanaian cassava producers' decision-making behaviour towards variety selection and the values they place on different cassava traits. It employed mixed logit and latent class models to estimate the values place on cassava traits, by using choice experiment data of 450 cassava producers from Ghana. Results revealed farmers' preferences for longevity of root storage in the soil and disease resistance traits of cassava. The latent class model revealed that male youths were more likely to participate in improved varieties that take into account in-soil storage and multiple usages. The need for agricultural research systems to focus on other traits in addition to high yielding and disease resistance in order to boost adoption and increase production is imperative.

Keywords: choice experiment, decision-making behaviour, high yielding, mixed logit, in-soil storage

1 Introduction

Cassava has been identified as a commodity that could generate desired economic growth, fight poverty and improve food security in Ghana (Al-Hassan and Daio 2007). Annual per capita consumption of cassava is about 155 kg, which is one of the highest in the world (Ministry of Food and Agriculture 2016). Despite its food security role during periods of acute food shortages, the national average yield of cassava is about 16.8t/ha with a potential of increasing to over 47 t/ha through increased use of improved varieties and good management practices (Ministry of Food and Agriculture 2016).

Evidence suggests that one of the major causes of low productivity of cassava in Ghana is the continuous use of traditional, low yielding crop varieties (Ministry of Food and Agriculture 2007). Consequently, research and extension have focused on the development and dissemination of improved cassava varieties through multilocal, on-farm and adoption trials (Manu-Aduening et al. 2006). The improved cassava varieties are characterised by crop-specific traits such as high yielding, pest and diseases resistance, early maturity, high dry matter and starch contents (Crops Research Institute, 2010). Despite these efforts, limited adoption of the improved varieties persist (Owusu and Donkor 2012). Although improved crop varieties may be high yielding, farmers may not like them unless they have some traits that farmers consider important (Asrat et al. 2010). Recent studies on farmers' crop variety choices consider crop as a bundle of multiple characteristics (Wale et al. 2005; Edmeades et al. 2008). Notably, the crop variety traits or attributes are the performance characteristics of the plant varieties that include both the production capacity of the plant and the consumption attributes of the product (Edmeades 2008). Specifically for cassava, such bundle of traits may include production characteristics such as disease and pest resistance, high yielding, early maturity and adaptability to harsh environments (Manu-Aduening et al. 2006); consumption characteristics such as taste

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and colour and subjective importance farmers place on seeds (Wale et al. 2005).

Smale et al. (2001) argue that farmers choose crop varieties based on a set of attributes that best responds to production constraints, assures consumption preferences and satisfies specific market requirements. These crop-specific attributes suggestion have been highlighted in some adoption studies (Adesina and Zinnah 1993; Adesina and Baidu-Forson 1995; Adesina and Seidi 1995). Farmers' adoption decisions are not only driven by the drive to make profit, but rather on multifaceted processes that are affected by several socio-economic and psychological variables (Willock et al. 1999).

Furthermore, farmers grow crops that satisfy their needs and that once there is agreement between these needs and variety attributes, the result is varietal preference and the decision for land allocation (Wale and Mburu 2006: 48-62). Farmers' acceptance of crop varieties and their ability to use them properly is dependent on their preferences for attributes of those varieties. Farmers adopt crop varieties for different reasons, one of which is the overall satisfaction of their household consumption needs. The successful adoption of technologies by farmers is based on assessment of the characteristics of the technology (Adesina and Zinnah 1993).

Although some studies have explored the determinants of adoption of improved cassava varieties by farmers in Ghana (Dankyi and Agyekum 2007; Owusu and Donkor 2012) and other developing countries (Imoh and Essien 2006; Nwakor et al. 2011; Tarawali et al. 2012) the preferences of farmers for cassava variety traits have not received much attention. Using choice experimental technique, the present study explores farmers' preferences for cassava variety traits and the values that farmers place on different traits. It further examines the preferences in terms of the perceived benefits farmers obtain from the cassava variety traits. Most studies that have applied choice experiments have done so with much emphasis on livestock-specific traits, especially in East Africa (Scarpa et al. 2003; Ouma et al. 2007; Ruto et al. 2008; Zander and Drucker 2008; Girma et al. 2009). Fewer studies, however, have been undertaken on crop variety traits (Asrat et al. 2010; Wale et al. 2005). This study therefore expands the literature on crop variety traits in Africa by employing choice experiment to elicit farmers' preferences for cassava traits.

The goals of the study were to examine farmers' preferences for cassava variety traits and to establish the valuations for these traits using choice experiment technique. In particular, the mixed logit model was used to investigate the presence of preference heterogeneity and

the latent class model was used to examine the sources of heterogeneity across classes of cassava producers. In view of the fact that adoption is low, the study was designed to increase understanding of variety trait preferences for cassava breeding priority setting in Ghana.

2 Conceptual framework and empirical model

The choice experimental framework employed in this study originated from the Lancaster consumer theory (Lancaster 1971). This suggests that preferences for goods are a function of the traits, or characteristics possessed by the good, rather than the good itself. The overall utility of the good is decomposed into separate utilities for its constituent attributes. The utility function translates into attributes of the goods where the attributes can generate utility or disutility to individuals (Ouma et al. 2007). From the random utility theory, an individual 'n' receives utility 'U' from choosing an alternative equal to $U_{njt} = U(X_{njt})$ from a finite set 'j' alternatives in a choice set 't', if and only if, this alternative generates at least as much utility as any other alternative, with X_{njt} denoting a vector of the attributes of 'j'. The utility associated with each set of 'j' alternatives as evaluated by each individual 'n' in a choice situation t is expressed in a discrete choice function as;

$$u_{njt} = \beta_n \chi_{njt} + \varepsilon_{njt} \quad (1)$$

If the error term in the utility function is assumed to be independently and identically distributed (IID), following a standard extreme value type I distribution across individuals (Train, 2003; Hensher et al. 2005), a closed-form expression for the probability P of an individual n choosing alternative j from a choice set C is expressed as (McFadden, 1974):

$$p_r(c_n = j) = \frac{e^{\beta_n \chi_{njt}}}{\sum_j e^{\beta_n \chi_{njt}}} \quad (2)$$

This conditional logit model depends on the limiting assumption of independently and identically distributed (IID) error terms across alternatives and observations and hence, assumes homogeneity of preferences, which might not be well suited to the realistic taste preferences of individuals. Recently, researchers on choice experiment data have aimed at developing models that relax this strong assumption by adopting different distributions for the error term, and different structures in decision making (Scarpa and Willis 2010). The mixed logit and the

latent class models are examples of such models that are commonly used to relax the IID assumption.

From equation (1), $\mathcal{X}_{njt}$ is a vector of observed variables that includes the cassava variety traits and socioeconomic characteristics of the farmers. Coefficient vector β is unobserved for each i and varies in the population density $f(\beta_n / \theta)$, where θ is vector of parameters of a continuous population distribution, ε_{njt} is an unobserved random term that is assumed to be identically and independently distributed. The focus in random parameter shifts from finding estimates of β_n to finding estimates of θ , the population parameters which determines the behaviour of β_n . Given that β_n is unknown to the analyst, the unconditional probability is usually employed. The unconditional probability is the integral of the conditional probability over all possible values of β which depends on the distribution of β . This integral takes the form:

$$P_{njt}(\theta) = \int L_{njt}(\beta_n) f(\beta_n / \theta) d\beta_n \quad (3)$$

The simple random utility function in equation (1) can be re-written as:

$$U_{njt} = \alpha_j + X_j \beta_n + P_j \beta_p + \varepsilon_{njt} \quad (4)$$

where P_j denotes the cost parameter or price of alternative 'j' which is often included as one of the attributes of the choice alternative. X_j denotes the other observed attributes of choice alternative, 'j'. The constant, α_j , denotes individual 'n's' choice-specific intercept for alternative 'j', β_p is the coefficient for the cost parameter and X_j represents the coefficient vectors for the other traits, for individual 'n'. β_p and X_j are assumed to be random. The implicit prices or the willingness to pay (WTP) for the traits X_j can then be estimated as the rate of change in trait divided by the rate of change of cost parameter. The WTP for certain attribute or attribute level indicates the price the respondent agrees to pay for a unit increase in this attribute or the compensation he/she is willing to accept for a decrease in this attribute.

Following Roessler et al. (2008), the willingness to pay is calculated as follows:

$$WTP = -1 * \left[\frac{\beta_x}{\beta_{price}} \right] \quad (5)$$

Where β_x is the estimate for the attribute x from the model, and β_{price} is estimated price coefficient.

An important issue in mixed logit model specification is choosing the coefficients which are allowed to vary and the distribution they should take. In this model the cost attribute was treated as non-random (fixed) whilst all the other attributes were allowed to vary assuming normal

distribution. Revelt and Train (1998) pointed out many advantages when the cost coefficient is fixed, the foremost being that it assures the right sign of the coefficient. Also, a fixed cost coefficient implies that the distribution of willingness to pay for the remaining attributes follows the same distribution as the attribute coefficient that is if the coefficients are normally distributed then so is willingness to pay. Finally, fixing at least one of the coefficients in the model helps empirical identification, especially in applications using cross-sectional data (Hensher et al. 2005). The cost attribute, the purchase price of cassava, as well as the productivity trait, entered the models as continuous variables with their actual levels. All other attributes were treated as discrete variables. Therefore, for each attribute with L levels, L-1 discrete variables were created in order to avoid perfect dependence. Estimates were obtained using 500 Halton draws to simulate the likelihoods and were performed in Stata 11.2 software (Stata Corp. 2009).

Although the unobserved heterogeneity can be accounted for with the use of mixed logit model, it fails to explain the sources of heterogeneity (Boxall and Adamowicz 2002). To detect the sources of heterogeneity, it would have to be done by inclusion of respondent characteristics in the utility function as interaction terms. This would permit mixed logit model to pick up preference variation in terms of both unconditional taste heterogeneity, however it requires a prior selection of important individual specific variables. Latent class model (LCM) is more able to identify consumer heterogeneity by separating individuals into several classes. The LCM assumes that a discrete number of classes of respondents are sufficient to account for preference heterogeneity among classes (Boxall and Adamowicz 2002). If we assume the existence of C segments in the population, the choice probability of individual n choosing alternative j in class c of the Latent Class Model is expressed as:

$$P(njt/c) = \frac{\exp(\beta_c X_{njt})}{\sum_{c=1}^C \exp(\beta_c X_{njt})} \quad (6)$$

where X_{njt} is a vector of observable traits associated with alternative j, and β_c is a class specific parameter. Since the classes are not observable, class probabilities are specified by the multinomial logit form;

$$P(c) = \frac{\exp(\theta_c z_t)}{\sum_{c=1}^C \exp(\theta_c z_t)}, \theta_c = 0 \quad (7)$$

where z_t is a set of observable characteristics that enter the model for class membership. The c th parameter

vector is normalized to zero to ensure the identification of the model (Ouma et al. 2007). In this study each person makes repeated choices for eighteen cassava profiles and this assumes correlation across choices made by the same respondent.

3 Methodology

3.1 The Description of the study site

The map of the study area is shown in Figure 1. The study was carried out in three regions in Ghana. They were Ashanti, Brong Ahafo and Eastern regions of Ghana. The regions were selected based on large quantities of cassava production and their closeness to Ghana's foremost Crops Research Institute. They had received many interventions on cassava production from many projects and research.

Figure 1: Map of Ghana showing the study area. Source: <https://mfa.gov.gh/index.php/about-ghana/regions/>

The three regions fall within the semi-deciduous rainforest and the forest savannah transition agro ecological zones. The semi-deciduous forest has bimodal distribution of rainfall, and the mean annual rainfall is 1500 mm. The Forest savannah transition also has a bimodal rainfall,

and the mean annual rainfall is 1300 mm. The temperature ranges from 20°C to 31°C. The soils are generally good for food crops production.

3.2 Survey design

In this study, we employed a choice experiment technique to evaluate farmers' preferences for the various traits of cassava varieties. Under this method, the participants were asked to choose their most preferred alternatives from a sequence of grouped options that relate to different cassava varieties. Each option was described in terms of cassava attributes and a monetary price to be paid for the trait by the respondents.

The most important cassava variety attributes were identified in consultation with cassava experts (breeders and researchers), through focus groups discussion with key cassava informants and farmers, and by reviewing the literature. The expert consultations and focus group discussions made with farmers revealed that high productivity, root longevity in the soil after maturity, resistance to cassava mosaic virus disease, multiple usages and purchase price were the most important cassava traits (Table 1).

From an a priori perspective, the trait levels 'high productivity', 'high resistance to diseases', 'high root longevity in the soil' and 'multiple usage' are expected to increase a producer's utility. High productivity is expected to increase production per hectare and thus increase farmers' food stock and income. Therefore, high productivity is expected to influence farmers' utility positively. A high resistance to cassava diseases such as cassava mosaic virus disease would have a positive impact on productivity and thus on utility. Since cassava harvesting is spread over a period of time in the study area, good root longevity in the soil is expected to increase utility. Similarly, multiple usages are expected to influence utility positively as that guarantees all year round consumption. Finally, the trait coefficients associated with purchase price, that is, selling price of cassava is expected to have a negative sign, due to the negative marginal utility for cost generally exhibited by most individuals.

The identified traits and trait levels were combined in accordance to an experimental design that created choice sets. A full factorial design would have resulted in $108(3^3 \cdot 2^2)$ possible generic¹ choice sets. Since it was not practically feasible to work with such a large number

¹ Generic choice set implies that they do not refer to any particular variety

Table 1: Attributes and attribute levels used in the choice experiment

Attribute	Description	Attribute levels
Productivity	Average production harvested per hectare from planting a particular cassava variety.	15 tonnes 30 tonnes 60 tonnes
Disease and pest resistance	Whether a particular variety withstands cassava mosaic virus disease	Not resistant to cassava mosaic virus disease Resistant to cassava mosaic virus disease
In-soil storage	Whether a particular variety is able to remain in soil for 12 months or more or less than 12 months	Less than 12 months 12 months or more
Multiple Usage	Development of product from a particular cassava variety	Gari ¹ and fufu ² Dough, gari and fufu Dough and gari
Purchase price	Purchase price of traits. This was based on the selling price per 91kg bag of harvested cassava roots	Gh¢ 15 ³ Gh¢ 30 Gh¢ 45

¹Gari is made from cassava roots that have been crushed into a mash, fermented and sieved into small pieces.

²Fufu is made from cassava by boiling cassava roots and molding into paste.

³\$1=Gh¢1.74 in 2012. Gh¢ is Ghana cedi and it is the official currency of Ghana

Table 2: An example of a choice set. Assuming that the following cassava varieties were your ONLY choices, which one would you prefer to plant?

Attribute	Cassava variety 16	Cassava variety 17	Cassava variety 18
Productivity	15 tons per hectare	15 tons per hectare	30 tons per hectare
Disease and pest resistance	Resistant	Resistant	Resistant
In-soil storage	12 months or more	12 months or more	Less than 12 months
Multiple usage	Fufu and gari	Fufu, gari and dough	Fufu and gari
Purchase price	¢30	¢45	¢15
I would prefer to buy (✓ one)			

of choice sets, a partially orthogonal main effect only design was generated from the full factorial design to create feasible choice sets using experimental design techniques in SPSS Conjoint software (SPSS, 2008) to obtain an orthogonal design, which consisted of only the main effects. The design resulted in 18 fractional factorial profile plans or alternatives. The choice set that resulted from this design was used to construct profiles describing the differences in traits and levels of improved cassava variety and these were presented to respondents in terms of hypothetical settings. The profile plans (alternatives) were then grouped into six types of questionnaires with three profile plans (alternatives) forming a choice set. Table 2 provides an example of one of the choice sets used in the choice experiment.

The choice experiment was administered as part of farmer level questionnaire survey using in-person interviews. The rest of the questionnaires covered socioeconomic characteristics such as farm and farmer characteristics, institutional and resource endowments.

The administration of the choice experiment was carried out in the following ways: respondents were introduced to six choice sets and were asked to choose one out of the three given cassava profiles from each choice set. Cards with pictorial representations of the differences in the levels of traits were used to demonstrate each cassava variety profile to the survey respondents. Figure 2 presents an example of a choice card presented to farmers.

Unlike the traditional choice experiment, no “opt-out” was included in the choice sets. The farmer had to choose amongst one of the alternatives. The reasons being that the study did not focus on finding the willingness to pay for improved cassava varieties but rather marginal willingness to pay for the attributes of the variety and, therefore, it was not necessary to include an opt-out alternative (Carlsson et al. 2007). Also, cassava is traditionally part of the farming systems in the study area and therefore compelling farmers to make a choice is not out of place.

Attribute	Cassava variety 1	Cassava variety 2	Cassava variety 3
Productivity
	15t/ha	30t/ha	30t/ha
Disease and pest resistance
	Not resistant	Resistant	Not resistant
In-soil storage
	less than 12 months	12 months or more	12 months or more
Multiple usage
	fufu and Gari	Gari, Fufu and dough	Fufu and gari
Purchase price
	GH¢15	GH¢15	GH¢45

Figure 2: An example of a choice card

3.3 Sampling, data collection and data description

The study adopted multi-stage sampling in identifying Regions, Districts, villages and farmers. Three Regions in which the study was conducted were purposively selected to reflect not only cassava production and distribution patterns in the country but the agro-ecological zones as well. From the regions one district each was again purposively selected based on cassava production levels and familiarity with some of the improved cassava varieties. A list of all locations in each of the selected district was obtained from respective district and municipal offices of the Ministry of Food and Agriculture. Using random numbers from statistical table, ten villages

were randomly selected from each district. The list of cassava farmers in each of the selected villages had to be drawn up with assistance of the District Agricultural Extension officers and local people. From the lists of farmers 15 farmers were again randomly selected from each of the selected communities. On the whole a total of 450 farmers were selected for the farm level and choice experiment survey. The questionnaires were pretested in all three districts and results were discussed with the enumerators and necessary changes were made following farmers' responses. Overall, a total of 8100 choices were elicited from 450 farmers taking part in the choice experiment. To complement the choice experiment data, a separate survey was conducted to collect data on socio-economic characteristics. Information on the

socioeconomic characteristics of the farmers used in the econometric modeling is presented in Table 3. Generally more males than females cultivated cassava in the study area. Thirty nine percent of respondents were females and 61 percent were males. Farmers had relatively high family members. Average number of years in schooling was 7.3. Farmers had vast experience in cassava farming. The average number of years in cassava farming was 19.8. The average number of members in a family was 6. In terms of access to institutional infrastructures, 58% of respondents

had access to agricultural extension agents, however, they were located further away from market centres. Average distance from farm to market was 6.8km. They had somewhat large farm sizes of 3.8ha far bigger than national average of 2ha (Ministry of food and Agriculture 2016). Access to credit was low as only 11% of respondents were able to access formal credit.

Ethical approval: The conducted research is not related to either human or animal use.

Table 3: Descriptive statistics of respondents

Variable	Description	Mean	Std dev.
Gender	=1 if farmer is female and zero otherwise	0.39	0.48
Age	Age of farmer in years	46.20	12.31
Household size	Number of family members	6.4	2.9
Education	Number of years in formal education	7.3	6.1
Experience	Number of years in cassava farming	19.8	12.5
Distance to market	Average distance from farm to market in kilometres	6.8	4.5
Extension contact	=1 if farmer had access to extension agent and zero otherwise	0.58	0.49
Participation in demonstrations	=1 if a farmer has been participating in cassava demonstrations and zero otherwise	0.11	0.31
Farm size	Total farm size operated by the farmer in hectares	3.81	3.60
Access to credit	=1 if farmer has access to formal credit and zero other wise	0.11	0.32

Table 4: Simulated maximum likelihood estimates for cassava preferences from mixed logit

Variable	Coefficient	Standard error	Derived std deviation	Standard error
Non-random parameters in utility function				
Purchase price (€)	-0.01803***	0.0024	-	-
Random parameters in utility function				
Productivity	0.0076***	0.0016	0.0118**	0.0037
Disease resistance	0.8101***	0.1064	0.7894***	0.1014
In-soil storage	1.5073***	0.0208	0.4161***	0.1553
Multiple usage	0.4272***	0.0501	-0.1357	0.1044
N	8100			
P-value	0.001			
Mcfadden R-squared	0.24			
Log likelihood	-2547.88			
Halton draws	500			

Notes: ** significant at 5%, ***significant at 1%

4 Results and discussions

4.1 Farmers cassava traits preferences

The results of the simulated maximum likelihood estimates of the mixed logit model are as presented in Table 4. Mixed logit can only be estimated after conditional logit estimation. It derives initial start values for the means of the coefficients and sets the starting values for the standard deviations to 0.1 (Hole 2007). The relative performance of the conditional and the mixed logit can thus be compared. A likelihood ratio test was performed to test the null hypothesis that there is no difference between the conditional logit and the mixed logit. The log likelihood was 2547.88 with likelihood ratio of 30.19, degree of freedom four and P -value <0.001 thus rejecting the null hypothesis. This suggested that the mixed logit fitted the data better than the conditional logit.

With the notable exception of purchase price, the mean coefficients for all the random parameters were positive and significant. The implication was that all the respondents had positive preference for all the choice specific attributes. The coefficients of the random parameters were of the expected signs and were all significant at the 1% level. The model revealed preference for cassava varieties that were high yielding, disease resistant, commanded lower price, had long storage life in the soil after maturity and could be used for gari, fufu and dough. The mean coefficient estimates of each of the random parameters were linked with standard deviations which indicated the amount of spread that were present in the sample population. With the exception of multiple usages, the standard deviations of each of the random parameters were significant showing preference heterogeneity in the population. The results also showed that respondents had constant preference for multiple usages attribute hence its insignificant standard deviation coefficient. This result was not surprising as the levels for the multiple usage attribute were all very much appreciated equally by the respondents and the distribution for each of the three levels in the sample was 33.33%.

Farmers from different areas, whether urban or rural, have different concerns and may have different trait preferences (Birol 2004). Where such differences in trait preferences across production areas exist, they should be considered in order to ensure an efficient design of breeding programmes. In order to compare if parameter estimates of the pooled model are shared across the three different study areas, separate conditional logit models

have been calculated to obtain estimates for each study area. The null hypotheses that the parameter estimates of all the models from the pooled data and the subsamples are equal were tested against the alternative hypothesis that they are not equal. This has been done by checking if the log-likelihood function from the conditional logit estimation for the different sub-samples is significantly larger than the pooled sample log-likelihood function. The results from hypothesis tests are as shown below.

$$L_{pooled} = -2887.03 \quad \text{and} \quad L_{Atwima} = -1000.09$$

$$L_{Techiman} = -1983.05, \quad L_{Fanteakwa} = -882.25$$

The results indicated that the pooled data and the subsamples data were statistically different and consequently should not be pooled together. Therefore, the preferences for cassava traits were significantly different amongst the three districts. Table 5 presents the maximum likelihood estimates of Atwima Nwabiagya district, Techiman Municipality and Fanteakwa district.

Results from Table 5 indicated that the mean price coefficients were negative and significant in the three surveyed locations. This showed farmers' strong preferences for lower prices for inputs in all the Districts. Farmers would always want to buy at a lower price and therefore their negative utility for purchase price is not surprising. Smallholders consider lower prices for inputs as beneficial since it increases their incomes and thereby improving their livelihoods. Similar results were established in a study by Ouma (2007) who found that cattle farmers in Ethiopia and Kenya preferred lower prices for cattle traits. The productivity trait was only positive and statistically significant at the Fanteakwa district, while for the other two locations, productivity seemed to have a low rank in farmers' cassava trait preference, although the coefficients were positive. Fanteakwa district is mostly rural and farmers depend mostly on food crop production for their livelihoods. Atwima Nwabiagya District is mostly peri-urban and thus other off farm activities predominate. The Techiman Municipality is well known for the production of maize and yam. It is located in the Transition Zone and the aforementioned crops have production advantage and thus cassava may not be the most important crop. The attribute, disease resistance, was positive and statistically significant in all the three locations. This implies that smallholders attach importance to cassava varieties that are resistant to cassava mosaic virus disease. This ensures low input use and guarantees yields. Ghanaian farmers mostly practice low input agriculture (Ministry of Food and Agriculture 2007) and so any cassava variety with tolerance to cassava

Table 5: Simulated maximum likelihood estimates of preferences for cassava traits for subsamples

	Atwima Nwabiagya District		Techiman Municipal Area		Fanteakwa District	
	Mean Coefficient	Standard error	Mean Coefficient	Standard error	Mean Coefficient	Standard error
Cassava attributes						
Productivity	0.0113	0.0025	0.00329	0.0034	0.0087***	0.00341
Disease resistance	0.1329***	0.1062	0.6060***	0.1618	1.0425***	0.1618
Soil storage	1.393***	0.1304	1.1210***	0.1316	1.0904***	0.1471
Multiple usage	0.3681***	0.0542	0.1795***	0.0572	0.2579***	0.0579
Purchase price (¢)	-0.010***	0.0040	-0.016***	0.0046	-0.031***	0.0046
Standard deviations of random parameters						
Productivity	0.010	0.0704	0.0101	0.060	0.0221***	0.0053
Disease resistance	0.4913***	0.1908	0.7438***	0.1736	1.1689***	0.1943
Soil storage	0.2741	0.3823	-0.3293	0.3032	0.6328***	0.2172
Multiple usage	0.0076	0.2236	-0.2152**	0.1231	-0.1865	0.1443
Likelihood ratio	2.32		9.18**		29.58***	
Halton Draws	500		500		500	
Log likelihood	-837.56		-867.25		-818.36	
Pseudo R ²	0.16		0.12		0.10	
N	2700		2700		2700	

significant at 5%; * significant at 1%

mosaic virus disease and which would not need extra input would increase farmers' choice of that variety.

Estimates obtained for the full sample suggested that another important cassava breeding trait is in-soil storage. Subsample coefficients supported this result (Table 5). The mean coefficients for in-soil storage were positive and significant in all three subsamples. The ability of cassava to store in the soil for some time after maturity is very important to farmers. That serves as storage facility for the rather high deteriorating product. The multiple usage trait was also very important in farmers' choice of a cassava variety as the coefficients for all the three locations were positive and statistically significant. Farmers produce foremost for household use and then for sale and therefore, if farmers could consume a cassava variety and at the same time use it for the preparation of other products for sale, this could be an incentive for the choice of that variety. This suggests the reason behind the low adoption of improved cassava varieties, which are assumed to deteriorate a few months after maturity in the soil and subsequently cannot be used for 'fufu', a local diet.

4.2 Farmers' willingness to pay for cassava traits

In this study, the willingness to pay (WTP) was measured as the maximum amount that a farmer is willing to pay

in order to secure a unit change in a particular trait. WTP estimates are as shown in Table 6.

For the pooled sample, respondents were willing to pay ¢83.59 in order to obtain a year more increase in in-soil storage trait. For the disease resistance traits respondents were willing to pay ¢45.00 in order to obtain cassava with resistance to cassava mosaic virus disease. WTP results from the three districts were in support of the pooled sample results. Farmers were willing to pay ¢127.68, ¢69.83 and ¢35.50 for a year more increase in the in-soil storage trait at Atwima Nwabiagya district, Techiman Municipal and Fanteakwa district, respectively. By contrast, farmers were willing to pay ¢12.85, ¢37.49, and ¢33.70 for an increase in resistance to cassava mosaic virus disease traits respectively at Atwima Nwabiagya district, Techiman Municipal and Fanteakwa district. These results also confirm the high value farmers in the study area place on in-soil storage (longevity). This result has important implication for breeding of cassava varieties and for subsequent adoption. It shows how important the in-soil storage attribute is in motivating farmers to participate in improved cassava varieties adoption.

The results shown in Table 6 prove that farmers do not look for a single attribute of a variety when making their seed selection decisions, but also on other more important non-tradable attributes like root longevity in soil after maturity.

Table 6: WTP estimates for pooled and subsamples

Variable	Pooled sample		Atwima Nwabiagya District		Techiman Municipal		Fanteakwa District	
	WTP (C)	Std err	WTP(C)	Std err	WTP (C)	Std err	WTP (C)	Std err
Productivity	0.42***	0.11	1.04**	0.48	0.21	0.19	0.28**	0.023
Disease Resistance								
	45.00***	5.10	12.85	10.47	37.49***	10.93	33.70***	5.60
In-soil storage								
	83.59***	9.66	127.68***	50.07	69.83***	19.44	35.50***	6.89
Multiple usage								
	23.69***	2.61	34.34***	13.45	11.17***	4.50	8.35***	2.16

significant at 5%, *significant at 1%,

Table 7: LCM estimation results for five latent classes

Variable	Class 1	Class 2	Class 3	Class 4	Class 5
Choice model parameter					
Purchase price	0.063*** (0.025)	0.023*** (0.005)	-0.053** (0.032)	-0.026*** (0.004)	0.020*** (0.003)
Productivity	0.026** (0.015)	-0.006*** (0.002)	0.001 (0.003)	0.020 (0.027)	-0.006* (0.004)
Disease Resistance	-0.779*** (0.053)	2.195*** (0.452)	1.826*** (0.228)	-0.023*** (0.003)	0.074** (0.042)
In-soil storage	1.443*** (0.225)	0.546*** (0.223)	3.472*** (0.504)	2.062*** (0.228)	0.847*** (0.078)
Multiple usage	0.554*** (0.034)	0.009*** (0.004)	1.062*** (0.221)	0.038*** (0.006)	0.545*** (0.230)
Class membership parameters					
Age (Years)	-0.040*** (0.002)	-0.082*** (0.024)	-0.024*** (0.002)	-0.058*** (0.015)	
Gender(1=female)	-0.144*** (0.026)	-1.383*** (0.236)	-0.184*** (0.022)	-0.398*** (0.045)	
Education (Years)	0.038*** (0.005)	-0.064** (0.008)	0.150*** (0.054)	0.169*** (0.048)	
Farm size(ha)	-0.006*** (0.0023)	-0.032*** (0.011)	-0.003** (0.002)	-0.058*** (0.013)	
Constant	2.494*** (0.225)	5.958*** (1.145)	0.934** (0.201)	3.233*** (0.286)	
Class share	0.284*** (0.054)	0.179*** (0.040)	0.171 (0.039)	0.173 (0.038)	0.193 (0.135)

Note: class 5 is the reference class;

significant at 5%, *significant at 1%, Standard error in parenthesis

4.3 Sources of preference heterogeneity in the sample population.

The mixed logit model confirmed the existence of preference heterogeneity in the sample population. The latent class model (LCM) was thus used to estimate the sources of preference heterogeneity in the sample population. With the LCM the assumption was that respondents could be intrinsically grouped into a number of latent classes where, in each class, individuals' preferences were still assumed to be homogenous, but heterogeneous across classes (Boxall and Adamowicz

2002). The optimal number of latent classes to be used in the latent class model was selected based on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) proposed by Boxall and Adamowicz (2002). The log likelihood value at convergence improved as the number of classes increased from two to five. The BIC² values also got smaller as number of classes increased. Based on the lower is a better criterion, the latent class with five classes was used in the estimation. Table 7

² The BIC values for the 2 to 5 classes are 5017.35, 5002.34, 4964.26, and 4956.27 in progressive order.

presents maximum likelihood estimates from the latent class. The latent class presented five different preference groups with the estimated latent classes' probabilities of 28.4%, 17.9%, 17.1%, 17.3% and 19.3%, respectively. These are the probabilities of a randomly chosen respondent belonging to the first, second, third, fourth or fifth class, respectively.

In the first class, farmers within this group had positive utility towards purchase price, productivity, in-soil storage and multiple usages. They, however, had negative utility towards disease resistance. As indicated by the class membership, this group had members who were males, who were educated, had smaller farm sizes and were younger. There was a 28.4% probability that a randomly chosen individual belonged to this class, indicating that a slight majority of respondents were not concerned about disease resistance. Members of class two were males, they were younger, had not had much education and had smaller farm sizes. In this group, apart from productivity, they showed positive utility towards purchase price, disease resistance, in-soil storage and multiple usages.

Class three members were concerned for disease resistance, in-soil storage and multiple usages. They were males, they were younger, and they were educated with smaller farm sizes. Class 4 members had similar characteristics as those in class 3; however they were not concerned for disease resistance. These results have allowed for explicit testing and identification of important socioeconomic and crop specific variables.

5 Conclusion and policy recommendations

The study had employed mixed logit and latent class models to examine farmers' preferences for cassava variety traits in Ghana. Examination of farmers' preferences for cassava variety traits using the mixed logit models revealed that variety characteristics such as in-soil storage (longevity in soil after maturity), resistance to cassava mosaic virus disease and multiple usages were preferred. Willingness to pay estimates (WTP) demonstrated strong preferences for in-soil storage, resistance to cassava mosaic virus disease and multiple usage traits than increased productivity as farmers were willing to pay substantial amounts for those traits than for productivity trait. The latent class model revealed that males and younger farmers were

more likely to participate in improved varieties that take into account in-soil storage and multiple usages. These results have important implications for breeding priority setting, and targeted diffusion of improved cassava varieties in Ghana.

The results revealed that farmers attached greater importance to in-soil storage and disease resistance traits of cassava than productivity trait. Thus, for breeding priority setting, the fact that farmer's preferences for variety traits determine to a large extent their choice of a variety, breeding should satisfy the demand of farmers. The National Agricultural Research Systems primarily dealing with crop breeding programmes in Ghana should therefore prioritise these attributes in their direct or supportive breeding programmes. Cassava Breeding should target the improvement of in-soil storage and disease resistance attributes of cassava. The implication is that intervention to develop new cassava varieties should not focus only on the research assumed desirable traits such as yield and disease resistance but should also pay attention to other non-market traits like in-soil storage. According to the results, the productivity attribute is less demanded by farmers. This probably suggests the importance of developing market chains and value chains for cassava. Farmers would not see the need to adopt more productive cassava varieties when constraints to marketing are not alleviated. Government and private sector intervention should therefore emphasise improving markets for cassava.

The findings from the latent class model indicated the importance of considering heterogeneity within social classes as it offers a useful support for targeting during improved variety dissemination. Targeting in dissemination of improved cassava varieties is therefore important. The Latent class results have revealed that in all the classes, males and younger farmers are more likely to participate in improved cassava varieties that can store longer in the soil after maturity and have multiple usages. Therefore the Ghana's Ministry of Food and Agriculture and private organizations involved in cassava dissemination should consider gender targeting during dissemination activities.

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