Does quality affect maize prices in sub-Saharan Africa? Evidence from Benin

Didier Kadjo[1], Jacob Ricker-Gilbert[2], Corinne Alexander[3]
[1]Graduate Research Assistant, [2]Assistant Professor, [3] Professor;
Purdue University, Department of Agricultural Economics

Selected Paper prepared for presentation for the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco, CA, July 26-28.

Corresponding author
Didier Kadjo
403 W. State Street, Room 618
USA, West Fayette, IN 47907
Phone: +1 (765) 494 -4260
Fax: +1 (765) 494-9176
Email: dkadjo@purdue.edu

Abstract
This paper uses household survey data from Benin to evaluate how grain quality affects maize prices in rural markets of sub-Saharan Africa. Stated preference methods reveal that a 10% increase in insect damage results in a 9% maize price discount. However, revealed preference results from farmers involved in past market transactions indicate that this discount is only 3 %. Evidence also suggests that this discount is larger in periods of maize abundance than in the lean periods when maize is scarce. Our results contribute to explain why many smallholder farmers sell maize at harvest and do not invest in storage technology that would improve grain quality later in the season.

Key words: grain quality, maize price, revealed preference, stated preference, lean period, sub-Saharan Africa

JEL codes: O12, O13, Q13

1. Introduction

Smallholder farmers in sub-Saharan Africa (SSA) face many obstacles that impede their participation in grain output markets. While solving constraints such as limited liquidity at harvest, and the transactions costs associated with marketing, represent important milestones to improving rural food markets, price premiums for high quality grain (discounts for low quality grain) are needed to incentivize farmers to make investments that enhance productivity, storage and marketing. The fact is that many smallholder farmers sell their maize immediately after harvest rather than making the effort to preserve grain of good quality for later in the season, even if it may fetch a higher price.

The literature provides two main reasons why farmers may sell grain at harvest and forgo prices later in the year. One of the major reasons is the binding liquidity constraint that farmers face, making the need for cash at harvest imperative (Renkow, 1994; Saha and Stroud, 1994; Stephens and Barrett, 2011). In addition, without access to effective and affordable storage technology grain placed in storage may experience substantial damage from insects, rodents and mold (Affognon *et al*., 2015; Jones, *et al*., 2011). Insect and rodent damage are therefore major impediments to grain storage that create two problems. First, pest damage reduces the quantity available for households to sell and consume later in the year. Second, farmers will potentially receive a price discount for damaged grain that is marketed.

With these considerations in mind, the objective of this article is to estimate the extent to which insect damage affects the price that smallholder farm households in SSA receive and pay for maize. We test two main hypotheses that to our knowledge remain largely unanswered to date. The first hypothesis is: *there is no statistically significant price discount for maize that has been damaged by insects*. If markets in SSA do not place a premium on high quality maize (discount damaged maize), this can help explain why poor quality maize exists, and why farmers sell early after harvest and do not store much for sale later in the marketing year.

The second hypothesis is: *price discounts for insect damaged maize are not statistically different in the early post-harvest period compared to the lean period.* Markets may value quality and thus discount damaged maize in the period immediately following harvest, when quantity is plentiful and is generally of high quality. However, in the lean period maize becomes scarce and quality may become less important as people must eat what is available regardless of insect damage.

This article uses data from a random sample of 360 smallholder maize farmers conducted across Benin after the 2011/12 harvest. To test the two hypotheses presented above, we conduct a straightforward experiment showing farmers maize with different levels of insect damage. We first ask farmers the price per kilogram and level of insect damage for the maize that constituted their largest maize sale and purchase in the past post-harvest season. Second, we ask farmers to value maize at each damage level for purchase and sale. Our estimates include a parsimonious specification that includes only the level of insect damage as a control, and a full specification that incorporates other household-level, and market-level factors, along with information about transactions partners as control variables.

Since some farmers do not sell (buy) maize because they price they receive (pay) is below (above) their reservation value, we deal with this potential selection bias issue using the Heckman sample selection correction (Heckman, 1979).

This article makes three contributions to the literature. First we obtain quantitative estimates of maize damage discounts for a representative sample of smallholder maize farmers regardless of how long they store their maize. Many of these farmers are both producers and consumers of maize so we ask them how they value damaged maize when they operate on each side of the market. Second, we compare the results from past-transactions (revealed preference) with those from farmers' perceptions (stated preference) about the effects of insect damage on maize prices. We use these two methods to compare the accuracy of each estimation approach. Third, for sale and purchase transactions, we test whether the price discounts for damaged maize are significantly different between the time period immediately after harvest and the lean season.

Previous literature suggests that there may be unofficial price discounts for insect damage in West African cowpea markets (Langyintuo *et al*., 2004). However, there is limited information on possible insect damage discounts for maize, and virtually no information at the farmer-level. Compton *et al.* (1998) use trader focus groups in Ghana to construct a maize discount schedule, while Jones (2012) use a choice experiment to estimate price discounts for traders in Malawi. Hoffman *et al.* (2013) obtain the price discount of visible attributes of maize such as broken kernels and color from consumers in Kenya who have their maize milled. In another recent study, Hoffman and Gatobu (2014) survey a population of Kenyan farmers who store maize for longer than six months. They use an experimental auction and find that farmers bid lower prices when purchased maize contains broken and discolored kernels, while they do not discount the same attributes on their own-maize. They conclude that asymmetric information about food quality attributes may also contribute to the prevalence of smallholder autarky in staple grains.

The rest of this article is organized as follows. The next section describes how data collection and the experiment were conducted in the selected areas. Subsequent sections present the empirical estimations and the results.

2. Data

Data used in this study come from a random survey conducted from July to August 2012 in Benin. We selected 6 departments out of 12 in Benin using multiple criteria of agricultural productivity, food security and geographical repartition. Two counties called "Sous-Prefecture" were then randomly chosen in each department, followed by the random selection of one district in each identified county. The villages for farmer interviews were also randomly chosen in each district. In a final step we randomly selected 30 farmers from a census of maize farmers from each village. In total 360 farmers were interviewed, but we retain 357 observations because 2 farmers did not stored maize and 1 farmer was an outlier with a quantity produced far above (51 times) the average production of other farmers, and thus cannot be considered a smallholder.

The number of respondents differs depending on the evaluation method that is used. Only farmers who were involved in market transactions during the past post-harvest season were interviewed for the revealed preference (RP) evaluation. There were 246 farmers who sold maize (69% of the sample) and 134 (37% of the sample) who purchased maize. All 357 farmers were asked to elicit their preferences for a range of maize qualities for the stated preference (SP) evaluation.

In each sampled village the survey started with a focus group discussion. The enumerators explained the purpose of the study to participants, and participants helped to evaluate how realistic the damage levels that we presented were for marketed maize in the village. In addition, the focus group participants were asked to differentiate the major periods in the season when price and quality vary, to capture local market conditions. In summary, shortly after the harvest, maize prices are relatively low and the quality and quantity is generally high. Later in the post-harvest season maize becomes scarce, and the available maize is likely of lower quality than just after harvest, while at the same time prices are high. For the purpose of the analysis, we distinguish between an early post-harvest (PH) period and a lean period during the post-harvest season, which is the season after final storage on farm has been made (See figure 1).

[Figure 1. Here]

We set up the experiment by filling clear plastic boxes with maize that represented 5 different levels of insect damage: 0%, 10%, 20%, 30% and 50%. Only insect damage was examined among maize attributes, and was allowed to vary by these 5 levels[1]. Other attributes such as mold content, color, and variety were identical and held constant across samples. Each enumerator had 5 boxes of the different levels of damage that they showed to farmers. The farmers were not told what level of damage they were looking at, and the boxes of different damage levels were placed in a random order that was known to the enumerator for recording purposes, but not to the responding farmer.

In the revealed preference approach, farmers were asked to choose among the maize samples and pick the one box out of the five possible options that was closest in level of damage to the maize that constituted their largest sale and/or purchase transaction during the past post-harvest season. Farmers were then asked to report the transaction price for the

[1] Insect damage is a major concern for grain quality in West Africa (Affognon, 2015). Compton *et al.* (1998) indicate that moldy maize is unlikely to be marketed in grain markets in West Africa.

chosen maize quality. Other characteristics of the household such as demographic information annual income and savings were also recorded during the interview.

In the stated preference experiment, farmers were asked to state how much they would pay and accept for each level of maize quality that they were shown. Each respondent was shown all 5 samples in random order, so 5 responses were recorded for each person interviewed.[2]

We designed the SP survey to minimize measurement error and insure validity of the estimates by following recommendations in Carson *et al.* (2000) for implementing contingent valuation interviews. First, interviews were made in one-on-one settings with only the enumerator and the farmer. Second, identical boxes of different maize damage levels were shown to each respondent and they were allowed to touch the maize to evaluate the quality. Third, the respondent elicited his or her preference by stating a price for a given quality in the experimental transaction. In addition, the respondent was free to state a zero value as price when he or she was not willing to purchase the good. Fourth, respondents were asked about their willingness-to-pay (WTP) and willingness-to-accept (WTA) during the lean period, as it is the most realistic period for poor quality maize.[3]

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[2] The SP approach used in the present study is therefore an open-ended questionnaire about only one characteristic of a private good that respondents are very familiar with. Carson and Haneman (2005) contend that incentives for strategic behavior, such as cheap talk and free-riding, are absent for private goods and therefore do not have a differential effect on CV for stated preference experiments. Keally and Turner (1993) find that there is no difference in WTP with open-ended contingent valuation and closed-ended contingent valuation for private goods. Mitchel and Carson (1989) contend that the open-ended CV may work in cases where the respondents are familiar with the concept of paying for the good.

[3] Insect damage takes times to develop, and only becomes apparent one or two months after harvest (Kimenju and Degroote, 2010).

3. Empirical Estimation

(a) Revealed preference model

We build our empirical model upon a hedonic price from Lancaster (1966) and Rosen (1974). Rosen (1974) states that under competitive market conditions, implicit prices will normally be related to product attributes alone, without accounting for producer or supplier attributes. However, rural markets from SSA are rarely competitive, and several empirical studies have shown that prices are also related to the attributes of buyers, seller and markets (Dury *et al.*, 1991; Langyintuo *et al*., 2004; Parker and Zilberman, 1993).

Hence, we define an implicit form of the empirical model for factors affecting maize price for a household *(i)* as follows:

$$P_i = f(X_i, M_i, F_i, T_i, \mu_i) \quad (1)$$

Where the dependent variable *P* denotes the market price, which is the sale price when a farmer sells maize and the purchase price when he or she buys maize.

The main covariate of interest is measured through *X*, which denotes the levels of the visible characteristic insect damage. Through focus group discussions in Ghana, Compton et al. (1998) reveal that insect damage has an impact on maize price. In the present application, the vector *X* is treated under 2 forms. First, it is a set of dummy variables that correspond to the level of insect damage. These dummy variables are 10%, 20%, 30% and 50% with base 0% damage. The first four levels of damage follow Compton et al. (1998) who indicate the categories called undamaged, slightly damaged, badly damaged. By adding 50% damage, we complement Compton et al. (1998) with an additional level of insect damage to identify a probable rejection value for maize quality in the market. Second, in an alternative specification, *X* also represents a continuous variable that takes as value the level of insect damage. The marginal effect of *X* on price tests hypothesis one: *there is no statistically significant price discount for maize that has been damaged by insects*.

The vector *M* corresponds to market variables, which allows us to differentiate how maize quality may be valued in different market settings. For instance, there is a much higher prevalence of insect damaged maize during the lean period compared to the early post-harvest period. Therefore we include a dummy variable =1 when the household is in the lean period, so that we can compare price discounts between that period and the early post-harvest period. We also include an interaction between level of insect damage, *X*, and the lean season dummy. The statistical significance of this interaction effect tests the second hypothesis in this study: *price discounts for insect damaged maize are not statistically different in the early post-harvest period compared to the lean period.*

In addition, we incorporate the distance from market in kilometers within the vector *M*. Farmers farther from the market might place a lower valuation on maize quality than farmers closer to the market owing to transaction and storage costs, and constraints to access market information. We also introduce the department dummies to control for regional differences in insect infestation and price patterns.

The vector *F* represents a set of household characteristics. We include the demographic variables along with the determinants of a farmer's market participation. First, we consider determinants such as i) age of household head, ii) education of household head, iii) household size. We then add iv) a farmer's full income from activities other than maize production and v) saving at the beginning of harvest season. These two variables capture a household's liquidity constraints that may hinder the effectiveness of his or her market participation (Stephens and Barrett, 2011). We also assume that better information about market prices and the quality of maize traded depend on the degree to which a farmer participates in markets either as a seller or a buyer. Thus, we consider the variables vi) total quantity of maize traded by the household in the post-harvest period , vii) the share of production that is sold to measure the household's propensity to sell maize and viii) the share of maize purchased for consumption relative to quantity of maize produced by the household to infer their propensity to buy maize.

The vector *T* denotes a household's trading partner during the market transactions, namely maize buyers for sales, and maize sellers for purchases. For the sale model the vector comprises the following set of dummy variables: 1) farmers in the village, 2) traders from the market, 3) governmental grain marketing agency called ONASA, and 4) "other buyers" which serves as the base in the sales transaction. For the purchase model, we use "traders" as the base.

(b) Dealing with potential omitted variable bias

It is possible that unobserved factors in the error term of equation 1, denoted by μ_i, that affect the dependent variable maize price, also affect maize quality. If this is the case then the omitted variables could lead to biased estimates of the maize damage coefficients. To indirectly test and deal with the impacts of omitted variable bias, we present a parsimonious specification for each of our estimated models that only includes level of insect damage, department dummies, and a constant as covariates. Results of the parsimonious specification are presented next to results where a full set of observable household, season, and market characteristics are in the model, as explained in equation 1. There is little change in the insect damage coefficient estimates between the parsimonious and fully specified specifications. This lends validity to the notion that omitted variables are not biasing the insect damage coefficient estimates in this study. Nevertheless, our results cannot be taken as fully causal.

(c) Functional form

Most hedonic price models rely on Box-Cox transformation to identify the correct functional form, as there is no theoretical background to support the functional form of the dependent variable. The Box-Cox transformation of the dependent variable confirms the semi-log form for the sale model, but it indicates a simple linear form for the purchase model. To test the robustness of the estimates, we use a log-linear specification for the dependent variable along with a simple linear regression. The log linear regression is applied only when the covariate X is treated as a continuous variable representing the level of insect damage.

(d) Dealing with potential sample selection issues in the revealed preference models

Since only a sub-sample of households in our full sample actually purchase and/or sell maize, we may encounter selection bias in our estimation of factors affecting maize price. This occurs because some households do not sell (purchase) maize because the price they would receive (pay) is below (above) their reservation value for that maize. Therefore, the value of that maize is unobservable to us (it is not equal to zero), and failure to accurately correct for this problem can lead to biased coefficient estimates (see Wooldridge (2010) for discussion of this problem, which he calls incidental truncation).

Our problem is analogous to the common empirical situation where one needs to correct for labor market participation when estimating a wage equation. We test and correct for this concern using a two-step estimation of Heckman selection model, following Heckman (1979). In this context, the first step is the selection equation that corresponds to the household's decision to participate in markets for each type of transaction (sale or purchase). We then derive the inverse mills ratio (IMR) from the selection equation and include it as an additional covariate in the second step maize price equation as shown in equation 1. The statistical significance of the IMR in the second step tells us if selection bias is an issue under the null hypothesis that there is no selection bias.

We use total area cultivated to crops other than maize as our exclusion variable in the participation equation. This variable is appropriate because households with larger non-maize areas may be more likely to sell and less likely to purchase maize. However, this variable would not be expected to directly affect maize price.

Appendix 1 presents the results when the Heckman selection model is used to estimate the revealed preference maize price equation. The exclusion variable is significant in the first stage participation models for both purchases and sales (p-value<0.05), indicating that it is suitable to identify the equation. In the second stage, the IMR is insignificant in the maize price model for sales (p-value=0.94), suggesting that selection bias is not an issue. The IMR is statistically significant in the maize price models for purchases (p-value=0.00). However, the statistical significance of the coefficients on insect damage and lean season variables do not change when the IMR is included compared to the main results when it is not. This suggests that selection bias is not a major empirical concern in this setting.

(e) Empirical specification of the stated preference models

The stated preference model in our study uses a contingent valuation (CV) method. The CV method is very straightforward, and since we are interested to only one characteristic of the good, its level of insect damage, this method is widely accepted as valid (Bateman et al., 2002). In this application, we measure respondent's purchase decision as the maximum WTP in a situation where the respondent wants to acquire the good. We measure the sales decision as the minimum WTA, which represents the compensation value for which the respondent is being asked to voluntarily give up a good (Carson, 2000).

From an econometric perspective there are no special issues involved in estimating the WTP equation beyond those normally experienced with survey data (Carson, 2000). Thus, we specify the CV models as follows:

$$WTA_i = g(X_i, Q_i, F_i, M_i, e_i\ ) \qquad (2)$$

$$WTP_i = h\big(X_i, Q_i, F_i, M_{i,}\ a_i\ \big) \qquad (3)$$

where WTP represents a farmer's willingness-to-pay for the maize characteristics in the purchase model, whereas WTA represents a farmers' willingness-to-accept in the sale model. The covariates in equations (2) and (3) are defined as before, with e_i and a_i as the respective error terms. We exclude the time seasonal variable from the vector *M*, since the SP assumes an experimental market that occurs only during the lean season.

(f) Estimation strategy for the stated preference models

Testing the validity of the CV requires including variables that can help verify the conformity with economic theory (Mitchell and Carson, 1989) and knowledge of concerned goods (Carson and Herman, 2005). We follow these principles by including income and saving as covariates in the model. Similarly, we verify farmers' knowledge of the good by including variables that measure their propensity to sell and to purchase maize, measured in the ratio of sold/consumed maize, and the ratio of purchased/produced maize.

Furthermore, the combined use of WTA and WTP tests the convergent validity criteria as proposed by Carson (2000) and Venkatachalam (2004). Theoretically the difference between WTP and WTA should be small and unimportant as long as income effects and transactions cost are not large (Carson, 2000).

Some households state that they would not purchase or sell maize with particular levels of insect damage at any price in the state preference experiment. In this situation the zero price elicitation is a true measure of a household's willingness to pay or accept, and such a response suggest that farmers do not place a value on maize of that damage level. Therefore, while our main models are estimated via OLS, for robustness we compare the OLS estimates with estimates from a tobit and double hurdle. The latter two models explicitly deal with a non-trivial number of zero responses in the dependent variable. Appendices 2.a & 2.b. present the results when the stated preference modes are estimated via tobit and double hurdle. We find that there is no substantive difference in the coefficient estimates and standard errors between OLS and these two alternative estimators, suggesting that OLS generates reliable coefficient estimates in this context.

Since we ask each farmer to elicit his or her price preferences for five categories of maize damage in the state preference experiment, we end up with 5 observations for each respondent household. We deal with the five repeated covariates of each respondent by clustering the regression at the individual-level to make our standard errors robust to potential serial correlation and heteroskedasticity.

4. Results

a) Descriptive statistics for revealed preference models

Table 1 presents the descriptive statistics for the variables used in the RP analysis. The table indicates that in the lean season more farmers purchase maize (44%) than sell it (20%), which is not surprising. Given the mean purchase price is nearly 1.5 higher than the mean sale price, it is likely that farmers pay a higher price for purchased maize than they receive for maize they sell.

[Table 1. Here]

Table 2 shows that high quality maize (0% damage) is the most commonly traded grain for both sale and purchase transactions during the early post-harvest period, as we might expect. Although grain with higher insect damage is much more prevalent during the lean period, there are very few market transactions for extremely damaged grain (50% damage) which suggests that extremely damaged grain is not marketable.

[Table 2. Here]

b) Descriptive statistics for stated preference models

Table 3 presents the mean price for each level of insect damaged maize in the SP models. These results suggest that as insect damage increases there is a decrease in farmers' WTP for purchasing maize, and WTA for selling maize. Farmers' price elicitation is also consistent with the theory. The higher mean value of the WTA relative to the mean sale price of the RP confirms that the owner overestimates the value of the maize that will hypothetically be sold. Instead, the mean value of the WTP is close to and if not lower than the RP mean price for purchase, as expected (Carson *et al.*, 1996). The ratio between RP and SP is shown on the far right column of table 3.

[Table 3. Here]

c) Estimation results for the revealed preference sale model

Table 4 presents the results for the model of factors affecting prices that farmers receive when selling their maize. Columns 1, 3 and 5 present the parsimonious results where only level of insect damage and a constant are included in the model, while columns 2, 4, and 6 show the results with a full set of controls. The results are generally consistent across specifications, and indicate that farmers receive price discounts when they sell insect damaged maize.

In columns 1 and 2, the dependent variable is maize price in FCFA/kg, and the impact of insect damage on maize price is estimated using a set of 4 dummy variables with 0% insect damage as the base. The parsimonious regression in column 1 shows that only the variable for 50% insect damage is statically significant (p value = 0.04). In column 2 the price discount for maize with insect damage becomes statically significant when insect damage reaches 30% of the sample. These results suggest that maize buyers tolerate insect damage as low as 20% during sales transactions without requiring the maize to be discounted. Farmers whose marketed maize contains 30% insect damage receive about 15 F CFA/Kg ($ 0.029 /Kg) less than farmers selling high quality maize (0% damage). When insect damage reaches 50% of maize sold, the discount increases to 25 F CFA/Kg ($ 0.05) and this effect is also statistically significant (p-value=0.04).

In column 3 through column 6 of table 4 we treat the level of insect damage as a continuous variable to generate a linear damage slope. The dependent variable is also converted to log of maize price. The coefficient on the damage slope in columns 3, and 4 suggests that a 10% increase in damage level entails a 3.3% to 3.4% price discount on average that is statistically significant in both specifications (p-value < 0.05).

Columns 5 and 6 of table 4 show the results where insect damage is interacted with the lean period dummy variable, which allows the damage effects on maize price to vary between early PH and lean periods. In column 5 the results indicate that in the early PH period a 10% increase in insect damage lowers maize price by 4.1% (p-value=0.05). However, in the lean period the price discount for insect damage is minimal as a 10% increase in insect damage reduces maize price by just 0.2% (p value for the joint F-test = 0.05). In column 6 the results are very similar as a 10% increase in insect damage during the early PH period reduces maize price by 3.7% (p-value=0.01), but in the lean period a 10% increase in insect damage only reduces maize price by 0.8% (p value for the joint F-test = 0.04). These results indicate that the price discount for lower quality maize is substantial in the early post-harvest period, but is much smaller in the lean season. This finding makes sense as scarcity in the lean season makes people desperate, which in turn pushes prices up and makes them care less about quality. Our results are consistent with Compton et al.'s (1998) findings in Ghana that traders tolerate higher levels of insect damage later in the year when maize became scarce.

[Table 4. Here]

d) Estimation results for the stated preference sale model

Subsequent tables are presented in the same format as table 4, with the specifications showing a full set of variables following the corresponding parsimonious specifications.

The results for the stated preference for sale estimates in table 5 suggest that farmers are willing-to-accept a discounted price for every level of insect damage. Column 1 presents the parsimonious regression with the dependent variable, price in F CFA/Kg. Results in column 1 indicate that the discount is statistically significant for every level of damage (p value=0.00). The price discount is nearly 0.9 % for 1% insect damage, as shown in column 3 where the dependent variable is log price. In addition, households' characteristics have no effect on the discount, since the results of the discount slope are the same when the full set of variables are introduced in column 2 and 4.

We also find other drivers of farmers' WTA that can serve the internal validity test for the SP. For instance, household size has a negative and statistically significant effect on price (p-value < 0.05) in column 2 of table 5. The income effect is positive and significant (p-value <0.10) with a small effect on price. One possible explanation might be that larger households interact more frequently in the market for cash needs to the extent that they provide more realistic estimation of sale prices.

[Table 5. Here]

e) Estimation results for the revealed preference purchase model

Table 6 indicates that farmers discount prices depending on the maize quality purchased in markets. In the parsimonious regression in column 1, the negative signs of the coefficients are generally what we would expect for a consumer purchasing low quality maize. But the discount coefficients are marginally statistically significant for 50% damage level (p-value = 0.11). Controlling for other transactions characteristics in column 2 does not modify substantially the magnitude of the discount coefficients, but does modify the level of the statistical significance. The price discount is no longer significant at any level of insect damage. These results could mean farmers are not concerned about the quality of purchased maize because they have little choice but to pay what the market offers when they run out of stock, regardless of quality.

In columns 3 and 4 of table 6, we use the log price to determine the damage slope during purchase transactions. In column 3, the results indicate that a 10% increase in maize damage lowers the price farmers are willing-to-pay by 2.4%, but this damage slope remains marginally significant (p-value=0.11). When we account for transaction characteristics in column 4 the discount for a 10% increase in maize damage is 2.6%, and the statistical significance remains marginally significant (p-value=0.12).

Results from columns 5 and 6 in table 6 reveal that when the damage slope is interacted with the lean season dummy, the discount for purchases in the early post-harvest period is higher than it is in the lean period. In column 5, a 10% increase in insect damage translates to a 4.4% reduction in maize price during the early post-harvest period, but the joint effect suggests that during the lean period, a 10% increase in insect damage translates to just a 0.5% decrease on average. In column 6, a 10% increase in insect damage in the early post-harvest season, reduces maize price by 4.5% on average, but during the lean period a 10% increase in insect damage reduces maize price by 0.9% on average. However, we cannot make strong statistical inference for the price discount during the lean season in this specification because the joint F test for the quality slope and the interaction term is not statically significant (p value = 0.17).

Table 6 also provides insights about the effects on purchase prices of some household and market characteristics. Savings effect is highly significant across all columns of the table, whereas households' income effect is significant only in the log-linear estimation in columns 4 and 6. The sign of these coefficients shows that wealthier households pay less for maize quality, but the effect remains small. Of the market characteristics, farmers purchasing maize from the government pay a much lower purchase price and this effect is highly statistically significant. Farmers who have access to the government market are able to purchase maize at a 65% discount or on average 140 F CFA lower than the market average. But few farmers buy from this market channel mainly because there is a high transaction cost to access government shops generally located far from the villages.

[Table 6. Here]

f) Estimation results for the stated preference purchase model

Results in table 7 show that farmers are willing-to-pay less for maize that has more damage. In the parsimonious specification shown in column 1, the discount is statistically significant for every level of insect damage (p-value = 0.00). Likewise, the quality slope estimation in column 3 shows that a 10% increase in insect damage generates 9.0% price discount. We find little effect if any of household characteristics on the quality valuation in the WTP model. Indeed, when we control for households' characteristics in columns 2 and 4, the coefficient on the damage dummies and the damage slope are almost unchanged compared to their parsimonious regressions in columns 1 and 3, respectively.

Table 7 also provides evidence of the internal validity of the WTP estimation. First, the results are consistent with economic theory. Wealthier household are likely to elicit a higher willingness-to-pay for maize quality, even though the income effect is small. Income elasticity for demand is indeed positive for maize which is a normal good (Carson and Hanemann, 2005). In contrast, households with more members are willing to pay less for identical maize quality suggesting that farmers with higher family expenses might be more price-cautions (Su *et al.,* 2011). Second, the positive coefficient for the purchase/production ratio indicates that the more the household depends on purchases for food consumption, the more the household head is willing-to-pay for maize. Conversely, a household with a larger propensity-to-sell is less willing-to-pay a high price to consume maize. We also observe a similar effect for the saving variable most likely because farmers with larger savings are more likely to be maize sellers than buyers.

[Table 7. Here]

5. Conclusion

This article uses data from a random sample of 360 maize farmers from Benin to estimate the extent to which insect damage affects the price that farmers' in SSA receive when they sell maize and the price that they pay when they purchase maize. We also test whether or not there is a price discount in the early post- harvest period when maize is plentiful, compared to the lean period when maize is scare. The findings from this study add to the existing literature by helping to explain why many smallholders in SSA sell maize at harvest and do not invest in modern storage technology that can preserve maize quality for later in the post-harvest season.

The main results of this article suggest that there is a price discount for insect damaged maize in Benin. The size of the price discount varies depending on the evaluation method (revealed preference vs. stated preference) and side of the market transaction (sales vs. purchases). Our RP results for maize sales also find some evidence to support the idea that discounts for insect damage are higher in the early post-harvest period when maize is plentiful, compared to the lean season when maize is scarce. This suggests that when there is sufficient maize on the market immediately after harvest, people have quality grain available to them and subsequently discount grain that has been damaged by insects. Conversely, in the lean season people become desperate and do not have the luxury to select their maize based on quality.

These results complement recent studies that estimate how maize quality affects market participation. Hoffman and Gatobu (2014) infer that unobservable maize quality attributes, such as existence of aflatoxins, might help explain why many farmers in SSA remain semi-subsistence, and only purchase maize from the market when necessary. We contend that in situations of food scarcity, such as in the lean season, even visible grain characteristics like insect damage matter less to household decision making.

Our results also suggest that farmers who might otherwise want to store grain with the intention of selling it in the lean period, currently have little incentive to invest in effective storage technologies to preserve quality, because the market has a higher tolerance for low quality maize in the lean period. This creates a vicious circle where farmers do not protect their stored maize from insects, resulting in large post-harvest losses that further exacerbate maize scarcity. In turn, the scarcity of maize and prevalence of insect damage in the lean period means that farmers who must purchase maize in the lean season for food security will purchase maize of whatever quality is available in the market.

The results of our study lead to several recommendations. First, since price discounts exist in the early post-harvest period when maize is plentiful, productivity enhancing interventions such as adoption of improved maize varieties are needed to increase output and extend the plentiful season further into the marketing year. Second, increasing farmer adoption of improved storage technology can enhance their ability to store more good quality maize at harvest to consume and sell in the lean season. With an increase in the quantity and quality of maize available in the lean period, we hypothesize that the price discounts observed in the early post-harvest period would also become present in the lean period. Subsequently, with more maize produced and better storage technology households are less likely to be forced into purchasing poor quality grain during the lean season when food security concerns become acute.

References

Affognon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2015). Unpacking Postharvest Losses in Sub-Saharan Africa:A Meta-Analysis. *World Development,* 66, 49-68.

Bateman, I.J., Carson, R.T., Hanemann, B. Day, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D.W., Sugden, R. & Swanson, J. (2002). Economic valuation with stated preference techniques: a manual. *Edward Publishing Inc*, 2002, 480 pp.

Carson, R. & Hanemann, W.M. (2005). Handbook of Environmental Economics. 2, Edited by K.-G. Mäler and J.R. *Vincent, Elsevier B.V.*

Carson, R.T. (2000).Contingent Valuation: A User's Guide. *Environmental Science & Technology*, 34 (8), 9-1413.

Carson, R.T, Flores, N.E., Martin, K.M., & Wright, J.L. (1996). Contingent valuation and revealed preference methodologies: comparing the estimates for quasi-public goods. *Land Economic*s, 72, 80–99.

Compton, J. A. F., Floyd, S., Magrath, P. A., Addo, S., Gbedevi, S.R., Agbo, B., Bokor, G., Amekupe, S., Motey, Z., Penni, H., & Kumi, S. (1998). Involving grain traders in determining the effect of post-harvest insect damage on the price of maize in African markets. *Crop Protection*, 17, 483-489.

Dury, S. & Meuriot V. (1991). Do Urban African Dweller pay premium for food quality and if so, how much? An investigation of Malian fonio Grain Market. *Review of Agricultural and Environmental Studies,* 4, 417-433

Heckman, J. (1979). Sample Selection Bias as a Specification Error. *Econometrica*, 47(1), 153-61.

Hodges, R. J., Buzby, J.C., & Bennett, B. (2011). Postharvest losses and Waste in developed and less developed countries: Opportunities to improve resource use. *Journal of Agricultural Science*, 149 (SI), 37-45.

Hoffmann, V. & Gatobu, K. M. (2014). Growing their own: Unobservable quality and the value of self-provisioning. *Journal of Development Economics*, 106, 168-178.

Hoffman, V., Mutig, S., Harvey, J., Nelson, R., & Milgroom, M. (2013). Asymmetric Information and Food Safety: Maize in Kenya. *Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES, Joint Annual Meeting held on August 4-6 2013, Washington DC, USA.*

Jones, M. (2012). Measuring the value of African smallholder grain protection: two essays on storage economics and market valuation of maize attributes in Malawi. *MS Thesis, Purdue University. West Lafayette, IN, USA.*

Jones, M., Alexander, C., & Lowenberg-DeBoer, J. (2011). An initial Investigation of the potential Purdue Improved Crop storage (PICS) to improve income for maize producers in Sub-Saharan Africa. *Purdue University, Working paper* # 11-3.

Kealy, J. M. & Turner, R. W. (1993). A test of the Equality of Closed-Ended and Open-Ended Contingent Valuations. *American Journal of Agricultural Economics*, 5(2), 321-31.

Kimenju, S.C. & DeGroote, H. (2010). Economic Analysis of Alternative Maize Storage Technologies in Kenya. *Contributed Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, held on September 19-23, 2010, Cape Town, South Africa.*

Lancaster, K. J. (1966). A New Approach to Consumer Theory. *Journal of Political Economy*. 74(2), 132-156.

Langyintuo, A.S., Ntoukam, G., Murdock, L., Lowenberg-DeBoer, J., & Miller, D.J. (2004). Consumer preferences for cowpea in Cameroon and Ghana. *Agricultural Economics*, 30(3), 203-213.

Mitchell, R.C. & Carson, R.T. (1989). Using Surveys to Value Public Goods: The Contingent Valuation Method. *Johns Hopkins University Press, Baltimore, MD.*

Parker, D.D., & Zilberman, D. (1993). Hedonic Estimation of Quality Factors Affecting the Farm Retail Margin. *American Journal of Agricultural Economics*, 75, 458-466.

Renkow, M. (1990). Household Inventories and Marketed Surplus in Semi-subsistence Agriculture. *American Journal of Agricultural Economics*, 72, 664-675.

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product differentiation in Pure Competition. *The Journal of Political Economy*. 82(1).

Saha, A. & Stroud J. (1994). A Household Model of On-Farm Storage under Price Risk. *American Journal of Agricultural Economics*, 76, 522-534.

Stephens, E. & Barrett, C.B. (2011). Incomplete Credit Markets and Commodity Marketing Behavior. *Journal of Agricultural Economics*, 62, 1-24.

Su, L., Adam, B., Lusk, J., and Arthur, F. (2011). A Comparison of Auction and Choice Experiment: An application to Consumer Willingness to Pay for Rice with Improved Storage Management. *Selected paper prepared for the presentation at 2011 AAEA & NAREA, Joint Annual meeting, held on July 24-26,* Pittsburgh, Pennsylvania, USA.

Venkatachalam, L. (2004). The contingent valuation method: a review. *Environmental Impact Assessment Review,* 24, 89–124.

Wooldridge, J.M. (2010). Econometric Analysis of Cross Section and Panel Data, 2nd Edition. MIT Press Cambridge, MA.

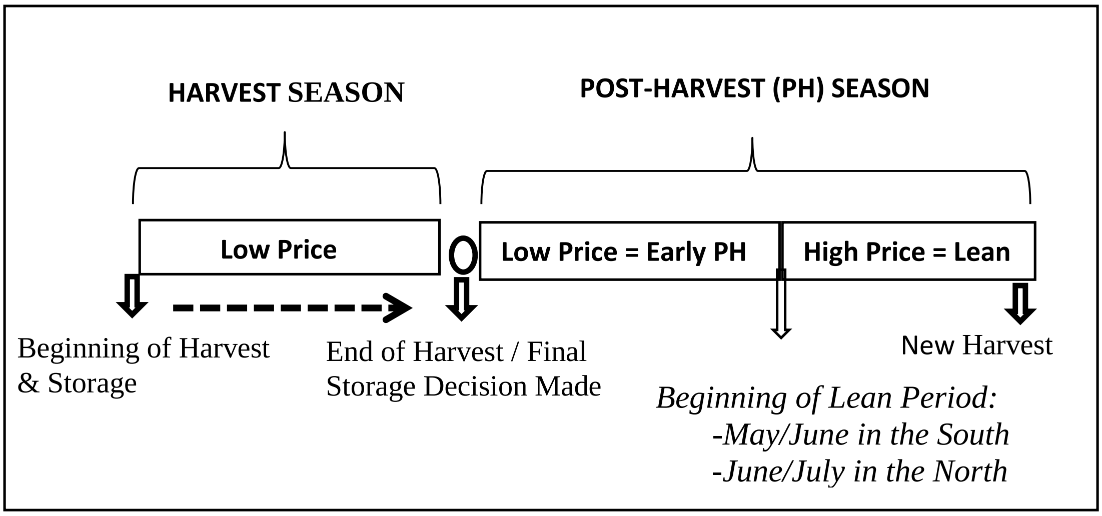

Figure 1. Maize consumption cycle in Benin

Table 1. Descriptive statistics for the sample

	Full sample		Sale		Purchase	
Variables	Mean	Sd.	Mean	Sd.	Mean	Sd.
Maize price (F CFA/Kg)			163	56	220	90
Age	42	13	42	13	45	14
Household size	10	6	10	6	9	5
Full income (x 10,000 F CFA)	79	294	69	141	102	456
Saving (x 10,000 F CFA)	8	23	10	27	5	13
Quantity sold (Kg)	1,417	7,180	2,056	4,262	480	1,111
Quantity purchased (Kg)	78	160	65	145	183	196
Distance (Km)	6	5	6	5	6	4
Ration Sale / Production (%)	41	53	60	55	24	28
Ratio Purchase / Consumption (%)	21	2	12	22	52	2
= 1 if HH head attended school (%)	37	-	35	-	36	-
= 1 if HH head is female (%)	10	-	9	-	12	
=1 if HH participates in Lean Season (%)		-	20	-	44	-
= 1 If HH buys from/sells to a Farmer (%)	-	-	4	-	18	-
=1 if HH buys from/sells to a trader (%)	-	-	87	-	77	-
=1 if HH buys from/sells to government (%)	-	-	2	-	5	-
=1 if HH buys from/sells to other partner (%)	-	-	7	-	-	-

Note: The symbol (-) indicates Not Applicable; 1 US $ = 512 Francs CFA at the time of the survey

Table 2. Level of insect damage in marketed maize

Maize	% of Observed Sales		% of Observed Purchases	
Quality	Early PH	Lean	Early PH	Lean
0% damage	53	31	54	49
10% damage	23	49	28	29
20% damage	11	4	5	10
30% damage	7	14	5	7
50% damage	6	2	8	5
Number of observations	197	49	75	59

Table 3. Price (in F CFA/Kg) for different levels of insect damage in revealed preference (RP) and stated preference (SP) models

Maize Damage	**SP**		**RP**				Mean Ratio*
	Lean		Early PH.		Lean		SP/RP
	Mean	SD	Mean	SD	Mean	SD	
	WTA		Sale				
0% damage	214	91	160	54	172	20	1.24
10% damage	192	88	174	75	171	32	1.12
20% damage	163	90	164	69	200	00	0.82
30% damage	154	85	140	43	175	56	0.88
50% damage	123	81	133	32	167	00	0.74
	WTP		Purchase				
0% damage	213	83	257	118	206	48	1.03
10% damage	191	78	217	89	228	91	0.84
20% damage	165	73	164	55	173	41	0.95
30% damage	160	73	193	33	204	34	0.78
50% damage	128	70	158	63	190	69	0.67

Note: SD = Standard deviation; 1 US $ = 512 Francs CFA at the time of the survey; (*) the ratio considers the lean season value for the RP.

Table 4. Factors affecting price of sold maize (F CFA/Kg) in the reveled preference model

	Price (1)			Price (2)			Log (Price) (3)			Log(Price) (4)			Log(Price) (5)			Log(Price) (6)		
Covariates	Coef		P>t	Coef		P>t	Coef		P>t	Coef.		P>t	Coef.		P>t	Coef.		P>t
Damage slope							-0.34	**	(0.02)	-0.33	***	(0.01)	-0.41	**	(0.05)	-0.37	***	(0.01)
Damage slope * Lean Season													0.39		(0.16)	0.29		(0.26)
10 % Damage	1.35		(0.83)	0.89		(0.88)												
20% Damage	-13.95		(0.15)	-10.91		(0.27)												
30% Damage	-11.14		(0.28)	-14.93	*	(0.07)												
50% Damage	-25.35	**	(0.04)	-25.12	**	(0.04)												
= 1 if transaction is in Lean season				11.03	**	(0.05)				0.10	***	(0.01)	0.10	**	(0.06)	0.07		(0.16)
=1 if HH attended School				12.81	**	(0.02)				0.07	*	(0.07)				0.07	*	(0.07)
Age				2.65	*	(0.06)				0.02	*	(0.07)				0.02	*	(0.08)
age square				-0.03	*	(0.08)				-2E-04	*	(0.10)				-2E-04		(0.11)
= 1 if HH head is female				-7.59		(0.35)				-0.02		(0.68)				-0.02		(0.68)
Household size				-1.32	***	(0.00)				-0.01	**	(0.02)				-0.01	**	(0.02)
Income(x 10,000 F CFA)				0.04	**	(0.03)				2.E-04	***	(0.00)				2.E-04	***	(0.01)
Saving (x 10,000 F CFA)				0.26	***	(0.00)				2.E-03	***	(0.00)				2.E-03		(0.00)
Quantity sold				0.00		(0.80)				4.E-06		(0.41)				4E-06		(0.41)
Ratio sale/consumption				-2.66		(0.68)				-0.03		(0.47)				-0.03		(0.45)
Ratio purchase/production				0.47		(0.98)				-0.03		(0.76)				-0.03		(0.82)
Distance from Market (Km)				0.97		(0.13)				2.E-03		(0.52)				2.E-03		(0.51)
= 1 if sold to Traders				-13.72		(0.31)				-0.04		(0.60)				-0.03		(0.63)
= 1 if sold to Government				-14.99		(0.45)				-0.07		(0.54)				-0.10		(0.36)
= 1 if sold to farmers				-24.23		(0.24)				-0.14		(0.27)				-0.14		(0.28)
Constant	175.53	***	(0.00)	117.40	***	(0.00)	5.17		(0.00)	4.78	***	(0.00)	5.11	***	(0.00)	4.80	***	(0.00)
N	246			246			246			246			246			246		
R-Squared	0.43			0.55			0.38			0.51			0.42			0.51		

Note: *, **, ***, indicate that corresponding coefficients are statistically significant at the 10%, 5 %, and 1% level respectively; 1 US $ = 512 Francs CFA (F CFA) at the time of the survey; Department dummies are not shown in the table.

Table 5. Factors affecting price of sold maize (F CFA/Kg) in the stated preference model

	Price (1)			Price (2)			Log (Price) (3)			Log(Price) (4)		
Covariates	Coef.		P>t	Coef		P>t	Coef		P>t	Coef.		P>t
Damage slope							-0.88	***	(0.00)	-0.88	***	(0.00)
10 % Damage	-20.65	***	(0.00)	-20.65	***	(0.00)						
20% Damage	-46.52	***	(0.00)	-46.52	***	(0.00)						
30% Damage	-51.14	***	(0.00)	-51.15	***	(0.00)						
50% Damage	-78.77	***	(0.00)	-78.46	***	(0.00)						
=1 if Household attended School				3.69		(0.44)				0.03		(0.16)
Age				1.74		(0.12)				0.01	*	(0.07)
age square				-0.02		(0.13)				0.00	*	(0.10)
= 1 if HH head is female				-6.64		(0.46)				0.01		(0.66)
Household size				-1.24	**	(0.03)				-3E-03		(0.16)
Income(X 10,000 F CFA)				0.01		(0.15)				3E-05		(0.45)
Saving (x 10,000 F CFA)				0.09		(0.17)				4E-04		(0.22)
Quantity sold				-5E-04		(0.46)				-4E-06		(0.18)
Ratio sale/consumption				-5.64		(0.23)				-0.02		(0.48)
Ratio purchase/production				1.25	*	(0.07)				0.01	**	(0.03)
Distance from Market (Km)				1.18	*	(0.06)				3E-03		(0.38)
Constant	206.79	***	(0.00)	163.06	***	(0.00)	5.27	***	(0.00)	5.05	***	(0.00)
N	1756			1756			1698			1698		
R-Squared	0.43			0.45			0.47			0.48		

Note: *, **, ***, indicate that corresponding coefficients are statistically significant at the 15%, 5 %, and 1% level respectively; 1 US $ = 512 Francs CFA at the time of the survey; Department dummies are not shown in the table

Table 6. Factors affecting price of purchased maize (F CFA/Kg) in the reveled preference model

	Price (1)			Price (2)			Log(Price) (3)			Log(Price) (4)			Log(Price) (5)			Log(Price) (6)		
Covariates	Coef		P>t	Coef		P>t	Coef.		P>t	Coef.		P>t	Coef.		P>t	Coef.		P>t
Damage slope							-0.24		(0.11)	-0.26		(0.12)	-0.44	*	(0.06)	-0.45	*	(0.06)
Damage slope * Lean													0.39		(0.19)	0.35		(0.23)
10 % Damage	-0.41		(0.97)	7.42		(0.50)												
20% Damage	-5.88		(0.65)	-15.27		(0.31)												
30% Damage	-20.48		(0.24)	-26.26		(0.20)												
50% Damage	-22.75		(0.11)	-24.95		(0.20)												
= 1 if transaction is in Lean season				-5.76		(0.56)				-0.01		(0.75)	-0.03		(0.56)	-0.05		(0.31)
=1 if HH attended School				12.66		(0.20)				0.05		(0.21)				0.05		(0.24)
Age				0.70		(0.70)				0.00		(0.88)				0.00		(0.88)
age square				-0.01		(0.69)				0.00		(0.91)				0.00		(0.91)
= 1 if HH head is female				39.27	*	(0.09)				0.11		(0.12)				0.11		(0.13)
Household size				-1.36		(0.11)				-5E-03		(0.15)				-5E-03		(0.17)
Income(X 10,000 F CFA)				-0.01		(0.35)				-7E-05	*	(0.10)				-8E-05	*	(0.07)
Saving (x 10,000 F CFA)				-0.60	***	(0.01)				-4E-03	***	(0.00)				-4E-03	***	(0.00)
Quantity purchased (Kg)				-0.04		(0.23)				-2E-04		(0.19)				-2E-04		(0.19)
Ratio sale/production				1.78		(0.92)				0.02		(0.75)				0.03		(0.69)
Ratio purchase/production				1.34		(0.36)				0.01		(0.43)				0.01		(0.38)
Distance from Market (Km)				3.21	*	(0.08)				0.01		(0.12)				0.01		(0.12)
=1 if purchased from other farmers				-15.42		(0.24)				-0.05		(0.45)				-0.05		(0.42)
=1 if purchased from Government				-140.79	***	(0.00)				-0.65	***	(0.00)				-0.66	***	(0.00)
Constant	209.76	***	(0.00)	195.11		(0.00)	5.33		(0.00)	5.39	***	(0.00)	(5.34)	***	(0.00)	5.41	***	(0.00)
N	134			134			134			134			134			134		
R-Squared	0.45			0.63			0.51			0.70			0.52			0.71		

Note: *, **, ***, indicate that corresponding coefficients are statistically significant at the 10%, 5 %, and 1% level respectively; 1 US $ = 512 Francs CFA (F CFA) at the time of the survey; Department dummies are not shown in the table.

Table 7. Factors affecting price of purchased maize (F CFA/Kg) in the stated preference model

	Price (1)			Price (2)			Log(Price) (3)			Log(Price) (4)		
Covariates	Coef		P>t	Coef		P>t	Coef.		P>t	Coef.		P>t
Damage slope							-0.90	***	(0.00)	-0.90	***	(0.00)
10 % Damage	-23.02	***	(0.00)	-23.02	***	(0.00)						
20% Damage	-51.70	***	(0.00)	-51.70	***	(0.00)						
30% Damage	-58.60	***	(0.00)	-58.61	***	(0.00)						
50% Damage	-90.63	***	(0.00)	-90.59	***	(0.00)						
=1 if Household attended School				4.37		(0.46)				0.01		(0.73)
Age				1.79		(0.14)				-6E-05		(0.99)
age square				-0.02		(0.19)				-6E-08		(1.00)
= 1 if HH head is female				-7.58		(0.43)				-0.01		(0.74)
Household size				-1.12	**	(0.03)				-4E-03	**	(0.04)
Income(X 10,000 F CFA)				0.02	**	(0.02)				7E-05	**	(0.04)
Saving (x 10,000 F CFA)				-0.03		(0.69)				1E-04		(0.76)
Quantity purchased				0.01		(0.65)				-4E-05		(0.65)
Ratio sale/production				-7.95		(0.16)				-0.07	***	(0.01)
Ratio purchase/production				-1.11		(0.24)				0.02	*	(0.06)
Distance from Market (Km)				0.42		(0.59)				5E-04		(0.88)
Constant	180.77	***	(0.00)	152.17	***	(0.00)	5.12	***	(0.00)	5.21	***	(0.00)
N	1756			1756			1620			1620		
R-Squared	0.38			0.39			0.51			0.52		

Note: *, **, ***, indicate that corresponding coefficients are statistically significant at the 10%, 5 %, and 1% level respectively;
1 US $ = 512 Francs CFA (F CFA) at the time of the survey; Department dummies are not shown in the table.

Appendix 1. Heckman selection correction for the revealed preference models

	Revealed preference for sales						Revealed preference for purchases					
	Probit (1=HH sold Maize)			**OLS** (Price F CFA/kg)			**Probit** (1 = HH bougt Maize)			**OLS** (Price F CFA/kg)		
	Coef.		P > t	Coef.		P > t	Coef.		P > t	Coef.		P > t
10 % Damage				1.79		(0.76)				8.01		(0.51)
20% Damage				-11.95		(0.16)				-33.63		(0.11)
30% Damage				-20.83	**	(0.02)				-26.10		(0.24)
50% Damage				-18.80	*	(0.09)				-1.48		(0.95)
= 1 if transaction is in Lean season				5.63		(0.39)				6.12		(0.60)
=1 if Household attended School	-0.20		(0.23)	18.04	***	(0.00)	-0.14		(0.41)	22.65	*	(0.09)
Age	-0.04		(0.29)	3.16	***	(0.01)	-0.03		(0.37)	5.67	**	(0.05)
age square	3.40E-04		(0.36)	-0.03	***	(0.01)	3.90E-04		(0.30)	-0.06	**	(0.05)
= 1 if HH head is female	-0.33		(0.21)	-9.50		(0.33)	-0.07		(0.81)	56.53	***	(0.01)
Household size	-0.03	**	(0.04)	-1.49	***	(0.01)	0.01		(0.69)	-1.48		(0.22)
Income(x 10,000 F CFA)	-2.86E-04		(0.37)	0.05	***	(0.00)	2.13E-04		(0.55)	-0.02		(0.26)
Saving (x 10,000 F CFA)	0.01	*	(0.08)	0.22	*	(0.09)	-3.19E-03		(0.43)	-0.97	**	(0.03)
Distance from Market (Km)	0.01		(0.42)	1.19	*	(0.08)	-0.03	*	(0.07)	-15.69		(0.49)
Quantity traded (sold/purchased)				-9.86E-05		(0.90)				-0.03		(0.41)
Ratio sale/production				-4.07		(0.47)				-15.69		(0.49)
Ratio purchase/production				1.77		(0.91)				0.74		(0.71)
= 1 if partner is Traders				-28.59	***	(0.00)						
= 1 if partner is Government				-27.34		(0.17)				-17.10		(0.23)
= 1 if partner is farmers				-23.85		(0.12)				-134.41	***	(0.00)
Exclusion Var. : Area other than maize	0.13	**	(0.05)				-0.21	***	(0.00)			
Inverse Mills Ratio				2.08		(0.94)				-0.21	***	(0.00)
Constant	1.00		(0.26)	124.78	***	(0.00)	1.10		(0.21)	102.81		(0.15)
N				357.00						356.00		
Rho				0.06						-0.86		
Wald-Chi2				280.63						118.42		

Note: *, **, ***, indicate that corresponding coefficients are statistically significant at the 10%, 5 %, and 1% level respectively;
1 US $ = 512 Francs CFA (F CFA) at the time of the survey; Department dummies are not shown in the table.

Appendix 2.a Robustness check: Alternative estimators used to estimate factors affecting price of sold maize (F CFA/Kg) in stated preference model

	OLS (main results, as shown in table 5)			**Tobit**			**Double Hurdle: Hurdle 1: Probit**			**Double Hurdle: Hurdle 2: Truncated Regression**		
	Coef.		P>t	Coef.		P>t	Coef.		P>t	Coef.		P>t
10 % Damage	-20.65	***	(0.00)	-20.75	***	(0.00)	-0.01		(0.24)	-19.47	***	(0.00)
20% Damage	-46.52	***	(0.00)	-46.80	***	(0.00)	-0.02	**	(0.05)	-44.98	***	(0.00)
30% Damage	-51.15	***	(0.00)	-51.51	***	(0.00)	-0.03	**	(0.02)	-48.78	***	(0.00)
50% Damage	-78.46	***	(0.00)	-79.58	***	(0.00)	-0.05	***	(0.00)	-71.52	***	(0.00)
=1 if Household attended School	3.69		(0.44)	3.42		(0.48)	-0.03	*	(0.06)	8.58	**	(0.03)
Age	1.74		(0.12)	1.78		(0.12)	0.00		(0.79)	1.72	**	(0.04)
age square	-0.02		(0.13)	-0.02		(0.14)	0.00		(0.74)	-0.02	*	(0.06)
= 1 if HH head is female	-6.64		(0.46)	-6.97		(0.45)	-0.03		(0.17)	0.74		(0.91)
Household size	-1.24	**	(0.03)	-1.32	**	(0.04)	0.00	**	(0.04)	-0.80	**	(0.04)
Income(X 10,000 F CFA)	0.01		(0.15)	0.01		(0.15)	3E-06		(0.85)	0.01	*	(0.08)
Saving (x 10,000 F CFA)	0.09		(0.17)	0.09		(0.16)	4E-04		(0.22)	0.05		(0.37)
Quantity purchased	-5E-04		(0.46)	-4E-04		(0.56)	1E-05	*	(0.07)	-9E-04		(0.12)
Ratio sale/production	-5.64		(0.23)	-6.09		(0.22)	-0.03		(0.15)	-3.86		(0.30)
Ratio purchase/production	1.25	*	(0.07)	1.25	*	(0.07)	6E-04		(0.86)	1.25	**	(0.05)
Distance from Market (Km)	1.18	*	(0.06)	1.20	*	(0.06)	9E-04		(0.69)	1.12	**	(0.05)
Constant	163.06	***	(0.00)	162.62	***	(0.00)						
N	1,756			1756			1756			1698		
R2 or Pseudo R2	0.45			0.05			0.17			1042.5[a]		

Note: *, **, ***, indicate that corresponding coefficients are statistically significant at the 10%, 5 %, and 1% level respectively; (a) indicates the value for Wald Chi2. 1 US $ = 512 Francs CFA (F CFA) at the time of the survey; Department dummies are not shown in the table.

Appendix 2.b Robustness check: Alternative estimators used to estimate factors affecting price of purchased maize (F CFA/Kg) in stated preference model

	OLS (main results, as shown in table 7)			Tobit			Double Hurdle: Hurdle 1: Probit			Double Hurdle: Hurdle 2: Truncated Regression		
	Coef.		P>t	Coef.		P>t	Coef.		P>t	Coef.		P>t
10 % Damage	-23.02	***	(0.00)	-23.50	***	(0.00)	-0.04	***	(0.02)	-21.27	***	(0.00)
20% Damage	-51.70	***	(0.00)	-53.47	***	(0.00)	-0.10	***	(0.00)	-47.78	***	(0.00)
30% Damage	-58.61	***	(0.00)	-60.46	***	(0.00)	-0.10	***	(0.00)	-54.15	***	(0.00)
50% Damage	-90.59	***	(0.00)	-94.76	***	(0.00)	-0.15	***	(0.00)	-83.71	***	(0.00)
=1 if Household attended School	4.37		(0.46)	5.01		(0.44)	0.02		(0.52)	4.04		(0.46)
Age	1.79		(0.14)	2.02		(0.12)	0.01		(0.14)	1.65		(0.13)
age square	-0.02		(0.19)	-0.02		(0.17)	-6E-05		(0.21)	-0.01		(0.18)
= 1 if HH head is female	-7.58		(0.43)	-7.60		(0.45)	-4E-03		(0.92)	-7.00		(0.42)
Household size	-1.12	**	(0.03)	-1.21	**	(0.03)	-3E-03		(0.27)	-1.03	**	(0.02)
Income(X 10,000 F CFA)	0.02	**	(0.02)	0.02	**	(0.02)	-2E-06		(0.94)	0.02	**	(0.02)
Saving (x 10,000 F CFA)	-0.03		(0.69)	-0.04		(0.69)	-2E-05		(0.96)	-0.03		(0.69)
Quantity purchased	0.01		(0.65)	0.01		(0.56)	2E-04		(0.19)	0.01		(0.65)
Ratio sale/production	-7.95		(0.16)	-7.62		(0.21)	0.02		(0.61)	-7.34		(0.16)
Ratio purchase/production	-1.11		(0.24)	-1.79	*	(0.10)	-0.01	***	(0.00)	-1.03		(0.24)
Distance from Market (Km)	0.42		(0.59)	0.35		(0.67)	-2E-03		(0.36)	0.39		(0.59)
Constant	152.17		(0.00)	147.64		(0.00)						
N	1,756			1756			1756			1756		
R2 or Pseudo R2	0.39			0.04			0.12			651.05[a]		

Note: *, **, ***, indicate that corresponding coefficients are statistically significant at the 10%, 5 %, and 1% level respectively; (a) indicates the value for Wald Chi2. 1 US $ = 512 Francs CFA (F CFA) at the time of the survey; Department dummies are not shown in the table.