Farmer Preferences on Seed Purchase Timing: Some Evidence From Nigeria

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Abstract: Timely availability of seeds, typically immediately before the planting season, is considered one of the important factors for rapid adoption of quality seeds of improved varieties in Sub-Sahara African (SSA) countries. Empirical information on whether farmers are willing to pay (WTP) premium for obtaining seeds at their desired timing, can help in assessing the feasibility of public sector support for timely delivery of quality seeds of improved varieties. This study estimates how farmers' WTP for seed varies depending on the timing of the purchase using both revealed preference (RP) and stated preference (SP) models. The results indicate that WTP varies with the timing. Low-income farmers in Nigeria may prefer to pay premium price for cowpea seeds if those seeds can be made available closer to the planting season, while most high income farmers may pay the same price regardless of the timing. Implications for future research needs are discussed.

Keywords: willingness to pay, revealed preference, stated preference, cowpea, maize, rice

1. Introduction

Timely availability of inputs highly determines the agricultural productivity in rural Sub-Saharan Africa (SSA) where production relies heavily on rainfall and traditional technologies. Demand for seeds may be high particularly at planting time. Farmers tend to wait until planting time to select seeds from their own stock (Wright et al., 1994; Lewis and Mulvany, 1997; Rice et al., 1998) or to decide whether to buy seed from off-farm sources (Griffiths, 1994). If the market does exist, seeds are bought at higher price around the planting time than other times (Tripp and Rohrbach, 2001). Market, however, often does not exist for such timely supply of quality seeds of improved varieties in much of rural SSA. Private sector regards it generally unprofitable to deliver seeds in most rural areas even at planting time, whereas public sector seldom has sufficient capacity.

Such missing market for timely availability partly limits the use of quality seeds of improved varieties in countries like Nigeria (Akulumuka et al., 2001; Okoko et al., 2008). Quality seeds of improved varieties in Nigeria are distributed by both private companies and public institutions (state government, Agricultural Development Projects, farmer service centers, or cooperatives). Due mainly to insufficient financial capacity, the institutions responsible for timely delivery of agricultural inputs in Nigeria are ineffective (Manyong et al., 2003). Quality seeds of improved varieties are often made available to farmers too early[1] or too late (Longtau, 2003; Saka et al., 2005; Omonona, 2006; Odoemenem and Obinne, 2010).

Farmers' WTP for seeds may generally rise near the planting time because of the risk of seed loss during storage. Seed purchased ahead of planting time may be lost during storage because of farmers' lack of resources for appropriate storage (Scott et al., 2003; Rohrbach and

[1] Personal communication with National Agricultural Seeds Council of Nigeria.

Kiala, 2007; Wambugu et al., 2009) or their vulnerability to theft and civil conflict (Longley et al., 2001).

Such rise in WTP may be particularly common for lower income farmers because they face various additional constraints not relevant for wealthier farmers. While wealthier farmers often have surplus grain in storage, usable as seed at planting time (Almekinders and Louwaars, 2002), low-income households tend to lack such surplus and often rely on any seeds accessible at planting time (Almekinders, 2001). Wealthier farmers may be able to exploit a rise in seed prices at planting time by purchasing seeds in advance at lower prices, and then reselling some of these at planting time for a higher price. Low-income farmers, however, may find such opportunities impractical, either because it is too difficult for them to acquire surplus seed stocks for resale purpose, or because they may face higher transaction costs because of their poor access to market information. Furthermore, liquidity constraints may be common for low-income farmers and can affect their WTP depending on their need to purchase other goods besides seeds (for example, fertilizer) and uncertainties associated with such needs.

Rise in WTP may also be more common for Nigeria's major staple crops like cowpea, which is subject to risks of loss during storage through pests (Taiwo, 1998; de Boef and Bishaw, 2008). Materials like airtight containers and agrochemicals required for storing cowpea seed (Dugje et al., 2009) are often inaccessible to farmers, and significant loss is often unpreventable even with agrochemicals. Other major staple crops in Nigeria like rice or maize, on the other hand, may be less susceptible to risk of such storage loss. Maize seeds in Nigeria, in particular, are effectively preserved during storage by the use of fumigation (Olakojo and Akinlosotu, 2004; Adejumo and Raji, 2007). Demand for timely availability of seed may thus vary across farmers with different income levels and crops.

This study analyzes how Nigerian farmers' willingness to pay (WTP) for cowpea, rice and maize seeds varies with the purchase timing (number of months before the planting date). Timing of availability is considered one of the attributes of each seed, from which farmers derive utility. We apply both revealed preference (RP) hedonic price model and stated preference (SP) choice experiment model for the estimation of WTP. Both models are appropriate for assessing WTP for the attributes of commodities, for which no direct market exists. Market is simply absent for seed at certain times (for which SP choice experiment model is used) or, while seed market exists, timing is not directly priced (where RP hedonic price model is used). Using the two models adds robustness to the estimated results and their implications. The RP hedonic price model reflects various time and budget constraints, which can be significantly binding for SSA farmers but may not be captured in SP choice experiment. The SP choice experiment model, however, informs farmers' WTP for different timeliness, most of which are difficult to observe. The results weakly support the hypothesis that lower income farmers are willing to pay higher prices for receiving seeds, particularly for cowpea, closer to the planting time. The study is innovative as it treats the timing as an additional attribute of seed, and assesses farmers WTP for it using both RP and SP framework.

2. Hypotheses

The premium in WTP for having access to seeds closer to planting time (denoted by ε) is defined in this study as the percentage change in WTP between any one month period leading up to planting time and is empirically estimated in this research. The study captures the magnitude of ε as well as its variation across crops (maize, cowpea, and rice) and farm households' income levels. Solving the utility maximization problem of an agricultural household, ε may be explained as how 1) seed loss during storage is mitigated, 2) how high-profit farmers earn from reselling at planting time, and 3) the perception of risk of not having seeds relative to the risk of not having other goods, such as fertilizer at planting time (see Appendix for details). These three factors are expected to be closely associated with farmers' income levels and type of crops. Low-income farmers often face greater losses in seed stock because of their lack of capacity to mitigate such losses, particularly in the case of cowpea. The potential net profit from the resale of seeds for low-income farmers, with little surplus at their disposal, may be small because the chances of realizing profits through resale are minimal. Lastly, farmers often regard the risk of not obtaining seed as relatively low, compared with the risk of not obtaining other goods before planting time, as they tend to have easy access to traditional seeds as a backup (either their own stock or traditional seeds obtained from neighboring farmers), whereas obtaining agricultural inputs like fertilizer or incurring other incidental expenses between time periods is more difficult. This is expected to increase relative risk, σ, and decrease WTP for seed significantly before planting time. For low-income farmers, the effect of such uncertainty may be even greater because they are more likely to face higher liquidity constraints significantly before planting time.

Consistent with the utility maximization behavior of the farming households and their seed purchase preferences, the following propositions will be tested empirically:

Proposition 1: Low-income farmers exhibit greater ε either because of liquidity constraints at t = 0, or , relative to their high-income counterparts, they are subject to a greater risk of seed damage during storage and a lower prospect for reselling seeds at higher prices.

Proposition 2: ε is generally larger for cowpea than for maize and rice, because cowpea is more susceptible to damage during storage than maize and rice.

3. Estimation Methodology

Borrowing consumer theory of Lancaster (1966), the price is the sum of economic values for all attributes of seeds, including the value of its timely availability. Measuring WTP for timely availability in such a framework includes the application of revealed preference (RP) and stated preference (SP) models. Although the two models are substantially different in their approaches, they both lead to an estimate of the relationship between farmers' WTP for certain seeds and the timing of their availability. Both the RP hedonic price model and SP choice experiment model have their advantages and disadvantages; the SP choice experiment model is free from such problems. This study thus employs both the RP and SP models to obtain a robust estimate of farmers' WTP for seed.

3.1 Revealed preference Hedonic Price Model

In deriving the RP hedonic price model, we assume that the price paid by a farmer i for variety ℓ ($w_{i\ell}$) is the sum of the values the farmer places on each attribute of ℓ. By dropping the notation i for simplicity, we get

$$\ln(w_\ell) = \alpha_\ell + \alpha_\psi \cdot \psi_\ell + \alpha_{\psi,income} \cdot [\psi_\ell \cdot \ln(\text{income})] + \alpha_{\psi,income,crop} \cdot [\psi_\ell \cdot \ln(\text{income}) \cdot \text{crop}_\ell] + \alpha_\mu \cdot \mu_\ell + \alpha_z \cdot z_u \tag{1}$$

where $\psi_{i\ell}$ is how many months before planting the farmer i bought seeds for ℓ (months to planting date, or MPD hereafter), μ are the variables of attributes for variety ℓ perceived by farmer i, and α's are estimated coefficients.

With respect to the attributes, yield, maturity length, palatability, and size of grain are included based on findings from previous studies (Horna et al., 2007; Mishili et al., 2009). In addition, we generate dummy variables for certain varieties that are popularly grown, in order to partly control for the differences in WTP associated to specific varieties. These varieties are presented in the data section below. The attributes also include the dummy variables of the channels of seed acquisitions, namely “other farmers”, “government” and “private companies” while the default is “local seed market”. These variables control for the premiums WTP farmers may attach to certain channels because of their trusts in seed qualities from those channels.

Equation (1) is estimated using the least square (LS) method[2]. The premium ε for farmer i for each crop ($\varepsilon_{i,crop}$) in WTP for buying seeds one month closer to planting date is calculated as:

$$\varepsilon_{i,crop} = \alpha_{\psi} + \alpha_{\psi,income} \cdot \ln(\text{income}_j) + \alpha_{\psi,income,crop}(\ln(\text{income}_j) \cdot \text{crop}_{ij}) \qquad (2)$$

[2] In theory, the hedonic price model consists of two steps (Rosen 1974). The first step requires estimating the economic values of attributes, which are called implicit prices of such attributes. Without further restricting assumptions, the second stage of the analysis requires information about implicit prices and the data pertaining to those attributes, and are combined with the results of the first step to identify the inverse demand function (Tyrväinen 1997). In practice, however, the strict requirements of the data and the econometric problems connected to the second step, most of the empirical studies have used only the first-step hedonic regression model, and despite the loss in accuracy these estimates are presumed adequate (Tyrväinen 1997). In addition, while various specifications have been suggested for the first-step hedonic regression model (Halvorsen and Pollakowski 1981; Dalton 2004), many studies continue to use simpler estimation techniques, such as ordinary least squares (OLS) or two-stage least square (2SLS). With the assumption that the market is in a short-run competitive equilibrium and the hedonic price function is the locus of the points connecting buyers' bids and sellers' offer curves, the specification in which observed price is regressed on various attributes provides the correct WTP for seeds with given attributes (Chattopadhyay et al. 2005).

By applying LS methods (1), farmers are assumed to pay the price up to their WTP, because seed sellers (whether they are dealers, public institutions, or other farmers) may be in a better bargaining position than farmers, implying the need to negotiate the price down so that when farmers buy, they are buying at the highest price they can afford, which is their WTP. The estimate employs both ordinary least squares (OLS) and two-stage least square (2SLS). The 2SLS method is used to correct for potential endogeneity, such as the possibilities that the timing of seed purchases ψ_ℓ is affected by the price w_ℓ, or some unobserved factors, e.g., the weather affects both the price w_ℓ and planting time, which is embedded in ψ_ℓ.

3.2 Stated preference–Choice Experiment Model

In the SP choice experiment model, each respondent is asked to imagine a hypothetical situation in which he or she buys the same variety seeds that has similar attributes to what they have been growing, and is presented with five different pairs of hypothetical options. For each pair, the respondent answers which option he or she prefers. Each option consists of the attributes of the seeds, the timing at which the seeds can be bought, and the price of the seeds (Table 1). The attribute of each option is defined by modifying the yield, growth length, and the prices of the varieties currently grown by the respondent. Similar approaches for using current conditions by the respondent as a benchmark have been used in several studies (Chattopadhyay et al., 2005; Patunru et al., 2007). Each farmer is asked to compare up to five pairs of options randomly picked from Table 2, and state their preferred options[3]. The 24 options in Table 2 are

[3] This study did not include the status quo option as it was not clear whether enough variations in responses could be obtained if the status quo option was used. The estimate in this paper therefore omits the alternative specific constants (ASC) from the specification, as choice sets presented to interviewees are purely random and no fixed effects are expected. Some studies exclude the ASC in such cases (Meyerhoff et al. 2009). The inclusion of ASC may also trivialize the impact of varying levels of the attributes on respondents' choices (Bennett and Blamey 2001, p55). In addition, it is not feasible to ask interviewees to choose among 24 options. Thus, the number of options is reduced to five. While many studies block all choice sets to a few groups, and ask the same set of options

orthogonal choices selected out of the 96 possible choices (= 2 x 2 x 2 x 3 x 4) using the fractional factorial design[4].

The conditional logit model is then used to estimate the WTP from the choice experiment data. Farmer *i* with characteristics z_u is presented with a pair of choices, for *J* times with different combinations of choices each time. Given the random utility theory, assuming that the utility of farmer *i* from choosing λ-th choice (λ = 1 or 2) from *j*-th pair of choices is (notation *i* is included for clarity):

$$U_{ij\lambda} = \beta_{\psi}\cdot\psi_{j\lambda} + \beta_{\psi,income}\cdot(\psi_{j\lambda}\cdot\ln(\text{income}_i)) + \beta_{\hat{w}}\cdot\ln(\hat{w}_{j\lambda}) + \beta_{\mu}\cdot\mu_{j\lambda} + \gamma_{\lambda}\cdot z_{u,i} + \eta_{j\lambda} \quad (3)$$

where $\psi_{j\lambda}$, $\hat{w}_{j\lambda}$, and $\mu_{j\lambda}$ are MPD, price, and other attributes of choice $j\lambda$, respectively, while $\eta_{j\lambda}$ is the idiosyncratic errors, and β's and γ are the estimated coefficients. Importantly, $\hat{w}_{j\lambda}$ is different from WTP (w), which is calculated as the function of $\beta_{\hat{w}}$. It is then assumed that $\eta_{j\lambda}$ follows type I extreme value distribution, meaning that its distribution function $F(\eta_{j\lambda}) = \exp[-\exp(-\eta_{j\lambda})]$. Then, the probability that farmer *i* chooses λ-th choice from *j*-th pairs of choices is expressed in conditional logit form $\exp(A_\lambda) / [\exp(A_1) + \exp(A_2)]$, in which $A_\lambda = \beta_{\psi}\cdot\psi_{j\lambda} + \beta_{\psi,income}\cdot(\psi_{j\lambda}\cdot\ln(\text{income}_i)) + \beta_{\hat{w}}\cdot\ln(\hat{w}_{j\lambda}) + \beta_{\mu}\cdot\mu_{j\lambda} + \gamma_{\lambda}\cdot z_{u,i}$.

The variables $z_{u,i}$ common across all *j* interact with dummy variables for each choice (d_λ), as suggested in Greene (2003). The coefficient γ_λ measures the effect of farmers' characteristics on their choices of certain varieties. The utility for different choice λ is affected by household characteristics ($z_{u,i}$) in different ways (through γ_λ). Although γ_λ is not the main interest, its inclusion leads to consistent estimates of β's.

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to interviewees who are assigned to the same block, this study randomly selects five options from 24 options for each interviewee. This approach is still acceptable (Bennett and Blamey 2001, p18).

[4] We use *oa.design* command in statistical software R version 2.8.0, which is an open-source software developed by the R Development Core Team.

The premium ε, which is the proportion of additional WTP for receiving seed one month closer to the actual price paid, can be estimated in the following way. As in Hanley et al. (2006), the WTP for particular attributes is expressed in the form of implicit price ratio, which is the negative of the ratio of the marginal utility of particular attributes and the marginal utility of price. In our case, the marginal utility from receiving seed one month closer to the planting time is obtained from (3) as $-[(\beta_{\psi} + \beta_{\psi,income} \ln(\text{income}_i)]$,[5] while the marginal utility of price is $\beta_{\hat{w}} / \hat{w}_{j\lambda}$. Therefore the premium ε in the SP framework as counterpart of (2) is:

$$\begin{aligned} \varepsilon_i &= -\{-[\beta_{\psi} + \beta_{\psi,income} \ln(\text{income}_i)] / (\beta_{\hat{w}} / \hat{w}_{j\lambda})\} / \hat{w}_{j\lambda} \\ &= [\beta_{\psi} + \beta_{\psi,income} \ln(\text{income}_i)]*\hat{w}_{j\lambda} / \beta_{\hat{w}} \end{aligned} \tag{4}$$

4. Data

This study uses the dataset from International Food Policy Research Institute (IFPRI) (2010) on rice, cowpea, and maize growers in Kano, Kaduna, and Ebonyi states in Nigeria. The three states are selected for their comparative advantages in each crop (Kano for cowpea, Kaduna for maize, and Ebonyi for rice), and because they represent different agroclimatic zones (Kano for dry savannah, Kaduna for moist savannah, and Ebonyi for humid forest). The data are collected from a total of 420 farmers who either grow rice, maize, cowpea, or some combination of the three. The study team collected data from 120 farmers in Ebonyi and 150 farmers in each of Kaduna and Kano state. These three states were selected because of their dominance in production of these crops in Nigeria (Kano for cowpea production, Kaduna for maize production, and Ebonyi for rice production, although all three crops are grown in all three states), and differences in their agro-ecological conditions (Kano is mostly dry-savannah, Kaduna is mostly

[5] Since our interest is the premium WTP for receiving seed one month closer, no earlier, to the planting time, there is negative sign in front of the expression.

moist-savannah, while Ebonyi is humid-tropic). The data were not collected through strict random sampling procedures and thus the interpretation of the results is only applicable to farmers with the characteristics described in the study. The local government areas (LGAs) were selected in consultation with the Agricultural Development Project (ADP) offices in each of the three states, which are in charge of state level agricultural extension activities in Nigeria, with the objective of covering diverse geographical zones, from which farmers were randomly selected.

The general household characteristics of surveyed farmers are summarized in Table 3, which shows the median and standard deviation of values of various categories across states. At the median of the sample, farmers are generally low income with an annual income of US$2000, a farm size of 3.5 ha, and household head who has seven years of formal or Koranic education. Most households are headed by males, although about 20 percent are headed by females from Ebonyi state. Median income farmers have the storage space of 6 tons of grain, are located 5 km away from the nearest food market, and 2 km away from the nearest all-weather road.

The information on ownership and values of assets was also collected, mainly to explain the timing of seed purchases, and was used as external instrumental variables for the months-to-planting date (MPD) in the 2SLS estimation. Regarding the transportation assets, most of the farmers in the sample owned a bicycle or motorcycle, while only 20 percent of them owned a car or a truck. Regarding the information assets, the majority of farmers in the sample owned a radio and mobile phones[6], while about half of them owned TVs. The ownership and values of transportation and information assets indicate that most farmers had basic means for collecting seed-related information and transporting seeds from the nearby market in small quantities, but

[6] Almost no farmer in the sample owned a landline phone.

their capacities may have been limited for collecting complete information on seeds and obtaining seeds when they are the cheapest.

Data also indicate farmers may experience higher risk of losing cowpea seed during storage, relative to rice and maize (Table 4). First, statistically significantly higher percentage of farmers (40%) lost some cowpea seed during the storage compared with maize seed (15%). Second, although much more farmers (55%) used chemicals to preserve cowpea seed than rice seed (19%), they are still as likely to lose some cowpea seeds as rice seeds (37%). These indicate that farmers may be more concerned about the risk of losing cowpea seed during storage, compared with rice and maize.

The data consist of one or more varieties of seeds purchased by each of interviewed farmers. From them, we selected all the rice and cowpea varieties, as well as open-pollinated varieties (OPV) of maize. We dropped any hybrid maize varieties since their seed systems are quite different from OPV maize. Nationally, most maize in Nigeria is still OPV (Alene et al. 2009), and this was also the case in our sample. Various varieties of seeds were found to be purchased by sampled farmers. Popularly grown varieties and their shares among the samples are the following; Rice (FARO 44 – 27%, FARO 52 – 13%, FARO 51 – 5%, NERICA – 6%); Maize (ACR – 14%, QPM – 6%); Cowpea (ITA 277 – 19%, Dan Bunkure – 13%, Dan Kaka – 8%). FARO varieties have been developed by either National Agricultural Research Institutes in other countries, Nigeria, or international agricultural research institutes like Consultative Group on International Agricultural Research (CGIAR) and released in Nigeria (Takeshima 2014). New Rice for Africa (NERICA) has been developed by Africa Rice Center, one of CGIAR institutes. ACR maize varieties are lines of varieties developed by institutions like IITA (another CGIAR institute) for various purposes including striga resistance (Kang 1995). Quality protein maize

(QPM) is a class of maize varieties that have been developed by CIMMYT (another CGIAR institute) and released for high lysine and tryptophan contained in proteins (Akande & Lamidi 2006). ITA 277 has been developed by IITA, while Dan Bunkure and Dan Kaka are traditional varieties that have been informally identified by farmers. As was discussed in the empirical methodology section above, we assign dummy variables to each of these varieties. We limit the assignment to these varieties only, as other varieties are all individually minor in the data (although, together they still constitute the majority) and assigning dummy variables to each of them can lead to efficiency loss in estimates.

Most seeds in the sample are likely to be non-certified. The assumption is not based on the information from farmers since often farmers themselves do not know it, but rather based on the rarity of certified seeds at the national level. Based on Bentley et al. (2011), between 2005-09, 2382 tons of OPV maize seeds had been certified per year in Nigeria. During the same period, about 96,000 tons of maize had been recycled as seeds per year (FAO 2014). Most maize in Nigeria is still OPV. Therefore, certified maize seed accounted for about only 2-3%. Similarly, certified rice seeds and cowpea seeds account for only 3% and 0.3%, respectively, of total seed uses (Bentley et al. 2011; FAO 2014). Even the seeds provided by the government are not guaranteed certified, if government officials embezzle them and replace them with non-certified seeds for distribution, because of weak regulatory enforcement capacity of the country (in Nigeria, similar leakage problem was believed common for subsidized fertilizer (Liverpool-Tasie & Takeshima 2013; Takeshima & Nkonya 2014)). Presumed dominance of non-certified seeds in the sample reduces the potential bias in estimates that are due to the certification related heterogeneity. We discuss the implications of the violations of this assumptions in section 5.3.

The data on seed purchase behaviors reveal interesting trends.[7] The majority of farmers in the sample purchased seeds within three months of the planting date for all three crops (Figure 1), although purchasing seeds within one month before planting is more common for cowpeas than maize and rice. Prices paid by farmers seem to relate to the months to planting. The price of cowpea seeds exhibits the most negative relationship, and to a lesser extent for rice seeds, while it is ambiguous for maize (Figure 1). Farmers' seed-purchase behaviors illustrated in Figure 1 roughly indicates that farmers' WTP may vary depending on the timing and crop.

5. Results and Interpretation

5.1 Determinants of the months-to-planting date

Although the main focus of the study is the WTP, the determinants of the timing of seed purchase are also estimated. The determinants of MPD were estimated by two-sided Tobit with truncation at 0 and 12 months (Table 5). The results indicate that farmers with less storage space tend to buy seeds later (smaller MPD), possibly because they have to store seeds outside the storage facility where seeds are more vulnerable to various damages. Rice farmers are also found to buy seeds earlier than maize and cowpea farmers, possibly because of the relative ease of storing rice. High-yielding varieties of each crop are bought earlier, possibly because the expected profit can compensate for the cost of the potential loss during storage. Farmers in Ebonyi and Kaduna state typically buy seeds much ahead of planting time than in Kano. This is possible because rainfalls are higher and rainy seasons are longer in these states than in Kano

[7] This study covers a large number of varieties, and it is possible that the frequency or the prices of seed purchases vary because different varieties are bought at different times. While we partly address the differences across varieties by aforementioned dummy variables, fully controlling for them is challenging, which is discussed in section 5.3.

state, and onset of the rainy season (which is typically the planting season) may be more uncertain. Some seeds of formal varieties (such as ACR maize variety and ITA 277 cowpea variety) seem to be bought earlier as well, reflecting some inherent variations in purchase timing across varieties. The MPD seems to be affected by relatively few household characteristics, indicating that the timing of seed purchase may be relatively fixed and determined by the availability of seed sellers once regions, and varieties are controlled for.

5.2 Results from revealed preference and stated preference models

Table 6 contains the results of the RP model (1) under various specifications. The OLS specification is based on the most restrictive assumption that the WTP equals the prices paid and that the timing of the purchase is exogenous to the price. The estimated coefficients on MPD indicate the percentage premium a farmer is willing to pay for receiving seeds one month closer to the planting date (in our specification, this applies to any two points in time that are one month apart (Figure 2)). In the first specification under the OLS, the month to planting has a negative effect on the price with the coefficient estimated at -0.028, although it is statistically insignificant. If it is statistically significant, the price paid would increase by 2.8 percent if the seeds are purchased one month closer to the planting date.

The other models, however, indicate that the effects of timing can be significant for some crops and they can also vary across farmers' income levels. The strongest link between timing and WTP may be observed for cowpea. The results also indicate that low-income farmers exhibit a higher WTP for cowpea seeds closer to the planting date, while the opposite holds for high-income farmers, with more than 95 percent statistical significance for most income ranges (Figure 3). More specifically, the lowest income farmer in the data exhibits a 40 percent higher WTP for cowpea seeds one month closer to the planting date, whereas the highest income farmer exhibits a 30 percent lower WTP. WTP is also higher for some of the formally released seeds such as hybrid maize and QPM, and lower for traditional cowpea varieties, indicating that the model controls for some of the variations in variety specific WTP. While the endogeneity of purchase timing is suspected, the 2SLS results are qualitatively similar to the OLS, indicating that the main implications of the OLS results are valid.

Contrary to cowpea, timing and WTP is insignificant for rice and maize. This may be because seed market for maize is slightly more developed and more efficient regardless of timing because it is open-pollinated and requires more frequent seed purchase by farmers, while for rice which is self-pollinating, options of saving and recycling seeds may largely obviate the needs to purchase seeds when prices are high. However, while cowpea is self-pollinating as well, cowpea seeds may face greater risk of storage loss as discussed above, and may induce farmers to buy seeds closer to the planting date. While future studies need to test these more formally using different datasets, the results here provide interesting insights that the WTP for timing may vary across crops.

While the inclusions and interactions of crop dummy variables partly control for the potential differences in WTP and the effects of timing across crops, it is possible that the mechanisms of WTP formation for cowpea and rice may be quite different from maize. We therefore also ran another model excluding maize seed. Results are shown in Table 6 as well. Results are qualitatively similar to the full model with all crops combined, indicating that OPV maize seeds are traded in the market in similar ways as cowpea and rice seeds, and sometimes recycled by farmers, due to the dominance of informal seed sector in countries like Nigeria.

The results from the SP choice experiment model are similar to those of the RP hedonic price model, but different in some respects (Table 7). The results indicate that the preference for the timing may vary for households at different income levels, which is similar to the RP model. Results in the second column, however, indicates that this timing effect is significant for all crops. For maize which is the base crop, this is indicated by statistically significant coefficients on MPD. Statistically significant effects on the term MPD × rice indicate even stronger preferences for timing for rice seeds, even though seed saving and recycling is often an option for rice. This may be because the SP model can pick up farmers' WTP for next time the farmer plans to purchase seeds again, after recycling for several years. Since MPD is statistically significant, we do not try specifications where MPD interacted with income level is further interacted with crop dummies, as was done in RP model. Figure 4 illustrates the WTP expressed as premium (percent) in proportion to the current price. For comparison with Figure 3, we use the results for cowpea in Figure 4. As is seen in Figure 4, low-income farmers may be willing to pay almost a 30 percent higher price on average albeit lower estimation accuracy.

No dummy variables for the channels are significant in either RP or SP models, indicating that farmers do not attach preferences to particular channels. These are consistent with aforementioned assumptions that even seeds from the formal channels (government and private companies) may have questionable qualities in Nigeria due to the weak regulatory capacity.

Overall, the SP model suggests a clearer increase in WTP for low-income farmers not only for cowpea but also for rice and maize, but with larger confidence interval than the RP model. A clearer increase in WTP in the SP model may be partly because the RP model takes into account the market constraints that farmers may actually face, whereas the SP model does not. The more noise in the estimated premium in WTP by the SP model may be because the formula for WTP in the SP model includes a division by additional estimated coefficients $\beta_{\hat{w}}$ as in (4), while the formula for the RP model in (2) does not. Each of the RP and SP models, however, has its advantage, as discussed earlier. Both models suggest variations in WTP depending on MPD and income, indicating the robustness of such results. Altogether, the results from the RP and SP models roughly support proposition 1 and, to a lesser extent, proposition 2.

5.3 Limitations of the study and future research needs

The results suggest various important issues for future research. First, while time-varying WTP is suggested by the results, more studies are required to identify the causes described in the conceptual framework, including liquidity constraints and seed storage skills, which are approximated by the household's income level in this study. Future studies examining the impacts of these two factors on the premium can make the findings of this study more robust. From the perspective of policy on the seed sector, relaxing those constraints may be as important as supporting the timely delivery of seeds.

Second, it is difficult to assess whether the estimated WTP is high or low at this point, for various reasons. For example, the information is scarce in Nigeria and many other African countries on the responsiveness of seed supply to higher prices (such as price elasticity of seed supply). In addition, the estimate of such responsiveness is also complicated because the seed supply chain consists of diverse actors (private companies, farmers, seed producers, distributors), basic marketing infrastructures (urban center and rural areas), with different short-term adjustment capacities. The failure to incorporate such complicated structures leads to an incorrect estimate of the aggregate responsiveness of seed supply to higher price by the entire seed sector, thereby leading to inappropriate policy suggestions for public support for each actor in the seed sector.

Third, we have so far not fully incorporated the varietal diversity and quality variations in of the seeds in the model. While we partly differentiate the WTP across popular varieties by including their dummy variables, it is based on the assumption that farmers correctly identify and distinguish different varieties. However, in rural setting in low income countries like Nigeria, such assumption may be violated if some varieties which were formally released in one location spread informally to other locations under local varietal names instead of official varietal names. In addition, while most seeds in the sample are assumed non-certified based on the national statistics and results are partly consistent with the assumption, it is challenging to formally test this assumption. If these types of heterogeneity is not controlled and is correlated with the explanatory variables or the way the WTP is affected by the timing of seed purchase, estimated coefficients can be biased and our interpretations of the relationship between WTP and timing can be incorrect. Again, these aspects must be investigated in future studies.

There are various limitations to the results obtained in this study. First, the sample of farmers is not representative of the country and the generalization of the results is limited. There are also potential sampling biases, which could lead to an overestimation or underestimation of the premium WTP. Secondly, the obtained results are applicable only for specific cases in which the farmer buys the same varieties he or she has been growing. The results do not consider the case in which farmers who have been using traditional varieties switch to improved varieties or to different varieties. Thirdly, the WTP is assumed the same for all varieties within the same crop except those for which we inserted dummy variables, and do not fully distinguish the difference in seed systems across crops, open-pollinated, or self-pollinated, or other attributes (they are used as shifters but not interacted with WTP).

6. Conclusion

Seed demand in Africa has complicated factors, which often leads to slow adoptions of improved varieties by farmers. Among the many factors, various empirical studies point out that farmers do not use quality seeds of improved varieties partly because these seeds are often not available at planting time, indicating the possibility that adoption of these seeds may increase significantly if they are available at planting time. The empirical evidence has been scarce with respect to whether and how much more farmers are willing to pay to obtain seeds at the right time.

This study attempts to narrow such knowledge gaps by assessing how farmers' WTP for seed changes across time, particularly toward the planting time, by applying both RP and SP models. The results indicate that the Nigerian farmers surveyed exhibit different WTP at different times. Most importantly, the results of the RP model indicate that low-income farmers may have significantly higher WTP for seeds closer to the planting season for certain crops like cowpea, while such effects are not significant for high-income farmers and crops like rice and maize. The findings from the RP model are consistent with the hypotheses that farmers' WTP for seed at different times is highly influenced by the susceptibility of seeds to damage during storage and challenges typically faced by low-income farmers such as the high risk of seed stock loss, few seed sales opportunities, and liquidity constraints, which discourage paying for seeds ahead of planting time. The results from the SP model also generally point to a similar tendency by low-income farmers.

Future research should address some of the limitation of the current study. First, the analysis may need to be conducted with a larger nationally representative sample, which will provide adequate information about the varieties available at various times in the market, but are not actually purchased by the farmers. This will help improve the robustness of the findings by allowing for testing diverse alternative hypotheses. Second, more empirical studies may also be useful in identifying more clearly the causes of higher WTP at planting time, and whether low-income farmers are more constrained by their lack of good seed storage facilities or limited seed resale opportunities at planting time. Finally, future empirical studies should also incorporate the diversity of varieties and quality of seeds into the analyses to allow more robust assessment of the impact of timing on farmers' WTP for seeds.

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Appendix: Detailed conceptual frameworks

Seed purchase behavior around the planting season among agricultural households is expressed as a utility maximization problem in a two-period model[8]. The two time periods considered are months $t = \{\tau, T\}$, in which τ is ahead of the planting date, and T is planting date. For a household, T is fixed while τ can be any point leading up to T. Conceptual framework here focuses on mapping a farm household's transactions of seeds during or before planting season and how the willingness to pay at $t = \tau$ changes as τ approaches T. In the model, a farmer purchases seed either at τ or T but not at both periods.

In this framework, K represents all the goods relevant for crop-production purposes, where $\mathrm{K} = \{k, \ell\}$. Here the goods k are produced without using seed as a direct input into the production process (such as livestock and other non-farm products), and goods ℓ are produced using seed for crop production. While the focus here is a farm household's purchases of seeds for crops ℓ, goods k are also included in the model because decisions on goods k also affect the decisions on seeds for crops ℓ. We define the farm household's behavior as follows:

$$\max_{w_{\ell t}, s_{\ell t}, \psi_{\ell t}, q_{\mathrm{K}t}, x_{\mathrm{K}t}, m_{\mathrm{K}t}, c_{\mathrm{K}t}} \sum_{t \in \{\tau, T\}} u_t \left[c_{\mathrm{K}t}(p_{\mathrm{K}t}, I_t, \Omega_t, A_{\mathrm{K}t}, F_\ell, \pi_\ell, \omega_{\ell t}, G, \sigma); z_u \right] \cdot \delta^{T-\tau} \quad (5)$$

Here, a farm household's utility at time t (u_t) is a function of the consumption of goods K at t ($c_{\mathrm{K}t}$) and other residual factors (z_u). Consumption $c_{\mathrm{K}t}$ is determined by a set of exogenous factors, which are explained below. The farm household's utility is maximized subject to a set of constraints (6) through (15).

[8] For simplicity, the presentation here, focuses on two discrete periods while maintaining the essential illustration of how WTP can vary over time given the characteristics of farmers' constraints.

$$\sum_{K} p_{Kt} m_{Kt} + I_t + \Omega_t + \sum_{\ell} \{ [-w_{\ell t} - \theta_{\ell} + \pi_{\ell}] s_{\ell t} + \omega_{\ell t} \psi_{\ell t} \} \geq 0 \quad \forall\, t \tag{6}$$

Condition (6) refers to the farm household's liquidity constraint in which the net revenue from the sales of the goods they produce (the net sales of goods K at time t (m_{Kt}) times its prices (p_{Kt})), income from other sources at time t (I_t), and non-productive liquid assets (Ω_t) must cover net seed purchase. The net seed purchase is determined by the seed price for ℓ at t ($w_{\ell t}$) and the quantity of seed purchased at t (s_t), along with the costs incurred towards seed storage (per-unit cost θ_ℓ), net profit (π_ℓ) per unit of seed bought at $t = \tau$, which realizes at $t = T$, through means like reselling it to others at T, and any income from net sales of farmer-owned seed of the same variety (its price at t ($\omega_{\ell t}$) times net sales at time t ($\psi_{\ell t}$))[9]. While it is possible for the farm household to borrow seeds instead of purchasing them (van Wijk 1996), seed sellers do not easily provide credit to buyers due to high transaction costs for monitoring repayments (van Bastelaer and Leathers 2006).

Importantly for crop ℓ, $\psi_{\ell t}$ denotes net sales as 'seed', which is different from '$m_{\ell t}$' which is comprised of net sales of the all the outputs that include grains. Subsistence farm households often sell surplus grains as seed (farmer owned) before the planting season along with grains depending on the market conditions or demand.

The non-productive liquid assets at $t = T$ (Ω_T) is a carryover of its balance in $t = \tau$ (Ω_τ) as in (7).

$$\Omega_T = \sum_{K} p_{K\tau} m_{K\tau} + I_\tau + \Omega_\tau + \sum_{\ell} [(-w_{\ell\tau} - \theta_\ell + \pi_\ell) s_{\ell\tau} + \omega_{\ell\tau} \psi_{\ell\tau}] \geq 0 \tag{7}$$

[9] The availability of farmer-saved seed plays an important role in determining how much the farmer is willing to pay for the same varieties purchased from others, and thus included here. The empirical analysis in this paper, however, does not explicitly use information on farmer-saved seed because of the following reasons. First, the information on farmers' income used in the empirical specification may partly reflect the availability of own saved seed. Second, depending on how long farmers have saved the seed, attributes may have been altered, and it is difficult to obtain information on the changed attributes.

Condition (8) states that the quantity of goods k produced at t (q_{kt}) plus the initial endowment (A_{kt}) must cover its allocation as inputs at t (x_{kt}), net sales at t (m_{kt}) and consumption (c_{kt}) at both time periods.

$$q_{kt} - x_{kt} + A_{kt} - m_{kt} - c_{kt} \geq 0 \qquad \forall\, k, t. \tag{8}$$

The initial endowment A_{k1} is simply the sum of A_{k0} and the net physical balance of goods at $t = 0$;

$$A_{kT} = q_{k\tau} - x_{k\tau} + A_{k\tau} - m_{k\tau} - c_{k\tau}, \qquad \forall\, k, t. \tag{9}$$

For crops ℓ, the physical balance and initial endowments are similar to (8) and (9), except that they are also affected by their sale as seed at t ($\psi_{\ell t}$), distinguished from their sale as grain ($m_{\ell t}$) as in (10) and (11).

$$q_{\ell t} - x_{\ell t} + A_{\ell t} - m_{\ell t} - c_{\ell t} - \psi_{\ell t} \geq 0, \qquad \forall\, \ell, t \tag{10}$$

$$A_{\ell T} = q_{\ell\tau} - x_{\ell\tau} + A_{\ell\tau} - m_{\ell\tau} - c_{\ell\tau} - \psi_{\ell\tau}, \quad \forall\, \ell, t \tag{11}$$

in which $q_{\ell 0} = 0$ for all crops ℓ grown by the farm household. The total quantity of traditional seed used as inputs in production at $t = T$ (x_ℓ*) is

$$x_\ell^* = x_{\ell\tau} + x_{\ell T} \quad \forall\, \ell. \tag{12}$$

The total quantity of purchased seed usable for production of ℓ at $t = T$ (s_ℓ*) is

$$s_\ell^* = s_{\ell T} + s_{\ell\tau} \cdot F_\ell(\theta_\ell) \quad \forall\, \ell \tag{13}$$

in which s_ℓ* is the sum of seed purchase at $\ell = T$ ($s_{\ell T}$) and the seed purchase at $t = \tau$ minus those lost during storage, depending on the per-unit cost spent for preservation, which is expressed as $s_{\ell\tau} \cdot F_\ell(\theta_\ell)$. The purchased seed available at planting date is the initial purchase quantity at $t = \tau$ times F_ℓ, which is a function of θ_ℓ (per unit cost spent for preserving seed).

The production technology G represents the relationship between inputs and outputs as

$$q_{\ell t} = G(X_t, x_\ell^*, s_\ell^*; z_q),\ q_{kt} = G(X_t; z_q), \qquad \forall\, k, \ell, t \tag{14}$$

where goods k and ℓ are produced by a vector of all inputs k other than seeds at t (X_t), x_ℓ*, s_ℓ*, and other factors that affect the total factor productivity (z_q). The non-negativity condition required for the choice variables are

$$c_{\mathrm{K}t},\ q_{\mathrm{K}t},\ x_{\mathrm{K}t},\ \mathrm{w}_{\ell t},\ s_{\ell t},\ \psi_{\ell t} \geq 0 \qquad \forall\ \mathrm{K},\ \ell. \tag{15}$$

We include in the above formulation, the farm household's perceptions as a 'relative risk' σ resulting from not having sufficient quantity of seeds during or before planting time relative to not obtaining other agricultural and consumption (non-seed) goods. The σ reflects the farm household's perceptions at time t, and affects whether the farm household prefers to cut down on seed purchases at t due to higher risks for obtaining non-seed goods. The σ could explain how the farm household's liquidity constraints may lead to a higher WTP_0 when $t = \tau$ is closer to T.

Following the utility maximization, the WTP at t ($w_{\ell t}$*) can be expressed in the following reduced forms which are the functions f of relevant exogenous factors,

$$w_{\ell t}^* = f\,(p_{\mathrm{K}t},\ I_t,\ \Omega_t,\ A_{\mathrm{K}t},\ G,\ z_u,\ F_\ell,\ \pi_\ell,\ \sigma), \tag{16}$$

and the premium ε is expressed mathematically as

$$\varepsilon = \frac{w_{\ell\tau}}{w_{\ell,\tau-1}}\,. \tag{17}$$

In (16), assuming that p_{K}, I, Ω, A_{K}, G, and z_u vary little over time, the premium ε can be roughly explained by F_ℓ, π_ℓ and σ, which are likely determined by the crops and income level of farmers.

Table 1. Choice experiment

Categories		Values
Base attributes		Varieties grown by the respondent
Modified attributes	Attributes 1 (yield)	Same, +25%
	Attributes 2 (growing length)	-25%, Same
	Timing	1. On the day of planting 2. 1 month before planting 3. 3 months before planting
	Channel	1. Other farmers 2. Government or ADP 3. Agrodealers; 4. Village chief
	Price	Same, -25%

Source: Authors.

Table 2. Orthogonal choice set from fractional factorial design

	Yield	Length	Price	Timing	Channel
1	Same	Same	Same	On the day of planting	Government or ADP
2	+25%	–25%	–25%	3 months before planting	Village chief
3	Same	Same	–25%	3 months before planting	Agrodealer
4	Same	–25%	Same	On the day of planting	Other farmers
5	+25%	Same	Same	On the day of planting	Agrodealer
6	Same	Same	Same	On the day of planting	Village chief
7	Same	–25%	Same	3 months before planting	Government or ADP
8	+25%	–25%	–25%	On the day of planting	Agrodealer
9	Same	Same	–25%	1 month before planting	Village chief
10	Same	–25%	Same	3 months before planting	Other farmers
11	+25%	Same	–25%	3 months before planting	Government or ADP
12	+25%	Same	Same	1 month before planting	Village chief
13	Same	–25%	–25%	1 month before planting	Government or ADP
14	+25%	Same	Same	1 month before planting	Other farmers
15	Same	Same	–25%	1 month before planting	Other farmers
16	Same	–25%	–25%	On the day of planting	Village chief
17	+25%	–25%	Same	3 months before planting	Village chief
18	+25%	–25%	Same	1 month before planting	Government or ADP
19	+25%	Same	–25%	On the day of planting	Government or ADP
20	+25%	–25%	Same	1 month before planting	Agrodealer
21	+25%	Same	–25%	3 months before planting	Other farmers
22	Same	–25%	–25%	1 month before planting	Agrodealer
23	+25%	–25%	–25%	On the day of planting	Other farmers
24	Same	Same	Same	3 months before planting	Agrodealer

Source: Authors.

Table 3. Descriptive statistics (median with standard deviation in parentheses)

		Total	Ebonyi	Kaduna	Kano
Household size		12 (10)	10 (5)	10 (7)	15 (12)
Income (US$/year)		2000 (11209)	2500 (4473)	2400 (12177)	1667 (14251)
Farm size (ha)		3.5 (11)	4 (3)	3 (18)	4 (8)
Household head age[a]		50 (11)	52 (11)	48 (10)	53 (14)
Household head years of education (formal)[a]		7 (5)	6 (5)	7 (5)	7 (6)
Household head years of education (koranic)[a]		7 (6)	6 (5)	7 (6)	7 (6)
% of female household head		10	18	5	5
Storage space (ton)[b]		6 (232)	9 (3)	5 (134)	3 (417)
Distance (km)					
nearest food market		5 (24)	5 (7)	4 (28)	6 (29)
nearest all-weather road		2 (31)	2 (6)	0.5 (36)	2 (38)
Asset					
Bicycle	Own (%)	69	69	70	68
	Value (US$)	40 (86)	40 (25)	47 (43)	53 (141)
Motorcycle	Own (%)	76	73	82	74
	Value (US$)	433 (318)	533 (216)	400 (260)	400 (433)
Car / truck	Own (%)	19	19	24	15
	Value (US$)	5000 (5000)	5333 (4184)	3333 (4430)	2333 (6640)
Wheel barrow	Own (%)	57	71	68	28
	Value (US$)	40 (31)	43 (28)	33 (30)	33 (42)
Radio	Own (%)	90	94	97	76
	Value (US$)	27 (46)	40 (36)	20 (57)	20 (36)
TV	Own (%)	54	55	72	35
	Value (US$)	120 (96)	160 (85)	100 (80)	67 (126)
Mobile phone	Own (%)	82	83	92	68
	Value (US$)	40 (150)	40 (49)	40 (62)	47 (281)
Cattle	Own (%)	19	15	22	21
	Value (US$)	667 (2870)	533 (187)	567 (568)	2667 (4300)
Bull	Own (%)	20	7	28	26
	Value (US$)	800 (1270)	533 (211)	800 (998)	1333 (1593)
Goat	Own (%)	72	74	71	69
	Value (US$)	140 (280)	100 (100)	121 (190)	334 (390)

[a]Some respondents only gave information of their own, and not of their household heads, which are excluded.

Table 4. Seed loss and use of chemicals by crop (numbers in parentheses are standard deviation)[ab]

	Cowpea	Rice	Maize
Percentage of households losing seed stock	40% (7)	37% (4)	8% (3)**
Percentage of households using chemicals to preserve seed	55% (7)	19% (3)**	15% (4)**

Source: Author's calculation.

[a]Asterisk indicates that estimated proportion is different from that of cowpea at 5% significance level.

[b]Changing the unit to seed variety from household yields similar results.

Table 5. Determinants of timing (OLS and Tobit)[abcd]

Dependent variable:	OLS		Two-sided tobit	
Month to planting date (MPD)	Coefficient	Std.err	Coefficient	Std.err
ln(income)	.018	(.088)	-.029	(.100)
ln(yield)	.130*	(.063)	.178*	(.080)
Channel – other farmers	.024	(.222)	-.125	(.291)
Channel – ADP / Government	-.282	(.215)	-.439	(.287)
Channel – agrodealer	-.076	(.217)	-.124	(.280)
Rice (=1 if the crop is rice)	.619**	(.165)	.707**	(.184)
Cowpea (=1 if the crop is cowpea)	.289	(.268)	.256	(.319)
Maturity (days)	-.002	(.004)	-.003	(.006)
Size (large = 1, small = 0)	.070	(.151)	.016	(.239)
Palatable (1 if yes)	.047	(.194)	-.060	(.224)
Household size	-.008	(.010)	-.021	(.019)
ln(farm size)	.085	(.143)	-.070	(.239)
Kaduna (=1 if the farmer is in Kaduna)	.677**	(.248)	.886**	(.354)
Ebonyi (=1 if the farmer is in Ebonyi)	.865**	(.203)	1.089**	(.304)
Distance to all-weather road (km)	.007	(.007)	.010	(.008)
Distance to nearest food market (km)	-.007	(.007)	-.009	(.008)
Storage space (ton)	.014†	(.008)	.019†	(.010)
Transportation assets owned (US$1000)	-.003	(.016)	-.005	(.019)
Information assets owned (US$1000)	.151	(.181)	.254	(.207)
FARO 44 (Rice)	.017	(.171)	.073	(.209)
FARO 51 (Rice)	.097	(.252)	.176	(.283)
FARO 52 (Rice)	.098	(.279)	.179	(.302)
NERICA (Rice)	-.263	(.361)	-.262	(.408)
ACR (Maize)	1.084*	(.474)	1.180*	(.576)
QPM (Maize)	.166	(.306)	.103	(.421)
ITA 277 (Cowpea)	.414	(.242)	.651†	(.338)
Constant	-.621	(1.188)	-.576	(1.358)
σ			1.392**	(.145)
p-value for overall fit	.000		.000	
Observation	582		582	

[a]The asterisks indicate the level of significance level, with ** as 1%, * as 5% and † as 10%, respectively.
[b]This regression is a reduced form. Endogeneous factors such as price are excluded. The standard error is adjusted for village cluster.
[c]The transportation assets include car, truck, motorcycle and bicycle, while the information assets include radio, mobile phone and TV.
[d]Dummy variables for cowpea varieties, Dan Kata, and Dan Bunkure were dropped as the timing did not very for these varieties.

Table 6. Results of RP hedonic-price model[a]

Samples	All OPV seeds						Maize seeds dropped	
Dependent variable: ln(price)	**OLS**		**OLS**		**2SLS[b]**		**OLS**	
	Coef	Std. err	**Coef**	Std. err	**Coef**	Std. err	**Coef**	Std. err
Month-to-planting date (MPD)	-.028	(.021)	.099	(.312)	***.772***	***(.864)***	.340	(.255)
MPD*rice			.368	(.378)	***.448***	***(1.001)***		
MPD*cowpea			-1.481*	(.664)	***-3.616****	***(1.500)***	-1.801**	(.632)
MPD*ln(income)			-.009	(.021)	***-.029***	***(.068)***	.110*	(.049)
MPD*ln(income)*rice			-.027	(.026)	***-.059***	***(.072)***		
MPD*ln(income)*cowpea			.112*	(.050)	***.255****	***(.124)***	.136**	(.048)
ln(yield)	-.092	(.083)	-.107	(.078)	-.216*	(.093)	-.108	(.069)
ln(yield)*rice	-.079	(.107)	-.060	(.106)	.073	(.132)		
ln(yield)*cowpea	.031	(.088)	-.005	(.073)	.060	(.113)	.039	(.106)
Channel – other farmers	-.050	(.137)	-.044	(.129)	.043	(.130)	-.031	(.159)
Channel – ADP / Government	.109	(.139)	.122	(.132)	.266†	(.151)	-.058	(.148)
Channel – agrodealer	.172	(.149)	.194	(.150)	.270	(.170)	.065	(.169)
Rice	.521	(.727)	.320	(.741)	-.320	(1.185)		
Cowpea	.166	(.615)	.467	(.517)	.395	(.684)	.305	(.747)
Maturity (days)	-.003†	(.002)	-.003	(.002)	-.003†	(.002)	.001	(.002)
Size (large = 1, small = 0)	-.064	(.085)	-.057	(.082)	-.027	(.087)	-.012	(.070)
Palatable (1 if yes)	.107	(.089)	.101	(.088)	.054	(.109)	.063	(.088)
Household size	-.000	(.004)	-.001	(.004)	.002	(.004)	-.001	(.005)
ln(farm size)	-.028	(.049)	.018	(.051)	-.060	(.085)	-.052	(.054)
Kaduna	-.109	(.119)	-.110	(.122)	-.160	(.204)	-.094	(.140)
Ebonyi	-.362**	(.099)	-.385**	(.099)	-.464†	(.279)	-.442**	(.100)
FARO 44 (Rice)	-.109	(.085)	-.092	(.080)	-.088	(.085)	.061	(.069)
FARO 51 (Rice)	-.008	(.103)	.008	(.102)	.010	(.111)	.065	(.082)
FARO 52 (Rice)	-.138	(.153)	-.114	(.149)	-.099	(.143)	.006	(.136)
NERICA (Rice)	-.177	(.188)	-.190	(.190)	-.063	(.154)	-.141	(.189)
ACR (Maize)	.023	(.176)	-.016	(.179)	-.214	(.285)		
QPM (Maize)	.401	(.259)	.381	(.249)	.475†	(.262)		
ITA 277 (Cowpea)	-.265†	(.140)	-.247†	(.146)	-.272	(.218)	-.092	(.155)
Dan Bunkure (Cowpea)	-.730**	(.141)	-.686**	(.187)	-.618	(.405)	-.468*	(.194)
Dan Kaka (Cowpea)	-.862*	(.350)	-.795*	(.378)	-.811*	(.391)	-.965*	(.421)
Intercept	5.195**	(.495)	5.253**	(.499)	5.576**	(.616)	5.470**	(.632)
p-value (overall fit)	.000		.000		.000		.000	
R^2	.220		.238		.076		.331	
p-value (overidentification)					.494			
p-value (endogeneity)[c]					.167			
Observation	601		594		582		410	

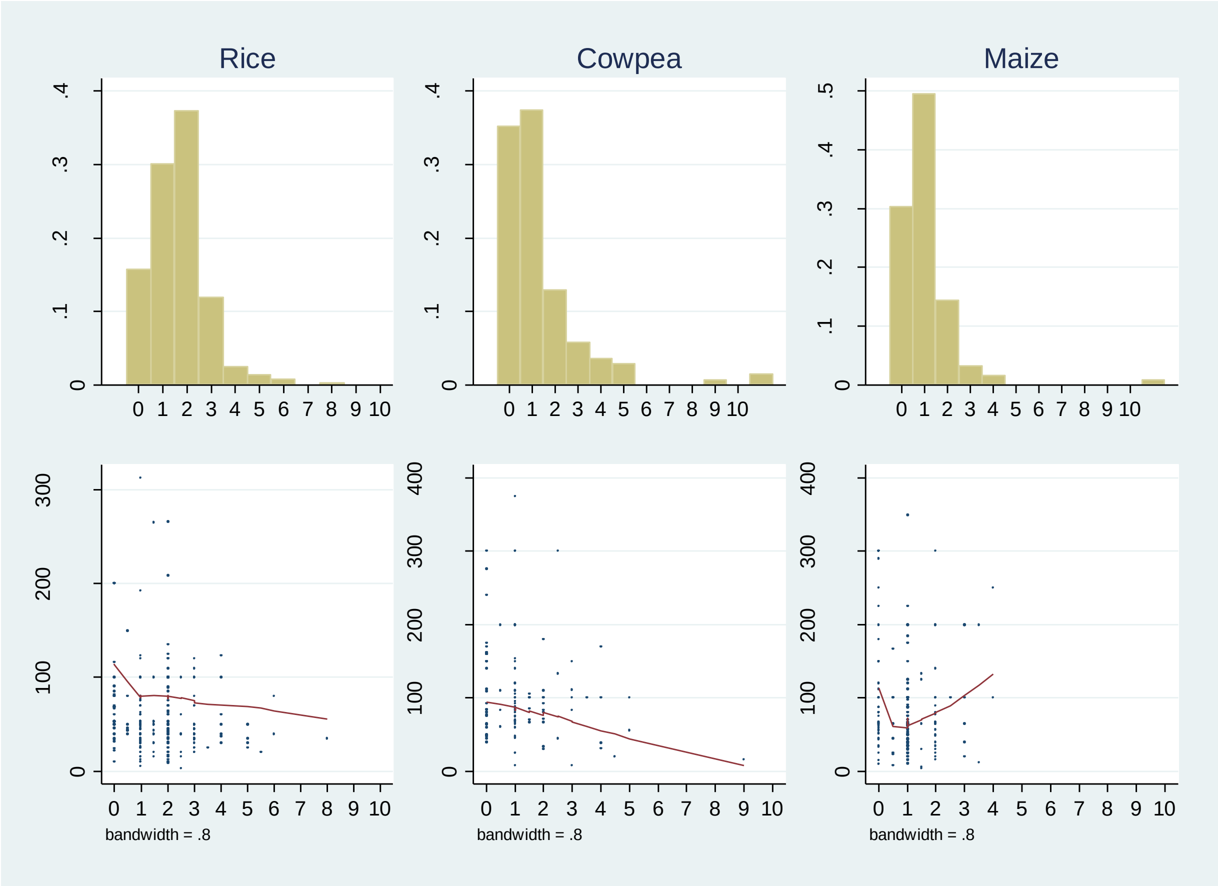
[a]The asterisks indicate the level of significance level, with ** as 1%, * as 5% and † as 10%, respectively. The standard error is adjusted for village cluster.

[b]Italic bold numbers are variables considered endogenous in 2SLS specification.
[c]Endogeneity test is bast on Hausman (1978).

Table 7. Results of SP choice experiment

Dependent variable = 1 if the choice is selected, 0 otherwise	**Coef**	Std.err	**Coef**	Std.err	**Coef**	Std.err
MPD	.016	(.060)	-.966†	(.519)	-.982†	(.537)
MPD × cowpea			-.327	(.204)	-.317	(.205)
MPD × rice			-.266†	(.157)	-.259	(.159)
MPD × ln(income)			.085*	(.043)	.086*	(.044)
ln(price)	-1.704**	(.629)	-1.687**	(.617)	-7.973	(5.334)
ln(price) × ln(income)					.497	(.439)
ln(yield)	5.178**	(1.306)	5.201**	(1.259)	5.202**	(1.276)
Maturity (days)	-.018**	(.006)	-.018**	(.006)	-.017**	(.006)
Channel - other farmers	.281	(.316)	.329	(.320)	.333	(.313)
Channel – ADP / Government	.247	(.301)	.250	(.306)	.250	(.306)
Channel - agrodealer	.268	(.223)	.298	(.227)	.305	(.230)
Log-likelihood	-202.327		-194.402		-193.940	
p-value						
Overall fit	.000		.000		.000	
Pseudo-R^2	.134		.142		.144	
Observation	674		654		654	

[a]The asterisks indicate the level of significance level, with ** as 1%, * as 5% and † as 10%, respectively. The standard error is adjusted for village cluster.



[a]The red lines in the figures are mean of price at different MPD estimated by locally weighted regression with bandwidth = 0.8.

Figure 1. Frequency of seed purchase and prices at different months to planting, by crops[a]

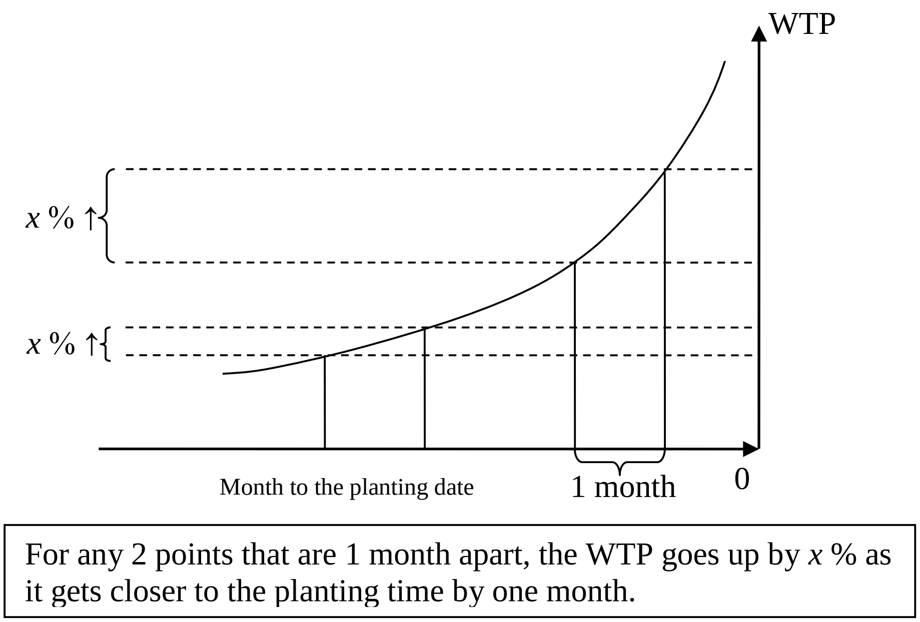


Figure 2. Illustration of premium WTP

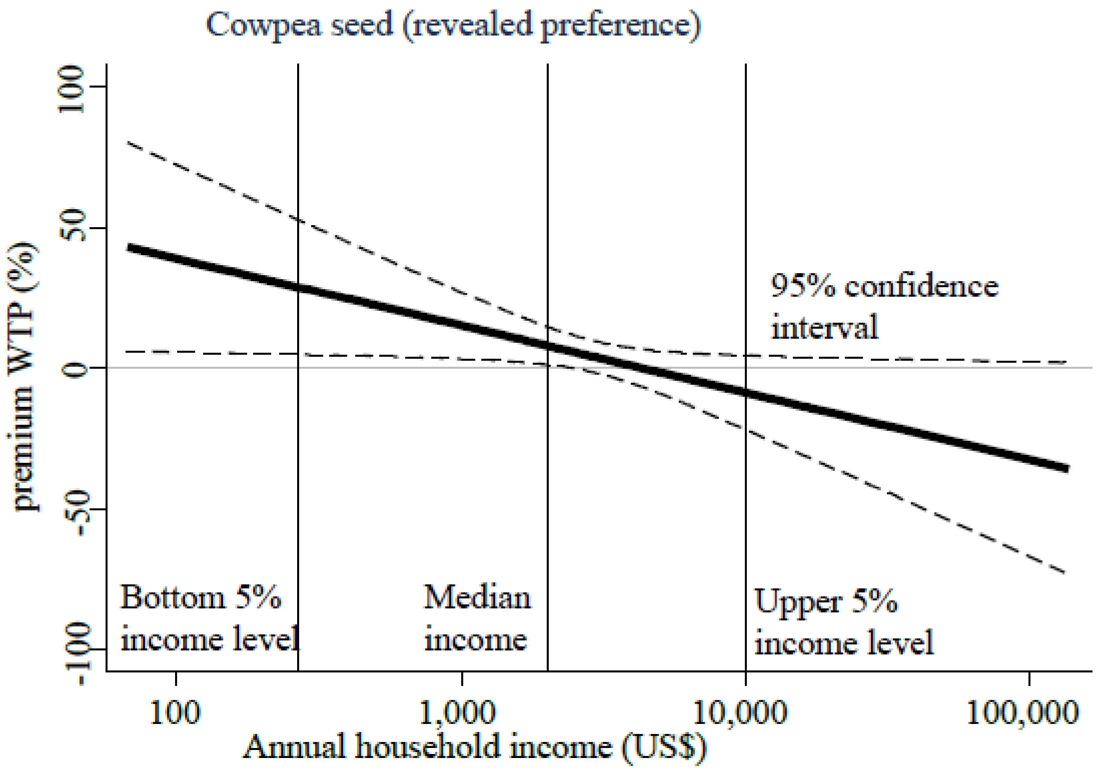


Figure 3. Percentage premium for receiving cowpea seeds one month closer to planting date (revealed preference model)

[a]Confidence interval (CI) was estimated by the Delta-method

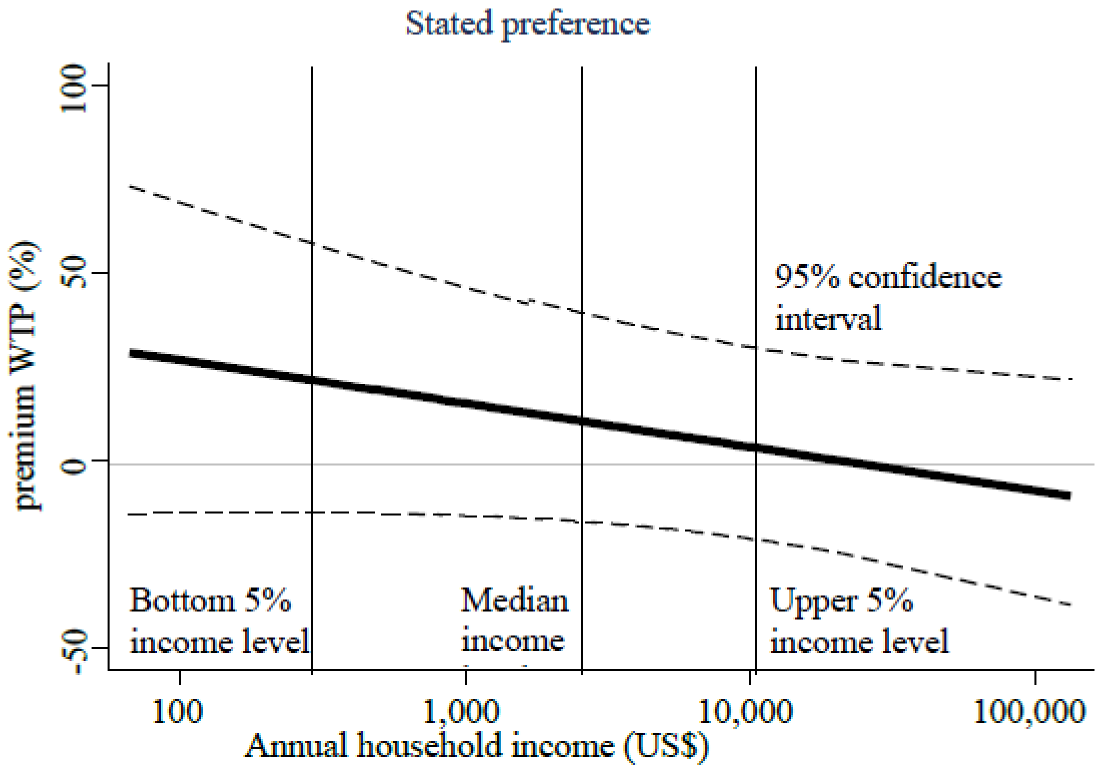


Figure 4. Percentage premium for receiving cowpea seeds one month closer to planting date (stated preference model)

[a]Confidence interval (CI) was estimated by the Delta-method