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Nigerian Farmers' Preferences On Specific Timing and Channel for Cereals and Legume Seeds Delivery– An Empirical Estimation of Willingness to Pay (WTP) through Mixed Preference Models

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1. Research questions

Adoption rates of improved seed are low in Nigeria. Formal sector lack efficient distribution seed system , resulting in

- **non availability of improved seeds especially during planting time; though available at other times of the year that often discourage farmers from adopting them**
- **non availability of seeds through the channels preferred by farmers**

Why do farmers prefer particular timing and channels?

- Lower income farmers may prefer to obtain seed around planting date due to liquidity constraints ; poor maintenance seed storage skills (e.g. legume crops - cowpea , are highly susceptible to storage pests)
- Due to weak certification system, farmers may place higher trust to certain channels from they receive or exchange seeds

=> Important to empirically test

Hypotheses to be tested in this study

- ***Low income producers have a higher willingness to pay for seed that is available closer to the planting date***
- ***Difference in willingness to pay is more evident for cowpea than for rice and maize***
- ***Willingness to pay also vary across different channels***

Key contributions of the study

Empirical methods

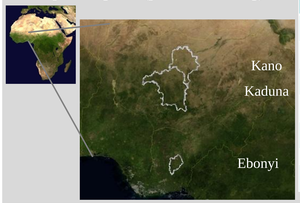
- Employ **both revealed and stated preference models to test the stated hypotheses**

Policy implications

- Feasibility of participation of private sector to engage in timely distribution of improved seed for certain crops through appropriate channels in Nigeria

2. Data

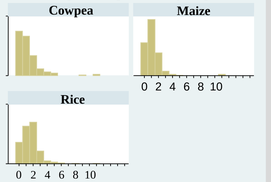
Descriptive figures (purchase timing)



Household characteristics (Median of data)

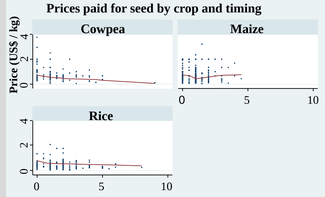
State	Kano	Kaduna	Ebonyi
Agro-ecology	Dry-Savannah	Moist-Savannah	Humid tropics
Observations (household)	150	150	120
Annual household Income (US$)	1667	2400	2500
% of female headed household	5	5	18
Household head education (years)	7	7	6
Farmsize (ha)	4	3	4
Nearest all-weather road (km)	2	1	2

Timing of seed purchase by crop



(x-axis: Months between seed purchase and planting)

Prices paid for seed by crop and timing



(x-axis: Months between seed purchase and planting)

Most seed is purchased no earlier than 2 months before planting date for rice, and 1 month before planting date for cowpea and maize

Prices paid for seed are generally higher near the planting date, particularly for cowpea and rice, although less so for maize

3. Conceptual framework

Household Utility Maximization

$$\max_{z_{kt}, s_{kt}} \sum_{t=0}^{1} u_t(c_{kt}; z_u) \cdot \delta^t \quad (1)$$

subject to

$$\sum_{k=1}^{K} p_{kt} m_{kt} + I_t + \Omega_t + \sum_{k=1}^{K} [-w_{kt} s_{kt} - (1-t) \cdot \theta_k \cdot s_{kt} + \pi_k s_{kt} + \omega_{kt} \psi_{kt}] \geq 0 \text{ for } t = 0, 1 \quad (2)$$

$$q_{kt} - x_{kt} + A_{kt} - m_{kt} - c_{kt} \geq 0, \quad \text{for all goods } k,\ t = 0, 1 \quad (3)$$

$$\Omega_1 = \Omega_0 + \sum_{k=1}^{K} [-w_{k0} s_{k0} - \theta_k \cdot s_{k0} + \pi_k s_{k0} + \omega_{k0} \psi_{k0}] \quad (4)$$

$$\psi_{kt} \leq A_{kt} \quad (5)$$

$s_k^* = s_{k1} + s_{k0} \cdot f_k(\theta_k)$ (the purchased seed available at planting date is the initial purchase quantity at $t = 0$ times the discount factor f_k which is a function of θ_k (per unit cost spent for preserving seed)) (6)

$$\psi_k^* = A_{k0} - \psi_{k0} - \psi_{k1} \quad \text{stock seed balance} \quad (7)$$

$$q_{kt} = G(x, \psi_k^*, s_k^*; z_q) \quad (8)$$

$$c_{kt}, q_{kt}, x_{kt}, s_t \geq 0 \quad (9)$$

Utility from buying seed at t = 0 and 1

$$U = u_0\{c_{k0}[p_{k0}, I_0, f_k, \pi_k, A_{k0} - \psi_{k0}, \Omega_0 - w_{k0}s_{k0} - \theta_k s_{k0} + \omega_{k0}\psi_{k0}], z_u\} + \delta \cdot u_1\{c_{k1}[p_{k1}, I_1 + \pi_k s_{k0}, f_k s_{k0}, A_{k1} - \psi_{k1}, \Omega_1 - w_{k1}s_{k1} + \omega_{k1}\psi_{k1}, G(\cdot)], z_u\}$$

The two cases can be simplified as,

$$U_0 = u_0\{c_{k0}[\ldots, \Omega_0 - w_{k0}s_{k0} - \theta_k s_{k0} + \omega_{k0}\psi_{k0}], z_u\} + \delta \cdot u_1\{c_{k1}[\ldots, I_1 + \pi_k s_{k0}, f_k s_{k0}, \Omega_1 + \omega_{k0}\psi_{k0}], z_u\} \quad \text{(buy seed at } t = 0\text{)}$$

$$U_1 = u_0\{c_{k0}[\ldots, \Omega_0 + \omega_{k0}\psi_{k0}], z_u\} + \delta \cdot u_1\{c_{k1}[\ldots, I_1, \Omega_1 - w_{k1}s_{k1} + \omega_{k1}\psi_{k1}], z_u\} \quad \text{(buy seed at } t = 1\text{)}$$

2 time periods

- $t = 0$: substantially before the planting date
- $t = 1$: immediately before planting and including subsequent production season

Seed purchased at $t = 0$: incurs cost for storage/preservation and risk of loss, but may also lead to profit if it can be resold at higher price at $t = 1$

Symbol	Definition
t	Period
A_{kt}	initial endowment
c_{kt}	consumption of goods k at t
f_k	a function of θ_k
I_t	income from other sources at time t
m_{kt}	net sales of goods k at t
p_{kt}	prices
q_{kt}	quantity of goods k produced at t
s_t	seed purchase quantity at t
s_k^*	total quantity of purchased seed usable for the production of k at $t = 1$
u_t	Utility
w_{kt}	seed price for k at t
x_{kt}	use as inputs at t
z_q	other factors that affect the total factor productivity
z_u	other residual factors
ψ_{kt}	net sales of farmer-owned seed of the same variety at time t
θ_k	cost incurred to preserve seed during the storage (per-unit cost)
Ω_t	non-productive liquid assets
π_k	net profit per unit of seed bought at $t = 0$
ω_{kt}	price of farmer-owned seed of the same variety

Willingness to pay for obtaining seed at planting date

$$U_0 = U_1(\ldots, w_{k1} + \varepsilon, \ldots) = u_0\{c_{k0}[\ldots, \Omega_0 + \omega_{k0}\psi_{k0}], z_u\} + \delta \cdot u_1\{c_{k1}[\ldots, I_1, \Omega_1 - (w_{k1} + \varepsilon)s_{k1} + \omega_{k1}\psi_{k1}], z_u\} < U_1(\ldots, w_{k1}, \ldots) = u_0\{c_{k0}[\ldots, \Omega_0 + \omega_{k0}\psi_{k0}], z_u\} + \delta \cdot u_1\{c_{k1}[\ldots, I_1, \Omega_1 - w_{k1}s_{k1} + \omega_{k1}\psi_{k1}], z_u\}$$

For farmers with $U_0 < U_1$ given the set of parameters including seed prices w_{kt}, there is a premium ε the seed sellers can charge in addition to w_{k1} which the farmer is still willing to pay at $t = 1$ if the seed is available

4. Empirical results and policy implications

Revealed preference and stated preference

Revealed preference: simple hedonic form

$$\ln(p_{ij}) = \alpha_{ij} + \beta_t t_{ij} + \beta_{t,income}(t_{ij} \cdot \ln(\text{income}_j)) + \beta_{t,income,crop}(t_{ij} \cdot \ln(\text{income}_j) \cdot \text{crop}_{ij}) + \beta_{channel}\,\text{channel}_{ij} + \beta_c c_i + \beta_x x_{ij} + v_{ij}$$

p_{ij} = price paid for seed i by household j (natural log)
t_{ij} = months to planting date (MPD)
$\ln(\text{income}_j)$ = annual household income of household j (natural log)
channel_{ij} = channel (sellers) of seed i
c_i = key household characteristics of household j
x_i = key attributes of seed i

Potentially endogenous: Instrumented with ownership and values of various assets, storage space

WTP premium (%) for 1 month closer to planting date = $\beta_t + \beta_{t,income} \cdot \ln(\text{income}_j) + \beta_{t,income,crop}(\ln(\text{income}_j) \cdot \text{crop}_{ij})$

Stated preference

Choice experiment:

• Farmers are given 2 hypothetical options defined by the 5 parameters (Table) with their current varieties as benchmark, and choose preferred option

Parameters used for options and levels

Parameters	Levels
Price	Same, − 25%
Yield	Same, + 25%
Maturity length	Same, − 25%
Channels	Other farmers, government, agrodealers, village chief
Months to planting date	0, 1, 3

Conditional logit: $I(\text{Select} = 1,\ \text{do not select} = 0)$

$$= \alpha_{ij} + \beta_t t_{ij} + \beta_{t,income}(t_{ij} \cdot \ln(\text{income}_j)) + \beta_p \ln(p_{ij}) + \beta_{channel}\,\text{channel}_{ij} + \beta_c c_i + \beta_x x_{ij} + v_i$$

WTP for 1 month closer to planting date = $[\beta_t + \beta_{t,income} \ln(\text{income})] / \beta_p$

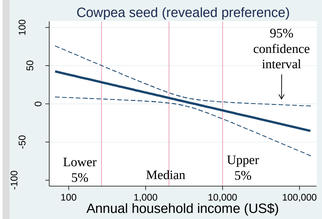
Revealed preference results

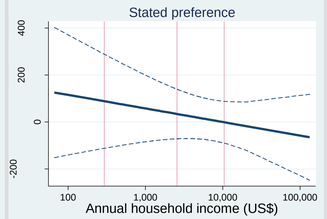
	OLS				2SLS			
	Coef	Std.err	Coef	Std.err	Coef	Std.err	Coef	Std.err
Month to planting date (MPD)	-.054**	(.022)	.249	(.277)	***-.099***	***(.512)***	***.308***	***(.497)***
MPD*rice			.233	(.378)	***.972***	***(.669)***	***.417***	***(.629)***
MPD*cowpea			-1.643**	(.630)	***-1.879****	***(1.085)***	***-2.557****	***(1.270)***
MPD*ln(income)			-.019	(.018)	***.004***	***(.032)***	***-.019***	***(.032)***
MPD*ln(income)*rice			-.022	(.027)	***-.058***	***(.039)***	***-.034***	***(.039)***
MPD*ln(income)*cowpea			.124***	(.047)	***.159****	***(.084)***	***.194****	***(.100)***
ln(yield)	-.029	(.030)	-.039	(.053)	***-.117***	***(.108)***	***-.210****	***(.107)***
Channel – other farmers	-.058	(.098)	-.050	(.133)	-.213	(.130)	***.207***	***(.327)***
Channel – ADP / Government	.013	(.100)	-.032	(.145)	-.077	(.133)	***-.080***	***(.361)***
Channel – agrodealer	.350***	(.115)	.364**	(.167)	.157	(.142)	***-.291***	***(.363)***
cowpea	.253***	(.092)	.357***	(.119)	.012	(.273)	.182	(.304)
rice	-.399***	(.099)	-.338**	(.130)	-.503	(.394)	-.119	(.392)
maturity (days)	-.001	(.002)	-.001	(.002)	-.002	(.002)	-.002	(.002)
size (large = 1, small = 0)	-.004	(.064)	-.003	(.068)	-.025	(.075)	.039	(.077)
palatable (1 if yes)	.214**	(.099)	.206**	(.084)	.134	(.105)	.157	(.104)
Household size	-.004	(.004)	-.003	(.004)	-.001	(.004)	.004	(.005)
ln(farmsize)	-.025	(.044)	.012	(.048)	-.009	(.059)	.022	(.062)
Kaduna					-.121	(.122)	-.079	(.173)
Ebonyi					-.502***	(.151)	-.356	(.123)
Intercept	4.186***	(.438)	4.446***	(.375)	5.454***	(.756)	5.711***	(.705)
p-value (overall fit)	.000		.000		.000		.000	
R^2	.191							
p-value (overidentification)					.449		.399	
Observation	635		635		549		635	

Stated preference results

	Coef	Std.err	Coef	Std.err	Coef	Std.err
ln(yield)	4.522***	(.664)	4.373***	(.683)	4.369***	(.693)
maturity (days)	-.012**	(.005)	-.011**	(.005)	-.010*	(.006)
ln(price)	-.471	(.374)	-.485	(.437)	-12.564**	(5.334)
MPD	.014	(.055)	-1.405*	(.743)	-1.470*	(.788)
Other farmers	.208	(.193)	.266	(.193)	.266	(.195)
Government / ADP	.398*	(.210)	.377*	(.212)	.369*	(.214)
Agrodealer	.311	(.201)	.325*	(.193)	.326*	(.197)
ln(price) × ln(income)					.924**	(.187)
MPD× ln(income)			.111*	(.059)	.115**	(.062)
Log-likelihood	-279.406		-265.896		-263.380	
p-value						
Overall fit	.000		.000		.000	
Pseudo-R^2	.096		.097		.106	
Observation	892		850		850	

Premium WTP for purchasing 1 month closer to planting date (by income level)





Revealed preference model

- Lower income farmers exhibit positive WTP for obtaining cowpea seed closer to planting date (with 95% significance level)
- The premium farmers are willing to pay is about 5% at the median income, but can be 30% at the lower income

Stated preference model

- Lower income farmers exhibit positive WTP for obtaining seeds closer to planting date (all of cowpea, rice and maize)
- The premium farmers are willing to pay is about 20% at the median income, can be 100% at the lower income
- The accuracy of WTP is, however, low as indicated by wide confidence interval

Summary of findings

- Evidence for higher WTP for obtaining seed closer to planting date is observed for cowpea in both *revealed preference model* and *stated preference model*
  => Support the hypotheses
- In the revealed preference model, there is no evidence for the variation in WTP based on the timing for rice and maize seed
- The WTP estimates from the *revealed preference model* seems more reliable (narrower confidence interval) than from the *stated preference model*, possibly because the WTP in *stated preference model* is the ratio of estimated coefficients

Implications of preliminary results

Motivate further studies for assessing the feasibility of

- private companies, traders to engage in business of distributing improved cowpea seeds at particular timings
- Government to provide support for private companies or public institutions to distribute the improved seeds at appropriate timing and through appropriate channels

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