THE INFLUENCE OF COWPEA CHARACTERISTICS ON COWPEA PRICES IN SENEGAL

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Abstract

In examining demand for a product it is useful to think of consumers not as purchasing the product, but as purchasing its characteristics that provide utility. Consequently, it is important to measure the specific characteristics that consumers perceive as providing them with utility. In this article a hedonic pricing model is used to investigate the influence of different cowpea characteristics on cowpea prices in Senegal. The results provide valuable information for research institutions, producers, and traders. Cowpea plant breeders should emphasise large grain size as the main characteristic since buyers are willing to pay a premium for this characteristic. This should translate into higher returns on R&D. There exist differences between markets in terms of consumer preferences for testa colour and texture. The result is that sorting and grading of cowpeas according to these characteristics should increase profits, as there would be fewer discounts for undesired characteristics. The importance of adequate storage is also emphasized to protect seeds against insect damage. Finally, it appears that prices in different markets are not equally responsive to changes in the supply of cowpeas. Higher returns could hence be realized through more efficient sequencing of sales.

1. INTRODUCTION

Cowpeas are one of the more important indigenous African legume crops, especially in West and Central Africa. It is regarded as a key protein source for the urban and rural poor and plays an important role as cash crop (Langyintuo *et al*, 2003). However, very little is known about the willingness of consumers to pay for certain characteristics of cowpea. This state of affairs puts producers, middlemen and other role players in the marketing chain at a disadvantage. In other words, if they have knowledge about characteristics of cowpeas that consumers demand, they could alter their respective operational activities accordingly and thus improve their own state of welfare. Information on what consumers regard as important could also guide

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research related to, for example plant breeding, and thereby increase the returns to research and development (R&D).

In this article, the influence of different cowpea characteristics on cowpea prices in Senegal is discussed. The article is organized as follows: Section 2 focuses on applicable literature and describes the theoretical model related to the willingness of consumers to pay for different product characteristics. Section 3 describes the data used and in Section 4 the specific model used in this study is specified. Sections 5 and 6 contain the results and conclusions, respectively.

2. LITERATURE REVIEW AND THEORETICAL MODEL

Demand theory has traditionally been based on the fundamental precept that a product or a service generates utility. Hence, utility theory has been used to analyse consumers' choice of a good or a service based on price and a budget constraint. In the case of food products, the price a consumer is willing to pay may be a function of the marginal implicit prices that an individual is willing to pay for each nutrient (Brooker *et al*, 1986). Based on the economic principle that product demand stems from the utility provided as a function of its quality characteristics (Berndt, 1991), a hedonic pricing model can be used to investigate the impact of different product characteristics on product prices. As defined by Lancaster (1971), a hedonic price function is a regression of observed prices of a commodity against its quality attributes.

The hedonic pricing method is most often used to value the individual characteristics of agricultural goods because it is relatively straightforward and uncontroversial to apply, since it is based on actual market prices and uses fairly easily measured data. Since its introduction, numerous economists have employed hedonic pricing models as a tool for estimating the price-quality relationships of commodities over time or through cross-sectional data analysis (see for example Rosen, 1974; Brorsen *et al*, 1984; Espinosa & Goodwin, 1991; Jefferson Institute, 1999; Faye *et al*, 2000).

The general theory of hedonic pricing as used by the aforementioned authors closely relates to the current study in one important way. It follows the consumer demand approach, i.e. utility experienced by users of cowpeas is a function of its characteristics. From this, it can be assumed that cowpea consumers behave as utility maximizing agents.

The utility maximization problem can be set as follows:

$$\text{Max}(U(z))$$
$$\text{s.t. } z_j = \Sigma_i b_{ij}\, q_i$$
$$E = \Sigma_i p_i q_i$$

Where:

U = Utility
z = good's characteristics
b = components of the good
q = quantity of the good consumed
p = price of the good
E = total expenditure

From the partial derivatives:

(1) $\delta U/\delta z_i$ = marginal utility of the j^{th} product characteristic
(2) $\delta z_i/\delta q_i$ = marginal yield of the j^{th} product characteristic by the i^{th} product
(3) $\delta U/\delta E$ = marginal utility of income

The above utility maximizing problem is underlined by the following assumptions:

- Expenditure equals income, i.e.
  $(\delta U/\delta z_i)/\ (\delta U/\delta E)$
  the marginal implicit price of the j^{th} characteristic denoted as
  $P_i = \Sigma\ (\delta z_i/\delta q_i\ )((\delta U/\delta z_i)/\ (\delta U/\delta E))$

- Constant marginal implicit price, i.e.
  $(\delta U/\delta z_i)/\ (\delta U/\delta E) = ß_{ij}$ is constant

- Product characteristics are constant, i.e.
  $\delta z_j/\delta q_i = z_{ij}$

After some rearrangements, the hedonic price model can be expressed as:

$$P_i = a + \Sigma_{j=1}\, ß_{ij}\, Z_{ij}$$

Where:

P_i = price of good *i*
a is an intercept
$ß_{ij}$ = marginal value of characteristic *j* for good *i*

3. DATA USED

To examine the influence of cowpea characteristics on cowpea market prices, data were collected from January 1998 until December 2002 at six Senegalese markets. Data were collected each month on the first market day of the third week. At each market 5 samples were bought from 5 different vendors. The choice of the vendors at a given market was done randomly. The sample starts from a randomly chosen seller and every 5th seller was then selected from whom a sample was purchased. The number of samples eventually used amounted to 203 because of a lack of vendors during the rainy season in certain markets, data recording errors and missing data.

For each sample, the following variables were recorded: market price, weight of 100 grains, average length and width, skin texture, testa colour, eye colour, number of bruchid holes per 100 grains, whether sale was by weight or volume, category of vendor and selling periods (months and years).

The markets were chosen according to their location and volume of cowpea sales. The six Senegalese markets included were:

- MPal and Sagatta in the main cowpea production area;
- Bambey and Nioro in the peanut basin where cowpea is a secondary crop; and
- Tilene and Castors in Dakar, which is a major urban consumption area where cowpea is not grown.

Table 1 shows descriptive statistics for different markets for cow pea prices, grain weight (w100) and insect damage (nh100). It is clear that prices show relatively large variations over time and between different markets, which makes analysis of this nature vitally important to understand these deviations better. For example, apart from the hypothesis that seasonality and the distance between markets will explain price changes and differences, it is also important to know if there are other variables that affect cowpea prices.

The average grain weight varied between 17 and 19g/100 grains. The heaviest grains were observed in Bambey, Castors and Tilene, while the lightest was observed in Nioro and MPal. The low standard deviation is indicative that grain weight is largely uniform in different regions. It also appears that there only exist small differences across regions.

Insect damage was, on average, surprisingly low. The average number of bruchid holes per 100 grains is between 6 and 9. The low rate of insect damage can probably be attributed to the high rate of use of metallic drums to store cowpea. Faye and Lowenberg-DeBoer (1999) found that over 80% of cowpeas in Senegal are stored in metallic drums.

Table 1: Descriptive statistics for prices, weight and insect damage in selected Senegalese markets

Item	N=203	Bambey	Castors	Nioro	Mpal	Sagatta	Tilene
PRICE (FCFA)	Mean	188	316	278	156	169	269
	St. Dev	96	111	105	70	91	118
	Min	66	150	100	58	46	100
	Max	532	650	500	400	500	600
w100 (g)	Mean	19	19	18	17	18	18
	St. Dev	3	3	3	3	3	3
	Min	11	11	10	10	10	12
	Max	29	30	25	25	26	30
nh100	Mean	6	6	8	7	9	7
	St. Dev	11	11	10	8	12	8
	Min	0	0	0	0	0	0
	Max	98	100	46	48	102	47

Table 2 shows information pertaining to testa colour, testa texture and eye colour. In respect of testa colour, on average, 47% of the cowpeas sold were black speckled, 32% were white and 21% were red. In MPal and Sagatta the sales of white testa cowpeas are, however, higher than that of black speckled and red testa cowpeas. The reason for this can be traced back to the fact that Mauritanian buyers mainly buy from these markets and prefer white cowpeas.

Table 2: Distribution of testa colour, testa texture and eye colour (%)

Variables	Bambey	Castors	Nioro	MPal	Sagatta	Tilene	Average
Black speckled	48	53	66	32	27	53	47
White testa	22	22	30	53	44	18	32
Red testa	30	25	4	15	29	29	21
Smooth testa	34	30	30	52	54	32	39
Rough testa	66	70	70	48	46	70	61
Brown eye	47	52	52	56	59	59	54
Black eye	53	48	48	44	41	41	46

The sample included two types of skin texture, namely smooth and rough. The former represents 39% of the sample and the latter 61% of the sample. As for eye colour, only black and brown were registered. Black eye colour

represented 46% of the whole sample, whilst 54% had a brown eye colour. It was only in Bambey where the black eye colour is dominant over brown eye colour. In the Sagatta, Nioro, Castors and Tilene markets the brown eye colour was the most common.

4. MODEL SPECIFICATION

As is common with statistical analysis of this nature it is necessary to conduct several statistical tests on the data in order to determine whether heteroskedasticity, autocorrelation and contemporaneous correlation are present. In this study the randomization across vendors was done to reduce heteroskedasticity and autocorrelation. According to Langyintuo *et al* (2003), who studied cowpea production and marketing in West and Central Africa, when using longitudinal data where the cross-sectional units are distinct units, such as households and individuals, the disturbances of the cross-sectional time series units may be assumed mutually independent and not heteroskedastic. More specifically, these studies have shown that heteroskedasticity and autocorrelation are in fact negligible by randomizing across vendors as was done in this study.

However, a main estimation problem remains contemporaneous correlation, i.e. correlation between disturbances of different equations at a given period, which will influence the method of analysis. In other words, cowpeas are an agricultural commodity, and hence seasonal effects in a given year due to, for example variable weather conditions, are expected to have related effects on the disturbances for different demand equations in different markets. These disturbances are not always related to the characteristics of the cowpea, and hence the necessity to test for contemporaneous correlation by using the Breush and Pagan method (Judge *et al*, 1985) based on the following steps:

(1) Estimate separate least squares estimates of each equation.

(2) Calculate the error variance ($\sigma_{ii} = e_{ii}/T$) and covariance ($\sigma_{ij} = e_{ij}/T$), where T is the number of observations.

(3) The squared contemporaneous correlation between equations are computed as $r^2_{ij} = \sigma^2_{ij} / \sigma_{ii}\, \sigma_{jj}$

(4) The test statistics for contemporaneous correlation is set as $\lambda = T^*(\sum r^2_{ij})$
λ follows a CHI-square distribution with m(m-1) degrees of freedom where m is the number of equations in the model.

(5) λ is used to test if:
H_0: all $\sigma_{ij} = 0$
H_1: at least one covariance is not zero

The null hypothesis of no contemporaneous correlation was rejected after conducting the aforementioned test. Consequently, demand models for the different markets were estimated using seemingly unrelated regressions (SUR) to account for correlation between disturbances from different equations. More specifically, in order to measure the explanatory power associated with all the variables listed, a linear hedonic demand system of five equations was estimated using the Shazam econometrical software package.

The hypothesis tested is whether the information conveyed jointly by dummy variables and the quantitative variables can explain the observed price variations at a given point in time. As in most hedonic pricing studies, the linear model is used for easy interpretation of its coefficients, which are seen as discounts or premiums on price due to a given characteristic. The estimated discounts or premiums were rounded up because the Senegalese currency doesn't have decimals.

The SUR is denoted by the following equations:

BPRICE = f (Bw100, Bnh100, Brsc, Bbsp, Bsmo, Bbey, Bmret, D1, D2)
CPRICE = f (Cw100, Cnh100, Crsc, Cbsp, Csmo, Cbey, D1, D2)
NPRICE = f (Nw100, Nnh100, Nrsc, Nbsp, Nsmo, Nbey, D1, D2)
PPRICE = f (Pw100, Pnh100, Prsc, Pbsp, Psmo, Pbey, Pmret, D1, D2)
TPRICE = f (Tw100, Tnh100, Trsc, Tbsp, Tsmo, Tbey, D1, D2)

Where:

- The first letter of the independent and dependant variables indicates the name of the markets, i.e. B stands for Bambey, C for Castors, N for Nioro, P for MPal and T is for Tilene.
- The dependent variable is price (*PRICE*) in FCFA per kg.
- *nh100* = Number of bruchid holes per 100 grains.
- *w100* = Grain weight or grain size (average weight of 100 grains).
- Testa colour (*rsc* for red skin; *bsp* for black speckled skin and *wsc* for white skin).
- Testa texture (*smo* stands for smooth skin and *rou* for rough skin).
- Eye colour (*bey* for black eye and *mey* for brown eye).
- D1 and D2 represent respectively month and year.
- Other qualitative variables such as gender of sellers (*mret* for male retailer *fret* for female retailer) are also included in the model.

The qualitative variables are handled as dummy variables with the value "1" for the colour, texture, gender, month or year and "0" otherwise using the coefficient restriction $a_i = 0$ where *i* is a characteristic used in a point of reference (e.g. rsc has the value 1 for red testa samples, and zero otherwise). See Appendix A for the reference variables for the dummies used in the analysis.

5. RESULTS OF THE SPECIFIED MODEL

In Table 3 the results of the analysis described in the previous section is reported. The results show an overall R^2 of 90.6%, which suggests that the independent variables included in the model jointly explain 90.6% of the variation observed in prices.

In terms of grain size (w100) consumers in all markets are willing to pay a premium for each additional unit of grain weight. In MPal consumers are willing to pay the highest premium, i.e. up to 25 FCFA for each additional unit of grain weight per 100 grains. The willingness to pay premiums can be explained by (i) consumers preference for large seeds for their sauce or rice and (ii) processors that prefer large seeds since it yields a larger amount of flour.

The impact of bruchid holes (nh100) on cowpea prices is only significant at Tilene market in Dakar where consumers discount price for just 1 FCFA for any additional bruchid hole. The negligible affect of bruchid holes on prices can be attributed to the low level of infestation by insects due to the high rate of use of metallic drums to store cowpeas. As mentioned, Faye & Lowenberg-DeBoer (1999) found that over 80% of cowpeas in Senegal are stored in metallic drums that reduce insect infestation by limiting air contact.

The impact of testa colour (bsp) on price is significant in the MPal and Bambey markets. In Mpal market consumers discount prices for black speckled skin compared to the white testa colour (the reference variable), but are willing to pay a premium of 15 FCFA for red testa colour (rsc). In Bambey, on the other hand, consumers are willing to pay a premium for black speckled skin.

With regard to testa texture (smo), consumers discount prices for smooth skin cowpeas in Nioro, MPal and Tilene markets. This discount varies from 20 FCFA at Nioro to 30 FCFA at Tilene. The reason for this is that cowpea varieties with smooth skin are not easy to cook. However, consumers in Bambey and Castors appear to be indifferent to the skin texture of the cowpea. As for eye colour these markets tend to discount prices for black eye, whilst the other markets appears to be indifferent to eye colour.

Table 3: Results of the SUR analysis

Variables	Bambey	Castors	Nioro	MPal	Tilene
w100	6***	4***	4***	25***	5***
	(4.1)	(2.61)	(2.98)	(4.75)	(2.53)
nh100	0.44	0.22	-0.32	-0.15	-1**
	(1.31)	(0.64)	(-0.87)	(-0.15)	(-2.15)
bsp	30*	7	-25	-25***	20
	(1.70)	(0.43)	(-1.48)	(-2.89)	(0.97)
rsc	10	-8	10	15**	13
	(0.96)	(-0.72)	(0.49)	(2.22)	(1.21)
smo	1	-2	-22**	-25***	-30***
	(0.73)	(-0.14)	(-2.18)	(-3.22)	(-2.58)
bey	-40**	-25***	-5	10	-20
	(-2.40)	(-2.50)	(-0.18)	(1.40)	(-1.05)
mret	25***	-	-	25.66***	-
	(2.62)			(4.75)	
Jan	15	-40***	-55***	-20**	-60***
	(0.84)	(-2.4)	(-2.93)	(-2.15)	(-3.42)
Feb	25	50***	85***	15	70***
	(1.58)	(2.99)	(4.61)	(1.55)	(3.99)
Mar	40***	60***	75***	30***	65***
	(2.49)	(3.25)	(4.08)	(3.34)	(3.65)
Apr	25	40**	50***	25***	60***
	(1.59)	(2.39)	(2.69)	(2.81)	(3.34)
May	60***	45***	70***	60***	60***
	(3.74)	(2.58)	(3.86)	(6.95)	(3.37)
Jun	70***	65***	85***	45***	90***
	(4.24)	(3.79)	(4.63)	(5.13)	(4.84)
Jul	75***	40*	85***	70***	95***
	(4.50)	(1.94)	(4.75)	(8.53)	(5.30)
Aug	80***	55***	55***	65***	95***
	(5.14)	(3.15)	(2.97)	(7.38)	(4.79)
Sep	50***	100***	60***	55***	80***
	(3.15)	(4.67)	(3.35)	(5.45)	(4.40)
Oct	-10	0.02	-2	15*	25
	(-0.66)	(0.87)	(-0.94)	(1.70)	(1.42)
Dec	-1	-10	10	35***	-25
	(-0.79)	(-0.55)	(0.54)	(3.48)	(-1.21)
Y99	-55***	-20***	-20***	-30***	-20***
	(-5.29)	(-6.16)	(-17.58)	(-6.15)	(-17.63)
Y00	-50***	-20***	-20***	-40***	-20***
	(-4.93)	(-4.88)	(-21.33)	(-7.41)	(-17.78)
Y01	110***	-20*	-15	100***	-25*
	(9.46)	(-1.75)	(-1.64)	(17.13)	(-1.76)
SYSTEM R-SQUARE = 0.906					

*The t-statistics are in parentheses.
*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

As far as gender is concerned consumers in Bambey and MPal prefer males (*mret*) sellers. In other markets all sellers are male, and for this reason, the

variable *mret* was not included in their respective equations since it was a constant.

For almost all the markets considered in this study, monthly dummies have a positive and significant impact on cowpea prices. More specifically, the monthly premiums reflect the storage premium relative to harvest time sales during the October to December period. None of the October variables are significant at the 5% level, whilst only one of the December variables is significant. Almost all the other months are significant showing a very consistent seasonal price pattern.

Regarding the yearly dummies, compared to 1998, which is the base year, the model shows that prices were under considerable pressure in 1999, 2000 and most markets in 2001. This is largely due to the fact that production went from 41,000Mt in 1998 up to 68,000Mt in 1999. Although production in 2000 dropped to 47,000Mt is was still higher than in 1998. Production decreased further in 2001 to 32,000Mt, but it appears that prices only reacted positively in the production areas of Bambey and MPal.

6. CONCLUSION

In this paper the impact of different cowpea characteristics on cowpea prices in Senegal is investigated. The paper provides valuable information for researchers/research institutions, producers and traders. In the case of researchers/research institutions the analysis yields information that could guide plant breeding research. For example, cowpea plant breeders should focus on new breeding programs with the emphasis on large grain size as main the characteristic since buyers are willing to pay premiums for this characteristic throughout.

The importance of proper post-harvest handling by farmers and traders are confirmed. Sorting and grading cowpeas according to certain characteristics could greatly enhance supply chain efficiency, e.g. the paper emphasizes differences between markets in terms of consumer preferences for testa colour and texture. In other words, if producers sort and grade cowpeas according to these characteristics traders could plan their distribution activities better, which in turn should increase profits as there would be fewer discounts for undesired characteristics in markets where the analysis provided significant results. The importance of adequate storage is also emphasized to protect seeds against insect damage.

Finally, it appears that prices in different markets are not equally responsive to changes in the supply of cowpeas. Higher returns could hence be realized through more efficient sequencing of sales.

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Appendix A

Table A.1 shows the refer ence variables for the dummies used in the analysis.

Table A.1: Reference variables

Variables	**Base**
Testa colour	White (wsc)
Skin texture	Rough (rou)
Eye colour	Brown eye (mey)
Market	Sagatta
Gender	Female (fret)
Month	November
Year	1998