A Hedonic Perspective to Estimating a Marginal Value Function for Variety Attributes of a Subsistence Crop

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Abstract

A hedonic price model is used to estimate the marginal value function for output characteristics of a subsistence crop in a developing economy. Within the framework of the agricultural household, with non-separable consumption and production decisions, prices reflect the implicit marginal valuation of both consumption and production attributes jointly. Variety-specific crop product farm-gate prices are used in the hedonic analysis. The findings provide guidance for future crop improvement efforts, while revealing those attributes most likely to capture premiums at the market place. Implicit premiums for attribute scarcity are also revealed. Improvements in infrastructure could partially reduce the implicit costs of transportation, leading to higher farm-gate prices and price premiums for size and quality.

Introduction

The composition of goods traded in markets is an integral part of market price determination. Market prices reflect the value of goods as bundles of attributes. Goods' attributes, rather than the goods themselves, have been postulated to determine the preference structure of individuals (Lancaster, 1966). When objectively measured goods' attributes are mapped to observed equilibrium market prices in a competitive economy, the marginal implicit worth of output characteristics can be derived from a hedonic price function that traces the behavior of consumers and producers of the various characteristics of a differentiated product (Rosen, 1974). The economic value of goods' attributes has been further disentangled for consumer goods and for factors of production (Ladd and Suvannunt, 1976; Ladd and Martin, 1976).

Applications of the hedonic price method abound, from housing and automobile markets to agricultural products. Generally, however, the hedonic model has been used to estimate relationships between prices and attributes in competitive markets in developed countries. Thus, marginal implicit prices of consumption and production attributes have typically been derived separately from either utility maximization or profit maximization frameworks, with greater emphasis given to the consumer side. To a limited extent, hedonic models have also been applied to assess the marginal value of output characteristics of crops in developing economies (e.g., Unnevehr, 1986; Dalton, 2004; Langyintuo et al., 2004). While these approaches recognize the role of attributes in explaining crop product prices, there have been few attempts to estimate an explicit marginal value function for attributes in developing economies (e.g., Knudsen and Scandizzo, 1982). This has partly been due to data limitations and econometric constraints to estimation of marginal value functions.

This article uses the hedonic price method, within the framework of a non-separable model of the agricultural household, to estimate the marginal value function for output characteristics of a subsistence crop in a developing economy. Several aspects distinguish the present analysis from previous applications of the hedonic model. Firstly, the conceptual model recognizes that although output markets for crop products in developing countries are functional and competitive, input market failure may lead to non-separability between production and consumption household decisions. This is reflected in the derivation of output prices as functions of the marginal values and levels of consumption and production attributes jointly. Secondly, market information at the farm-gate, the first link of the market chain, is used for the analysis, rather than observed prices at the market place, as is commonly done. Actual variety-specific crop product farm-gate prices are employed in the hedonic analysis. Thirdly, a second-stage hedonic approach is formulated to reveal the marginal value function for attributes of a subsistence crop in a developing economy. Because producing households maximize utility not profits, and they transact in output markets as either sellers, buyers or both, their marginal valuation of output characteristics encompasses both consumption and production attributes. This has an implication for the interpretation of the marginal value function as revealing the marginal willingness to value, rather than strictly to pay or to accept, product attributes.

The hedonic price method is applied to bananas in Uganda. Bananas, the staple crop of the country, are important for meeting immediate consumption requirements and for income generation of semi-subsistence households. While banana varietal diversity is evident on-farm, it is also well pronounced at the market place with many different banana types sold, primarily at the farm-gate. The practical motivation for this work is to disentangle a separate value function for different attributes of a subsistence crop from actual farm-gate prices. The implicit prices of attributes are derived from three separate hedonic functions, each corresponding to a different region in Uganda. This information is pooled and then incorporated into inferences of the marginal value function for specific variety traits. Marginal attribute values are found to depend on the levels of attributes, exogenous income and, in some instances, household size, gender and the local stock of variety attributes. These findings provide greater insight into the importance of attributes in the preference structure of individuals, as revealed in market transactions, guiding future crop improvement efforts and revealing those attributes most likely to capture premiums at the market place.

Theoretical Model

The theoretical model draws from the theory of consumer choice (Lancaster, 1966) within the framework of the agricultural household (Singh, Squire, and Strauss, 1986). Intrinsic attributes of goods consumed and produced are implicit in household consumption preferences and production decisions. They are also integral determinants of prices. Prices of goods and factors of production have been derived from the maximization problem as linear functions of input characteristics, as well as linear summation of output characteristics, separately (Ladd and Suvannunt, 1976; Ladd and Martin, 1976). Within the framework of the agricultural household, with consumption and production decisions often being non-separable, prices reflect the implicit marginal valuation of both consumption and production attributes jointly.

A representative agricultural household derives utility from the set of intrinsic attributes ($\mathbf{z}^c$) of goods it consumes ($\boldsymbol{c}$), from other goods (x) and home time (h), given household (α_{HH}) and local market characteristics (γ_M):

(1) $$u(\mathbf{c}(\mathbf{z}^c), x, h \mid \alpha_{HH}, \gamma_M)$$

Semi-subsistence households meet their consumption requirements largely from own production. Their technology for crop production ($\mathbf{q}$) is defined by the expected levels of agronomic traits embodied in planted varieties (z^p), as perceived by the farmer, and a variable input, labor (l). The production function is conditioned on physical characteristics of the farm, denoted by β_F and market factors, γ_M:

(2) $$\mathbf{q}(\mathbf{z}^P, l \mid \beta_F, \gamma_M)$$

Consumption and production attributes, implicit in different plant varieties, are exogenous to the decision process. The vector of market characteristics is included in both the utility and production functions to reflect factors (e.g., transactions costs) affecting both demand and supply sides.

Household preferences are constrained by household budget limitations, depicted by the full income constraint, where **p** is a vector of crop product prices, *g* is the price of other goods, *I* is exogenous income and *M* denotes the full income:

(3) $$\mathbf{pc}(\mathbf{z}^c) + gx = \mathbf{pq}(\mathbf{z}^p) + I = M$$

The full income constraint is defined over all tradable crop products, meaning that product markets exist and households participate in market transactions for these crop products.

Input markets are often imperfect or missing, implying that production decisions are frequently motivated by endogenous shadow values of inputs. Family labor, used for production, is one example. The time constraint captures the distribution of total available household time (*T*) between production and home activities:

(4) $$T = l + h$$

The household maximizes utility subject to (2), (3) and (4). Formulating the Lagrangean and assuming interior solutions, the following first-order conditions are derived, summing separately over $i = 1,..., N$ consumption attributes and $j = 1,..., J$ production attributes:

(5) $$\sum_i \left(\frac{\partial u}{\partial c} \frac{\partial c}{\partial z_i^c} - \lambda \mathbf{p} \frac{\partial c}{\partial z_i^c} \right) + \sum_j \left(\mu \frac{\partial q}{\partial z_j^p} + \lambda \mathbf{p} \frac{\partial q}{\partial z_j^p} \right) = 0$$

Representing the Lagrangean multiplier for the full income constraint as the marginal utility of full income, $\lambda = \partial U / \partial M$, and re-arranging yields the following expression for price:

(6) $$\mathbf{p} = \frac{1}{k} \sum_i \left[\frac{\partial u}{\partial c} \Big/ \frac{\partial u}{\partial M} \right] \frac{\partial c}{\partial z_i^c} + \frac{1}{k} \sum_j \left[\mu \Big/ \frac{\partial u}{\partial M} \right] \frac{\partial q}{\partial z_j^p}$$

where $k = \sum_i \frac{\partial c}{\partial z_i^c} - \sum_j \frac{\partial q}{\partial z_j^p}$, a function of the marginal yields of consumption and production attributes in a good, respectively.

The ratios in the square brackets represent the marginal rate of substitution between consumption goods and full income and production parameters and full income, respectively. As full income equals expenditure, defined in (3), the terms in the brackets also represent the marginal implicit price of consumption and production attributes, respectively. Therefore, output prices are functions of the product of marginal implicit prices and marginal yields of consumption and production attributes embodied in goods. Marginal yields of attributes and their marginal valuations are both assumed to be constant for each unit of good (Unnevehr, 1986). Simplifying the notation:

(7) $$\mathbf{p} = \sum_i \phi_i^c z_i^c + \sum_j \phi_j^p z_j^p$$

The product price, derived from the maximizing behavior of semi-subsistence households is a function of the marginal values (ϕ) and the levels (z) of both consumption and production attributes.

Estimation Approach

The estimation approach is organized in two stages. In the first stage, a hedonic price function is estimated. The derived price for crop product a is regressed on the levels of output characteristics, including consumption and production attributes (z_i^c, z_j^p), while controlling for other market factors that may influence prices (e.g., transactions costs), denoted by γ_M, and an error term, u:

(8) $$p_a = \sum_i \phi_{ai}^c z_{ai}^c + \sum_j \phi_{aj}^p z_{aj}^p + \beta\gamma_M + u_a$$

What constitutes an appropriate functional form for the hedonic equation is a widely discussed topic in the hedonic literature. There is no rule of thumb, however, and different variable transformations and model specifications have been employed in different contexts (Cropper, Deck and McConnell, 1988; Freeman, 1993).

The marginal implicit price of output characteristics is computed by differentiating the hedonic price function (8) with respect to each attribute:

(9) $$\hat{\phi}_a = \frac{\partial p_a}{\partial z_a}$$

This relationship gives the marginal monetary value of each attribute to the household, or an increase in the expenditure on crop product *a* required to obtain one more unit of the attribute. Desired attributes are those with positive marginal valuations, i.e. $\hat{\phi}_a > 0$. Depending on the specification of the hedonic price function, the marginal implicit price of a crop product attribute ($\hat{\phi}_a$) may depend on the levels and the estimated marginal valuations of other attributes. However, while $\hat{\phi}_a$ is a measure of the marginal implicit value of a given attribute, it does not directly reveal the underlying structure of preferences that define the marginal value function for this attribute.

In the second stage of the estimation approach, the computed marginal implicit prices are regressed on the levels of attributes (**z**) and other explanatory variables (**X**), in an attempt to estimate the marginal value function for each attribute *i,j*:

$$\hat{\phi}_a = f(\mathbf{z}, \mathbf{X}) \quad (10)$$

Problems of identification and endogeneity typically encumber the second-stage estimation because the marginal implicit prices are functions of the same explanatory variables used in the estimation of the marginal value functions, namely levels of attributes. The price and level of an attribute are chosen simultaneously, where the estimated marginal value function (10) and the marginal implicit price function (9) intersect, making it difficult to separate shift effects from the price-quantity relationship (Freeman, 1993). Without correction for identification and endogeneity problems, marginal value function estimation simply reproduces the coefficients of the estimated hedonic price function without adding new information.

A feasible approach to identifying the marginal value function for an attribute is to use information on marginal implicit prices from several spatially distinct markets (Brown and Rosen, 1982; Palmquist, 1984). Marginal implicit prices are typically estimated for *m* different cross-sectional markets and then pooled together under the assumption that the underlying structure of attribute demand is the same in all markets. The pooled data is then used to estimate the marginal value function, identified by *m* points of intersection. Solving for endogeneity requires the use of truly exogenous explanatory variables as instruments (Mendelsohn, 1984; Bartik, 1987).

Data

Sample Design

The data, collected in 2003, are drawn from a geo-referenced multi-stage random sample of banana-growing households in Uganda. The sample domain spans the major banana producing areas in Eastern, Central, and Southwestern Uganda. The sample was stratified according to elevation, with a threshold of 1,400 meters above sea level. Prior biophysical information suggests that elevation is correlated with the incidence and severity of pests and diseases - factors contributing to variation in productivity and the potential yield savings associated with adoption of resistant banana varieties.

A total of 27 primary sampling units were defined at the sub-county level and allocated proportionately with respect to elevation. Secondary sampling units were defined at the village level. One village was randomly selected per sub-county. A total of 20 households with access to land were selected randomly in each village. The total sample comprises 540 rural households in Uganda, of which 517 are identified as banana growers.

Crop Characteristics

Uganda is one of the largest producers and consumers of bananas in the world. Bananas occupy the largest cultivated area among staple food crops in the country, with production taking place year round on small subsistence farms using low input, traditional farming methods. Excess production is sold in local markets with almost no international trade in the crop. Bananas is a synonym for food in Uganda and are typically prepared by steaming or cooking. Several banana varieties are consumed raw as fruit; others are fermented for the production of local beer and a few are consumed by roasting[1]. The multiple end uses of bananas, as well as binding biotic and abiotic pressures, influence the mixture and number of distinct banana varieties grown, with surveyed farmers growing up to 27 different varieties simultaneously in their groves, and a sample average of 7 varieties.

[1] Uganda is recognized as an important center of diversity for bananas. Most of the varieties grown in the country (85%) are endemic to the East African highlands and consist of two use-determined types: cooking and beer bananas. The non-endemic bananas are locally adapted varieties introduced to the country from Southeast Asia, such as certain beer and all sweet bananas. Other non-endemic types, recently introduced in the country, are hybrids from Honduras, typically considered to be multi-use varieties.

Market Participation and Banana Types

Bananas are produced for home consumption with excess production sold in local markets. Bananas are typically sold in bunches. The bulky nature of banana bunches constrains their transportation to local trading centers or urban markets. Thus, the point of sale is predominantly the farm gate. Half of the surveyed households sell banana bunches at the farm gate, with few of them also transacting at local trading centers. At the farm gate, transactions costs are typically born by buyers (middle men) and they are reflected in the level of farm-gate prices received by selling households.

The diversity of banana varieties grown on-farm is reflected in the composition of varieties sold. The majority (64%) of sold varieties are endemic to the region. Cooking varieties represent 54%, with beer varieties capturing 26% and sweet varieties representing 17% of all banana types sold, with the remaining 3% made up of multi-use and roasting banana types. While the market share for cooking banana bunches sold is comprised of 40 different varieties, each representing a different bundle of attributes, the number of beer and sweet varieties sold is 18 and 3, respectively.

Regional differences exist both in the composition and the share of varieties sold. While only half of all varieties sold in the Eastern and Central region of the country, the historical locus of banana production, are cooking types, in the Southwestern highland region three quarters of the sold varieties is comprised of cooking bananas, with 92% of bananas sold in this region being endemic. Cooking varieties thrive in the highlands because of better management practices adopted by farmers, thus leading to lower incidence of pests and because of elevation, being correlated with lower disease pressures.

The survey data reveal that households sell only a fraction of the types of bananas they grow in their groves. The ratio of the number of different varieties sold to those grown is 0.47 for the sample. While an average household grows seven different varieties, it only sells the bunches of 4 of them. This is likely indicative of household planting decisions being driven by preferences for home consumption of some varieties, with others destined for sale. Meeting household consumption requirements, rather than specializing in the production of a given variety, appears to be an objective of production and sale.

Dependent Variable

The dependent variable used in the analysis is the price elicited from farmers selling their banana bunches at the farm-gate, by variety. Variety-specific farm-gate prices were calculated using a triangular distribution of actual bunch prices received by farmers in the previous year (Hardaker, Huirne and Anderson, 1997)[2]. Price information was elicited from farmers participating in banana markets. Market price data, obtained from households who purchase banana bunches, were limited and aggregated into use groups (cooking, beer, roasting and sweet banana types). Information on farm-gate prices was much richer, since most farmers participate as sellers at the farm gate and actual farm-gate prices were elicited per type of variety sold, rather than aggregating varieties into use groups.

Moreover, farm-gate prices convey information about market transactions that take place outside of the ordinary market environments of trading centers in villages and markets in urban areas, which is particularly true in Uganda (Fafchamps and Hill, 2005). They are equilibrium prices tracing the behavior of sellers and buyers at the first link of the market chain. Unlike market prices, farm-gate prices are net of additional markups and are, arguably, more indicative of the value of implicit quality characteristics of varieties sold.

The survey data reveal differences among farm-gate prices of different varieties within use and endemic groups and across regions. Differences in average farm-gate prices are also observed across regions, and within each region, across genomic and use groups (table 1). Banana bunches from endemic varieties capture a higher farm-gate price. Endemic varieties are considered superior in terms of their cooking quality. In the Eastern region, where disease pressures have contributed to the limited availability of cooking bananas, the farm-gate price also reflects a scarcity value farmers place on endemic varieties. Across regions, cooking banana varieties, the staple food in Uganda, are highly

[2] Average farm-gate prices for each variety sold were calculated using the first moment of the triangular distribution $E[fgp] = \frac{(a+m+b)}{3}$, where a, m, b are the minimum, mode and maximum reported actual farm-gate prices received by farmers in the previous year.

valued in comparison with bananas from other use groups. The high price for roasting bananas mainly reflects the large size of bunches and fingers.

Explanatory Variables

The farm-gate price is used in a hedonic price model to derive the implicit value of banana output characteristics, as specified in equation (8). Previous participatory research was used to select output characteristics believed to influence prices. Among them are: one consumption attribute (quality) and two production traits (size of bunch, size of banana fingers). Farmers were asked to rate each banana variety they growl according to its provision of attributes (adapted from Reed et al. 1991). Farmers were found to differ in their subjective valuation of alternative bundles of attributes.

Quality is measured as a categorical variable (1 = bad, 2 = neither good nor bad; 3 = good), reflecting farmers' perceptions of the consumption attribute. Quality reflects the taste, color and softness of prepared food. Good cooking quality usually implies bad beer brewing quality. For sweet and roasting bananas, quality implies taste. A positive relationship between quality characteristics and farm-gate price is expected.

Bunch size, measured as a continuous variable (in kilograms) was calculated from subjective yields elicited from farmers as triangular distributions (Hardaker, Huirne and Anderson, 1997). The variable is constructed as the maximum expected bunch size conditional on no presence of pests and diseases. The other production trait, size of banana fingers, is measured as a categorical variable (1 = short, 2 = medium; 3 = long). The threshold for length is below 15 centimeters (for short) and above 20 centimeters (for long), as perceived by farmers. It is hypothesized that higher prices are paid for larger bunches and larger banana fingers per bunch.

All variables are defined and summarized in table 2. Variables included in the hedonic regression are output characteristics, summarized at the variety level. Time needed to travel to nearest banana market, is also included in the hedonic function to control for the effect of transaction costs on market participation. Variables used in the estimation of the marginal value function are presented at the household level. Among the variables hypothesized to affect the value function are: gender of the household member in charge of banana production, reflecting preferences for attributes; years of experience in tending for the banana grove, an indicator of acquired human capital in banana related decisions; education, as a proxy for other acquired human capital; livestock assets and exogenous income, as indicators for household wealth; household size and banana production area, reflecting consumption and production scale, respectively; the number of distinct banana varieties locally available, representing the local stock of variety attributes and time taken to get to closest banana market, as a proxy for transaction costs.

Results

Hedonic Price Function

Before estimating the hedonic price function, the data were tested for structural breaks associated with geographic location. The Chow test supports the existence of three regionally segmented markets for banana bunches[3]. Hence, three separate hedonic price functions were estimated, each reflecting a different geographic location (Eastern, Central and Southwestern regions). This allows for the identification of the marginal value function in the second stage while reducing potential problems of endogeneity. All data from the different regions were measured in the same way.

For each region (R=*1,2,3*), the hedonic price was specified as a log-linear function to allow for the joint effect of attributes on marginal implicit prices:

(11) $$\log(p_a^R) = \phi_{a1}^c z_{a1}^c + \sum_{j=1}^{2} \phi_{aj}^p z_{aj}^p + \beta\gamma_M + u_a$$

The marginal implicit price of each attribute in each region was computed as the partial derivative of price with respect to the attribute of interest:

(12) $$\hat{\phi} = \frac{\partial p_a}{\partial z_a} = \exp(.)\phi_a$$

The implicit value of each attribute is a function of the marginal implicit prices and levels of other attributes, controlling for the effects of transaction costs.

[3] The Chow test at two specified breakpoints in the data (corresponding to three different regions) yields significant coefficient estimates: at the 10% for the breakpoint between Eastern and Central region (p=0.0939) and at the 1% for the breakpoint between the Central and Southwestern region (p<.0001).

The results of the hedonic equations (summarized in table 3, by region) reveal the statistical significance of production and consumption attributes in determining the farm-gate price of banana bunches. Better (perceived) quality, bigger bunches and larger banana fingers per bunch all increase the price received by farmers at their gates. Price premiums for size and quality could have implications for farmers' preferences and the choice of varieties destined for sale. The significance of the transactions cost variable is another important result. In the Eastern and Southwestern regions, geographic isolation of farmers, relative to banana markets, increases the cost incurred by buyers at the farm-gate reducing the price farmers receive per bunch sold. Therefore, improvements in infrastructure could partially offset the transactions costs borne by buyers, having a positive impact on the farm-gate price of bananas.

Marginal Value Function

The information derived from the hedonic price functions in the three regions is pooled and then used to estimate the marginal value function for each variety attribute in a system of seemingly unrelated equations. The Breusch-Pagan test supports a system of equations estimation approach accounting for correlations across equations[4] associated with common factors influencing the value of attributes. The marginal value is expressed as a function of the levels of all attributes, thus allowing for substitute and complementary relationships among attributes, while controlling for exogenous income and preference-related variables, scale characteristics, and other exogenous factors. Results are summarized in table 4.

The marginal value of each attribute appears to be strongly influenced statistically by the levels of all attributes, exogenous income and the local stock of variety attributes, and to a lesser extent, by household/individual and market factors. Better quality increases the value of bunch and banana finger size, indicating a complementary relationship between the consumption attribute and the production traits. Consequently, popular varieties will be those that provide a set of desirable consumption and production attributes simultaneously. Exogenous income reduces the marginal value of quality and finger size,

[4] The Breusch-Pagan test strongly rejects the independence across equations (p=0.000), at the 1% level of significance.

suggesting that these are inferior goods. By contrast, higher exogenous income increases the marginal worth of bunch size, a normal attribute. This result could have important policy implications if poorer farmers are unable to afford planting material that yields larger bunches.

Among the individual characteristics, gender of the banana production decision-maker has a significant effect on the marginal value of quality and finger size. Women, who are typically in charge of food preparation, attribute greater value to quality and the size of the fruit. This has implications for adoption behavior, as often women are in charge of banana production decisions. Acquired human capital, either through formal education or experience, does not appear to influence the marginal value of attributes. Larger households place higher value on the size of the fruit rather than the size of the bunch. This finding reflects efficiencies in consumption behavior per unit of output, considering that bananas are typically sold in bunches. The scale of production also has a positive impact on finger size, which also reflects efficiencies in producing the same attribute per unit of output. Moreover, the smaller the local stock of attributes the higher the marginal value placed on each attribute, suggesting that implicit in the marginal value of attributes is a premium for attribute scarcity. Transactions costs appear to have an effect on the marginal value of quality and bunch size. The implicit price of these attributes is reduced for more isolated households, perhaps because of the greater opportunity cost of participating in banana markets. Therefore, considering the bulky nature of banana bunches, reducing transactions costs to participation in banana markets, such as improvements in infrastructure that partially reduce the implicit costs of transportation, extending the margins on price premiums for size and quality.

Concluding Remarks

This study applies the hedonic price method as a tool for generating implicit values of consumption and production traits and estimating the marginal value for specific attributes of a subsistence crop in a developing economy. The hedonic price is derived within the framework of a utility maximizing agricultural household that makes consumption and production decisions simultaneously. This is reflected in the specification of the hedonic function to account for both consumption and production attributes. By using spatially segmented information from three regions in Uganda, marginal value functions for three attributes were identified and estimated as a system.

Attributes such as quality, bunch size and fruit size are found to determine the price paid/received for bunches at the farm-gate, supporting the specification of agricultural hedonic models to include for consumption attributes and production traits (Dalton, 2004). Complementary relationships between attributes are also evident from the estimated marginal value functions. The role of exogenous income and gender on marginal valuation of attributes can have important policy implications about preferences and budget limitations to obtaining specific sets of attributes. Reducing transactions costs to participation in banana markets was also identified to lead to higher farm-gate prices reflecting larger premiums for quality and size.

The type of economic agents whose market behavior is analyzed (semi-subsistence agricultural households in a developing economy) and the use of farm-gate prices, rather than prices recorded at the market place, requires the refinement of the concept of marginal valuation. Rather than considering strictly marginal willingness to pay (a value function that traces consumer behavior) or marginal willingness to sell (a value function of producers), the marginal value function is adapted to the framework of an agricultural household. Because agricultural households make production and consumption decisions simultaneously, no clear cut separation in their value structure is readily identifiable. They possess a marginal value for attributes which is implicit in their decisions as consumers and as suppliers and as such the value function captures their behavior as an envelope of their consumption and productions motivations. This is a conceptual issue that needs further development if the hedonic price method is to be applied to issues concerning production and consumption behavior in developing economies with imperfect input markets.

The insights obtained into trait valuation could also be used to link farmer demand for traits and adoption potential, estimated with farm-level data, to industry-level models of consumer valuation of traits in urban markets. It could also be used as an input into variety selection by breeding programs, providing an insight into important attribute trade-offs, as well as in priority setting, and impact assessment.

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Table 1. Mean of average farm-gate prices (in Ugandan Shillings) across genomic and use groups, by region

	Means* (standard deviations)			
	Region			All regions
	Eastern	Central	Southwestern	
Genomic group				
Endemic	3317.82 (198.01)	1692.08 (184.68)	2098.72 (135.14)	1950.21 (189.36)
Non-endemic	664.09 (146.42)	498.19 (120.21)	973.49 (119.27)	550.14 (131.57)
Use group				
Cooking	3317.81 (200.27)	1875.32 (171.37)	2277.78 (113.75)	2137.26 (177.25)
Beer	273.14 (62.92)	525.26 (110.77)	786.97 (89.18)	523.52 (101.94)
Sweet	940.93 (184.37)	608.54 (133.71)	1016.94 (123.84)	709.96 (155.22)
Multi-use	979.28 (76.17)	458.56 (160.91)	2477.91 (91.01)	1060.20 (188.25)
Roasting	5500.00 (**)	1318.39 (161.22)	1800.00 (**)	1477.26 (142.94)

Note: *Mean values are weighted means, with weights calculated using survey sampling fractions. ** Indicates that no standard deviation exists since only one observation is recorded for this group in this region.

Table 2. Summary statistics for dependent and explanatory variables

Variable		Mean	St. D.
Hedonic functions			
Dependent variable			
Farm-gate price*	Expected price received at farm gate, by variety	1596.09	1158.52
Explanatory variables			
Output characteristics			
Quality*	Taste, softness, color (1=bad; 2=neither good nor bad; 3=good)	1.59	0.89
Bunch size*	Expected size of banana bunch (in kg)	15.57	7.14
Finger size*	Size of banana fruit (1=bad; 2=neither good nor bad; 3=good	1.89	0.68
Time to market		0.89	0.44
Marginal value function			
Dependent variables			
Implicit price of quality	Computed from first stage hedonic price function	771.24	500.04
Implicit price of bunch size	Computed from first stage hedonic price function	44.25	29.03
Implicit price of finger size	Computed from first stage hedonic price function	319.06	259.06
Explanatory variables			
Gender	Gender of household member in charge of banana production (1=male)	0.64	0.48
Experience	Years of experience of household member in charge of banana production	11.72	11.02
Education	Years of schooling of household member in charge of banana production	5.55	3.87
Livestock assets	Value of livestock owned by the household (in 10,000's Ugandan Shl)	40.08	90.49
Exogenous income	Income received in previous year (in 10,000's Ugandan Shl)	61.35	179.94
Household size	Total number of household members	5.79	2.64
Banana area	Area allocated to banana production (in acres)	1.16	1.71
Stock of attributes	Number of distinct banana varieties available in the village	24.02	5.95
Time to market	Time to nearest banana market (in hours)	0.89	0.44

Note: *The means for these variables are computed over all household-variety observations (N=886). The means of the other explanatory variables are computed at the household level (N=253 households).

Table 3. Estimation results for the hedonic price function, by region

Variable	Eastern Region	Central Region	Southwestern Region
Quality	0.6914** (7.70)	0.5710** (17.26)	0.4591** (13.43)
Bunch size	0.0362** (3.39)	0.0290** (6.03)	0.0324** (7.16)
Finger size	0.2765** (2.48)	0.3378** (7.30)	0.0749^ (1.64)
Time to Market	- 0.4089^ (-1.63)	- 0.0715 (-1.03)	- 0.2220** (-3.19)
	N=167	N=461	N=258
	R^2=42%	R^2=63%	R^2=58%

Note: t-values in parenthesis; **,*,^ denote significance at 1%,5% and 10% levels, respectively

Table 4. Estimation results from seemingly unrelated regression for marginal value functions, by attribute

Variable	Implicit Price of Quality	Implicit Price of Bunch Size	Implicit Price of Finger Size
Quality	325.9388** (38.35)	18.2636** (37.77)	141.8417** (19.97)
Bunch size	26.0931** (23.20)	1.5826** (24.74)	8.0382** (8.55)
Finger size	164.0266** (14.33)	8.5032** (13.06)	83.5727** (8.74)
Gender	-44.2569** (-2.82)	-0.0891 (-0.10)	-51.8728** (-3.95)
Experience	-0.5351 (-0.81)	0.0099 (0.26)	-0.5740 (-1.03)
Education	1.9486 (0.93)	0.1264 (1.07)	1.5086 (0.87)
Livestock assets	0.0103 (0.15)	0.0050 (1.23)	-0.1071^ (-1.80)
Exogenous income	-0.0775^ (-1.86)	0.0064** (2.71)	-0.2637** (-7.56)
Household size	1.9162 (0.67)	-0.3640* (-2.24)	10.5507** (4.42)
Banana area	7.7963^ (1.78)	-0.0165 (-0.07)	11.3739** (3.10)
Stock of attributes	-9.5435** (-7.86)	-0.2616** (-3.78)	-5.8743** (-5.79)
Time to market	-135.7582** (-7.45)	-9.2204** (-8.89)	-11.7659 (-0.77)
	N=886 R^2=82%	N=886 R^2=83%	N=886 R^2=54%

Note: t-values in parenthesis; **,*,^ denote significance at 1%,5% and 10% levels, respectively