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APPLICATIONS OF HEDONIC PRICING ANALYSIS IN AGRICULTURE: A REVIEW

A. A. Ghide*, J. M. Bukar and H. Danladi

Department of Agricultural Economics, University of Maiduguri, Borno State, Nigeria.

ABSTRACT: This study aimed to review literature on the use of hedonic pricing on agricultural products. There have been considerable number of articles published in different fields of agriculture in both developed and developing countries using the hedonic technique. The model deconstructs the price of a good into its component parts, then uses regression analysis to examine how each individual attribute uniquely contributes to the item's overall value. The review observed that in live animals, most important determinants of price were sex, age, body size and body condition and consumers would be willing to pay premium for taste, neatness and freshness in beef. In cowpea, large sized grains attracted premium, swelling capacity and colour influenced market price for rice and farm size were shown to influence farm land values. The hedonic tool is an important tool for market players, investors, consumers and policy makers as it allows the understanding of how markets operate thus increasing efficiency.

Keywords: Hedonic pricing, Hedonic analysis, Hedonic regression, Attributes, Agriculture

INTRODUCTION

Hedonic Pricing Model is an economic valuation technique that makes use of revealed preferences. Revealed preference approaches also called indirect methods of non-market valuation rely on a surrogate market that provides a behavioural trail to estimate the value of a non-market good of interest (Mungatana, 2013). That is, the non-market good is not valued directly, it is only valued through a surrogate market. Most widely used revealed preferences methods are Hedonic pricing method and Travel cost method. Other revealed preferences methods include Production function approach, Random utility model and Averting behaviour model (Bann, 2002).

Hedonic pricing model is used to estimate economic values for attributes or product characteristics that directly affect prices for products and services. It is also widely used to evaluate the effects of changes in quality on prices of heterogeneous commodities (Dwyer *et al.*, 2012). Goods' attributes, rather than the goods themselves, have been postulated to determine the preference structure of individuals (Lancaster, 1966). Most goods have a variety of characteristics that are positively or negatively valued by consumers in the market, such goods are referred to as composite goods (Gilbert, 2013). For example, the characteristics of a farm land that contribute to (or detract from) its value would include the size of the land, soil quality, availability of water in the area (for irrigation) and proximity to roads. A well-specified hedonic model will estimate the contribution to the total price of each of these features separately. It deconstruct the price of a good into its component parts, and then use some form of regression analysis to examine how each individual attribute uniquely contributes to the item's overall value (Sopranzetti, 2015). This technique also helps to determine which attribute(s) most significantly impact the price (Monson, 2009). This will enable producers to produce the right amount of attributes that would receive price premium and reduce those that are expected to be discounted.

Market prices (explicit price) reflect the value of goods as bundles of attributes (Edmeades, 2005). The explicit price of a product is observable in the market, and is composed of the aggregated values of these characteristics. The implicit (marginal) prices of the characteristics of products are not readily observable in the market because the attributes are not bought and sold independently; they are embodied in the product. These implicit prices however, may be determined by regressing the product's price against its attributes and then differentiating the resulting equation with respect to each attribute. Statistically derived implicit prices indicate the average marginal price of each attribute at

*Corresponding author: asmaughide@gmail.com Phone: +234 706 1319100

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each attribute level, *ceteris paribus*, thus determining the average price of each attribute as observed in the specified market (Brown *et al*., 1995). Hedonic pricing approach have over the past four decades become the most relevant technique for dealing with heterogeneity in valuation of goods (Ramalho and Ramalho, 2011).

Applications of the hedonic price method are vast in housing and automobiles to agricultural products as agricultural markets provide many opportunities to value outputs and inputs with non-tradable attributes (Richards and Jeffrey, 1995; Edmeades, 2005). Hedonic pricing approaches have been used to estimate the value of characteristics for a variety of agricultural products in both developing and developed countries. The hedonic price model has been the most widely used technique to empirically estimate the prices of quality attributes of agricultural commodities (Obih and Baiyegunhi, 2017). First use of Hedonic pricing approach in Nigeria was by Megbolugbe in 1986 although in property appraisal research (Abidoye and Chan, 2017). It is presently gaining popularity in agriculture. Understanding consumer perceptions for the attributes or characteristics associated with the price of a product that a consumer is willing to make an extra payment for and those that are irrelevant in the determination of consumer choices and preferences are important in pricing. This paper focuses on the use of Hedonic pricing in agriculture, its advantages and limitations.

Concepts in Hedonic Study

Hedonic models, hedonic functions, Hedonic pricing, Hedonic regressions are common terms in Hedonic studies and are sometimes used interchangeably. Hedonic models are general equilibrium frameworks that characterize the pricing of differentiated goods, viewed as bundles of attributes, in addition to the demand and supply of those goods (attributes) under different assumptions about preferences and technology. They allow for a systematic economic analysis of the demand and supply of quality which includes enhancement of the attributes of a good embodied in a unit of the good, characteristics of a job or the amenities offered by an environmental or recreational improvement (Heckman *et al*., 2005).

A hedonic function is a technical relationship between the prices of different varieties of a product and the quantities of characteristics in them. The hedonic function contains, therefore, both prices and quantities. These characteristics prices and quantities are almost like other conventional prices and quantities for goods. The hedonic function disaggregates the complex good itself into a bundle of constituent prices and quantities (the characteristics), where the characteristics are the true economic variables for both buyers and sellers (Triplett, 2004).

Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them (Rosen, 1974). Ethridge and Davis (1982) also gave a similar opinion. They defined Hedonic prices as the implicit prices of attributes or characteristics embodied in a commodity as opposed to the price of the commodity itself. Attributes can be classified in a number of ways. Attributes are product characteristics that are either intrinsic, like taste, texture, colour, or extrinsic to the product, like packaging, brand, label. Another attribute classification distinguishes between search, experience and credence attributes. Search attributes are available for product evaluation before purchase such as price, appearance, brand and packaging. Experience attributes can only be evaluated upon product experience after purchase or product use such as taste and texture. Credence attributes are attributes that consumers cannot evaluate or verify themselves but put trust in peoples or institutions claim, such include attributes relating to production, processing and product contents (Lancaster, 1966; Triplett, 2004; Rutsaert *et al*., 2013). A hedonic regression equation treats these attributes (or bundles of attributes) separately, and estimates prices (in the case of an additive model) or elasticity (in the case of a log model) for each of them (Sopranzetti, 2015).

Theoretical Foundation

The first formal contributions to hedonic price theory were those made by Court in 1941 although earlier informal works by Hass in 1922 and Wallace in 1926 had the same concept (Sopranzetti, 2015). Court introduced the term "hedonic" which is derived from the Greek word h*edonikos*, which simply means pleasure. In the economic context, it refers to the utility or satisfaction one derives from the consumption of goods and services (Chau and Chin, 2002). In the years that followed Court's work, empirical works using hedonic modelling techniques such as Griliches (1961) were published but Lancaster (1966) was the first attempt to create a theoretical foundation for hedonic modelling. Lancaster postulates that it is not necessarily a good itself that creates utility, but instead the individual characteristics of a good that create utility. Specifically, an item's utility is simply the aggregated utility of the individual utility of

each of its characteristics. Furthermore, he argues that items can be arranged into groups based on the characteristics they contain. Consumers make their purchasing decisions within a group based on the number of characteristics a good possesses per unit cost. Although Lancaster is the first to discuss hedonic utility, he says nothing about pricing or pricing models. Rosen (1974) was the first to present a theory on hedonic pricing. Rosen argues that an item can be valued as the sum of its utility generating characteristics; that is, an item's total price should be the sum of the individual prices of its characteristics. This implies that an item's price can be regressed upon the characteristics to determine the way in which each characteristic uniquely contributes to the price. The Lancaster's model and Rosen's model are the two main approaches that contributed greatly towards the theoretical work on hedonic pricing.

Estimation Approach

The estimation is organised in two stages (Rosen, 1974; Brachinger, 2002; Melichar *et al*., 2004; Edmeades, 2005). In the first stage, a hedonic price function is estimated. The derived price of product **a** is regressed on the levels of the product characteristics (x), including consumption and production attributes, while controlling for other market factors that may influence prices:

$p_{a} = f(x)$ …….. (i)

Where: Pa = Price of product a, f = functional relationship, x = product characteristics

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

$\frac{dp}{dx_k}(x) = \frac{df}{dx_k}(x) = \phi a$……... (ii)

(k = 1,……n number of attributes)

This relationship gives the marginal monetary value of each attribute of the product, or an increase in the expenditure on product **a** required to obtain one more unit of the attribute. Desired attributes are those with positive marginal valuations, i.e

$\frac{dp}{dx_k}(x) > 0$ …… (iii)

This function could be linear or non-linear. The prices may change at an increasing or decreasing rate when the characteristics change. Depending on the specification of the hedonic price function, the marginal implicit price of a product attribute may depend on the levels and the estimated marginal valuations of other attributes. However, while $\frac{dp}{dx_k}(x)$ 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, the implicit prices are regressed against the actual characteristics chosen by consumers in order to obtain the marginal willingness to pay for the attribute. The results of this analysis will indicate the changes in product values for a unit change in each characteristic, given that all the other characteristics are constant. Some variables however may be correlated. This will result in similar changes in their values. In other words, the computed marginal implicit prices are regressed on the levels of attributes (**x)** and other explanatory variables (**z**), in an attempt to estimate the marginal value function for each attribute *i,j*:

$\phi_{a} = f(x, z) + u$ …… (iv)

A linear form of the hedonic approach using (iv) is presented as:

$pa = \beta o + \sum_{k=1}^{k} \beta_k x_k$ …… (v)

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With hedonic prices $\frac{dp}{dx_k} = \beta_k$ …… (vi)

The regression coefficient β_k (k = 1,…,n) indicates the marginal change of price with respect to a change of the k[th] characteristic x_k of the good (product).

A double log approach is presented as:

$\ln p = \ln \beta o + \sum_{k=1}^{k} B_k \ ln \ x_k$ ……. (vii)

With hedonic prices $\frac{d_p}{dx_k} = \frac{\beta_k}{x_k} p$ …… (viii)

Here, the regression coefficients can be interpreted as partial elasticities. The coefficient β_k (k = 1,…,n) indicates how many percent the price p increases at a certain level if the k[th] characteristic x_k changes by one percent.

The first stage develops a measure of the implicit price function, but does not directly reveal the inverse demand function. The second stage estimation is to identify the inverse demand function (the marginal willingness to pay function), derived from the implicit price function estimated in the first stage. 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 and the marginal implicit price function intersect, making it difficult to separate shift effects from the price-quantity relationship. 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. Marginal implicit prices are typically estimated for 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. Solving for endogeneity requires the use of truly exogenous explanatory variables as instruments.

Empirical Issues

A major empirical issue pertaining hedonic price model is the choice of functional form (Chau and Chin, 2002). An incorrect choice of functional form may result in inconsistent estimates. The theory of hedonic pricing provides very little guidance on the choice of the proper functional form despite having a long history. Rosen's model does not, *a priori*, specify a particular functional relationship between the attributes and commodities, although he adopted the "goodness-of-fit" criterion, and this is widely used in empirical studies. The most widely used functional forms are linear, semi-log, double log and the Box-Cox transformation. As the hedonic price model deals with the implicit prices of quantities of attributes of a product, the problem of misspecification of variables is inevitable (Gilbert, 2013). Misspecification is a situation in which an irrelevant independent variable is included (over-specification), or where a relevant independent variable (attribute of a product) is omitted (under-specification). Over-specification gives estimated independent variables that are both unbiased and consistent, but inefficient because of the inclusion of the irrelevant variable, whereas under-specification results in estimated coefficients that are both biased and inconsistent. To avoid misspecification, models that use a small number of key variables generally would suffice. Also, measurement errors may also arise if proxy variables are used in the hedonic price model when actual data is unavailable (Chau and Chin, 2002). Consequently, the results generated will be biased and inconsistent. Finally, multicollinearity can lead to inefficient estimates (Triplett, 2004). If some variables are collinear then separate equations for each may need to be stated otherwise implicit prices will be difficult to entangle. For instance, it may be the case that large farmlands are only found in rural areas with low pollution, and small farmlands are in urban areas with high pollution. In this case it would be impossible to separate out pollution and farmland size accurately.

Advantages of Hedonic Pricing Approach

The hedonic approach offers insight into the economics of variety and heterogeneity in product quality which is a hallmark feature of modern economies. It offers a consistent approach to adjusting price indices for quality and

allowing for valuation of new goods (or environmental offerings) that can be viewed as new packages of old attributes (Heckman *et al*., 2005). The method's main strength is that it can be used to estimate values based on actual choices. It is versatile; it can be adapted to consider several possible interactions between market goods and non-market goods e.g environmental quality, transport benefits. It can be applied to any commodity that has definable, differentiable quality characteristics. One needs to have only certain information such as the price of the good, the composition of attributes, and a proper specification of the functional relationships for estimation of a hedonic function (Brown *et al*., 1995). The marginal implicit prices as well as the willingness to pay for are obtained simultaneously by estimating the parameters of the hedonic price function. It is a straightforward approach because only the coefficients of the estimated hedonic regression are needed to indicate the preference structure. The hedonic price approach has an advantage over other valuation techniques as it does not require joint consumption of goods within a group. Therefore, the inverse demand of specific goods individually can be estimated rather than modelling the whole system of demand and supply (Ochieng, 2010).

Limitations of Hedonic Approach

Hedonic pricing does not always incorporate external factors or regulations such as taxes and interest rates, which could also have a significant impact on prices. The model requires that all individuals have prior knowledge of the potential positive and negative externalities that are associated with the product (perfect information) which is unrealistic (Bann, 2002). It also assumes that market prices adjust immediately to changes in attributes. In reality there will likely be a lag in price transmission between interlinked markets, especially in areas where product sales and purchases are rare. Finally, the model requires a high level of statistical knowledge and expertise for interpretation (Gebreselassie, 2015).

Empirical Reviews

Many studies have been conducted to estimate the price of product attributes in agriculture using hedonic techniques both in developing and developed nations. Bett *et al*. (2011) used Hedonic price analysis to determine indigenous chicken attributes that will guide in breeding and production of indigenous chicken in Kenya. The model used in the study was log transformed. Attributes such as weight, body size, plumage colour, general body condition and sex of the chicken significantly influenced the price. Other important factors were the sex of the trader, transportation costs, number of traders and the presence of market information. In a study on chicken by-products, Karipidis *et al*. (2005) used hedonic pricing approach to examine retail egg prices in Greece which was highly differentiated. The objective was to identify the product attributes that affect egg prices. Egg retail price was studied in relation to product attributes, production and distribution methods, and packaging. The model for the study was estimated using linear form. Findings revealed that the retail price was influenced by specific natural attributes of eggs indicative of their quality. The main attributes that positively affect the retail price of eggs are egg size, omega 3 enrichment, poultry feeding system (i.e. organic and free-range feeding methods) and package appearance.

A study on hedonic pricing of Atlantic cod considering the effects of size, freshness and gear in the Northeast United States from 2005 to 2011 was carried out by Lee (2014). The hedonic price model was used to estimate premium price. It was reported that the largest cod received premium prices that are approximately 0.20 per pound lower than fish in the next largest market category. For freshness, cod caught on trips that last four days receive 0.04 less per pound than fish caught on shorter trips. The discount rises to nearly 0.15 per pound for trips lasting 10 days or longer.

Gebreselassie (2015) studied hedonic price analysis of indigenous sheep and goats traits in two districts (Atsbi-Wemberta and Adwa) of Eastern and Central Tigray, Northern Ethiopia. Using a simple linear model, the study observed that phenotypic traits of traded indigenous sheep and goats were important determinants of prices than buyers' and sellers' attributes or other factors. The most influential sheep traits in determining the prices paid in the studied markets were age, body size, body condition and tail size. On the other hand, the most influential determinants of goat traits were sex, age, body size and body condition. Similarly, in Lagos State, Nigeria, age and body weight were found to be significant characteristics influencing sheep and goat prices (Akinleye *et al*., 2005).

Lawal *et al*. (2016) carried out a hedonic price analysis of characteristics influencing cattle prices in Ngalda livestock market in Yobe State, Nigeria. The hedonic regression showed that female cattle, carcass size, length of horn and height were found to be significant determinants in cattle price. Buyers would willingly pay more premiums for any unit increase in these variables.

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In studying the beef market in Benin Metropolis, Nigeria, Ojogho *et al.* (2013) used the hedonic framework to calculate the implicit demand for beef and the implicit or shadow price of beef. A linear form of the model was adopted in the study. The results of the Hedonic analysis showed that, with an average unit price of ₦836.57 per Kg for beef, consumers were strongly willing to pay additional ₦229.27 for beef with good taste, ₦227.10 for neat beef, ₦163.05 for beef of 'proper' processing style and ₦380.21 for fresh beef. Similarly, consumers were willing to pay additional ₦110.70 for properly packaged beef and ₦139.11 for beef processed in a hygienic environment. Thus a consumer in the study area will willingly pay about twice the normal price for a Kg of beef if he requires beef with good taste, neat, fresh, proper processing style, properly packaged in a hygienic environment. Other consumers who are keen on the modern processing style for beef production will pay an additional ₦163.05 per Kg which amounts to about ₦1,700.00 per Kg of beef while others who possibly value modern processing style, in addition to well-packaged beef from a hygienic environment, will pay additional ₦249.81 per Kg which amounts to ₦1,900.00 per Kg of beef.

A study on consumer preferences for quality characteristics along the cowpea value chain in Nigeria, Ghana and Mali by Mishili *et al*. (2009) also used hedonic pricing method to estimate premiums and discounts. The results of the study indicated that cowpea consumers were willing to pay a premium for large cowpea grains. Cowpea consumers discount grains with storage damage from the very first bruchid hole. The impact of price on other cowpea quality characteristics such as skin color, texture, and eye color varies locally. Consumers paid more for black eye colour than other eye colours in Ghana and Mali. Rough skin texture was discounted in Ghana and Nigeria while white skin colour was discounted in Ghana, Mali and Nigeria. In a similar study in Nigeria, Ibrahim *et al*. (2013) investigated consumer preference of cowpea attributes in Kontagora market, Sabon wuse market and Minna market in Niger State. The result revealed that consumers were willing to pay a premium for additional unit of grain weight at ₦0.96; rough testa texture at ₦40.64 and white eye color at ₦21.42 and ₦11.90 from different markets estimated. On the other hand, consumers discounted prices for bruchid hole damage at ₦1.00, white testa color in Kontagora market at ₦17.73; ₦40.90 in Sabon Wuse market and ₦46.66 in Minna market. Ifegwu and Ajetomobi (2014) reported that eye colour was the most important determinant of cowpea market prices in Osun State, Nigeria. Attributes such as brown colour and large grain size command a clear premium and consumers discount prices for insect damage in most markets.

Obih and Baiyegunhi (2017) conducted a study in the Federal Capital Territory (FCT), Nigeria on implicit price estimation of quality attributes influencing rice prices and choice decisions of consumers using a Hedonic model. The study revealed varying prices paid for rice attributes. Respondents paid an average of ₦10,416 and ₦7,567 for a 50 kg bag of imported and local rice brands respectively. Quality attributes contribute about 48-52% of the prices consumers paid. High swelling capacity, whiter after-cook color, neatness, and grains separateness mostly influenced market price of imported rice as consumers paid a premium of ₦326, ₦320, ₦158 and ₦122 respectively on these quality attributes. Dalton (2004) determined the combination of production and consumption characteristics that best explain the willingness for farmers to pay for new upland rice varieties in West Africa. Using a quadratic functional form, the hedonic household model determined five traits that explain the willingness to pay for new rice varieties: plant cycle length, plant height, grain colour, elongation/swelling and tenderness. Yield was not a significant explanatory variable of the willingness to pay for seed.

The value of marginal changes in the characteristics of farmland in England and Wales using Hedonic price analysis was studied by Maddison (2000). The study revealed that structural attributes such as cottages per acre, number of bedrooms per acre are highly significant and very important determinants of farm land prices. Non-production characteristics of farmland such as size of plot, population density, and soil quality also exert a significant influence on price while average elevation significantly reduces farm land values. Ehirim *et al.* (2017) also used the hedonic pricing approach to study farm land values in Imo State, Nigeria. Taking double-log as the lead equation, farm size, output/yield and productivity were revealed to influence land values positively.

CONCLUSION

This paper provides an overview of the theory and estimation of the hedonic pricing approach. Hedonic pricing models deconstruct the price of a product into the prices of the product's individual attributes and shows the contribution of each attribute to the products overall price. For live animals, the most important determinants of price were shown to be sex, age, body size and body condition and consumers would willingly pay premium for taste, neatness and freshness in beef. In cowpea large sized grains attracted premium and swelling capacity and colour influenced market price for rice, while farm size was shown to influence farm land values. Although not without limitations, the hedonic

technique is a useful tool in valuation of agricultural products. This technique can be used by producers, breeders and traders in promoting desired attributes and discouraging unwanted ones so as to enhance production and marketing.

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