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Hedonic Analysis of Residential Housing Market in a Third World City: A Preliminary Investigation

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Abstract: Quite a large number of housing studies have been estimated with hedonic pricing methodology with majority of these studies imposing a priori restrictions on the functional form. However, estimating the composite housing price through imposition of a prior restriction may lead to model misspecification, erroneous and inconsistent estimates. In specifying a model, it is germane to derive information from the data itself instead of imposing an untested restriction in advance. It is against this backdrop that this study estimated the relationship between housing price and its associated characteristics using a flexible model of Box-Cox transformation framework without a priori restriction. With this framework, the importance of structural housing characteristics that were more pronounced than any other housing traits was revealed. Therefore, it is important for both public and private operators in the housing market to give preference to structural, neighbourhood and locational characteristics of housing since they have great influence on housing price.

Key words: Hedonic pricing methodology, Box-Cox transformation, housing price, preliminary investigation

INTRODUCTION

Housing has been viewed as an economic good that is highly complex in nature and characteristics (Beyer, 1965; Demko and Briggs, 1971; Englund *et al*., 2002). It is the structure, design and built-in-equipment (such as the amount of space, the heating, lighting, sanitary and similar facilities) of dwelling (Agbola, 2005; Ogunjumo and Olatubara, 1997; Odumosu, 1999). Otegbulu (1996) assert that housing includes the layout and equipment of the neighbourhood such as the open space, streets, walks, utilities, nursery and elementary schools, shops and other neighbourhood facilities. This shows that housing encompasses the immediate environment, sanitation, drainage, recreational facilities and all other economic and social activities that make life worthwhile. However, unlike other consumption goods, the housing market is unique because it manifests the characteristics of durability, heterogeneity and spatial fixity.

In spite of these characteristics and conceptualizations of housing and given the fact that it constitutes one of the most basic human needs apart from food and clothing, the supply of which is still far less than demand; suggesting the inelastic supply of housing (Court, 1939; Case *et al*., 2005). Thus to model this differentiation effectively, hedonic pricing model has been introduced in the literature. The hedonic price model posits that goods are typically sold as a package of inherent attributes (Rosen, 1974) The hedonic technique was first suggested by Court (1939) and implemented by Griliches (1961) and further elaborated by Rosen (1974). According to Triplett (2004), hedonic methods were developed and employed in price indices. Lancaster (1966)'s consumer theory and the Rosen (1974)'s model greatly contributed towards the theoretical research on hedonic prices. Both of these approaches aimed to impute prices of attributes based on the relationship between the observed prices of differentiated products and the number of attributes associated with these products.

Thus from the theoretical perspective, Hedonic pricing theory. In its simplest form, the hedonic model can be used to decompose housing and neighbourhood attributes that are capitalized into housing prices. By implication, it does not assume that a house's quality remain constant overtime therefore, it explicitly estimates prices for the attributes that determine house quality. In effect, the hedonic method is an equilibrium approach in product differentiation implying that the value of a dwelling unit is a function of the value of its physical characteristics (such as size) as well as the characteristics of its neighbourhood and amenities available in the area. Equalizes peoples' residential choice preference to their demand for housing characteristics which includes among others: structural factors (such as lot size, average room size, number of bedrooms, ground floor space); neighbourhood factors (i.e., pollution, school quality, recreational facilities and security) and locational attributes (for instance, average distance to Central

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Business Districts (CBDs), average distance to hospitals and airports). These characteristics indicate that influential factors of housing price are very complicated and closely related to housing characteristics. Earlier studies measured the volume of housing services as housing expenditure but essentially ignore the heterogeneity and for large policy purposes, the distribution of housing consumption into qualitatively different categories is of more interest than an aggregate qualitative measure of housing alone.

Quite a large number of these studies that has been conducted on hedonic pricing model have always assumed a prior a particular functional form prior to estimation (Quigley, 1985; Rosen, 1974; Arimah, 1992; Selim, 2008). Smith and Huang (1995) in their meta-analysis study also showed that hedonic approach is sensitive to model specification which may account for the mixed results in various studies.

Thus, estimating the composite housing price through imposition of a prior restriction may lead to model misspecification, erroneous and inconsistent estimates.

In specifying a model, it is germane to derive information from the data itself (data-based model specification) instead of imposing an untested restriction in advance. In addition, most housing studies conducted so far employing hedonic method as their main methodological tool having macroscopic focus and were conducted at the district or metropolitan level. This is likely to cause estimation problem because wide variations in the many attributes of properties in the same district may introduce too much noise in the model.

This study is therefore, interested in examining the relationship between housing characteristics and housing price in Lagos residential housing market using a flexible method of Box-Cox transformation framework for choosing the appropriate functional form rather imposing a prior a more restricted functional form at the onset.

MATERIALS AND METHODS

Data sources: The major source of data for the hedonic pricing analysis in this study is from the survey conducted by the Lagos state government through Central office of statistics and ministry of economic planning and budget in collaboration with the World Bank in 2006. The number of respondent samples used for the study was 6000 which were randomly selected across the 20 local government areas in Nigeria.

The 6000 samples were divided into equal parts. The first half of the sample size was scientifically selected using Probability Proportional to Size (PPS) of the populace and the other half was divided equally (ES) among the entire local government areas. The 2 values were added to arrive at the actual sample size.

Model specification: In capturing the relationship between housing price and its characteristics as espoused in the hedonic pricing theory, we then specify hedonic price function of the general form as follows:

$$\text{LogP} = \text{Constant} + \alpha_i(X_i) + \alpha_2(Y_i) + \varepsilon_i \quad (1)$$

Where:

P_i = Either rental or a house value
X_i = A vector of characteristics of the house structure
Y_i = A vector of its neighbourhood characteristics

This classical hedonic price model poses a relationship between housing prices and traits. The housing traits can be classified into three categories: structural traits denoted by S; neighbourhood traits denoted by N and locational traits denoted by L. Thus, the market prices of housing dented by H vectors where h is any units of H are generally expressed as:

$$P_{hi} = P_h(S_{ij}, N_{ik}, L_{im}) \quad (2)$$

The structural traits consists of roofing materials, walling materials and water sources while the neighborhood traits as identified in the survey are waste disposal methods, security services and pollution and locational traits also are distance to employment, public transports and water supply. In the light of the above, the researchers, therefore specified the empirical model of hedonic pricing for estimation as follows:

$$\begin{aligned}\text{Log}(P) = {} & \Phi_0 + \Phi_1 \text{Roofing\_Mat}_{ij} + \\ & \Phi_2 \text{Toilet\_fac}_{ij} + \Phi_3 \text{Water\_s oc}_{ij} + \\ & \Phi_4 \text{Waste\_disp}_{ij} + \Phi_5 \text{Security}_{ij} + \\ & \Phi_6 \text{Distance\_emply}_{ij} + \Phi_7 \text{Distance\_} \\ & \text{pubtran}_{ij} + \Phi_8 \text{Distance\_watssp}_{ij} + \varepsilon_{ij}\end{aligned} \quad (3)$$

Estimation of the implicit prices of the hedonic prices can be done by regressing market values of house prices P, measured as rents as a function of various housing attributes such as what we have in Eq. 3. Since, the researchers do not have any prior notions about the shape of the hedonic functions the researchers estimate alternative forms of Box-Cox transformations. The researchers estimate the general Box-Cox functional forms given:

$$P(Z)^{(\tau)} = \delta_0 + \sum_{i=1}^{k} \delta_i Z_i^{\lambda_i} + 0.5 \sum_i \sum_j \theta_{ij} Z_i^{\lambda_i} Z_j^{\lambda_j} \quad (4)$$

$$P(Z)^{(\tau)} = [(P(Z))^{(\tau)} - 1)]/\tau \quad (5)$$

$$Z^{(\lambda_i)} = (Z^{(\lambda_i)} - 1)/\lambda_i \quad (6)$$

Where:

ß's = The market determined parameters

λ = A parameter used to transform housing characteristics to do Box-Cox transformation

τ = Transformation parameter for rent (P)

Non-linear methods are used to find optimal values of transformation parameters. The study employs a Box-Cox transformation to transform the specification in Eq. 4 and the Box-Cox obtains the maximum likelihood estimates of the parameters according to:

$$\frac{y^{\theta} - 1}{\theta} = \alpha + \sum \beta_k \frac{x_k^{\lambda} - 1}{\lambda} + \sum \delta_j Z_j + \varepsilon \quad (7)$$

where, $\varepsilon \sim N(0, \sigma^2)$ and $\theta, \lambda \in (-\infty, +\infty)$. The dependent variable y is transformed by the parameter and each of the independent variables x_k is transformed by the same parameter λ. The transformed variables must be strictly positive to be defined for all values of θ and λ. Thus, variables that have negatives values or contain zeros such as dummy variables are not transformed.

Since, Box-Cox embeds several standard functional forms, estimating θ and λ allows us to test these functional forms without them a priori on the data. In particular when $\theta = \lambda = 1$, then Eq. 7 becomes linear. When $\theta = \lambda \to 0$, the transformed elements of Eq. 3 become log-linear. Finally when $\theta = \lambda = -1$, the transformed elements of the regression become the multiplicative inverse specification. Another benefit to be derived from using the Box-Cox transformation is that it makes the residuals more closely normal and less heteroskedastic.

RESULTS AND DISCUSSION

Table 1 shows the results of Box-Cox transformation. The estimate for lambda (λ) equals -0.4818 for the specification. The likelihood tests show that the linear, log-linear and multiplicative inverse specifications are strongly rejected across all the specifications. This simply provides compelling support for using the Box-Cox model rather imposing a particular specification from the outset. The initial model covered all of the variables of interest as identified in the housing literature and of which the selection of the variables are based and then the most insignificant ones were removed from the model until parsimonious model is achieved. This simply suggests estimates of hedonic price model. In Table 2, it is clear that most of the housing characteristics variables are highly significant given their t-statistic and probability values. Apart from this, it is also observed that the sign of the coefficients are consistent with the a priori expectations.

Analysis of structural characteristics: The type of roofing material is said to contribute greatly to hedonic price of the house, such that corrugated roof increases house rent by 0.089 units compared to cement roof, tile roof and asbestos which increase the rent by 0.062, 0.013 and 0.026, respectively. This suggests that houses roofed by corrugated roofing sheets attract more house rent than house roofed either by tiles or asbestos as the case may be. The availability of toilet facilities also contribute to increased house rent depending on the degree of sophistication.

From the result, it is observed that the flush to piped sewer system increases house rent more than any other type of toilet facilities available for instance, it increases house rent by 0.0177 compared to flush to septic tank which is 0.0150, flush to pit is 0.0541, composting is 0.0041, VIP/pit latrine with slab is 0.0096, covered pit is 0.0053, uncovered pit is 0.0038 while pail is 0.0121. House rent tends to reduce if there were no toilet facilities by -0.0103.

What can be said at this point is that irrespective of the toilet facilities that are made available by house owners, it would not prevent increase in the housing rent. A possible explanation for this can be likened to the problem of overpopulation that is associated with lagos metropolis which accommodates immigrants from other parts of the country. The source of water is another contributory factor to the price of rented houses. Water from pipe borne is mostly preferred and highly sought

Table.1: Result of Box-Cox transformation values

MRENT	Coefficient	SE	Z	P>[Z]
Lambda(λ)	-0.4818027	0.0560678	-8.59	0.000
Test H0:	Restricted Log Likelihood	LR Statistic χ^2		P-valueProb>χ^2
$\Delta = -1$	-1933.8130	86.12		0.000
$\Delta = 0$	-1929.7174	77.93		0.000
$\Delta = 1$	-2345.2825	909.06		0.000

source of water hence, it implicitly accords higher value to a house through increased rents. What can be inferred from the result is that regardless of source of water, increase in house rent still occurs at different rates depending on the type and location of the house. It is interesting to note that all these water source type have the expected signs and they are all statistically significant.

Analysis of neighbourhood characteristics: Neighbourhood characteristics constitute another important component of hedonic housing price of which waste disposal source is an important element of these characteristics. PSP which represents wastes collected by the government bears the expected sign with housing rent. Availability of this waste disposal method adds to house rent by 0.0022, though it is insignificant. Unlike dumping refuses in an unauthorized places which has a negative sign but significant at 5% level of significance. This means that having refuses dumped on the ground tend to reduce house rent. The same arguments go for dumping refuse within a compound and other dump site might likely reduce the rent charged on house. Provision of either government or community security also has direct relationship with house rent. That is, there is one-to-one relationship between provision of security services and house rent. Though, both have expected signs but only that of government security is significant at 10% level of significance.

Analysis of location characteristics: Location characteristic is another important element in a hedonic pricing model. It is obvious from the results that distances from household head employment/workplace, public transportation system and supply of water exert positive impact on housing rents particularly if such distances lies within the time range of 0-44 min. House rents might get reduced if the distance is >45 min as can be observed from the results. For instance, the house rent decreases by 0.0023 for houses whose distance coverage to household head workplace is >60 min; even at that point it is only significant at about 10% level of significance. This reason that could be adduced for is that there are places in lagos that are very remote to the main city yet this will not reduce such places to being labelled as rural area. At such people can live and secure an apartment in any part of the city since, they are linked up with well road network and other social amenities.

Due to this reason, rent of accommodations still go for the same price with that in main city but with some slight differences. A different picture emerges in the case of distance to public transportation. A distance of 0-14 min increase house rent by 0.0048 but the rent would be reduced immediately the distance coverage extends beyond 15 min. This is confirmed by the value of t-statistics of -2.50 and -3.24 as can be shown in the Table 2. Locating is another important criterion that is often considered before such decision is eventually taken. Proximity to water source is equally as important as it

Table 2: Results of Box-Cox hedonic estimation –dependent variable is monthly house rent

	Structural characteristics		
Roofing materials type	Coefficient	T-statistics	Probability value
Corrugated_roof	0.089(0.0090)	3.62***	0.002
Cement_roof	0.062(0.0081)	2.72**	0.008
Tile_roof	0.013(0.0053)	2.15**	0.020
Asbestos	0.026(0.0060)	2.33**	0.004
Toilet facilities			
Flushpipe	0.0177(0.0028)	6.25***	0.000
Flush_septic	0.0150(0.0028)	5.40***	0.000
Flush_pit	0.0066(0.0027)	2.39**	0.017
Composting	0.0041(0.0021)	2.45**	0.014
Vip_pit	0.0096(0.0030)	3.24***	0.001
Covered_pit	0.0053(0.0027)	1.93*	0.054
Uncovered_pit	0.0038(0.0029)	1.30	0.195
Pail	0.0121(0.0057)	2.11**	0.035
No_toilet	-0.0103(0.0051)	-2.00**	0.046
Water source			
Pipebor_water	0.0561(0.0258)	2.17**	0.008
Public_water	0.0451(0.0255)	1.77*	0.077
Borehole	0.0462(0.0254)	1.82*	0.069
Well_water	0.0455(0.0254)	1.80*	0.071
SSvendor_water	0.0450(0.0254)	1.77*	0.076
Tanker_truck	0.0425(0.0254)	1.72*	0.090
Other_water	0.0440(0.0254)	1.73*	0.083
Neighbourhood characteristics			
Waste disposal source			
PSP	0.0022(0.0028)	0.78	0.437
Dump_ground	-0.0102(0.0032)	-3.16***	0.002
Truck_push	0.0017(0.0028)	0.59	0.557
Comp_dump	-0.0017(0.0037)	-0.46	0.646
Others_dump	-0.0029(0.0041)	-0.71	0.480
Security services			
Com_Pol	0.0009(0.0010)	0.83	0.404
Gvt_Pol	0.0027(0.0014)	1.93*	0.054
Locational characteristics			
Distance to employment (mins)			
Distemployd 0_14	0.0008(0.0012)	0.64	0.519
Distemployd15_29	0.0015(0.0012)	1.24	0.213
Distemployd30_44	0.0003(0.0013)	0.24	0.808
Distemployd60_abv	-0.0023(0.0013)	-1.74*	0.082
Distance to public transport (mins)			
Dispubtrans0_14	0.0048(0.0025)	1.94*	0.052
Dispubtrans15_29	-0.0078(0.0025)	-2.50**	0.002
Dispubtrans30_44	-0.0091(0.0044)	-3.24***	0.000
Distance to water supply (mins)			
Diswat0_14	0.0064(0.0049)	-1.31	0.189
Diswat15_29	-0.0062(0.0051)	-1.22	0.224
Diswat30_44	-0.0121(0.0056)	-2.17**	0.030
Diswat60_abv	-0.0235(0.0061)	-4.57***	0.000
Constant	1.9851(0.0302)	65.74	0.000
Lambda(?)	-0.4818	-	-
S.E	0.5601	-	-
Log likelihood	-1890.75	-	-
LR Chi-squared	175.80	-	-

Standard errors are in parentheses; (*) the coefficient is statistically significant at 10%; (**) the coefficient is statistically at 5%; (***) the coefficient is statistically significant at 1%

increases house rent for the distance ranges between 0-14 min. Beyond this range, a declining house rent may ensue.

CONCLUSION

This study uses the hedonic pricing model in estimating residential housing market in Lagos State, Nigeria. The findings revealed the importance of structural housing characteristics more pronounced than any other housing traits. The findings of this study is important both in the planning and management of urban cities because of its capability in assisting the policy makers and private sector participants alike in according more importance to both interior and exterior decorations of the built houses. The absence of regular city-wide analysis of the prevailing housing circumstances and the general area of tendency largely precludes policy makers, urban planners, urban managers and other stakeholders to be innovative in their methods and approaches at solving emerging urban problems. In addition, the a priori imposition of linear, semi-log , multiplicative inverse and double-log are rejected across all the specifications; suggesting the use of Box-Cox transformation in arriving at the appropriate functional form.

The value of -0.4818 is considered appropriate for lagos residential market based on the household survey data used for the estimation. In its simplest form, the hedonic model can be used to decompose housing and neighbourhood attributes that are capitalized into housing prices. By implication, it does not assume that a house's quality remain constant overtime therefore, it explicitly estimates prices for the attributes that determine house quality. In effect, the hedonic method is an equilibrium approach in product differentiation implying that the value of a dwelling unit is a function of the value of its physical characteristics (such as size) as well as the characteristics of its neighbourhood and amenities available in the area.

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