The Social Sciences 5 (6): 559-564, 2010
ISSN: 1818-5800

Does the Functional Form Matter in the Estimation of Hedonic Price Model for Housing Market?

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Abstract: The age-long contentious issue in the housing literature concerning the use of hedonic pricing methodology borders on the choice of appropriate functional form to adopt in its estimation. Different types of functional forms-linear, semi-log and log-log-have haphazardly been applied in empirical studies on housing, most especially with reference to Sub-saharan African countries without any form of formal verifiable evidence to show for it. The void is filled by this study via the use of alternative functional forms. The results using Nigerian data however, provide additional evidence in support of earlier findings from the developed country on the superiority of semi-log specification over other functional forms. The policy relevance which could be drawn from this is that the use of an inappropriate functional form may result into formulating defective housing policy as well as inform wrong policy conclusions and recommendations.

Key words: Hedonic pricing methodology, functional forms, housing policy, formulating, semi-long, Nigera

INTRODUCTION

The housing market, unlike other consumption goods is unique because it manifests the characteristics of durability, heterogeneity and spatial fixity. Thus to model this differentiation effectively, Hedonic pricing model has been introduced. 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, hedonic methods were developed and employed in price indices. Lancaster (1966)'s consumer theory and the Rosen (1974)'s model of greatly contributed towards the theoretical work 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 productions.

Hedonic pricing methodology has been a widely used methodology in housing studies. Its wide usage stems from the fact that there are no explicit markets for trading qualitative characteristics inherent in a differentiated product like housing. It therefore, becomes important to infer peoples' willingness to pay for these housing characteristics through the prices paid on them. Hedonic price model has found applications in studies involving both durable and non-durable commodities for which no formal explicit market exists. For example, several studies has applied hedonic pricing model to evaluate environmental amenities, outdoor recreation good, quality life, open space land uses, racial discrimination, neighbourhood change and accessibility to work etc., (Lerman, 1979; Mok *et al*., 1995; Rahmatian and Cockerill, 2004; Bello and Bello, 2008).

Not with standing the foregoing, the most contentious and unresolved issue has been that of choosing appropriate functional form specification for estimating Hedonic pricing model. Different researchers have adopted different functional forms for estimating housing price. These include linear-linear, semi-log, log-log and a flexible Box-cox transformation framework. Despite all these, preferences have always been accorded to one form of specification over another without verifiable proofs and justifications.

Thus, failure to utilize an appropriate functional form may result into obtaining unreliable, inefficient and erroneous estimates. This may consequently translate and inform wrong and misguided policy conclusions and recommendations.

It is against this background that the present study intends to test for different functional forms specifications for housing market in Lagos, Nigeria. The selection of this state of choice is not accidental as its housing market is relatively developed and organized as compared to other states in the federation. In addition, we are not aware of any study thus, far in Nigeria that has conducted a study

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to test for different functional forms that will produce a best-fit for data generated to studying housing market in Lagos, Nigeria.

MATERIALS AND METHODS

The basic data set used for this study was collected through structured questionnaires administered on 983 randomly selected households using sampling frame of Lagos State Household Survey conducted in the year 2006. Though, the number of the representative household samples used for the study appears small but still could not render the analysis and conclusion to be drawn for policy applications meaningless once the scientific method of choosing the samples and collecting the data are strictly adhered to Neuman (1991)'s asserted that larger population permit smaller sampling ratios for equally good samples.

According to him as population size grows, the returns in accuracy for sample size shrink. Thus, the households were drawn randomly across the 20 local government areas of the state Table 1 and 2. The questions in the questionnaire were structured into two main parts. The first part was designed primarily to elicit response from the respondents' households about their socio-economic characteristics such as age, sex, educational level, occupation and question about the apartment occupied like rent paid and type of tenure status and choice of dwellings are also raised. The 2nd segment was basically focusing on hedonic pricing variables like structural, locational and neighbourhood factors.

A brief overview of the study area: Lagos state was created on May 27th 1967 when Nigeria was restructured into 12 states. Before this period, Lagos municipality was under the administration of the federal government through the Federal Ministry of Lagos Affairs as the regional authority. The city of Lagos was under the Lagos City Council. The regions of Ikeja, Ikorodu Agege, Mushin were under the former Western Region. Lagos state lies approximately between longitude 2042'E and 30420'E and latitude 6022'N and 6052'. The state is located on the South-Western part of Nigeria with the southern boundary of the state framed by about 180 km along Atlantic coastline while the northern and eastern boundaries are framed by Ogun state.

Table 1: Distribution of selected households by local government areas

Local government area	Population (a)	No. of political wards (b)	No. of households listed ©	No. of households sampled (0.05% of C) (d)
Agege	1,180,358	10	1134	58
Ajeromi/Ifelodun	1,588,361	17	980	49
Alimosho	1,175,622	11	947	47
Amuwo/Odofin	560,814	12	833	42
Apapa	432,686	9	750	38
Badagry	332,685	11	614	31
Epe	292,049	18	1401	70
Eti osa	424,434	9	809	40
Ibeju-Lekki	62,988	16	1054	53
Ifako Ijaiye	645,471	14	924	46
Ikeja	533,237	10	929	46
Ikorodu	558,422	18	1066	53
Kosofe	1,102,661	12	1275	64
Lagos Island	454,714	18	1328	66
Mainland	721,733	10	1005	50
Mushin	1,439,556	15	981	49
Ojo	635,366	13	767	38
Oshodi/Isolo	1,192,652	11	928	46
Shomolu	949,730	8	967	48
Surulere	1,183,886	12	975	49
Total	15,467,425	254	19667	983

Lagos State Government Household Survey (2006)

Table 2: Variable definitions

Variables	Parameters	Description	Expected sign
Structural characteristics			
RS	Room size	Measure in m^2	+
BA	Building age	Number of years	-
FLR	Floor level	Measure in m^2	+
KT	Kitchen	Availability is 1 if otherwise 0	+
WM	Wall material	Availability is 1 if otherwise 0	+
TL	Toilet	Availability is 1 if otherwise 0	+
CL	Ceiling	Availability is 1 if otherwise 0	+
FC	Fence	Availability is 1 if otherwise 0	+
WD	Window	Availability is 1 if otherwise 0	+
DG	Drainage	Availability is 1 if otherwise 0	+
WA	Water	Availability is 1 if otherwise 0	+
Neighbourhood characteristics			
CR	Crime rate	If crime is low is 1 if otherwise 0	-
POL	Pollution	If pollution is low is 1if otherwise 0	-
Locational characteristics			
AE	Accessibility to employment	1 if it accessible, 0 if otherwise	+
ASC	Accessibility to children schools	1 if it accessible, 0 if otherwise	+
AH	Accessibility to hospital	1 if it accessible, 0 if otherwise	+
AMK	Accessibility to market	1 if it accessible, 0 if otherwise	+
ARC	Accessibility to recreational centre	1 if it accessible, 0 if otherwise	+
APT	Accessibility to public transport	1 if it accessible, 0 if otherwise	+

The Republic of Benin formed the western boundary. The state is the smallest state in Nigeria in land area with an area of about 358,861 ha or 3577 km^2 (Odumosu, 1999). This represents only 0.4% of the entire area of the country. This size accommodates about 10% of the entire 140 million appropriate population of the country. The state is also the most urbanized in Nigeria (Ayeni, 1979). Only about 5% of the state total population are of rural areas. This has serious consequences on land use planning in the state, especially in urban areas. It also has great implication on infrastructure such as housing, water supply, storm drainage, roads, electricity, telephone, waste management and other socio-economic, cultural and administrative issues.

Ironically except for Abuja, Lagos stands out to be the best served with infrastructural facilities in the country yet it is where these facilities are most inadequate due to the high population density. The state is also the most affluent in spite of its small size.

Theoretical model: The theoretical foundation of the Hedonic price model is generally, regarded as Hedonic price theory. The American researcher Lancaster (1966) was the first person to came up with a new consumer theory.

The theory was expanded from the consumer theory of classical economics also known as Lancaster preference theory. From this theory, he argued that for heterogeneous products such as housing, its demand was not based on the product itself but rather on its characteristics. According to him, all of these characteristics are variables of the utility function of the consumer. Therefore, the utility level depends on the quantity of different characteristics.

The American economist named Rosen (1974) submitted within the context of Lancaster preference theory, the first equilibrium model of market supply and demand based on product characteristics. He analyzed theoretically, the long and short term equilibrium of the heterogeneous goods market.

Thus, in capturing the relationship between housing price and its characteristics as espoused in the hedonic pricing theory, the researchers then specify Hedonic price function of the general form as follows:

$$P = \alpha_0 + \sum \alpha_i Z_i + \varepsilon_i \quad (1)$$

Where:

P_i = Either rental or a house value
α = Under decided coefficients
Z_i = A vector of housing characteristics variables
ε = Random error

This classical Hedonic price model poses a relationship between housing prices and traits. The housing traits can be classified into 3 categories: structural traits denoted by S; neighbourhood traits denoted by N and locational traits denoted by L. The above Eq. 1 can be further rewritten as:

$$P = P(S,N,L) \quad (2)$$

The structural traits consists of the lot size, total square feet of living space, number of bedrooms, room size, building age, availability of bathroom, kitchen, toilet, etc. While the neighbourhood traits as identified in the survey are waste disposal methods, security services and pollution and locational traits also are accessibility to job employment, accessibility to children schools, accessibility to public transports, accessibility to hospitals, accessibility to shopping centre, etc.

Empirical model specification: Since, Hedonic pricing models have often been criticised on the ground of not having appropriate functional form specification, the researchers therefore specified 3 empirical models of hedonic pricing to allow for more flexibility:

$$P = \alpha_0 + \alpha_1 Z_i + \varepsilon \quad \text{(linear)} \quad (3)$$

$$\text{Log}P = \beta_0 + \beta_1 Z_i + \varepsilon \quad (\text{semi} - \log) \quad (4)$$

$$\text{Log}P = \varphi_0 + \varphi_1 \log Z_i + \varepsilon \quad (\text{double} - \log^5) \quad (5)$$

All the variables remain as they were earlier define but HP in the equations below represents housing price. More explicitly, we re-specify each of the equations in a more estimable form as thus:

$$\begin{aligned} HP = {} & \alpha_0 + \alpha_1(RS) + \alpha_2(BA) + \alpha_3(FLR) + \alpha_4(KT) + \\ & \alpha_5(WM) + \alpha_6(TL) + \alpha_7(CL) + \alpha_8(FC) + \alpha_9(WD) + \\ & \alpha_{10}(DG) + \alpha_{11}(WA) + \alpha_{12}(CR) + \alpha_{13}(POL) + \alpha_{14}(AE) + \\ & \alpha_{15}(ASC) + \alpha_{16}(AH) + \alpha_{17}(AMK) + \\ & \alpha_{18}(ARC) + \alpha_{19}(APT) + \mu \quad \text{(linear)} \end{aligned} \quad (6)$$

$$\begin{aligned} \text{Log}HP = {} & \beta_0 + \beta_1(RS) + \beta_2(BA) + \beta_3(FLR) + \beta_4(KT) + \\ & \beta_5(WM) + \beta_6(TL) + \beta_7(CL) + \beta_8(FC) + \beta_9(WD) + \\ & \beta_{10}(DG) + \beta_{11}(WA) + \beta_{12}(CR) + \beta_{13}(POL) + \beta_{14}(AE) + \\ & \beta_{15}(ASC) + \beta_{16}(AH) + \beta_{17}(AMK) + \\ & \beta_{18}(ARC) + \beta_{19}(APT) + \mu \quad \text{(Semi-log)} \end{aligned} \quad (7)$$

$$\text{LogHP} = \varphi_0 + \varphi_1 \log(\text{RS}) + \varphi_2 \log(\text{BA}) + \varphi_3 \log(\text{FLR}) + \varphi_4(\text{KT}) + \varphi_5(\text{WM}) + \varphi_6(\text{TL}) + \varphi_7(\text{CL}) + \varphi_8(\text{FC}) + \varphi_9(\text{WD}) + \varphi_{10}(\text{DG}) + \varphi_{11}(\text{WA}) + \varphi_{12}(\text{CR}) + \varphi_{13}(\text{POL}) + \varphi_{14}(\text{AE}) + \varphi_{15}(\text{ASC}) + \varphi_{16}(\text{AH}) + \varphi_{17}(\text{AMK}) + \varphi_{18}(\text{ARC}) + \varphi_{19}(\text{APT}) + \mu \quad \text{(Double-log)} \tag{8}$$

From Eq. 5-8, the regression coefficients α = 1-10; β = 1-10 and φ = 1-10 are variables of structural characteristics; α =11-13; β = 11-13 and φ = 11-13 are the neighbourhood characteristics and α = 14-19; β = 14-19 and φ = 11-19 are the locational traits. α, β and φ with subscript of zeros are all constant terms. The error term denoted by μ simply reflects the unobserved variations in the house prices other than the variables stated. In addition, the rental or house value, room size, building age and the floor area are continuous variables while the other explanatory variables are dummy variables with either zero or one value.

RESULTS AND DISCUSSION

Table 3 shows a summary of descriptive statistics of housing characteristics in Lagos, Nigeria. The average monthly house price paid by representative samples is N25,765.67 with a standard deviation of N546.75. The average number of years of these houses is around 7 years which shows that majority of houses in Lagos are still fairly old. What is clear from the statistics is that a large number of houses possess more structural housing characteristics than other housing traits as depicted by their mean values except with some with comparatively lower mean values like fencing and drainages. In terms of neighbourhood variables considered in the study, the level of pollution and crime rates are very high given their mean values of 0.58 and 0.53, respectively. While the locational housing traits prominently show that the accessibility to households' employment on the average is not very close as compared to that of children and public transport whose average range between 0.69-0.75, respectively.

Table 3: Descriptive statistics

Variables	Mean	S.D
HP (housing price)	25,765.67	546.750
RS (Room Size)	335.67	45.782
BA (Building Age)	6.87	8.890
FLR (Floor Level)	2.78	5.650
KT (kitchen)	0.69	0.380
WM (Wall Material)	0.78	0.470
TL (Toilet facilities)	0.82	0.260
CL (house ceiling)	0.74	0.560
FC (Fencing)	0.37	0.540
WD (Window)	0.88	0.320
DG (Drainage)	0.41	0.730
WA (Water)	0.66	0.890
CR (Crime Rate)	0.53	0.240
POL (Pollution Level)	0.58	0.230
AE (Accessibility to Employment)	0.23	0.510
ASC (Accessibility to Childrenschools)	0.75	0.470
AH (Accessibility to Hospital)	0.44	0.360
AMK (Accessibility to Market)	0.22	0.590
ARC (Accessibility to Recreational Centres)	0.19	0.620
APT (Accessibility to Public Transport)	0.69	0.550

Analysis of alternative functional forms of Hedonic price models: Table 4 shows a summary of the three functional forms that were used in the models. Of all the 3, semi-log functional form gives the best fit most, especially with respect to the coefficient of determination (R^2) which is 0.67 but reduces marginally to 0.66 when it is being adjusted for.

This simply suggests that 67% variation in house price is being accounted for by the explanatory variables specified in the model. Linear model provides the least R^2 with 0.56 while that of log-log stands at 0.63. It is evidently clear, however that the fit of the linear model is not as good as the semi-log and log-log models. The result further supports earlier studies which states that semi-log functional form is the most preferred because it fits the data particularly well.

Rahmatian and Cockerill (2004) study corroborates this outcome that it is highly probable that a non-linear functional form will perform better than a linear form because people cannot costlessly repackage the characteristics of a home.

Other researchers like Beron *et al.* (1998) and Palmquist (1984) also reiterate this theoretical conjecture as well as many other empirical studies employing the hedonic methodology. The estimation results also present interesting picture about the importance of housing features in the valuation of houses or rent payment as the case may be. House structural characteristics, locational and neighbourhood qualities are strongly associated with house values. In all specifications, house structural characteristics; like kitchen, wall materials, toilets, ceilings, fencing, good drainage and water are all positively associated with house rent and are significant at the 5% level. Of all the three house qualities, structural features appear to be highly significant than any other housing characteristics.

For instance, 8 out of 9 structural characteristics though conform to expectation and are significant at the 5% level. Locational characteristics directly follow that of struc tural with 5 out of 6 variables appearing to be positively correlated with housing price across all the specifications. The accessibility to recreational facilities does not appear significant in all the model specified.

Table 4: Hedonic price model estimates for linear, semi-log and log-log functional forms

	Linear model		Semi-log model		Log-log model	
Independent variables	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
Structural characteristics						
RS	3897.4100	37.64210**	0.007432	38.87230**	0.005805	33.67420**
BA	-3245.5600	-31.45360**	-0.006633	-34.90980**	-0.004834	-20.31970**
FLR	2675.7300	26.54320**	0.003425	23.87640**	0.003599	20.92210**
KT	1567.7600	15.12250**	0.002631	14.90320**	0.002632	17.09840**
WM	1652.4200	16.34630**	0.002461	12.09880**	0.002821	19.08760**
TL	1876.2300	19.78110**	0.004346	21.99820**	0.004865	28.98720**
CL	107.3421	2.12360**	0.000678	2.35461**	0.002466	13.86660**
FC	512.9040	5.98380**	0.000517	1.92562**	0.000573	2.77622**
WD	42.1726	0.98740	0.000148	0.89765	0.000089	1.08763
DG	119.7623	2.14320**	0.000228	1.89025**	0.000465	1.88736**
WA	1243.8900	14.56440**	0.005547	28.09820**	0.005547	32.71170**
Neighbourhood characteristics						
CR	-609.4540	-2.09530**	-0.000611	-1.97110**	-0.000369	-1.95720**
POL	-435.7860	-2.18640**	-0.000596	-1.90910**	-0.000853	-2.98760**
Locational characteristics						
AE	356.6540	4.78120**	0.001421	7.98030**	0.001611	9.52360**
ASC	688.9830	6.90836**	0.001029	3.65240**	0.001411	8.52230**
AH	290.6250	3.08664**	0.000427	2.98035**	0.000105	1.89437*
AMK	745.5530	9.02352**	0.001092	4.98020**	0.000757	3.56250**
ARC	99.9016	1.12374	0.000167	1.29809	0.000023	1.18738
APT	569.5680	6.23430**	0.002572	15.75270**	0.000899	3.98770**
Constant	32415.7800	46.76530	0.006743	23.98430	0.076336	35.38520
R^2	56.0920	-	67.908000	-	63.215000	-
Adjusted R^2	54.3340	-	66.980000	-	62.654000	-
F-statistics	253.9000	(0.000)	354.730000	(0.000)	298.080000	(0.000)

(*) indicates 10% level of significance (**) Indicates 5%, level of significance

CONCLUSION

The study contributes and adds to the existing literature about the unresolved issue that borders on the choice of appropriate functional form to be adopted in estimating hedonic pricing models. The findings revealed, however the importance of structural housing characteristics are more pronounced than any other housing traits. In addition, the superiority of semi-log functional form over other functional forms was clearly brought into fore with coefficient of determination appearing as the highest. Thus, the import of this study therefore lies in the fact that the outcome of the results will assist both the planners, policy makers and urban manager alike in designing and formulating a workable housing policy which is not based on erroneous and wrong estimates.

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