

## Prediction of House Prices Using Hedonic and Bayesian Models: An Application to Uyo Housing Market, Nigeria

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**Abstract:** Hedonic price model has been used to improve the direct sales comparison approach due to its inaccuracy and reliabilities; however there is still lack of precision with regards to market information. Real estate market prices of houses are uncertain due to numerous factors that affect its price. Bayesian theory offer opportunity of improving the quality of the estimate for decision making by taking into account additional information. The study uses the Hedonic and Bayesian models to predict the house prices in Uyo, Nigeria. The result shows that Hedonic and Bayesian model enhances the prediction of houses price by 26.14%.

**Key words:** House Prices • Value • Hedonic model • Bayesian model • Property Market • Nigeria

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### INTRODUCTION

Housing market is dominated by many players: users, developers, investors, valuers, tax administrators, financier and many others. The conventional methods or approaches real estate practitioners uses to predict house prices are market comparison, cost approach and income or investment approach such as discounted cash flow techniques. These approaches have suffered lot of criticisms because they lack accuracy and reliability. One of the criticisms in the use of investment method is the distinction between price and rent as used by the Appraisers or Valuer. The principle in the use of income or investment approach is the conversion of net income to value or price. The argument is that the resultant capitalization is not price but value, in that there is a difference between value and price from the perspective of an investor and owner-occupier of houses. A prospective owner-occupier of a house would primarily focus on price of the property, whereas an investor would focus on the expected net rental from the property to capitalise. That is to say rents are notional or imputed, but price are actual cost of the commodity. 'Price is the amount a particular purchaser agrees to pay and a particular seller agrees to accept under the circumstance surrounding their transaction' [1]. However, it has been observed that sales prices are direct references for the market value of properties, but they do not provide

information about the separate values of land and building [2]. The focus of this paper is on predicting the price of houses. Predicting house price based on other methods such as cost and direct sales comparison lack accuracy and reliabilities because of the numerous assumptions underlying their applications. Hence, the needs for models of house price prediction that will help fill up or resolve this inaccuracy and enhance the efficiency in the real estate market analysis. Lack of precision with regards to market information has force real estate analyst to work with small data set in the application of hedonic pricing model [3]. In spite of this low transparency in information, housing market will continue to thrive as long as there are those who seek to buy them.

In Nigeria, the ratio of house owners is higher than renters. That is house owners know the benefit of owning a house, because it is considered as a profitable investment and social manifestation. It has well documented that homeowners have greater total wealth than renters, (Beracha, Skiba and Johnson). [4]. The general belief in Nigeria has been that a man who has no landed property is regarded as a failure [5]. This belief is based on the premise that a person who is his own master is more important than increase in his income. The societal perception of independence is the instrument of ensuring man's capacity to survive the stiff economic and social competition [6] which is rooted in

many Nigerians. The manner of owning home is through incremental building and purchases from property development companies (private and public developers). [7] believe that house price rises yearly, as a result there is a need for a method to predict house prices in the future. The benefits of predicting house price are to enable developers determine the selling price of houses and assist home owners to plan for finance and arrange time for the purchase. Housing market is thriving in Nigeria, so house price prediction becomes an important issue for decision making by its seeker as [8] believe that prediction are a central part of any investment decision.

There have been several empirical studies using Hedonic model to determine property values and house price prediction. Some of those studies are: [9-16]. Most of these valuation studies are conducted in the property market of developed countries where there are ready and reliable data. In analysing the housing market in developing countries would go a little further in filling that gap in the literature. The general consensus of these studies is that there are bundles of characteristics of houses that determine the value or price. Examples of these characteristics of houses are numbers of bedrooms, numbers of bathroom, plot size, parking facilities and environmental or location attributes. However, the challenge in real estate market is that values or prices of houses are uncertain due to numerous factors that affect its price which are quantitative and qualitative variables. So there will always be some doubt that the correct prediction has been done. The expectation in the real estate market is that sellers would expect higher prices and buyers lower prices. It is expected that a deal would be reached in the run-long where both will agree at a particular price. Bayesian theory offer opportunity of improving the quality of the estimate for decision making by the players in the property market [17]. However, there are few studies in the area of using Hedonic and Bayesian models to predict house prices. The aim of this study is to use the Hedonic and Bayesian models to predict house prices in Uyo, Nigeria with a view to contribute to the existing literature in this area.

**Literature Review:** Housing is very vital in any nation as it is a stimulant of the national economy. It is one of the most important necessities of man after food. Housing as part of the environment, it has strong consequence on the health, efficiency, social behaviour, satisfaction and general welfare of the people and the community in general. It is a reflection of the cultural, social and economic values of a society and one of the best

historical evidences of the civilization of a country [18]. Housing Price may be defined as the sum of money for which a house may be bought or sold [19]. This definition has however omitted one very important element which is, time consideration. Consequently, housing price for the purpose of this study is defined as the sum of money for which a house may be willingly bought or sold at a given point in time. Thus the availability and adequacy of housing is tied to its price or otherwise is a function of the price. Housing as a commodity is very expensive. In Nigeria, housing problems are increase in population occasioned by the high birth rate and migration of people from the rural to the urban centres. There is no much doubt that house prices vary vastly over geographical areas; the most expensive tends to be in more densely populated areas and areas of economic significance like state capital cities. Hence, the future of need, demand and supply of housing in any economy is of great concern to home buyers, sellers and policy makers. This notwithstanding [20] have argued that the most important development determining housing market and housing policies is the credit crunch.

There are several studies on the use of hedonic model, Bayesian approach and other approaches in the prediction and determination of real estate prices or values. The fact remains that house price play a significant role in stimulating economy of any nation. Housing renovation and construction boost the economy by increasing the house sales, employment and externalities. Of the several methods of predicting house prices, the comparison method is considered as the most reliable method to assess real estate price. In supporting this claim, [21] have argued that the traditional tedious price prediction process is based on the sales process comparison and stochastic process prediction, which hardly achieve valuable accuracy. However, for this estimation to be accurate and reliable it depends upon access to good quality data [22]. Therefore, the existence of property data bank system that consists of reliable land and property valuation database is a necessity to obtain accurate comparables, which are the cornerstone of the market valuation [23-25] argued that the sales comparison approach as one of the valuation methods is from a mathematical and statistical point of view based on a multiple linear regression analysis.

[26] opined that all property markets are characterised by spatial relationships. Property values are affected by the attributes of other properties within the vicinity, by proximity to positive attributes such as open spaces, greenery, city centres to negative attributes such as waste

dumpsites or landfills, flood prone areas. [27] suggested that there are two important objectives in hedonic price analysis, which are prediction of sale prices and delineate submarkets based on location and functional considerations. [28] argued that hedonic technique is an acceptable method for accommodating attribute differences in a house price prediction model. However, it is generally unrealistic to deal with the housing market as a single unit in any location rather it should be constituent unit. In this regard, it is better to compare the predictive power of the hedonic power of the hedonic model with an artificial neural network model on house price prediction. The variable used by Limsombunchai [28] were house size, house age, house type, number of bedroom, number of bathroom, number of garage, amenities around the house and geographical location. [29] believed that hedonic price model has limited ability to handle spatial variation in house prices. Spatial pattern of house price is the sum of many casual factors such as access to the central business district, decentralised employment, neighbourhood amenities and dismantles. Thus to prediction spatial variation, it requires models that can deal with all of these sources of spatial factors. This entails that using hedonic model alone is not sufficient to predict housing price, it requires combination of other models.

[25] have shown that the uncertainty in the estimation of real estate market value can be enhanced by the use of Bayesian regression analysis. [27] applied Bayesian models with spatially varying coefficients in an analysis of housing sale price in the city of Toronto, Ontario in a delineated submarket. They evaluated the model performance and identified patterns of submarkets by the spatial coefficient processes. The results show that Bayesian model is capable of predicting housing sale prices well and provide useful inference regarding heterogeneity in prices within a submarket and may be specified to include an expert market. [29] argued that the Bayesian approach enables us to predict complete inference in the form of a posterior distribution for each model parameter. That is the nonparametric part of the Bayesian model allows sufficient flexibility to find substantial spatial variation in house values. [3] argued that Bayesian approach is suited to real estate appraisal because it makes use of small sample and its inference technique leads to reliable results. This could be suitable to developing countries especially in Nigeria where there are paucity of data on house sales. In real estate market, analysts often have useful but precise knowledge about effective demand and market transactions. In such a case,

Bayesian approach can offer an appropriate compromise between assuming that such quantity of people are in need of property are known and assuming that nothing is known of the need for property.

Bayesian approach considers the uncertainty in variables estimates and can extend and transform this uncertainty into predications. In fact, Bayesian method is stronger to correct the uncertainty, since it uses mean variables values instead of choosing a single point estimate. [17] opines that Bayesian methods remain contentious in reliability data analysis in some application because of the concern about where the needed prior information should come from. This means that the minimum data is missing in such markets, so an estimation of market price by classical regression analysis will lead to an inaccurate estimate. Also, the result would be more uncertain than by using informative prior information in a Bayesian approach.

[30] suggested that the Bayesian approach should be applied only when the 'quality' of the valuer is ensued. This is very difficulty to the experts' knowledge affects the results, accurate expert's knowledge will lead to more certain outcomes. This can be done by allowing small sample data in combination with the expert's knowledge and provides statistically certain results to predict price of houses. [31] developed a statistical method for the valuation of residential properties using a hierarchical Bayesian approach, which took into consideration the unique structure of the Hong Kong property market. This model was calibrated on a dataset that covered all residential real estate transactions in ten major Hong Kong residential areas between 2008 and 2009. Most residential properties in Hong Kong property market were high-rise condominiums, with many units sharing the same floor plan within a building. Their study made use of only three independent variables: effect of time, building block and floor level to predict the dependent variable price. The consideration of the floor level was based on the fact that higher floor levels generally commanded higher values. They found out that median per-square-foot price of a property changed by as much as 12.7% month over month. Consequently, they advised that, when modelling property values, the valuer must account for not only the transaction history and the characteristics of the property unit, but make adjustment for general market conditions at that time under consideration.

[32] predicted the housing prices of two properties in Aspen Neighbourhood in Colorado. They used the following variables: age, floor area in square metres, number of car spaces in the garage, basement

development, month of sale, number of wood burning fireplaces and distance from the neighbourhood to the central business district (CBD). In their work, they used a sample of 133 single homes sold through a multiple listing system during a one year period. Each house was described by some forty characteristics in the listing information. From that sample size of 133, the mean, the smallest observation, the largest observation and the standard deviation were derived and they served as the posterior information in the use of Bayes' Theorem. What this implies is that, given the availability of similar data in a given location, price can be predicted for investment decision. However, in a situation where one does not have at one's disposition, the use of it becomes a problem.

[33] used Bayesian methods to investigate the importance of the link between rising house prices and higher consumption expenditures that operated through improvements in house-hold debt capacity. The findings showed that the presence of borrowing constraints improved the performance of the model in terms of overall goodness of fit. In particular, the presence of housing collateral generated a positive correlation between consumption and house prices. Bayes' Theorem was also used by [34] to estimate the value of the bank's collateral for mortgage and its associated risk on owner-occupied single family houses in Austria. In a previous study by [35] used a simple Bayesian procedure for sample size determination in an audit of property value appraisal. The technique addressed elicitation of appraisers' prior beliefs, computation of reappraisal sample sizes and reporting of audit results. The study found that to integrate expert judgment and respond flexibly to the arrival of new information. The implication is that Bayesian procedure significantly reduced the number of reappraisals required to regulate appraisal systems when they were functioning well. Kim, [36] opined that, Bayesian inference approach allows one to obtain individual household estimates of utility parameters and household utility estimates are used to compute the value of each variety. This implies that the value of housing can be estimated from the utility parameters in housing.

**Microeconomic and Macroeconomic Determinants of Housing Price:** Microeconomic determinants of housing prices investigate the supply and demand for house. It focuses on the analysis of the users and developer's markets. Macroeconomic investigate the causes and consequences of boom and recession: rate of inflation, unemployment and growth, change in interest rate,

demographic data, employment and real income. Housing Supply refers to the total amount of the housing units that are produced annually by both private and public sector that are ready for consumption [37, 38] believed that housing supply has strong influence on house price and demand for housing is a reflection of population growth. Population impacts directly on the number of households requiring accommodation. The persistent rise in the prices of goods and services has a direct relationship with housing price. The cause of inflation is the devaluation of currency, frequently brought about by the introduction of more currency into the economy. [39] studied the effect of house price expectations on house price on residential properties. The result of the study indicated that price expectations account for 8 percent of the housing price in Spanish house market. This is the reflection of inflationary trends in an economy. [40] suggested that the reason for price increase was the expectation of higher selling price in future, which is good signal for investors to capitalise. However, [41] have warned that the unprecedented house price boom and Great Recession of 2005-2011 have had unusual and unusually large effects on housing turnover in USA especially in Chicago Illinois. In Europe such effects were noticeable. [42] compared the financial crisis and national housing market in Europe and find out that there were differences in the housing market with respect to house prices. Some house prices declined and some have not fallen and some fairly stable. However, the similarities across Europe are that there is much lower investment in housing and transactions.

House price prediction is dependent of numbers of households engaged in full-time employment and earning real income. An increase in employment rate, real wages will fuel expectation of future prosperity and help sustain the capacity and willingness of consumers to purchase a home or invest in property. [43] opined that buying a home required financing and that changes in incomes especially ability of young households to afford down payment affected housing price levels. [44] concluded that the rising of housing prices was related to increasing incomes.

**Hedonic Price Model:** Hedonic price model presupposes that the price of a good depends on the implicit prices of the characteristics or attributes of the good. Specifically the values or prices of property are influenced by their characteristics, with predicted values strongly influenced by quality of available real estate data. That is to say price distribution (dependent variable) is representative of a deterministic function of the real estate characteristics

(independent variable). [45] is of the view that hedonic model is perhaps the flagship of all mainstream methods of predicting house price. It is also used for the construction of price index and other attributes that have significant welfare impact.

[46] presupposes that real estate involves complex goods, with sales price, which depends on location-specific environmental characteristics, structural characteristics, social and neighbourhood characteristics and location characteristics. [47] has shown that the truth about the housing market is the strong positive correlation between prices and trading volume. The hedonic price model involves regressing sale prices for the house against those attributes of a house that determine sale price. Attributes that contribute to the price of a house include land size, age of the house, numbers bedroom, numbers of bathrooms, numbers of toilet and garages, type of house and amenities around the house. In addition, the geographical location of the house also plays an important factor in influencing the house price. This includes access to public facilities such as schools, campus, hospital and health centres, recreation facilities or even beautiful scenery [48].

The advantages of using hedonic model in predicting houses prices are based on the fact that it is versatile, it interacts with several variables easily and relatively efficient in responding to information. Also the data collection for its application is comparatively easier. The limitations are that it requires large data set, assumes that every user needs to have prior knowledge about property variables. Price of property is dynamic and changes with time and it require high knowledge of statistics in its applications.

In general, the characteristics of property are denoted by

$$X = (X_1, X_2, \dots, X_n) \tag{1}$$

where  $X$  ( $i=1$  to  $N$ ) is the level of any of the many characteristics of a property. That is to say, the characteristics  $X$  describes the services that the property

provides to the user. The hedonic price assumes that the price of property will be determined by the combination of the house characteristics. Therefore we assume that a price of property can be denoted as:

$$Y = f(X) \tag{2}$$

That is to say that the price of a property  $Y$  is a function of the characteristics of the values of  $X$ . This is what is called hedonic price function. This is because it describes the characteristics that determine the different qualities of the different properties that people preferred. In order to develop a model for predicating house price, we adopted the general regression equation as:

$$Y = a + bx_1 \dots b_n + \tag{3}$$

where  $Y$  is the price of house,  $a$  constant,  $b$  coefficient of the characteristics of  $X$  and the error of the equation.

**Hedonic Method of Analysing House Prices:** The sample size of the study consists of 156 housing units sold between the years 2006 and 2017 as shown in Table 1 below.

The data were obtained from the marketing department of the developers of the Estates in 2017. The residential Estates under consideration are the only one in the city and are located outside the city centre in scenic environment. The housing units consist of the different building typology and are situated in a homogeneous urban area under the profile of the distribution of public and private infrastructure services and amenities. Only heterogeneous real estate characteristics have been selected for each sampled unit of property. These characteristics form the variables used in the study as shown in Table 2 below. Other property characteristics such as age of the property, noise level and accessibility have been excluded from the analysis. Age was excluded because the years of the development where virtually the same.

Table 1: Sample Size

S/N	Sector	Housing Estates	No. of Housing Transactions	Percentage
1.	A	Shelter Afrique and Extension	11	7.05
2.	B	Osong Ama and Extension	28	17.95
3.	C	Ewet Housing	23	14.74
4.	D	Federal Housing	7	4.49
5.	E	Akwaima Housing	52	33.33
6.	F	Akpasak Housing	35	22.44
Total	156	100		

Table 2: Hedonic model Variables specification and Definition

Identity	Variable	Remarks
SALE	Sale price	The selling price of the properties by the developers as provided by their marketing departments and is expressed in Naira per (x 1000).
PLOT	Plot size	Plot size is measured in metre square. The larger the size of plot, the higher the price. Market comparable price of land is determined by per metre square.
NB	Number of Bedroom	Residential buildings are defined in terms of the number of bedrooms they have. In an ideal situation, there is no way a 2 Bedroom house will be higher in price than a 3 Bedroom. That is a house that has more bedrooms is expected to command a higher price than a house that has less number of bedrooms
BATH	Number of bathroom	In residential buildings, the number of bathrooms is important and as to be expected, the greater the number of bathroom, the higher the price.
PARK	Car parking space	In any building, one is always particular about the safety of one's car; consequently, the availability of a car space in a building affects the price positively. In terms of assessment, Yes = 1 while No = 0.
FLOOR	Number of floors	A one floor is expected to have lower value than two floor houses. It is measures as 0 for one floor, 1 for two floor and 2 for three floor houses.
DIS	Distance to road	Distance of the property from access roads measured (1= if the distance between the house unit and the road is lower than 1000m; = 0 if otherwise).
OC	Occupancy	Occupancy status (OC) is expressed with score of 1 not rented or occupied, 0 rented or unoccupied)
BQ	Boys quarters	Properties that have additional rooms as servant quarters attract high value than those that don't have. It is express 1= availability and 0=known.
Dummy	Dummy	This variable include quality of houses, neighbourhoods or vocational peculiarities which are expressed as 1 poor, 2 fair, 3 good, 4 very good and 5 excellent.

Selection of the real estate characteristic is based on the direct knowledge of authors of the Nigerian property market and pre-processing of the data. The selection is done to reduce the effects of correlation among the variables and to obtain a better coverage of the characteristics of the variables.

**Bayesian Model:** When decision is made where the outcome of the decision is uncertain, there will always be some doubt that the correct decision has been taken. Bayesian theory is bases on expected values; which consider the possibility of improving the quality of decision by providing more information about the likely outcome. The house price predicted using the hedonic model has the doubt whether it is correct information to be used in decision making. The fact is that house price is confronted with future uncertainty such as changes in demography data, inflation, interest rate and political uncertain both locally and internationally. The question is whether there is perfect information about house prices? However, one of the characteristics of real estate is that there is imperfect knowledge about its market transaction. Bayesian theory consider the possibility that if there is no perfect information, prediction of house prices will be wrong, but with perfect information the best prediction of house prices would be correct. The correctness of the prediction is that there is new or additional information [49]. The Bayesian approach is better to use in decision making when there is a high level

of uncertainty or limited information in which to base decisions on and where expert opinion or historical knowledge is available. Bayes model is also useful when explaining the findings in a probability sense to people who are less familiar and comfortable with comprehending statistics.

The reason for the use of Bayesian method are that: it allow an analyst to incorporate prior information into a data analysis and modelling problem to supplement limited data, often providing important improvement in precision. The method can handle with relative ease, complicated data model combination for which no maximum likelihood software exist or difficult to implement. When using Bayesian it is easy to predict estimates of property price or values that are credible. The disadvantage of using Bayesian model for predicting house prices is that there is no 'correct' way to choose a prior data. Therefore the inferences require a thorough analysis to translate the subjective prior beliefs into a mathematically formulated prior probability to ensure that the results will not be misleading and consequently lead to the disproportionate analysis of pre-posteriors [50].

The subjective definition of probability and the selection and use of the priors have led to statisticians criticize this subjective definition of probability that underlies the Bayesian approach [51]. Bayes' Theorem is a simple mathematical formula used for calculating conditional probabilities. It features prominently in statistics and inductive logical reasoning. Subjectivists,

who maintain that rational belief is governed by the laws of probability, lean heavily on conditional probabilities in their theories of evidence and their models of empirical learning [52]. The Bayesian formula is as follows:

$$P(A/B) = \frac{P(A \cap B)}{P(B)} \quad (4)$$

$$P(B/A) = \frac{P(A \cap B)}{P(A)} \quad (5)$$

where:

P(A) is the probability of A occurring and is called the Prior Probability.

P(A|B) is the conditional probability of A given that B occurs. This is the posterior probability due to its variable dependency on B. This assumes that the A is not independent of B.

P(B) is the probability of B occurring.

P(B|A) is the conditional probability of B given that A occurs.

If one is interested in the probability of an event of which one has prior observations; this is called the prior probability. However, there are many situations where one event occurs given that another event is known to have occurred. New information might occur as a result of sample, a special report, changes in interest rate, demography data, income and inflation or deflection etc in respect of real estate. In this situation one would take the advantage of this new information in calculating a new probability or revised probability for the prior event. The probability is called posterior probability. This is where Bayes theorem provides a means for computing these posterior probabilities. This is how Bayes' theorem uniquely allows one to update one's previous ideas with new information.

The general Bayes' theorem to the case where there are n mutually exclusive events A<sub>1</sub>, A<sub>2</sub>, ..., A<sub>n</sub> and where one of the n events must occur when the experiment is concluded. In such a case Bayes' theorem for the computation of any posterior probability P(A<sub>i</sub>|B) appears as follows:

Bayes theorem is

$$P(B/A_i) = \frac{P(B/A_i) P(A_i)}{P(B/A_1) P(A_1) + P(B/A_2) P(A_2) + \dots + P(B/A_n) P(A_n)}$$

where: For A<sub>i</sub> = A<sub>1</sub>, A<sub>2</sub>, ..., A<sub>n</sub> mutually exclusive events'

With prior probability P(A<sub>1</sub>), P(A<sub>2</sub>)...P(A<sub>n</sub>) and the appropriate conditional probability

P(B/A<sub>1</sub>), P(B/A<sub>2</sub>)...P(B/A<sub>n</sub>), equation 6 can be used to compute the posterior probability of an event A<sub>1</sub>, A<sub>2</sub>, ..., A<sub>n</sub>.

## RESULTS AND DISCUSSIONS

The data were applied using the hedonic model is as shown in the descriptive statistic in Table 3 below.

The result of the prior and posterior estimate for the variables and constants are presented in Table 4. The prior results show that R<sup>2</sup> 0.67. This means that 67.8% of the housing characteristics are capable of predicting housing prices leaving 32.2% unexplained. The assumption is that these unexplained variables could be attributed to macroeconomic variables such as inflation, fiscal measures such as tax, real interest, unemployment rate population, demographic information (size of population and growth rate etc) which were not included in the model. For household it is not the inflation rate alone that explains the changes in house price within the same period of time, but due to real changes in the economy [53]. In this case, the property price index (PPI) is a good measure of the real change in the housing sector. The PPI are not always reported in Nigeria, but consumer price index (CPI) which is an aggregate of house price and consumption goods are often. Within January 2016 and 2017 the CPI ranges between 191.5% between 249.07% meaning that prices of consumption good have appreciated between years 2016 and 2017 up to 249.07%. This information is an aggregate price movement within an economy in the consumption subsectors. To determine what happened in the house sector and how macroeconomic variables play an important role in the predication of housing prices. The additional information derived from macroeconomic economic variables, indeed the average inflation trend in Nigeria, is 14%. In order to apply Bayesian model, the conditional probability is essential. The inflationary rate of 14 % lives a conditional probability of 86% meaning that housing price would not rise more than that and housing price would rise up to 14%, all other macro economic variables held constant. This additional information was applied to compute posterior probability which yield 26.14% using equation 6. This has revised the posterior probability of 32.2% in the light of new information.

Table 3: Descriptive Statistics

	Mean	Std. Deviation	N
house price	3.977E4	17327.1901	152
Plot size	6.1232E2	197.31605	152
Number of Bedrooms	2.7632	.96794	152
Number of bathrooms	3.8684	1.02734	152
Number of car parking space	3.8553	1.02555	152
Number of floors	1.1447	.56858	152
Distance to road	.7961	.40426	152
Occupancy rate	.7105	.45502	152
Boys Quarters	1.1382	1.06758	152
Dummy	.7303	.44529	152

Table 4: Prior and Posterior estimate

Variables	Coefficient	
	Prior Informative Model 1	Posterior informative Model 2
(Constant)	10181.007	13042.265
Plot size	49.074	62.319
Number of Bedrooms	4345.986	5514.762
Number of bathrooms	-924.478	-1227.663
Number of car parking space	-4836.37	-6117.605
Number of floors	6742.807	8114.415
Distance to road	-1140.524*	-1265.235*
Occupancy rate	1196.519*	1628.638*
Boys Quarters	3465.606	4368.137
Dummy	-2341.799	-3101.915
R <sup>2</sup>	0.698	0.702
Adj.R <sup>2</sup>	0.678	0.676
F-Stat.	36.38	36.16
Standard Error	9826.7419	12408.19
	n-152	n-152

Note: Dependent variable is house price

\*not significant at 5% confident level

Model 1 is Prior informative using hedonic model alone

Model 2 Posterior informative adjusted using Bayesian model.

Table 4 shows the values for the mean of the regression coefficient in both cases, prior and posterior densities estimates. The observation is that the mean values of the regression coefficient for informative prior is lower than posterior informative indicating that housing price predication would be higher when model 2 is considered. The confidence intervals for both cases are significant at 5% level, only distance and occupancy variables that are not significant at the level. The understanding of this result is that with additional information on the variables that determine housing prices invariably improve the quality of the results of the prediction. That is if Bayesian approached is used in conjunction with hedonic model, it enhances the regression function for the predication of house prices.

Based on 152 transactions in the Uyo property market over the period of years, the regression function for prior informative is estimated form table 4 using model 1. This predication equation becomes:

$$Y=10181.007+49.074PLOT+4345.986NB-924.478BATH-836.370PARK+6742.807FLOO-1140.524DIS+1196.519OC+3465.606BQ-2541.799DUMMY+9826.7419ERROR \quad (7)$$

The house prices can be derived from equation 7 which is the summary of the variables of coefficient of estimation of housing characteristics. This form the prior informative density derived from field work on 152 housing units sold in Uyo within the 7 housing estates.

To estimate housing prices integrating the Bayesian model posterior density information as shown in model 2 is used as is reveal in equation 8.

$$Y=13042.265+62.319PLOT+5514.762NB-1227.663BATH-6117.605PARK+8114.415FLOR-1265.235DIS+1628.638OC+4368.137BQ-3101.915DUMMY +12408.19 Error \quad (8)$$

Equation 8 is an enhancement of the prior density by the application of Bayesian model. It is simply an integration of the prior results of the hedonic model by additional information obtained from Bayesian model, in this case the inflationary trend in the economy. The reality of this model is that house prices are sensitive to uncertainty of the economic situation, but not only to the characteristic of the properties. The uncertainty here lies on the macroeconomic variables and the general economic and political situations of the country, which are not captured in the prior model, living doubt on the accuracy of the model.

**Illustration:** Akwa Ibom State Housing Development Corporation is currently developing various units of residential houses for its civil servants: 3 bedroom 40 units; 4b bedroom 20 units; 5 bedrooms; 15 units and 2 bedroom 60 units and all detached houses. The corporation wishes to predict the market prices of the houses to enable her determine what the target beneficiaries would pay.

Table 5 describes the characteristics of the housing units by the corporation and the predicated price using the two model parameters. In substituting model 1 with



Table 5: Predication of Housing prices using the two models

HOUSING TYPE	PLOT SIZE	BR	BATH	PARK	FLOOR	DIS	OC	BQ	DUMMY	Model 1 Predicted housing price (N)	Mode 2 Project House Price (N)
A3	600	3	3	2	1	1	1	1	1	48,604.28	73,211.9854.29
A4	900	4	3	3	2	1	1	2	1	73,044.86	103,787.4
A5	1200	5	3	3	2	1	1	2	1	92,113.04	127,997.9
A2	450	2	2	1	1	1	1	1	1	42,657.67	65,694.64

the characteristics of the property developed by Akwa Ibom State Housing Corporation, produce the results as shown in column model 1 and model 2. The percentage changes on the various categories of housing units 50.62%, 42.09%, 38.955 and 54.00% respectively. This is an enhancement of the hedonic approach in model 1. This reveals that relying solely on the estimation of housing prices using prior information as shown model 1 leads to an underestimation of housing prices as the estimation is based only on property characteristics and held macroeconomic variables constant. Relying on the historic data of sales information over the period of ten years to estimate the current price of houses is unreliable. The data used in the analysis on sales prices are from 2006 to 2017. The model 1 is compensated by the adjustment to include inflation rate which thereby enhanced the accuracy of the housing price estimation. This informed analyst that in a normal market with sufficient data, integrating Bayesian model into hedonic model leads to more certain results. This study assumes that Bayesian approach achieved special relevance for use in markets with few data sets. The implication is that Akwa Ibom State Housing Corporation could fix the sales prices using the results in model 2; however, this depends on the economic situation and the purchasing powers of the buyers.

**CONCLUSION**

The study suggests that Bayesian approach is a powerful model for researchers and practitioners to analysis valuation assignments for decision making where there is uncertainty and paucity of data. It clearly indicates that relying only on the characteristics of the property in determination of housing prices is deceptive and inaccurate. This is because the value arrived at is unlikely to be the best estimate under all circumstance, regardless of what the actual outcome is. The argument is that there is some probability that the best estimate will not be done, giving the way actual information turns out in the future. The method introduces many other improvements on the hedonic price model.

The improvement is that when both micro and macroeconomic variables which form perfect information are integrated using Bayesian model, the result would be the best opinion of value or price for decision making.

The result of the study further reveals that housing prices are primarily influenced by housing characteristics specifically variables such as number of bedroom, boys quarters, number of bathroom, plot size, parking space, distance to roads or transportation routes, city centre, shops etc. Furthermore, macro economic variables especially inflation, fiscal factor like taxes and interest rate play an important role in housing prices prediction. The shortcoming of the study is that it is only one macroeconomic variable that is considered. However, the study reveals opportunity for further research on Bayesian approach especially in the developing countries where data mining is paucity and the need to include more macroeconomic variables in the Bayesian approach.

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