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A CATEGORICAL MODELLING APPROACH FOR DETERMINING RENTAL HOUSE PRICES IN LOW-INCOME NEIGHBOURHOODS OF NORTH-CENTRAL NIGERIA

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Abstract
Over the years, researchers in developing countries have applied varied methodologies to study housing attributes and house prices. This study utilised the categorical modelling approach to determine the contributory effect of housing attributes on rental house prices in a major town in North-Central Nigeria. A total of 827 housing units were sampled by stratified and random selection. The data used were generated through a questionnaire survey. Nine housing attributes were found to sustain residential buildings in the study area and these accounted for 45% and 61% variance in the rental prices of two major low-income house types. Results revealed that the identified housing attributes significantly predicted rental values for the sampled house types. The mean of predicted rental values was further computed for each house type and compared to the means of the actual rental values collated in the course of data collection and presented with line graphs. Results showed predicted values that are reasonably similar to the actual rental values of the dwelling units. This suggested a reasonably accurate prediction of rental house prices using the categorical regression approach. The study recommended the model to house managers to ensure accurate house pricing.
Keywords: Categorical modelling; Low-income; North-Central Nigeria; Rental house.

1. INTRODUCTION

Available literature shows that the most widely used estimates of the impacts of a wide range of housing attributes on house prices are derived from hedonic models (Sirmans, *et al.*, 2005; Stetler *et al.,* 2010, Hoen *et al.*, 2011; Boucq & Stratec, 2011; Ansah, 2012; Kieti & Ogolla (2020) and Neelawala, *et al.,* n.d). The hedonic model assumes that the prices of dwelling units are composed of a number of factors, thus using a regression analysis, the impacts of each of these factors can be estimated. Wilhelmsson (2009) described the hedonic model as a regression

technique used to reveal the implicit prices of various attributes. It is based on the premise that the value of a good is determined by the utility that the various attributes of the particular product bear, thus when house prices are regressed on the various housing attributes, the empirical magnitudes of the coefficients of the various attributes constitute the hedonic prices of the various characteristics (Wilhelmsson, 2009). Specifically, a hedonic equation helps to explain house price in terms of its own characteristics such as the size of the flat, age, floor, neighbourhood characteristics, and job accessibility.

Researchers from social and behavioural sciences in developing countries have however recently begun to look in the direction of the quality of housing attributes on house prices. These attributes are best measured qualitatively on ordinal and/or nominal scales. Srijan (2009) observed that the zero point of the scales used to measure the values in such cases is uncertain, the relationships among the different categories are often unknown, and although frequently it can be assumed that the categories are ordered, their mutual distances might still be unknown. Srijan (2009) further explained that the uncertainty in the unit of measurement is not just a matter of measurement error because its variability may have a systematic component. As such, an important development in multidimensional data analysis is the optimal assignment of quantitative values to such qualitative scales. This form of optimal quantification (scaling, scoring) is a general approach to treating multivariate categorical data (Srijan, 2009). This study utilised the categorical modelling approach which is a unique methodology aimed at arriving at an accurate house pricing.

2. LITERATURE REVIEW

Quite a number of studies have employed varied methodologies to investigate the impacts of numerous attributes on house prices. The most common method is the hedonic model which has been used to show the impacts of rail stations, bicycle paths, public schools, industrial sites and a host of other amenities on house prices (Netusil, 2003; Racca & Dhanju, 2006; Beta Bio-statistics Inc., 2007; Johnson 2007; Vor & Groot, 2009; Stetler, et al 2010; Hoen, et al, 2011; Ansah, 2012; and Famuyiwa & Otegbulu, 2012). Other similar studies were analysed using Linear and non-linear models (Chernih and Sherris, 2003; Chau, et al, 2004; Chun & Hui, 2014). On the contrary, Ge & Du (2007) used the entropy method, Okoh (2010) and Akogun (2011) utilised Likert scaling and simple percentages, among others. Depending on how analysed data were collated, these studies showed different levels of accuracy when predicted house prices were compared to existing/actual house prices.

Categorical Regression (CATREG) was developed as a method for regression when the data consist of ordered or unordered categorical variables (Van der Kooij & Meulman, 2006). It uses the optimal scaling methodology as developed in the Gifi system (Gifi, 1990) to quantify categorical variables according to a particular scaling level, thus "transforming" categorical variables into numeric variables. By using optimal scaling, numerical values are calculated to replace the categorical values, while at the same time, regression coefficients are estimated. The idea behind optimal scaling is to assign numerical quantifications to the categories of each variable, thus allowing standard procedures to be used to obtain a solution on the quantified variables (Meulmam & Heiser, 2012). Scaling all variables at the numerical level corresponds to standard multiple regression analysis. According to Meulman (1998), the optimal scaling process turns qualitative variables into quantitative ones. Optimality is a relative notion because it is

always obtained with respect to the particular data set that is analysed and the particular criterion that is optimised.

According to Jacqueline and Willem (2005), the use of Categorical Regression is most appropriate when the goal of the analysis is to predict a dependent (response) variable from a set of independent (predictor) variables measured on a combination of nominal, ordinal, and/or interval scales. The goal of categorical regression with optimal scaling is to describe the relationship between a response variable and a set of predictors. By quantifying this relationship, values of the response can be predicted for any combination of predictors (Jacqueline & Willem, 2005). Srijan (2009) described categorical regression as quantifying categorical data by assigning numerical values to the categories using the optimal scaling method and resulting in an optimal linear regression equation for the transformed variables.

Categorical regression extends the standard approach by simultaneously scaling nominal, ordinal, and numerical variables. The procedure quantifies categorical variables so that the quantifications reflect the characteristics of the original categories. The procedure treats quantified categorical variables in the same way as numerical variables. Using nonlinear transformations allow variables to be analysed at a variety of levels in order to find the best-fitting model. The estimated parameters of the model reveal the significance and magnitude of the effect of any housing feature. Similar to other regression analyses, it allows a researcher to estimate, on average, how specific factors (called explanatory, or independent variables) affect the price of a good (called the dependent variable), holding other key factors constant (Netusil, 2003).

3. MATERIALS AND METHODS

3.1 Study area

Niger State is the largest state in Nigeria in terms of land mass. Minna is the capital of Niger state and it lies between latitude 9^{o} 40′ N & 9^{o} 33′ N and longitude 6^{o} 31′ E & 6^{o} 35′ E. It occupies an area of about 884 hectares. Spanning from Tudun Fulani in the North West to Chanchaga in the South, Minna is about 135km away from Abuja, the Federal Capital Territory (FCT) and about 250 km to Kaduna city. Today, the significance of Minna has been further enhanced with the movement of the seat of the Federal Government from Lagos to Abuja as it is the closest state capital to the Federal Capital Territory. Minna is characterised by fertile soil which can support a large variety of agro-allied industries. The town experiences distinct dry and wet seasons with annual rainfall varying from 1,100 mm in the northern parts to 1,600 mm in the southern parts.

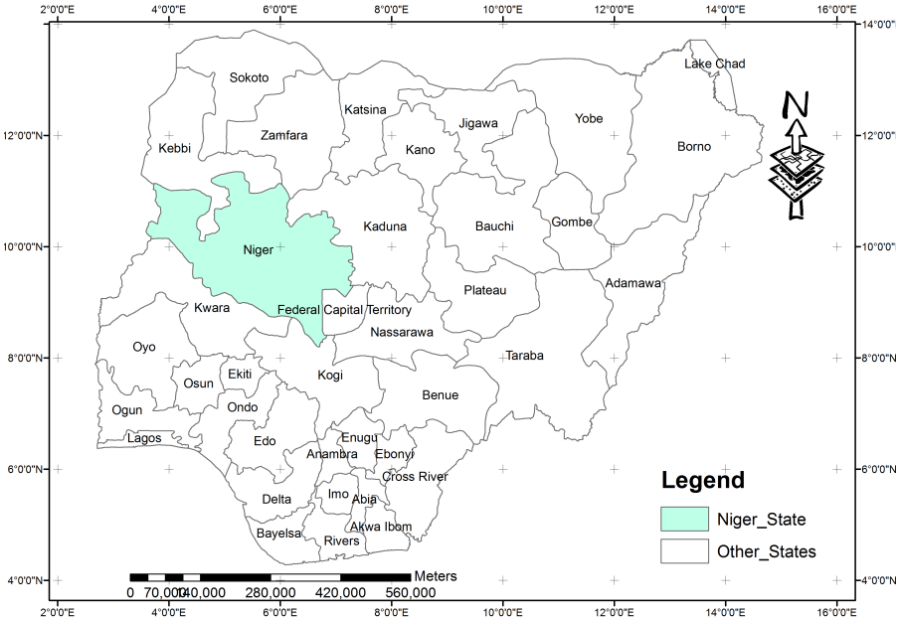

Figure 1: Map of Nigeria showing Niger State
Source: Department of Urban and Regional Planning, Federal University of Technology, Minna (2023)

There are numerous residential housing units scattered all over Minna. Facilities such as drainages, electricity and water supply from the public mains, and other facilities such as airport, railway lines, Hydro – Electricity Power Stations, stadium, hotels, and primary, secondary and tertiary institutions are available in Minna. Poor sanitary conditions exist in many parts of Minna. However, efforts are being made by the government to keep the town clean by clearing indiscriminate waste dump sites, clearing blocked drainages, and removing illegal structures. Minna is being serviced by the Chanchaga and Bosso water works stations which are under the Niger State Water Board. Unfortunately, the majority of residents do not have access to regular pipe-borne water from the mains which has been attributed to the poor conditions of the water plants. Residents have resorted to the use of hand-dug wells and boreholes for water supply.

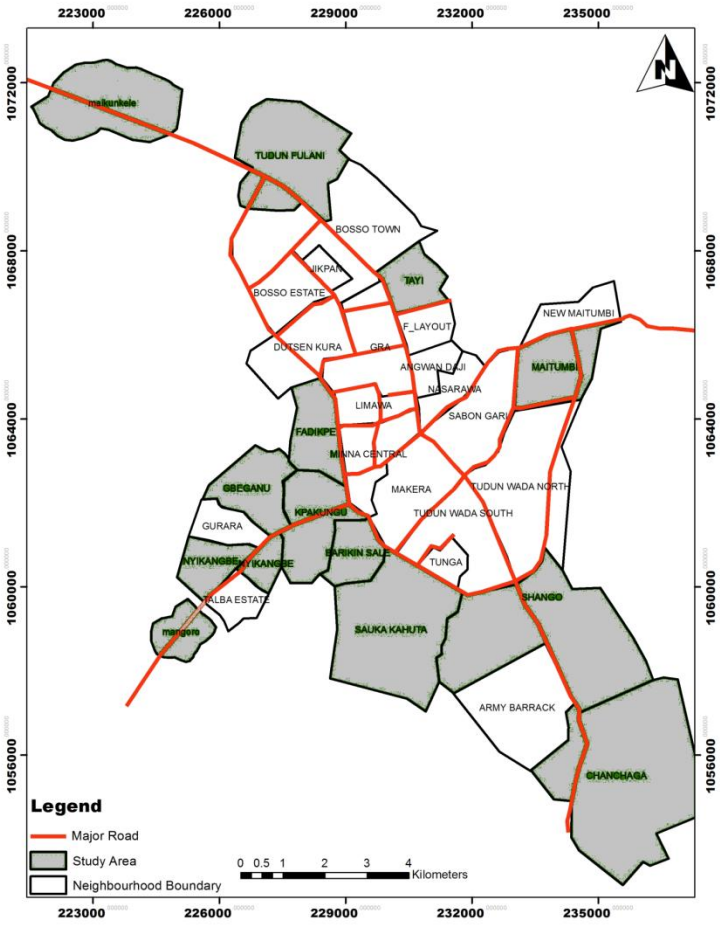

Figure 2: Map of Minna showing the sampled neighbourhoods
Source: Dept. of Urban and Regional Planning, FUT, Minna (2023)

3.2 METHODS

Ogunbajo (2018) put the total number of rented residential buildings in thirteen selected neighbourhoods of the Minna metropolis at 9,008. This research adopted + 10% precision (margin of error), a confidence level of 90%, and sampled a total of 827 housing units by stratified and random selection. The study focused only on two predominant low-income house types in the study area. These are multi-tenanted roomy apartments otherwise known as tenement buildings and one-bedroom apartments which are locally referred to as 'self-contain'. The data used were generated through a questionnaire survey and it centred on rental house prices (rental values) between 2006-2021 as well as proximities to amenities sustaining residential properties in the study area.

Due to the unorganised and informal nature of the sampled neighbourhoods, proximities to nine housing attributes were measured on ordinal scales and categorised as 'far', 'fair' and 'very close' based on consensus opinions of residents in the sampled neighbourhoods. In order

to establish the impacts of the housing attributes/amenities on the rental values of residential buildings in the study area, this research utilised the optimally scaled categorical regression analysis. This analytical tool was adopted due to the nature of the data which entailed a dependent variable measured on ratio scale, an independent variable also measured on ratio scale, and another eight independent variables measured on ordinal scales. The dependent variable is rental values of residential buildings (in Naira), while the predictors/independent variables are amenities which entailed the proximity of the residential buildings to shopping complexes, educational institutions, health care centres, recreation centres, major roads, and refuse dumps. Others are the level of security of the neighbourhood (measured in terms of reported crime cases in each area), electricity supply (number of hours of supply per day), and sources of water supply.

3.3 Data analysis

In this study, rental house prices of housing units are related to certain housing attributes/ amenities within neighbourhoods of Minna, Nigeria. A regression analysis was performed for the study area. The dependent variables comprised rental values (y), while the independent variables are the amenities sustaining the housing units in the various neighbourhoods (x). Thus, a functional equation designed to capture the relationship between rental values and amenities takes the form:

$$REV = f(x) \quad \text{..... (1)}$$

Where REV = Rental value
And x consist of the following:

X =>
- X_1 = Shopping centres
- X_2 = Educational institutions
- X_3 = Health care centres
- X_4 = Recreational facilities
- X_5 = Major access roads
- X_6 = Refuse disposal sites
- X_7 = Security/ Crime rate
- X_8 = Electricity supply
- X_9 = Water supply

The CATREG model

The CATREG model fits the classical linear regression model with nonlinear transformations of the variables, and it is written as:

$$\varphi_{r\,(y)} = \sum_{j=1}^{J} \beta_j \, \varphi_j \left(x_j\right) + e \quad \text{..... (2)}$$

by minimising the least squares loss function

$$L\left(\varphi_r : \varphi_1, \ldots \varphi_j : \beta_1 \ldots \beta_j\right) = N^1 \, \| \varphi_r \, (y) - \sum_{j-1}^{J} \beta_j \, \varphi_j \left(x_j\right) \|^2 \quad \text{.....(3)}$$

Where N = the number of observations,
J = the number of predictor variables,
{βj}, j =1,...,J = the regression coefficients,
φ_r (y) = the transformation for the response variable y,
φ_j (x_j) = the transformations for predictor variables {x_j}, j =1,...,J,
e = the error vector, and
$\| \cdot \|^2$ denotes the squared Euclidean norm.

Therefore, the categorical regression equation that describes the impact of housing attributes/amenities on rental house prices in Minna is given as:

$\varphi_{r\,(REV)} = \sum_{j=1}^{9} \beta_j \, \varphi_j \left(x_j\right) + e$ ..... (4)

Where φ_r (REV) = the transformation for the response variable (rental value),

β_j = the regression coefficients,

$\varphi_j (x_j)$ = the transformations for predictor variables (externalities), and

e = the error vector.

Substituting the x parameters into equation (4), the equation is simplified as:

$$\varphi_{r\,(REV)} = \beta_1 \varphi_{j(SHOP)} + \beta_1 \varphi_{j(EDUC)} + \beta_1 \varphi_{j(HEALTH)} + \beta_1 \varphi_{j(RECRE)} + \beta_1 \varphi_{j(ROAD)} + \beta_1 \varphi_{j(REFUSE)} + \beta_1 \varphi_{j(SECURE)} + \beta_1 \varphi_{j(ELECT)} + \beta_1 \varphi_{j(WATER)} + e \quad \text{.....(5)}$$

4 RESULTS AND DISCUSSION

The model summary in Table 1 showed a R^2 value of 0.451 for tenement buildings, an indication that the regression model explains approximately 45% of the total variation in the rental values of tenement buildings in the study area. The remaining 55% can be related to other unaccounted factors which are not included in the model such as the size of the dwelling unit, the condition of the physical building components of the house, the age of the building, and the number of toilets. The model summary in Table 1 also showed a R^2 value of 0.610 for one-bedroom apartments and it implied that amenities explained 61% of the variability in the rental values of one-bedroom apartments in the study area. The remaining 39% can also be related to other unaccounted factors which are not included in the model.

The F ratios in Table 2 tested whether the overall regression models are good fits for the data. Analysis in the table showed that the independent variables can significantly predict the rental values of the sampled house types (the dependent variable) in the study area. Table 2 showed F ratios: $F_{(15, 457)} = 25.016$ for tenement buildings, and $F_{(11, 342)} = 48.495$ for one-bedroom apartments. The corresponding p-value for each of these F ratios is 0.000. The p-values are less than 0.05, thus an indication that the regressions are good fits for the data.

Table 1: Model Summary (Standardised Data)

House Type	Multiple R	R Square	Adjusted R Square
Tenement buildings	0.671	0.451	0.433
One bedroom apartment	0.781	0.61	0.598

Table 2: ANOVA test for statistical significance

	Sum of Squares	Df	Mean Square	F	Sig.
Tenement Buildings					
Regression	213.265	15	14.218	25.016	0.000
Residual	259.735	457	0.568		
Total	473	472			
One bedroom apartment					
Regression	215.708	11	19.61	48.495	0.000
Residual	138.292	342	0.404		
Total	354	353			

Other important information is contained in Table 3. The table showed the standardised coefficients which enabled a comparison of the contribution of each independent variable to be made. The standardised beta coefficient compares the strength of the effect of each independent variable to the dependent variable (Pallant, 2011). 'Standardised' means that the values for each of the different variables have been converted to the same scale so that they can be compared. The higher the absolute value of the beta coefficient, the stronger the effect. Standardised coefficients are often interpreted as reflecting the importance of each predictor. Categorical regression standardises the variables, so only standardised coefficients are reported. These values are divided by their corresponding standard errors, yielding an *F* test for each variable.

Table 3: Beta Coefficients of the independent variables

	Standardised Coefficients				
		Bootstrap (1000) Estimate of Std.			
	Beta	Error	Df	F	Sig.
Tenement buildings					
Shopping Centres	-.127	.039	2	10.681	.000
Educational Institutions	.088	.038	2	5.404	.005
Health care Centres	-.064	.046	1	1.990	.159
Recreation Centres	.090	.057	1	2.455	.118
Major Roads	.232	.039	2	35.829	.000
Refuse Dumps	-.115	.036	2	10.053	.000
Security of the Neighbourhood	.281	.037	2	59.340	.000
Electricity supply	.384	.037	1	104.799	.000
Water supply	.162	.036	2	20.069	.000
One bedroom flat					
Shopping complexes	.085	.037	1	5.216	.023
Educational Institutions	.142	.038	1	14.000	.000
Health care Centres	-.128	.038	1	11.395	.001
Recreation Centres	.036	.052	1	.493	.483
Major Roads	.319	.036	2	78.885	0.000
Refuse Dumps	-.036	.063	1	.337	.562
Security of the Neighbourhood	.196	.037	2	28.580	.000
Electricity Supply	.611	.033	1	352.148	0.000
Water Supply	-.083	.063	1	1.711	.192

Figures in the last column of Table 3 (known as the p-values) tell whether the respective independent variables make a significant contribution to the dependent variable. Variables whose p-values are less than 0.05 imply that the variables are making a significant unique contribution to the dependent variable. A careful look at Table 3 showed that the distance of shopping centres to educational institutions, major roads and refuse dumps to tenement buildings made significant unique contributions to the rental values of these buildings in the study area. Others are the level of security of the area, electricity supply and water supply. An examination of the standardised beta coefficients in the second column of Table 3 further indicates that electricity supply makes the strongest unique contribution to explaining the rental

values of tenement buildings in the study area. This is a result of its having the highest beta coefficient. Other amenities which also contribute strongly to explaining the rental values of tenement buildings in the study area are the security of the neighbourhood, proximity to major roads and sources of water supply. As further shown in the table, the proximity of dwelling units to health care centres and recreation centres did not contribute significantly to the rental values of tenement buildings in the study area since the p-values for these variables exceeded 0.05.

For one bedroom flats, electricity supply made the strongest unique contribution to explaining the rental values. It had the highest beta coefficient, followed by proximity to major roads, security of the neighbourhood, and proximity to educational institutions. Proximity to shopping centres and health care centres made the least contributions to the rental values of one-bedroom apartments in the study area. The two variables had standardised beta coefficients of 0.085 and 0.128 respectively. A careful look at the table showed that the proximity of dwelling units (one-bedroom apartments) to shopping centres, educational institutions, health care centres, and major roads made significant unique contributions to the rental values of this category of residential dwellings in the study area. Others are neighbourhood security and electricity supply.

However, as explained by Meulman and Heiser (2012), regression coefficients may not fully describe the impact of a predictor or the relationships between the predictors. Alternative statistics must be used in conjunction with the standardised coefficients to fully explore predictor effects. The alternative statistics employed as recommended by Meulman and Heiser (2012) are the correlations (zero-order) and importance indexes. The zero-order correlation is simply the correlation between each predictor and the dependent variable after these variables have undergone the appropriate transformations. Nathans, Oswald and Nimon (2012) described the zero-order correlation as a measure of direct effect which describes the magnitude and direction of the relationship between an independent variable and the dependent variable without accounting for the contributions of other independent variables in the regression equation. Comparing the zero-order correlation coefficients in this research emphasises the magnitude and direction of the relationship between each of the sampled amenities and the rental values of each of the house types. Negative correlation coefficients indicate that the respective amenities had negative relationships with rental values, while positive correlation coefficients implied positive relationships with rental values. Negative relationships translate to a decline in rental values as a result of closer distances to the amenities, while positive relationships translate to an enhancement or improvement in rental values as a result of closer distances to the concerned amenity. 'Importance' on the other hand (which is given in the 3rd column of Table 4) simply indicates the importance of each predictor using Pratt's measure. The importance index uniquely reflects the direct and total effects of each of the independent variables (LeBreton, Ployart, & Ladd, 2004). It is roughly equivalent to the product of the regression coefficient and zero-order correlation (Moss, 2016). The importance index is primarily used to uncover suppressor variables, and it enables rank orderings of variable importance based on the partitioning of the regression coefficient (Nathans, *et al*, 2012).

The zero-order correlation and the importance indexes which served to establish the impacts of the nine housing attributes / amenities on each of the two house types are presented as follows:

Table 4: Zero-order Correlation and Importance Index for the relationship between amenities and rental house prices

Independent Variables	Zero-Order Correlation	Importance Index
Tenement buildings		
Shopping complexes*	-.204	.057
Educational Institutions*	.093	.018
Health care Centres	-.042	.006
Recreation Centres	.051	.010
Major Roads*	.285	.147
Refuse Dumps*	-.203	.052
Security of the Neighbourhood*	.319	.199
Electricity Supply*	.492	.419
Sources of Water Supply*	.256	.092
One bedroom flats		
Shopping complexes*	.017	.002
Educational Institutions*	.262	.061
Health care Centres*	-.066	.014
Recreation Centres	.112	.007
Major Roads*	.333	.174
Refuse Dumps	-.074	.004
Security of the Neighbourhood*	.269	.087
Electricity Supply*	.670	.673
Sources of Water Supply	.157	-.021

*Variables with significant impact on rental house prices

It can be deduced from Table 4 that, of all the independent variables having a significant impact on rental values of tenement buildings, electricity supply which had an importance index of 0.419 is the most important amenity which affects residential rental values in the study area. A zero-order correlation of 0.492 signified a moderate and positive relationship between tenement buildings' rental values and electricity supply. Other predictors of rental values arranged in order of importance are: security, proximity to major roads, sources of water supply, proximity to shopping complexes, refuse dumps, and educational institutions. The magnitude of the relationship between these independent variables and residential rental values is reflected in their zero-order correlations which are 0.256, -0.203, and -0.204 respectively. It was also observed from Table 4 that shopping centres and refuse dumps had negative zero-order correlation coefficients. The negative sign implied that rental values tend to decrease with closer distance to these amenities.

Results also revealed that the rental house prices of one-bedroom flats were reduced with closer distances to health care centres and refuse dumps. This is emphasised by their zero-order correlation coefficients which are -0.066, and -0.074 respectively. The table further showed that of all the housing attributes/amenities having a significant impact on the rental prices of one-bedroom apartments, electricity supply which had an important index of 0.673

was the most important in the study area. A zero-order correlation of 0.670 further signified a strong and positive relationship between the rental values of one-bedroom apartments and electricity supply, thus rental values improved with an improvement in electricity supply. Other predictors of the rental values of one-bedroom apartments arranged in order of importance were: proximity to major roads, security of the neighbourhood, and proximity to educational institutions. Results further established a weak but positive relationship between rental values and neighbourhood security and between rental values and proximity to educational institutions. Both indices had zero-order correlations of 0.269 and 0.062 respectively.

Rental Value prediction model

By substituting the coefficients generated from the regression analysis into equation 5, the prediction models developed to predict residential rental house prices in the study area are given as:

i. Tenement buildings

$$\varphi_r\,(REV) = -0.127_{SHOP} + 0.880_{EDUC} + 0.232_{ROAD} - 0.115_{REFUSE} + 0.281_{SECURE} + 0.384_{ELECT} + 0.162_{WATER} + e \quad \text{.....(6)}$$

ii. One bedroom apartments

$$\varphi_r\,(REV) = 0.085_{SHOP} + 0.142_{EDUC} - 0.128_{HEALTH} + 0.319_{ROAD} + 0.196_{SECURE} + 0.611_{ELECT} + e \quad \text{.....(7)}$$

Model Testing (Comparing predicted rental values with the actual rental values)

The mean of predicted rental values were computed for each house type across the neighbourhoods and compared to the means of the actual rental values collated in the course of data collection. Line graphs showing the actual Vs that predicted rental values for each house type are shown in Figures 1 and 2. Figures 3 and 4 showed predicted mean rental values that are reasonably similar to the means of the actual rental values of the dwelling units.

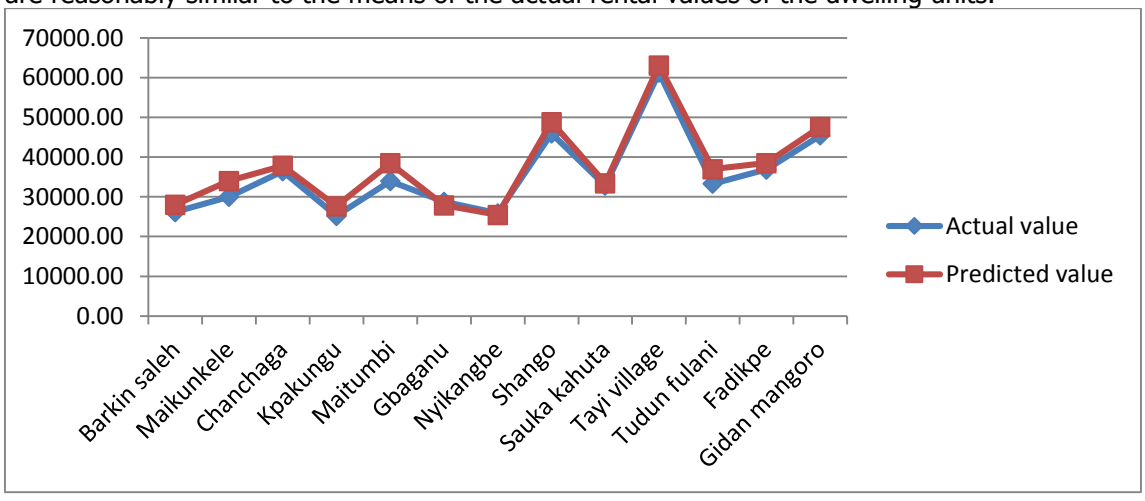

Figure 3. Actual and predicted mean rental values of tenement buildings

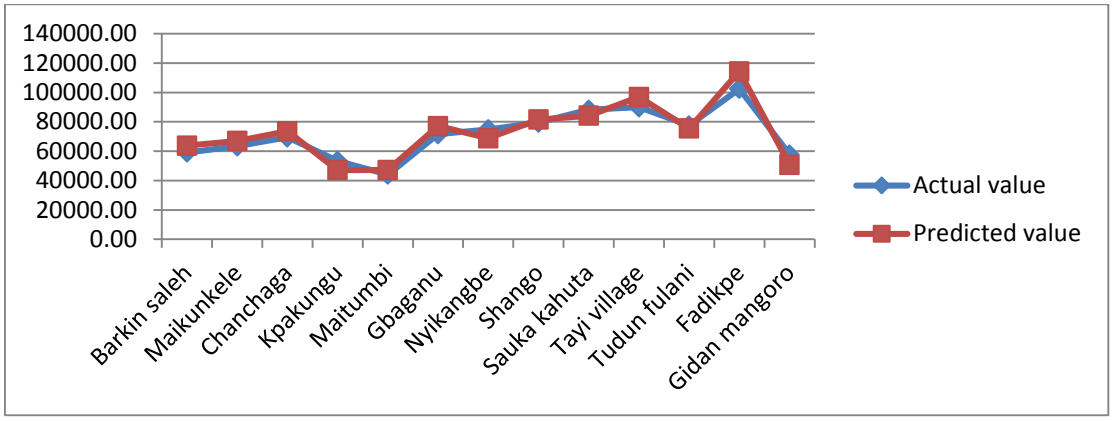

Figure 2. Actual and predicted rental values of one bedroom apartments

4. CONCLUSION

It is important to note that each of the amenities made distinct contributions to the rental values of each of the house types. For tenement buildings, closer distances to shopping centres and refuse dumps brought about a decline in rental values, while closer distances to educational institutions and major roads enhanced the rental values. Other amenities that enhanced the rental values of tenement buildings in the study area were: improved neighbourhood security, electricity supply, and water supply. Findings also revealed that for one-bedroom apartments, closer distances to shopping centres, educational institutions, and major roads, as well as improved security and electricity supply resulted in a significant improvement/enhancement in rental values. On the contrary, closer distances of one bedroom apartments to health care centres resulted in a significant decline in their rental values.

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