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# The Application of Partial Least Square Regression to Develop a Model for Reliable Investment Valuation Estimates in South-East Nigeria

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**Abstract**
Against the increasing criticism of the reliability of the conventional investment method of property valuation practice in Nigeria, this study examine the ability of the Estate Surveyors and Valuers to estimate accurately the selling prices of residential properties in South-East Geopolitical Zone of the country with a view to formulate a model for reliable value estimates. Questionnaires were administered in a sample of randomly selected forty (40) Estate Surveyors and Valuers in the four selected towns of (Aba, Enugu, Onitsha and Owerri) in the South-East Geopolitical Zone. From the analysis of variance, the total of degree of freedom is seventeen, while the sum of square is 2682.44 and P-value in the table is 0.00, meaning that there is a statistically significant relationship between the Prices and Valuer estimates. The study further used the application of partial least square (PLS) regression model to develop model for perfect reliable price estimates. The model is thus:
$P=2.25 0.13_{v1} 0.23_{v2} 0.08_{v3} 0.17_{v4} 0.17_{v5}+0.1_{v6} 0.03_{v7} 0.25_{v8}+0.14_{v9} 0.02_{v10}+0.07_{v11}+0.26_{v12}+0.37_{v13}+0.07_{v14}+0.07_{v15}+0.09_{v16}+0.1_{v17}+0.06_{v18}+0.08_{v19}+0.2_{v20}+0.2_{v21}$. The model developed has the highest independent (X) variance, lowest level of the predicted error and highest coefficient of determination (R-square) between the value estimates and market prices and gives optimal and reliable result.
**Keywords:** Partial least square, regression analysis, investment method of valuation, Valuation reliability, South-East Zone of Nigeria.

## 1.0. Introduction

The reliability of an assessment tool is the extent to which it consistently and accurately measure learning. When the results of an assessment are reliable, we can be confident that repeated or equivalent assessments will provide consistent results. This puts us in a better position to make generalized statements about a student's level of achievement, which is especially important when we are using the results of an assessment to make decisions about teaching and learning, when we are reporting back to the students and their parents or caregivers. No results however can be completely reliable. There is always some random variation that may affect the assessment, so educators should always be prepared to question results.

Factor which can affect reliability are: A larger assessment generally produces more reliable results. The suitability of the question or tasks for the students being assessed. The phrasing and terminology of the question, examples, the length of time given for the assessment instructions given to students before the text. The design of the marking schedule and moderation of marking procedures. The readiness of students for the assessment: for example, a hot afternoon or straight after physical activities may not be the best time for students to be assessed. To be sure that a normal assessment tool is reliable, check in the user manual or evidence of the reliability coefficient. These are measured between zero and 1. A coefficient of 0.9 or more indicates a high degree of reliability. Information is reliable if a user can depend upon it to be materially accurate and if it faithfully represents the information that it purports to present significantly. Misstatement or omissions in financial statements reduce the reliability of information contained in them. Reliability of financial information is enhanced by the use of following accounting concept and principles: Mentality, Faithful Representation and Prudence. The values for reliability coefficient ranges from 0 to 1. Coefficient of 0 means no reliability and 1 means perfect reliability. All things being equal, reliability coefficients never reach 1.0. Generally, if the reliability of a standardized text is above 0.80, it is said to have very good reliability, if it is below 0.50, it would not be considered a very reliable text. Reliability according to Allan (2000) is the degree to which a measurement instrument gives the same results each time it is used, assuming that the underlying object/situation being measured does not change, one can test reliability by determining whether several observers of an objective/situation will give similar accounts of it. Reliability is used interchangeably with the term accuracy in this study. Mathematically, reliability/accuracy is usually measured either in terms of percentage, standard deviations ranging from +-5% to +-15%, or through statistical tests such as regression equation, where it is expected that the intercept of the equation would be statistically indistinguishable from zero or the constant indistinguishable from one. The study will adopt Crosby et al (2003) definition of reliability/accuracy as to closeness (proximity) of the valuation to the realized exchange price. According to French (2007) uncertainty was defined as any thing that is not known about the outcome of a venture at the time the decision was made. Similarly, Malison and French (2000) observed that "normal uncertainty is a universal and unsurprising fact of

property valuation. The open acknowledgment of that fact and transparent management of its implications will enhance the utility of valuation.

## 2.0. Literature Review

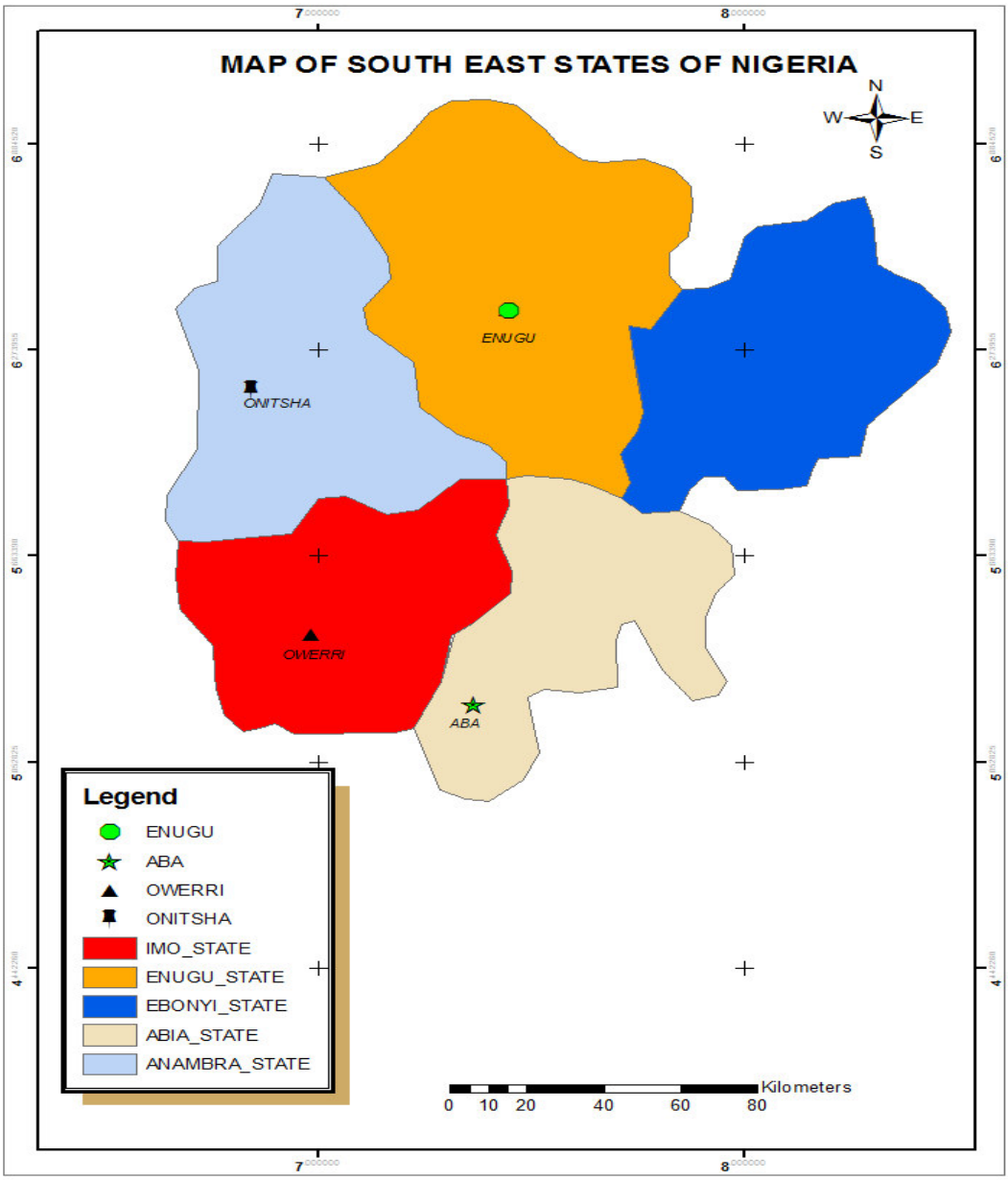
Millington (1985) described accuracy of valuation as an "aim" that should neither be expected nor necessarily sought to be achieved because a valuation that matches a market price would rather be considered anomalous. He further argues that expectation of absolute accuracy (zero percent margin of error) is "foolish" and akin to an aspiration of predict of the winner of the Grand National, which if achieved, would remove risk, and the prospect of gains and losses from investment. The fundamental characteristics of property as an asset class which can preclude accuracy as stated by Mainly for students (1985) and Millington (1985) are the imperfect of nature of the property market, the lack of a central register of sales, the individual character of buildings and confidentiality of information. Millington (1985) further observes that the condition of full information of prices, homogeneity of product, case of mobility of participant and product and competition between numerous active participants which exists for a perfectly competitive market are completely absent for the property market. According to him, such imperfection is compounded by other factors which also influence supply or demand for investment property, including the cost and availability of credibility, tax charges on investment framework with which the author contends "great" and "regular" accuracy are impossible. The various opportunities for rounding up numbers of figures during the valuation process, was also given as reason why total valuation accuracy cannot be achieved. (Millington, 1989) while noting that "where a series of figures are all "rounded off" there is always the possibility of cumulative errors being unacceptably large". Acceptance of Millington's arguments does not however preclude the establishment of an appropriate margin of error acceptable to all stakeholders: Valuers, courts, the Valuer's clients, professional institutions etc. For now, there appears to be no universal consensus as to what the acceptable level of accuracy should be. What level of inaccuracy can be recommended to all valuations.

## 2.1. The Study Area

The research is restricted to the South-East geopolitical zone of Nigeria. The Zone comprising (Abia, Anambra, Ebonyi, Enugu and Imo States). The zone covers the bulk of the Igbo speaking ethnic territory, the reminder of which extends westwards into Delta and South wards into Rivers state. The zone also include a few non-Igbo speaking communities on the Northern and Eastern borders. In pre-colonial times, Igbo land maintained a strong organic entity, with strong genetic and cultural linkages among the communities and deep interpenetration of their societies and economics through migration and trade. Under colonial rule and from Independence until 1967 the area was administered as part of the Eastern Region. With the creation of a 12 –state structure in 1967, it became a state of its own as the East central state, but could not attain full operational status until the end of the civil war in 1970.

Progressive state creation restructured the area into two in 1976, then four in 1987, then five states in 1991. Through all this, the area and the people have retained a recognizable identity and character within the Nigeria nation state. By territorial size, the South-East zone is by far the smallest in Nigeria in terms of land mass, accounting for mere 3.2% of the national land mass. However, the 2006 census data put the population of the zone at 16,431,555 people (about 11.7% of the country's population), giving it a population density of nearly four times the national average. The zone is bounded on the North by Kogi and Benue states, on the West by Edo and Delta states, on the south by the Rivers, Akwa Ibom and Cross Rivers states (see fig.1) The major cities in the zone are: Enugu, Onitsha, Awka, Nnewi, Aba, Owerri, Umuahia and Abakaliki and these are the cities where the bulk of practicing estate surveying and valuation firms are located.




## 3.0. Methodology

The data for the study was collected from the sample of forty Estate Surveyors and Valuers from forty Estate Surveying and Valuation firms from the four major town of Aba, Enugu, Onitsha and Owerri), where Estate Surveying and Valuation practice is most active in the South-East Geographical Zones. Out of these, the twenty-one (21) Estate Surveyors and Valuers representing 52.5 of the respondents were retrieved

A sample of eighteen (18) properties which were sold between January-June, 2014 were collected and the respondents Estate Surveyors and Valuers were ask to value each property without knowing the selling prices, using the conventional investment method of valuation.

The data collected was used to formulate a model that is capable of given a reliable valuation estimate, using partial least square regression method.

## 4.0. Presentation and Analysis

**Table 1:**

**Table 14: Sale prices of the 18 sample properties and their valuation estimates by the 21 respondent Estate Surveyors and Valuers in South-East, Nigeria.**

| Prices | Values by each Estate Surveyor and Valuer | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Properties | P(₦m) | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ | $V_6$ | $V_7$ | $V_8$ | $V_9$ | $V_{10}$ | $V_{11}$ | $V_{12}$ | $V_{13}$ | $V_{14}$ | $V_{15}$ | $V_{16}$ | $V_{17}$ | $V_{18}$ | $V_{19}$ | $V_{20}$ | $V_{21}$ |
| 1 | 48 | 14 | 38 | 28 | 35 | 65 | 68 | 28 | 27 | 30 | 29 | 31 | 50 | 45 | 35 | 40 | 50 | 44 | 49 | 43 | 16 | 50 |
| 2 | 15 | 6 | 7 | 10 | 18 | 17 | 12 | 16 | 18 | 15 | 17 | 14 | 17 | 14 | 15 | 10 | 11 | 17 | 9 | 6 | 12 | 13 |
| 3 | 18 | 6 | 8 | 20 | 16 | 18 | 12 | 17 | 18 | 20 | 19 | 16 | 20 | 21 | 7 | 16 | 15 | 14 | 18 | 7 | 20 | 9 |
| 4 | 40 | 31 | 30 | 15 | 25 | 42 | 51 | 30 | 28 | 27 | 29 | 31 | 38 | 42 | 30 | 25 | 36 | 32 | 28 | 39 | 35 | 35 |
| 5 | 15 | 11 | 7 | 8 | 20 | 20 | 15 | 19 | 17 | 20 | 18 | 14 | 13 | 16 | 9 | 10 | 20 | 18 | 14 | 7 | 12 | 17 |
| 6 | 9 | 6 | 6 | 5 | 7 | 8 | 7 | 14 | 15 | 13 | 12 | 10 | 8 | 10 | 15 | 11 | 9 | 7 | 8 | 6 | 6 | 10 |
| 7 | 50 | 37 | 45 | 30 | 50 | 44 | 32 | 31 | 32 | 30 | 35 | 33 | 76 | 50 | 45 | 50 | 45 | 38 | 55 | 49 | 60 | 45 |
| 8 | 30 | 30 | 17 | 18 | 35 | 34 | 13 | 26 | 30 | 28 | 29 | 27 | 48 | 38 | 30 | 30 | 45 | 25 | 40 | 35 | 17 | 30 |
| 9 | 20 | 22 | 25 | 10 | 35 | 42 | 26 | 28 | 25 | 27 | 26 | 24 | 30 | 20 | 22 | 20 | 38 | 18 | 15 | 25 | 21 | 19 |
| 10 | 14 | 12 | 15 | 8 | 12 | 11 | 25 | 14 | 12 | 15 | 13 | 16 | 15 | 12 | 14 | 14 | 8 | 5 | 11 | 10 | 12 | 14 |
| 11 | 13 | 11 | 11 | 10 | 15 | 9 | 10 | 17 | 16 | 15 | 20 | 18 | 30 | 8 | 12 | 13 | 5 | 11 | 14 | 5 | 10 | 12 |
| 12 | 35 | 35 | 30 | 18 | 45 | 44 | 8 | 35 | 36 | 38 | 37 | 39 | 40 | 45 | 36 | 40 | 45 | 37 | 34 | 36 | 40 | 35 |
| 13 | 28 | 38 | 35 | 25 | 27 | 54 | 50 | 29 | 27 | 28 | 25 | 26 | 30 | 26 | 29 | 27 | 29 | 25 | 28 | 35 | 25 | 30 |
| 14 | 33 | 35 | 26 | 20 | 25 | 33 | 47 | 28 | 30 | 29 | 32 | 31 | 35 | 30 | 36 | 32 | 22 | 26 | 25 | 30 | 35 | 30 |
| 15 | 22 | 35 | 30 | 26 | 30 | 43 | 48 | 28 | 30 | 32 | 31 | 29 | 20 | 25 | 23 | 19 | 15 | 24 | 25 | 38 | 25 | 20 |
| 16 | 9 | 14 | 6 | 12 | 7 | 7 | 25 | 15 | 17 | 14 | 18 | 16 | 8 | 8 | 10 | 10 | 6 | 9 | 10 | 9 | 8 | 10 |
| 17 | 18 | 13 | 25 | 15 | 22 | 30 | 35 | 26 | 25 | 24 | 27 | 23 | 16 | 20 | 17 | 18 | 20 | 21 | 20 | 20 | 20 | 16 |
| 18 | 25 | 32 | 28 | 25 | 25 | 33 | 45 | 24 | 26 | 27 | 25 | 28 | 25 | 26 | 30 | 29 | 25 | 27 | 28 | 22 | 25 | 30 |

**Table 2: Analysis of Variance for the Sampled Properties**

| Source | DF | SS | MS | F-Value | P-Value |
|---|---|---|---|---|---|
| Regression | 10 | 2681.97 | 268.197 | 3968.42 | 0.000 |
| Residual Error | 7 | 0.47 | 0.068 | | |
| Total | 17 | 2682.44 | | | |

**Table 3: Variance, errors and R-Square for the Model Selection**

| Component X | Variance | Error | R-Sq |
|---|---|---|---|
| 1 | 0.800984 | 302.263 | 0.887318 |
| 2 | 0.847545 | 75.808 | 0.971739 |
| 3 | 0.863327 | 26.388 | 0.990163 |
| 4 | 0.895268 | 18.219 | 0.993208 |
| 5 | 0.932881 | 13.514 | 0.994962 |
| 6 | 0.955799 | 8.661 | 0.996771 |
| 7 | 0.966670 | 4.215 | 0.998429 |
| 8 | 0.971349 | 0.956 | 0.999644 |
| 9 | 0.974121 | 0.554 | 0.999793 |
| 10 | 0.983133 | 0.473 | 0.999824 |

**Constant** **2.25050** **0.000000**

**Table 4: Coefficients and Standardized form of the eighteen sampled properties**

| No of properties | Coefficients | Standardized |
|---|---|---|
| v1 | -0.13224 | -0.128898 |
| v2 | -0.23173 | -0.226656 |
| v3 | -0.08046 | -0.049234 |
| v4 | -0.17363 | -0.165427 |
| v5 | 0.17420 | 0.235461 |
| v6 | 0.09985 | 0.146657 |
| v7 | -0.02754 | -0.014739 |
| v8 | -0.25307 | -0.139453 |
| v9 | 0.14307 | 0,083425 |
| v10 | -0.02045 | -0.011940 |
| v11 | 0.06547 | 0.042491 |
| v12 | 0.26488 | 0.364387 |
| v13 | 0.36735 | 0.397954 |
| v14 | 0.07302 | 0.065173 |
| 15 | 0.07469 | 0.070997 |
| 16 | 0.09119 | -0.109819 |
| 17 | 0.10843 | 0.094880 |
| 18 | -0.06280 | -0.068283 |
| 19 | 0.07898 | 0.094648 |
| 20 | 0.19945 | 0.214357 |
| 21 | 0.19025 | 0.188610 |

The selected model is given as

P(m) =
2.25 – 0.13v1- 0.23v2-0.08 v3-0.17v4-0.17v5+0.1v6-0.03v7-0.25v8+0.14v9-0.02v10+0.07v11+0.26v12+0.37v13+0.07v14+0.07v15+0.09v16+0.11v17+0.06v18+0.08v19+0.2v20+0.2v21
P(m)= Prices of properties in millions of Naira
$V_1$ to $V_{21}$ = value estimates from the Estate Surveyors and Valuers.

**Table 5: Fits and Residuals for the eighteen sampled properties**

| Row | Prices (₦m) | Fits | Res | SRes |
|---|---|---|---|---|
| 1 | 48 | 48.0526 | -0.052609 | -0.86294 |
| 2 | 15 | 14.8871 | 0.112871 | 0.49709 |
| 3 | 18 | 18.0384 | -0.038433 | -0.28793 |
| 4 | 40 | 40.1473 | -0.147288 | -1.60729 |
| 5 | 15 | 14.7778 | 0.222177 | 1.07303 |
| 6 | 9 | 9.3474 | -0.347382 | -2.10518 |
| 7 | 50 | 49.9583 | 0.041687 | 0.51654 |
| 8 | 30 | 29.9737 | 0.026329 | 0.19593 |
| 9 | 20 | 20.0987 | -0.098749 | -0.71932 |
| 10 | 14 | 13.7959 | 0.204058 | 0.98684 |
| 11 | 13 | 13.0645 | -0.064467 | -0.31346 |
| 12 | 35 | 35.0257 | -0.025716 | -0.18667 |
| 13 | 28 | 27.7771 | 0.222855 | 1.16046 |
| 14 | 33 | 32.8600 | 0.139974 | 0.92623 |
| 15 | 22 | 22.1690 | -0.168976 | -0.06948 |
| 16 | 9 | 9.0551 | -0.055102 | -0.26553 |
| 17 | 18 | 17.7571 | 0.242930 | 1.62902 |
| 18 | 25 | 25.2142 | -0.214160 | -1.38088 |

The method used is the application of partial least square regression model to analysis, predict and to model the system that will predict the best prices of properties using the actual data. From the analysis of variance (Table 2 and table 3), the total degree of freedom is seventeen, while the sum of square is 2682.44. However, the regression model probability value shows that the model developed is significance with a significance level of 0.000. Several models were developed for component one to component ten but the optimal of all the models is the model for the tenth component.

However, the model developed reveals that the tenth component has the highest independent (X) variance, lowest level of the predicted error and highest coefficient of determination (R-Sq) between the dependent and independent variables. The graph below reveals that the tenth component has the optimal model that can predict the best result for the prices of properties (in millions) as it is in a graphical view

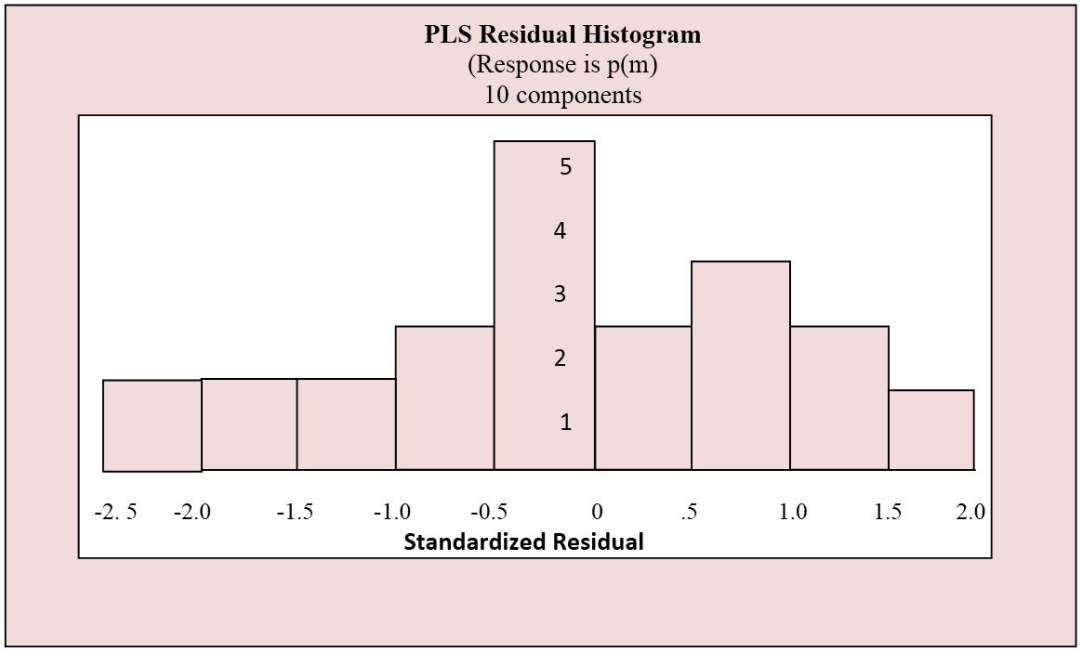



Figure 2: PLS Residual Histogram for Prices of the properties in million of Naira.

Partial Least Square residual plot of the prices of properties (in millions of Naira) shows the rate or the

frequency by which the standard residuals occurs in the row. It shows that the standard residual histogram chart occurs highest (i.e. five times) between the average of -0.5 to 0. However, the lowest occurrence of the standard residual is between the average of -2.5 to 1.0 and 1.5 and above.

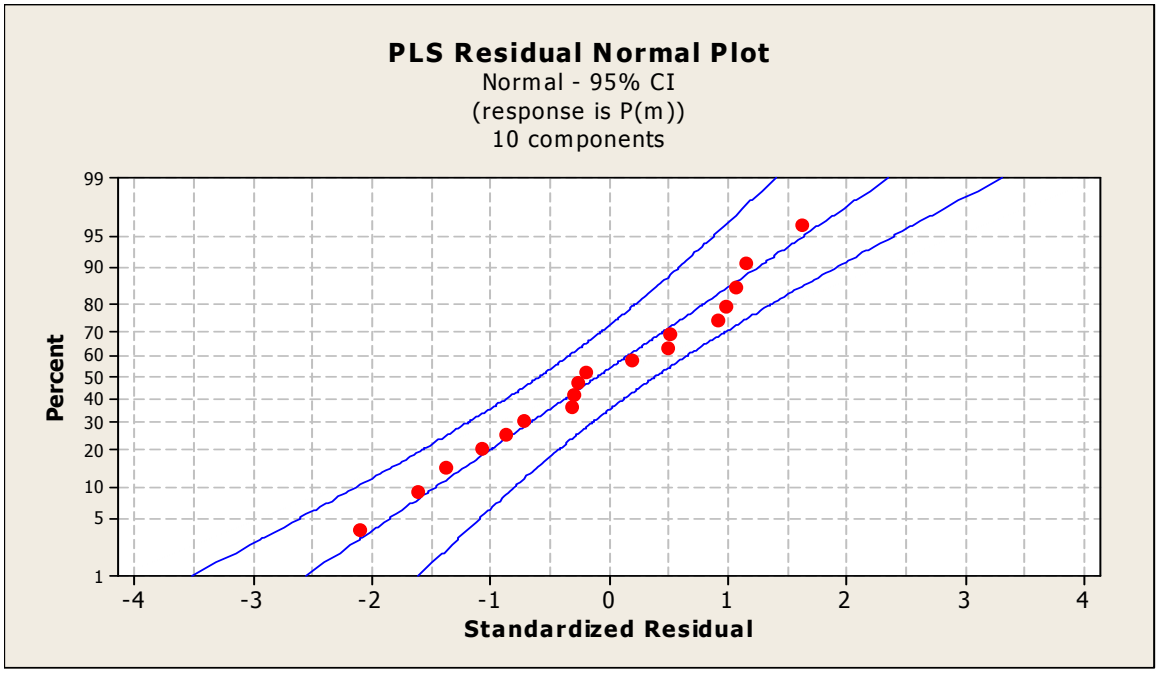



Figure 3: PLS Residual Normal Plot for Prices of the properties in millions of Naira

In figure 3, Partial Least Square residual normal plot of the prices of properties (in millions of Naira) shows the percentage by which the standard residuals occur in the row. It shows the fitted line that is in between the upper and the lower control lines in the chart. The dotted points revealed the percentage by which the standard residuals occur in the row. The result of the chart shows that the data standard residual is within the expected limits.

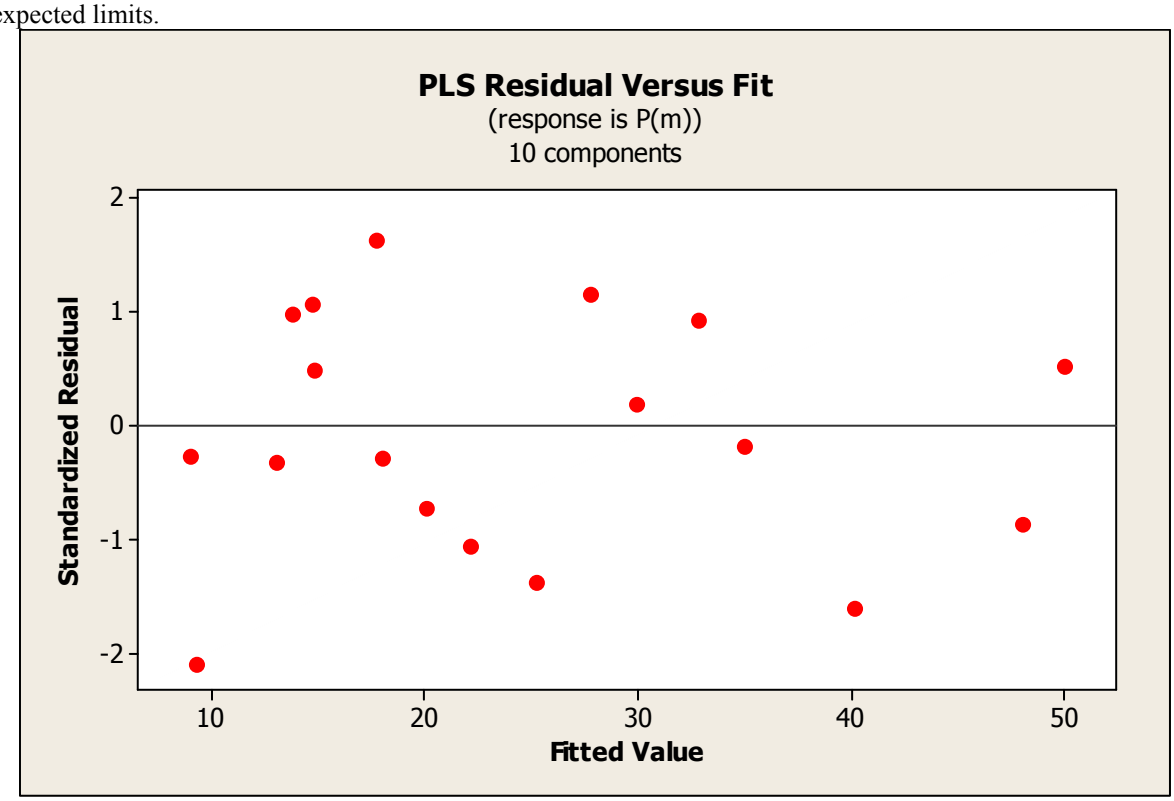



Figure 4: PLS Residual Versus Fit for Prices of the properties in millions of Naira

In figure 4, Partial Least Square residual versus fitted value plot of the prices of properties (in millions

of Naira). It shows the effect or the influence of standard residual in the fitted value.

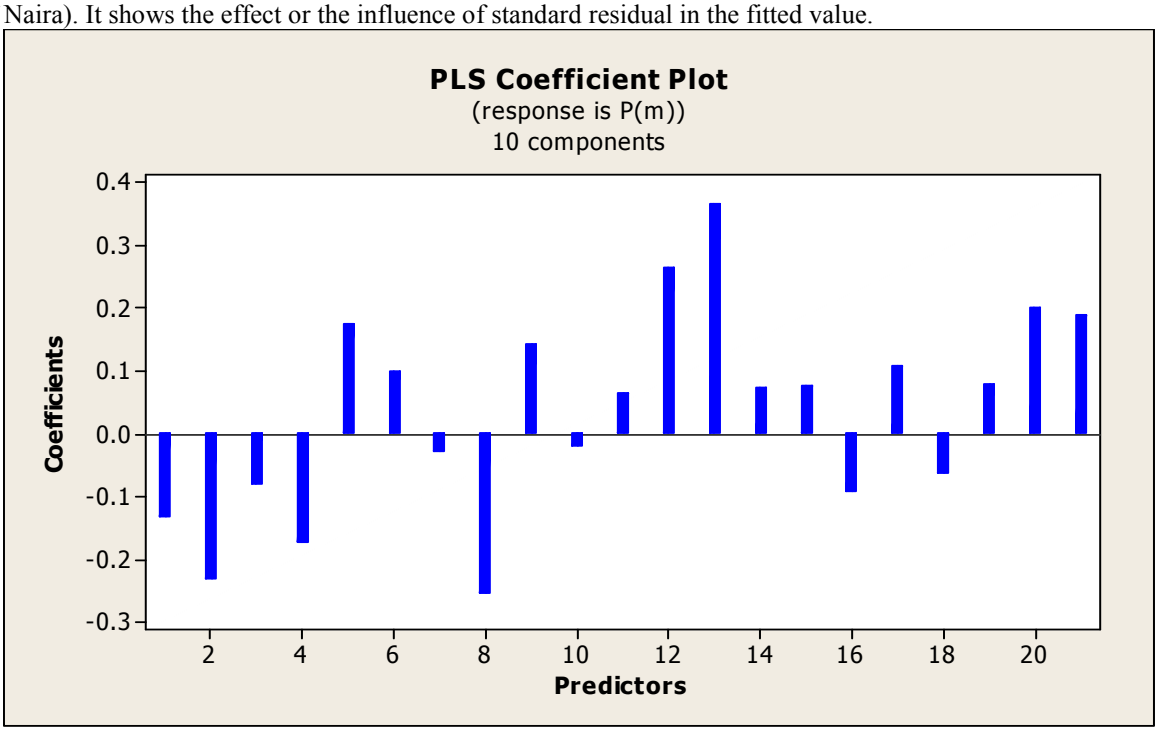



Figure 5: PLS Coefficient Plot for Prices of the properties in millions of Naira

In figure 5, Partial Least Square coefficient plot shows the graph of the predictors versus the coefficients of the independent variables. The plot shows the model developed for the prices of properties (in millions of Naira) in a graphical view. The results of the graph reveal the coefficients and the predictors of the independent variables developed by the model.

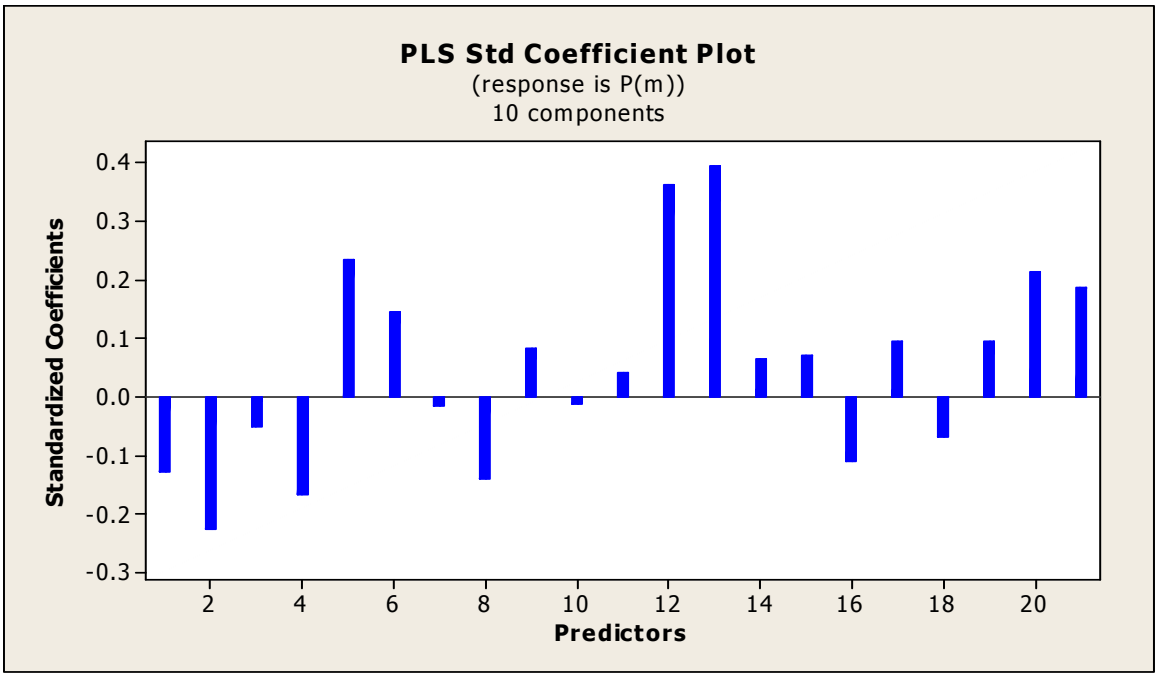



Figure 6: PLS Std Coefficient Plot for Price of the properties in millions of Naira

In figure 6, Partial Least Square standard coefficient plot shows the graph of the predictors versus the standardized coefficients of the independent variables. The plot shows the standardized coefficients for the tenth component of the model developed for the prices of properties (in millions of Naira) in a graphical view.

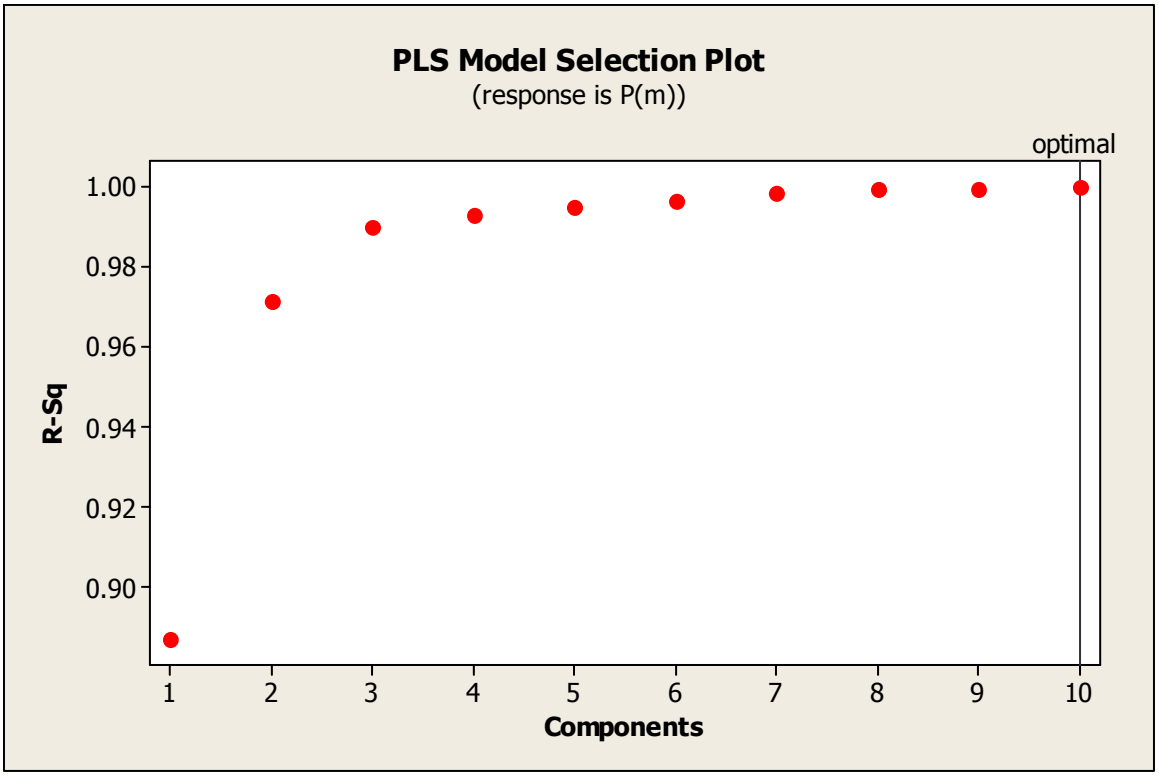



Figure 7: PLS Model Selection Plot for Price of the properties in millions of Naira.

In figure 7, Partial Least Square model selection plot shows the graph of the developed model that reveals one to ten components. The analysis of each of the components reveals the independent variance (X), the level of the error in the model and the coefficient of determination or the level of relationship of the dependent and the independent variables in the data. The graph reveals that the tenth component has the optimal model that can predict the best result for the prices of properties (in millions of Naira) as it is in a graphical view.

## 5.0. Conclusion

The tenth component has the highest independent (X) variance, lowest level of the predicted error and highest coefficient of determination (R-Sq) between the dependent and independent variables. However, the significance of the model has a significance level of 0.000 which shows that the model developed will strongly predict a good result when applied. Correlations of the independent and the dependent variables using Pearson correlation, Spearman's rho correlation and Kendall's taub correlation reveals that the relationship between the independent and the dependent are significance and also the relationships between the dependents are all highly significance. The data shows that the correlation of the independent variables has a strong relationship between each other and that the correlation between the dependent variable and the independent variables are highly significance. The results show that the variables are strongly correlated and can predict a perfect result for the dependent variable. Therefore, the tenth components gives a model of:

P(m) =

2.25 – 0.13v1- 0.23v2-0.08 v3-0.17v4-0.17v5+0.1v6-0.03v7-0.25v8+0.14v9-
0.02v10+0.07v11+0.26v12+0.37v13+0.07v14+0.07v15+0.09v16+0.11v17+0.06v18+0.08v19+0.2v20+0.2v21

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