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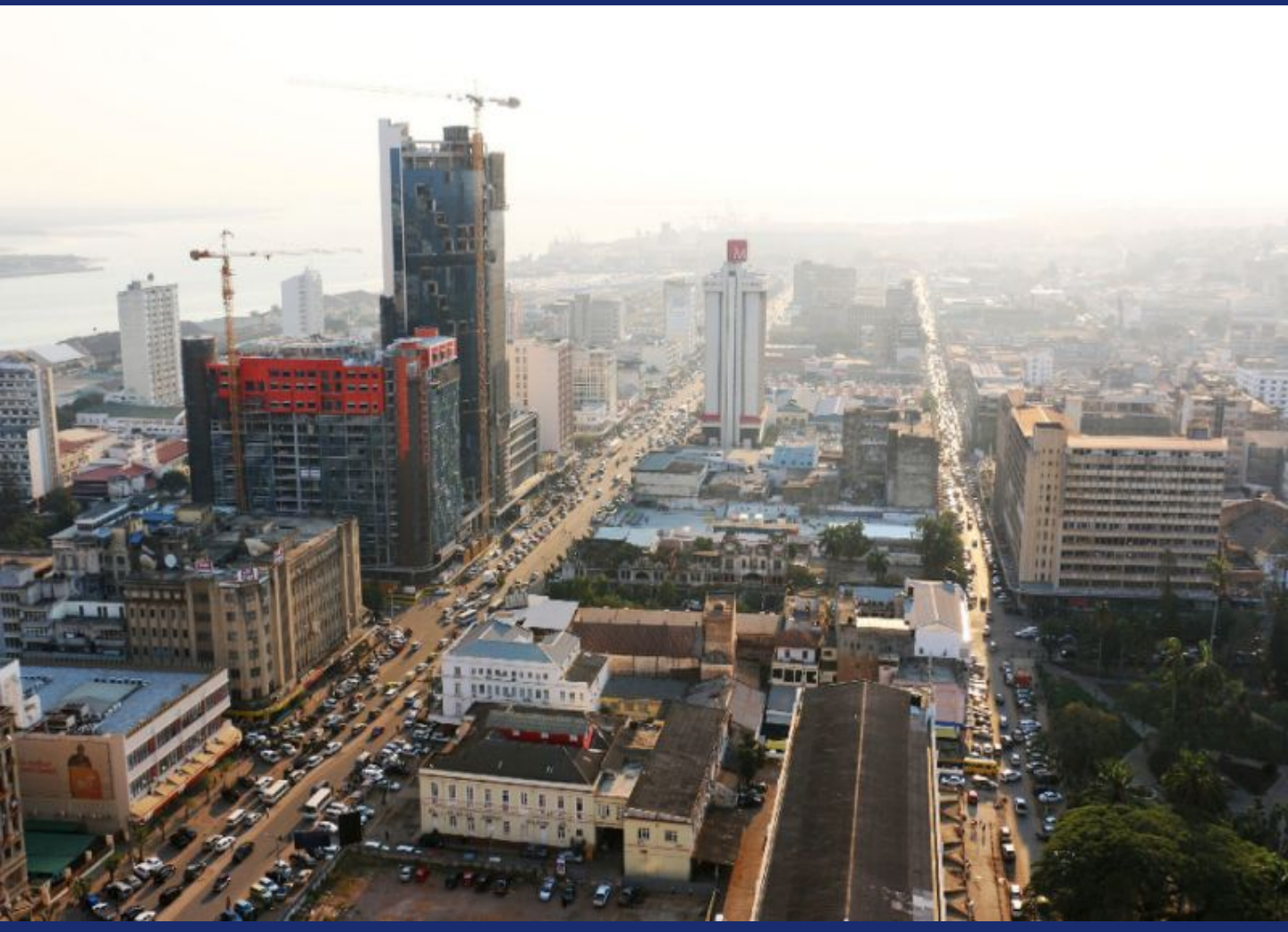

Volume 4, Issue 2

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Volume 4 Issue 2

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Editorial

Welcome to the Volume 4 (2019) Issue 2 edition of the Journal of African Real Estate Research (JARER). So far, JARER has been providing valuable resources supporting academics and professional researchers throughout the African continent. The journal continues to offer an exciting platform for the dissemination of scholarships and the different types of applied research within the real estate sector in Africa. JARER reflects one of the objectives of the African Real Estate Society (AfRES) to promote research and education among property professionals and academics across the continent. We have undergone some recent changes at JARER with the reconstitution of the Editorial Board to bring in greater diversity to the journal. This issue represents the final issue with the existing Editorial Board, and I would like to take this opportunity to show my gratitude to the hard work and dedication that it has demonstrated in ensuring the success of JARER to date. The achievements we have accomplished could not have been down without them. Thank you.

The current issue; Vol. 4, Issue 2, 2019, has had a slightly delayed publication due to the additional capacity required in establishing the new Editorial Board. We apologise for any inconvenience experienced by our readership. This issue of JARER contains exciting, interesting, thought provoking and informative topics and is a must read by everyone who cares to have an understanding of the African real estate research.

The first paper by Bax et al. focuses on addressing contemporary economic and business problems with novel machine learning capabilities. This innovative work explores the use of machine learning to develop immediate valuation estimates to properties using data from online property portals. This aims to aid sellers in quickly obtaining an accurate price estimates for their property.

The second paper, which evaluates the productivity of the housing sector in Cameroon using the data from CAHF of the ministry of Housing and Urban Development analysis (DEA), was written by Minfede Raoul. The paper reported a fall in total productivity which was attributed to a fall in technical efficiency and technological progress.

The third paper by Michael Ayodele Olukolajo examines the discrepancies in valuers' opinion on monetary compensation due to claimants for oil spill damage in the Niger Delta, Nigeria. The paper concluded that, weak standards/codes of practice, inadequate legal framework and gap in valuers' knowledge, among others, were the factors contributing to value discrepancies. This is vital and relevant work being conducted in one of the world's most oil-polluted regions.

A critical part of real estate discourse recently has been the introduction of new and innovative technology, otherwise called PropTech. This is the subject of the fourth paper by Vincent Uwaifiokun Aihie. The study sheds more light on the new wave of property technology and how its emergence has brought changes to the current perception of real estate and the challenges Nigerian real estate practitioners face when grappling with new models of operation brought about by this technological revolution.

Lastly, the fifth paper, written by Dabara and Ogunba is an examination of the correlations among the structure, conduct and performance of Real Estate Investment Trusts in Nigeria (N-REITs). The Granger Causality Test conducted revealed a bi-directional causal relationship among the structure, conduct and performance of N-REITs. A practical benefit of this paper is the information it provides that is capable of enhancing and guiding real estate investment decisions in the Nigerian market.

The standard and quality of the papers illustrates the excellence that exists across the continent and is testament to the world-leading real estate research that is being produced from within Africa. I would like to thank the authors who have dedicated their time and energy in highlighting the potential of African-led research publications. Without them there would be no JARER. The continuing publication of the journal is also made possible through the support of AfRES, IRES, ERES, Prof. Karl-Werner Schulte of IREBS at Regensburg University, the Library Services at the University of Cape Town, South Africa, and the Managing Editor, Luke Boyle, who works tirelessly to oversee the publication process.

The journal is growing from strength to strength and the board has seen the need and importance of supporting female researchers in real estate related fields across the continent. Thus, JARER will be publishing a special issue devoted to highlighting the works of female researchers in real estate, property, housing, urban development and related subjects. The issue is being co-edited by our Guest Editors; Karen Gibler and Geci Karuri-Sebina.
If you are interested in publishing your work in this special issue, or require further details, please contact Karen at kgibler@gsu.edu

I am interested in hearing from readers on their views of this, previous and subsequent issues of the journal.

Best wishes,

Professor Abel Olaleye
Editor-in-Chief

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A Machine Learning Web Application to Estimate Listing Prices of South African Homes

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Abstract

Due to the heterogeneous nature of residential properties, determining selling prices which will reconcile supply and demand is difficult. Establishing realistic listing prices is vitally important for sellers to prevent prolonged time on the market. Sellers have several resources available to assist in this endeavour, all of which involve understanding current market dynamics through analysing recent sales and listing data. Property portals which aggregate real estate agencies' data, hosting it on online platforms, are one such resource, along with individual real estate agencies. Leveraging this data to develop solutions that could aid sellers in listing price decision making is a potential business objective that could not only add value to sellers but create a competitive advantage by increasing traffic to an online real estate platform. Using data provided by a South African online property portal, this paper creates a web application using machine learning to estimate listing prices for different types of homes throughout South Africa. This study compared log linear and gradient boosted models, estimating residential listing prices over a four-year period. The results indicate that although log linear models are suitable to account for spatial dependency in the data through the inclusion of a fixed location effect, the assumption of linear functional form was not satisfied. The gradient boosted models do not impose explicit functional form requirements, making them flexible candidates. Similarly, these models were able to handle the spatial dependency adequately. The gradient boosted models also achieved a lower out of sample error compared to the log linear models. The findings show that over the observation period, larger properties consistently experience a diminishing return at some point over the marginal distribution of physical characteristics. The web application details how sellers are easily able to obtain mean listing price estimates and gauge the growth thereof, by simply inputting their property interest criteria.

Keywords: Machine Learning; H2o.ai; Hedonic Modelling; Residential Property Valuation

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1. Introduction

People wishing to sell their homes are faced with the challenging question of what price to list their property for on the market. They have several resources available to help determine this themselves, namely print material such as real estate listing publications or online sources, including real estate agency websites and property portals. Online property portals aggregate property listings from real estate agencies and disseminate these pooled listings through online user interfaces, such as smartphone applications and websites. South African examples of property portals include Private Property and Property24, and some international examples include Zillow, Zoopla and Rightmove. Regardless of the source of information that sellers may use, they are faced with the time-consuming task of trawling through a plethora of listings in order to gauge what price their homes could fetch on the market.

Alternatively, interested sellers may seek the help of professional real estate agents to value their homes which often results in an expensive sales commission when the property is sold. A comparative market analysis is a frequently used and recommended method for estate agents to use when valuing homes. This method examines several sources of information, including what similar properties have sold for recently, initial listing prices and duration on the market (Private Property, 2019). Real estate agents may also consider important home and neighbourhood characteristics in their estimates. PropertyFox, an online South Africa real estate agent, does not send agents to examine properties, choosing rather to use technology to combine traditional sales index methods with real time listing prices of similar homes for sale in order to derive estimates (PropertyFox, 2019). In real estate economics literature, hedonic pricing is a common approach employed to estimate home prices conditional on a property's set of characteristics, such as: size, number of bedrooms, number of bathrooms and location, amongst others. Similarly to estate agents, a hedonic model performs a comparative market analysis, however, it does so with a mathematical model. Property portals and real estate agencies are well positioned to leverage their extensive market data, developing such models to guide sellers in their price setting endeavours.

This study compares traditional log linear models to ensemble tree-based, machine learning models, namely gradient boosting, thereby developing hedonic listing price functions for the South African property market. A web application is developed to present how the proposed framework can be democratised to sellers by property portals or real estate agencies as a service offering. The web application allows users to quickly obtain property market listing price estimates and gauge historic growth.

2. Background and Objective

Hedonic pricing is a popular quality adjusted technique used in estimating property prices and constructing residential price indices (Jiang, Phillips & Yu, 2015; Shimizu et al., 2016). Hill (2013), in an extensive literature survey on various residential property index techniques, concluded that hedonic

indices have been favoured over other methods. A hedonic pricing function describes the price of a heterogeneous product through its utility bearing attributes (Rosen, 1974). De Haan and Erwin (2011) outline linear regression as a prominent hedonic pricing technique to estimate the marginal contributions of each property's attribute, taking the form of the full linear model (1) or the logarithmic linear model (2) given by:

$$p_n^t = \beta_0^t + \sum_{k=0}^{n} \beta_k^t \; z_{nk}^t \qquad (1)$$

$$ln\, p_n^t = \beta_0^t + \sum_{k=0}^{n} \beta_k^t \; z_{nk}^t \qquad (2)$$

The assumption that the price p_n^t of property n in period t is a function of a fixed number of parameters. β_0^t and β_k^t are the intercept and characteristic coefficients. Two main approaches exist using this technique. Firstly, the time dummy approach where a single regression is run on the pooled cross-sectional data. In this case the characteristic coefficients are fixed over time with a time coefficient that varies between periods (de Haan & Erwin, 2011). A disadvantage of this approach is the problem of temporal fixity which means that adding new periods to the data will result in changes to the coefficient estimates, resulting in revision estimates (Hill, 2011). The second main approach is the characteristics approach where separate regressions are run for the respective periods allowing the characteristic coefficients to vary from period to period. This is far more reasonable than the fixed time dummy approach (de Haan & Erwin, 2011). The characteristics method deals with temporal fixity and is more popular for computing residential price indices used by statistical agencies and government bureaus (Hill, 2011). The estimation of the hedonic price function is the starting point in developing a hedonic price index where index number theory is then applied to the counterfactual predicted values to produce the property price index. This study focuses on the starting point, estimating hedonic price functions for the South African property market.

Day (2003) developed a hedonic house price function for Glasgow, Scotland, where the natural logarithm of selling price was regressed on physical and locational property attributes. The research showed that along with the physical attributes of the properties, spatial effects were statistically significant. Bourassa et al. (2007) also applied a log linear hedonic model to the Auckland, New Zealand, housing market where similarly spatial and physical attributes were statistically significant. A key finding was that a dummy locational variable was able to account for spatial autocorrelation adequately. Els and Von Fintel (2010) developed pooled log linear and quantile regression models to estimate house price growth in the Western Cape, South Africa. The researchers found that the parametric assumptions of the log linear model were violated, and that the explicit functional form was incorrectly specified. This led the researchers to develop a quantile regression model where they found the model coefficients varied across quantiles, indicating that hedonic prices were sensitive across the price distribution. Du Preez, et al. (2013) developed a hedonic price function for houses in Walmer, South Africa, using the local constant estimator where the

direct estimate of $E(y|x)$ is produced with a kernel function that produces a smooth estimate of the densities. The researchers found that this non-parametric technique outperformed the parametric linear model. Bax and Chasomeris (2019) developed a hedonic price function for apartments listed for sale in coastal submarkets in KwaZulu-Natal, South Africa, using a gamma generalised linear model. The findings showed that the gamma distribution was appropriate and that treating the location as a fixed effect accounted for the spatial dependency effectively. These studies investigated certain property types and submarkets in isolation. This study aims to bridge this gap in South African real estate pricing literature by extending the scope to different property types and submarkets across South Africa.

The assumption that residential property prices depends linearly on a set of property coefficients makes the use of models, given in equations 1 and 2, attractive techniques to estimate hedonic functions with the added benefit of model transparency. However, Rosen (1974) suggests that this relationship is unlikely to be linear as the marginal cost of characteristics increase, coupled with the inability to unbundle characteristics. Lisi (2013) points out that the non-linear relationships between housing prices and housing characteristics is a key feature in developing hedonic pricing functions, although the specific functional form is not known *a priori*. Parametric hedonic models often suffer from misspecification due to the assumption of an explicit functional form, however, semi-parametric and non-parametric models have flexible functional forms which are capable of capturing more meaningful relationships. Pace (1998), Anglin and Gençay (1996) and Bin (2004) conducted different studies comparing several semi-parametric hedonic price functions to traditional parametric techniques where they showed an improvement in out of sample errors using approaches like generalized additive models. Van Wezel et al. (2005) applied gradient boosting, a non-parametric machine learning algorithm and stepwise linear models to develop hedonic price functions for three different datasets, two of which were US and UK housing datasets. The findings showed that the gradient boosting algorithm achieved a reduction in the out of sample errors in comparison to the stepwise linear models.

The ubiquity of hedonic pricing in real estate economics is evident where models that assume explicit functional form, such as log linear, are often used to map property characteristics to property prices. Although several studies exist that explore the use of semi-parametric and non-parametric techniques, there appears to be a lack of extensive research conducted in South Africa using contemporary machine learning algorithms to derive hedonic price functions for the residential property market. Furthermore, previous South African real estate pricing studies have focused on specific segments of the property market. This study contributes to South African real estate economics literature by comparing gradient boosting to traditional log linear models, developing yearly cross-sectional hedonic listing price functions for different residential property types throughout South Africa over a four-year period. An important feature of this study is the ability to visualize the gradient boosted hedonic price functions in an interpretable way, leveraging recent developments in machine learning literature. This paper presents an

algorithmic solution that could be used as an alternative to, or in conjunction with, manual comparative market analyses. The hedonic price functions are delivered through a web application which has practical implications for real estate agents, sellers and property portals. Sellers and real estate agents simply input the characteristics and location of the property of interest into an online user interface and easily obtain the expected listing price for each year in the data. The application allows users to gauge listing price growth over the study period, which can be informative in pricing decision making. Property portals and real estate agencies are well positioned to leverage their data, developing similar solutions, using potentially richer data.

3. Data and Design Framework

The open source statistical programming language R was used in this study. The dataset comprised of residential property listings spanning January 2014 to August 2017. These were obtained from an online South African property portal, Private Property (Pty Ltd). Table 1 describes the variables used in this study.

Table 1: Description of the Data

Variable	Description
Listing Price	The advertised price of the property in ZAR
Size	The size of the physical structure of the property in square meters
Bedrooms	The number of bedrooms in the property
Bathrooms	The number of bathrooms in the property
Property Type	The type of property e.g. apartment
Suburb	The suburb the property is located
Province	The province the property is located
Area	Concatenation of suburb and province
Listing Date	The advertisement date of the property on the portal
Latitude	The latitude coordinates of the area the property is located
Longitude	The longitude coordinates of the area the property is located

The longitude and latitude coordinates were collected via a geocoding API which was necessary for testing for spatial autocorrelation. Duplicate listings were identified and removed using row-wise matching along with incomplete observations. The initial data summary statistics are presented in Table 2.

Table 2. Data Summary Statistics

	Listing Price	Size	Bedrooms	Bathrooms
Minimum	R1,000	2	0	0
1st Quartile	R950,000	98	2	2
Median	R700,000	200	3	2
Mean	R2,461,210	259.8	3.135	2.252
3rd Quartile	R2,950,000	330	4	3
Maximum	R200,000,000	85,102	78	78

The data could be subject to incorrect data capturing arising from human error as real estate agents manually capture the information before it is disseminated via automatic feeds to the property portal. Examining Table 2, the maximum and minimum values seem improbable, therefore incorrect data capturing is a fair assumption. An autoencoder, which is a deep learning neural network, was developed to identify anomalous data points. Autoencoders generalize the concept of non-linear principal component analysis where the feature space is reduced via a bottleneck at the hidden middle layers, learning the non-linear representation of the inputs, with the output layer aimed at reproducing the input layer given this restricted representation (Hastie et al., 2015). The network is able to learn the identity of the data via a non-linear reduced representation of the original data where a high reconstruction error for data points indicate non-matching of the learned pattern (Candel et al., 2018). Reasonable lower limits were set on some variables using the ABSA bank property price index, the oldest price index in South Africa, as a guideline (Luus, 2002). Listing price was set to ≥R200,000 and size was set to ≥35m2. The autoencoder produced more feasible data by discounting data with a high reconstruction error. Table 3 presents the summary statistics of the final dataset which comprised of 382,826 properties.

Table 3. Final Data Summary Statistics

	Listing Price	**Size**	**Bedrooms**	**Bathrooms**
Minimum	R200,000	35	1	1
1st Quartile	R958,000	100	2	2
Median	R1,690,000	200	3	2
Mean	R2,159,173	231.3	3.1	2.16
3rd Quartile	R2,799,000	316	4	3
Maximum	R19,700,000	2,080	13	12

South Africa is approximately 1.2 million squared kilometres, comprising of nine provinces (Luus, 2002). The distribution of listings throughout the nine provinces is presented in Table 4. Gauteng represents the largest market share of listings over the period. Gauteng is also the smallest province, yet has the largest population (Statistics South Africa, 2019).

Table 4: Spatial and Temporal Distribution of Listings

Province	**Listing Year**			
	2014	**2015**	**2016**	**2017**
Eastern Cape	4,086	4,380	5,899	3,973
Free State	763	1,171	1,770	1,210
Gauteng	37,420	41,105	63,852	46,341
KwaZulu-Natal	9,602	10,731	13,519	9,946
Limpopo	737	748	1,164	770
Mpumalanga	3,079	3,397	4,697	2,067
North West	371	228	324	199
Western Cape	26,422	26,342	34,103	22,395
Northern Cape	0	0	10	5
Total	**82,480**	**88,102**	**125,338**	**86,906**

The period 2016 saw a large increase in listings, likely due to mechanisms of data collection peculiar to the property portal, nevertheless it was not discounted.

This study adopts the characteristics method proposed by de Haan and Erwin (2011) because of the advantage of avoiding revision estimates which would be beneficial in a production environment, making it the practical choice for property portals. This means that yearly cross-sectional models are developed. All statistical hypothesis tests used had a level of significance of 0.05.

3.1 Gradiant Boosting and H2o

Statistical learning is a recent development in the field of statistics. It leverages machine learning and computer science to understand complex data and solve contemporary business and scientific questions (James et al., 2013). Supervised statistical learning develops models used in predictive tasks where an output is estimated as a function of one or more inputs (Kuhn & Johnson, 2018). Supervised statistical learning involves developing predictive models on training data that generalize to unseen holdout data (Hastie, Tibshirani & Friedman, 2005). Boosting is an example of supervised statistical learning where decision trees are grown sequentially using information from previous trees. Boosting is a technique of improving a learning algorithm which executes repeated iterations of a weak learner by constructing decision trees sequentially from the residuals (Freund & Schapire, 1996; Friedman, 2001). Therefore, each tree is grown using information from previously grown trees. Boosting seeks to combine performance of iterations of learners, let $h_1, h_2, \dots h_T$ represent a set of hypotheses with the composite ensemble hypothesis given by:

$$f(x) = \sum_{t=1}^{T} \alpha_t h_t(x) \qquad (4)$$

Where α_t is the coefficient with which the ensemble h_t is combined, α_t and h_t are learned through the boosting procedure (Meir & Ratsch, 2003). The boosting algorithm learns slowly by fitting a decision tree to the residuals from the model then adding this new decision tree into the fitted function in order to update the residuals. Importantly, previous trees affect the construction of new trees.

H2o.ai is a highly scalable open source provider of parallelized machine learning algorithms that are distributed in memory, making it a fast and efficient machine learning platform (LeDell et al., 2019). Gradient Boosting Models (GBMs) are part of the H2o.ai stack that can be developed using different programming languages such as R and Python, or the easy to use H2o.ai flow web interface for non-programmers. Gartner (2018), a global research and advisory firm, named H2o.ai a leader amongst 16 vendors in their '*Magic Quadrant for Data Science*'. H2o.ai describes GBMs as forward-learning, non-linear ensembles of tree-based models where weak trees are sequentially grown from the incrementally changed data, resulting in an ensemble of weak prediction models that gradually improve estimations

of a response variable iteratively. Key features for using the H2o.ai implementation of GBM in this study include the ability to fit exponential families of distributions, automatic early stopping based on convergence of a specified metric and the use of stochastic GBM which improves generalization through column and row sampling during model building (Friedman, 2002; Click et al., 2016). R or Python scripts using the H2o.ai functionality can be embedded into backend or cloud systems for deployment purposes. Alternatively, the final model can be exported as a Java object and embedded into web applications. This makes the H2o.ai implementation of the GBM algorithm portable and interoperable for organisations like property portals.

4. Model Evaluation and Selection

Two model validation approaches are adopted in this study, firstly splitting the data into training and validation sets, and secondly, the use of cross validation. The log linear models and GBMs are built using the training data and evaluated on the holdout (validation) data. Cross validation is then applied to the GBMs to optimise the hyperparameters, with the aim of reducing the out of sample error. Cross validation is not applied to the log linear models as hyperparameters are not applicable, coefficients are estimated through minimizing the sum of squared residuals (Greene, 2003). In both approaches, the root mean squared error (RMSE) is used to test model fit and generalizability. RMSE measures the closeness of model estimates to the observed data (Gujarati, 2004).

The data splitting procedure involved splitting the data into training and holdout sets for each respective year, where 70% of data was used for training and the remaining 30% used to test model generalizability as unseen holdout data. The holdout error provides a robust estimate of model generalizability (Blum, Kalai & Langford, 1999). A function was written to ensure that the assignment of data to the yearly splits was random and that distribution of the response was similar for each split and to the original sample. Finally, for each year, the function kept each area present in each split.

In supervised machine learning problems, model tuning involves finding the optimal hyperparameters for a predictive task. Tuning hyperparameters vary the complexity of models with the aim of finding the values of the tuning parameters that minimize the average prediction error (Hastie, Tibshirani & Friedman, 2001). Searching over a high dimensional hyperparameter space to find the optimal combinations thereof can be computationally expensive. This is often a drawback of traditional (cartesian) and manual grid searches which can be mitigated by using a random grid search which samples uniformly from the set of all possible hyperparameter value combinations (Bergstra & Bengio, 2012). This study implements a random grid search which allows for early stopping of model building based on convergence of the user supplied training error metric. The findings of Bergstra and Bengio (2012) shows that a random grid search strategy is able to produce models that are at least as good or better than those from manual and traditional grid searches. Zhong et al. (2018) provide evidence that early stopping is useful

in the reduction of the hyperparameter search space in neural network architectures. Early stopping is applied in this study which stops the algorithm if the root mean squared error (RMSE) does not improve for 25 training rounds based on a moving average of 10,000.

Evaluation of model generalization hyperparameter selection can be achieved using k fold cross validation. This involves splitting the data into k roughly equal parts whilst maintaining the original distribution of the response, Table 5 illustrates an example of 5-fold cross validation.

Table 5: 5-Fold cross validation structure

Fold 1	Fold 2	Fold 3	Fold 4	Fold 5
Training Set	Validation Set	Training Set	Training Set	Training Set

The procedure involves fitting a model to the training folds and calculating the prediction error on the validation fold which is then repeated for folds $k = 1, 2, \dots K$ and finally, combining the K estimates of prediction error (James et al., 2013). Hastie, Tibshirani and Friedman (2001) provide a detailed description which is summarized in the following sentences. Let: $\kappa : \{1, \dots, N\} \rightarrow \{1, \dots, K\}$ be an indexing function indicating which fold observation i belongs to from the randomised fold splits. The fitted function is denoted by $\hat{f}^{-k}(x)$ which is computed with the validation set. This provides a measurement of the cross-validation prediction error, given by:

$$CV(\hat{f}) = \frac{1}{N}\sum_{i=1}^{N} L\left(y_i, \hat{f}^{-\kappa(i)}(x_i)\right) \qquad (5)$$

Extending this framework to include a set of models $f(x, \alpha)$ indexed by a tuning parameter α is given by:

$$CV(\hat{f}, \alpha) = \frac{1}{N}\sum_{i=1}^{N} L\left(y_i, \hat{f}^{-\kappa(i)}(x_i, \alpha)\right) \qquad (6)$$

Cross validation can be applied to models with many tuning parameters to search for the combination of hyperparameters that produce the lowest prediction error. The 5-fold cross-validated GBMs are built on 80% of the data with 20% withheld as the final validation set, making the generalization framework robust (LeDell et al., 2019). Yearly property listings from all respective areas are randomly blended into the 5-folds, making the cross validation spatially mixed based on the distribution of response.

Typically, when splitting data into training and validation sets or cross validation folds, researchers want validation sets to be independent from training sets, however, spatial data often violates this requirement. The random selection of validation data from the entire spatial domain will result in dependence between training and validation sets because of spatial structure. This leads to overly optimistic error estimates when extrapolating outside the spatial structure. Blocking is an approach designed to remedy this by forcing testing on spatially distant records (Trachsel & Telford, 2016).

However, if the objective of the model is to interpolate or predict within the same spatial structure, random cross validation or random splitting techniques are reasonable approaches as the model's conditions do not change (Roberts et al., 2017). The models developed in this study are interpolation models, meaning that they aim to use the property portals existing data and make predictions on the same spatial structure. Therefore random data splitting and cross validation techniques are employed.

The RESET test, proposed by Ramsey (1969) is applied to the log linear models, designed to detect inappropriate functional form (Shukur & Mantalo, 2004). Under the alternative hypothesis, a model generated by taking powers of the covariates has significant influence (Ramsey, 1969). GBMs do not make any explicit functional form, with the aim of keeping estimates on the original scale, the gamma distribution is used to estimate listing prices, assuming the canonical link function. This will result in arithmetic mean estimates where no back transformation is necessary. Linear models assume that the coefficients combine linearly with the covariates, the best way to investigate these relationships is through a graphical assessment using partial residual plots. A partial residual plot results in a bivariate scatter plot which removes the effect of other covariates except the one of interest and describes its relationship to the response through model residuals (Fox & Weisberg, 2018). These diagnostic plots are used to evaluate the fit of the log linear models. Similarly, Partial Dependence Plots (PDP) are developed for the GBMs to understand the effect of the covariates on the response. PDP's are a useful interpretation tool for 'blackbox' machine learning algorithms which plot the marginal effect of a covariate on the response holding other covariates constant (Friedman, 2001; Hastie et al., 2009).

The estimation of residential hedonic price functions often suffers from spatial autocorrelation, manifesting in correlation of the residuals in regression models (Bourassa et al., 2007). This violates the assumption of independence and needs to be checked. Model fit and validation techniques using random data splits are only reliable for situations where assumptions of independence are checked and in non-extrapolation cases (Roberts et al., 2017). The Moran I test (1950) is used to test for spatial autocorrelation of the residuals which simply measures how the residuals behave in two dimensional space (Anselin 2006). The coefficient ranges from -1 to 1 which shows the strength and direction of spatial autocorrelation. In the case of this study the alternative hypothesis is that positive spatial autocorrelation exists. Positive spatial autocorrelation is when high or low value properties tend to cluster together in space.

5. Results and Discussion

The goodness of fit and diagnostics of the log linear models are presented in Table 6. The RMSE and R_2 statistics are reported as the measures of goodness of fit. The R_2 indicates how much variation in listing price is explained by the variation in the physical and locational characteristics.

Table 6: Log Linear Model Summary and Diagnostics

Year	R_2	Training RMSE	Holdout RMSE	RESET Test p-value	Moran's I Statistic	Moran's I p-value
2014	0.87	766,117	762,544	1.38e-54	-0.029487	0.99
2015	0.87	767,251	774,243	1.22e-56	-0.024477	0.99
2016	0.87	714,015	741,349	1.4e-49	-0.025836	0.99
2017	0.88	724,097	726,167	3.34e-38	-0.030789	0.99

Notes: R_2 has been rounded to two decimal places and RMSEs to the nearest whole number.

The R_2 measures are very high, showing that 87% to 88% of the variation in listing prices is explained by the variation in the explanatory variables. Overall, the log linear models appear to generalize to the unseen, holdout data well, showing robustness. The RESET tests indicate that there is sufficient evidence to reject the null hypothesis of correct specification of linear functional form. These results are congruent to the findings of Els and Von Fintel (2010) who turned to quantile regression after log liner models failed to satisfy the functional form requirement. Unfortunately, the test provides no direction on how to proceed if the model is rejected, however, the partial residual plots shown shortly may provide some guidance. The Moran I specification test shows that there is not enough evidence to reject the null hypothesis in favour of the alternative, positive spatial autocorrelation. The test statistic shows a weak negative correlation between residuals in space. This means that including a fixed effect location variable accounted for the spatial dependency in the data, a similar finding to Bourassa et al. (2007) and Bax and Chasomeris (2019). Examining the residual diagnostic plots is vitally important for parametric models where the assumptions are checked. Figure 1 illustrates the fitted versus residual and quantile-quantile plots for each yearly model.

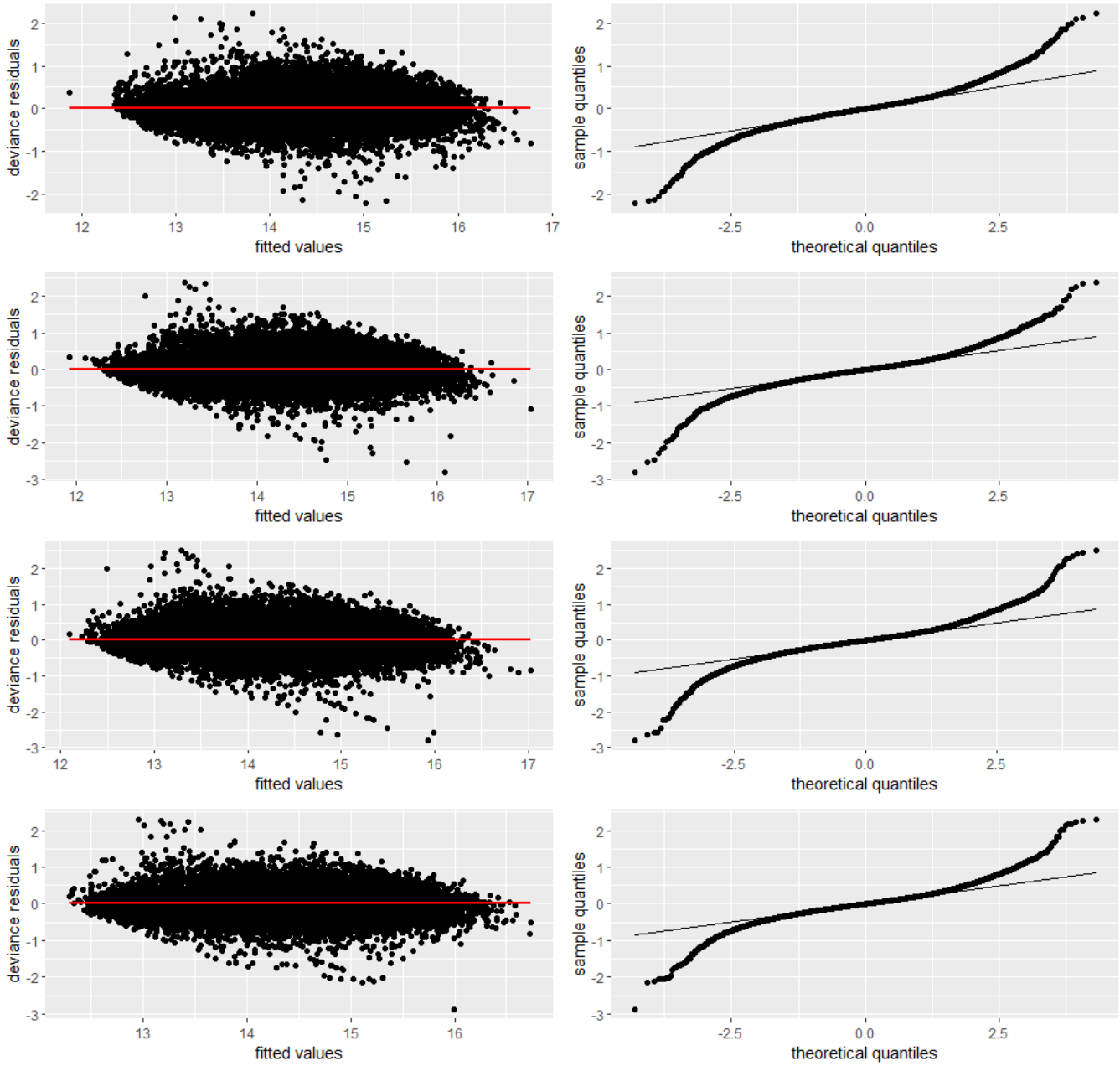

Figure 1: Log Linear Goodness of Fit Plots

Notes: Each row represents a yearly model beginning at 2014 and ending at 2017.

The fitted versus residuals appear homoscedastic, meeting the assumption of constant variance, though the quantile-quantile plots show deviation from normality at the upper and lower quantiles indicating the residual distribution is heavy tailed. However, Schmidt and Finan (2018) provide empirical evidence that linear models without normally distributed residuals may still provide valid results, given sufficient sample size. Figure 2 details the partial residual plots for the yearly log linear models.

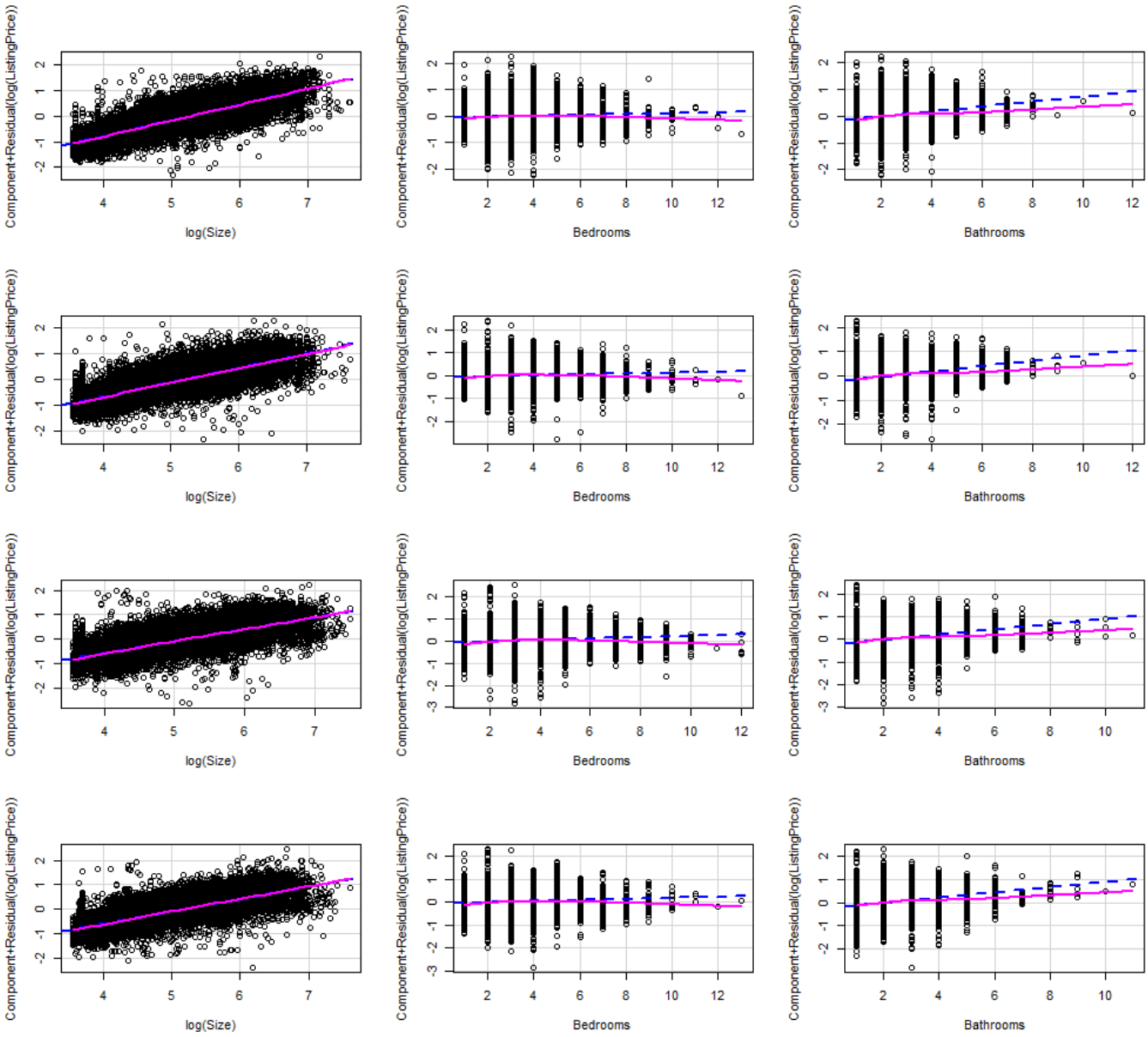

Figure 2: Log Linear Partial Residual Plots

The plots show a positive linear relationship between the log of listing prices and the log of size. The natural logarithm was applied to the size variable to improve linearity which was an appropriate choice given the partial residual plots above. The number of bathrooms shows greater utility over the marginal distribution compared to the number of bedrooms. This means, on average, sellers can expect greater utility from additional bathrooms. The number of bedrooms and number of bathrooms are not linearly related to listing prices suggesting a transformation may be appropriate.

The GBMs using the default hyperparameters are presented next, Table 7 shows the goodness of fit for the training and holdout sets without applying cross validation.

Table 7: GBM Default Hyperparameter Summary

Year	Training RMSE	Holdout RMSE
2014	750,247	779,314
2015	747,383	790,662
2016	733,249	762,224
2017	717,520	753,224

Although the GBMs generalize to the unseen data, the log linear models achieve a lower holdout RMSE for each respective year, indicating the GBMs require tuning. A 5-fold cross validation is applied next using a random grid search and early stopping to find the optimal combination of hyperparameter to reduce the holdout error. The results of the 5-fold cross validation yearly GBMs are presented in Table 8.

Table 8: GBM Cross Validation Summary

	Fold 1		Fold 2		Fold 3		Fold 4		Fold 5	
Year	RMSE	R_2	RMSE	R_2	RMSE	R_2	RMSE	R_2	RMSE	R_2
2014	716,860	0.83	705,882	0.83	744,746	0.82	710,181	0.82	708,496	0.83
2015	700,373	0.83	734,539	0.82	712,935	0.83	706,369	0.83	702,167	0.84
2016	664,084	0.84	659,409	0.84	651,150	0.85	665,760	0.84	659,930	0.84
2017	670,688	0.84	680,751	0.84	673,863	0.84	686,535	0.84	661,416	0.84

The goodness of fit measures in each fold for each respective yearly GBM are quite consistent showing that the models generalize well. Combining the holdout predictions to gauge an unbiased overall average fit is presented in Table 9.

Table 9: GBM Combined Holdout Error Summary

Year	Combined holdout prediction RMSE	Improvement from log linear model	Moran's I Statistic	Moran's I p-value
2014	717,398	6%	0.00789	0.031
2015	711,415	8%	-0.00775	0.970
2016	660,072	11%	-0.00242	0.706
2017	674,687	7%	-0.00520	0.903

The holdout errors are fairly consistent for each yearly model with 2016/7 producing the lowest generalization errors. The holdout errors are lower using cross validated gradient boosting with a random hyperparameter sweep, showing that this framework has a lower prediction error benefit. The holdout RMSE for the cross validated GBMs are slightly lower compared to the log linear models, shown in the improvement from log linear model column. These findings are similar to those of van Wezel et al. (2005). The Moran's I test shows that GBMs account for the spatial dependency in the data with the exception of 2014 where we observe statistically significant positive spatial autocorrelation, although the strength of this dependency in the residuals is very weak.

The random grid search applied to each yearly GBM allowed for different hyperparameters to be selected for different the models. Table 10 details the hyperparameters chosen in the final models with summary statistics about each tree.

Table 10: GBM Model Summaries

Year	Number of Trees	Sample Rate	Column Sample Rate per Tree	Learn Rate	Min Depth	Max Depth	Mean Depth	Min Leaves	Max Leaves	Mean Leaves
2014	809	0.6	0.77	0.02	3	19	9.47	4	55	28.19
2015	809	0.6	0.77	0.02	2	19	9.85	4	58	29.69
2016	809	0.6	0.77	0.02	3	19	10.74	5	81	39.94
2017	809	0.6	0.77	0.02	2	19	9.63	4	58	29.33

The number of trees, sample rate, column sample rate per tree, and learning rate hyperparameters were constant for each yearly model. The difference in model complexity is derived from how the individual trees were grown. On average 2016 had deeper and larger trees grown. The year 2016 also experienced the lowest holdout RMSE. The deeper trees could be attributed to fact that 2016 had substantially more data than other years.

The PDP for each of the numeric covariates are presented next. The implementation of PDP's in this study summarises the estimated relationship along with the actual relationship between the response and covariates by showing a calibration curve. A covariate is first grouped into 1% bins where the mean of the predicted outcome and response is calculated holding other covariates constant. Figure 3 shows how the mean response changes with a change in the given numeric covariate, namely: log size, bedrooms and bathrooms.

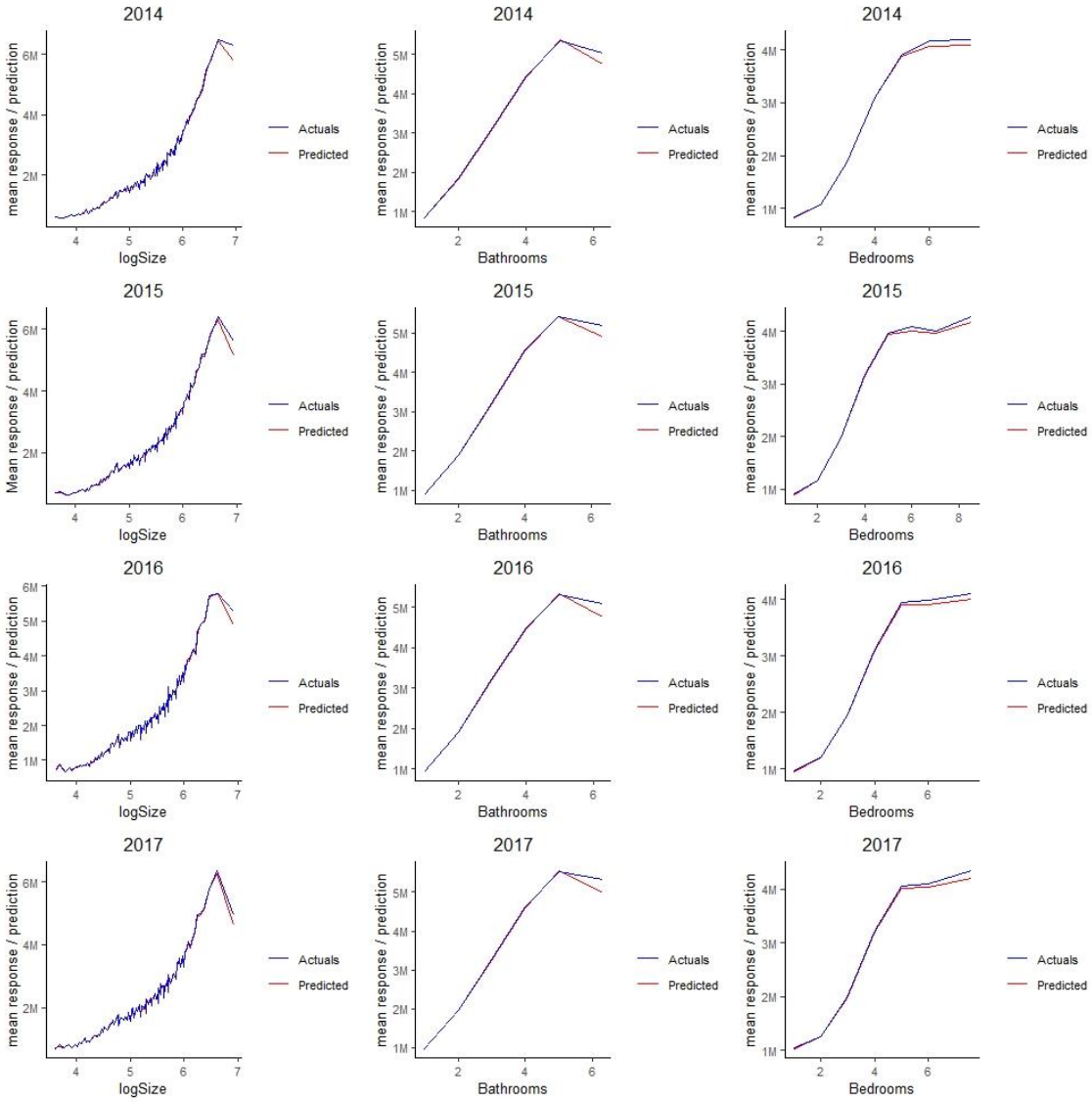

Figure 3: Partial Dependence Calibration Plots

The yearly log size curves share a similar shape where tapering is evident. The utility increases steeply initially but then drops over the marginal distribution. This suggests that larger sized properties, greater than ≈800m2 experience a diminishing return. The marginal utility of bedrooms is positive up to 5-6 bedrooms. Thereafter, flattening out is evident for properties with an increased number of bedrooms. The number of bathrooms PDP shows that the marginal utility for bathrooms increases up to 5 bathrooms where additional bathrooms added no extra value. The yearly PDP plots reveal a diminishing return for larger properties, showing that larger homes do not necessarily result in increased prices. Applying the characteristics method proposed by de Haan and Erwin (2011), where separate cross-sectional models were developed, provided value in being able to distinguish how the physical characteristics utility curves vary from period to period.

Variable importance is calculated and presented in Figure 4. Friedman (2002) applied variable importance to GBMs leveraging the work of Breiman (2001) who used randomization of the out-of-bag observations which are

observations held back during random forest training and applied before the algorithm has completed.

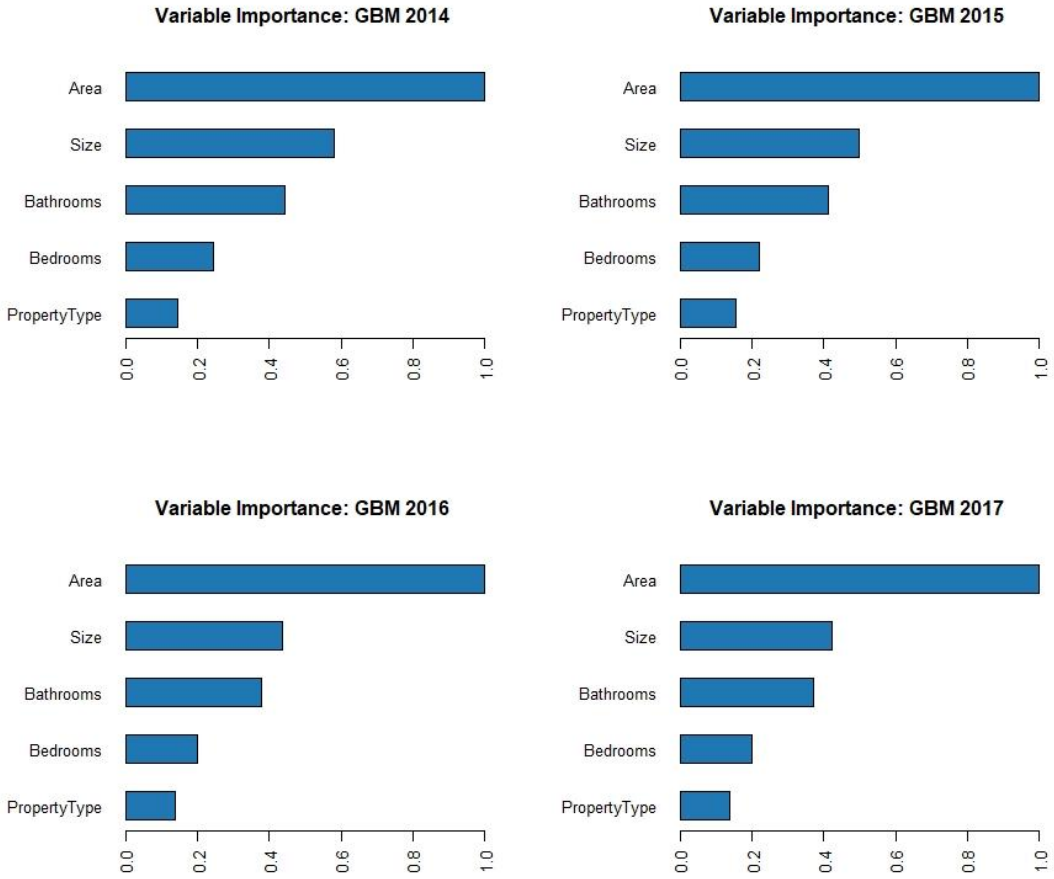

Figure 4: Variable Importance Plots

The area a property is located in is the most important predictor of listing price in each yearly GBM. This result coincides with previous hedonic studies which highlight locational effects as statistically significant. The size of the property and number of bathrooms are consistently deemed the most important physical attributes for each yearly model.

Zillow, a US based property portal, provides its users with a simple online interface to obtain property valuations using a proprietary algorithm (Zillow 2019). Private Property (Pty) Ltd could leverage the data they collect and store and provide a similar service, using the framework proposed in this study. To demonstrate this, a web application was developed which provides the ability to obtain mean listing prices and gauge listing price growth. Figures 5 and 6 present the listing price and growth calculator application created for this study.

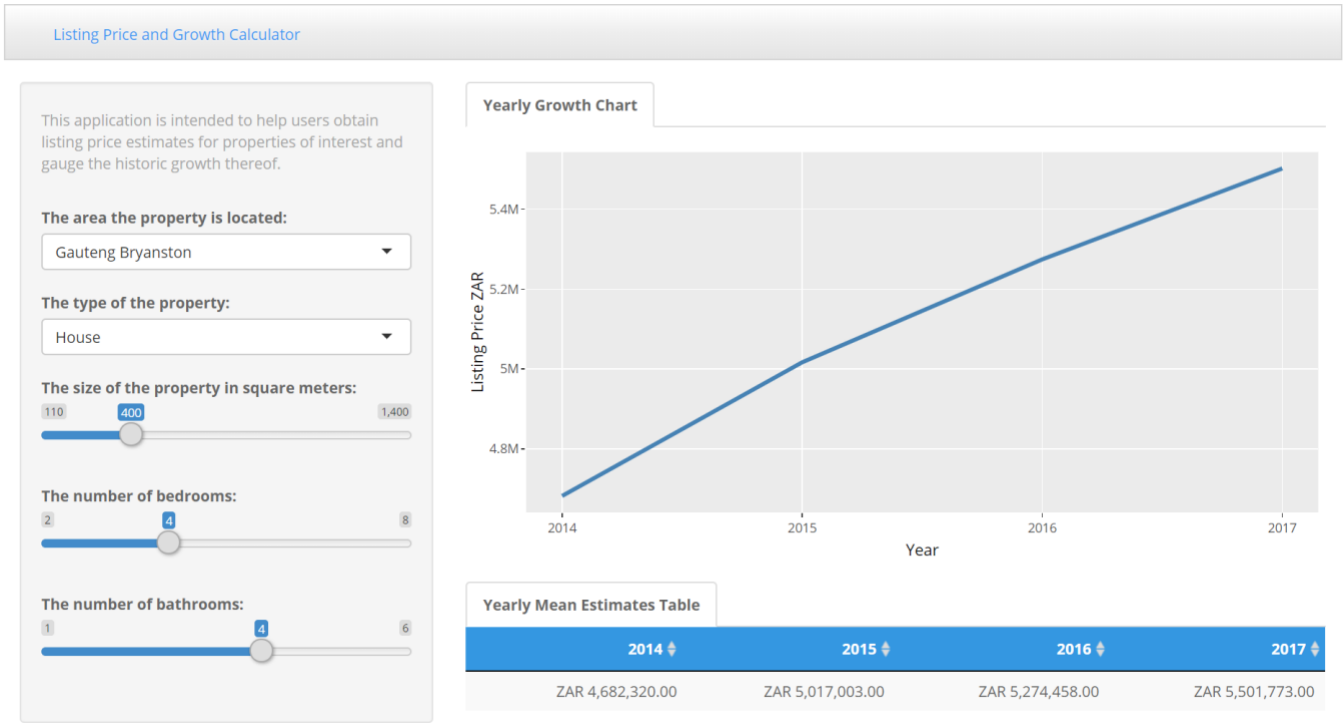

Figure 5: Listing Price and Growth Calculator (example one)

This example shows the mean price estimates for a house in Gauteng Bryanston that that is 400m2 in size with 4 bedrooms and 4 bathrooms. The mean estimates are plotted in a chart over time, and tabulated.

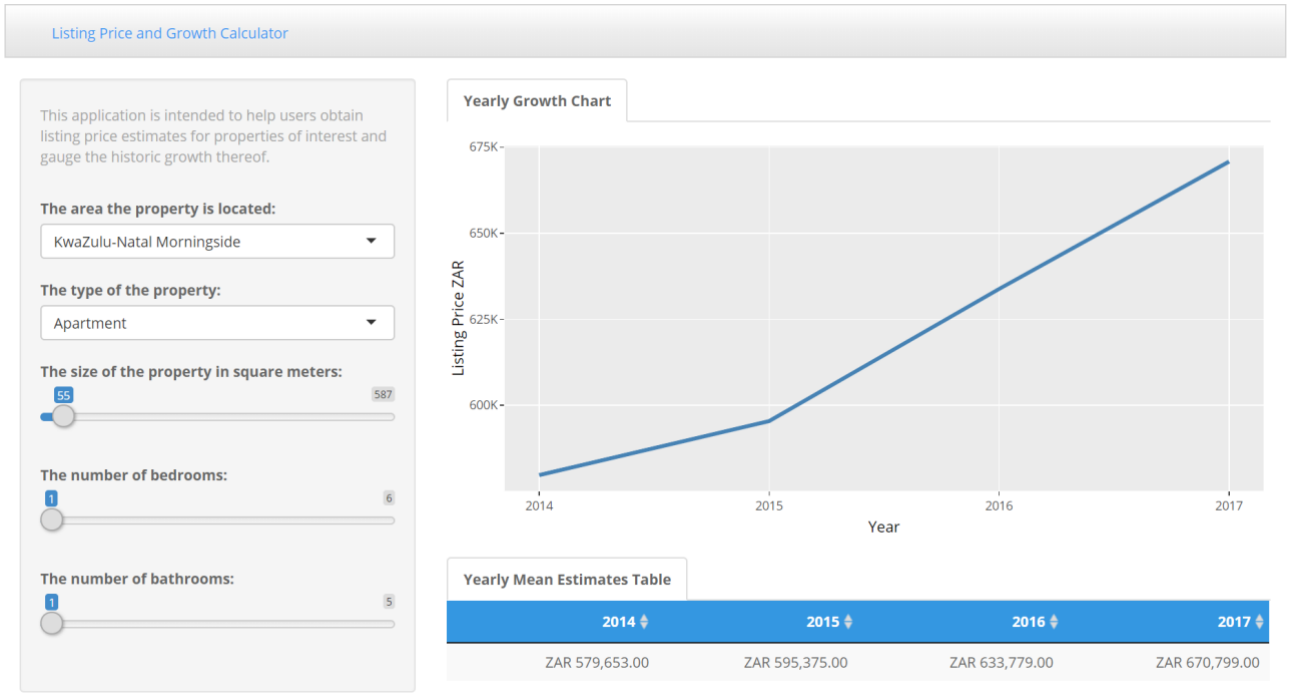

Figure 6: Listing Price and Growth Calculator (example two)

The second example illustrates the mean price estimates for an apartment in KwaZulu-Natal Morningside that is 55m2 with 1 bedroom and 1 bathroom.

The application was built using the GBMs and provides yearly mean estimates to a user given the location and physical characteristics of interest. This means that someone wishing to sell their home can quickly gauge what listing price to set by simply inputting where the property is located and some of the properties physical characteristics. This is can be a convenient alternative or first source of information for a potential seller, compared to trawling a plethora of listings or using the services of an estate agency or paid service.

6. Summary

Determining what price a home will sell for on the market through the reconciliation of supply and demand is challenging and is further compounded for sellers by the multitude of available sources of information. Typically, the services of real estate agents are employed where comparative market analyses are used to produce listing price estimates. This study proposed an algorithmic solution which can be used as an alternative to, or in conjunction with, traditional comparative market analysis methods.

Various studies exist that explore the use of parametric, semi-parametric and non-parametric techniques to estimate residential property prices for different segments of the South African market. This study contributes to the existing real estate pricing literature by developing parametric and non-parametric hedonic price models for different property types throughout South Africa. Traditionally, log linear models have been widely used, both globally and locally, to estimate residential property prices, measuring the utility over the marginal distribution of physical attributes and the effects of categorical variables. Although the framework provides transparency, it often suffers from misspecification of functional form. This study developed and compared yearly hedonic price functions using log linear and Gradient Boosted Models (GBMs). The log linear models seemed to provide a good fit, however, testing whether the functional form was correctly specified resulted in the violation of this assumption, which is congruent to previous South African studies. GBMs were chosen as a flexible alternative. The 5-fold cross validated GBMs outperformed the log linear models, providing a lower out of sample error. Both approaches were able to account for the spatial dependency adequately in the data by including a location categorical variable.

Developments in making the results of ‘blackbox’ machine learning techniques more transparent has come a long way, where the use of partial dependence and variable importance plots reveal the relationships and importance of covariates on the outcome variable. The partial dependence plots showed that the marginal utility for different physical characteristics varied at different quantiles showing that, on average, larger sized properties don’t necessarily yield higher prices and result in diminished returns. The area location variable was consistently deemed the most important followed by size and the number of bathrooms, reinforcing the old adage about the importance of location and property. A key feature of this study was to

develop a framework to democratise the proposed methodology, showing how property portals or real estate agencies could leverage their data to guide home owners on what price to sell their homes for. A web application was developed that allows a user to simply select the location and physical characteristics of the property of interest and easily obtain mean price estimates and the growth thereof.

Future work could involve the construction of a price index extrapolating to new spatial structures with spatial models or blocking cross validation.

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The Challenge of Productivity in the Housing Sector of a Developing Country: The Case of Cameroon

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Abstract

This paper evaluates productivity in terms of housing delivery levels of the housing sector in Cameroon. The data used is from the Centre for Affordable Housing Finance in Africa and the Ministry of Housing and Urban Development. These data relate to: the number of dwellings delivered during the study period; the amount of hours of work required to produce a housing unit; the unit cost of labour; the cost of producing a housing unit; and the area used to produce a housing unit. The technique of analysis was Data Envelopment Analysis. The level of productivity is evaluated using the Malmquist index. The results revealed that between 2010 and 2018 the housing sector in Cameroon produced an average of 13,126 houses per year. This production gives an average cost per housing unit of $39,612. The study found a fall in total productivity of factors (labour and capital factors) to the order of 24.5% for the period considered. The fall observed is explained by a decrease in both technical efficiency and technological progress. To increase the productivity of the housing sector in Cameroon two types of measures are possible. Firstly, a better use of resources where particular attention is paid to the factors limiting productivity growth, namely the cost of labour, capital and materials. Secondly, use a skilled workforce and implement incentives for innovation based on the use of local materials and better operational organisation. It is argued that the incorporation of these suggestions would make it possible to increase the productive capacities of housing firms in Cameroon.

Keywords: Housing Sector; Productivity; Cameroon; Frontier Production; Malmquist Index

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1. Introduction

As early as 1776, Adam Smith opened the perspective of a vicious cycle of growth based on gains in productivity. From then the notion of productivity has received particular attention in economic analysis. The interest in the analysis of productivity comes from the competitiveness of firms, increase in incomes and the improvement in the well-being of populations (Englander & Gurney, 1994). The theoretical basis of productivity is in efficiency (Leibenstein, 1966). From a conceptual viewpoint productivity translates the ratio between the volume of production to the volume of factors of production (Smith & Stewart, 1963). As such, it enables the measurement of efficiency of the use of factors for a given level of production. In this vein, productivity is a measure of economic performance that enables the comparison between the quantity produced for a certain period with the inputs necessary to obtain this production (Dyckhoff & Spengler, 2010). Productivity can be evaluated using two approaches; notably in physical units and in value[1]. In the latter case we obtain a number without unit that is useful only by comparison.

For several decades the growth of the productivity of the real estate sector has been one of the engines of growth in global productivity of developed countries. Maclennan and Miao (2015) established a linear correlation between the productivity of the housing sector and economic development in terms of job creation and the reduction of poverty. Hacker (2003), in his studies on the movements of previous years in socialist Poland revealed that a lower proportion of housing per inhabitant could have a negative effect on the productivity of labour. More recent studies by Krugman (2014) and Hsieh and Moretti (2014), revisited the question of productivity of the housing sector. They showed that high housing costs displaced households from areas where salaries and productivity are high and incite enterprises as well as qualified labour to migrate to areas where productivity is not maximal. In other words, the weak productive capacity of the housing sector reduced global productivity by introducing changes in the production capacity. According to Krugman (2014), these losses in productivity calls for housing programmes that are more sensitive to growth so as to increase the elasticity of the supply of housing. In this same vein, the capitalist development theory developed by Piketty (2014) attracts attention to the manner in which the housing market can lead to an economy of rents instead of harmonious economic development.

Several studies focusing on the sources of the growth in the productivity of the real estate sector were carried out based on the positive effects that the growth of productivity of the real estate sector can have on global growth (Stokes, 1981; Allen, 1985; Schriver & Bowlby, 1985; Orr, 1989; Tan, 2000; Mason & Osborne, 2007;). However, the studies mostly evaluate the growth of the productivity of labour. On the contrary, very few studies have evaluated productivity in terms of the stock of houses delivered by the real estate sector.

[1] In the first case it is, for example, the number of houses per worker and per year, whereas in the second case, production and the factors are evaluated in monetary value.

Moreover, this problem has not been studied much in Sub-Saharan African (SSA) countries such as Cameroon. This study's contribution is to begin to close this gap.

In Sub-Saharan Africa (SSA), the problem of the productivity of the housing sector is important because of the high demographic growth of SSA economies (2.7% according to the World Bank, 2017). According to Centre for Strategic and International Studies (2018), SSA has experienced rapid urbanisation and a subsequent increase in populations living in slums. By 2050, SSA will have about 1.2 billion citizens and about five million informal houses. Further, currently more than half of the population in SSA do not have access to decent housing (World Bank, 2017). It is therefore clear that African countries South of the Sahara have to reinforce their productive capacity. This suggests the reduction of the obstacles to the optimal allocation of available resources (Duranton, 2008).

In Cameroon, according to the National Institute of Statistics (NIS, 2018a), the housing sector has registered a deficit of more than one million houses for two decades. The situation has a negative impact on the purchasing power of the population. The expenses on houses represent 33% of the income of poor households (NIS, 2018b). This is an important burden for the millions of poor families. This situation is not only unjust but also represents heavy losses in terms of well-being and individual productivity. A study carried out by the NIS (2010) on the performance of Cameroon firms revealed that between 1995 and 2010 the value added per head in the real estate sector had a stagnation of 1%. For the same period, the total productivity of factors in terms of houses produced had years of growth alternating with years of decline between 1% and 2%. In addition, the same study showed that the average rate of use of the production capacity of the real estate sector was evaluated at 31%. This figure shows that there is an underuse of production resources in the real estate sector in Cameroon. Only 31% of the available resources are used. This rate is less than that obtained by other sector with rates of utilisation of production capacity of more than 60%.

Recent statistics show that the contribution in terms of value added of the enterprises in the real estate sector to the national economy remains small (0,168%). Moreover, between 2016 and 2018 the real estate sector had a growth rate of 2.1%. On the contrary the dynamics of inflation in 2017 resulted in a 1.2% increase in the prices of goods of the real estate sector (INS, 2018a). According to the World Bank (2018), the housing sector of Cameroon, just like in most countries of SSA, have production costs of 30-40% higher than those of other areas of the world.

All these raise questions on the productive capacity of the real estate sector to meet up with the long-term economic and social expectations. It is in this perspective that this study aims to evaluate the growth of the productivity in terms of the volume of houses delivered in the real estate sector of Cameroon.

This study is of interest for at least two reasons. First, it has the particularity of treating the issue of the productivity of the real estate sector under the prism

of the volume of housing delivered. In addition, contrary to previous studies, this study has the particularity of using a model that is nevertheless popular in other studies but which is not very often used in the real estate sector. Second, it is one of the first studies on productivity in the SSA context, and particularly in Cameroon. The evaluation of the productivity of the housing sector in Cameroon has implications for economic efficiency and the improvement of the quality of life of the Cameroonian population. The results of this study can be used as a policy tool in decision making.

The paper is structured into five sections. The first section discusses the problem and presents the paper's aim. The second section provides the review of literature. The third section deals with the methodology. The fourth section presents the results and discussions. While fifth section gives the conclusion of the study and the economic policy implications.

2. Literature Review

Two points are articulated in this section. The first point precises the theoretical framework of productivity models. The second point shows the state of empirical literature. Analysis of productivity in economics is not new. The articulation retained in this section allows us, on the one hand, to better grasp the theoretical controversies in order to identify the coherent framework of our analysis, and on the other hand, it allows us– from an empirical point of view– to identify the knowledge gap that justifies our study.

2.1 The Theoretical Framework of the Productivity Models

The theoretical anlysis of productivity has been intensively debated throughout the history of economic thought. Although Adam Smith is considered to be the spearhead of a transformation in the understanding of productivity, the preoccupation is already present among philosophers of natural law and French physiocrats who located productivity in a surplus of natural goods (Quesnay, 1766). The contribution of Smith (1776) is striking in that it opens up the prospect of a virtuous cycle of growth based on productivity gains. For Smith, productivity gains result from the division of labour. The author advocated the organisation of tasks as an explanatory factor for productivity gains. This vision is not agreed by other classical authors like David Ricardo and Karl Marx. For them, productivity gains are the result of variations in capital intensity of productive processes on labour through machinery (Jessua, 1991). However, classical thoughts share a rather pessimistic view: long-term productivity gains are destined to disappear gradually to cancel each other out in a "stationary state". The reason for this lies in the evolution of the distribution of national income, induced by the accumulation of factors: labour, capital and land.

Such a conclusion is questioned by the proponents of the neoclassical school. Solow (1956) provided an answer to the pessimistic predictions of classical authors. This author built a growth model generating more and more activity over time. Solow raised the hypothesis of rigidity of the production technique as postulated by the classics, enabling him to fracture the sources

of growth. It showed that sustainable productivity gains can be explained by shifting production techniques. However, Solow viewed technical progress as exogenous to the model. According to the theorists of endogenous growth, productivity is explained by the behavior of economic agents accumulating physical capital (Romer, 1986), technology (Lucas, 1988), human capital and public capital (Barro, 1990). In this case the technical progress is not exogenous but rather endogenous to the model.

The evolutionary theory contributed to this reflection by amending previous conclusions (Penrose 1959; Leibenstein 1966; Nelson & Winter, 1982). Indeed, it is part of a neo-Schumpeterian perspective insisting on an economic analysis of technological and organisational dynamics. It considers productivity as the result of an accumulation of competences. These competences are built over time through the effects of learning and routines. Learning is a cumulative process involving organisational and collective competences, spurring new opportunities in the production process (Libenstein, 1966). According to Nelson and Winter (1982), routines improve human capital, encourage organisational and technological innovation; therefore, a source of technological change and growth productivity (Nelson & Winter, 1982).

The theories discussed above have represented a certain advancement towards productivity modeling for the purpose of researching the actual sources of productivity growth in economies. Under the assumption of overall economic growth driven by sectoral productivity gains, several studies have been conducted in different sectors of modern and developing economies. The construction sector is not isolated from these reflections.

In order to measure the growth of the productivity of the housing sector the previous studies use different techniques namely: the technique of price indices; the econometric technique of estimation of national production functions, and the linear programming technique. The technique of price indices was used in several sectors including the housing sector (Stokes, 1981; Allen, 1985; Schriver & Bowlby, 1985). It considers a set of vectors of products and factors of production associated to a price vector. Three indices are generally used, in particularly the index of Paasche (P), the index of Laspeyers (L) and the index of Fisher (F) (see Diewert, 2002 for a discussion of the choice of the best index). The calculation of the indices is based on the principle of weighting by the quantities or the prices when it involves the price and quantity indices respectively. This technique considers that the factors of production have different degrees of importance. For example, the weighting by prices consists of placing the most costly goods with the least costly ones. This technique has the particularity of aggregating good production units To several researchers, the calculation of productivity using the method of indices has limits related to the use of current price deflators which can either underestimate or overestimate production (Cassimatis, 1969; Pieper, 1991). In addition, the calculation of indices is not based on any economic hypothesis especially that related to production technology (Farrell, 1957). It is however adapted to the analysis of productivity at the national level.

Other studies use the technique of compatibility of growth (Dacy, 1965; Schriver & Bowlby, 1985; Orr, 1989; Chau, 1993; Mason & Osborne, 2007). This technique is based on the definition of an aggregate production function that translates the manner in which an economy uses factors of production in an optimum manner for production (Solow, 1957). The objective of this method is to evaluate the determinants of the growth of productivity. Several forms of the production function are generally used: the Cobb-Douglas function; the function of Constant Elasticity of Scale (CES) and the function of Variable Elasticity of Scale (VES). In order to appreciate the growth of productivity, one supposes the existence of a neoclassic function such that: *F(A,K,L)*. It defines a production technology that represents the manner in which factors of production are combined, namely capital (*K*) and labour (*L*). The factor *A* translates a level of technology enabled to appreciate the total productivity of factors. However, the measure of the growth of productivity will depend on the hypotheses made on the national economy (increasing returns, decreasing returns etc.). This approach is often criticised for several reasons:

i) The difficulty of establishing an aggregate production function.

ii) The results obtained depend on the form of the production function chosen.

iii) Given the different products and services rendered by the housing sector which vary with time, it is very difficult to define an exact unique form of a long-term production function (Carlaw & Lipsey, 2001).

iv) This technique does not take into account the efficiency of firms which is an essential notion for the measurement of the growth of productivity of firms. In other words, no distinction is precised between pure technological changes and changes in efficiency or an optimal allocation of resources.

In order to overcome these limitations, other researchers define an additional theoretical framework for the analysis of productivity adapted to several sectors including the housing sector. The theoretical framework proposed is that of the distance function, as initiated by Shephard (1953). The distance functions are defined for a particular production technology. The technique used is that of Data Envelopment Analysis (DEA) (Farrell, 1957). It tries to analyse the manner in which a firm, with a given level of technology, combines different factors of production to obtain a product in an economically efficient manner. It supposes the existence of an optimal production frontier that represents best practice. With the aim of positioning itself on the optimal production frontier (efficient behaviour) the firm can have two types of behaviour: it can either maximise production or minimise the factors of production (Koopmans, 1951). In theory, the analysis of productivity from the distance function tries to examine the evolution (the growth or otherwise) of the efficiency of the firm over time. It involves the measurement of the extent to which the behaviour of a firm is far away from a situation of optimal production on the basis of a production technology.

Even though this method is largely used and recognised as pertinent for the evaluation of productivity in several sectors, it however remains less exploited in the housing sector. This method has the advantage that it is based on a theoretical framework of the rational management of resources. In other words it permits to distinguish the gains from efficiency from those from pure technical progress. The theoretical framework exposed has been used by several studies which conclusions revealed varied results.

2.2 Empirical Review

Stokes (1981), Allen (1985) and Schriver and Bowlby (1985) used the approach of price indices in the context of the United States. They found a fall in the productivity of the housing sector without determining the cause. The studies of Allen (1985) showed that from 1968 to 1978, the movement from a highly productive industry to a lowly productive one reduced productivity in housing by 0.46% per year. Tan (2000) used the same technique in Singapore and obtained the same results between 1980 and 1996.

Kazaz, Manisali and Ulubeyli (2010) defined an Index of Relative Importance (IRI). On a sample from 0 to 5, they evaluated the productivity of labour of the housing sector in Turkey. They showed that the growth of the productivity of labour is attributed to organisational factors. In the same vein in Uganda, Alinaitwe, Mwakali and Hansson (2007) established an average index of the importance of productivity. They evaluated the productivity of labour of the Ugandan housing sector. They found a fall in the productivity of labour of the housing sector. In addition, they indicated that a fall in the productivity of labour in the housing sector is due to lack of competence and technology.

By defining the respective production functions that represent the sector other studies are realised. Dacy (1965) was the first to estimate a production function in the construction industry of the United States. The results he obtained revealed the growth of productivity between 1947 and 1963. Later studies were carried out in the United States (Borcherding, 1976; Koch & Moavenzadeh, 1979; Maloney, 1983; Schriver & Bowlby, 1985; Koehn & Caplan, 1987); Hong Kong (Chau, 1993); and in the Nertherlands (Orr, 1989; Mason & Osborne, 2007). All these studies revealed a growth of the productivity of labour in the construction industry. Law (1987) evaluated the total productivity of factors in the construction sector of the United Kingdom. He used the cost per unit of production in the construction sector as the output. With the help of a production function of the sector they found a growth in the total productivity of the factors. In addition, they show that the growth of the productivity of capital is less than that of the productivity of labour.

In the same vein, and more specifically to the real estate sector, other studies are carried out. They generally used the approach of the functions of production representing the real estate sector. Chen, Jefferson and Zhang (2011) studied the growth of the productivity of labour of the real estate sector between China and the United States with the help of the production function and they showed that the Chinese real estate sector had a delay in the productivity of labour with respect to that of the United States. They revealed

that this delay was due to the lack of efficiency of Chinese equipments. Corrado, Haskel and Jona-Lasinio (2017) examined the channels through which used assets' effect on the productivity of the real estate sector. From a national production function they found a positive effect of immaterial capital on the productivity of the real estate sector. They showed that this effect transits through the new technologies of information and communication. Oloke et al. (2017) used a regression on panel data to evaluate the growth of productivity of employees in the real estate sector of Nigeria. They established a positive correlation between salary incentives and the growth of the productivity of employees in the Nigerian real estate sector.

The literature above suggests two major conclusions. The first is that there is a lack of consensus on the techniques used to measure the growth of productivity of the real estate sector. This divergence in tools translates the plurality of the objectives of each study. This shows that the debate on the productivity of the real estate sector remains current. The second is that housing productivity in SSA is less examined. This study tries to improve what is known about this topic in Cameroon. The methodology adopted as well as the results obtained are presented in the next sections.

3. Methodology

The idea of the methodological approach of this study is to relate the factors of production and the level of production of the housing sector in Cameroon. We want to establish the contribution of each factor of production to the total production of the housing sector. This allows us to see how companies in the housing sector use the factors of production. The use of the productivity model will reveal whether companies in the housing sector make rational use of available resources (capital, labor, technology, etc.). We reason from a normative production function reflecting the best use of resources. The ultimate goal of this reasoning is to see if the housing sector is capable of achieving growth gains that tend towards the best use of resources. In this section we first specify the model used; then we define the variables and finally we present the data used.

3.1 Specification of the Model

This study measures the growth of productivity in terms of the volume of houses delivered between 2010 and 2018 in Cameroon. The housing sector in Cameroon is particularly heterogeneous in nature (comprising of a minority of large formal enterprises and a majority of small enterprises, sometimes informal), making it difficult to associate a precise production function. Moreover, the rational management of resources is one of the major problems faced by enterprises in Cameroon's housing sector. In addition, these enterprises are generally exposed to exogenous fluctuations in prices of imported factors of production thus reducing their margin of liberty in terms of planification. For all these reasons the method of DEA seems to be better adapted for this study. We use the index of decomposition of productivity proposed by Malmquist (1953). This index involves the comparison of the observed production between two periods for different baskets of factors of

production. This approach takes into account the technology available for each period.

The index of Malmquist permits researchers to distinguish the movements of the production frontier, that is: technological changes (techch), and the movement of firms towards the frontier that is change in efficiency (effch). Under the hypothesis of variable returns to scale (VRS), change in efficiency (effch) is decomposed into change in pure efficiency (pech) and change in efficiency of scale (sech). The change in pure efficiency measures the evolution of the proximity of firms to the frontier without scale effect. Whereas the change in efficiency of scale indicates if the movements in the frontier are in the right direction. This is to attain the reference point where the modifications of production leads to modifications proportional to costs. It is therefore possible to obtain an index of total productivity of factor by making the product of the index of change in technological efficiency, the index of change in pure efficiency and the index of change in efficiency of scale. Any value higher than one indicates growth; any value less than one translates a decline/fall. Whereas any value equal to one indicates the stagnation of each index.

The formulation of the Malmquist index is based on the definition of a production technology as established by Fare et al. (1994). According to these authors, for each period $\mathrm{t} = 1, 2, \ldots, \mathrm{T}$, there exist a technology given by:

$$P(x) = \{x \in R_+^N : x\ can\ produce\ y\ ; y \in R_+^M\} \qquad (1)$$

Following this technology the calculation of the index of Malmquist implies the definition of two distance functions (Farrell, 1957). The first distance function orientated output is defined as follows:

$$D_0^t(x,y) = \min\left\{\lambda: \left(x_i^t, \frac{y_i^t}{\lambda}\right) \in P(x)\right\} = [max\{\lambda: (x_i^t, \lambda y_i^t) \in L(y)\}]^{-1} \qquad (2)$$

The expresion of the curve translates the technology of units of production of the housing sector. The second distance function that enables the calculation of the index is given by the expression:

$$D_0^t(x_i^{t+1}, y_i^{t+1}) = \min\left\{\lambda: \left(x_i^t, \frac{y_i^t}{\lambda}\right) \in P(x)\right\} \qquad (3)$$

This expression measures the maximum proportional change of output obtained at period $t+1$, relative to the technology used at period t. If we assume that a unit of production in the housing sector uses a quantity x of input in view of obtaining the quantity y of output, the index of Malmquist enables to measure the evolution of the productivity between two periods. We formalise this index in the following manner:

$$M_t^{t+1} = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}\right]^{1/2} \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{1/2} \qquad (4)$$

$$M_t^{t+1} = \left[\frac{D_0^t(x^{t+1},y^{t+1})D_0^{t+1}(x^{t+1},y^{t+1})}{D_0^t(x^t,y^t)D_0^{t+1}(x^t,y^t)}\right]^{1/2} \quad (5)$$

In equation (4), the first expression measures the displacement of a firm in the housing sector between two periods (t and t+1) relative to the efficient frontier of period t. The second expression of equation 4 measures the displacement of the same firm with respect to the efficient frontier of the period t+1. The calculation of the index of Malmquist is thus carried out as the geometric mean of these two terms (Coelli et al., 1998). For a more refined interpretation of the index of Malmquist, Fare et al. (1994) proposed a decomposition based on a product with two terms. They later express the main sources of growth in productivity. The product of the two terms is defined as follows:

$$M_t^{t+1} = \frac{D^t(y^t\ ,\ x^t)}{D^{t+1}(y^{t+1}\ ,\ x^{t+1})} \cdot \left[\frac{D^{t+1}(y^{t+1},\ x^{t+1})}{D^t(y^{t+1}\ ,\ x^{t+1})} \cdot \frac{D^{t+1}(y^t,\ x^t)}{D^t(y^t,\ x^t)}\right]^{1/2} \quad (6)$$

The first expression represents the change in efficiency of each firm in the housing sector between the period's t and t+1, with respect to the pertinent frontiers of each period. The second expression translates the progress in technology between the two periods.

The appreciation of the results is done according to the following decision criterion: we must always keep in mind that productivity reflects the efficiency of a firm over time. Efficiency is approached from an optimal production boundary. Since the coefficient of efficiency is between zero and one (Farrell, 1957), any value less than one exhibits a dynamic fall in productivity, because the firm is below the optimal boundary. The rate of the decrease is obtained by making a difference between the optimal value (that is one) and the result obtained after calculation. Also, it is applied as well for any value greater than 1, which would translate a growth of productivity. The productivity growth rate is also obtained by making a difference between the optimal value (i.e. one) and the value derived from the calculation. And finally, any value equal to one would translate into a stagnation of productivity. Stagnation reflects the idea of productivity stability (no decline and no growth) over time.

3.2 Variables of the Study

From an operational stand point, the production of housing requires: the availability of viable land, the mobilisation of construction material, the availability of long-term financing, the presence of qualified man power, and the utilisation of technologies.

3.2.1 Choice of Inputs

From a theoretical point of view two factors are usually used: labour and capital (Law, 1987; Mason & Osborne, 2007; Chen et al., 2011). This study equally retains these two factors.

– *The Labour Factor*

The evaluation of the productivity of labour raises the debate on the choice of the indicator. Literature proposes the number of employees, expenses on the salaries of the employees, and the number of hours of labour. Each of these indicators has advantages and disadvantages (Stokes, 1981; Maloney, 1983; Oloke et al., 2017; Hsieh & Moretti, 2019). A simple identification of salaried employees would mask the variations in the average number of hours of work in enterprises provoked by the evolution of part time labour, variations in overtime hours, and the absence of the place of work or modifications of the normal working period. The expenses on the salaries of employees are of particular interest from an economic stand point, but in the case of the production of houses it is often difficult to estimate the cost of labour. Very few enterprises in the housing sector have permanent workers and labour is often recruited informally. For this purpose, it is difficult to establish a salary database. For all these reasons we retain as the indicator of the factor labour: «*the real number of hours of labour*».

– *The Capital Factor*

In the housing sector capital has a technical character. It refers to all the producer goods, including: machines, industrial installations, communication or transport networks, raw materials, energy, etc. From these different components literature retains two types of capital: fixed and circulating (Smith, 1776). The first type refers to all the installations which do not disappear in the production process. Fixed capital items are generally used for production for many years; they undergo each year a certain wear and end up being unusable. This is the material wear of machinery and equipment. The second type refers to all intermediary consumptions engaged in the production process. This is the part of the capital expended for the purchase of the labour force, as well as for the purchase of means of production: raw materials, fuel and other auxiliary materials, which do not enter into the composition of fixed capital.

The production of houses requires fixed capital in the form of land. No production of houses is possible without land. In Cameroon, the problem of land tenure is very crucial. In this context the rational management of land becomes a source of efficiency in the housing sector (CAHF, 2017). The availability of land is a constraint for most firms in the housing sector in Cameroon. In order to take this constraint into account we retain the following as indicators of fixed capital: «*the surface area used to produce a unit of standard house*».

Moreover, the mobilisation of financial resources is an essential element in the production of houses. In most SSA countries the financing of the housing sector is still at its infancy. In Cameroon, the system of mortgage loans is not well developed (World Bank, 2017). Consequently, very few banks are engaged in the financing of real estate investments. The housing sector in Cameroon is mostly supported by small firms. Most of these firms cannot meet the loan conditions of formal banking finance. In these situations these firms resort mostly to informal financing and to formal micro credits. It is

therefore difficult to clearly evaluate the volume of financing received by firms in the sector. For all these reasons we retain the following as financial capital: *«the estimated cost of production of a unit of house»*. The estimated cost integrates the cost of infrastructure, the cost of construction material, the labour cost and the development cost.

3.2.2 Choice of Output

In the literature there is no consensus on the choice of output (Gullickson & Harper, 1999). We evaluate the production capacity of the housing sector. which involves examining if each factor used enables the improvement of the level of production in the housing sector. This level is measured by the number of houses produced. That is why we retain as output: «*the number of houses produced per year and per sector»*.

3.3 Data

The questions contained in the questionnaire were all closed-end type structured as inspired by other related studies.

The data used is from the Center for Affordable Housing Finance in Africa (CAHF, 2018) and from the Ministry of Housing and Urban Development (MINHDU, 2018). The CAHF is a non-profit organisation with the aim of reinforcing the capacity of public and private agents with the aim of creating a financing system that is capable of ensuring access to housing for all. Since 2010, it has collected information relative to the housing market of different African countries with the participation of different states and local African actors. The information collected relates to the indicators of economic growth, the system of financing houses, the costs of production, the prices of houses, and regulatory policies. In the case of this study we will exploit only the information on the costs of production per unit of housing as well as the surface area of land used per unit of housing produced. MINHDU is a government institution in charge of housing in Cameroon. Each year they produce databases on the performance of the real estate sector in Cameroon. This database presents information on: the size of the real estate sector; the volume of housing produced each year by the sector; the number of hours of labour per employee; the cost of factors of production, and many others. The study is based on 123 units of production of the real estate sector in Cameroon. These production units are authorised to exercise on the entire national territory in conformity with law no. 97/003 on real estate activities in Cameroon. The data used is for the peroid from 2010 to 2018.

The use of all the above information enabled the researchers to obtain a series of results that are presented below.

4. Results

4.1 Descriptive Results

The statistics of the different variables retained are in the table below.

Table 1: Descriptive Statistics of Input and Outputs Retained

	Number of years of observation	Minimum	Maximum	Mean	Standard deviation
The estimated cost of production of a unit of house	9	18,500.00	56,000.00	39,612.11	15,092.85
Cost of labour	9	3,900.00	11,805.00	8,350.22	3,181.57
Number of hour of labour	9	40.00	60.00	50.44	6.85
Surface area of land used	9	50.00	250.00	166.77	74.97
Number of houses produced every year	9	12,000.00	14,220.00	13,126.66	798.12

Source: Author from data of CAHF and MINHDU (2018)

From 2010 to 2018 the housing sector in Cameroon has produced an average of 13,126 houses (see Table 1). This production gives an average cost per unit of house of $39,612. It incorporates about 50 hours of work every day and requires an average consumption of 167m_2 of land. These statistics reveal a less productive sector since the demand for houses in Cameroon is estimated at more than one million houses. The annual growth in demand is evaluated at 10% (NIS, 2018). However it is noticed that the housing sector in Cameroon is capital and labour intensive. This can lead to a relatively weak productivity of factors. To clarify this first tendency, we analyse the results of the productivity model. This is presented below.

4.2 Results of the Productivity Model

The Table 2 below gives the decomposition of the index of Malmquist into its sub-components.

Table 2: Total Productivity of Factors of the Housing Sector between 2010 and 2018

Years	Change in Technical Efficiency	Change in Technological Efficiency	Change in Pure Efficiency	Change in Efficiency of Scale	The Total Productivity of Factors
2010	0.967	0.666	0.915	1.057	0.644
2011	0.353	0.875	0.526	0.672	0.308
2012	0.363	1.010	0.535	0.680	0.366
2013	0.406	0.876	0.580	0.701	0.355
2014	0.441	0.810	0.605	0.730	0.357
2015	0.968	1.138	0.906	1.069	1.101
2016	1.751	0.907	0.970	1.806	1.588
2017	1.052	0.876	1.027	1.025	0.921
2018	1.801	0.645	1.121	1.607	1.161
Mean	**0.900**	**0.867**	**0.798**	**1.038**	**0.755**
2010-2011	0.666	0.770	0.720	0.864	0.476
2012-2018	0.968	0.894	0.820	1.088	1.001
2010-2018	0.900	0.867	0.798	1.038	0.755

Source: Author from data of CAHF (2011-2018) and MINHDU (2018)

4.2.1 Interpretation of the Results

The Interpretation of the results obtained follows a very simple logic: the researchers consider that the firms of the housing sector in Cameroon evolve in an input/output space. From this space we can identify the best performing firms. That is those which are on the efficient frontier. Then we compare the existing firms to this frontier. This production frontier represents all the efficient observations for which no other production unit uses more or less input without modifying the quantity produced nor produces more or less of each product without modifying the quantity of input. However, from a dynamic perspective the production frontier can witness changes related to the reinforcement of human capital and externalities of technology. For this reason, we will finally analyse the movements of the frontier, the movements of the firms towards the frontier, the change in pure efficiency, the change in efficiency of scale as well as the variation in the total productivity of factors.

We observe that the housing sector has recorded between 2010 and 2018: an average fall in total productivity of 24.5%, a regression in technical efficiency of 10%, a fall in technological progress of 13.3%, and a deterioration in pure efficiency of 20%. However, the fall in productivity is compensated by an increase in efficiency of scale (3.8%). These results indicate that the fall in the productivity of the housing sector in Cameroon is as a result of pure efficiency, a relative technological contraction and technical inefficiency. Nevertheless, since 2010, there have been slight improvements in the productivity components of the housing sector in Cameroon from year to year. The sector recorded remarkable gains in technical efficiency (75%; 5.2% and 80%) in 2016, 2017 and 2018, respectively. As for technological efficiency, we observe that the sector has a lot of difficulties in absorbing innovative technologies. The sector recorded a gain in efficiency between 2017 and 2018 (2.7% and 12.1%). A gain in efficiency of scale is equally observed between 2017 and 2018 (2.5% and 60%). These results conform to those obtained by Snyman and Smallwood (2017), in the South African housing industry. However, studies carried out in developed countries reveal contrary results with relatively high levels of productivity (Chen et al., 2011). These results provide very important information to guide efforts to improve the productivity of the housing sector in Cameroon. The results show that the decline in the productivity of the housing sector in Cameroon is linked to poor management of available resources and a lack of technological innovation. In addition, the size of the companies remains too small to achieve good performance.

5. Conclusion and Implications

The demographic growth of African states in general, and of Cameroon in particular, confers a role of social stability, equity and justice to the housing sector. In addition, the perspectives of economic opportunities of this sector reaffirm its strategic role in the development of developing countries. These different issues challenge the productivity of the housing sector. As Solow (1956) affirms, an increase in productivity is a source of economic growth and improvement in well-being. Unfortunately, less scientific attention has

been paid to the productivity of the housing sector in SSA countries. This study evaluates the productivity of the housing sector in Cameroon. Furthermore, the study shows that the housing sector in Cameroon has low productivity.

These results suggest two implications. First, a fall in technical efficiency implies poor management of resources within the housing sector. Technical efficiency translates the technical capacity of the housing sector to increase its output with a given level of input, or inversely; the capacity to reduce its inputs for a given level of production. Second, a decline in technological efficiency reflects a weak level of innovation or modernisation in the housing sector in Cameroon. An increase in the productivity of the housing sector in Cameroon would require, on one hand a better allocation of resources, and on the other hand, the reinforcement of the innovation capacity and the modernisation of production and organisational techniques. The decline in the recorded productivity can be interpreted as the result of: a misallocation of resources; weak technical progress and lack of organisational. To increase total factor productivity in the sector firms need to develop new production systems, such as the use of production technology adapted to local materials which would help to reduce production costs and increase production volume.

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Causes of Discrepancies in Value Estimates on Compensation for Oil Spill Damages in the Niger Delta

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Abstract

This study examines causes of discrepancies in valuers' opinion when determining monetary compensation payable to claimants for oil spill related damages in the Niger Delta, Nigeria. The study elicited data on factors responsible for differences in opinion of compensation values from valuers in practicing firms in Niger Delta using survey questionnaire. Eighty-three (83) Estate Surveying and Valuation (ESV) firms participated in the survey. The sample was selected from the total population of 190 ESV firms in the region based on the evidence of their experience with oil spill compensation valuation. Weighted mean score and factor analysis were employed in the data analysis. Results indicated that the factors causing discrepancies are: weak standards/codes of practice, inadequate legal frameworks, gaps in valuers' knowledge, and professional misconduct. It was recommended that a specific code of practice for compensation for oil spill damage be developed by the Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON) in collaboration with the Nigerian Institution of Estate Surveyors and Valuers (NIESV) to guide valuers when undertaking valuation for compensation for damages arising from oil spills.

Keywords: Oil Spills; Monetary Compensation; Valuer's Opinion; Claimants; Discrepancies

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1. Introduction

The oil spill threat resulting from the extraction, transportation and processing of crude or refined oil requires an assessment so as to determine the compensation due to those who have suffered loss or impaired interests (Olukolajo, 2017a). Thébaud et al. (2005) noted that three categories of estimates (compensation) are usually produced in practice when determining the monetary cost of oil spills. These are estimates of damages determined by experts, claims submitted for compensation by the claimant, and ultimately, the compensation paid to the claimant. These figures often do not agree in practice. In Nigeria, many host communities to Multinational Oil Companies (MNOCs) engage in incessant conflict over the quantum of monetary compensation offered for oil spill damage (Falode, Ogedengbe & Bickersteth, 2006; Emuedo & Abam, 2015; Gbenemene & Eric, 2017). In some cases, the operations of oil producing companies have been disrupted, equipment vandalized and installations destroyed, in response to dissatisfaction with degradation of the natural environment and meager compensation offered for the impaired interests (Bello & Olukolajo, 2016a; Njoku, 2016).

Nigeria hosts the majority of MNOCs in the Niger Delta Region (NDR) and activities of oil extraction and processing began as far back as 1937. Since then, oil spills have commonly occured. Steiner (2010) reported that over the past 50 years, there have been at least 115,000 barrels of oil spillage per annum in the Niger Delta region; out of these, more than 90% have yet to be cleaned up (Okeowo, 2014). As a result, the NDR is described as the most polluted area in the world because of the menace of oil spills to fragile ecosystems (Vidal, 2010). Oluduro (2012) expressed that oil spillage in the Niger Delta has robbed people of their community development at the expense of the national development; such that their lives, traditions/culture, health, environment and way of living have been negatively impacted.

In Nigeria, Estate Surveyors and Valuers (ESVs) play a major role as professionals in determining the compensation payable to claimants. The oil companies engage valuers to determine the compensation value a claimant is entitled to for the affected interests; claimants (be it individuals, families or communities) also involve valuers to represent them and ensure that they receive adequate compensation for the impaired interests. One would expect that the valuers representing claimants and the oil companies would work hand in hand, but this is not always the case. Valuers sometimes disagree in a bid to favour their client (Odudu, 2001). The valuer representing an oil company may be conservative on the admissible claims included in the damage assessment, while the valuer representing the claimant strives to use all available means to claim substantial sums for their clients. This mostly results in two different figures emanating from the professionals, thereby complicating the compensation process. To worsen the situation, Emuedo and Abam (2015) expressed that oil companies considered oil spill situations as a condition which should rather attract sympathy for the companies and should not pay compensation to claimants.

Where the difference in the expected compensation is much higher than the payment made to the claimants, some resort to violent conflict, threatening valuers' lives as well as disrupting the activities of oil companies. It is within this context that this study aims to identify the factors causing discrepancies in valuers' opinion on compensation payable for damages due to oil spillage in the Niger Delta, Nigeria.

2. Literature Review

This section reviewed some of the existing literature relevant to the subject of this study. Specifically, the first section reviewed various legislations determining the practice of oil spill damage assessment for compensation purposes, while the latter part reviewed some of the previous studies on factors causing variations in value opinion.

2.1 Legal Provisions and Compensation Claims for Damages from Oil Spillage in Nigeria

Valuation for the purposes of compensation is generally considered a statutory valuation, conducted under various policies, statutes and regulations that determine the basis and approach to its assessment (Kakulu et al., 2014). However, there are a number of such statutes and regulations in Nigeria that provide compensation related to the acquisition of land and landed properties, however only the Oil Pipeline Act Cap 145, LFN (1990) contains provisions that are directly related to compensation for oil spills. Others, such as Minerals Act Cap 121 of 1946, Petroleum Act No. 51 of 1969 (Now The Petroleum Act P19, LFN, 2004), Land Use Act of 1978 (now Cap L5, LFN, 2004), the Mining Act No. 24 of 1990, Oil in Navigational Water Act, Cap 337 LFN 1990 [all consolidated in the latest Laws of Federation of Nigeria (LFN, 2010)], do not directly provide for compensation for oil spill damages. On the contrary, they only refer tangentially to acquisition of land for oil and gas facilities and not primarily injurious affection (Imosemi & Abangwu, 2013). Most of these laws prescribe adequate or fair compensation without the details of what constitute the adequacy and how to achieve it (Nuhu, 2009; Otegbulu, 2009; Kakulu & Nuhu, 2012). It has always been a bone of contention that many claims as considered by claimants are not provided for in compensation value assessment. This often means the expected compensation is at variance with the actual payment offered to claimants.

The Oil Pipeline Act Cap 145, LFN (1990) imposed responsibility on the minister on issues related to oil fields and oil drilling; granting permission to investigate petroleum pipeline routes for transporting natural gas, mineral oil or their products for any purpose relating to the trading or operation of oil [Part II section 5(1)]. Section 6(3) allows the permit holder to enter and survey any land, but with caution to prevent unnecessary damage to the land, buildings and crop or profitable trees thereon. Section 11(5) compels the permit/license holder to compensate victims whose land is impacted or who suffers damage from oil spillage due to pipe breakage or leakage from ancillary installations.

2.2 *Variation in Valuers' Opinion of Value*

A variation in value judgments is a measure of the difference in value-determining factors as expressed or interpreted by the various valuers (Boyd & Irons, 2002). Studies have established variations in the opinion of value of valuers. Many of these studies (Baum et al., 2000; Ayedun et al,. 2012; Akinjare et al., 2013; Bello et al. 2015), however, focused on market values of real properties. Akujuru and Yalaju (2015) opined that disagreements between the valuers' opinion on value should be envisaged because the assessment combines science and art, judgment and personal perspective of the valuer. In relation to property compulsorily acquired for public interest in Finland, Hiironen et al. (2014) observed that the standard value of the market estimate offered by experienced valuers is 32% with overall change (range) of -68% and +113% from the median estimates. It was also found that 50% of the estimates remained within -16% and +33% of the median estimates. In a similar study of commercial properties in Lagos, Bello and Thomas (2015) observed a coefficient of variation in valuers' opinion of value of between +5% and 11%. Ogunba (2004) had earlier observed that the mean difference between valuation and market price in Lagos far exceeded the +/-5% margin of error. With respect to commercial properties, Baum et al. (2000) posited that in the UK property market, an acceptable level of variation in actual value was around +/-10% to 15%.

Studies have attempted to establish the factors influencing the variation observable in valuers opinion of value. For example, experience and knowledge of valuer, characteristics of valuer and that of his firm, and valuation practices, have been found to have important implications for value variation (Babawale & Omirin, 2012). In a study conducted on value variation in Thailand and Malaysia, Ayuthaya and Swierczek (2014) hypothesized factors that could decrease variation in valuation outcomes as: better purpose of valuation, more complete reports, better scope and assumptions, better roles of valuers, better valuer qualifications, better written confirmation, appropriate valuer conduct, better enforcement, appropriate disclosure, less conflict of interest, less client influence, and more investor confidence. Thus, the study through a regression analysis, established that the factors that were found significant to cause a decrease in variation in values are: clients' influence, incomplete reports, written confirmation, investor confidence, and the role of the valuer.

Oloyede and Durodola (2012) examined the reasons for the variance and inaccuracy in valuation in Nigeria. Factors that contribute to the variation were: a dearth of relevant market evidence/data, the use of valuation and techniques that are out-of-date, outdated valuation data, the absence of valuation controls and regulatory frameworks, a lack of valuation standards/manuals, inadequate training, failure to punish errant valuers for negligence, imperfection of the property market, the use of financial material and other forms of inducements by clients to influence the valuer, and inexperienced valuers. Among these, the lack of relevant market evidence/data, use of valuation and method techniques that are out-of-date, outdated valuation data ranked 1st, 2nd and 3rd respectively. The findings in

this research is similar to that of Effiong (2015) in which variance and accuracy in valuation between Nigeria and United Kingdom were examined. Among all the identified factors, lack of standards took 1st place while lack of market/comparable data and lack of a regulatory framework ranked 2nd and 3rd respectively.

Akinjare, Iroham and Oloke (2013) categorized factors responsible for discrepancies in the value opinion of professional valuers' in Lagos, Nigeria as endogenous and exogenous factors. The former comprise adjusting values to suit recent valuations of similar properties, use of different methods of valuation, working with different parameters such as yield, and the professional experience of valuer. The latter are professional experience of valuer, clients influence on valuation, lack of adequate market information, and lack of support from other valuers conversant with the market. The prevalent margin of variance amongst valuers in the study area was attributed to the predominant use of different parameters such as yield by valuers, the use of different methods of valuation while carrying out valuation, lack of adequate market information and clients influence on valuation.

Thébaud et al. (2005) analysed several major international oil spills from tankers. These include the Amoco Cadiz accident of 16 March 1978, the Tanio oil spill at the coast of North Brittany on 7 March 1980, the Aegean Sea oil spill at the La Coruna's entrance in Spain on the 3rd of December 1992. Others are, the Braer oil spill at the South of the Shetland islands in the United Kingdom on 5 January 1993, the Sea Empress oil spill at at the entrance of the port of Milford Haven in South Wales in the United Kingdom on 15th February 1996, and the Erika accidents off the Atlantic coast of Brittany in France on the 12th December 1999. These oil spill accidents were within the International Oil Pollution Compensation Fund (IOPC Fund) in Europe. Factors found responsible for divergence in the cost estimates and compensation value included: a lack of empirical data, difficulty in determining the baseline scenario (the scenario without the occurrence of an oil spill), choice of methods of valuation, and the strategic behavior of agents involved in the compensation process.

Although studies on valuation variance with respect to compensation for compulsory land acquisition abound, there is generally a dearth of studies that have focused on compensation for oil spill damage. It is noteworthy that discrepancies in value opinions as highlighted in the above studies are diverse and are evident in both local and international valuation studies and practice; factors responsible for the discrepancies in value estimates are potential causes of inadequate compensation as reported in Bello and Olukolajo (2016b).

3. Research Methodology and Data

The study adopted a survey approach and data was obtained from ESV firms who are the targeted population in the NDR, Nigeria. Specifically, five out of nine states constituting the region were randomly selected. These are Ondo, Edo, Bayelsa, Rivers and Delta states. According to Eregha and Irughe,

(2013), communities and states in the NDR have similar experiences and exhibit similar characteristics in terms of the menace of oil spills and its antecedent implication on human wellbeing as well as the natural environment. Consequently, the selected states were judged suitable to represent the region for the purpose of this study. The valuers in these ESV firms are members of the Nigerian Institution of Estate Surveyors and Valuers (NIESV); the professional association in charge of valuation in Nigeria, as well as the Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON); which regulates the practice of estate surveying and valuation in Nigeria. The ESV firms, as corporate entities, do represent oil companies, individual claimants as well as community interests depending on who engaged their services for compensation valuation. Based on the records of various branches of the NIESV in the selected states in the NDR, there are 190 registered firms to whom survey questionnaires were administered. The survey achieved a return of 123 (64.74%). Out of the retrieved questionnaire, the total number of valuers who have actually been involved in oil spill damage valuations were 83, 67.48% of the retrieved sample. Further analyses were based on responses obtained from this group of valuers.

Data were obtained through the use of questionnaires backed with interviews from respondents on potential factors causing differences in valuers' opinion in respect to compensation value prepared by the agent of the claimants as well as that of the oil companies. Apart from questions on personal details of the respondents and the profile of their respective firms, other questions were prepared in a 5-point Likert scale in order to enable respondents to express their opinions more explicitly. Data analysis was done descriptively using frequency tables and Weighted Mean Score (WMS). The formula for WMS is as follows:

$$\text{WMS } (\bar{x}_W) = \frac{\sum_{i=1}^{n} (x_i * w_i)}{\sum_{i=1}^{n} w_i}$$

Where: $\bar{x}_W$ *= the weighted mean variable*
w_i *= the allocated weighted value*
x_i *= the observed value*

The study further used factor analysis combined with Principal Component Analysis (PCA). Factor analysis was used to identify, organize and minimize large elements on specific dependent variable being investigated, while PCA optimally combines variables investigated into smaller numbers.

3.1 Suitability Test of Dataset for Factor Analysis

The suitability of the dataset used in the Factor Analysis was performed using Bartlett's test and the Kaiser Meyer Olkin (KMO) measure of sampling adequacy measure. The two tests were conducted to determine the factorability of the matrix as a whole. The results obtained are shown in Table 1.

Table 1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.728
Bartlett's Test of Sphericity	Approx. Chi-Square	762.858
	df	66
	Sig.	.000

The KMO measure, as shown in Table 1, is 0.728, while the sphericity by means of Bartlett's test yielded a significant of p=0.000. The result of KMO statistics ranges between 0.1 and 1; when it is 0, it is unlikely that factor analysis is appropriate because the sum of partial correlations is greater than the sum of correlations, indicating diffusion in the correlations pattern. When KMO value is close to 1, it denotes compactness in the pattern of correlations and factor analysis test is adjudged reliable in such instance (Hutcheson & Sofroniou, 1999). Consequently, the KMO value in this study yielded an acceptable result (0.728), which is higher than the minimum value 0.6 commonly accepted for this type of study (Hoque & Awang, 2016).

4. Results and Discussion

The results presented in this section are divided into two categories. The first describes the demographic features of respondents and their firms of practice. The second part is the empirical results of the factors responsible for differences in valuers opinion of value in compensation in the study area.

4.1 Demographic Features of Respondents and their Firms of Practice

This section presents the demographic characteristics of the respondents and the firms they represent and describes the demographic features of surveyed ESV firms and the surveyed respondents.

Table 2. Characteristics of the Firm/ Responding Estate Surveyors and Valuers

Respondents' Characteristics	Frequency	Percentage
Age of Firm		
Below 2 years	2	2.41
2 – 4 years	6	7.23
5 – 6 years	27	32.53
7 – 9 years	19	22.89
10 and above	29	34.94
Total	83	100.00
Position of Respondent in the Firm		
Principal Partner	9	10.84
Managing Partner	28	33.73
Senior Estate Surveyor	41	49.40
Staff Surveyor	5	6.02
Total	**83**	**100.00**
Professional Status of the Respondent		
Fellow	22	26.51
Associate	61	73.49

Total	**83**	**100.00**
Firm Affiliation with Local and International Professional Bodies		
NIESV	83	100
ESVARBON	69	83.13
FIABCI	2	2.41
RICS	4	4.82

Source: Field Survey, 2015

The analysis in Table 2 indicates that the respondents' firms have been in operation for a considerable period of time. The result indicates that 90.36% of these firms have been in operation in the Niger Delta for a continuous period above five years. Results on respondents' status in their respective firms indicate that 10.84% of them were principal partners/directors of their firms; 33.73% were managing partners, while the majority of the respondents (49.40%) were senior estate surveyors. The remaning 6.02% were staff surveyors. All sampled ESV firms are duly registered with NIESV; 26.51% of the respondents were fellows of NIESV; while 73.49% were associate members. Apart from NIESV, to which all of them belong, 83.13% have also registered with ESVARBON. In addition, some of the respondents (2.41%) belong to the international professional body, Federation Internationale des Administrateurs de Bien-Conselis Immobiliers/ The International Real Estate Federation (FIABCI). Based on these data, it is believed that the respondents were able to provide valid responses needed in this study. Consequently, the reliability of the data obtained from them is assured.

4.2 Factors Responsible for Differences in Valuers' Opinion of Value in Compensation Valuation

In this section, the results of respondents' opinion on how significant they considered the identified factors responsible for discrepancies in opinion of value is presented. These factors were identified in the literature as well as interview conducted on them. Consequently, the result of this inquiry is presented in Table 3.

Table 3: Ranking of Factors Responsible for Differences in Valuers' Opinion of Value for Compensation Purpose

Causes of Differences in Valuers' Opinion of Value for Compensation Purpose	**Mean Score**	**Standard Deviation**	**Rank**
Lack of or poor definition of adequate/fair compensation	4.46	0.738	1
Undue influence of oil companies (polluters)	4.34	0.859	2
Incomprehensiveness of heads of claims	4.29	1.164	3
Lack of input from other professionals in determining value	4.10	1.605	4
Inadequacy of legislation guiding compensation for oil spill damage	4.08	0.940	5
Undue influence of compensation claimants	4.01	1.184	6
Imposition of valuation method to be applied in assessment	3.98	0.826	7
Imposition of value by the "Appropriate Officer"	3.90	1.543	8
Non application of Total Economic Value concept as basis for valuation	3.64	1.077	9
Differences in the valuation method applied	3.39	1.584	10
Experience of the valuers	2.88	1.678	11
Deliberate hiking of value to earn higher commission	1.47	0.860	12

Source: Field Survey, 2015

From Table 3, almost all identified factors have significant influence on valuers' opinion of value. Lack of proper definition of what constitutes adequate compensation was ranked 1st with a 4.46 mean score. Although the intent of compensation is to adequately restore the oil spill victims to the financial and economic position they were in before the spill, what is considered to be adequate is left without clear definition. Thus, valuers use their discretion based on certain assumptions to arrive at the compensation value for their clients. Undue influence of oil companies (i.e. polluters) was ranked 2nd with a mean score of 4.34. Further information from interviews suggests that the extent to which the polluter's agent (valuer) can influence the compensation payable sometimes determine retention or renewal of contract of services with the oil company. Incomprehensiveness of heads of claims was ranked 3rd with a mean score of 4.29.

The usual OPTS (Oil Producers Trade Section) of the Lagos Chamber of Commerce and Industry; a private sector group which represents the interests of oil and gas producing companies in Nigeria, compensation schedule is used as a guiding document in damage assessment but is not all encompassing with respect to head of claims. Thus valuers differ in opinion on inclusion of certain claims in valuation reports. Lack of input from other professionals in determining value was ranked 4th with a mean score of 4.10. In oil spill situations, certain damages may be inflicted on land, body of waters and vegetation. Valuers require input from other expert such as soils, crop, chemical and water scientists, to determine the extent of damage and likely period of remediation/restoration in order to objectively determine the compensation value. The quality of the input is germane to the success or otherwise of the compensation exercise. Inadequacy of legislation guiding compensation for oil spill damage was ranked 5th with a mean score of 4.08. Out of the entire factors responsible for discrepancies in value, the least is hiking of compensation value by valuers in order to earn higher commission; this was ranked 12th with a mean score of 1.47. Although the fee charged by valuers is based on the quantum of compensation arising from a valuation assessment, the results shows that this hardly motivates valuers to influence value.

Further to the above rankings, factor analysis was conducted to classify the variables. Table 4 shows the results obtained from factor analysis and indicates that four factors were extracted. These extracted factors have their eigenvalue from 5.023 for factor one to 1.080 for factor four and all the factors accounted for 80.048% variation in the factors influencing discrepancies in valuers' opinion of value for monetary compensation for oil spill damage in NDR.

Table 4: Factors Analysis of Causes of Differences in Valuers' Opinion of Value for Oil Spill Damage Compensation

Factors	Component			
	1	2	3	4
Factor 1: Weak Standard/code of Practice				
Lack of or poor definition of adequate/fair compensation	.758			
Incomprehensiveness of heads of claims	.932			
Undue influence of compensation claimants	.928			
Lack of input from other professionals in determining value	.935			
Variance (%)	**41.857**			
Factor 2: Inadequate Legal Framework and External Influence on Valuer				
Imposition of method of valuation to be applied in assessment		.733		
Inadequacy of legislation guiding compensation for oil spill damage		.669		
Imposition of value by the "Appropriate Officer"		.785		
Differences in the valuation method applied		.768		
Undue influence of oil companies (polluters)		.810		
Variance (%)		**17.610**		
Factor 3: Gap in Valuers' Knowledge				
Experience of the valuers				
Non application of Total Economic Value concept as a basis for valuation			.897	
Variance (%)			**11.579**	
Factor 4: Professional Misconduct				
Deliberate hiking of value to earn higher commission				.931
Variance (%)				9.003
Total Variance (%)				**80.048**

Source: Field Survey and Data Analysis, 2015

The first factor is named '*Weak Standard/code of Practice*' and explained 41.86% of the total variance. Variables loaded under this factor are: lack of/poor definition of adequate/fair compensation; incomprehensiveness of heads of claims; undue influence of compensation claimants; and lack of input from other professionals in determining value. There is therefore the need to strengthen the standard or code of compensation valuation practice to forestall usage of different parameters for damage valuation assessment. Since impaired interests arising from oil spill damages can be enormous and diverse, valuers should, by standard or code of practice, seek input from appropriate allied professionals whose work is germane to arriving at reasonable compensation value. The launching of the 'Green Book' of ESVARBON is encouraging. However, specific code for oil spill damage valuation is necessary. Oil Spill damage compensation codes should spell the process, the bases, and appropriate method to be applied in the valuation of different heads of claims (Olukolajo, 2017b).

The second factor is tagged '*Inadequate Legal Framework and External Influence'* with 17.61% of the total variance. Variables loaded under this are: imposition of method of valuation to be applied in assessment; inadequacy of legislation guiding compensation for oil spill damage; imposition of value by the appropriate officer; differences in the valuation method applied; and undue influence of oil companies. Compensation valuation in Nigeria is

generally considered as statutory because of myriad regulations that direct its course. However, these regulations lack harmony and leave a number of issues loosely defined (Byrne & Viitanen, 2009; Oluduro, 2012; Kakulu et al., 2014; Bodo & Bodo, 2018).

The third factor is '*Gap in Valuers' Knowledge'* with 11.58% of the total variance. Variable under this are: experience of the valuers; and non application of total economic value concept as a basis for valuation. Kayode and Ukabam (2018) highlighted the importance of valuers having appropriate technical skill, knowledge and experience as germane to successful valuation practice. A valuer who lacks all these will produce contestable values. NIESV deserves credit for the establishment of various faculties and mandating the state branches to organize Mandatory Continued Professional Development (MCPD). All these are geared towards educating their members to enhance their knowledge in professional services. However, members must continue to update their knowledge through these platforms more as attendance is voluntary.

The fourth factor is '*Professional Misconduct*' having 9.00% of the total variance. The only variable under this is deliberate hiking value to earn higher commission. It is unfortunate that the drive to earn higher commission can make some valuers hike compensation claimant interest's value. ESVARBON and NIESV already have measures to deal with such unethical members. However, the measure must be strengthened and operate without fear or favour. Licenses of such a valuer may be withdrawn or have them suspended to deter potential erring members.

5. Conclusion

The study has identified factors causing discrepancies in valuers' opinion of compensation value for damages resulting from oil spills in the Niger Delta area of Nigeria. Through factor analysis, these factors were classified into four categories, these are: weak standards/codes of practice, inadequate legal frameworks and external influences, gaps in valuers' knowledge, and professional misconduct. A specific code of practice on oil spill damage compensation should be prepared by ESVARBON in conjunction with NIESV. The content of the code should reflect peculiarities of the claims from the Niger Delta. This will minimize the agitations in the region. Valuers must undertake training and retraining programmes as new methods and approaches are evolving towards best practices globally.

This study specifically focused on compensation for damages relating to oil pollution. Consequently, the findings herein cannot be generalised on all aspects of compensation practice. At best, the recommendation herein is specifically related to oil spill situation in the Niger Delta region of Nigeria.

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The PropTech Revolution: The Imperatives for Nigeria's Estate Surveying and Valuation Professionals to Catch Up or Get Left Behind

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Abstract

Information and Communication Technology (ICT) has become the bedrock of modern societies with activities being streamlined to technologically meet the needs of individuals willing to adopt it in their day-to-day lives. The emergence of ICT has influenced the activities of real estate practitioners all over the world. Despite sectoral shifts and the introduction of innovative technologies, real estate professionals have been quite conservative towards industry modernisation (whether it is information provision, transaction or management), which threatens to limit their influence in society. PropTech, or property technology, has commanded this movement by promising more efficient portfolio management, faster ways of renting accommodation and more accurate techniques of carrying out property appraisals. It has provided innovative solutions for an industry yearning for change. This paper, therefore, describes the emerging property technology industry known as PropTech. It illustrates how its development has brought changes to global perceptions of real estate. The paper also critically examines the challenges that Nigerian estate surveyors and valuers face in the advent of fast-paced information technology. It strongly proposes that professionals must learn to utilise this emerging trend or face becoming redundant in the real estate industry.

Keywords: PropTech; FinTech; Information and Communication Technology; Estate Surveryors and Valuers, Nigeria

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1. Introduction

Developments in Information and Communications Technology (ICT) have brought about change in almost every sphere of modern humanity. This change has been facilitated in no small way by three activities; information provision, transaction, and effective control (Baum, 2017). Real estate practice has also enjoyed the presence of ICT, particularly in developed nations. For instance, prospective investors in faraway locations can get information regarding property yields, vacancy rates and properties' initial rates of returns of a particular place with just one click online. Face to face transactions are no longer needed for real estate transactions to take place as safe and secure transfers between the buyer and seller are now possible with the advent of internet banking. Even property management is now less stressful with the introduction of technology. This is because one can keep track of several property portfolios, monitor their progress and effectively plan future expansions of properties within the organisation purview.

Furthermore, globalisation has played a major role in how the internet has improved the economics of location. A more mobile and technologically advanced workforce now means that businesses can operate anywhere. Although not every company can afford telecommuting gadgets for employees' use, many organisations have been able to develop strategies that reduce the amount of office space needed to accommodate employees. This has helped to increase efficiency among businesses by reducing the cost of leasing large spaces in expensive locations. The internet has made it possible for several transactions and activities to be carried out without the need to travel for a meeting in a specific location. The rapid growth of the internet and the need to gain a competitive advantage in business made it imperative that organisations embraced the use of ICT for productivity and strategic management (Kakabadse et al., 2005). Although various industries, such as finance, manufacturing and telecommunications, were quick to latch onto the ICT trend, the real estate industry, particularly in developing nations, have been slow to adopt this movement. For those developing nations that eventually have, growing data availability afforded them more options in terms of robust finance-grounded quantitative modelling, valuation software and property management (Baum, 2017).

As the property market is a highly heterogeneous one which lacks adequate information, the earliest application of ICT in real estate was to market real estate products to clients. For instance, marketing of properties requires concerted effort and adequate information in order to attract would-be investors (Baum, 2017). Moreso, most property market information is concealed because of heterogenous agents. This made it impossible to access, at the first instance, but with the introduction of ICT, marketing of properties has become quite easy with specific information. An example of this is the setting up of property websites that provide multiple listings services of different types of properties, their descriptions and their sale/rental prices. However, these websites still had to be run by property agents who served as intermediaries between the buyer and seller to ensure that the advertised properties were disposed off successfully. The ability to

replace physical with virtual proximity meant that clients could easily browse the internet for property listings and complete transactions online within a short space of time (Dumpe, 2015). The relative ease with which money exchanged hands for transactions is a welcomed development. The business world, for the sake of convenience, had finally found a way to bridge the gap between finance and technology. Further research and advancements into how the finance sector could improve businesses with the aid of technology has given rise to what is today termed '*financial technology*' with the acronym '*FinTech*'.

It is suggested that the real estate industry needs an upgrade – a property technology or '*PropTech'* upgrade (Feth & Gruneberg, 2018). Whether it is seen as a disruption or a positive turning point in the way real estate services are rendered, most real estate professionals opine that PropTech is the way forward in terms of advancement in the real estate sector (RICS, 2019; AIC, 2019). PropTech is expanding at a rapid pace, considering the number of investors showing interest in the sector. Although still relatively new in Africa, the increased sophistication constantly being demanded of end users of real estate has led to its growth in most developed countries. PropTech promises to bring down the old crumbling wall that represents the property industry and build something entirely different with the aid of technology. Its proponents believe that PropTech brings more people to the property sphere, thereby enabling information, transaction and controlling interactions in a shared economy.

The PropTech revolution is relatively new in Nigeria, especially among estate surveyors and valuers. At present, the real estate industry has a low level of technological expertise and insufficient financial power to effectively manage large data. Therefore, one could argue that estate surveyors and valuers in Nigeria are not fully positioned to take advantage of the opportunities that the PropTech revolution offers (Oyetunji et al., 2018). This is evidenced by current rudimentary estate appraisal, management and agency practices, which have seen estate surveyors and valuers underperform in relation to their billing when providing real estate advisory services. Against this backdrop, this paper explores the history and workings of the PropTech industry, delving into the challenges facing the Nigerian real estate surveyor and valuer in the use and adoption of ICT. It explains how embracing PropTech could revolutionise the activities of these individuals, thereby making them better equipped as professionals in an ever-changing market.

2. The PropTech Evolution

PropTech collectively defines start-up companies which use technological innovations to provide solutions to real estate problems (Pyle et al., 2017). PropTech emerged as a culmination of years of development, finance and innovation, centred around real estate transparency, participation and understanding. This multidisciplinary development has evolved into a lucrative industry (Baum 2017; Forbes, 2018; Shaw 2018). According to Baum (2017), the first wave of PropTech, known as PropTech 1.0, took

place around the mid-80s in the United States of America and the United Kingdom. The introduction of the personal computer and the floppy disc, which supported spreadsheet data analysis applications such as Excel, changed the world and this industry. This innovation, along with the growth of the Real Estate Investment Trust (REIT) in terms of investors, capital and advisory services, prompted growth in property ICT (Baum, 2017).

Despite these ground-breaking innovations, the storage and transfer of a large amount of data was increasingly becoming a problem, as was its accessibility to the general populace. Subsequently, the 90s brought about an increase in online trade with the mainstreaming of the internet and email (Coffman & Odlyzko 2001). This technological expansion led to the establishment of market places, such as Craigslist, in the US and print market places, and Exchange and Mart, in the UK. These sites began the transition from print to web, selling and letting real estate alongside household goods and holidays to a growing online public. The development during this time paved the way for e-commerce as a platform and business both in real estate and finance.

Improvements in the analysis of data with the help of mainframe computers both in the US and the UK birthed property research companies such as the Investment Property Databank (IPD) (1985) and Prudential (1987). These technological innovations in research were not limited to the property investment sector as engineering, construction and management industries also benefitted from these advancements (Ojo et al., 2018). Autodesk, Yardi, Argus and CoStar were property softwares developed at this time to provide support for architecture, construction management and investment-based decisions in real estate. As innovative as PropTech 1.0 was, it suffered an oversupply of expensive and uncollaborative real estate computer technology, which lacked adequate demand in terms of traffic (Baum, 2017).

The increase in demand for rental accommodation and the need to make sales and purchase of real estate more efficient has led to the evolution to PropTech 2.0 at the start of the 21st century (ING, 2018). This bridged the gap between Proptech 1.0 and the public. Baum (2017) suggested that the use of technology as well as awareness on accessibility and affordability of connectivity such as mobile phones, PCs, cloud computing, Wi-Fi and 4G technology brought about change in the real estate sector. Clients are gradually dissatisfied with just buying real estate online as they demanded that these properties incorporate smart technology. This led to the introduction of PropTech 2.0. Table 1 depicts the PropTech 2.0 platform and the services rendered in different countries.

Table 1: PropTech Platforms in Different Countries

PropTech Venture	Country	Services
IPD (2003)	United Kingdom	Organises and analyses data describing the performance of commercial property in the UK.
Redfin (2004)	United States	Online real estate portal that enables its customers to perform map-based property searches. It provides value-added features such as home tours (use of virtual reality).
Propertyfinder (2005)	Dubai	Online property portal that helps customers find properties that fit their requirements. The company lists top-class properties, allowing customers to browse through them and shortlist their choices easily.
PropertyGuru (2006)	Singapore	Online real estate portal that provides its customers with the edge they require when conducting their property search and helps them make well-informed decisions on property purchases, sales or letting.
Zoopla (2008)	United Kingdom	Provides users with access to information such as sold house prices, area trends, statistics and current value estimates for domestic properties in the UK.
PropTiger (2006)	India	Online real estate portal that helps those wanting to buy, sell or let out homes on a turnkey basis. The web portal enables people to shortlist their favourite homes and check attractive visuals of properties along with details of the neighbourhood. PropTiger assists its customers in getting home loans and completing their property registration process.
Zumper (2011)	United States	Online real estate portal that enables tenants to walk into a house and make an offer to the landlord on the platform.
Fangdd (2011)	China	Online real estate portal that provides customers with a strong platform where they can buy, sell and rent out properties. It allows customers to search for rooms to rent in old or newly constructed properties.
Compass (2012)	United States	Real estate portal equipped with cutting edge technology to make property search, sale and buying processes hassle-free, intelligent and seamless.
Housing.com (2012)	India	Online real estate portal that focuses on simplifying the home search process for people through its state-of-the-art web platform. The company's mission is to make the process of buying, selling and letting homes swift, smart and simple for all its customers.
Properati (2012)	Argentina	Online real estate portal that connects thousands of buyers and sellers in the Latin American region in a fast and effective manner, facilitating smooth deals.
Radpad (2013)	United States	Online real estate portal that locates houses and apartments for rent in various cities and towns in the US for free.
Nestpick (2014)	Germany	Online real estate portal that lists furnished apartments for people to buy. It provides customers with a wide selection, fast search results, and the best possible prices for furnished apartments in top cities.
Mogoroom (2014)	China	Real estate portal that provides a rental online-to-offline (O2O) platform for customers to find a house to rent quickly. It provides verified property listings of landlords at highly affordable rental prices.

Roomi (2015)	United States	Online real estate portal that helps its customers find flexible and affordable homes while connecting with roommates to make them feel at home in a big city.

It is interesting to note that these start-ups/platforms have used information technology not only to provide real estate services for their clients but also to enable ease of payment through collaboration with the FinTech Industry (RICS, 2017). Despite this, these start-ups require a lot of capital in order to meet real estate information needs, and acquire technological advancements. As a result of this close interaction, the line between both FinTech and PropTech are often blurred.

2.1. FinTech and PropTech

The FinTech and PropTech industries are two distinct industries that have, over time, evolved with technological innovations. While the two overlap at certain intersections, they are two distinct industries. The confusion stems from the close collaboration that they share because of the funds required to transact in real estate. Real estate is a trillion-dollar asset class that affects all and is a biological and social necessity (Linklater, 2013; Dorling, 2014; Savills, 2016). With limitations such as physical deterioration, illiquidity and legal regulations, there is a need to incorporate innovations of the FinTech industry in making the real estate sector more fluid for investment purposes (Baum, 2015; 2017).

The need to cope with speed and competitiveness in real estate transactions has given rise to real estate FinTech (PWC, 2019). Research has shown that the advent of FinTech has helped to improve lending practices among real estate investors. Gaughan (2017) explains that although FinTech's new approaches to granting credit have the potential to help previously underserved and unbanked communities, it may also lead lenders to deny credit because of a lack of access to internet or an avoidance of social media. CB Insights (2012) states that real estate technology companies, including start-ups, have raised almost $6.4 billion in funding, an attestation to the fact that undertaking an investment in property technology is very expensive and requires a lot of pooled funds.

Studies by Buchak et al. (2017) have also shown that FinTech lenders were more likely to enter the real estate market where traditional banks faced more regulatory constraints in dealing with investors. Overall, the real estate sector has lagged in other areas of financial services in its adoption of technology and given the massive size of the real estate market, it is hoped that many innovative FinTech startups will be able to address the challenges that this market faces in undergoing a digital transformation.

The World Economic Forum (2015: p.3) report on The Future of FinTech defined FinTech as: *"the use of technology and innovative business models in financial services".* KPMG and CB Insights (2016) submit that although

FinTech might be made up of several companies, it would typically include the following business niches:

Lending tech: Lending companies, primarily peer-to-peer lending platforms, as well as underwriter and lending platforms using machine learning technologies and algorithms to assess creditworthiness.

Payments/billing tech: Payments and billing tech companies provide solutions ranging from the facilitation of payment processing to subscription billing software.

Personal finance/wealth management: Tech companies that help individuals manage their bills, accounts and/or credit as well as manage their assets and investments.

Money transfer/remittance: Money transfer companies, including peer-to-peer platforms, to transfer money between individuals across countries.

Blockchain/bitcoin: An emerging technology that uses distributed databases, maintained by users, to record and transfer digital assets across all participants in the network without a third party or exchange.

Institutional/capital markets tech: Companies providing tools to financial institutions such as banks, hedge funds, mutual funds or other institutional investors. These range from alternative trading systems to financial modelling and analysis software.

The current PropTech environment can be broadly divided into three specific markets, namely: Smart Real Estate, Shared Economy, and Real Estate FinTech (ING, 2018). Smart Real Estate supports real estate assets, which could be single property units or entire cities. These platforms provide information about building or urban centre performance and may directly facilitate control of building services. The goal of Smart Real Estate and smart cities is to improve the quality of life of occupants/residents. Technology is used to improve the efficiency of services and meet residents' needs while maintaining the highest level of sustainability. These international technological platforms such as Nest, Digital Realty, Equinix, and Aggreko, deliver intelligent houses that promote healthy living and energy conservation for clients (Baum, 2017).

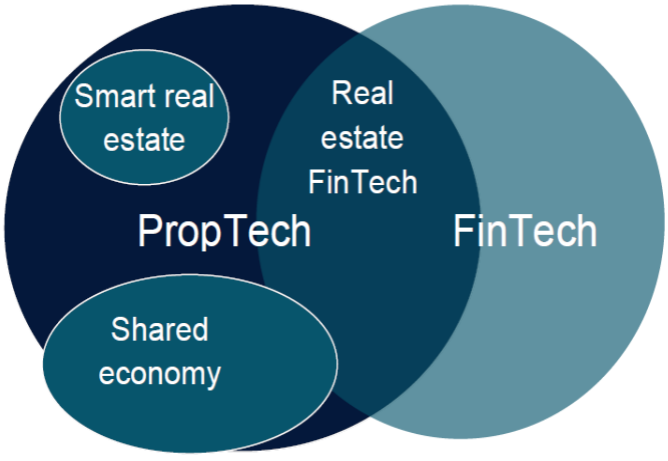

Figure 3: Real Estate FinTech: An overlap of PropTech and FinTech
(Source: Baum, 2017)

The Shared Economy facilitates the use of real estate assets. In an age of unaffordability, co-sharing of space has become the norm. This platform provides information for prospective users and sellers of such spaces. It goes a step further to ensure that rent or fee-based transactions are possible between user and seller. Some of the examples of businesses in the shared economy include Airbnb and WeWork. The American Airbnb business deals with the booking and rental of private accommodation and currently has over 4 million listings spanning more than 190 countries as of September 2017 (Airbnb Fast Fact, 2017). WeWork, which is currently valued at USD 20 billion, manages approximately 10 million square meters of office space in a bid to provide a community feel for entrepreneurs and small businesses in shared workspaces (Hempel, 2017).

Statistics show that 77% of executives indicated that the sharing economy is having the greatest impact on Airbnb business, followed by 66% co-working at WeWork business and 61% e-commerce at Amazon business (Microsoft, 2019). Not only that, 61% of commercial real estate executives indicated that their firms are using, or already trying out, online lending places, with 23% using them in a significant way (Altus, 2019). With improved technologies, such as cloud computing and Artificial Intelligence (AI), increasingly gaining relevance the Sharing Economy is a trend more businesses are looking to adopt in order to reduce the cost of using space while creating greater operational efficiencies (Moreno-Izquierdo et al., 2018). For instance, the use of machine learning is becoming increasingly frequent in companies' search for competitiveness. In many cases, AI can help companies improve their knowledge about users to optimise prices or in guiding buyers choices.

Real Estate FinTech provide direct products and services to real estate end-users, often through online and mobile channels. Companies like Zillow, Zoopla, LendInvest, OpenDoor (all technology-based platforms) help facilitate the trading of real estate assets (freehold or fee simple title, long leaseholds and shorter leases) (Baum, 2017). As highlighted earlier, real estate FinTech operates in a transparent and fluid market where data is readily available and financial regulations are put into place to curtail the excesses of overzealous investors in both the financial and real estate sector (WEF, 2015). Transparency in data has driven transaction time down and as data has become more commoditised, real estate financial markets have become more efficient.

Another current subset of the PropTech environment is a term known as ConTech. Although not part of the use, sale or lease of real estate, it is worthy of mention as it is very important to building companies. ConTech refers to the use of new technologies during construction to make the process more efficient. Robotisation and 3D printing are some of the applications in ConTech which can influence the real estate sector in areas such a project development, renovation and maintenance (ING, 2018).

2.2. The Professional Consensus and Influence of Proptech on the Real Estate Industry

The 2018 survey by Teesside University and RICS to understand the challenges and opportunities of PropTech among professionals found that 95% of real estate professionals agreed that PropTech presented more of an opportunity than a threat to the real estate surveying profession (RICS, 2019). With technological advancements in companies such as Amazon, Uber, and WeWork, the need to understand how future real estate markets will operate has united wealthy real estate 'organisation men' with younger, technology-savvy entrepreneurs. The combination of capitals allows these professionals to harness the technology needed to change the way real estate is perceived (Himanen, 2001; Baum, 2017). But what trends account for their faith in the sector? Much of it boils down to the impact of new ventures streamlining the roles of real estate professionals in a fast-changing economy. Analysis shows that a record of $12.1 billion was invested by venture capital funds to grow the PropTech industry in 2017 (Ivens & Barbirogli, 2018). Furthermore, a cursory glance at the delegates list of Proptech related events, such as Le marché international des professionnels de l'immobilier hosted in France, and #PropTech2017 held in Central London, reveals that serious interest in technology is far from lacking. For example, the eight-hundred delegate list for #PropTech2017 from over five hundred organisations included twenty-four venture capital funds; six of Europe's top ten real estate funds (representing at least $250 billion of European real estate assets under management); and numerous start-ups with registered offices in the vicinity of Shoreditch's famous creative digital cluster, Silicon Roundabout (Foord, 2013; Shaw, 2018)

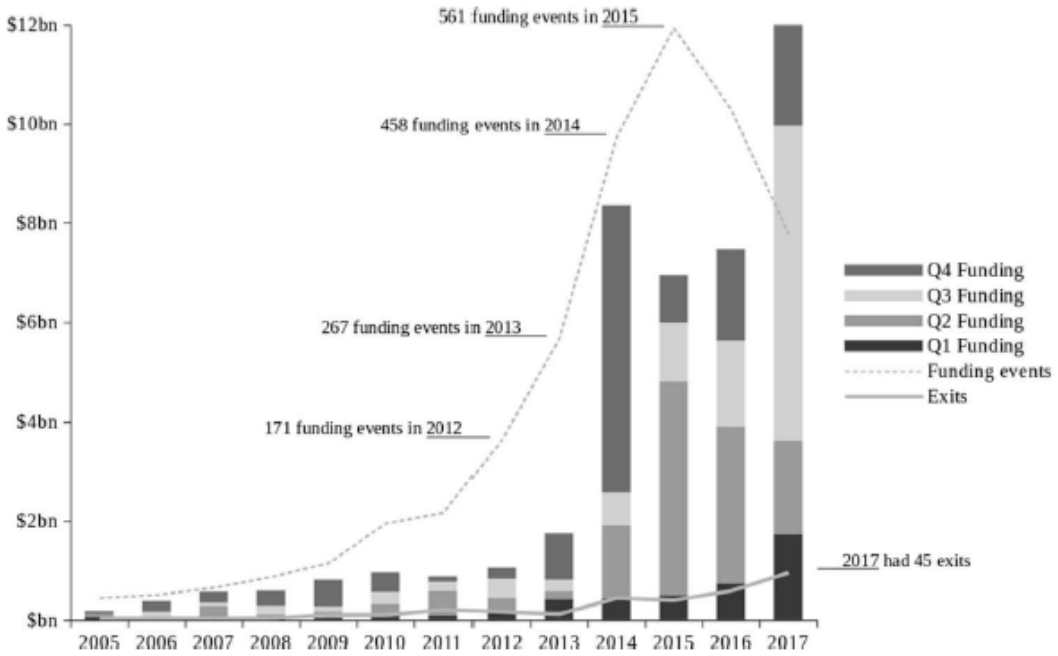

Figure 4: PropTech Investment Through Venture Capital Funds from 2005 – 2017

(Soutce: Ivens & Barbiroglio, 2018)

The consensus among professionals is that PropTech is a smart market to invest in. Innovation in the industry is desperately needed and property technology serves to meet the demands of an increasingly digital business landscape. But what effect will this technology have? Piazolo (2018) summarised the effects of technology on real estate in the long-run to include these driving forces: increased transparency, improved efficiency, enhanced flexibility and provision of employment opportunities for individuals with new skill sets. According to Piazolo, these driving forces would be the bedrock for future developments in real estate.

3. Estate Surveying Practice and the Proptech Industry in Nigeria

In many ways, PropTech is seen as the innovative use of technology to solve real estate problems more efficiently and in real time. Possessing the technology is not enough to deliver on the goals of PropTech, but being able to harness large amounts of data, transform it into something useful (information) and communicate it to the final consumer (clients), to a large extent will determine how effective the PropTech industry will perform in the long-run. According to Obayan (2010), ICT has become the bedrock of modern societies with activities being streamlined to technologically meet the needs of individuals willing to adopt it in their day-to-day lives. The emergence of ICT has influenced the activities of real estate practitioners all over the world and Nigeria is no exception (Swanepool & Tuccilino, 2003; Kakulu, 2008; Babawale, 2012). Kakulu (2008) admits that the introduction of ICT to Nigeria has brought about new ways of conducting real estate business. Although the adaptation of ICT in the real estate sector is more pronounced in developed economies, Nigerian professionals have sought ICT technology to attract international investors and improve market transparency (Oke et al., 2017). The introduction of ICT in Nigerian real estate transactions started sometime in the 21st century with property websites publishing property information for the perusal of potential buyers (Gwin, 2004; Chukwuemeka, 2012). Its impact in Nigeria is concentrated on auctioneering and property sales. Despite this, the PropTech industry has not yet developed into a full-blown industry in Nigeria because of the lack of property data, costs involved, technical know-how, lack of transparency and instability of the market (Udobi et al., 2016; Olapede & Olaleye, 2019).

Adeyemo et al. (2015), explore the motivating factors influencing the use of ICT in real estate practice in Minna, suggesting that external factors such as the size of real estate firm, management and overall cost of running an ICT associated practice, are limiting factors for firms. Due to the current economic situation of the country, which sees at least 70% of Nigerians living under the poverty line, professionals are finding it difficult to run their businesses or even pay their employees. Clients are not forthcoming either as only the very wealthy can afford to engage and pay for real estate services. The multiplier effect of this is that most real estate firms in Nigeria would rather spend money on essential office needs than invest in technology (Oyetunji et al., 2018). For those few firms that invest in

technology, affordability and non-availability issues continue to remain a hindrance (Ayotunde, 2013).

Similarly, Oyetunji et al. (2018) argued that most of the real estate firms in Lagos lack the technological skills to elevate local real estate practices. They note that estate surveyors and valuers are mostly familiar with general-purpose tools like email, Microsoft Office, Excel, PowerPoint and Adobe Reader. Furthermore, the few professionals with software knowledge tend to only be proficient in AutoCAD and Revit. Thus, the knowledge and use of specialised real estate designed software like Yardi, ARGUS, IBM Tririga, Propertyware, etc. remain limited in Nigeria. The reason is not far-fetched as training of real estate surveyors and valuers, both as undergraduates and graduates, touches very little on the use of technology to improve their skillsets. The training of valuers in Nigeria places a lot of emphasis on 'bricks and mortar' with very little training put into how to engineer data to perform tasks such as valuation, feasibility studies, property management and other critical functions of a contemporary property professional. A promising example is a cursory look at the National University Commission of Nigeria's curriculum of Estate Management. Most universities still make use of valuation tables to teach real estate students how to carry out valuations and the management of leases is still mainly theoretical, making the entire process of learning quite inappropriate for the realities of modern property markets.

Even in the area of property listing and advertising, where the use of ICT has been effective, Babatunde et al. (2016) reveal that banners, phone calls and emails still rank higher as methods for disseminating property information. The use of video recording by professionals in the display of properties is also minimal, given the technicalities of the medium. Thus, one can deduce that PropTech 1.0 has still not fully evolved in the Nigerian real estate practice, as property management is still carried out traditionally. Paperwork and files remain at the forefront of lease management because of the inability of professionals to make use of property management software packages, such as Yardi, Angus, or Entrata. As such, property management remains a largely manual task.

Nigeria is currently ranked number 144 out of 180 on the corruption index by Transparency International. With very weak institutions and a high rate of insecurity, in the last 10 years the country has struggled with attracting international investors. Although termed the '*giant of Africa*', Nigeria has lagged behind other African countries like Kenya and South Africa in terms of foreign direct investment (FDI). FDI to West Africa declined by 15% to $9.6 billion, largely due to Nigeria where flows plunged by 43% to $2 billion (UNCTAD, 2019). The reason can be attributed to the corruption and lack of transparency currently experienced in the country (Adebiyi et al., 2019). Investing in PropTech is a very expensive venture, one that Africa (especially Nigeria) is not yet prepared for because of the level of poverty, corruption and political instability that reigns (Adebiyi et al, 2019). Direct foreign investment is no doubt required to hit the ground running in developing PropTech as it is quite costly to set up. The problem is that no

investor would want to put in such huge funds in developing technology in a country with little certainty that returns on their investment will be secured. Nigeria, with a population of over 180 million people, is a country laden with opportunities, especially in the real estate sector. Unless it solves the plethora of socio-political issues currently facing the economy, it will continue to miss out on opportunities to pursue new frontiers for developing its real estate professionals.

Amidu and Aluko (2007) identify three issues that estate surveyors and valuers in Nigeria are currently facing in the area of valuation; inaccuracy, bias and client influence. This is because most valuers are only apt in traditional methods of valuation that do not require as much ICT and quantitative knowledge as those of the advanced methods (Pagourtzi et al., 2003). The consequence of this is that valuers are not able to accurately determine property values which capture the ever-changing price volatility of the contemporary property market (Hui et al., 2009). Computer-Aided Valuation (CAV) is a popular solution to this issue. Although the approaches of valuation remain universal, the ability to use CAVs accurately is still dependent on the skill and technical know-how of the valuer (Ibrahim et al., 2005; Tretton, 2007).

Given these contextual challenges, it's important to also note the other factors that impact the technological adoptation in Nigeria's property sector. Eyenubo (2015) highlights that the recapitalisation of the Nigerian banking sector in June of 2004, has seen the financial sector leverage considerable capital and improve its ICT technology. As a result, more businesses in Nigeria, including start-ups, have been established and collaborated with the financial sector to increase the value of their services (KPMG, 2016). Despite this positive (collaborative and technological) trend across various Nigerian sectors, the real estate and financial sector have failed to materialise joint service delivery. An instance of this is a case where issues of mortgage financing and housing affordability persist in Nigeria as many property professionals have been seen to exploit the financial sector for personal gain rather than seek public solutions (Ndubueze, 2009).

4. Problems Militating the Adoption of Proptech by the Estate Surveying and Valuation Profession in Nigeria and its Implications

Real estate professionals in most countries are slow to accept changes that might affect their inherent roles (KPMG, 2018). Valuers in Nigeria are no exception. Unlike the financial world which readily embraces change, the property sector and its professionals are typically quite conservative, hence the reluctance to fully accept ICT as an integral part of the services they render. While the financial sector in Nigeria continues to grow with the aid of technological advancement, the real estate sector and its professionals seem to be lagging. In a developing country like Nigeria, the factors militating the growth of technology in the real estate sector are numerous and, as mentioned and alluded to earlier, they hinder Proptech adoption in the Nigerian property sector. This section focuses on factors such as the cost

and maintenance involved, technical know-how, lack of transparency and the instability of the market. While all these factors are interlinked in reality, their individual impact are worth noting.

Various authors highlight several barriers to the deployment of ICT in real estate firms in Lagos state. Out of these (Babajide et al., 2018; Oyetunji et al., 2018), stated that inability to keep up with rapid changes in ICT technologies, lack of technical know-how and high cost of technological investment are the major barriers at the forefront. These remain significant because of the inadequate training real estate students in tertiary institutions are exposed to in the area of technology, the high rate of poverty among the citizenry and the political/economic instability currently experienced in the country today. Another important factor that could make it significant can be attributed to insufficient motivation to spend more on current technologies due to the erratic power supply bedevilling the nation (Oyetunji et al., 2018).

It would be unfair to say there are no valuers in Nigeria trying to add value to their services through technology, but their numbers are few and innovation in the profession is still lacking. Most practising valuers and viable corporate firms in the country would rather embrace traditional methods than learn to master new technology. This is due to the lack of technical knowledge among older professionals. This highlights that technology and investment vehicles for investment in PropTech are not enough and there needs to be a critical mass of appropriate skills to enable the unlocking of the potential of these innovations in the Nigerian real estate sector. The younger generation of valuers are more likely to challenge the status quo but unfortunately, younger valuers do not have the capital to venture into the PropTech industry.

Oni (2013) concludes that most valuers show a lack of commitment in embracing ICT as a result of certain factors ranging from high costs of acquisition, training and maintenance charges paid for by the use of this software. Information obtained from phone calls that were put across to staff of ARGUS, (a real estate software company which specialises in real estate investment analysis and development with headquarters in the United States of America) offers its basic package to real estate professionals at $600 a month or $2600 annually. At today's exchange rate ($1= ₦360.00) this amounts to ₦216,000 monthly or ₦936,000 annually (XE, 2019). The real estate sector contracted by -3.85% in Q4 2018 from 2.68% in Q3 2018 and -5.92% in Q4 2017. On an annual basis, the nominal growth rate for real estate services in contribution to the national GDP was 0.48% in 2018, lower than the 3.01% recorded in 2017 (NBS, 2019). This evidence supports how a contracting real estate sector is unable to make largescale investments in technology when the sector is experiencing pervasive austerity and as a result, professionals are becoming risk averse. If real estate professionals in Nigeria cannot benefit from the technological innovations of PropTech, such as the use of real estate software because of a lack of affordability, it begs the question of how productive their practice would be, both now and in the future.

Although a few valuers possess the appropriate skillset to apply ICT in real estate, the emphasis on direct human contact in conducting real estate business in Nigeria has meant that the valuer has come to be regarded as a '*low tech, high touch*' professional (Ayotunde, 2013: p.6). As a result of this belief, there is a strong emphasis on ability to express oneself qualitatively rather than quantitatively in this profession. The multiplier effect of this is that there are more valuers prone to carrying out valuations/rendering real estate services in a manner that is quite localised and unsophisticated. Even at the university level, undergraduate students of Estate Management are hardly exposed to any software technology that is relevant to their field of study. A study carried out by Egbenta (2015) shows that Estate Management graduates have very low to average employability skills, especially in the area of ICT. The effect of this is that these graduates, who eventually become valuers, cannot understand or manipulate the most basic of computer software to execute tasks. A good example is the modelling of investment cash flows with Excel. This involves estimating the value of an investment based on projections of its future cash flows. Excel can be used to work out the present value of a particular real estate portfolio investment and, at a glance, provide a basis for an investor to make informed decision on whether to proceed with a project or abandon it. The use of Excel also helps eliminate the errors that can be encountered when calculations involving summations are carried out manually.

It is also instructive to note that the Nigerian Institution of Estate Surveyors and Valuers (NIESV) currently has 15 faculties set up for the professional development of its members, yet not a single faculty is strategically dedicated to the technological advancements of its constituents (NIESV, 2019). The implication of this is that many of the registered valuers, especially those of the older generation heading these various faculties, are not skilled in applying technology to their crafts as professionals. These faculties are, at best, dormant and lacking the much-needed technological expertise to fine tune the skill sets of valuers. This puts the average Nigerian valuer at a disadvantage when compared to his foreign counterpart as the latter, armed with advanced computer-based skills, is able to provide real-time solutions to the most complex of real estate problems. Another consequence of the non-existence of a faculty dedicated to the technological development of valuers is the fact that as of today, the NIESV cannot showcase a data bank which investors both locally and internationally can rely on to easily make informed investment decisions.

The performance of real estate firms in the country still remains limited to the knowledge and decision-making ability of the principal partner of the firm. Oloke et al. (2013) attribute the bane of partnership formation primarily to dishonesty, undue family interference, and disagreement, which has made the sole proprietorship form of business a preferred choice amongst real estate firms in Nigeria. The sole proprietorship form of business practice by real estate firms in the country has been in vogue since the early 1970s when NIESV was formed. Out of the 915 registered real estate firms in Nigeria today, at least 85% of them are a sole proprietorship

form of businesses while the remaining 15% are some sort of partnership (NIESV, 2019). These sole proprietorship real estate firms are headed by a principal who is responsible for making all the decisions in the firm and provides the finances for the day to day running of the firm. These 'sole owner' real estate firms, at best, operate on a very local scale and do not have the financial muscle to engage in PropTech for the benefit of their firms.

In addition to the economic struggles that limit the adoption of technology, there are also structural issues that create further obstacles (World Economic Forum, 2018). These can be seen as political and external to the real estate sector itself, leading to scepticism amongst valuers in investing into technological advancement in the property sector. The implications of this to the estate surveying valuation profession in Nigeria are dire, and the effects are already being felt with the incursion of non-professionals into brokerage and valuation aspects of the profession. Also, the external factors impeding the growth of technology speak more broadly to investor sentiment in the nation as a whole, which is negative and unwilling to risk investment. This has knock-on effects to the adoption of tech in real estate as investors are hesitant to take a gamble on untested technologies in an unstable context.

5. The Way Forward

In order to bridge this technological knowledge gap exhibited by valuers in the country, it is recommended that valuers rigorously pursue continuous education and personal development. Estate Management university curriculums at undergraduate and postgraduate levels should be developed in such a way that students are proficient in real estate related software applications before they graduate. NIESV should also encourage aspiring valuers to be more innovative with the critical analysis they produce. This could come by way of displaying mastery in the use of technological softwares to proffer solutions to real estate problems, whether it is rendering real estate services to a client or helping improve the skill set of a valuer.

The traditional way of running real estate firms internally in Nigeria must be re-evaluated both by the NIESV and the Estate Surveyors and Valuers Registration Board of Nigeria (ESVARBON). The sole proprietorship form of estate practice, although once thought to be entrepreneurial and quite promising, has not been dynamic enough to encourage growth amongst young valuers in the country today. Thus, in re-evaluating the industry, firms must implement sustainable practices of management, recruitment, investment and knowledge production.

Dominant ideological practices which promote ICT and collaboration should be embraced by Nigerian valuers, given its emphasis on innovation and sustainability. NIESV must change its development faculties to ensure technological trends are accessible to Nigerian practising professionals. Furthermore, NIESV must start welcoming professionals with different skillsets into its folds. Collaboration between the NIESV and technology

experts is paramount in preparing the real estate profession for the challenges of the digital journey ahead. As the digital threat to the estate surveying valuation professional grows, the onus is on estate surveyors and valuers in Nigeria to stand up and be counted in terms of technological advancement or lose out to more innovative professionals

6. Conclusion

This study has investigated the need for Nigerian real estate professionals to key into PropTech as a way of bridging the technological gap that may negatively impact real estate practice. This paper looked into factors militating the growth and development of technological advancement, the reasons why most firms could not afford investing in technological development, and the way forward, so that they will not be left behind by their counterparts in developed economies. Although the revolution of PropTech is progressing in European nations, Nigerian appraisers must key into the opportunities that surround the application of such technologies. Professionals in the real estate sector will have to adapt to new technologies sooner or later, and those who embrace change will benefit the most. As with any industry, change is necessary for growth, and those who accept and assimilate PropTech into their current practices stand to gain from it. Whether real estate professionals in Nigeria are ready to key into the prospects of the PropTech industry is yet to be seen, but one thing is certain, the 'PropTech Ship' has set sail, and there is no stopping it.

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The Structure, Conduct and Performance of REITs in Emerging Markets: Empirical Evidence from Nigeria

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Abstract

Purpose: This study examines the correlations between the structure, conduct and performance of Real Estate Investment Trusts in Nigeria (N-REITs) with a view to providing information that will enhance and guide real estate investment decisions on N-REITs.

Design/Approach: The study population consists of all three REIT companies in Nigeria, namely: Skye Shelter Fund, Union Home REIT and UACN Property Development Company (UPDC) REIT. Secondary data on dividends and share prices of N-REITs; Total Business Revenues (TBR) and Total Individual Expenditure (TIE) on conduct variables were sourced from periodicals of the respective companies covering the period from 2008 to 2016. The data series for the study were analyzed by means of the Kwiatkowski-Phillips-Schimidt-Shin (KPSS) unit root tests, Philip-Perron (PP) unit root tests, Granger Causality tests, and the Ordinary Least Square (OLS) regression.

Findings: The study shows a Herfindahl Hischman Index (HHI) that ranged between 41.81% (recorded in 2010) and 100% recorded in 2008. This suggests a high concentration in the N-REITs industry. Similarly, the Granger Causality test conducted reveals a bi-directional causal relationship between the structure, conduct and performance of N-REITs.

Practical Implications: The study provides essential information (on the HHI, return performance and causal relationships) for stakeholders in the real estate sector regarding the influence of structure and conduct on the performance of N-REITs. This information will be valuable for equipping asset managers, insurance companies, pension funds and individual real estate investors in making informed investment decisions.

Originality/Value: This study is unique as it is the first to draw a link between the structure, conduct and performance of REITs in an African emerging real estate market; something that has not been considered in previous studies.

Keywords: Real Estate Investment Trusts; Conduct; Structure; Investment Performance; Real Estate; Nigeria

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1. Introduction

The Structure, Conduct and Performance (SCP) framework was pioneered by Mason (1939) and Bain (1951). It has since become one of the most effective models used in analysis of the causal relationships among the structure, conduct and performance of various industries. The central hypothesis of the model posited that structural characteristics of an industry determines the conduct (behavior) of companies in the industry, which subsequently affects the industry's performance. The model has been modified over time to suit diverse industries and to include variables beyond the purview of Mason and Bain's ideas (Kaonga, 2015). Since its inception, it has been used to analyze industries including, but not limited to; banking, manufacturing, agriculture and real estate, among others.

Real Estate Investment Trusts (REITs) were first introduced in the United States of America in 1960. The purpose of the creation of REITs is to provide opportunities for all categories of investors to enjoy the advantages and benefits of investing in real estate without actually being involved directly in the real estate development process (Naido, 2014). Manoj (2016: p.156) posited that a "*REIT is a trust that pools capital from various investors and uses same to purchase and manage income producing real estate or real estate related assets.*" REITs can be classified into: equity, mortgage and hybrid (Seguin, 2016).

Drew (2016) asserted that REITs have become one of the vital investment vehicles in the economy of many countries. This is shown by the amount of investments in REITs industries across the globe. For example, Aro-Gordon, Bashir, Abdulsalam and Abdullahi (2014), Li and Chow (2015), NAREIT (2018) and NAREIT (2019) revealed that in 2012, REIT market capitalizations for the US was $400 billion; Singapore was $30.5 billion; and Japan was $42 billion (Aro-Gordon et al., 2014). In 2013, the estimated global REITs capitalization was about $1.1 trillion (Li & Chow, 2015). In 2016 the global REITs market capitalization was estimated at over $2 trillion and more recently (2018/2019) it was estimated at over $3 trillion (NAREIT, 2018; NAREIT, 2019). Despite the fact that REITs are said to be one of the viable and profitable investment asset classes in global markets (Jackson, 2008), it has been observed that REITs are underperforming in Nigeria (Akpan & Ogunba, 2015; Dabara et al., 2018). The first Nigerian Real Estate Investment Trust (N-REIT) was introduced by the Skye Shelter Fund in 2007 with an IPO (Initial Public Offering) capitalisation of ₦2 billion ($6,535,948). In 2008, Union Home Hybrid REITs was similarly created with an IPO capitalisation of ₦50 billion ($163,398,623), while the UPDC (UACN Property Development Company) REITs was introduced in 2013 with an IPO capitalisation of ₦30 billion which was estimated at $98,039,216. From the three companies, only the Skye Shelter Fund was able to raise the IPO capitalization that was targeted (₦2 billion), which is equivalent to $6,535,948. Both the Union Home REITs and the UPDC REITs could not raise the total capitalization targeted. The Union Home REITs raised ₦12,500,986,050 ($40,852,896); while the UPDC REITs raised

₦26,682,695,000 ($87,198,350) during their respective IPO's (Skye Shelter Fund, 2007; Union Home REIT, 2008; UPDC REIT, 2013).

In Nigeria, the Security Exchange Commission (SEC) is the regulatory body saddled with the responsibility of regulating the activities in the REITs industry. The operational and regulatory guidelines for N-REITs as stipulated by SEC are: a property requirement which mandates a 75% real estate investments in the N-REITs portfolio; at least 75% of income should be regenerated from real estate or real estate related assets; 90% distribution requirement of taxable profit to unit holders; exemption from tax; management must be overseen by a board of directors or trustees; the company's shares must be fully transferrable and the company should have a minimum of 100 shareholders. N-REITs derives its income from real estate investments that are mostly residential and commercial properties; predominantly in Lagos, Abuja and Port-Harcourt. Real estate plays an integral role in the country's economy. It is Nigeria's fifth biggest contributor to GDP with a contribution of about 6.5% to Nigeria's GDP (Nigerian Bureau of Statistics, 2018; Dabara et al., 2019).

Previous studies, such as Akpan and Ogunba (2015), Olanrele, Said and Daud (2015) and Dabara et al. (2018), revealed that all the N-REITs companies provided low, and in some cases, even negative return values on investment. This has negatively impacted on the N-REITs industry by impeding the growth of the industry and patronage from both domestic and foreign investors. This scenario is quite contrary to what was found in literature on the performance of REITs in other parts of the world (Jackson, 2008; Manoj, 2016). The problem is exacerbated and becomes more perplexing by the fact that the property assets in Nigeria (from which REITs derive their income) are performing well in terms of returns on investment (Dabara, Ogunba & Araloyin, 2015; Dabara & Oyewole, 2015). This is also a true reflection of the performance of real estate in other African countries. For example, a study carried out in South Africa by Ntuli and Akinsomi (2017) revealed that REITs are good return-enhancers and also have diversification benefits in a mixed asset portfolio. Similarly, a study conducted by Olanrele (2014) found that economic factors influence the performance of REITs. Dabara et al. (2018) in a more recent study found that the financial structure of REITs impacts greatly on REITs performance.

Questions have begun to emerge surrounding the possible causes of the underperformance of N-REITs. In order to answer to these questions, it is important that empirical research be carried out which will determine why the performance of N-REITs is contrary to what was found in the literature. Additionally, the research aims to provide insight into the factors causing the poor performance of N-REITs. This is important as Nigeria is largely regarded as one of the fastest growing economies in Africa. Nigeria is also considered as one of the top ten most improved on the Ease of Doing Business ranking across global economies in the world, thereby making it a good playing field for both domestic and foreign investments in the real estate sector (Ankeli et al., 2017). Furthermore, the N-REITs industry is still new with only three REIT companies whose major investments focus is mainly in

commercial and residential properties. Similarly, the fact that N-REITs fall under developing markets is another motivation for this study. However, there is dearth of data on N-REITs to assist investors, hence, this study will add to the scanty existing research work in yet another important African emerging real estate market (Nigeria). The study adapts Bain's (1951) SCP theory as a major initial underpinning to addressing the research problem in this study. The theory purports that there is a one-way causal relationship between the structure (characteristics of an organization e.g. market structure), conduct (the actions or behavior of a firm in the market e.g. advertisement) and performance (the outcome or results obtained from a firm e.g. returns).

This study, which aims at examining the correlations among the structure, conduct and performance of N-REITs, to the best knowledge of the researches, is the first study that draws a link between the structure of the Nigerian REITs industry, its conduct, as well as its performance. This is because the SCP theory postulates that if there are faults in the structure of an industry, this affects the conduct of that industry, which in turn affects the performance of the industry. Hence, this paper attempts to establish the relationship between N-REITs and the SCP paradigm. To the best knowledge of the authors, no study had looked at REITs performance vis-a-vis its structure and conduct. This paper makes a contribution to the REIT literature by extending the frontier of knowledge as it fills this gap. The study examines the following research question: what is the relationship and effect of the REIT industry structure and conduct on REIT performance in Nigeria? The rest of the paper is organized as follows: section two reviews relevant literature; section three presents the methodology adopted for the study; section four presents results and discussion of results while section five presents conclusion of the study.

2. Literature Review

Most of the REIT literature focuses on performance related to inflation hedging, diversification, return/risk, dividend yield and capital gains. Jackson (2008) asserted that REITs are one of the most viable and profitable investment asset classes in global real estate markets. This is evident in the performance of REITs in most developed economies, such as the US, UK, and Germany, among others (NAREIT, 2018). Some developing economies such as Malaysia, Taiwan and Thailand are also doing well. However, REITs in most developing nations, particularly African nations, are still new and characterized by property market immaturity, non-availability of data for investment decisions and challenges of liberalization and integration into the global market (Bekaert, Harvey & Lundblad, 2003; Dabara et al., 2018).

It is obvious that maximizing profits is the objective of rational investors. To achieve this, investors and researchers all over the world are assessing the investment performance of various asset classes. In the real estate sector (specifically REITs), a group of studies have examined the inflation-hedging potentials of REITs. These studies include Kloosterman (2009), Aik (2012) and Dabara et al. (2019). Kloosterman (2009) found some hedging

effectiveness against unexpected inflation for all REITs and Equity REITs in the US. Aik (2012) compared conventional and Islamic REITs performance in Malaysia. Findings from the study revealed that REITs underperformed during and immediately after the global financial crisis experienced around 2008. Dabara et al. (2019) found perverse hedging characteristics associated with investments in N-REITs. Similarly, studies such as Khoipham (2013) examined the investment performance of Asian REITs in a mixed-asset portfolio from 2001 to 2012. Findings from the study indicated that REITs provided strong diversification benefits for the mixed-asset portfolio. This is in agreement with the findings of Naidoo (2014). Another group of studies have evaluated the performance of REITs in terms of their risk/return characteristics. Such studies, including Akpan and Ogunba (2015), revealed that investments in N-REITs were underperforming in terms of total returns, total risk and risk-adjusted return. This is not in agreement with the findings of Niskanen (2012), which asserted that REITs provide good returns on investments. More recently, studies such as Olanrele, Adegunle and Fateye (2018), investigated the correlations between REITs and Money Market Indicators, such as Treasury Bills, among others. The Granger Causality tests conducted in the study revealed an insignificant long-run causal relationship, but a significant short-run causal relationship between N-REITs returns and Money Market Indicators.

A group of studies conducted in South Africa by Akinsomi et al. (2016) investigated the performance of the Broad Based Black Economic Empowerment (BBBEE) of both listed and delisted property firms in South Africa. The study covered the period from 2006 to 2012. The return and risk performance of the property firms were obtained by means of holding period returns formulae, capital asset pricing model, sharpe ratio and alfa, among others. Findings from the study revealed that BBBEE compliant firms outperformed the non-BBBEE compliant firms with respect to both returns and risk performance. Similarly, Akinsomi et al. (2017) revealed that speculation in the gold market has an impact on REIT returns in South Africa, particularly during the global economic meltdown experienced around 2008 to 2011. In the same vein, Ntuli and Akinsomi (2017) found that South African REITs are good return-enhancers with diversification benefits, which could encourage shrewd investors to consider its inclusion in their mixed asset portfolios. Another study conducted in South Africa by Ijasan, Tweneboah and Mensah (2017) showed evidence of anti-persistence in South African REIT returns. With the earlier authors' analysis of performance of REITs, the current study focuses on a new perspective of the SCP paradigm by unravelling the relationship of the structure, conduct and performance in the REIT industry in Nigeria.

Bain (1951) conducted the earliest study on the structure, conduct and performance (SCP) framework. The study examined the relationship between the market structure of manufacturing industries in the US using variables such as buyers and sellers' concentration, level of product differentiation as well as condition of entry/exit from the market and how it relates to the conduct as well as the profit rate of the companies in the industry accordingly. Data for the study covered the period from 1936 to 1940. The methodology

involved the use of both z test and regression analysis. Findings from the study indicated that firms/industries with higher levels of concentration (above 70%) recorded higher profits. Ferguson (1998) argued that the Bain's theory has some limitations, which borders on the complexities associated with firms and industries. Hence, the author is of the opinion that the SCP framework could be linked to other factors rather than restricting it to only structure, conduct and performance. To buttress this assertion, Matyjas (2014) posited that the SCP paradigm can be modified to go beyond the scope of structure, conduct and performance variables, and could also include other variables such as government policies and other basic conditions including location and technology. This was in agreement with an earlier studies conducted by Porter (1981).

Delorme et al. (2002) examined the correlations between structure, conduct and performance of manufacturing industries in the US in 1982, 1987 and 1992. The study found that the conduct of the manufacturing industry in the study area (proxied by advertising) do not influence the profitability in the industry. Tung et al. (2010) examined the performance of the tourist hotel industry in Taiwan using the SCP paradigm. Data was obtained to cover a period spanning 1995 to 2006. Findings from the study revealed that the profitability or performance of the the hotel industry in the study area was significantly influenced by the market structure of the industry. The paper focused on only direct investment in real estate (hotels) and did not consider investment in indirect real estate, such as REITs.

For the application of the SCP framework in real estate in Nigeria, Ogunba (2004) examined the conduct of valuation exercises in Nigeria using Bain's (1951) SCP model which was subsequently modified. The study proxied conduct of valuation exercises using variables relating to the valuer's use of investment valuation inputs and some unconventional manipulations of data amongst valuers. The methodology adopted in the study used descriptive statistical tools, such as mean, percentages, and charts in analyzing the data. Findings from the study revealed that valuation inaccuracy, which was observed to exist in the study area, arises due to the way the valuation exercises were conducted in the valuation profession. The results showed that the conduct of valuation exercise in the study area was characterized by non-uniformity of valuation inputs used by valuers as well as the observable practice of valuers resorting to unconventional manipulation of data. This result aligns with Chan, Erickson, and Wang (2003) in a similar study that investigated the structure, performance and investment opportunities in the REITs industry. Lee (2012) evaluated the performance of accounting firms (a service industry) in Taiwan from 1992 to 2003 using the SCP model. The study used the stepwise regression model in the analysis of the data obtained for the study. Findings from the study revealed that there was a significant relationship between market structure, conduct and performance of accounting firms in the study area. Nabieu (2013) analyzed the structure, conduct and performance of commercial banks in Ghana over a period from 2007 to 2012 using the SCP model. Both descriptive (mean, percentages, standard deviations) and inferential (regression) statistical models were used in the study. Findings from the study suggested that market structure and

conduct significantly determined the performance of commercial banks in Ghana within the study period. This is congruent with a similar study conducted by Gavurova, Kocisova and Kotaskova (2017), which examined the structure and performance of European Union (EU) banking markets using the SCP paradigm. The main problem or gap observed from these studies is the dearth of studies in African real estate markets that look at the performance of REITs from the perspective of the conduct, structure and performance of REIT companies. Therefore, this present study will extend the frontier of knowledge in this field by considering the correlations among the structure, conduct and performance of N-REITs.

3. Methodology

To interpret the SCP model, Bain (1951: p.304) defined structure as "*characteristics of an organization which seems to influence strategically on the nature of competition and pricing within a particular market*". Ray (1992: p.68) on the other hand, explained that in the SCP model "*structure represents a firm's internal characteristics which include: market share, entry barriers of new firms and number of buyers and sellers (i.e. concentration)".* The structure of a firm or industry is found by its Herfindahl-Hirschman Index (HHI). This is obtained by calculating the firm's individual market share (using the Total Business Revenue data i.e TBR) which is subsequently translated into its concentration ratio and finally calculated as the HHI. The concentration ratio is usually calculated from census data which shows market shares of the said firms. The firm concentration ratio is calculated by the addition of the market shares of the nth largest firms found in the same market. While the HHI is calculated as the addition of the squares of the percentage market shares of the firms within a market (Scherer & Ross, 1990; Matyjas, 2014).

In line with previous studies such as Kaonga (2015), the market structure for this study was obtained by using the total business revenues obtained by each of the N-REITs companies over the study period to calculate the market shares of the respective companies. These were subsequently translated to the concentration ratio of the N-REITs industry and the HHI which shows the type of market structure of the industry. Studies, such as Abdul Majid and Sufian (2007) and Bhandari (2010), posited that the major market structure types comprise of: perfect competition[1]; monopoly[2]; oligopoly[3]; and monopolistic competition[4].

Tung et al. (2010) posited that in the SCP analysis, conduct is measured by any activity undertaken by a company or firm to improve its performance,

[1] characterized by many buyers and sellers, identical products, no price regulation in the market, free entry and exit in the market and sellers and buyers having adequate information about the product

[2] characterized by only one seller or producer, no substitutes for product, restriction to entry into the market and the seller or producer have complete control over price of the product

[3] characterized by only few sellers or producers, similar or identical products, the market is very difficult for other producers to enter and firms are mutually dependent

[4] characterized by large number of buyers and sellers, product differentiation, and free entry and exit of firms

such as: advertisement, innovations, marketing strategies, research and development, etc. This study used relevant conduct variables in the N-REITs industry that have available data for analysis. These include: advertisement, property maintenance, insurance of properties, and administrative expenses. In this study, advertisement is defined as private or public notices which are designed to inform and motivate the buying behavior of the recipient by the advertisers to persuade the former to make decisions or take actions that the latter desired. This can be by means of television, radio, telephone, text messages, bill boards, etc. (Macarena & Davide, 2014). Property maintenance involves overall upkeep of landed properties which may include specific or general repairs, installation of fixtures, etc. Property insurance is a policy that provides financial reimbursement to the owner or renter of a structure and its contents in the event of damage (Surminski, 2014). While administrative expenses in this study includes all expenses incurred by the company that are vital to the company's success as well as impacting positively on the performance of the company. These include: management fee, AGM (Annual General Meeting) expenses, sitting allowance, professional fees (auditors, lawyers, valuers, etc.), bank charges, subscriptions and donations, travelling expenses, etc. In line with studies such as Dabara (2015) and Akpan and Ogunba (2015), the performance component of this study was measured using the holding period returns. The holding period return captures both changes in dividends and capital growth of the investment asset in question. For this study, holding period return= capital growth of share prices (capital return) + income return.

The study population consists of all the REITs in Nigeria, namely: Skye Shelter Fund REIT, Union Home REIT and UPDC REIT. Data required for the structure of N-REITs comprised of the Total Business Revenue (TBR) of the N-REIT companies within the study period (2008 to 2016). This data was sourced from the annual reports and accounts of the respective N-REITs. Data required for the conduct component of N-REITs comprised the Total Individual Expenditure (TIE) on conduct variables proxied by factors, such as: advertisement, maintenance of properties, insurance of properties and administrative expenses. This data was also sourced from the annual reports and accounts of the respective N-REITs for the study period. Data required for the performance of N-REITs comprised of dividend and growth in share prices of the respective companies.

Descriptive and inferential statistical tools, such as: averages, frequencies, mean scores, as well as Ordinary Least Square (OLS) regressions were used in analyzing the data obtained. The structure of the N-REITs industry was analyzed by means of Equations 1, 2 and 3 in a chronological order. That is, the market structure of a company which is proxied by the HHI in line with previous studies such as Tung et al. (2010) and Kaonga (2015) was calculated accordingly by firstly obtaining the market share using Equation 1. Secondly, the market share was used to obtain the Concentration Ratio using Equation 2; and finally, the market structure of the company was obtained using the Concentration ratio to calculate the HHI by means of Equation 3. The Market Share is given as:

$$MKS = \frac{TBR\ (n1)}{TBR\ (n1+n2+n3)} \quad (1)$$

Where:
MKS = Market share
TBR = Total business revenue for a particular REITs company
n1, n2, n3 = Individual N-REITs companies

The Concentration Ratio is given as:

$$CR_n = MKS_1 + MKS_2 + MKS_3 \quad (2)$$

Where:
CR_n = Concentration ratio of N-REITs companies
MKS_{1-3} = Market share of individual N-REITs companies

The Herfindahl-Hirschman Index is given as:

$$HHI = \sum_{i=1}^{n} (MKSi)^2 \quad (3)$$

Where:
HHI = Herfindahl-Hirschman Index
MKSi = Market share of the ith N-REITs company
n = Total number of N-REITs companies
i = The ith N-REITs company (e.g. UPDC REITs)

According to Kwoka (2007), the HHI ranges from 1/N to one, where N is the number of companies in the market or industry. If percentages are used as whole numbers (for example: 85 instead of 0.85), the HHI index can range up to 100^2, or 10,000. The decision rule is that an HHI below 0.01 (or 100) indicates a highly competitive industry. An HHI below 0.15 (or 1,500) indicates unconcentrated industry; an HHI between 0.15 and 0.25 (or 1,500 to 2,500) indicates moderate concentration, while an HHI above 0.25 (above 2,500) indicates high concentration.

The data required for conduct variables consisted of data on the companies' conduct or style of operation in the capital market which was proxied by factors such as advertisement, property maintenance, insurance of properties, and administrative expenses of the 3 N-REIT companies for the study period. The TIE and TBR for the N-REIT companies were used to calculate the conduct indicators using Equation 4. This is congruent with previous studies such as Kambhampati (1996) and Bhattacharya (1997). The conduct equation used is as follows:

$$Xn = \frac{\text{TIE}}{\text{TBR}} \quad (4)$$

Where:
Xn = Individual Conduct Indicator (e.g. advertisement)
TIE = Total Individual Indicator's expenditure
TBR = Total REITs Company' Business Revenue for individual REITs company

Similarly, the researchers used Equation 5 to measure the holding period return of the N-REIT companies. The holding period returns is expressed as:

$$HPR_t = \frac{NIt + (CV_t - CV_{t-1})}{CV_{t-1}} \quad (5)$$

Where:
HPR_t = Holding Period Return
CV_{t-1} = Share price of N-REITs at the beginning
CV_t = Share price of N-REITs at the end
NI_t = Income (Dividend) of N-REITs received during the holding period

Furthermore, the researchers analyzed the correlations among the structure, conduct and performance of N-REITs. To realize this first, unit root test (test of stationarity) of the datasets used in the study was carried out using the Kwiatkowski-Phillips-Schmidt-Schin (KPSS) as well as the Philip-Perron (PP) models for analyzing the stationarity characteristics of the data series. Second, the Granger Causality analysis was conducted to determine the causal relationships among the structure, conduct and performance of N-REITs within the study period. Third, the relationships among the structure, conduct and performance of N-REITs in line with previous studies on the SCP concept, such as Tung et al. (2010) and Kaonga (2015), was determined using OLS regression models.

Decision rule for stationarity test:
If KPSS Statistics > KPSS critical value, do not reject null hypothesis, i.e., unit root exists (non-stationary).
If KPSS Statistics < KPSS critical value, reject null hypothesis, i.e., unit root does not exist (stationary).
If PP Statistics > PP critical value, do not reject null hypothesis, i.e., unit root exists (non-stationary).
If PP Statistics < PP critical value, reject null hypothesis, i.e., unit root does not exist (stationary).

Decision rule for Granger Causality tests:
If P-Value > 0.05, do not reject the null hypothesis of no Granger Causality (there is no causal relationship).
If P-Value < 0.05, reject the null hypothesis of no Granger Causality (there is a causal relationship).

In line with previous studies, such as: Delorme et al. (2002); Tung et al. (2010); Nabieu (2013); and Kaonga (2015), the model specification for the regression model adapted for endogenous variables of Structure (STR), Conduct (CON) and Performance (PER) in this study is given as follows:

$$STR = f(CON, PER) \quad (6)$$
$$CON = f(STR, PER) \quad (7)$$
$$PER = f(STR, CON) \quad (8)$$
$$STR = a_0 + b_1CON + b_2PER + e_1 \quad (9)$$

Where:
STR= Structure of N-REITs
a_0= The intercept
b_1= Conduct
b_2= Performance
e_1= The error term

$$CON = a_0 + c_1 STR + c_2 PER + e_2 \quad (10)$$

Where:
CON = Conduct of N-REITs
a_0 = The intercept
c_1 = Structure
c_2 = Performance
e_2 = The error term

$$PER = a_0 + d_1 CON + d_2 STR + e_3 \quad (11)$$

Where:
PER= Performance of N-REITs
a_0= The intercept
d_1 = Conduct
d_2= Structure
e_3= The error term

4. Results and Discussion

This section presents and analyzes the data collected for the study. Table 1 presents the TBR for the N-REIT industry.

Table 1 presents the annual TBR for the N-REIT industry which was calculated as the summation of the annual revenues of the three N-REIT companies for each investment year accordingly. Similarly, the total share units subscribed and fully paid for by investors was presented in Table 1.

From Table 1, the highest TBR for the N-REIT industry was obtained in the year 2015 (₦6,907,443,855 i.e $22,573,345). The least TBR for the industry was obtained in 2008 (₦594,417,008 i.e $1,942,539). This could be attributed to the economic recession experienced in the country around that period. There was a gradual decrease in TBR generated from 2009 to 2011 (this was the period of the global economic meltdown). In 2012 there was a slight increase which was sustained in 2013 (at this time there was an improvement in the economy). The TBR generated by the N-REITs industry within the study period seemed to be very small when compared to REIT industries of other nations such as the UK and Germany, which started their REIT industry the same year as Nigeria (that is in 2007). This could be attributable to the level of acceptability of REITs by investors in these countries as well as variation in the stability and strength of the economy of these nations as noted in a similar study by Olanrele et al. (2015).

Table 1: Total Business Revenues (TBR) of the N-REITs industry

Year	N-REITs Annual TBR		Number of Share Units
	₦	$	
2008	₦594,417,008	$1,942,539	20,000,000
2009	₦1,918,470,009	$6,269,509	270,019,781
2010	₦1,000,829,010	$3,270,683	270,019,781
2011	₦1,145,809,971	$3,744,477	270,019,781
2012	₦1,274,980,353	$4,166,602	270,019,781
2013	₦1,102,936,216	$3,604,366	270,019,781

2014	₦6,852,999,381	$22,395,422	2,938,289,281
2015	₦6,907,443,855	$22,573,345	2,938,289,281
2016	₦6,819,902,942	$22,287,264	2,938,289,281
Mean	**₦3,068,643,194**	**$10,028,245**	**1,131,662,972**

Source: Annual reports/statement of accounts and online database of Skye Shelter Fund, Union Homes REIT and UPDC REIT.

Note: The figures in parenthesis are the USD equivalent of the TBR within the study period ($1 to ₦306 at Central Bank of Nigeria' official exchange rate).

Table 2 presents the TIE on the conduct variables in the N-REITs industry within the study period. There was a sharp consistent decrease in the amount expended on advertisement from 2009 to 2015. The highest amount expended was in 2009 (9.7%) of the TBR; while the lowest was in 2011 (0.02%). There was some level of fluctuations in the amount expended on maintenance of properties in the N-REITs. The highest amount expended was in 2013 (4.83%) while the least was in 2011 (0.1%). There was a gradual but consistent increase in the amount expended on insurance of properties between 2009 and 2012; however in 2012 there was a gradual decrease until 2015. The highest amount expended was 2.64% in 2014, while the least expended within the study period was 0.54% in 2015. Administrative expenditure had the highest amount expended when compared to other variables. There was a consistent increase from 2008 to 2010, the figures decreased in 2011 and the decrease kept on till 2014. The highest amount expended on administrative expenditure was 28.6% in 2010, while the least was 13.41% in 2015. The mean percentage expenditure for advertisement, maintenance of properties, insurance of properties and administrative expenses were 1.2%, 1.7%, 1.3% and 20.0% respectively. Studies, such as Niskanen (2012) and Kaonga (2015), indicated that higher percentages of the companies' TBR were used in conduct activities. This implies that there may be need for Nigerian REITs to increase the amount expended on operation of conduct indicators. The data on Table 2 was used in analyzing the conduct of N-REITs using Equation 4.

Table 2: Total Individual Expenditure (TIE) in Percentage on Conduct Indicators in the N-REITs Industry

Year	ADV	MP	IP	ADM	TOTAL
2008	0	0	0	13.94	**13.94**
2009	9.74	0	0.74	15.14	**25.62**
2010	0.36	2.33	0.88	28.6	**32.17**
2011	0.02	0.1	0.81	25.39	**26.32**
2012	0	2.23	2.26	23.06	**27.55**
2013	0	4.83	1.45	20.85	**27.13**
2014	0.59	3.37	2.64	24.62	**31.22**
2015	0	0.8	0.54	13.41	**14.75**
2016	0.87	1.64	1.92	14.89	**15.07**
Mean	**1.2**	**1.7**	**1.3**	**20.0**	**23.8**

Source: Analyses of survey data, 2017

Note: ADV = Advertisement, MP = Maintenance of Properties, IP = Insuring of Properties, ADM = Administrative expenses

Table 3 presents data on the annual dividend and share prices of N-REITs covering a period from 2007 to 2016. From inception in 2007 to 2016, Skye Shelter Fund's share prices ranged between ₦98.55 ($0.322) and ₦117.42 ($0.384) per share unit; and its dividend ranged between ₦4.04 ($0.013) and ₦7.15 ($0.023) per share unit. The share prices of the Union Homes REIT ranged between ₦45.55 ($0.149) and ₦50.00 ($0.163) per share unit within the study period. While its dividend ranged between ₦0.75 ($0.003) and ₦4.01 ($0.013) per share unit. The UPDC REIT sold shares from ₦9.50 ($0.031) to ₦10.00 ($0.033) per share unit from 2013 to 2016; with dividend payout that ranged between ₦0.23 ($0.001) and ₦0.43 ($0.001) per share unit within the same investment period. The share prices and dividend of N-REITs is considered low when compared to other global REITs companies (Jackson, 2008; Naido, 2014). The share prices and dividends presented in Table 3 were used to calculate the performance of N-REITs (holding period returns) and the results are presented in Table 4.

Table 3: Annual Data on Dividend and Share Prices of N-REITs (in Naira) Companies from 2007 to 2016

Year	Skye Shelter Fund		Union Homes REIT		UPDC REIT		N-REITs	N-REITs
	Share	Dividend	Share	Dividend	Share	Dividend	Share	Dividend
2007	100	0	-	-	-	-	100	0 (0)
2008	117.42	4.65	50.00	-	-	-	167.42	4.65
2009	103.21	7.00	50.00	4.01	-	-	153.21	11.01
2010	99.55	6.40	50.85	0.75	-	-	150.4	7.15
2011	98.55	4.04	50.00	2.27	-	-	148.55	6.31
2012	100	5.00	50.00	2.13	-	-	150	7.13
2013	100	5.25	50.00	-	10.00	-	160	15.25
2014	98.56	5.80	48.54	-	9.50	0.31	156.6	6.11
2015	100	7.15	45.55	-	9.78	0.43	155.33	7.58
2016	100	5.3	50.00	-	10.00	0.23	160	0.23

Source: Annual report and online data bases of Skye Shelter Fund, Union Homes REIT and UPDC REIT.

Note: The figures in parenthesis are the USD equivalent of the TBR within the study period ($1 to ₦306 at Central Bank of Nigeria' official exchange rate).

Table 4 shows that, from the inception of the N-REITs companies up until 2016, the HHI of the N-REITs industry ranged between 41.81% (recorded in 2010) and 100% recorded in 2008. This indicates a high concentration in the N-REITs industry which is characteristic of an oligopolistic market structure. In comparison, the US has over two hundred REIT companies operating in a perfectly competitive market structure. Similar REIT industries include the UK, Australia and Malaysia which have about 22, 52 and 15 REITs respectively (NAREIT, 2018). From Table 4 the highest amount expended on conduct indicators was 32.17% in the year 2010; while the lowest was in 2015, with 0.02%. There was some level of fluctuations in the amount expended on the conduct variables over the years. The highest amount expended was in 2013 (4.83%), while the least was in 2011 (14.75%). This could be attributable to the national economic recession experienced in

Nigeria at this time. The performance of N-REITs in terms of holding period returns was observed to have fluctuated between -0.24% and 22.07%. The highest return value recorded was 22.07%, obtained in 2008. The least return value was recorded in 2014 (-0.24%), and the mean value within the study period was 4.7%. This is rather small when compared to other investment assets in Nigeria. For example, the 3 month's Treasury Bills provides a return of 8.5% and return on cash ranges between 4.5% and 10.5%. Olanrele et al. (2018), in a study carried out to determine the causal relationship between N-REITs dividend yield and Money Market Indicators (MMI) such as T-Bills and Currency in Circulation (CIC) found a short-run causal relationship between N-REITs dividend yield and MMI.

Table 4: Data on the Structure, Conduct and Performance of N-REITs Industry

Year	N-REIT Structure	N-REIT Conduct	N-REIT Performance
2008	100	13.94	22.07
2009	63.8	25.62	0.94
2010	41.81	32.17	2.93
2011	69.35	26.32	2.93
2012	68.83	27.55	5.4
2013	64.12	27.13	2.63
2014	70.69	31.22	-0.24
2015	67.97	14.75	2.86
2016	68.94	16.98	2.93
Mean	68.39	23.9	4.7

Source: Analysis of survey data, 2017

Table 5 presents the descriptive statistics of the structure, conduct and performance variables of the N-REITs industry. It shows the mean, minimum and maximum values of the variables. It also shows the standard deviation, skewness and kurtosis for each of the variables. Table 6 presents the Granger Causality test for the structure, conduct and performance of N-REITs.

Table 5: Descriptive Statistics of the Structure, Conduct and Performance Variables of N-REITs Industry

Statistics	N-REIT Structure	N-REIT Conduct	N-REIT Performance
Mean	68.39	23.96	4.7
Std. Deviation	14.80	6.94	6.7
Skewness	-1.3	-1	0.7
Kurtosis	0.3	-1	1.7
Minimum	41.81	13.94	-0.24
Maximum	100	32.17	22.07

Source: Analysis of survey data, 2017

The computed KPSS and PP test-statistics as seen in Table 6 are integrated of order I(0). It was observed that the KPSS and PP statistics were smaller

than the critical values - "tau" at 10%, 5%, and 1% significance levels respectively. Therefore we can reject Ho for the SCP variables. This means that the data series are all stationary series at 10%, 5% and 1% significance levels and are integrated of order I(0) at level. In order to analyze the relationships among the structure, conduct and performance of N-REITs; Equations 9, 10 and 11 were used in line with previous studies such as Zietz, Sirmans and Friday (2003), Tung et al, (2010) and Kaonga (2015). The results are presented in Table 8.

Table 6: KPSS and PP Unit Root Test on Data for the Structure, Conduct and Performance of N-REITs

SCP Variables	KPSS Statistics	1% Critical Value	5% Critical Value	10% Critical Value	PP Statistics	1% Critical Value	5% Critical Value	10% Critical Value
N-REIT Structure	0.225299*	0.739	0.463	0.347	-4.2413*	-4.18265	-3.32097	-2.80138
N-REIT Conduct	0.202396*	0.739	0.463	0.347	-3.8771*	-5.60462	-3.69485	-2.98281
N-REIT Performance	0.346833*	0.739	0.463	0.347	-12.523*	-4.58265	-3.32097	-2.80138

Source: Analysis of survey data, 2017
*Note: *= Stationary at level*

Table 7 presents the results of the Granger Causality tests of the N-REITs industry, and Figure 1 shows the causal relationships among the structure, conduct and performance of N-REITs. The results obtained indicated a bi-directional Granger Causality for the N-REITs industry. This implies that there is a two-way positive relationship existing among the structure, conduct and performance of N-REITs. This means that the structure of N-REITs affects both the conduct (with P-value as 0.0244) and performance (with P-value as 0.0073) of the N-REITs industry. Similarly, the conduct of N-REITs also affects both the structure (with P-value as 0.0480) and performance (with P-value as 0.0045) of the N-REITs industry. By the same token, the performance of the N-REITs also affected the structure (with P-value as 0.0372) and conduct (with P-value as 0.0078) of the N-REITs industry. This is congruent with what was found in literature as confirmed by studies such as Porter (1981) and Mu'azu et al. (2013) which posited that the SCP concept has a reverse causal relationship referred to as 'feedback'. However, this refutes the hypothesis postulated by Bain (1951).

Table 7: Granger Causality Tests for Structure, Conduct and Performance Components of N-REITs industry

Null Hypothesis:	F-Statistic	P-Value
N_REIT_PERF does not Granger Cause N_REIT_COND	0.65565	0.0078
N_REIT_COND does not Granger Cause N_REIT_PERF	0.01585	0.0045
N_REIT_STRU does not Granger Cause N_REIT_COND	4.24982	0.0244
N_REIT_COND does not Granger Cause N_REIT_STRU	7.63015	0.0480
N_REIT_STRU does not Granger Cause N_REIT_PERF	0.23871	0.0073
N_REIT_PERF does not Granger Cause N_REIT_STRU	1.79972	0.0372

Source: Analysis of survey data, 2017

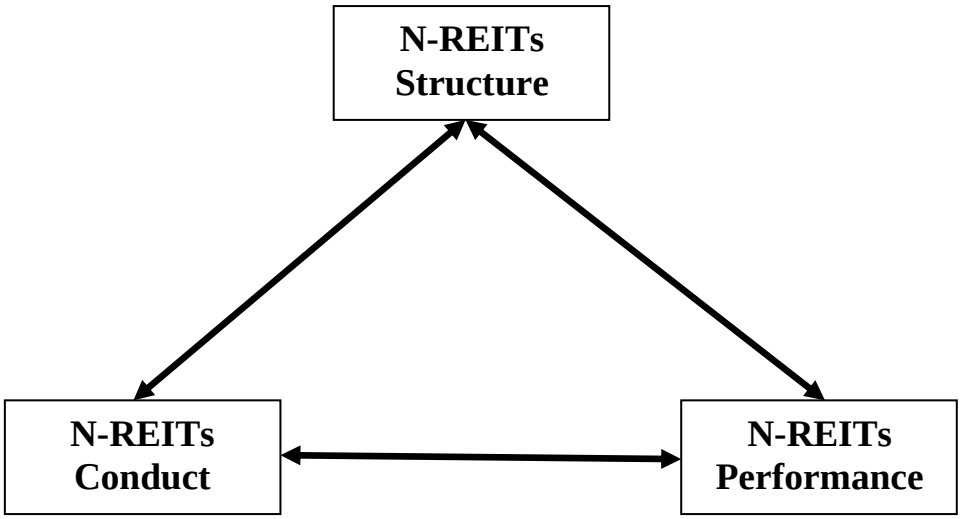

Figure 1: Bi-directional Causality Relationships among the Structure, Conduct and Performance of N-REITs.

Table 8 shows the regression analysis of the structure, conduct and performance of N-REITs. When the structure component of the SCP was used as a dependent variable, the regression results indicated a strong positive correlation of 0.753 between all the variables, with a coefficient of determination (R^2) of 0.567 meaning that the model explains 56.7% of the variance in the dependent variable by the independent variables in the N-REITs industry. Looking at the significance values of the individual β's, it was revealed that all the predictors, i.e. performance and conduct, significantly predicted the structure of N-REITs with t=2.312; p=0.045<0.05; and t=0.147; p=0.008<0.01 respectively. Hence they are statistically significant (note that 0.05 and 0.01 above indicates the significance levels at 5% and 10% respectively).

When conduct was used as the dependent variable and structure and performance as the independent variables, the regression result indicated a strong positive correlation of 0.817 between all the variables, with a coefficient of determination (R^2) of 0.667. The beta coefficients of the individual β's showed that all the predictors significantly predicted the conduct of N-REITs with t=-1.352; p=0.025<0.05; and t=2.312; p=0.045<0.05 respectively. Hence they are statistically significant at both 5% and 10% level of significance.

When performance was used as the dependent variable and structure and conduct as the independent variables, results from the regression analysis indicated a positive correlation of 0.611 between all the variables, with a coefficient of determination (R^2) of 0.373. From the significance values of the individual β's, it was shown that both structure and conduct significantly predicted the performance of N-REITs with t=0.147; p=0.008<0.01;and t=-1.352; p=0.025<0.05 respectively. Hence they are statistically significant at both 5% and 10% level of significance accordingly.

From the analysis above, it is evident that there exists a strong positive relationship among the structure, conduct and performance of N-REITs. This finding is congruent with other similar studies in the real estate industry such as, Chan et al. (2003), Ogunba (2004) and Tung et al. (2010). The implication of this for the REITs industry is the need to ensure that the respective REIT companies are properly structured and conduct activities given priority to enhance performance, as the study revealed that both structure and conduct influence performance and vise-versa. This information can be used by stakeholders in the real estate industry such as pension funds, asset managers, individual investors and insurance companies in making informed investment decisions.

Table 8: Regression Analysis of the Structure, Conduct and Performance of N-REITs Industry

Dependent	Independent Variables	R	R_2	Beta	T	P-Value	Level of
N-REITs Structure		0.753	0.567				
	N-REITs Conduct			2.67	2.312	0.045	0.05
	N-REITs Performance			0.355	0.147	0.008	0.01
N-REITs Conduct		0.817	0.667				
	N-REITs Structure			0.176	2.312	0.045	0.05
	N-REITs Performance			-0.736	1.352	0.025	0.05
N-REITs Performance		0.611	0.373				
	N-REITs Structure			0.01	0.147	0.008	0.01
	N-REITs Conduct			-0.317	-1.352	0.025	0.05

Source: Analysis of survey data, 2017

5. Conclusion

This study used Bain's Structure, Conduct and Performance (SCP) model to examine N-REITs and found a positive significant and bi-directional causal relationship among the structure, conduct and performance of REITs in Nigeria. This is congruent with what was found in the literature as confirmed by studies such as Ogunba (2004) and Mu'azu et al. (2013). However, this disagrees with the hypothesis postulated by Bain (1951) which purports that there is a one-way causal relationship between the structure, conduct and performance of firms/industries. The implication of this result to the N-REITs industry is that to improve the performance of the industry the respective companies in the industry must be properly structured. Similarly, conduct indicators, such as advertisement, should be given priority. The study also provides essential information for stakeholders in the real estate sector regarding the influence of structure and conduct on the performance of N-REITs. This information will be valuable for equipping asset managers, insurance companies, pension funds as well as individual real estate investors in making informed investment decisions.

This is also congruent with findings of previous studies such as Tung et al. (2010), Nabieu (2013) and Kaonga (2015). The study concluded that the below optimal performance of N-REITs was traced to the deficiencies inherent in the internal factors impacting on the N-REITs industry as it relates

to the structure and conduct in the N-REITs industry. This suggests that there is a need to improve in the aforementioned areas. This is pertinent because the study revealed that there is a strong positive bi-directional relationship among the structure, conduct and performance of N-REITs. The study is limited by the number of observations used with respect to the available data. This is because REITs are still new in Nigeria when compared to other REITs industries such as the US and hence provided limited data from inception to date. Data covering a longer period of time could present a better picture of the REITs industry in Nigeria.

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