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Property Supply, Economic Factors and House Prices in Nairobi Kenya

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Abstract

Residential real estate is an important asset class for both institutional and individual investors. The housing bubble in the US led to a global financial crisis in 2007 – 2008. As such, understanding the factors that influence property prices is central to the investment process and portfolio management. The objective of the paper was to first construct a Nairobi house price index and then determine the relationship among economic factors, property supply, and house prices. The study period was ten years (2011 Q1 to 2020 Q4). Autoregressive Distributed Lag (ARDL) model was adopted to estimate long-run and short-run relationships. The Nairobi real estate price index was developed using a hedonic model based on the data collected on actual selling prices and characteristics of a sample of houses in Nairobi spanning ten years. The paper finds that GDP and inflation have significant positive long-run effects on house prices. Property supply has a significant negative long-run effect on real estate prices. However, interest rates do not have a significant effect on house prices. In the short run, however, GDP had a significant negative effect on prices. The speed of adjustments towards the equilibrium relationship was 71.9%. The real estate market seems to be efficient despite its illiquid nature. The paper contributes to knowledge by including property supply, a departure from past studies. The findings may have implications for investors, banks, regulators of securities and policymakers. The government of Kenya may be motivated to commission an official house price index.

Keywords: *ARDL, ECM, Cointegration, Hedonic*

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1. Introduction

Real estate price is an important variable central to the investment process. Investors use prices to make investment decisions including buying or selling. Family-owned houses constitute a major part of household wealth. Many factors may influence house prices. Such factors may include economic factors, property characteristics, and property supply. Economic factors are likely to influence demand for houses thus affecting prices. Household income is an indicator of the ability to pay and may therefore affect property prices (Cameron, Muellbauer & Murphy, 2006). The GDP growth rate is expected to affect positively housing prices due to increased economic activity and demand. Inflation tends to have mixed effects (Zhou, 2021, Kibunyi et al., 2017; Quan 1999). An increase in interest rates may reduce house prices due to increased discount rates used in valuation. High interest rates may also slow down new supply and if demand does not fall, prices may surge. Therefore, the effect of interest rates on property prices may be uncertain. The effect of economic factors on prices may be dependent on the state of property supply in the market. Increased demand with constrained supply is likely to increase property prices (Paradkar, 2013). Property supply has been measured using building permits, approved building plans, new units completed, and financing costs amongst others (Sorina, 2014; Breedon & Joyce, 1993). The availability of financing affects the supply of properties in the market and in turn the real estate price. The relationship between these individual factors on residential real estate prices and the interplay amongst them in price determination may be significant to different parties that monitor residential real estate prices.

The valuation and pricing models have evolved all working toward robust models. The different approaches include the traditional valuation methods in finance such as discounted cash flow (DCF) techniques. Others include hedonic pricing models (Zhou, 2021; Sirmans, Macpherson & Zietz, 2005). Repeat sales models are based on the prices of houses that have been sold more than once which is an attractive way of monitoring price changes (Case & Shiller, 1990). On the other hand, atheoretical models attempt to predict prices by leveraging the statistical properties of time series data (Al-Marwani, 2014; Keith, 2007). Hedonic models and repeat sales models are useful in the development of house price indices that track prices. Most markets globally have developed housing price indices that track the market prices (Al-Marwani, 2014). The market is inherently heterogeneous and illiquid hence there are no quick gains in a unified pricing model.

This study focuses on the residential market in Nairobi. Nairobi is the capital city of the Republic of Kenya. Non-residential market in Nairobi accounts on average for 15% of new developments both in units and value while residential is 85% (Kenya National Bureau of Statistics, 2020). The significant size of the residential market explains the need for this study. Over the last ten years (2010 Q2 – 2020 Q1) the average house prices have gone up by about 70% and rent by 73% (HassConsult, 2020). Nairobi is a renters' market with about 90.7% of households renting (Kenya National Bureau of Statistics, 2019). Individual investors provide 87% of rental houses and 5% by the government. Therefore, the Nairobi market is dominated by individual real estate investors with the government as a small player. However, the government is leading the way in the affordable housing market where 500,000 houses are set to be built (Amwayi, 2018). The house prices in relation to the current market structure that is a private investor driven juxtaposed with intervention by the government on the affordable segment are unclear to investors. It is still not clear in literature how the confluence of all these fundamental factors affects house prices.

Investors' returns namely rental yield and capital gains are predicated on changes in house prices. However, there are problems relating to how these prices are characterised in the first place and secondly the understanding of their determinants. Specifically, previous studies in Nairobi have been based mainly on asking prices and indices that use median or average house prices (Mwololo, 2014; Makena, 2012). The resulting price changes do not account for the changing characteristics of houses. The paper addresses this gap by adopting the hedonic model to estimate pure price changes based on actual transaction prices controlling for house characteristics. It is these characteristics-adjusted prices, developed into a price index that is used to determine relationships with other key house price drivers such as economic factors and property supply. In the process enriching the empirical evidence.

Capozza, Hendershott and Mack (2004) assert that property markets are dynamic, and the pricing models and determinants are unique to specific markets. The market products are heterogeneous. There are contradicting findings on the effect of inflation with certain studies indicating positive while others negative effects (Zhou, 2021, Kibunyi et al., 2017; Quan 1999). Several studies have been done in Kenya on factors affecting house prices. Kibunyi et. al. (2017) found economic factors, except inflation to be positively related to real estate prices. Mwololo (2014) examined the relationship between lending rates and residential real estate prices while Makena (2012) studied economic factors and house prices in Nairobi. Past local

studies have not focused on the interplay of economic factors and property supply in influencing house prices. The focus has been mainly on economic factors which may not adequately explain price changes. The infusion of supply in the pricing model may increase, cancel out or reduce the effect of economic factors on house prices. This is important to investors keen on maximising real estate returns. Regulators and governments are also interested in understanding policy implications for the real estate market. Governments are likely to intervene on the property supply side to address socioeconomic issues such as affordable housing. The paper has two objectives. The first is to construct a Nairobi house price index using a hedonic model that operationalises house prices. The second objective is to determine the effect of property supply and economic factors on house prices.

The findings of the study will benefit theory, practice, and policy formulation. The empirical findings of this study will contribute to the body of knowledge on determinants of housing prices beyond the current state of play. The outcome of this study will help practitioners and investors when making investment decisions and in portfolio management. Policymakers and regulators in National and Local governments may also benefit from the study.

2. Literature review

2.1.Theoretical Framework

The study was anchored on broad theories that can be used to explain the changes in house prices. These include the hedonic model, stock-flow model, efficient market hypothesis (EMH), financial accelerator mechanism and life-cycle theory of savings. The hedonic pricing model provides a framework for pricing property characteristics such as size, house type, location, green space, presence of basement, and availability of amenities. It helps in controlling for quality bias in property pricing. The hedonic models were first developed by Lancaster (1966) and thereafter Kain and Quigley (1970) were the pioneers in applying to real estate. In their study, they included neighbourhood characteristics and distance to downtown. Sirmans, Macpherson and Zietz (2005) reviewed several studies that used a hedonic model in pricing houses and found mixed findings on how house characteristics affect house prices in different contexts. This paper leverages on hedonic model in operationalising house prices.

There are other approaches to developing real estate price indices besides hedonic (Hill, 2011). Firstly, a price index may be constructed using the average or median house prices of a sample of houses in a certain period relative to a previous or base period. This is simple to implement. However, it fails to account for changing quality characteristics of the properties. Secondly,

repeat sales methods are used to develop house price indices. This method uses data on houses that have been sold more than once. However, the method is considered inefficient since it leaves out a lot of data on houses not sold more than once.

Stock-flow models attempt to explain the flow of money and different stocks of assets within an economy, they provide an accounting framework. Caverzasi and Godin (2015) developed the models further into integrated stock-flow consistent models. Keith (2007) described the movement in real estate prices based on the stock-flow model. The underlying principle is the law of demand and supply. The model describes how durable stock such as real estate moves up and down over time and the effect on the price. Demand for real estate is characterised by among others economic factors such as GDP, inflation, household income etc. The movement in prices through cycles is caused by a mismatch in demand and supply due to the elasticity of supply (Paradkar, 2013).

EMH postulates that market prices reflect all the available information regarding a particular asset (Fama, 1965). The degree of efficiency depends on the speed with which markets incorporate information in pricing. This is key when studying the influence of fundamental factors such as demand and supply on property prices. EMH assumes investors are rational. Behavioural finance is attributed to Kahneman (1979) who debunked the rational approach to decision-making by investors. De Bondt (2002) developed this further by explaining asset price bubble psychology and its implications. This paper looks at the effect of fundamental factors namely economic, and property supply on house prices. It is expected that an increase in demand factors and a reduction in supply will have a positive effect on residential real estate prices. The absence of strong influence by the fundamental factors may be an indication of market inefficiency.

The financial accelerator mechanism can be used to explain how monetary policy affects investment decisions in housing. Bernanke and Gertler (1995) sought to explain the transmission mechanism of monetary policy through the balance sheet channel and bank lending channel. For example, an increase in policy rates may erode the balance sheet of a household thus affecting the capacity to pay mortgage deposits and monthly repayments. The increase in interest rates will increase the mortgage burden measured by the ratio of household income to mortgage payments. The effect of monetary policy is also accelerated by the business cycle and the financial position of the specific households. As such, tightening of monetary

policy may dampen demand for housing by households while accommodative monetary policy may spur housing demand and price.

The life cycle theory of savings credited to Modigliani also provides a framework for understanding the impact of economic factors on house prices (Deaton, 2005). Households are motivated to save for future spending, especially during retirement. As such, young people will save more, and older people will spend more during retirement. The aggregate savings rate affects credit which in turn affects demand for houses. The savings rate is an increasing function of population and national income. Therefore, the demand in the housing market, a predicate of a nation's wealth, is moderated by the life cycle of savings.

2.2. Empirical Review

Sorina (2014) studied the real estate market in Spain and Germany. The number of construction permits issued, and mortgage credit positively influenced house prices. The macroeconomic variables did not have a direct effect on prices, but they affected the supply-side variables namely the amount of credit and new construction permits issued. Breedon and Joyce (1993) reported that the effect of mortgage availability on house prices in the UK was mediated by investments in new houses. Demography and disposable income also had a significant effect on prices. Saks (2008) researched the impact of regulation on property supply in the US. The impact was higher on land prices relative to new houses supplied. The study focused mainly on supply without considering the interplay of economic factors. Similar findings were reported in Glaeser, Gyourko, and Saiz (2008).

Li, Razali, Fereidouni and Adnan (2018) examined the effect of macroeconomic variables on house prices in Beijing, Shanghai and Tianjin. They concluded that GDP, inflation, disposable income and interest rates were key in explaining changes in house prices in China.

Nneji, Brooks and Ward (2013) found that house prices did not significantly respond to changing macroeconomic variables during the crash regime in the US. The findings underscore the cyclicality of the residential market with policy implications, especially on monetary policy interventions. Leung and Ng (2019) studied the US market confirming the importance of cycles and regimes. They found that the effect of macroeconomic variables on house prices reduced after the global financial crisis of 2008. They specifically found that GDP and inflation were positively associated with house prices while trade surplus and unemployment negatively

affected house prices. However, the correlation between macro-finance variables and house prices increased. They found that the stock market and federal funds rate positively correlate with house prices while term rate and external finance premium negatively correlate with house prices.

Al-Marwani (2014) modelled property prices in England. Change in income had a significant effect on prices but only in flats. Taxes, inflation, and changes in employment did not affect prices across property types. The study did not consider property supply factors. Sivitanides (2018) reported that GDP and population had a long-run run effect on house prices in London, UK. However, property supply measured by the housing completion series and cost construction series negatively affected house prices.

Cameron, Muellbauer and Murphy (2006) found that interest rates, demographics and income had a significant relationship with house prices. Zietz, Sirmans and Smersh (2008) studied single-family home sales in Florida, US. They found that home prices were significantly influenced by the size, location, and age of the homes. Apergis (2003) found that inflation and employment rates positively affected house prices in Greece. However, interest rates exerted a negative effect on house prices due to high financial costs.

Lekhuleni and Ndlovu (2023) reported that GDP, exchange rate, affordability household debt-disposable income ratio, foreign direct investment and producer price index had long-run positive effects on house prices in South Africa. On the other hand, share prices and mortgage rates exhibited long-run negative effects on house prices. Habanabakize and Dickason's (2022) findings indicate that inflation and interest rates positively affect house prices while political risk and rent negatively affect prices in South Africa.

Okey (2023) concluded that interest rates and prices of oil sector products negatively affected house prices in Nigeria. Interestingly, mortgage credit did not significantly affect house prices. Oyetunji and Olowofeso (2016) found that exchange rates significantly affected house prices in Lagos, Nigeria. Interest rates, GDP and inflation were positively correlated with house prices but statistically insignificant. The results were replicated for flats, detached houses and duplexes.

Musa, Yahaya and Nuhu, (2020) found a strong positive correlation between inflation, exchange rate and house prices in Abuja, Nigeria. GDP, crude oil prices, and household income

exhibited a positive but weak correlation. Interest rates were found to have a weak negative association with house prices.

Kibunyi et. al. (2017) investigated the possibility of bubbles in the real estate market in Kenya. They found no evidence of bubbles in Kenya. Besides, GDP, lending rates, diaspora remittances, cost and loans were found to positively affect house prices. However, inflation negatively affected house prices. However, Quan (1999) had contradictory findings on inflation. Context differences may explain the mixed findings.

Mwololo (2014) found that lending rates had a significant negative impact on the prices in Kenya. The study also established that GDP, unemployment, and inflation had a positive influence on house prices. Makena (2012) concluded that the level of money supply significantly influenced real estate prices in Nairobi. The other variables studied included interest rate, inflation, population growth, and employment growth; all were significant. The effect of property supply was not considered.

In summary, most of the papers focused on the effect of economic variables on house prices in isolation of the property supply. There is a need for evidence of the interplay of economic factors, property supply and prices. The local studies operationalised property prices using the same single price index published in Kenya. There is a gap in the use of property prices that is adjusted for house characteristics. Besides, there are mixed findings in relation to inflation and interest rates.

3. Methodology of research

3.1.Design, Population and Data Collection

Research design is the blueprint of the study that links the empirical data to the study's research questions and finally to its conclusion (Yin, 2009). The study used a quantitative descriptive design in which the secondary data was analysed, and the research hypothesis tested. The research targeted the Nairobi residential real estate market. The period of study was ten years with quarterly data between 2011 and 2020. House prices were operationalised by a housing price index. The hedonic price model was used to estimate the average house price changes controlling for house characteristics. Data used in the construction of the housing price index included house selling price, house size, location, number of bedrooms, and house type. Data was collected for a sample of houses that were sold in the ten years under study. Data sources included commercial banks, real estate developers and agents in Nairobi. The total number of

house purchase transactions in Nairobi over the ten-year period is not readily available in both government and private publications. However, on average 10,896 new units were released into the market annually between 2016 and 2020 (Kenya National Bureau of Statistics, 2020). This number does not capture the sale of existing houses but is indicative of market activity. Besides, most of the units sold are identical and are sold at the same time hence a fraction of the total number is representative. Therefore, purposive sampling was suitable in this case since the researcher was not in control of all the data available and required judgment in determining the number of sale transactions per bank and real estate agent (Cooper & Schindler, 2011). The sample size was set at a minimum of 20 houses sold in each quarter over the ten years totalling 840 houses.

Besides, quarterly data on inflation, GDP, value of approved plans and interest rates was collected. Property supply has been measured using building permits, approved building plans, new units completed, and financing costs amongst others (Sorina, 2014). This study operationalised property supply through a pipeline of new residential houses in Nairobi. This was measured by the value of the approved building plans obtained from the Nairobi City County Government. Economic indicators variables were obtained from the Kenya National Bureau of Statistics.

3.2.Data Analysis

The Nairobi house price index was constructed using a hedonic model. The key variants of the hedonic model include a time-dummy method, imputation methods and characteristics methods (Hill, 2011). Time-dummy method utilises time dummy variables used to estimate the price index by exponentiating coefficients of dummy time variables. The method is simple though it revises the index when new periods are added. This may be problematic, especially in the construction of official price indices but poses no problem for academic purposes. The problem is overcome through the adjustment-period method. Imputation methods use imputed house prices for houses that are not available in both periods of estimating the index. The method overcomes the temporal fixity problem. The characteristics method is similar as it uses the imputed prices. The difference is that the index is calculated using the prices of a hypothetical house. The weakness of this method is in the use of a hypothetical house which may be non-existence or unrepresentative of available houses. This paper used the time-dummy method specified as follows:

$$Ln\ Price_{it} = \propto\ + \beta_1 Ln\ Size_i + \ \beta_2\ Hse\ Type_i + \beta_3 Location_i + \ \beta_4 Bedroom_i + \sum_{t=2}^{T} \theta_{it} D_{it} + e_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..[1]$$

Where:

Ln Price$_{it}$ = Log of the price of house i

Size = Area measured in square feet

Hse Type = Takes the value of 1 if Apartments and 0 if the standalone house

Location = Takes value of 1 if the house is in an upmarket area and 0 if located elsewhere

Bedroom = Number of bedrooms

D$_{it}$ = The dummy variables for time denoting the quarters in the study period

it = error term

The index was derived from the exponents of the coefficients of the dummy time variables for the 40 quarters under study.

We now embark on the analytical model relating to the second objective of the paper. GDP was measured by the quarterly real growth rate in aggregate economic output in Kenya. Inflation was measured by the quarterly consumer price index in Kenya. The interest rate was operationalised by the average commercial bank's lending rate. Property supply was proxied by the value of the approved house plans obtained from the Nairobi County Government.

Diagnostic tests were carried out to ensure the data series did not violate any of the assumptions of classical ordinary least squares and other models. In addition, interventions and implications of any violations were also discussed. Diagnostic tests included stationarity tests, serial dependence tests, heteroscedasticity tests and multicollinearity tests.

Breusch Godfrey's LM test for autocorrelation was used to detect serial dependence. Serial dependence problems may be addressed through variable transformation and an introduction of dummy variables amongst others. The Breusch-Pagan test was used to detect heteroscedasticity. The presence of a heteroscedasticity problem may be treated by transforming variables. Multicollinearity was tested using variance inflation factors (VIF). Multicollinearity problems may be treated through variable transformation or the removal of

certain variables. Jarque-Bera test was used to test for normality. Non-normality may be treated by removing outliers, introducing dummy variables, or transforming variables. Besides, normality could be assumed if the sample is large by invoking the central limit theory (Brooks, 2019).

Stationarity was tested using Augmented Dickey-Fuller and Phillips-Perron unit root tests. If the test results indicate mixed stationarity, the use of static ordinary least squares regression may not be suitable as it would potentially lead to spurious inferences (Granger & Newbold, 1974; Nkoro & Uko, 2016). Therefore, the literature proposes a dynamic model that factors in lagged variables of both the dependent and independent variables. The study will therefore adopt the Autoregressive Distributed Lag Model (ARDL). ARDL will be specified and implemented in hypothesis testing. This will be a specification of an error correction model to test long-run and short-run relationships depending on the outcome of the cointegration test. ARDL has several advantages including its suitability in the presence of mixed stationarity and efficiency with small samples (Kripfganz & Schneider, 2020). ARDL model is specified as follows:

$$y_t = C_0 + \sum_{i=1}^{p} \emptyset i \, y_{t-i} + \sum_{i=0}^{q} \beta'_i \, X_{t-i} + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

The value of the dependent variable is determined by its lagged values and the lagged values of the independent variables. Dynamic models such as ARDL as opposed to static models such as OLS provide a framework for modelling inertia. For instance, past values of approved building plans are likely to affect the current house prices.

ARDL model was implemented in five steps. The first was to select an optimal number of lags. Bayesian Information Criterion (BIC) was used since it provides parsimonious results (Kripfganz & Schneider, 2020). The second was to test the model's overall significance using F-test. The third was the cointegration test to determine the existence of a long-run relationship using the Bounds cointegration test (Pesaran, Shin, & Smith, 2001). The fourth was to implement an error correction model (ECM) to determine both the long-run and short-run relationships between the dependent and independent variables. The ECM is generally specified as follows:

$$\Delta y_t = C_0 + \sum_{i=1}^{p} \emptyset i \, \Delta y_{t-i} + \sum_{i=0}^{q} \beta'_i \, \Delta X_{t-i} + ECT_{t-1} + u_t \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

Where ECT is the error correction term being the residuals from the estimated long-run model.

Lastly, post-estimation tests were done to confirm the validity of the outcome of the hypothesis tested. The post-estimation tests included heteroskedasticity, autocorrelation, normality, and parameter stability.

4. Results

The residential property price index was constructed using data collected for 1,073 houses for the ten-year period under study against a minimum sample size target of 840. The description of the house data collected is as follows.

Table 1: Descriptive Statistics for House Data

Description	**Statistic**
Number of houses	1,073
Minimum Price (Kenya Shilling)	1,600,000
Maximum Price (Kenya Shilling)	150,000,000
Mean Price (Kenya Shilling)	19,527,840
Number of Houses in Upmarket Areas	521
Number of Houses Located in Low-Market Areas	552
Number of Apartments	684
Number of non-apartments	389
Minimum Surface Area (Square Feet)	215
Maximum Surface Area (Square Feet)	8,167
Mean Surface Area (Square Feet)	1,883
Minimum Number of Bedrooms	1
Maximum Number of Bedrooms	7
Mean Number of Bedrooms	3.1

Source: Field survey (2023)

The minimum house price was Kenya Shilling (KSH) 1.6 million and the maximum KSH 150 million with the average price being KSH 19.5 million. The data on the location of houses

indicated that 521 houses out of 1,073 were in upper-middle and high-end locations. While the remaining 552 were in lower-middle and low-end locations.

The data on the types of houses indicated that 684 houses out of 1,073 were apartments while the remaining 389 were non-apartments. Non-apartments include bungalows, maisonettes, and other stand-alone houses. The prevalence of apartments reflects the pattern in Nairobi due to limited land for development. The minimum number of bedrooms was one and the maximum seven with the average being 3.1. The minimum house size as measured by the built surface area was 215 sq. ft. and the maximum 8,167 sq. ft. with the average size being 1,883 sq. ft.

The results of the pooled regression analysis based on the hedonic model are summarised in Table 2.

Table 2: Regression results for price index

Price	**Coef.**	**St. Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
Size	.72	.037	19.42	0	.647	.793	***
House Type	-.114	.031	-3.68	0	-.174	-.053	***
Location	.613	.026	23.14	0	.561	.665	***
Bedroom	.171	.019	8.91	0	.133	.208	***
Constant	10.274	.252	40.81	0	9.78	10.768	***
Mean dependent var	16.381	SD dependent var	0.855				
R-squared	0.821	Number of obs	1073				
F-test	104.425	Prob > F	0.000				
Akaike crit. (AIC)	956.213	Bayesian crit. (BIC)	1185.211				

**** p<.01, ** p<.05, * p<.1*

Source: Author (2023)

The overall model was significant based on the F-test. House size, location and the number of bedrooms had significant and positive effects on house prices. While house type had a significant negative effect on house prices. Therefore, the fitted hedonic model was suitable for deriving the price index.

The results indicate that a 1% increase in the house surface area will result in a 0.72% increase in house price. Also, apartments were on average priced 10.8% below stand-alone houses such as bungalows, maisonettes etc. Houses located in upmarket areas were on average sold at a

premium of 84.6%. Finally, an additional bedroom would result in a house price increase of 18.6% on average in Nairobi.

The house price index was derived based on the exponents of the coefficients of the dummy time variables for the 40 quarters under study. The resulting index is depicted in Figure 1. It shows the residential real estate prices over the years from 2011 Q1 to 2020 Q4. Prices were on an upward trajectory between 2017 and 2019 with a drop in 2020 possibly due to covid -19.

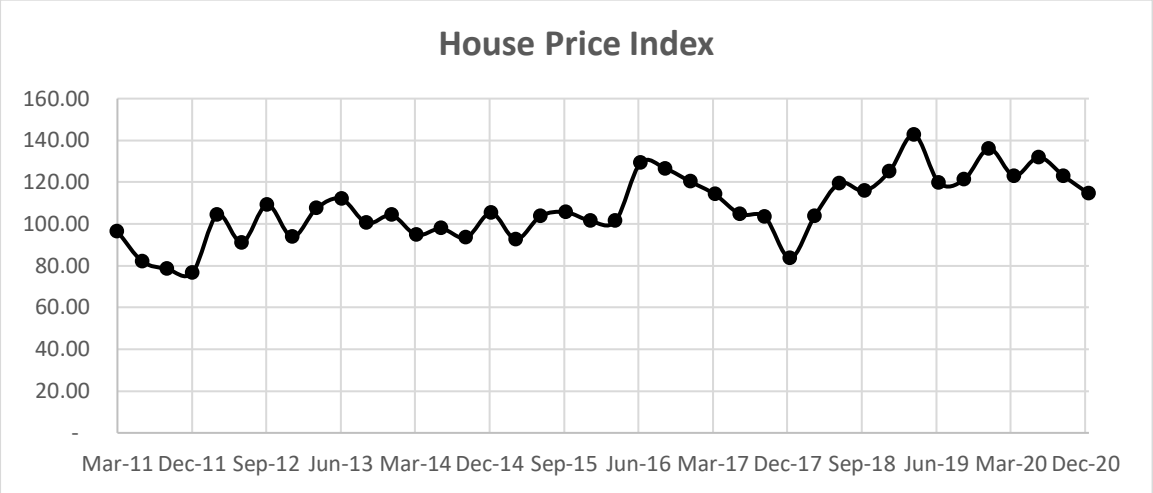

Figure 1: Residential real estate price index
Source: Field survey (2023)

Therefore, the paper's first objective of constructing the house price index was achieved. The constructed price index was used as the dependent variable in addressing the paper's second objective.

We now embark on the second objective of the paper which was to establish the effect of property supply and economic factors (GDP, Interest rates and Inflation) on house prices. The following is a summary of descriptive statistics.

Table 3: Descriptive Statistics – Economic and Property Supply Data

Variables	Obs	Mean	Std. Dev.	Min	Max	Skew.	Kurt.	JB (Pr)
GDP (%)	40	4.7	2.3	-4.1	7.6	-2.672	10.873	.000
Value of Approved Plans in Nairobi (KSH billions)	40	33.885	11.227	8.339	59.99	-.209	2.698	.8018
Inflation Index (Quarterly CPI)	40	167.157	29.769	114.62	219.01	.058	1.781	.2866
Interest (%)	40	15.2	2.5	11.9	20.2	.333	1.938	.2702

Source: Kenya National Bureau of Statistics (2021)

The real GDP growth rate peaked at 7.6% with the lowest rate at negative 4.1%. The negative growth rate of 4.1% was in the second quarter of 2020 owing to COVID-19. The mean quarterly real GDP growth rate was 4.7%. The following is a trend analysis of GDP.

Figure 2: GDP Trend Analysis

Source: Kenya National Bureau of Statistics (2021)

Property supply was operationalised by the value of building plans approved each quarter by Nairobi City County. This indicated the ongoing developments that are likely to affect residential real estate prices. The following is a trend analysis of property supply.

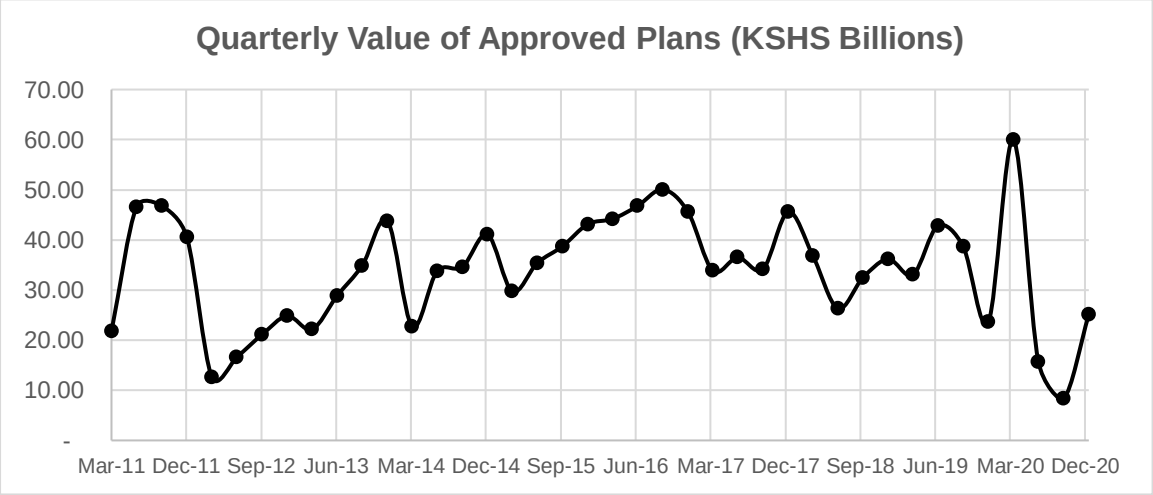

Figure 3: Property Supply Trend Analysis

Source: Nairobi City County Government (2021)

The minimum value approved during the study period was KSH 8.339 billion while the maximum was KSH 59.991 billion. The mean value was KSH 33.88 billion. The Jarque-Bera (JB) normality test indicates normality (p-0.8018>0.05).

Inflation was measured by the consumer price index in Kenya over the study period. The CPI was rebased to 100 in February 2019. However, for the purpose of the study, the CPI was extended using the actual growth rates in the revised index. This was to forestall the appearance of structural breaks in the time series data. The inflation index minimum value was 114.6 and the maximum was 219. The JB normality test indicates normality (p-0.2866>0.05). The following is a trend analysis of inflation.

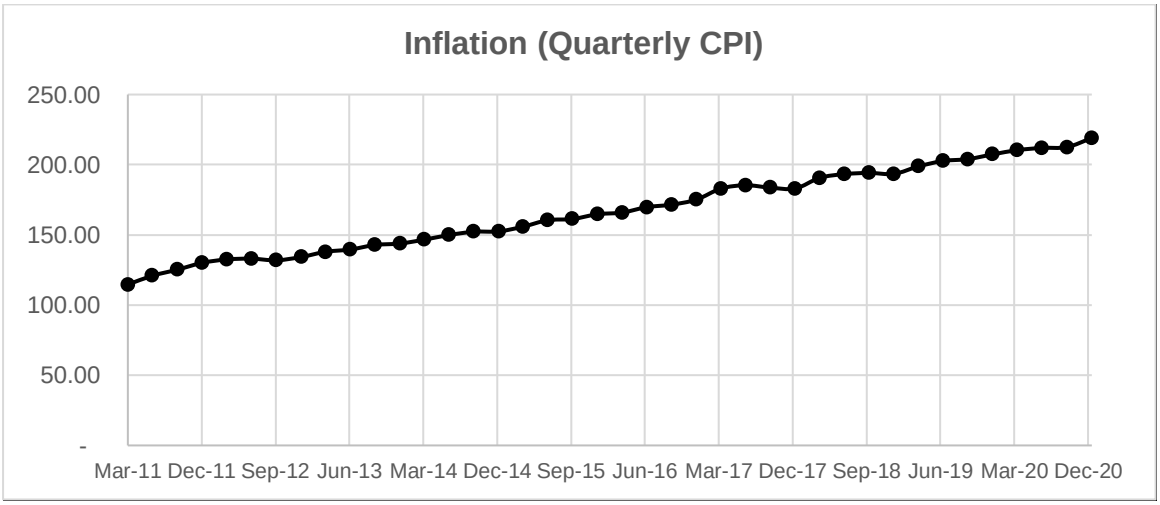

Figure 4: Inflation Trend Analysis

Source: Kenya National Bureau of Statistics (2021)

Average lending rates by commercial banks in Kenya reached a high of 20.2% in June 2012 and a low of 11.9% in September 2020. The average interest rate was 15.2%. The interest rates in Kenya have been stable. The JB test also supports normal distribution (p-0.2702>0.05). The following is a trend analysis of interest rates.

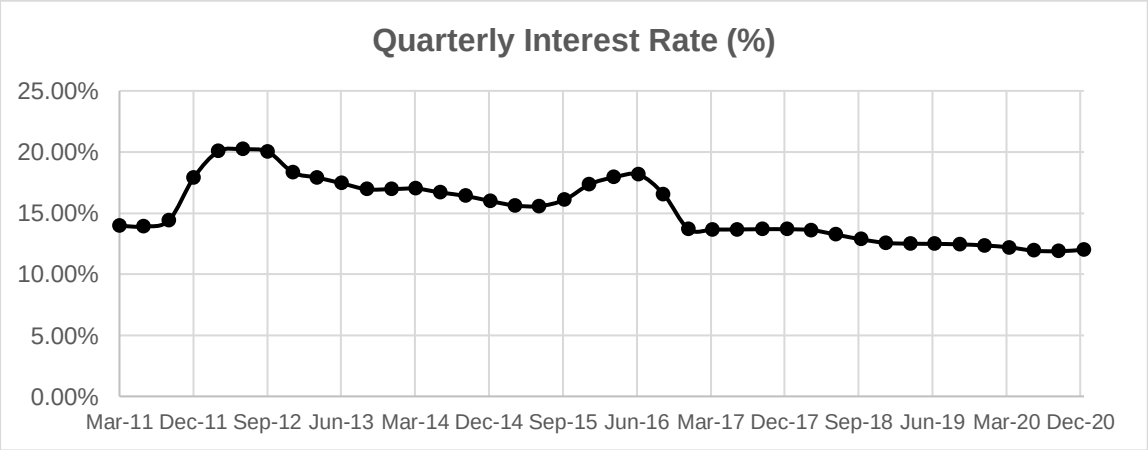

Figure 5: Interest Rate Trend Analysis

Source: Kenya National Bureau of Statistics (2021)

Diagnostic tests were carried out to ensure the data series did not violate any of the assumptions of classical ordinary least squares and other models. The data set passed autocorrelation, heteroscedasticity, normality and multicollinearity tests as depicted in Table 4 and Table 5.

Table 4: Diagnostic test results

Test	Method	Statistic	Prob
Autocorrelation	Breusch Godfrey LM test	2.62	0.6232
Heteroscedasticity	Breusch-Pagan test	22.80	0.2985
Normality	Jarque-Bera	0.24	0.8854

Source: Author (2023)

Table 5: Multicollinearity test

Variable	VIF
Inflation Index	2.592
Interest	2.448
GDP	1.833
LN Value of Approved Plans	1.516
Mean VIF	2.097

Source: Author (2023)

The Augmented Dickey-Fuller and Phillips-Perron unit root tests were used to test for stationarity with outcomes depicted in Table 6 and Table 7 respectively.

Table 6: Stationarity test (Augmented Dickey-Fuller)

Variable	Test statistic	P-value	I (0)	Test statistic	P-value	I (1)
Price Index	-2.162	0.220		-5.517	0.000	✔
Interest	-2.014	0.281		-4.019	0.001	✔
GDP	-3.077	0.028	✔			
Value of Approved Plans	-3.451	0.009	✔			
Inflation Index	0.157	0.969		-6.56	0.000	✔

Source: Author (2023)

Table 7: Stationarity test (Philips-Perron)

Variable	Test statistic	P-value	I (0)	Test statistic	P-value	I (1)
Price Index	-2.564	0.101		-9.012	0.000	✔
Interest	-1.207	0.671		-3.577	0.006	✔
GDP	-3.276	0.016	✔			
Value of Approved Plans	-4.286	0.001	✔			
Inflation Index	-0.326	0.922		-5.910	0.000	✔

Source: Author (2023)

GDP and log of the value of approved plans were stationary at levels [(I (0)]. On the other hand, the price index, interest, and inflation index were not stationary at levels. However, the series became stationary at first difference [1 (1)]. The stationarity test resulted in mixed stationarity. The study therefore adopted the ARDL model. The ARDL model was implemented in five steps and the results are presented as follows. The ARDL optimal lags were determined as (1 1 0 0 0) using BIC as shown in Table 8.

Table 8: Optimal lags selection

Model	N	ll (null)	ll (model)	Df	BIC
.	36	-145.1738	-127.8625	7	280.8096
Price Index					1
GDP					1
Inflation Index					0
Interest					0
LN of Value of Approved Plans					0

Source: Author (2023)

The ARDL (1,1,0,0,0) was specified as follows:

$$PriceIndex_t = C_0 + \emptyset PriceIndex_{t-1} + \beta_1 GDP_t + \beta_2 GDP_{t-1} + \beta_3 InflationIndex_t + \beta_4 Interest_t + \beta_5 Ln\, Value of Approved Plans_t + u_t \ldots\ldots \quad [4]$$

The ARDL was run to test for the model's goodness of fit. Table 9 summarises the result.

Table 9: Model summary

ARDL (1,1,0,0,0) regression

Sample: 2011q2 thru 2020q4

Source	**SS**	**df**	**MS**	Number of obs.	=	39
Model	6720.25703	6	1120.04284	F (6, 32)	=	13.13
Residual	2730.17149	32	85.317859	Prob > F	=	0.0000
Total	**9450.42852**	**38**	**248.695487**	R-squared	=	0.7111
				Adj. R-squared	=	0.6569
				Root MSE	=	9.2368

Source: Author (2023)

The model was significant (F=13.13; p<0.05). Therefore, the specified ARDL (1,1,0,0,0) model was suitable for further analysis.

The next step was to determine whether the long-run relationship among the variables exists using a bounds test for cointegration specified as follows:

$$\Delta PriceIndex_t = C_0 + \emptyset\Delta PriceIndex_{t-1} + \beta_1\Delta GDP_t + \delta_1 PriceIndex_{t-1} + \delta_2 GDP_{t-1} + \delta_3 InflationIndex_{t-1} + \delta_4 Interest_{t-1} + \delta_5 LNValueofApprovedPlans_{t-1} + u_t \ \ldots\ldots [5]$$

The terms with β and ∅ are coefficients associated with the differenced variables, and they indicate short-run relationships. While δ indicates the long-run relationships. The null hypothesis is no cointegration. Table 10 provides a summary of the cointegration test results.

Table 10: Cointegration test

Pesaran, Shin, and Smith (2001) bounds test

H0: no level relationship F = 8.129

Case 3 t = -5.152

Finite sample (4 variables, 39 observations, 1 short-run coefficient)

Kripfganz and Schneider (2020) critical values and approximate p-values

	5%		**p-value**	
	I (0)	**I (1)**	**I (0)**	**I (1)**
F	3.236	4.587	0.000	0.002
t	-2.909	-4.074	0.000	0.006

	5%
Decision	**. r**

Source: Author (2023)

The null hypothesis of no cointegration was rejected at a 5% significance level given the F, t, and p values hence house prices have a long-run relationship with property supply and economic factors. Therefore, the following error correction model (ECM) was specified to determine the significance of the long-run relationships:

$$\Delta PriceIndex_t = C_0 + \emptyset \Delta PriceIndex_{t-1} + \beta_1 \Delta GDP_t + \delta ECT_{t-1} + u_t \ldots . [6]$$

The ECM was run to test for overall model significance. Table 11 summarises the result:

Table 11: ECM model summary

ARDL (1,1,0,0,0) regression

Sample: 2011q2 thru 2020q4

Source	**SS**	**df**	**MS**			
Model	3473.33566	6	578.889277	Number of obs	=	39
Residual	2730.17149	32	85.317859	F (6, 32)	=	6.79
Total	**6203.50715**	**38**	**163.250188**	Prob > F	=	0.0001
				R-squared	=	0.5599
				Adj R-squared	=	0.4774
				Root MSE	=	9.2368

Source: Author (2023)

The model was significant ($F=6.79$; $p<0.05$). As such, it was found suitable to estimate the relationship among property supply, economic factors and house prices. ECM was then implemented, and the output summary is in Table 12.

Table 12: ECM Regression results

ARDL (1,1,0,0,0) regression

Sample: 2011q2 thru 2020q4 Number of obs = 39

R-squared = 0.5599

Adj R-squared = 0.4774

Log likelihood = -138.18548 Root MSE = 9.2368

D. Price Index	**Coefficient**	**Std. err.**	**T**	**P>t**
ADJ				
Price Index				
L1.	-0.719	0.140	-5.150	0.000
LR				
GDP	484.340	176.530	2.740	0.010
Inflation Index	0.706	0.145	4.880	0.000
Interest	242.373	163.963	1.480	0.149
LN Value of Approved Plans	-18.722	8.042	-2.330	0.026
SR				
GDP				
D1.	-221.910	92.540	-2.400	0.022
_cons	88.785	66.075	1.340	0.188

Source: Author (2023)

The results indicate that economic factors and property supply explain 55.99% of the variation in house prices. Inflation and GDP have a positive significant effect on house prices while the value of approved plans has a negative effect. However, interest rates had no significant long-run effect ($p>0.05$) on house prices.

The adjustment factor of negative 0.719 is significant ($t= -5.15$; $p<0.05$). This indicates that 71.9% of the deviations from the long-run equilibrium in a particular quarter will be corrected in the subsequent period. The high speed of adjustment may point to the efficiency of the housing market as it experiences correction from shocks. This tends to agree with the stock-flow model and EMH.

In the short run, changes in GDP ($t = -2.40$; $p<0.05$) have a significant effect on prices. A 1% increase in GDP will lead to a 2.21% decline in real estate prices in the short run. This seems out of step with the theoretically expected relationship.

The validity of the outcome of the hypothesis test was subject to post-estimation tests. The model passed the four tests as shown in Table 13, Figure 6 and Figure 7. Specifically, there was no autocorrelation and heteroscedasticity on the fitted model. The errors were also normally distributed.

Table 13: Summary of post-estimation tests

Test	**Method**	**Statistic**	**Prob**
Autocorrelation	Breusch Godfrey LM test	4.021	0.4032
Heteroscedasticity	Breusch-Pagan test	30.33	0.2994
Normality	Jarque-Bera	0.395	0.8206

Source: Author (2023)

The fitted model assumes that the estimated parameters will remain stable over time. Cumulative sum (Cusum) and Cumulative sum of squares (CUSUMSQ) tests for parameter stability were used (Brooks, 2019). The fitted model was found to be stable as shown in Figure 6 and Figure 7.

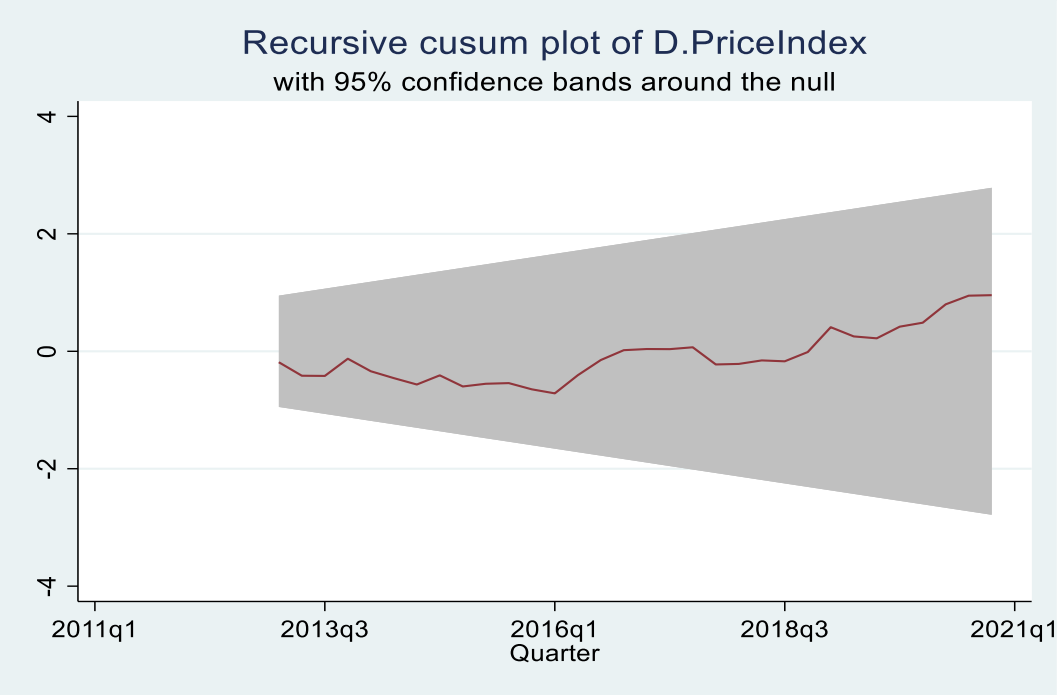

Figure 6: Recursive CUSUM plot

Source: Author (2023)

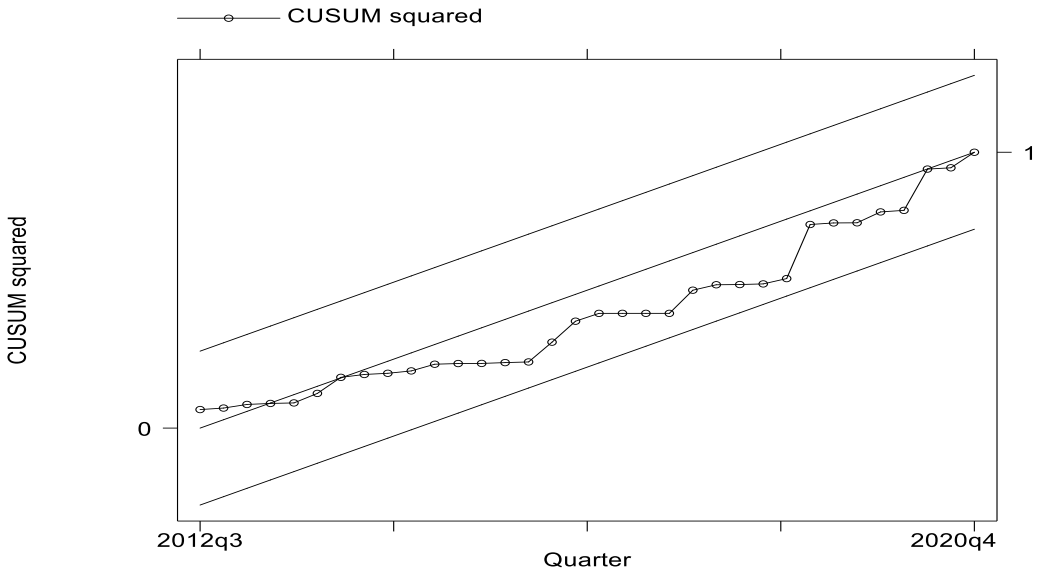

Figure 7: CUSUMSQ plot

Source: Author (2023)

5. Discussion and conclusion

The first objective was to construct the Nairobi house price index. This was achieved using the hedonic model based on data collected on actual selling prices and house characteristics. Apartments were on average priced 10.8% below the stand-alone houses indicating investors' preference. Houses located in upmarket areas were on average sold at a premium of 84.6%. The price premiums established in this study seem in tandem with the growth in construction and the purchases in upper middle and wealthy segments of Nairobi's property market. The price premium also reveals the strong preference for a suitable location in the decision-making process of real estate investors.

House surface area, location and number of bedrooms had significant and positive effects on house prices. House type had a significant negative effect on house prices. This agreed with Zietz, Sirmans and Smersh (2008) who studied single-family home sales in Florida, US. They found that home prices were significantly influenced by the size, location, and age of the homes. Zhou (2021) found that the effect of size on house prices was mixed in China depending on the location. The findings relating to house type were different from what was reported by Dubin (1998) who studied Baltimore, US and found no effect. While the findings of this study on the effect of the number of bedrooms concur with the literature, Zheng (2014) found no effect in Singapore. The construction of the index was a departure from the previous studies in Kenya which relied on one published property index. The resulting price index was used as the dependent variable in the model used to address the second objective of the current study.

The second objective was to establish the effect of economic factors and property supply on house prices. The selected economic factors were GDP, inflation, and interest rates. Property supply was proxied by the value of approved building plans. Residential real estate prices were measured by the price index. The results indicated that GDP had a positive and significant long-run effect on residential real estate prices. This agrees with the theory. Also, the findings are like those of past local studies (Kibunyi et. al. 2017; Makena, 2012). The findings are also in agreement with regional and international studies (Li, Razali, Fereidouni & Adnan, 2018; Sivitanides, 2018; Lekhuleni & Ndlovu, 2023; Leung & Ng, 2019).

Inflation also had a significant positive long-run effect on real estate prices. This agreed with the findings of Quan (1999), Habanabakize and Dickason (2022), and Apergis (2003). However, the finding was different from Al-Marwani (2014) who studied the UK market and

found no significant effect. Whereas Njoroge (2018) and Kibunyi et. al. (2017) found that inflation negatively affected real estate prices.

The effect of interest rates on real estate prices was negative but statistically insignificant. The finding differed with Kibunyi et. al. (2017), Habanabakize and Dickason (2022), and Njoroge (2018) who reported a positive significant effect. Keith (2007), Lekhuleni and Ndlovu (2023), and Mwololo (2014) reported negative effects. The mixed findings in relation to inflation and interest rates continue to persist. High interest rates may increase the opportunity cost of funds thus reducing house prices. Alternatively, high interest rates may constrain property supply thus increasing house prices. Therefore, the mixed results seem to depend on the net effect obtained in different study contexts.

Property supply had a significant negative long-run effect on residential real estate prices. This conforms to the stock-flow model (Paradkar, 2013; Keith, 2007; Keynes, 1936). The finding agrees with Glaeser, Gyourko and Saiz (2008) who studied the US market and Sivitanides (2018) who studied the property market in London, UK. However, Belke and Keil (2018) reported that the supply of newly constructed houses had a positive effect on house prices in Germany. This could be an indication of excess demand, not an increase in supply. The mixed findings underscore the importance of studying demand and supply factors together to determine the overall effect.

6. Contributions, recommendations and limitations

The paper developed the house price index for Nairobi and showed its importance in monitoring residential real estate prices. Kenya does not have an official government house price index and as such this paper underscores the importance of having an official price index in Kenya that tracks house prices.

The study tested the short-run and long-run relationships among the variables of interest which expands knowledge. GDP had a negative and significant short-run effect on real estate prices. This seemed to negate the stock-flow model anchored on the law of demand and lending support to behavioural finance. However, the speed of adjustment towards equilibrium was high at 71.9% meaning any deviations from the equilibrium relationship are corrected within two quarters. This lends support to the standard theory as espoused the in stock-flow model and EMH. Therefore, house prices are influenced by economic factors and property supply as opposed to the random evolution of prices.

The study found that the market players have a strong preference for location and house type as demonstrated by the premium paid for upmarket locations and stand-alone houses. Also, price indexes can be used as benchmarks for portfolio performance attribution and the creation of new products such as index funds. Policymakers in National and County governments may also find a basis for formulating policy on property taxes from the study findings. Currently, property taxes are based on old valuation rolls. County governments can adjust house values by the amount of the price index and then apply the property tax rate. Banks and mortgage providers will find the study outcome useful in pricing mortgage loans. This can be done through risk premium adjustments informed by the volatility of the real estate market measured by the index akin to the concept of notching in the credit rating market. The performance of the mortgage loans and real estate collateral held is closely tied to the performance of the real estate sector as captured by the price index. Regulators such as the Insurance Regulatory Authority, Retirement Benefits Authority, Capital Markets Authority, and Central Bank of Kenya may tailor investment and prudential guidelines for their licensees to the study findings. Any vulnerabilities and weaknesses in the real estate sector as evidenced by the index, supply and economic factors may call for adjustment in investment guidelines issued.

However, the study had a couple of limitations. In developing the real estate price index using a hedonic model, the study used only four characteristics namely size (measured by built surface area), location, house type and number of bedrooms. The study balanced the need for more attributes versus data availability hence the choice of fewer but key attributes. Government bodies can create a robust database for the property market that can expand future studies.

The study focused on the residential property market in Nairobi, Kenya. However, generalisations of the findings of the study to the country, region or in Africa should be cautioned. Besides, the study was limited to the residential real estate market. As such other property markets such as office space, retail, warehouses, hotels, etc. were not part of the study. In addition, the study was limited to the chosen variables in the study. There are other economic variables that were not included such as household income, employment rate, exchange rate etc. Also, additional indicators of property supply and investor characteristics may be of interest to future research as guided by theory or practice.

7. Non-technical summary

The objective of the paper was to first construct a Nairobi house price index and then determine the relationship among economic factors, property supply, and house prices. The Nairobi real estate price index was developed using actual selling prices and characteristics of a sample of houses in Nairobi spanning ten years. The paper finds that as the economy grows, and inflation rises so do house prices. On the other hand, as more houses are supplied in the market, house prices decline. Changes in borrowing rates did not affect changes in house prices mainly because the interest rates have remained stable over the years. The findings may have implications for investors, banks, regulators of securities and policymakers. The government of Kenya may be motivated to commission an official house price index.

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