ECONOMIC FACTORS, PROPERTY SUPPLY, RENT VALUE, AND RESIDENTIAL REAL ESTATE PRICES IN NAIROBI COUNTY

DAN KIBET CHIRCHIR

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JANUARY 2024

DECLARATION

DECLARATION BY THE CANDIDATE

I declare that this PhD thesis is my own original work and has not been presented for award of any degree in any University or Institution.

Signed … Date 15/01/2024

Name: Dan Kibet Chirchir

Reg. No. D80/73845/2012

DECLARATION BY SUPERVISORS

This PhD thesis has been submitted for examination with our approval as the University Supervisors.

Signed ……. Date ……16/1/2024
Name: Prof. Mirie Mwangi
Department of Finance and Accounting

Signed …. Date…….16/01/2024
Name: Prof. Cyrus Iraya
Department of Finance and Accounting

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DEDICATION

I dedicate this thesis in memory of my late paternal grandparents Barmao Serem Kibirir and Toiyoi Kibirir, my late maternal grandparents Julius Chemwetich and Priscilla Kabilo. Besides, I dedicate it to my lovely parents Mr and Mrs Birir. My siblings the A-G crew strong as ever. More importantly, my Rib and Progeny. Finally, to my heritage the entire Talai (Ng'etundo) and Talai (Mororo) clans with special mention to the house of Kap Nakai.

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ABBREVIATIONS

AR	Auto Regressive
ARDL	Autoregressive Distributed Lag
ARIMA	Auto Regressive Integrated Moving Average
BIC	Bayesian Information Criterion
BVAR	Bayesian Vector Autoregressive
CBD	Central Business District
CBK	Central Bank of Kenya
CMA	Capital Market Authority
COPI	Construction Input Price
COVID -19	Corona Virus Disease 2019
CPI	Consumer Price Index
CUSUM	Cumulative Sum
DCF	Discounted Cash Flows
ECM	Error Correction Model
EMH	Efficient Market Hypothesis
GAR	Generalised Autoregressive
IRA	Insurance Regulatory Authority
JB	Jarque - Bera
KAR	Kalman Filter Auto Regressive
KNBS	Kenya National Bureau of Statistics
KPDA	Kenya Property Developers Association
KSH	Kenya Shilling
LM	Lagrange Multiplier
LN	Natural Log
NHC	National Housing Corporation
OLS	Ordinary Least Square
RBA	Retirement Benefit Authority
RID	Ratio of Indirect Effect to Direct Effect

RIT	Ratio of Indirect Effect to Total Effect
RMSE	Root Mean Squared Error
SEM	Structural Equation Modelling
SKTEST	Skewness Kurtosis Normality Test
SQ. FT	Square Foot
US	United States
VAR	Vector Auto Regressive
VECM	Vector Error Correction Model
VIF	Variance Inflation Factor

ABSTRACT

Residential real estate is a key investment for both institutional and individual investors. Investors' returns namely rental yield and capital gains is predicated on changes in house prices. As such, understanding the factors that influence house prices is central to the investment process. The problem is that there is no unified model for house pricing which is exacerbated by uniqueness of context. The focus was on the residential real estate market in Nairobi County, Kenya. Nairobi is a renters' market dominated by individual investors with about 90.7% of households renting. House prices and rent value have been on the rise. The effect of rent on house prices is scarcely studied. There was a gap in understanding the interplay of demand drivers, property supply, house characteristics and rent value in determining house prices. There was also a gap in the way house prices and rent value have been characterised in past studies necessitating the construction of house and rent indices in this study. The study aimed at determining the relationship among economic factors, property supply, rent value and residential real estate prices. The study was anchored on the hedonic pricing model, stock flow model and efficient market hypothesis. It was also anchored on positivist philosophy and quantitative research design. Hypotheses were developed in keeping with the objectives of the study. Quarterly data was collected for the ten-year period under study and subjected to diagnostic tests. Autoregressive Distributed Lag model was adopted due to mixed stationarity. Real estate prices and rent value were operationalised by price index and rent index developed using hedonic model based on the data collected on actual selling price, rent paid and characteristics of a sample of houses in Nairobi spanning ten years. The study found out that GDP and inflation had significant positive long run effect on real estate prices. Property supply had a significant negative long run effect on real estate prices. However, interest rates did not have significant effect on house prices. In the short run however, GDP had a significant negative effect on prices. The speed of adjustments towards equilibrium relationship is 71.9%. Therefore, 71.9% of deviations from long run relationship in a particular quarter is corrected in the following quarter. The real estate market seems to be efficient despite its illiquid nature. The findings of the study indicate that rent value mediate partially the effect of inflation on real estate prices. As such, inflation has some residual direct effect. GDP and property supply have direct non-mediated effect on real estate prices. Also, the joint effect of economic factors, property supply and rent value on real estate prices was found to be significant. The study contributes to knowledge through its development of both price and rent indices. It adds to knowledge by finding that the effect of selected economic factors on real estate prices is partially direct and partially channelled through rent value. The findings also added to the mixed findings in literature in relation to the effect of interest and inflation rates on real estate prices. The finding relating to price and rent indices may inform property tax policy for county governments. Banks and mortgage providers will find the study outcome useful in pricing mortgages loans. Regulators such as IRA, RBA, CMA, CBK may tailor investment and prudential guidelines for their licensees to the study findings. Also, house price and rent indices can be used as benchmarks for portfolio performance attribution and creation of new products such as index funds. Future studies can focus on non-residential real estate markets, incorporate atheoretical models, include other variables such as investor characteristics guided by theory and practice in furthering understanding of the determinants of real estate prices.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Residential real estate price is an important variable central to the investment process. Investors' returns namely rental yield and capital gains is predicated on changes in house prices. As such, understanding the factors that influence house prices is key. Investors would want to know the correct price for properties before taking investment action whether buying or selling. For many families, the owner-occupied houses constitute the biggest part of their total wealth (Barari, Sarkar, Kundu & Chowdhury, 2014). There are many factors that may affect residential real estate prices. Such factors may include property characteristics, economic factors, property supply and rent. The interplay of these factors in price determination is important. Economic factors drive demand for properties affecting prices. However, the effect on prices will be dependent on the state of property supply in the market. High demand with constrained supply is likely to lead to a surge in property prices (Paradkar, 2013). Holding economic and supply factors constant, property attributes such as location and rental value may affect house prices. High household income, an economic factor, may increase the rent value that households are willing and able to pay which in turn increases property prices. However, this increase in property prices on account of household income and rent may be affected by the supply or availability of houses in the market. High property supply can dampen the price increase while low supply may exacerbate the price increase. 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 study is anchored on four broad theories that attempt to explain the movement in real estate prices: Stock Flow Model, Hedonic Pricing Model, Efficient Market Hypothesis (EMH) and Behavioural Finance. The underlying principle in stock flow model 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 resulting effect on the price. The movement in prices through cycles is caused by mismatch in demand and supply due to elasticity of supply (Paradkar, 2013). Hedonic pricing model provides a framework for pricing property characteristics such as size, location, house type, availability of green space, quality of finishing and availability of amenities (Sirmans, Macpherson & Zietz, 2005). It helps in controlling for quality bias in property pricing. Efficient market hypothesis posits that all the available information regarding a particular asset is reflected in the prices (Fama, 1965). The degree of efficiency depends on the speed with which markets incorporate information in prices. This is key when studying the influence of fundamental factors such as demand and supply on property prices. EMH assumes investors are rational. However, behavioural finance contends that investors are not necessarily rational and therefore pricing of securities should consider the behaviour of investors. Behavioural finance is credited to Kahneman (1979) who debunked the rational approach to decision making by investors. De Bondt (2002) developed this further by explaining asset price bubbles psychology and their implications.

The real estate market is of critical importance especially due to its large size. Residential market comprises the larger proportion of the total real estate market (Al-Marwani, 2014;

Amwayi, December 2018). Residential market in Nairobi accounts for 85% of new developments both in units and value while non-residential 15% (Kenya National Bureau of Statistics, 2020). Kenyan government embarked on an ambitious project with 500,000 houses set to be built from 2018 (Amwayi, 2018). The success of this project will provide impetus to real estate market. The basic human need for shelter underscores the vastness of this market. As such there is continuous trading of both existing and new stock of real estate. Property as an investment asset class has continued to grow as investors allocate funds to it. Portfolio managers find real estate attractive not only for potential upsides in returns but also for its perceived diversification benefits owing to little or lack of correlation with the traditional asset classes such as stocks and bonds (Worthington & Higgs, 2003).

The housing bubble in the United States (US) in 2007 brought to the fore the importance of this sector. The effect extended beyond the US due to the integrated nature of the global financial markets (Vishwakarma, 2013). Banks were among the biggest casualties necessitating in some instances bail out from the governments. As part of risk management strategies, banks and other institutions that deal with mortgages, must rethink mortgage pricing and how it relates to determinants of real estate prices. Policy makers including central banks are concerned about the implication of real estate prices on monetary and fiscal policy. Regulators of insurance companies, pension funds, savings and credit, banks amongst other financial institutions are also interested in the real estate markets. This is because these institutions have investment portfolio exposure to real estate asset class.

There are several stakeholders including financial investors such as households, governments, regulators, and policy makers who would be interested in determinants of

real estate prices. Interest amongst stakeholders in the movement of house prices has led to a plethora of valuation and pricing models or techniques (Keith, 2007). The problem is that property market is quite different from the stock market. Heterogeneity and illiquidity characterise real estate market dampening the prospects for generally acceptable pricing models. Valuation process utilises the fundamental factors and applies statistical techniques to analyse the data. The cycles and seasonality in property markets prices coupled with investor behaviour compounds the problem of pricing (Case & Shiller, 1990). As such, studies on factors that affect real estate prices should be informed by the possible impact of contextual differences to avoid generalization.

1.1.1 Economic Factors

Economic factors are fundamental information or variables that affect the economy (Vishwakarma, 2013). Economic factors can also be considered as set of indicators of the performance of the economy (Xiao, 2015). Economic factors such as economic growth and household incomes, inflation, interest rates etc. may influence housing prices (Ikromov, 2009). These factors underly demand drivers that affect prices.

GDP growth rate is expected to affect positively housing prices due to increased economic activity and demand. Household income and employment rate are also expected to positively affect house prices due to an increase in purchasing ability increasing demand (Cameron, Muellbauer & Murphy, 2006). Inflation tends to have mixed effects (Zhou, 2021; Quan, 1999; Kearl, 1979). The effect of interest rate on property prices may be uncertain. As market rates increase, the opportunity costs increase, and the rate used to discount cash flows increases hence leading to low present value of investments (Keith, 2007). Increased cost of financing may lead to reduced supply of real estate properties. If

demand exceeds supply, then prices for residential real estate properties surge. Therefore, the net effect of interest rate may end up being uncertain as is the case with inflation.

Literature is replete with studies on the effect of selected economic factors on residential real estate prices albeit with mixed findings. These studies should be explored in different real estate markets globally. Besides, the effect of these economic factors should also be studied in the context of other factors. For example, does property characteristics affect how economic factors affect prices? In addition, the mixed findings in past studies may be due to lack of delineation of demand and supply factors and their impact on real estate prices.

1.1.2 Property Supply

Property supply is the quantum of stock of houses available in the real estate market (Paradkar, 2013). Property supply has been measured using building permits, approved building plans, new units completed, financing costs amongst others (Sorina, 2014; Breedon & Joyce, 1993). According to the stock flow model (Paradkar, 2013), demand for property increases the prices if supply is inelastic and adjusts once the supply is made. The number of new units supplied in the market affects rent income. Also, rent income may influence the number of units to be supplied in the market. The availability of financing affects supply of properties in the market and in turn the real estate price. Besides, good rental income may trigger the supply of new houses which financing make possible. Sorina (2014) studied the real estate market in Spain and Germany. She found significant relationship between new construction permits issued and real estate prices.

The above studies find the relationship between property supply and property prices. However, the effect of property supply on prices given other factors at play has not been researched on. Most studies look at macroeconomic factors which primarily are demand factors and their effect on real estate prices in the absence of a possible impact of supply factors. The impact of supply in the context of demand drivers on real estate prices is ripe for study.

1.1.3 Rent Value

Rent is consideration paid to the owner for use of property. Rent is reward to factor of production namely land and all that is attached on it permanently (Brueggeman & Jeffrey, 2011). Rent value is therefore the income earned by property owners as such it is expected to have positive relationship with house prices. The higher the income generated by a property, the higher the price assigned to it (Keith, 2007). McNamara and Paul (1997) in their study found forecasts in house prices are driven by the growth in rental income. Demand in real estate without corresponding supply will drive rental income upwards which in turn will increase the real estate prices. This conforms to the stock flow model (Paradkar, 2013). Malpezzi (1999) studied long run relationship of house prices and rental income in the US market. The study finds that reversions in real estate prices are because of movement in rental income.

The above studies find the relationship between rent and property prices. However, the effect of rent on prices given other factors at play has not been researched on. Most studies look at macroeconomic factors and their effect on property prices in the absence of a plausible transmission mechanism through rent value. The effect of rent on prices may also vary across property types and markets.

1.1.4 Residential Real Estate Prices

Residential prices refer to the values ascribed to real estate assets (Brueggeman & Jeffrey, 2011). How price is measured varies in research. House price may be measured in terms of actual transaction prices, ask prices and appraised values. Price movements may be due to pure price changes, changing characteristics of the house or a combination of both. Pure price changes reflect appreciation and house inflation. Whereas changing characteristics due to redevelopment, renovation among others may influence price changes. The prices may be intrinsic value computed based on certain assumptions which may vary across different parties (Keith, 2007). These individual values inform the bid and asking prices in the market. Prices may also mean those observed in the market from actual transactions that have taken place.

The valuation and pricing models have evolved over time 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; Hill, Rambaldi & Scholz, 2021; Montero, Mínguez, & Fernández-Avilés, 2018). Hedonic models adjust prices for house characteristics to arrive at pure price changes. Repeat sales models are based on prices of houses that have been sold more than once which is an attractive way of monitoring price changes (Oust, Hansen, & Pettrem, 2020; Case & Shiller, 1990). However, it is thought to be inefficient as it ignores data on houses not sold more than once. On the other hand, atheoretical models attempt to predict prices by leveraging on the statistical properties of time series data (Temur, Akgun & Temur, 2019; Al-Marwani, 2014; Keith, 2007). Hedonic models and repeat sales models are useful in development of house price indices that track prices.

House prices are a key component of the residential market. The market is inherently heterogeneous and illiquid hence there are no quick gains on unified pricing model. In many markets globally, there are developed housing price indices that track the market prices (Al-Marwani, 2014; Hill, Rambaldi & Scholz, 2021). The indices values measure real estate prices. These indices may be national or regional. They could also be specific to property types for example apartments, detached houses and semi-detached.

1.1.5 Residential Real Estate Market in Nairobi County

Nairobi is the capital city of the republic of Kenya. It is also one of the 47 counties in Kenya. About 12% of Kenya's households are in Nairobi and 32% of urban households in Kenya are in Nairobi (Kenya National Bureau of Statistics, 2019). This study focuses on the residential real estate market in Nairobi. House prices and rent value have been on the rise. The average house prices have gone up by about 70% and rent by 73% between 2010 and 2020 (HassConsult, 2020). The high-end segment of the market has grown more than the affordable segment leading to perceived inequalities in pricing and quality of housing. The call for interventions by government to address homeownership rates and affordability in Nairobi is likely to upset the status quo with ramifications for house prices and investor returns.

Real estate market in Nairobi can be divided into residential and non-residential. Residential market consists of single family and multi-family houses. Residential market in Nairobi accounts for 85% of new developments both in units and value while non-residential 15% (Kenya National Bureau of Statistics, 2020). The significant size of the residential market explains the choice for this study. The residential real estate market in Nairobi can also be divided into private and public. Private investment is spearheaded by

the private sector. Nairobi is a renters' market dominated by individual investors with about 90.7% of households renting (Kenya National Bureau of Statistics, 2019). The public sector through government agencies such as National Housing Corporation (NHC). NHC is leading government's big 4 agenda where affordable housing is a key pillar. The affordable housing agenda is aimed at providing affordable housing to residents in urban areas mainly in Nairobi. It is an ambitious project with 500,000 houses set to be built (Amwayi, 2018). The success of this project will provide impetus to real estate market. This government intervention likely to affect the house price in Nairobi and in turn the investor returns currently dominated by private sector. As such the understanding of house price determinants is important for all players in private and public sectors.

According to Kenya Property Developers Association (KPDA), there are 79 property developers, 11 real estate managers and 34 industry suppliers that are registered with KPDA (KPDA, 2020). These professionals are involved in development and management of properties in Nairobi. Besides, they are intermediaries in the purchase or sale of residential properties in Nairobi. The residential real estate market in Nairobi has grown over the years underscoring the investments by both private and public entities. The number of completed units of residential properties increased from 7,834 in 2015 to 11,802 in 2019 representing compounded annual growth rate (CAGR) of 11%. The units developed by the government grew by 85% CAGR over the same period. The market value of completed units done by the private sector jumped from KSH. 61.6 billion in 2015 to KSH. 80.3 billion in 2019 representing 7% annual growth rate. The supply pipeline is also growing as shown by the value of approved residential building plans in Nairobi. The value

of approved plans was KSH. 210.2 billion in 2015 and KSH. 207.6 billion in 2019 (Kenya National Bureau of Statistics, 2020).

1.2 Research Problem

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 as houses may differ in terms of size, structure, location, and other qualities (Brown, 1997). The problem is there is no unified model for house pricing which is exacerbated by uniqueness of context. As such replication and generalisation of determinants of the prices across markets may not be possible. This study focuses on Nairobi residential real estate market.

Nairobi City County contributes significantly to the economy of Kenya. Nairobi's population is about 10% of the country underscoring the importance of the city. Besides, Nairobi is home to big diplomatic establishment including United Nation and a host of diplomatic missions within the blue zone. The need to accommodate the increasing population attracted by prospects of economic fortune, has led to a vibrant residential real estate market. House prices and rent value have been on the rise. Over the last ten years (2010Q2 – 2020Q1) 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, 7% by private institutional investors, 5% by government and the balance by community organisations. 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 with affordable housing which is aimed at providing affordable housing to residents in urban areas mainly in Nairobi. It is an ambitious project with 500,000 houses set to be built (Amwayi, 2018). The house prices in relation to current market structure that is private investor driven juxtaposed with intervention by government on the affordable segment is unclear to investors. It is still not clear in literature how the confluence of all these fundamental factors affects house prices. What will be the impact of government intervention on the supply side of the market? Does the use of average ask prices to track house prices in Nairobi appropriate? In other markets house price indices are constructed to track pure price changes adjusting for differences in property characteristics.

Residential real estate is an important asset class for individual and institutional investors globally. Investors' returns namely rental yield and capital gains is 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 its determinants. In literature, price has been characterised as either actual transaction prices, ask prices or appraised values. It is these different meanings of prices that have been deployed in research. The outcome of these studies may have different meanings and implications due to biases inherent in the different characterisation of prices. Specifically, in this study context (Nairobi), previous studies have mainly been based on ask prices and indices that use median or average house prices (Mwololo, 2014; Makena, 2012). The resulting prices changes do not account for changing characteristics of houses. This important gap is addressed by adopting the hedonic model to estimate pure price changes based on actual transaction prices controlling for house characteristics. The hedonic approach also provides an additional insight into determinants of house prices since it statistically shows the relationship between house

prices and the primary characteristics such as location, size, house type and number of bedrooms. 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.

The second problem with residential real estate prices is in the understanding of its determinants. The determinants of house prices may include property characteristics, economic factors (that characterise demand drivers), rent and property supply. Emphasis and the pattern in empirical literature has been the study of the effect of the foregoing determinants (individually and independently) on house prices (Sections 1.1.1, 1.1.2 & 1.1.3). Fewer studies have adopted a comprehensive approach (Belke & Kiel, 2018; Sorina, 2014; Case & Shiller, 1990). The current study seeks to bridge this gap by adopting a comprehensive approach to determining real estate prices in the chosen context of Nairobi. Firstly, the primary determinant of house prices is property characteristics such as location, size, type etc. Empirical evidence for Nairobi lacks a deep dive into establishing the effect of house characteristics and prices. This study addresses this gap comprehensively with a ten-year study period. Besides, shedding light on the relationships, the hedonic model culminates into a house price index. Secondly, literature is scanty in relation to rent as a determinant of house prices in Nairobi. Matete (2021) studied rent for office space in Nairobi. The current study addresses this gap by modelling rent value using hedonic model culminating into a rent index, the first academic study to do so for Nairobi to the best of the authors knowledge. The developed rent index is then used to establish relationship with house prices in the context of other factors. Specifically, the possible mediating effect of rent. Thirdly, there is extensive research on the effects of economic factors on house prices.

However, there are contradicting findings on the effect of inflation (Zhou, 2021, Kibunyi et al., 2017; Kearl, 1979; Wurtzebach et.al, 1991; Quan 1999) and interest rates. This study addresses this gap by evaluating the relationship of economic factors and house prices in the context of property supply indicators in Nairobi in attempt to extend the boundaries of knowledge.

In summary, there are gaps in relation to characterisation of residential real estate prices, the significance of property characteristics in house pricing, the effect of economic factors in the context of property supply, and the role of rent as a mediator in the way other factors affect house prices. The current study has been conceptualised to holistically look at the interplay of all these factors in determining house prices specifically in Nairobi residential real estate market. The gaps in characterisation of house prices and importance of house characteristics are addressed simultaneously through construction of the Nairobi house price index based on actual transaction prices using hedonic model. The gap relating to rent value is addressed by first developing the Nairobi rent index that adjusts for property characteristics using hedonic model. Then the mediating effect of rent on the relationship between economic factors and property supply is studied. The gaps relating to economic factors is dealt with by incorporating property supply to better understand the combined effect of these two fundamental factors on house pricing. The research aims to answer the following question:

What is the relationship among economic factors, rent value, property supply and residential real estate prices in Nairobi?

1.3 Research Objective

The objective of this research is to establish the relationship among economic factors, property supply, rent value and residential real estate prices in Nairobi. The specific objectives include:

a) To establish the effect of economic factors on residential real estate prices.

b) To establish the effect of property supply on residential real estate prices.

c) To determine the mediating effect of rent value on the relationship between economic factors and residential real estate prices.

d) To determine the mediating effect of rent value on the relationship between property supply and residential real estate prices.

e) To establish the joint effect of economic factors, property supply, and rent value on residential real estate prices.

1.4 Value of the Study

This study stands to benefit different stakeholders interested in factors affecting housing 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 and further academic pursuits in an endeavour to establish the determinants of housing prices beyond the current state of play. The study can inform efficient market hypothesis by empirically testing whether the housing prices are affected by fundamentals or market noises. The results indicate that house prices are affected by economic factors, property supply and rent value. The study also found that bulk of short run deviations from the equilibrium

relationship among the variables are corrected in the subsequent quarter. These findings support EMH and the tenets of the stock flow model.

The study found that GDP, inflation, and property supply significantly affect real estate prices. GDP and property supply directly affect real estate prices whereas inflation is partially mediated by rent value. The study developed residential price index and rent index that can track performance in real estate sector. The outcome of this study will help practitioners and investors both individual and institutional when making investment decisions and in portfolio management. Price and rent indices can be used as benchmarks for portfolio performance attribution. Besides, the indices can herald new securities products in the market such as real estate index funds. Such products can offer investors indirect exposure to real estate market plus hedging opportunities.

Banks and Mortgage Institutions will find the determinants of housing prices useful in mortgage pricing through monitoring price and rent indices. Changes in GDP, inflation and property supply may trigger adjustments to loan-value ratios by banks to enhance collateral. Policy makers in National and County governments may find basis in the rent and price indices together with house price determinants for formulating property tax amongst other things. Regulators may benefit from the study including Capital Market Authority, Retirement Benefit Authorities, Insurance Authorities and Central Banks whose licensees are heavy investors in real estate. These regulators may use the price and rent indices to inform the investment guidelines and other prudential guidelines issued to their licensees. Besides, Central Banks will benefit because of implication of housing price and rent movements on monetary policy. Real estate market may affect consumer price index (CPI) and can be an indicator of the state of the economy. Therefore, Central Banks may

formulate monetary policy interventions informed by the turning points in the real estate market.

1.5 Organisation of the Thesis

This thesis has six chapters. The first chapter is introduction of the study that justifies the study. The key variables of the study are defined and described briefly to highlight the emerging issues. Also, the theories on which the study is anchored are outlined. The chapter also provided a background on the context of the study which is the Nairobi County residential real estate market. The research problem section highlights the current state of play and the emerging research gaps that the study pursued. In addition, the research question and the objectives are documented. The chapter also identifies the beneficiaries of the study including how they stand to benefit from the findings of the study.

Chapter two begins with a discussion on the key theories relevant for the study. This is followed by an elaborate documentation of the empirical evidence on the key concepts of the study. A synthesis of the empirical literature is provided highlighting the emerging research gaps. The conceptual framework is then presented depicting the relationship among the key variables of the study. This is followed by formulation of the hypotheses to be tested.

Chapter three summarises the research methodology. It begins with justification of the research philosophy and design adopted for the study. A description of the population, sample and data collection method is presented. Specifically, the unit of analysis is identified as the Nairobi residential real estate market. A sample of house sale transactions in this market is identified to be studied over ten years (2011 – 2020) to establish the

determinants of residential real estate prices. Operationalisation of the study variables is also presented in this chapter. The chapter also discusses the diagnostic tests done to check suitability of the data and consequently the validity of the outcomes. Finally, the analytical models used to test the research hypotheses are presented.

In chapter four, the house price index and the rent index are constructed to operationalise real estate prices and rent value, respectively. This is followed by descriptive analysis of all the study variables including trend analysis. The results of the diagnostic tests are summarised together with implications on analytical models adopted. The chapter closes with a discussion on the outcome of the correlation analysis.

Chapter five presents the results in line with the objectives of the study. This is followed by a detailed discussion of the findings juxtaposed with current literature and theory. The chapter closes with a summary of the findings.

Chapter six begins with key findings based on chapter five. Research conclusions are presented based on the study objectives. This is followed by contributions to knowledge, practice, and policy. The chapter also highlights the limitations of the study. Finally, suggestions for future studies are made.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The literature review section has three broad sections. The first is a discussion of the key theories that anchor this study. The second section is review of empirical literature. The third section presents a summary of empirical literature, research gaps followed by the conceptual framework and research hypotheses.

2.2 Review of Key Theories

This section describes four broad theories that attempt to explain the movement in real estate prices: Efficient Market Hypothesis, Behavioural Finance, Stock Flow Model and Hedonic Pricing Model. The underlying principle in stock flow model 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. Hedonic pricing model provides a framework for pricing property characteristics such as size, location, house type, availability of green space, quality of finishing and availability of amenities. It helps in controlling for quality bias in property pricing. Efficient market hypothesis posits that all the available information regarding a particular asset is reflected in market prices. The degree of efficiency depends on the speed with which markets incorporate information in pricing. Behavioural finance contends that investors are not necessarily rational and therefore pricing of assets should consider the behaviour of investors. Behavioural finance is credited to Kahneman (1979) who debunked the rational approach to decision making by investors.

2.2.1 Efficient Market Hypothesis

Fama (1965) published his dissertation postulating that prices of securities such as stocks follow the random walk process. In a market with different participants, it is expected that any information on a particular stock is quickly adjusted in the prices of the stocks. As such it becomes hard for traders to trade with the information and make profits. Fama (1970) coins three distinct forms of efficiency that may preclude abnormal profits from trades.

Empirical studies over the years have identified market anomalies that tear into the tenets of EMH. Such anomalies can still be exploited by investors. The development of behavioural finance may be an indication of the weakness of the EMH. This forms the basis for some of the pricing models that attempt to find patterns that may recur in the market with a view of acting on them for profit making. Anomalies in real estate market have been confirmed (Gau, 1987; Case & Shiller ,1990; Hamilton & Schwab,1985). This study looks at the effect of fundamental factors namely economic, supply and rent value on residential real estate prices. The changes in these factors are expected to be incorporated in real estate prices. It is expected that an increase in demand factors, reduction in supply and increase in rent value will have positive effect on residential real estate prices. The absence of strong influence by the fundamental factors may be an indication of market inefficiency.

2.2.2 Behavioural Finance Theory

There is a notion that investors are rational. Investors may not be patient and as such want to make gains on short term investing. The personality of a person can affect investment decision in real estate market. Therefore, when analysing demographics, analyst must consider behavioural tendency of investors. The assumption that investors are rational is

central to EMH. Over time another school of thought has developed. This school of thought contends that investors are not necessarily rational and therefore pricing of securities should consider the behaviour of investors. Behavioural finance is credited to Kahneman (1979) who debunked the rational approach to decision making by investors. He is famous for the prospect theory. De Bondt (2002) developed this further by explaining asset price bubbles psychology and their implications. Hamilton and Schwab (1985), Ndiritu (2015) found evidence of irrational behaviour on the part of household investors that rendered real estate market inefficient.

Biases may imply that people can create money machines. However, it is not evident that traders are able to make persistent abnormal returns on account of heuristics. As such the markets may be considered progressively efficient as information is incorporated in pricing. This study looks at the fundamental factors namely economic, property supply and rent value and how they influence residential real estate prices. It is expected that a decrease in demand factors, increase in supply and decrease in rent value will have negative effect on residential real estate prices. The absence of strong influence by the fundamental factors may be an indication of behavioural biases at play.

2.2.3 Stock Flow Model

Stock flow models attempt to explain the flow of money and different stocks of assets within an economy, it provides an accounting framework. Keynes (1936) developed the early framework of stock flow model. This was further developed into integrated stock flow consistent models (Godley & Lavoie, 2012; Caverzasi & Godin, 2015). Keith (2007) describes 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 resulting effect on the price. Consider residential housing units. Demand for real estate is characterised by economic factors such as GDP, inflation, household income etc. Besides, population demographics may influence demand. If the demand for housing units increases due to demographic factors, then available stock of houses must be checked. It is unlikely that there will be any houses available because supply is inelastic and takes long time to build new houses. This will cause the prices to increase. When demand fall the price decreases will be more than previous increases because of the durability of real estate. Construction of new units will be triggered by price increase which could be a function of increased rent.

The movement in prices through cycles is caused by mismatch in demand and supply due to inelastic nature of supply. It takes time to build new units. Once the new units are supplied in the market, it eases pressure on prices. Paradkar (2013) factored in uncertainty in the stock flow model to help explain the price movements. This is implemented with data on vacancy rates, existing stock of houses and employment data. This model does not consider other factors outside demand and supply such as irrational investors. The stock flow model will inform the research on the effect of economic factors and property supply on residential real estate prices and whether that effect is influenced by rent value.

2.2.4 Hedonic Pricing Model

Hedonic pricing model employs cross-sectional regression analysis using property characteristics as independent variables. The identified characteristics include size of the house, location, number of rooms, amenities available, age, parking, green space,

construction type etc. The thrust of this model is the assumption that investors buy certain characteristics in a house such as have been mentioned. Therefore, these characteristics must be priced individually before getting the aggregate figures (Kummerow, 2002).

The hedonic models were first developed by Lancaster (1966) and thereafter Kain and Quigley (1970) were the pioneers in applying to real estate. Kain and Quigley (1970) in their study included neighbourhood characteristics and distance to downtown. Malpezzi (2002) and Heikkila et al. (1989) modelled property location in their pricing models.

Sirmans, Macpherson and Zietz (2005) reviewed several studies that used hedonic model in pricing house prices. Age was found to have negative effect on prices in 63 out of 78 studies. Size of the house measured by square feet always had positive effect on prices. Half of the reviewed studies indicate that number of bedrooms positively affected prices, 25% of the studies had negative effect while the remaining 25% had insignificant effect on house prices. The effect of distance from the city centre on house prices was varied. One third of the studies indicated positive effect, the second third negative effect and the last third no effect on house prices. Besides, three-quarters of the studies found that presence of basement had positive effect on prices while 25% showed no significant effect on prices.

The weakness of hedonic model is in the model specification due to potentially many variables involved. Repeat sales model is an alternative model which can be used to develop indices with fewer variable requirements. However, repeat sales model picks only those houses that have been sold more than once hence suffering bidirectional price biases. The hedonic model will be used to calculate the residential property price index which operationalises the dependent variable of the study. Also, the residential rent index will be

developed using hedonic model to operationalise rent value. The calculated indices control for quality bias which make them suitable for the study.

2.3 Empirical Studies

This section presents a synthesis of the empirical studies. The first section examines the various models used in estimating house prices including construction of price indices. Such models include hedonic, repeat sales, moving average and atheoretical. The second section is literature on how rent value is estimated using various models such as hedonic and repeat rent method. The third section is a review of the relationship between rent value and real estate prices. The fourth section reviews evidence on the property supply and house prices. This is followed by the empirical review on economic factors and real estate prices. The last section captures the relationship amongst the above variables.

2.3.1 Residential Real Estate Prices

Residential prices refer to the values ascribed to real estate assets (Brueggeman, & Jeffrey, 2011). House prices are a key component of the residential market. House price indices track house price changes over time. Price movements may be due to pure price changes, changing characteristics of the house or a combination of both. Pure price changes reflect asset appreciation. Whereas changing characteristics due to redevelopment, renovation among others may influence price changes. It is therefore instructive and preferable to track price movements controlling for changing quality characteristics. The property prices used in developing the indices may also vary. This may include actual transaction prices, ask prices, appraised values, and opinion survey of players in the industry. There are different approaches to developing price indices.

Firstly, price index may be constructed using the average house prices of a sample of houses in a certain period relative to a previous or base period. Alternatively, the median prices may be used instead of average prices. The advantage of this method is that it is simple to implement. However, it fails to account for changing quality characteristics of the properties. As such it may be biased. In addition, the index may be distorted by price differentials in affluent and other locations. Segmentation and stratification of houses therefore is imperative in overcoming location biases. Some of the indices that use this method include the NAR index (US), REIA index (Australia) including Hass consult locally.

Secondly, repeat sales methods are used to develop house price indices. This method uses data on houses that have been sold more than once. Therefore, it tracks movements in prices for the same houses which is a desirable assumption. However, the method is considered inefficient since it leaves out a lot of data on houses not sold more than once. Besides, it does not account for changes in house characteristics such as renovation and upgrades that may occur over time. Therefore, the method may suffer from upward and downward bias. The key indices include Standard and Poor's/Case-Shiller index and Federal Housing Oversight Indexes in the US.

Thirdly, hedonic models have been used to construct house price indices. The key advantage of the hedonic models is that they adjust for characteristics and locational attributes of the properties. Therefore, it approximates closely the pure price changes. The key criticism of this method is model specification challenges since there are a myriad number of characteristics that can be included coupled with various ways in which they are operationalized. Also, sample selection bias may affect the outcome of the model. It is

worth noting that the other methods may still suffer from sample selection bias. Examples of indices that use hedonic are Halifax Home Price Index (UK), INSEE index (France), ZWEX (Switzerland) including Kenya bankers' property index (Kenya). The ensuing paragraphs provide a review of the empirical evidence on modelling house prices.

Sirmans, Macpherson and Zietz (2005) reviewed several studies that used hedonic model in pricing houses. Age was found to have negative effect on prices in 80% of the studies. Size of the house measured by square feet always had positive effect on prices. Half of the reviewed studies indicate that number of bedrooms positively affected prices. The next quarter of those studies reported negative effect while the remaining quarter indicated insignificant effect on house prices. The effect of distance from the city centre on house prices was varied. The study findings spread uniformly among those that reported positive, negative and no effect. Besides, 75% of the studies found that presence of basement had positive effect on prices while 25% showed no significant effect on prices. The foregoing demonstrates varied findings and therefore room for further studies. This paper leverages on this with application on rent pricing besides house price.

Zhou (2021) researched on the factors affecting real estate prices in China. This was motivated by rising prices that occasioned social problems. She identified seven factors and employed regression model using quarterly data covering 2005 to 2016. The model was implemented for eight regions in China. House prices were estimated as the average selling price in a specific quarter. Generally, money supply influenced prices positively in seven of the eight regions. The effect of inflation was positive in six of the eight regions. Interestingly, GDP was found to negatively affect prices in five out of the eight economic regions. Curiously also, household disposable income negatively affected house prices in

three regions while it did not have effect in the other regions. Finally, the effect of house size was mixed with some regions exhibiting positive while others negative effect. The study's shortcoming was its use of average prices for the indicators relating to property. The current study used individual house prices and characteristics to estimate price changes using hedonic model.

Fraser and Allen (2016) sought to determine the premiums paid for houses with golf membership. They studied houses in Fort Myers County in Florida, US. Data relating to 800 sale transactions completed between 2003 and 2012 was collected and analysed. They included other house characteristics as control variables when estimating the effect of golf membership on prices. They concluded that houses with golf membership attracted 7.66% price premium. House size, presence of garage and the floor the house is situated on had positive and significant effect on prices. The number of floors in the building did not have effect on prices. Also, the property's view of the golf course did not affect the house prices. The study was limited to only one real estate project in a single County in Florida. As such, generalization of the findings may be constrained.

Acharya, Basu and Hanink (2022) researched on the effect of locational attributes on house prices in Las Vegas, US. The research focused on cell towers and house prices given the health concerns that residents are thought to have. They employed spatial hedonic models using data from 2014 to 2017. They find that distance from the cell tower is positively related to house prices. Also, the height of a cell tower negatively affects property prices. However, the visibility of a tower from the house did not influence house prices. The paper focused on only one locational attribute namely cell tower. The current study seeks to provide evidence from Nairobi incorporating locational attributes.

Ozalp and Akinci (2017) investigated how environmental and structural characteristics of properties affect house prices. They used data on 81 houses sold during 2015 in Artvin City in Turkey. They employed hedonic regression to test hypotheses. Their findings indicated that age of house and size had significant influence on prices. Besides, location was an important variable since the distances from city centre and schools affected house prices. The shortcomings of the study include the use of a small sample size and shorter study period. The current study addressed this by extending the study period to ten years.

Ayan and Erkin (2014) studied the factors affecting apartment prices in Metropolitan Izmit area in Turkey. They specified hedonic model with house characteristics, locational attributes and segments representing the major apartment complexes as the explanatory variables. House size, number of bathrooms and air quality positively influenced apartment prices. However, low construction quality, distance from city centre, lower floor level apartments and age exhibited negative effect on prices. Segmentation of the apartment complexes indicates significant variation in prices across submarkets. The current study built on this by factoring market segments in Nairobi. In addition, the current study looked at other property types besides apartments over a ten-year period.

Zheng (2014) researched Singapore private housing market. She used the hedonic model to establish the determinants of house prices. Data consisted of 8,870 transactions for 2013. She found that house size had direct relationship with prices. However, the age of the house negatively affected house prices. In addition, houses under construction are highly priced relative to completed houses. Besides, floor level up to twentieth had no effect on house prices. However, higher floor levels exhibited a significant positive relationship with prices. Number of bedrooms had no effect while population density level depicted negative

effect on prices. Cultural beliefs such as Feng Shui also had a significant effect on prices. The current study extended the study period to ten years with new evidence from the Kenyan context.

Montero, Mínguez and Fernández-Avilés (2018) modelled house price prediction in Madrid, Spain. The study used traditional and spatial hedonic models. House size, floor location, air conditioning, garage, presence of swimming pool and elevator positively influenced apartment prices in Madrid. On the other hand, age, house type, crime rates, number of immigrants and number of dependent children showed negative effect on house prices. They also find that non-linear models provide better price prediction. The study was limited to the first quarter of 2010. The current study examined the contextual difference with an extended study period covering ten years.

Hill, Rambaldi and Scholz (2021) studied house prices in Sydney, Australia for the period 2001-2014 using hedonic imputation method. They used spacio-temporal method to improve the effectiveness of hedonic for high frequency housing data. They tested the prediction accuracy of the state space model and the traditional hedonic model relative to the repeat sales index. They find that state space model outperforms the traditional hedonic model as evidenced by the RMSE. This was especially key at high frequency data such as weekly as was case in their study. The current study focused on Nairobi, Kenya. It also, included economic and property supply in determining house prices.

Bin (2004) researched on prediction of house prices in North Carolina. The period of the study was 2000-2002, covering 2,595 home sales. He used both semi-parametric and parametric regression models with locational attributes incorporated using GIS. He found

out that semi-parametric model outperforms the conventional model in predicting house prices. The study focused on only one county in North Carolina. Therefore, different contexts may result in different outcomes.

Shetty et al., (2020) sought to compare the valuation of properties using different methods. They proposed multiple regression analysis as an alternative to the traditional appraisal methods. The appraisal methods include rental income approach, composite rate method, detailed estimation, and land & building method. They estimated the model using data on twenty comparable properties. The data included house price, age, location, number of rooms, surface area, number of floors and access road. The estimated model was used to calculate the value of a target property. They find significant variation in prices compared to the traditional methods. However, the estimates from traditional appraisal methods were closer to the market values. The study was limited to the extent that the model was based on twenty properties and predicted price for only one property. The current study used a hedonic model with a larger sample and extended period of ten years to estimate the model. Also, a city-wide approach was used as opposed to a single property.

Kim et al., (2015) researched the residential market in Seoul, Korea. They employed quantile regression model on data covering 2006 – 2012 for three sub-regions. The overall results indicate that size, apartment floor level and total building floors positively affect house prices. Age exhibited negative effect in concert with majority of literature. Apartments with scenic views and within walking distance of schools had higher prices. The effect of scenic views is greater in high-priced areas. While the effect of proximity to schools is far greater in low-priced areas compared to high-priced areas. This underscored the importance of stratifying the regions. The study did not augment economic and other

factors that drive house prices. The current study modelled house prices using hedonic model incorporating supply and economic variables including rent.

Kryvobokov and Wilhelmsson (2007) studied location attributes and apartment prices in Donetsk, Ukraine. The study used the hedonic model to analyse 325 apartments that were on sale in February 2005. The study used ask prices and compared the results with those of valuation experts. The results indicate that distance to CBD and prestigious areas had significant effect on prices. However, locational attributes such proximity to water body, secondary centre and nuisance was critical for apartments located far from the city centre. The findings are contrary to the location weights usually assigned by valuation experts in Donetsk. The shortcoming of the study was smaller sample size and use of asking price instead of actual transaction price. The current study used a bigger sample over ten years and used actual transaction prices instead of asking lists.

Villada et. al (2022) modelled house prices in Medellin, Columbia. They adopted clustering and kriging methodology to incorporate locational attributes. Data relating to 293 properties spanning 2014 – 2019 was used. The information used included number of rooms, bathrooms, age, geographic location, built-up area, type of property and appraised prices. They found that clustering based on house size and age was sufficient and inclusion of other variables did not provide meaningful information. The models used included circular, exponential, gaussian and spherical. The circular model with three sub-markets identified by clustering was the most efficient in predicting prices. The model minimised RMSE. The shortcoming of the study was the small sample size. The current study used a different context with a bigger sample size covering ten years.

Kaya and Atan (2014) looked at how house features affected property prices across different regions in Turkey. The study period was between 2010 and 2012 with the hedonic approach used in estimating the model. They report that house size, presence of balcony and elevator positively affected house prices. Besides, they reported that luxury houses and those with high quality of finishing had higher prices. Houses located on middle level floors were assigned low prices compared to those on higher floors. The same was reported regarding house size as measured by surface area. Properties with surface area of up to 250 square metres had negative relationship with prices. However, house prices started to increase as house size increase beyond 250 square metres. The study also concluded that changes in house prices was dependent on location. Istanbul experienced the highest price increases followed by Ankara and finally Izmir. The current study improved the study in Turkey by expanding the sample size and study period.

Selim (2008) sought to understand the effect of house characteristics on house prices in Turkey. He sourced data from the official 2004 household budget survey. The Hedonic model was used on a sample of 5,741 households. The findings indicate that houses in the urban areas had higher prices relative to rural areas. Number of rooms and house size positively influenced house prices. However, the marginal effect of size reduces with increase in size. All other house types including fully detached were priced lower relative to duplex. This is contrary to expectation as one would expect detached or standalone houses to have higher prices. The age of the house exhibited a negative relationship with prices as expected. However, properties older than twenty years had higher prices. Houses built using stone, timber, mudbrick had lower prices relative to ferroconcrete. The research

was limited to data for the year 2004. The current study looked at a longer period and a different context to enrich literature.

Oust, Hansen and Pettrem (2020) studied the house market in Oslo, Norway. They used data covering seventeen months between August 2016 and December 2017. The methodology adopted was a mix of repeat sales and the hedonic models with spatial enhancements. They find that inclusion of repeat sales method enhances prediction accuracy of house prices. The improvement in prediction was about 6.8% to 9.5%, which could be attributed to the mix model and spatial effects. The paper covered data for seventeen months only. The current study provided empirical evidence from Nairobi, Kenya with a longer study period.

Gupta, Kabundi and Miller (2011) modelled house prices in twenty US states. They used VAR and BVAR models with the data period being 1976 – 1994. The study tested prediction accuracy of the models using out of sample data. They find that the spatial BVAR models provided the best estimates of house prices. Augmenting macroeconomic factors in the models only improved the house price forecasts in thirteen out of the twenty states. The current study sought to provide additional evidence on the effect of macroeconomic factors on house prices in Kenya with inclusion of property supply factors.

Adair et al., (2000) studied the effect of property characteristics, location, and accessibility on prices in Belfast urban area. The focus of the study was accessibility, which may be affected by different modes of transportation such as private cars and public systems, among others. They operationalize accessibility using an index which they use in 182 traffic zones. They also sampled 2,648 houses that were sold in 1996. The findings

indicated that accessibility did not influence house prices in Belfast. However, they also stratified the city into high-income and low-income areas. Accessibility was found to have significant influence on house prices in low-income segment with contrary evidence in affluent areas. The study period was short given that it covered only one year. The current study factored in location differences and sought to provide empirical evidence in Kenya with a longer period of study.

Dubin (1998) looked at predicting house prices in between sales. He used multiple listing data in Baltimore, US. Traditional hedonic model was used with the addition of correlation of the prices of neighbouring houses. The results indicated that incorporating spatial correlations improved the accuracy of the predicted house prices. The number of rooms, baths, house size, and availability of parking had a positive effect on prices. The age of the house and number of stories negatively affect house prices. House type whether detached, semi-detached or apartments did not affect house prices. The study was limited to only one year. The focus of the current study was ten years in a different context.

Conway and Dale-Johnson (1994) studied house prices in the Los Angeles metropolitan area. The focus was communities within a metropolitan area. Data was collected for 300,000 property transactions for the period between 1971 – 1991. They find significant variations in housing characteristics and prices over time and across cities. Living space was found to account for 80% of the variation in prices across sub-markets. They assert that drilling to submarkets may reduce the need for many predictor variables in hedonic models. The current study provides empirical evidence from Nairobi employing hedonic models augmented with other fundamentals.

Wolverton and Senteza (2000) studied property market in the US. They used data from the National Association of Realtors for the period 1986 – 1992. The study aimed at examining the effect of house characteristics on prices and how that varies across different regions in the US. They found that house size, house type, age and location significantly affect house price. In addition, they conclude that the existing indices understated price variance since they do not account for regional differences. The current study seeks to determine pure price changes in house prices in Nairobi controlling for house characteristics and locational attributes.

Choy, Mak and Ho (2007) researched house prices in Hong Kong using one year data with 747 observations. Besides, incorporating the physical characteristics of the property, they also factored a Chinese cultural attribute known as feng shui that is rooted in superstition. This cultural attribute was operationalised by the apartment floor number since there are floors that are considered lucky and unlucky. They found size, age and location significantly affect house prices. However, location was measured in terms of access to transport, sea view and the apartment floor number. They also find that apartments located in unlucky floor number were sold at discount. However, lucky number did not exert effect on prices. This study sought empirical evidence from Kenya and used a longer study period covering ten years.

Zietz, Sirmans and Smersh (2008) studied single-family home sales in Florida, US. The study period covered 1,500 home sales over one year. They used quantile regression to determine the marginal valuation of property characteristics. They found that home prices are significantly influenced by size, location, and age of the homes. Besides, they conclude that the property

characteristics are valued more for high-priced homes compared to low-priced homes. The current study seeks to obtain empirical evidence in the Kenyan market.

Al-Marwani (2014) studied modelling and forecasting real estate residential property market in Manchester City in United Kingdom. He used both all-UK property indexes and specific property type indices such as for detached, semi-detached, flats and terraces. His main contribution was in forecasting real estate prices for different property types within Manchester city. He found that simple ARIMA models fitted well the data and could be used for forecasting including factoring seasonality. Th current study provides evidence from Kenya by including other variables such as rent.

Sklarz et al. (1987) studied the Autoregressive (AR) and ARIMA models using US property data. The study found that AR did a better job than ARIMA in forecasting housing prices. This was the case owing to low forecasting errors in AR compared to ARIMA. Brooks and Tsolacos (2000) researched the UK market and made use of CB Hiller Parker series. They used AR, Vector Autoregressive (VAR), and random walk models. They find AR model to best fit the estimate and does a better job in forecasting compared to the other models. The current study addresses the contextual differences and incorporates house characteristics in pricing.

Birch and Suderman (2003) employed exponential smoothing when estimating residential prices. It was an improvement to the overreliance on ARIMA models. The forecast based on their technique did not outperform those of traditional hedonic models as was expected. Nevertheless, the model used in the study was able to surmount some of the challenges

associated with regression models. The study did not focus on fundamental economic variables. The current study incorporates house characteristics in pricing.

Hepsen and Vatansever (2010) studied Dubai residential prices. They used the Box Jenkins ARIMA model to forecast prices. They find the model to be appropriate. However, Stevenson (2007) asserts that ARIMA models have a bias on the model specifications thus giving varied outcomes. They studied Irish market and deployed ARIMA, VAR and Ordinary Least Squares (OLS) models. They find ARIMA models to be superior to the other models when the market sets aside the fundamentals. The current study incorporates house characteristics and economic fundamentals in pricing houses.

Clapp and Giaccotto (2002) studied house prices in Dade County in Florida. They used the several AR models, repeat sales and hedonic models in forecasting real estate prices in that County. They performed one step ahead forecasts. They concluded that the hedonic model outperformed the other models. The current study addresses the contextual differences and uses hedonic model to price houses in Nairobi.

Guirguis, Giannikos and Anderson (2005) in their study employed six methods using quarterly data between 1975 and 2002 drawn from US housing market. The techniques used included AR, VECM, Kalman filter and Random Walk (KRW), Kalman filter and Autoregressive (KAR), GARCH and exponential smoothing. They find that GARCH and KAR models outperform the rest when it comes to out of sample forecasts. The current study addresses the contextual differences and incorporates fundamentals such as house characteristics.

Crawford and Fratantoni (2003) studied the US housing market. They used ARIMA, GARCH and regime switching models to test their performance in both in sample and out of sample forecasts. The regime switching model was introduced to try and account for structural breaks and cycles in the market. They find that ARIMA family was the best in out of sample forecasts. Regime switching emerged more efficient with in-sample forecasts. The current study includes fundamental determinants such as supply, economic factors, and house characteristics.

Miles (2008) extended the work of Crawford and Fratantoni (2003). They included additional models namely Generalised Autoregressive (GAR) and bilinear models. They find that GAR was better than ARIMA model a departure from the findings in Crawford and Fratantoni (2003). They concluded that this was the case due to high volatility. Rapach and Strauss (2009) also studied the US market. They find that the AR models and economic models are efficient in forecasting house prices. Gupta (2010) researched twenty US state and used Bayesian Vector Autoregressive (BVAR) and VAR models to forecast house prices. They performed one step and four step ahead forecasts between Q1 2007 and Q1 2008. They found that BVAR model was better than the VAR models as evidenced by the average Root mean squared errors (RMSEs). The current study includes fundamental determinants such as supply, economic factors, and house characteristics.

Barari, Sarkar, Kundu and Chowdhury (2014) studied the US market with a focus on the existence of structural breaks. They first identified the structural breaks in the price indices and then deployed various models to make forecasts on prices. They used data for the period between 1995 and 2010. They find that indeed the real estate price series exhibited structural breaks. Upon running the models on the series with the breaks, they conclude

that ARIMA models fall short of the reality of real estate dynamics. The current study includes fundamental determinants such as supply, economic factors and house characteristics.

2.3.2 Rent Value

Rent is consideration paid to the owner for use of property. Rent is reward to factor of production namely land and all that is attached on it permanently (Brueggeman & Jeffrey, 2011). There are several factors that may influence rent values. This may include house characteristics such as size, number of rooms, house type, presence of basements, number of bathrooms, house type etc. Besides, locational attributes such as distance to the city centre, shopping malls, schools and scenic views may drive rent price. Also, macro variables such as population, economic growth, household income among others can affect rent price.

The hedonic pricing model anchors the relationship between house attributes and rent. Hedonic model has its origin in Lancaster (1966) and further developed by Kain and Quigley (1970). The thrust of this model is the assumption that tenants pay for certain characteristics in a house. Therefore, these characteristics must be priced individually before getting the aggregate figures of the property. As such, the rent price is the aggregate of the prices of individual property attributes.

The study is anchored on the hedonic pricing model. The model employs cross-sectional regression analysis using property characteristics as independent variables. The identified characteristics include size of the house, location, number of rooms, amenities available, age, parking, green space, construction type etc. The weakness of hedonic model is in the

model specification due to potentially many variables involved. This includes both observed and unobserved variables. Repeat rent model is an alternative model which can be used to develop indices with fewer variable requirements. However, repeat rent model picks only those houses whose rent have changed more than once hence suffering bidirectional rent value biases. It also requires robust data tracking repeat rent, which is a challenge, especially in Kenya.

As discussed in the preceding sections regarding house price index, rent indices may be constructed the same way. House rent indices track house rental changes over time. Rent value movements may be due to pure rent changes, changing characteristics of the house or a combination of both. Pure rent changes reflect inflation. Whereas changing characteristics due to redevelopment, renovation among others may influence rent changes. The rent values used in developing the indices may also vary. This may include actual rent based on leases, ask rent published by realtors, and opinion survey of players in the industry. There are different approaches to developing rent indices.

Firstly, rent index may be constructed using the average rent prices of a sample of houses in a certain period relative to a previous or base period. Alternatively, the median rent values may be used instead of average rent. The advantage of this method is that it is simple to implement. However, it fails to account for changing quality characteristics of the properties. Secondly, repeat rent methods are used to develop house rent indices. This method uses data on houses that have been leased more than once occasioning change in rent. Therefore, it tracks movements in rent for the same houses which is a desirable assumption. However, the method is considered inefficient since it leaves out a lot of data on houses not rented more than once. Besides, it does not account for changes in house

characteristics such as renovation and upgrades that may occur over time. Thirdly, hedonic models have been used to construct house rent indices. The key advantage of the hedonic models is that they adjust for characteristics and locational attributes of the properties. Therefore, it approximates closely the pure rent changes. The key criticism of this method is model specification challenges since there are a myriad number of characteristics that can be included coupled with various ways in which they are operationalized. The ensuing paragraphs provide a review of the empirical evidence on modelling house rent.

Zisheng, Mats and Zan (2020) analysed Beijing market in China. They constructed rent housing rent index using hedonic model. The data period covered 2016 to 2018. They find size and number of bedrooms and house type have significant effect on house rent. The study was limited to a short study period (2016 – 2018). The current research addressed this by expanded the study period to ten years. Hoffmann and Kurz (2002) studied West Germany for the period 1985 to 1998. Their findings are like those of Zisheng, Mats and Zan (2020). Rezaeian, Asgari and Heshmatolah (2019) studied Ilam city in Iran. They modelled the housing rent using hedonic model. Physical variables, neighbourhood variables and access variables significantly affected rent. Interestingly, rooms and house type were reported not to have significant influence on rent prices.

Malpezzi, Ozanne and Thibodeau (1987) studied the US market. They found that the number of rooms, bathrooms, garage, and neighbourhood have positive effects on rent. However, age of the house, persons per room and length of tenure had negative effect. Frew and Jud (1988) on the other hand established that vacancy rate and number of floors positively influenced rent. While house age had negative effect on rent. These studies

provided evidence in the US market. There is need for empirical evidence from a different context such as Kenya.

Ambrose, Coulson and Yoshida (2015) studied rent values in the US. This was motivated by the rent's behaviour during the global financial crisis. Data was sourced from Experian RentBureau covering thirteen years (1998 - 2010). The collected data excluded existing renters but considered only newly signed leases to capture current information. The study covered properties outside of large metropolitan areas an improvement to the data used by Bureau of Labour Statistics. The researchers constructed quarterly rent index using repeat rent methodology. The research suffered the same limitations of the repeat sales index used for house prices. The current study provides new empirical evidence in Nairobi, Kenya using the hedonic model in constructing rent index.

Wickramaarachchi (2016) focused on a case study of a boarding home area in Sri Lanka. She considered physical attributes, locational factors and amenities services and their effect on rental value. Size measured by floor area per person, location measured by distance to the university and number of bedrooms had significant effect on rental value. The research was limited to only a small area targeting housing for university students. The current study expanded this to a larger sample and longer study period for Nairobi city in Kenya.

Empirical evidence from Kenya is not extensive. Kimani, Kuria and Ngigi (2021) analysed spatial factors affecting rental house prices in Nyeri County, Kenya. They collected data from 250 households through questionnaires and interviews. Population density, land value, proximity to towns, distance to road and slope were found to have a significant effect

on rent. The research was limited to a smaller sample of 250 households. The current study focuses on Nairobi with a larger sample and longer study period spanning ten years.

Matete (2021) researched on the determinants of office rents in Nairobi Central Business District (CBD). He identified location, office and lease characteristics as the main factors influencing office rent. He applied multiple regression models using a sample of 156 office buildings to test the hypotheses. His findings indicate that size, age, and management positively affected office rent. However, the lack of parking, floor number and type of finishes negatively affected rent. The focus was on office rent, but the current study looks at house rent. The current study develops residential rent index for Nairobi using hedonic model.

Guerrero (2023) researched on the determinants of rental rates in Los Angeles in the US. The study period was 21 years focusing on location factors, income demographics and building characteristics. Age, size, location, building height and occupancy rates were reported to have a significant effect on rent rates. However, availability of gym had no impact on rent. Interestingly, occupancy rates had a negative effect on rent, but this could be seen as an incentive given by property owners to reduce vacancy rates. The current study sought to provide empirical evidence from Kenya.

Belete and Yilma (2020) sought to determine factors affecting market rent in Addis Ababa, Ethiopia. They selected and studied 164 apartments. They considered fifteen factors which the analysed using multiple regression. The paper established that access to balcony, number of bedrooms, security of compound, hand significant impact on market rent. In addition, access to road and parking were reported to influence rent, However, the number

of bathrooms and floor level did not have significant effect on market rent. The current study enlarges the sample including multiple locations, house types and longer study periods in Nairobi, Kenya.

Darfo-Oduro (2020) provided empirical evidence from Accra Ghana regarding the determinants of house rental prices. He sampled 150 households and deployed multiple regression analysis. Distance to CBD and places of worship, access to electricity, availability of refuse dump showed significant relationship with rental price. In a departure from previous studies, they found that bedroom size and age of building did not have effect on the house rent. The study was limited to Accra, Ghana, and a smaller sample size of 150 households. The current study addressed this by exploring Nairobi with a longer study period and a larger sample size.

The importance of housing in any society cannot be discounted. The need for affordable housing is crucial. Therefore, understanding how rent is priced is welcomed. There are hardly studies in Kenya that have focused on rent pricing. This has motivated this study as it seeks to obtain empirical evidence from Nairobi the capital city of Kenya.

2.3.3 Rent and Residential Real Estate Prices

Ambrose, Eichholtz and Lindenthal (2013) studied the house market in Amsterdam, Netherlands. The objective was to establish the relationship between house prices and rent. The study period was 355 years between 1650 and 2005. They operationalized house prices and rent using indices from different sources. They find that price and rent have a long-run relationship. Therefore, the two may be affected by common fundamentals. The research also examined the deviations from the equilibrium by examining the rent-price ratio. They

find persistent periods of disequilibria. Subsequent corrections are through price adjustments and not rent. The current study used the hedonic model to construct the rent index and provide evidence from Kenya.

McNamara and Paul (1997) studied rent and real estate prices in United Kingdom. They used regression model with data collected over eight years. They found forecasts in residential prices are mainly driven by the growth in rental income underscoring the significant relationship between rent values and housing prices. They assert that long run prices are determined by rental income. The study did not consider whether rent is a consequence of the changes in macroeconomic factors that ultimately affect real estate prices. The current study looks at whether the effect of other fundamental factors on house prices are channelled through rent.

Malpezzi (1999) studied long run relationship of house prices and rental income in the US market. The study finds that reversions in real estate prices are because of movement in rental income. The error correcting relationship is market specific and is driven by price-income ratios. Similar findings were observed in Gallin (2006). The studies are specific to U.S. market and did not consider the interplay of other factors together with rent income in real estate prices reversals. The current study explores whether the effect of other demand and supply factors on house prices are transmitted through rent.

Larson (2011) sought to evaluate alternative methods of forecasting house prices post 2008 global financial crisis era. He used VECM to study key variables and their relationship with prices. He found significant long run relationships in personal income and rental prices in relation to house prices. Ghysels et al. (2012) assert that rent to price ratios fare

well in forecasting housing process especially in sample forecasts. These studies have context specific findings. Besides, it is not clear whether the effect of other factors such as economic and supply on real estate prices are transmitted through rental income. The current study addresses this by investigating the mediating effect rent income.

2.3.4 Property Supply and Residential Real Estate Prices

Breedon and Joyce (1993) researched on the relationship among housing stock, mortgage availability, income, demography, and housing prices in United Kingdom. Disposable income and demographic trends were found to have significant relationships. Interestingly, they observed that availability of mortgage affected supply of houses through investments which in turn affect the price of real estate. The study considered economic factors and cost of financing. However, the way rent income affects housing prices in the context of other factors was not considered.

Saks (2008) studied how regulatory factors affect supply of residential properties and demand. The study period was between 1970 and 1980. The key finding was that house prices increased marginally in areas with absence of construction barriers. However, volatile land prices were observed in areas with inelastic supply which is occasioned by regulation. The study focused on the U.S. property market and the finding may not be generalized. Besides, the study focused on property supply indicators specifically construction costs, barriers, land price and their effect on property prices in the absence of demand drivers and property characteristics.

Brooks and Tsolacos (2010) observed the significant relationship between vacancy rate and house prices. Vacancy rate depicts the supply/demand dynamics. Clapp (1993) also

asserts that actual vacancy rates exceed the natural rate an indication of oversupply in the market. This tends to negatively housing prices. These studies focused on the effect of vacancy rates on prices. The interaction of macroeconomic factors, vacancy rates, other property specific characteristics and housing prices in the context of other factors was not considered.

Glaeser, Gyourko, and Saiz (2008) come to the same conclusion with Saks (2008). They find that inelastic supply has an effect of increasing housing prices. They contend that the real estate cycles are a factor of supply dynamics as opposed to demand shocks. These two studies focused on the U.S. market and the finding may not be generalized. Besides, the studies focused on property supply and demand and their effect on property prices in the absence of property specific characteristics.

2.3.5 Economic Factors and Residential Real Estate Prices

Kibunyi et al. (2017) studied real estate prices and bubbles in Kenya using granger causality tests. They found positive relationship between house prices and loans, GDP, lending rates, diaspora remittances, and cost of construction. Inflation exhibited negative relationship. Besides, the study negated existence of a price bubble. However, the study did not include property characteristics and key supply factors.

Xiao (2015) researched on the Chinese real estate market motivated by its importance in the China's economy. The study tested empirically the effect of economic variables on the real estate prices. Real estate development investment, income, money supply and expected real estate prices were found to have significant influence. However, the findings are

context specific and may not be generalized. The influence of property supply factors and property specific characteristics was not considered in the study.

Kearl (1979) researched on the effect of inflation on housing prices. They find a negative relationship. Quan (1999) found conflicting results indicating that positive relationship due to the use of houses as a hedge against inflation. Wurtzebach et al., (1991) agrees that house returns cushions against inflation effects. The mixed findings amongst the studies may be due to contextual differences and other underlying factors. There is need to include additional factors such as property characteristics and supply indicators.

Miller and Sklarz (1986) studied leading indicators of market prices of real estates. They find that supply constraints, income, employment, and interest rates have long term relationship with prices. But the validity of any forecast depends on the correct choice of market indicators. Cameron, Muellbauer and Murphy (2006) find a significant relationship between demographics, interest rates and income in relation to real estate prices. In both studies, the effect of property attributes such as rent, location etc., were lacking.

Omboi and Kigige (2011) did research on economic drivers of real estate prices in Meru County in Kenya. Investors income emerged as a significant factor followed by demand for property and location. The study focused on Meru County only. Besides, the study collected opinions regarding demand, income, and location from real estate owners in Meru County. These opinions may suffer from bias affecting the findings. The study did not consider property supply factors.

Mwololo (2014) examined lending rates and residential prices in Kenya. He finds that lending rates have significant negative impact on the prices. The study also establishes that

GDP, unemployment, and inflation have positive influence on house prices. Makena (2012) studied determinants of residential market prices in Nairobi. She found that the level of money supply information was significant in determining real estate prices. The variables studied included interest rate, money supply, inflation, population growth, employment growth; all were significant. The effect of property supply and property attributes such as rent, location etc., were not considered in the study.

Ikromov (2009) focused on the land and house prices volatility in relation to key economic factors in the US market. The empirical findings indicate that land leverage, income and transport costs have significant positive relationship with volatility of house prices. On the other hand, transfer tax rates and household income were found to be negatively related to housing returns. The effect of property attributes such as rent, location etc. are lacking in the study. Besides, the study focused only on the U.S. market.

Al-Marwani (2014) studied forecasting of residential property market in Manchester City in United Kingdom. He used both all UK property indexes, specific property type indices such as for detached, semi-detached, flats and terraces. The study also combined Geographic Information System (GIS) with the fundamental economic variables in a bid to establish their relationship with house prices. Change in income was the only variable found to be significant in flats and not in other property types. The other variables namely inflation, council tax and employment, were not significant across property types. The researcher recommends multivariate models that can model prices for different properties simultaneously. Besides, GIS study can be extended with enriched observations and other variables to make it robust in forecasting. Another limitation of the study was that it focused

only on ARIMA family for the univariate time series models and failed to consider structural breaks and states.

Vishwakarma (2013) focused on the Canadian market and collected data between 2002 and 2011. He deployed ARIMA models that factored in economic variables inflation, exchange rates, interest rates and GDP. He finds that the ARIMA models in their simplicity outperform other previously used methods when it comes to short term determination of prices. The previously used methods were Kalman filter and VECM. The study did not consider property supply factors and only focused only on ARIMA family for the univariate time series models and failed to consider structural breaks and states.

2.3.6 Economic Factors, Property Supply, Rent Value and Residential Real Estate Prices

Belke and Keil (2018) researched on the fundamental factors that affect house prices in Germany. They sampled data covering the period 1996 to 2010 spanning 100 cities in Germany. House prices were operationalized by a house price index while several indicators were chosen for the fundamental factors. They used panel regression with 1,316 observations. The findings indicate that rent significantly influenced prices in a positive way. On the demand indicators, number of households, number of hospitals, income, number of sale transactions, and interest rates had significant and positive effect on house prices. Whereas, age of household dependents, unemployment, service sector labour influenced prices negatively. The property supply indicators had mixed effects. The number of newly constructed apartments had a positive effect on house prices. This indicated an undersupply of properties. The current stock of houses did not significantly

affect prices underscoring the supply problem. The current study sought to obtain empirical evidence in Kenya by constructing and using price and rent indices to address the contextual gaps.

Case and Shiller (1990) did massive research on the predictability of excess returns in US real estate market. They considered Chicago, Atlanta, San Francisco, and Dallas with data collected from 1970 to 1986. The excess returns were computed as the difference between property returns and treasury bill rates. They examined the relationship between the excess returns and a couple of factors including mortgage payment/income ratio, employment, construction costs, change in adult population, rent/price ratio, per capita income growth rate and marginal tax rates. They find that rent/price ratio, construction costs/price and change in adult population to have positive relationship with excess returns. The control variables of marginal tax rates and employment growths were also found to be significant. The study provided empirical evidence for the US market. There is need to research for contextual differences. Besides, an interplay of the factors could be researched to determine possible transmission mechanisms. The current provides empirical evidence in Kenya by constructing and using price and rent indices to address the contextual gaps.

Abraham and Hendershott (1996) researched on the efficiency of real estate prices in thirty metropolitan statistical areas in the US using repeat sales indices. They looked at the relationship of the property prices and lagged values of employment growth, real income, tax rate and change in construction costs. They find that real estate prices are more predictable in coastal and in land cities. Besides, the market prices are significantly affected by local supply shocks and elasticity mainly in relation to land. However, the study did not

consider property specific characteristics. Also, application of other pricing models such as hedonic could be considered in different contexts.

Wanjohi (2012) explored real estate pricing in Kenya. He did a case study of two properties. The properties were first valued using three traditional methods (income, capitalisation, sales comparison). The prices of the properties were then estimated based on the heterogeneous asset pricing model. He finds that the heterogeneous model is applicable in Kenya. However, the heterogeneous pricing model is susceptible to valuer's bias. It relies, heavily on judgement of the valuer. The current study explores the interplay of rent, supply, and macroeconomic factors on house values in Nairobi. The current study leverages on the hedonic model in constructing price and rent indices for Nairobi.

Sorina (2014) studied real estate market in Spain and Germany. Specifically, the focus was on the effect of residential building construction permits, mortgage credit, inflation, GDP, interest rate and labour costs on housing prices in Spain and Germany. The study was done for the period 1981 - 2009 for Germany and 1992 - 2009 for Spain. Number of constructions permits issued, and mortgage credit positively influenced house prices. The macro-economic variables did not have direct effect on prices, but they affected the supply side variables namely amount of credit and new construction permits issued. However, the study did not consider rent income and its effect on real estate prices. There are contextual differences that may not be generalised.

Brown (1997) identified key factors that drive real estate prices besides the market factors. The factors include location, economic factors, age of property and neighbourhood status. His observations were informed by the cyclic nature of the market compounded by

heterogeneity of real estate products. However, the study did not include the impact of property supply factors on real estate prices.

2.4 Summary of Empirical Literature Review and Research Gaps

The empirical evidence documented touched on key aspects including rent, house physical characteristics, location attributes, property supply and economic factors and joint effects. Table 2.1 captures contextual and knowledge gaps emanating from empirical review. It also discusses the way the current study addresses some of the gaps identified in literature.

Table 2.1: Summary of Literature and Research Gaps

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
Villada et al. (2022)	Modelled house prices in Medellin, Columbia.	Clustering and kriging methodology, Sampled 293 properties (2014 – 2019) period.	They found that clustering based on house size and age was sufficient and inclusion of other variables did not provide meaningful information. The models used included circular, exponential, gaussian and spherical. The circular model with three sub-markets identified by clustering was the most efficient in predicting prices.	The shortcoming of the study was the small sample size (293 houses)	The current study used a different context with a bigger sample size covering ten years.
Acharya, Basu, and Hanink (2022)	Effect of locational attributes on house prices in Las Vegas, US	Spatial hedonic models using data covering 2014 to 2017	Distance from the cell tower is positively related to house prices. Also, the height of a cell tower negatively affects property prices. However, the visibility of a tower from the house did not influence house prices	Focused only on one locational attribute, cell tower. There are contextual gaps.	The study sought to provide empirical evidence from Nairobi with market segmentation.
Zhou (2021)	Factors affecting real estate prices in China	Regression model using quarterly data (2005 – 2016)	Money supply influenced prices positively in seven of the eight regions. The effect of inflation was positive in six of the eight regions. GDP was found to negatively affect prices in five out of the eight economic regions. Household disposable income negatively affected house prices in only three regions. The effect of	Use of average house prices without adjusting for quality changes	The current study used individual house prices and characteristics. The study used hedonic model.

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
			house size was mixed with some regions exhibiting positive while others negative effect.		
Hill, Rambaldi and Scholz (2021)	House prices in Sydney, Australia for the period 2001-2014	Hedonic imputation method	They find that state space model outperforms the traditional hedonic model. This was especially key at high frequency data such as weekly used in the study.	Did not factor effect of rent and property supply. Also, there are contextual gaps.	The study focused on Nairobi, Kenya. It also, included economic and property supply in determining house prices
Kimani, Kuria and Ngigi (2021)	Spatial factors affecting rental house prices in Nyeri County, Kenya	Hedonic model using data on 250 households through questionnaires and interviews	Population density, land value, proximity to towns, distance to road and slope were found to have a significant effect on rent	Limited to a smaller sample (250 households). Also, context differences.	The current study focuses on Nairobi with a larger sample and longer study period spanning ten years.
Matete (2021)	Determinants of office rents in Nairobi Central Business District	Multiple regression models using a sample of 156 office buildings	Size, age, and management positively affected office rent. However, the lack of parking, floor number and type of finishes negatively affected rent	The study was limited to office space in Nairobi. There is contextual gap for residential market.	The focus was on office rent, but the current study looks at house rent. Also, the study uses a larger sample and longer study period spanning ten years.
Shetty et al. (2020)	Comparison of property valuation methods in India	Multiple regression analysis using 20	They find significant variation in prices compared to the traditional methods. However, the estimates from traditional appraisal methods were closer to the market values.	The study was limited to the extent that the model was based only on twenty	The current study used a hedonic model with a larger sample and extended period of ten years. Also, city-wide

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
		comparable properties		properties and predicted price for only one property	approach was used as opposed to a single property
Oust, Hansen, and Pettrem (2020)	House market in Oslo, Norway	Mix of repeat sales and the hedonic models. Data covering seventeen months.	Inclusion of repeat sales method enhances prediction accuracy of house prices. The improvement in prediction was about 6.8% to 9.5%, which could be attributed to the mix model and spatial effects	The paper used data covering seventeen months only	The current study provided empirical evidence from Nairobi, Kenya with a longer study period.
Zisheng, Mats and Zan (2020)	Constructed rent index for Beijing, China	Hedonic model. Data period (2016 – 2018).	They find size and number of bedrooms and house type have significant effect on house rent.	The study was limited to a short study period (2016 – 2018). Also, contextual differences need to be studied.	The current research addressed this by expanding the study period to ten years
Belete and Yilma (2020)	Factors affecting market rent in Addis Ababa, Ethiopia	Hedonic model using sample of 164 apartments.	Access to balcony, number of bedrooms, security of compound, had significant impact on market rent. In addition, access to road and parking were reported to influence rent. However, the number of bathrooms and floor level did not have significant effect on market rent.	The sample size (164 apartments) was small. The study was also limited to only one type of house (apartments).	The current study enlarges the sample including multiple locations, house types and longer study periods in Nairobi, Kenya.
Darfo-Oduro (2020)	Determinants of house rental prices in Accra, Ghana	Multiple regression analysis using	Distance to CBD and places of worship, access to electricity, availability of refuse dump	The sample size (150 households) was small. The	The current study enlarges the sample and

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
		data on 150 households.	showed significant relationship with rental price. However, bedroom size and age of building did not have effect on the house rent.	study was also limited Accra, Ghana thus contextual differences may arise.	longer study period for Nairobi, Kenya.
Belke and Keil (2018)	Fundamental factors that affect house prices in Germany	Panel regression with 1,316 observations	Rent significantly and positively influenced prices. Number of households, number of hospitals, income, number of sale transactions, and interest rates had significant and positive effect on house prices. Whereas, age of household dependents, unemployment, service sector labour influenced prices negatively. The property supply indicators had mixed effects. The number of newly constructed apartments had a positive effect on house prices.	Contextual differences, did not look at mediating or moderating effect.	The current study sought to obtain empirical evidence in Kenya using own developed price and rent indices to address the contextual gaps.
Montero, Mínguez, and Fernández-Avilés (2018)	House price prediction in Madrid, Spain	Traditional and spatial hedonic models.	House size, floor location, air conditioning, garage, presence of swimming pool and elevator positively influenced apartment prices in Madrid. While age, house type, crime rates, number of immigrants and number of dependent children showed negative effect on house prices.	The study was limited to the first quarter of 2010	The current study examined the contextual difference with an extended study period covering ten years.

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
			They also find that non-linear models provide better price prediction.		
Kibunyi et al. (2017)	Is there a bubble in in Kenya's Real Estate?	Granger Causality tests	Positive relationship between house prices and GDP, Diaspora remittances, lending rates, loans and cost of construction. Inflation exhibited negative relationship. The study negated existence of a price bubble	The study did not include the possible effects of property specific characteristics	The current study included rent value and property supply to enrich understanding of the price effects.
Ozalp and Akinci (2017)	How environmental and structural characteristics of properties affect house prices in Turkey.	Hedonic regression. Used 81 houses sold in 2015.	Age of house and size had significant influence on prices. Besides, location was an important variable since the distances from city centre and schools affected house prices.	Use of a small sample size (81 houses) and shorter study period (only 2015)	The current study addressed this by extending the study period to ten years.
Fraser and Allen (2016)	To determine the premiums paid for houses with golf membership in Florida, US.	Hedonic model	Houses with golf membership attracted 7.66% price premium. House size, presence of garage and the floor the house is situated on had positive and significant effect on prices. The number of floors in the building did not have effect on prices. Also, the property's view of the golf course did not affect the house prices	The study was limited to only one real estate project in a single County in Florida. As such, generalization of the findings may be constrained.	The current study used a larger sample spanning ten years. Also, it focused on a city rather than a district.
Xiao (2015)	Factors affecting real estate prices in China	VAR Model (China: 1998 - 2012)	Real estate development investment, income, money supply and expected real estate	The research did not include rent value, property characteristics,	This research on additional variables such as property supply rent value. Also, the

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
			prices were found to have significant influence.	and property supply	research focused on study Kenyan context.
Kim et al., (2015)	Residential market in Seoul, Korea	Quantile regression model on data covering 2006 – 2012 for three subregions	Size, apartment floor level and total building floors positively affect house prices. Age exhibited negative effect. Apartments with scenic views and within walking distance of schools had higher prices. The effect of scenic views is greater in high-priced areas. While the effect of proximity to schools is far greater in low-priced areas compared to high-priced areas	The study did not augment economic and other factors that drive house prices	The current study modelled house prices using hedonic model incorporating supply and economic variables including rent
Ambrose, Coulson and Yoshida (2015)	Studied rent values in the US.	Repeat rent index methodology. Data period (1998 – 2010)	The study was an improvement to the data used by Bureau of Labour Statistics. The collected data excluded existing renters but considered only newly signed leases to capture current information.	Context and methodological difference since scanty data in Nairobi is not capable of repeat rent methodology.	The current study provides new empirical evidence in Kenya using the Hedonic model in constructing rent index.
Al-Marwani (2014)	Forecasting real estate residential property market.	ARIMA Model (Manchester UK: 1998 - 2013)	Inflation, council tax and change in employment, were not significant across property types. Change in income was significant	Did not include rent value, property supply	The study focused on how macroeconomic factors affect house prices in the presence of property supply and rent value.

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
Sorina (2014)	Identifying factors impacting property values (Spain Germany)	Multiple Regression (Germany: 1981 - 2009; Spain: 1992 - 2009)	Constructions permits issued and mortgage credit positively affected house prices. The macroeconomic variables affected the supply side variables namely amount of credit and new construction permits issued.	Did not consider rent value and amenities	The current study aimed at establishing mediating of rent value. The research also studied the Kenyan context.
Ayan and Erkin (2014)	Factors affecting apartment prices in Izmit area in Turkey	Hedonic model	House size, number of bathrooms and air quality positively influenced apartment prices. However, low construction quality, distance from city centre, lower floor level apartments and age exhibited negative effect on prices. Segmentation of the apartment complexes indicates significant variation in prices across submarkets.	Contextual gaps. Also, the study focused on only one property type	The current study built on this by factoring market segments in Nairobi. In addition, the current study looked at other property types besides apartments over a ten-year period
Zheng (2014)	Researched Singapore private housing market	Hedonic model used data on 8,870 houses for 2013	House size had direct relationship with prices. However, the age of the house negatively affected house prices. Houses under construction are highly priced relative to competed houses. Floor level up to twentieth had no effect on house prices. However, higher floor levels exhibited a significant positive relationship with prices. Number of bedrooms had no effect while population density	Shorter study period of only one year. Contextual gaps.	The current study extended the study period to ten years with new evidence from the Kenyan context.

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
			level depicted negative effect on prices. Cultural beliefs such as Feng Shui also had a significant effect on prices		
Kaya and Atan (2014)	How house features affected property prices across different regions in Turkey	Hedonic model. Data period (2010 – 2012).	House size, presence of balcony and elevator positively affected house prices. Luxury houses and those with high quality of finishing had high prices. Houses located on middle level floors were assigned low prices compared to those on higher floors. Properties with surface area of up to 250 square metres had negative relationship with prices. However, house prices started to increase as house size increase beyond 250 square metres. Istanbul experienced the highest price increases followed by Ankara and finally Izmir	Contextual gap. Also, the study period was shorter (2010 – 2012)	The current study improved the study in Turkey by expanding the sample size and study period.
Ambrose, Eichholtz and Lindenthal (2013)	Studied house prices and rent in Amsterdam, Netherlands	Regression model. The study period was 355 years between 1650 and 2005	They find that price and rent have a long-run relationship. The research also examined the deviations from the equilibrium by examining the rent-price ratio. They find persistent periods of disequilibria. Subsequent corrections are through price adjustments and not rent	The study did not consider the effect of property supply and other fundamentals on house prices. Also, contextual gap.	The current study used the hedonic model to construct the rent index and provide evidence from Kenya

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
Vishwakarma (2013)	Forecasting real estate in Canadian market	ARIMA Model (Canada: 2002 - 2011)	Studied inflation, exchange rates, interest rates and GDP. ARIMA models outperform other models in short term determination of prices.	Did not include rent value and property supply	This research on additional variables such as property supply rent value. Also, the research sought to provide empirical evidence from Kenya.
Ghysels et al. (2012)	Forecasting real estate prices	Cross-sectional regressions (US: 2001 - 2012)	Construction costs and regulatory restrictions had significant influence on the returns of real estate.	Did not focus on the interplay of other factors	To include more variables besides construction costs and their mediating effects of rent value.
Larson (2011)	Alternative methods of house prices forecasting	VAR, VECM (US: 1975 - 2009)	Significant long run relationships in personal income and rental prices in relation to house prices	Did not consider mediating and intervening variables	The study introduced property supply and economic factors to expand understanding of the interlinkages in price effects
Gupta, Kabundi and Miller (2011)	Modelled house prices in twenty US states	VAR and BVAR models with the data period being 1976 – 1994	Spatial BVAR models provided the best estimates of house prices. Augmenting macroeconomic factors in the models only improved the house price forecasts in thirteen out of the twenty states	Contextual gap. Did not factor the effect of property supply	The current study sought to provide additional evidence on the effect of macroeconomic factors on house prices in Kenya with inclusion of property supply factors
Mulaku and Kamau (2009)	Location and residential property value (Nairobi, Kenya)	Multiple Regression model	Location attributes of distance to amenities and downtown were found to be significant.	Studied location but did include rent income, economic factors,	The current study aimed at establishing mediating of rent value in the presence of

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
				and property supply	economic factors and property supply.
Ikromov (2009)	Efficiency of real estate markets (US market)	Cross-sectional linear regression (US market: 1987 - 2008)	Land leverage, income and transport costs have significant positive relationship with volatility of house prices. Transfer tax rates and household income were found to be negatively related to housing returns	Did not include rent value, property supply	The study broadened the understating of property prices by introducing property supply and rent value in the Kenyan context
Selim (2008)	Effect of house characteristics on house prices in Turkey	Hedonic model was used on a sample of 5,741 households for the year 1994.	Houses in the urban areas had higher prices relative to rural areas. Number of rooms and house size positively influenced house prices. However, the marginal effect of size reduces with increase in size. All other house types including fully detached were priced lower relative to duplex. The age of the house exhibited a negative relationship with prices. However, properties older than twenty years had higher prices. Houses built using stone, timber, mudbrick had lower prices relative to ferroconcrete	The research was limited to data for the year 2004	The current study looked at a longer period and a different context to enrich literature
Saks (2008)	Regulation and house prices	Regression Models (US: 1980 - 2000)	House prices increased with absence of construction barriers. Regulation affects house supply and prices.	Did not factor more variables besides construction and	The study included more variables such as rent and property supply besides

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
				their mediating effects	construction and their mediating effects
Glaeser, Gyourko, and Saiz (2008)	Housing dynamics	Multiple Regression Models (US: 1982 - 2007)	Inelastic supply has an effect of increasing housing prices.	Did not focus on mediating and moderating factors	The current study explored mediating effects of rent
Kryvobokov and Wilhelmsson (2007)	Location attributes and apartment prices in Donetsk, Ukraine	Hedonic model to analyse 325 apartments sold in February 2005	Distance to CBD and prestigious areas had significant effect on prices. However, locational attributes such proximity to water body, secondary centre and nuisance was critical for apartments located far from the city centre. The findings are contrary to the location weights usually assigned by valuation experts in Donetsk	Smaller sample size and use of asking price instead of actual transaction price	The current study used a bigger sample over ten years and used actual transaction prices instead of asking lists
Worthington and Higgs (2003)	A multivariate Analysis of UK property market	VAR, Granger Causality (UK: 1976-2001)	They find long run relationships and causal linkages among the property markets studies.	Did not use exogenous variables in establishing movements in UK real estate market	The focus of the study was broadening the understanding of prices by including property supply and economic factors. Also, the Kenyan Context was studied.
Quan (1999)	Real estate price and stock prices	Regression Models (17 countries over 14 years)	Inflation positively related to house prices	Studied fewer variables such as inflation. As such, did not consider the interplay of	The study looked at mediating effects of rent value in the Kenyan context

Author	Study Focus	Methodology	Findings	Research Gap	Focus of current study
				other factors such as supply and property characteristics	
McNamara and Paul (1997)	Rental income and real estate prices	Regression model (UK: 1990 - 1997)	They assert that long run real estate prices are determined by rental income.	Did not consider other independent variables besides rent	The current study included more variables such as property supply and economic factors. The Kenyan context is studied.
Breedon and Joyce (1993)	House prices, possessions, and arrears: a three-equation model for the UK	VAR, Dynamic Equation. (UK: 1982 - 1993)	Disposable income and demographic trends were found to have significant relationships. Availability of mortgage affected supply of houses through investments which in turn affect the price of real estate	Did not include rent value in determining house prices.	The study sought to build on their work by introducing rent income, and test mediating effects on house prices
Case and Shiller (1990)	More Evidence on Risk and Returns on real estate investments	Cross-section regressions (US: 1970 - 1987)	Cost of construction a supply dynamic had a significant influence. Other variables found important in the study included income, population, and location.	The study only provided results for the US market. The interplay of the factors to test for possible transmission mechanisms.	The current study focused on the interplay of the factors to determine possible transmission mechanisms.

Source: Author, 2023

2.5 The Conceptual Framework

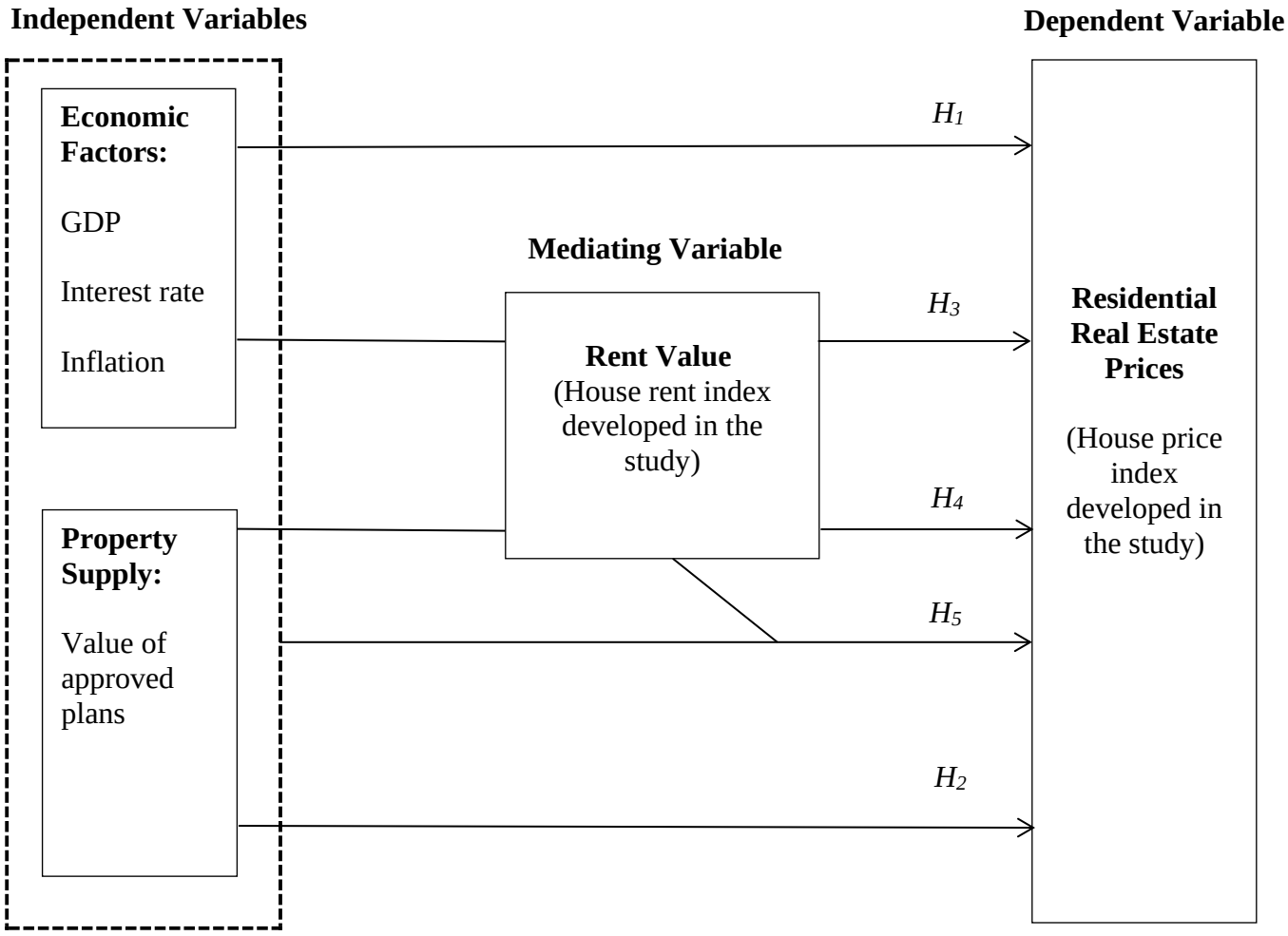
The goal of the study was to establish the relationship among selected economic factors, rent value, property supply and residential real estate prices. Besides, the mediating effect of rent value on the relationship between property supply, economic factors, and residential property prices was studied. Finally, the study examined the joint effect of economic factors, rent value and property supply on residential real estate prices.

Economic factors such as economic growth and household incomes, inflation, interest rates etc. may influence housing prices. These economic factors underly demand drivers that affect prices. Favourable economic environment characterised by low interest rates, high economic growth and high household income is likely to increase the demand for residential properties thereby increasing the prices.

High rental income increases cash flows generated which may affect house prices positively. Besides, favourable economic factors may affect the ability and willingness to pay rent which in turn affects property prices. Property supply factors such as approved building plans, new units completed, financing amongst others could also determine house prices. Supply indicators explain the stock of housing units available in the market. If more units are supplied and cost of financing is low, property prices are likely to fall.

Figure 2.1 depicts the conceptual framework.

Figure 2.1: Conceptual Framework



Source: Author (2020)

2.6 Hypotheses

The research hypotheses to be tested are as follows:

H_1: The effect of economic factors on residential real estate prices is not significant.

H_2: The effect of property supply on residential real estate prices is not significant.

H_3: The mediating effect of rent value on the relationship between economic factors and residential real estate prices is not significant.

H_4: The mediating effect of rent value on the relationship between property supply and residential real estate prices is not significant.

H_5: The joint effect of economic factors, property supply and rent value on residential real estate prices is not significant.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The first section of this chapter discusses research philosophy and design. This is followed by population and sample. Data collection method and analytical tools are then discussed.

3.2 Research Philosophy

Research philosophy can be categorised into realism, interpretivism, and positivism (Saunders, Lewis & Thornhill, 2009). Positivism approach involves empirical tests of concepts and theories. Whereas phenomenology is mainly qualitative and involves development of theory.

This study was anchored on positivist philosophy because it relies on existing theories. The research lends itself to statistical tests that are aimed at establishing relationships based on theory. The study empirically tested the relationship among economic factors, rent value, property supply and real estate prices in Nairobi.

3.3 Research Design

A research design is a plan and strategy that ensures the objectives are achieved. It is the blueprint of the study that relates the empirical data to the research questions and finally to its conclusion (Yin, 2009). The study used quantitative design in which the secondary data was analysed, and the research hypothesis tested. The study made use of both cross-sectional and time series data. The design was deemed appropriate for the study due to quantitative nature of the analysis (Al-Marwani, 2014; Xiao, 2015). Besides, the study sought to describe quantitatively the relationship among the identified research concepts.

3.4 Population and Sample

Cooper and Schindler (2011) define population as a group of entities with common features thar follow a given description. The research targeted the Nairobi County residential real estate market. The County constitutes the principal capital for real estate in Kenya hence the choice. Real estate market is highly concentrated in Nairobi City County given that the city generates sizeable portion of Kenya's GDP. Residential market in Nairobi accounts for 85% of new developments both in units and value while non-residential 15% (Kenya National Bureau of Statistics, 2020). Kenyan government embarked on an ambitious project with 500,000 houses set to be built (Amwayi, 2018).

Therefore, the variable of interest is the actual house purchase transactions that are completed in the Nairobi residential real estate market. 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 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. Given the foregoing, purposive sampling technique was used to determine the number of house purchase transactions per quarter on which data was to be collected over the 10 years under study. Purposive sampling was suitable in this case since the researcher was not in control of all the data available and required judgment in determining number of transactions per bank and real estate agents (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. The important thing is data on each house sold independent of the transacting bank, agent, or developer.

3.5 Data Collection

The study used secondary data. The period of study was 10 years with quarterly data (2011 Quarter 1 - 2020 Quarter 4). The real estate prices were operationalised by a housing price index. Rent value was also operationalised by a rent index. Data used in the construction of the housing price index and rent index included house selling price, house surface area, location, number of bedrooms, house type and rent amount (Appendix two). Data was collected for a sample of residential houses that were sold in the 10 years under study. The source was commercial banks in Kenya regulated by Central Bank of Kenya and real estate agents and developers in Nairobi. The respondents were provided with data collection sheet (Appendix two) to complete.

Besides, other data collected include GDP, inflation rate, interest rate and value of approved building plans (Appendix one). Economic variables were obtained from Kenya National Bureau of Statistics and Central Bank of Kenya. Property supply indicator, value of approved building plans was obtained from Nairobi City County Government.

3.6 Operationalization of the Variables

The study variables were operationalised as follows:

3.6.1 Residential Real Estate Prices

Real estate prices may be intrinsic value computed based on certain assumptions which may vary across different parties (Keith, 2007). Prices may also mean those observed in

the market from actual transactions that have taken place. In many markets globally, there are constructed housing price indices that track the market prices (Al-Marwani, 2014).

In this study, residential real estate prices were operationalised using a housing price index. The price index was useful in capturing the changes in residential property prices in Nairobi over time. The house price index was constructed based on actual transaction prices of houses in Nairobi as provided by property developers, agents, and mortgage lending commercial banks in Kenya. The Hedonic model was used as it controls for change of quality thus minimizing quality bias (Sirmans, Macpherson & Zietz, 2005; Wolverton & Senteza, 2000). The hedonic price model calculates the average house price changes having controlled for the characteristics of the house namely house surface area, location, number of bedrooms and house type. Data used in the construction of the housing price index included house selling price, house surface area, location, number of bedrooms and house type. The following model was used.

$$Ln\ P_i = \propto + \beta_1 Ln\ Area_i + \beta_2\ Hse\ Type_i + \beta_3 Location_i + \beta_4 Bed_i + \sum_{t=2}^{T} \theta_{it} D_{it} + e_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where:

Ln P_i = Log of the price of house i

Area = House surface area in squared feet

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

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

Bed = Number of bedrooms

D_{it} = The dummy variables for time denoting the 40 quarters in the study period

e_{it} = error term

The index was derived based on the exponents of the co-efficient of the dummy time variables for the 40 quarters under study.

3.6.2 Economic Factors

Economic factors are a set of indicators of the performance of the economy (Xiao, 2015). These factors underly demand drivers that affect prices. GDP growth rate is expected to affect positively housing prices due to increased economic activity and demand. Household income and employment rate are also expected to positively affect house prices due to an increase in purchasing ability increasing demand. Inflation tends to have mixed effects. The effect of interest rate on property prices may be uncertain.

This study operationalised economic factors through Gross Domestic Product (GDP), interest rates, and inflation. 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. Interest rate was measured by the average lending rate by commercial banks in Kenya.

3.6.3 Property Supply

Property supply is the quantum of stock of houses available in the real estate market (Paradkar, 2013). Property supply has been measured using building permits, approved building plans, new units completed, financing costs amongst others (Sorina, 2014; Breedon & Joyce, 1993).

This study operationalised property supply through pipeline of new residential houses in Nairobi. This was measured by the value of the approved building plans. This was obtained

from the Nairobi City County Government which is mandated by law to approve all building plans.

3.6.4 Rent Value

Rent is consideration paid to the owner for use of property. Rent is reward to factor of production namely land and all that is attached on it permanently (Brueggeman & Jeffrey, 2011). Rent value may be measured as actual rent based on leases, ask rent published by realtors, and opinion survey of players in the industry. There are different approaches to developing rent indices. Firstly, rent index may be constructed using the average rent prices of a sample of houses in a certain period relative to a previous or base period. Secondly, repeat rent methods are used to develop house rent indices. This method uses data on houses that have been leased more than once occasioning change in rent. Thirdly, hedonic models have been used to construct house rent indices. The key advantage of the hedonic models is that they adjust for characteristics and locational attributes of the properties.

In this study, rent value was operationalised using a housing rent index. The rent index was useful in capturing the changes in rent paid for residential real estate in Nairobi over time. The rent value index was constructed based on actual rent paid for houses in Nairobi as provided by property developers, agents, and commercial banks in Kenya. The Hedonic model was used as it controls for change of quality thus minimizing quality bias (Sirmans, Macpherson & Zietz, 2005; Malpezzi, Ozanne & Thibodeau, 1987). The hedonic price model calculates the average house rent changes controlling for the characteristics of the house namely house surface area, location, number of bedrooms and house type. Data used in the construction of the housing rent index included rent paid, house surface area,

location, number of bedrooms and house type. This data was collected for a sample residential property sold over the ten years under study. The following model was used.

$$Ln\ Rent_i = \propto\ + \beta_1 Ln\ Area_i + \beta_2\ Hse\ Type_i + \beta_3 Location_i + \beta_4\ Bed_i + \sum_{t=2}^{T} \theta_{it} D_{it} + e_{it} \quad \ldots (3.2)$$

Where:

$Ln\ Rent_i$ = Log of the rent for house i

Area = House surface area in squared meters

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

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

Bed = Number of bedrooms

D_{it} = The dummy variables for time denoting the 40 quarters in the study period

e_{it} = error term

The index was derived based on the exponents of the co-efficient of the dummy time variables for the 40 quarters under study.

3.6.5 Summary of Variables Operationalisation

Table 3.1 depicts a summary of the variables of the study:

Table 3.1: Operationalization of variables

Type	Variable	Operational Definition	Measure (Scale)	Source	Notation
Dependent Variable	Residential Real Estate Prices	Transaction prices of houses	The housing price index [based on house sale price (Ratio), location (Nominal), house type (Nominal), size (Ratio), number of bedrooms (Ratio)	Al-Marwani, (2014) Sirmans, Macpherson and Zietz (2005)	Price Index

Type	Variable	Operational Definition	Measure (Scale)	Source	Notation
			and dummy time variables (Nominal) see section **Error! Reference source not found.**]		
Independent Variables	Economic Factors: 1. GDP 2. Interest 3. Inflation Property Supply: Value of approved building plans.	 -Aggregate economic output -Cost of financing - Price level changes Value of ongoing house construction	 1. GDP growth (Interval) 2. Lending rate (Ratio) 3. Consumer Price index (Ratio) Log of the value of approved building plans (Ratio)	Xiao (2015); Al-Marwani, (2014); Vishwakarma (2013) Brooks and Tsolacos (2009); Saks (2008); Breedon and Joyce (1993)	 1. GDP 2. Interest 3. Inflation Index LN value of approved plans
Intervening Variable	Rent value.	Regular Price paid for occupation of houses	The rent price index [based on rent paid (Ratio), location (Nominal), house type (Nominal), size (Ratio), number of bedrooms (Ratio) and dummy time variables (Nominal) see section **Error! Reference source not found.**]	Zisheng, Mats and Zan (2020). Malpezzi, Ozanne and Thibodeau (1987) Malpezzi (1999); Podor and Nyiri (2010); Corsini (2009)	Rent Index

Source: Author, 2023

3.7 Diagnostic Tests

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

3.7.1 Stationarity Test

Stationarity was tested using Augmented Dickey-Fuller unit root test. A series is said to be stationary if it has a constant mean, variance and autocovariance (Brooks, 2019). Non-stationarity may lead to certain problems. Firstly, any unexpected change in the variables or shocks may not be corrected or revert to the long-run mean. Secondly, Nonstationary data can lead to spurious regressions. Finally, the standard assumptions for asymptotic analysis may not be valid. The test statistics will not follow the t-distribution and F-distribution. 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, literature proposes a dynamic model that factors in lagged variables of both the dependent and independent variables. The study will therefore adopt Autoregressive Distributed Lag Model (ARDL). ARDL will be specified and implemented in hypothesis testing. This will entail specification of error correction model to test long-run and short-run relationships depending on the outcome of the cointegration test.

3.7.2 Autocorrelation Test

Linear regression model assumes that the errors are uncorrelated with one another. If the errors are correlated, then then autocorrelation is detected or there is serial dependence. Autocorrelation may lead to incorrect standard errors of estimates hence wrong inferences made (Brooks, 2019). Breusch Godfrey LM test for autocorrelation was used to detect serial dependence. Serial dependence problems may be addressed through variable transformation, introduction of dummy variables amongst other.

3.7.3 Heteroscedasticity Test

Classical linear regression model requires the variance of the errors to be constant. This is the homoskedasticity assumption. The errors are said to be heteroscedastic if the variance is not constant. The consequence of heteroscedasticity may lead to incorrect standard errors of the estimates hence wrong conclusion of the hypothesis test (Green, 2002). Breusch-Pagan test for heteroskedasticity was used to detect heteroscedasticity. Presence of heteroscedasticity problem may be treated by transforming variables.

3.7.4 Multicollinearity Test

Multicollinearity problem exists when the independent variables are correlated (Brooks, 2019). This may inflate the standard errors of estimate. The incorrect standard errors may lead to wrong inferences. Multicollinearity was tested using variance inflation factors (VIF). Multicollinearity problems may be treated through variable transformation or removal of certain variables.

3.7.5 Normality Test

Linear regression model assumes errors are normally distributed [$ut \sim N(0, \sigma 2)$]. This is an important requirement for hypothesis testing of the model parameters. 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 assumed if the sample is large by invoking the central limit theory (Brooks, 2019).

3.8 Data Analysis and Analytical Models

The goal of this research was to study the relationship among economic factors value, property supply, rent value and residential real estate prices in Nairobi. The study employed stepwise regression analytical model. This model provides a framework for establishing intervening effects (Mackinnon et al., 2002; Baron & Kenny, 1986).

3.8.1 Economic Factors, Property Supply and Residential Real Estate Prices

Objective (a): To establish the effect of economic factors and property supply on residential real estate prices.

The first objective of the study was to establish the effect of economic factors on residential real estate prices in Nairobi. Economic factors were measured by real GDP growth rate, inflation index and commercial banks' average lending interest rates. Real estate prices were measured by the price index developed using hedonic pricing model.

The null hypothesis:

H_1: The effect of economic factors on residential real estate prices is not significant.

Objective (b): To establish the effect of property supply on residential real estate prices.

The second objective of the study was to establish the effect of property supply on residential real estate prices in Nairobi. Property supply was measured by the value of approved building plans by Nairobi City County. Real estate prices were measured by the price index developed using hedonic pricing model.

The null hypothesis:

H_2: The effect of property supply on residential real estate prices is not significant.

Multiple regression analysis addressing the first two objectives:

$$PriceIndex = \beta_0 + \beta_1 GDP + \beta_2 Interest + \beta_3 InflationIndex + \beta_4 LNValueofApprovedPlans + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.3)$$

Where:

Price Index = Real estate prices

GDP = Gross Domestic Product

Interest = Average lending rates by commercial banks

Inflation Index = Consumer price index

LN Value of Approved Plans = Indicator of property supply

ε = error term

β_0 = The regression intercept.

β_{1-4} = The coefficients of the independent variables.

The effect was determined based on the model's significance captured by F-statistic and significance of the estimates captured by t-statistic and corresponding p-values. The coefficient of determination was also used to establish the extent to which economic factors and property supply explain the changes in real estate prices.

3.8.2 Mediating Effect: Economic Factors, Property Supply, Rent Value and Residential Real Estate Prices

Objective (c): To establish the mediating effect of rent value on the relationship between economic factors and residential real estate prices.

The third objective of the study was to establish the mediating effect of rent value on the relationship between economic factors and house prices in Nairobi. Economic factors were

measured by real GDP growth rate, inflation index and interest rates. Rent value was measured by the rent index developed using hedonic model. Real estate prices were measured by the price index developed using hedonic model.

The null hypothesis:

H_3: The mediating effect of rent value on the relationship between economic factors and residential real estate prices is not significant.

Objective (d): To establish the mediating effect of rent value on the relationship between property supply and residential real estate prices.

The fourth objective of the study was to establish the mediating effect of rent value on the relationship between property supply and house prices in Nairobi. Property supply was measured by the value of approved building plans by Nairobi City County.

The null hypothesis:

H_4: The mediating effect of rent value on the relationship between property supply and residential real estate prices is not significant.

Multiple regression analysis-Stepwise as per the work of Baron and Kenny (1986) was used in testing the mediating effect addressing the third and fourth objectives:

Step 1:

$$PriceIndex = \beta_0 + \beta_1 GDP + \beta_2 Interest + \beta_3 InflationIndex + \beta_4 LNValueofApprovedPlans + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.4)$$

Step 2:

$$RentIndex = \beta_0 + \beta_1 GDP + \beta_2 Interest + \beta_3 InflationIndex + \beta_4 LNValueofApprovedPlans + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.5)$$

Step 3:

$$PriceIndex = \beta_0 + \beta_1 GDP + \beta_2 Interest + \beta_3 InflationIndex + \beta_4 LNValueofApprovedPlans + \beta_5 RentIndex + \varepsilon \ldots\ldots\ldots\ldots (3.6)$$

Where:

Price Index = Measure of residential real estate prices

GDP = Gross Domestic Product

Interest = Average lending rates by commercial banks

Inflation Index = Consumer price index

LN Value of Approved Plans = Indicator of property supply

Rent Index = Measure of residential real estate rent value

ε = error term

β_0 = The regression intercept.

β_{1-5} = The coefficients of the independent variables.

Step 4: Use equation 3.6 above to test level of mediation.

If β_5 in equation 3.6 is significant having controlled for the effect of the other independent variables, then rent value will be deemed a mediator. Also, if β_{1-4} in equation 3.6 are not significant then rent is complete mediator. Alternatively, if β_{1-4} and β_5 in equation 3.6 are significant, then rent is deemed partial mediator.

Baron and Kenny (1986) test for mediation entails running the three regressions (steps 1 to 3) separately. Iacobucci et al. (2007) have shown that this may result into larger standard errors. They therefore proposed estimating the coefficients and other parameters simultaneously through Structural Equation Modelling (SEM). The parameters associated with the direct effect (path c`) and the indirect effect (path a and path b) are estimated simultaneously using SEM. The indirect effect (mediation effect) parameter is [a*b]. “a”

and “b” are like those obtained through Baron and Kenny steps save for estimation technique which is through SEM.

The SEM estimated parameters were then tested for mediation effect using Sobel, and Aroian tests (Aroian, 1944; Sobel, 1982). The z-values and the corresponding p-values for each test were computed to determine the significance of the estimates. The z-tests were computed as follows:

Sobel

z-value = $a*b/\sqrt{(b^2*s_a^2 + a^2*s_b^2)}$

Aroian

z-value = $a*b/\sqrt{(b^2*s_a^2 + a^2*s_b^2 + s_a^2*s_b^2)}$

Where:

a = the coefficient of the independent variable (β_{1-4} in equation 3.5)

Sa = the standard error of the independent variable (based on equation 3.5)

b = the coefficient of the mediating variable (β_5 in equation 3.6)

Sb = the standard error of the mediating variable (based on equation 3.6)

Null hypothesis: Ho = No mediation effect

Therefore, $p<0.05$ indicated mediation effect. Whereas $p>0.05$ indicated non-mediation.

Zhao, Lynch and Chen (2010) discussed the shortcoming of the Sobel (1982) test. The shortcoming stems from the assumption that [a*b] is normally distributed. This may not be the case even when the individual distributions of [a] and [b] are symmetrical. They therefore proposed bootstrapping method (non-parametric) to generate a sampling distribution for [a*b] which is then tested independently. In this study we have used Monte Carlo simulation with 2,000 replacements to generate distribution for [a*b] and tested it for its significance (Jose, 2013).

In summary, the study employed three tests for mediation. The first approach was based purely on Baron and Kenny (1986). The second, was the extension proposed by Iacobucci et al. (2007). Here, the model parameters were estimated using SEM. Then Sobel and Aroian tests were carried to establish the mediation effect (Sobel, 1982; Aroian, 1944). The third approach was bootstrapping. This was done in keeping with the work of Zhao, Lynch and Chen (2010) and Jose (2013).

3.8.3 Joint Effect: Economic Factors, Property Supply, Rent Value and Residential Real Estate Prices

Objective (e): To establish the joint effect of selected economic factors, rent value, and property supply on residential real estate prices.

The fifth objective of the study was to establish the joint effect of economic factors, property supply, and rent value on residential prices in Nairobi. Economic factors were measured by real GDP growth rate, inflation index and interest rates. Property supply was measured by the value of approved building plans by Nairobi City County. Rent value and real estate prices were measured by the indices developed in the study using hedonic model.

The null hypothesis:

H_5: The joint effect of selected economic factors, property supply and rent value on residential real estate prices is not significant.

Hierarchical regression analysis:

Model 1: Economic factors and Real estate price

$$PriceIndex = \beta_0 + \beta_1 GDP + \beta_2 Interest + \beta_3 InflationIndex + \varepsilon \ldots (3.7)$$

Model 2: Economic factors, Property Supply and Real estate price

$PriceIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex + \beta_4\, LNValueofApprovedPlans + \varepsilon$ ……………………….… (3.8)

Model 3: Economic factors, Property supply, Rent value and Real estate price.

$PriceIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex + \beta_4\, LNValueofApprovedPlans + \beta_5\, RentIndex + \varepsilon$ ……….. (3.9)

Model 1 (equation 3.7) tested the extent to which economic factors (GDP, inflation, and interest) explain the changes in real estate prices (price index). This was captured by R^2. Besides, the model's significance as captured by F-statistic was determined. The significance of the β_{1-3} estimates was also determined by t-test and corresponding p-values.

Model 2 (equation 3.8) tested the extent to which economic factors (GDP, inflation, and interest) with addition of property supply (LN of value of approved plans) explain the changes in real estate prices (price index). This was captured by R^2. Besides, the model's significance as measured by F-statistic was determined. The significance of the β_{1-4} estimates was also determined by t-test and corresponding p-values. In addition, the significance of changes in R^2 with introduction of property supply relative to the outcome in model 1 was determined.

Model 3 (equation 3.9) tested the extent to which economic factors (GDP, inflation, and interest), property supply (LN of value of approved plans) with addition of rent value (rent index) explains the changes in real estate prices (price index). This was captured by R^2. Besides, the model's significance as assessed by F-statistic was determined. The

significance of the β_{1-5} estimates was also determined by t-test and corresponding p-values. In addition, the significance of changes in R^2 with introduction of rent value relative to the outcome in model 2 was determined.

The null hypothesis of no significant joint effect is upheld if R^2 does not increase progressively through Model 1 to Model 3. Besides, $p>0.05$ of the change in R^2 in model 2 and 3 confirms upholding of the null hypothesis. Otherwise, the null is rejected.

Analytical Model

The analytical model is depicted in Table 3.2.

Analytical Model

$Price\ index = f(x)$

Table 3.2 : Analytical Model

Objective	Hypothesis	Analysis techniques	Interpretation
Objective (a): To establish the effect of economic factors on residential real estate prices **Objective (b):** To establish the effect of property supply on residential real estate prices	**H_1:** The effect of economic factors on residential real estate prices is not significant. **H_2:** The effect of property supply on residential real estate prices is not significant.	Multiple regression analysis $PriceIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex + \beta_4\, LNValueof ApprovedPlans + \varepsilon$ …… (3.3)	Relationship exists if R^2 approaches ±1. Also test if $\beta_1, \beta_2, \beta_3, \beta_4$ are significant at 95% significance level.
Objective (c): To establish the mediating effect of rent value on the relationship between economic factors and residential real estate prices	**H_3:** The mediating effect of rent value on the relationship between economic factors and residential real estate prices is not significant.	Multiple regression analysis-Stepwise: **Step 1:** $PriceIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex + \beta_4\, LNValueof ApprovedPlans + \varepsilon$ …… (3.4) **Step 2:** $RentIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex +$	Relationship exists if R^2 approaches ±1. Also test if $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ are significant at 95% significance level in equation 3.6. The variables are mediators if their beta coefficients are significant controlling for the independent variables. There is full mediation if the beta coefficients for the mediators are significant while for the independent variables are insignificant.

Objective	Hypothesis	Analysis techniques	Interpretation
Objective (d): To establish the mediating effect of rent value on the relationship between property supply and residential real estate prices	**H_4:** The mediating effect of rent value on the relationship between property supply and residential real estate prices is not significant.	$\beta_4\, LNValueofApprovedPlans + \varepsilon$ ... ... … (3.5) **Step 3:** $PriceIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex + \beta_4\, LNValueofApprovedPlans + \beta_5\, RentIndex + \varepsilon$ ……..… (3.6) **Step 4:** Use equation 3.6 above to test level of mediation.	If the independent variables are still significant while controlling for mediators, then there is partial mediation. Sobel, Aroian and Bootstrapping tests were carried out separately to test for mediation. P<0.05 for the Sobel, Aroian and Bootstrapping tests indicate mediation. While p>0.05 indicate non-mediation.
Objective (e): To establish the joint effect of selected economic factors, property supply and rent value on residential real estate prices	**H_5:** The joint effect of selected economic factors, property supply and rent value on residential real estate prices is not significant.	Hierarchical regression analysis **Model 1:** $HPriceIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex + \varepsilon$ ……. (3.7) **Model 2:** $HPriceIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex + \boldsymbol{\beta_4\, LNValueofApprovedPlans} + \varepsilon$ ……. … (3.8)	Establish extent of relationship by R^2. Overall model is significant if p<0.05 of the F-statistic. (Equation 3.7). Joint effect exists if of R^2 in model 2 is greater than that of model 1. Also test for the significance of the change in R^2. Overall model is significant if p<0.05 of the F-statistic. (Equation 3.8).

Objective	Hypothesis	Analysis techniques	Interpretation
		Model 3: $PriceIndex = \beta_0 + \beta_1\, GDP + \beta_2\, Interest + \beta_3 InflationIndex + \beta_4\, LNValueofApprovedPlans + \boldsymbol{\beta_5\, RentIndex} + \varepsilon$ …… (3.9)	Joint effect exists if of R^2 in model 3 is greater than that of model 2. Also test for the significance of the change in R^2. Overall model is significant if $p<0.05$ of the F-statistic. (Equation 3.9).

Source: Author, 2023

CHAPTER FOUR: DATA ANALYSIS, RESULTS, AND DISCUSSION

4.1 Introduction

This chapter contains data analysis results and the discussion of the findings. The overall goal of the study was to establish the relationship among economic factors, property supply, rent value and residential real estate prices in Nairobi. Besides, the study had five specific objectives. The first section describes the data used in developing the housing price index and rent index. This is followed by the results of the hedonic model used to develop both the price index and rent index and the attendant model robustness tests.

A discussion of the descriptive statistics of all the variables in the study is then presented. Diagnostic tests were carried out and the results discussed including the implication on the hypotheses testing. The chapter closes with correlation analysis and summary of the chapter.

4.2 Descriptive Statistics for House Data

To construct the residential property price index and rent value index, the researcher collected data as per data collection sheet (appendix two). Data was collected for 1,073 houses between 2010 Q3 and 2020 Q4 against a minimum target of 840 specified chapter three. Table 4.1 is a summary of the data collected.

Table 4.1: Descriptive statistics for house data

Description	Statistic
Number of houses	1,073
Minimum Price (KSH)	1,600,000

Description	Statistic
Maximum Price (KSH)	150,000,000
Mean Price (KSH)	19,527,840
Minimum Monthly Rent (KSH)	8,750
Maximum Monthly Rent (KSH)	450,000
Mean Monthly Rent (KSH)	87,559
Number of Apartments	684
Number of non-apartments	389
Number of Houses in Upmarket Areas	521
Number of Houses Located in Low Market Areas	552
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: Author, 2023

The minimum house price was KSH. 1.6 million and the maximum KSH. 150 million with the average price being KSH 19.5 million. On the other hand, the minimum rent value was KSH. 8,750 and the maximum KSH. 450,000 per month with the average price being KSH. 87,559. This indicates that the sample captured data from the low end to high end properties in the market.

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 County due to limited land for development.

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 minimum number of bedrooms was one and the maximum seven with

average being 3.1. The data captured reflects the entire spectrum of the house sizes in Nairobi.

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 price being 1,883 sq. ft. The sampled houses are therefore reflective of the spectrum of houses available in the residential real estate market in Nairobi.

4.3 Residential Price Index

Residential real estate prices were operationalised using a house price index. The price index was useful in capturing the changes in residential real estate prices in Nairobi over time.

The house price index was constructed based on actual transaction prices of houses in Nairobi as provided by property developers, agents, and mortgage lending commercial banks in Kenya. The Hedonic model was used as it controls for change of quality thus minimizing quality bias (Sirmans, Macpherson & Zietz, 2005; Wolverton & Senteza, 2000). The hedonic price model calculated the average house price changes having controlled for the characteristics of the house namely house surface area, location, number of bedrooms and house type. Data used in the construction of the housing price index included house selling price, house surface area, location, number of bedrooms and house type. The following model was used.

$$Ln\ P_i = \propto + \beta_1 Ln\ Area_i + \beta_2\ Hse\ Type_i + \beta_3 Location_i + \beta_4 Bed_i + \sum_{t=2}^{T} \theta_{it} D_{it} + e_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where:

Ln P_i = Log of the price of house i

Area = House surface area in squared feet

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

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

Bed = Number of bedrooms

D_{it} = The dummy variables for time denoting the 40 quarters in the study period

e_{it} = error term

The index was derived based on the exponents of the co-efficient (θ_{it})of the dummy time variable for the 40 quarters under study. The base period (2010 Q3) index value was set at 100. The index for the subsequent quarters were derived (2010 Q4 to 2020 Q4). The period of the study was 40 quarters starting 2011 Q1 to 2020 Q4. As such the index values relating to that period were used in hypothesis testing.

The results of the cross-sectional regression analysis based on the hedonic model is summarised in Table 4.2 and the details in appendix 3:

Table 4.2: Regression results for price index

P	**Coef.**	**St. Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
Area	.72	.037	19.42	0	.647	.793	***
HseType	-.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	***
R^2	0.821	Number of obs				1073	
F-test	104.425	Prob > F				0.000	
AIC	956.213	BIC				1185.211	

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

Source: Author, 2023

The overall model was significant (F-statistic – 104.425; Prob > F = 0.000). Therefore, the model was fit for calculating the price index. The R^2 was 82.1% indicating that the independent variables explain 82.1% of the price value changes. House size (Area), House Type (HseType), Location, Number of bedrooms (Bed) significantly affect house price ($p<0.05$).

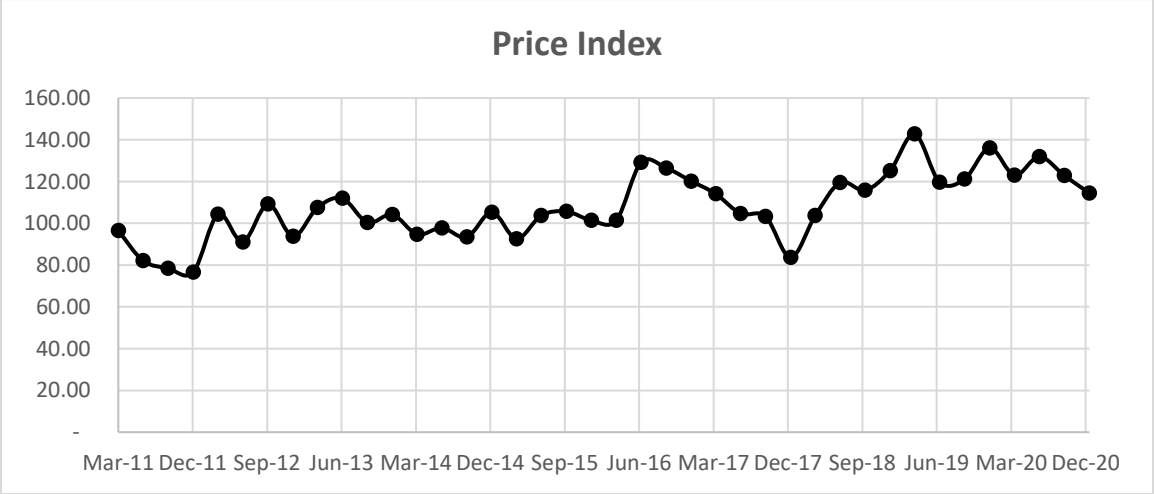
The results indicate that a 1% increase in the house surface area will result in 0.72% increase in house price. Also, apartments were on average priced 10.8% below the stand-alone houses such as bungalows, maisonettes etc. Investors in house prices prefer properties with own-compound and are willing to pay 10.8% premium on average relative to apartments. Houses located in upmarket areas were on average sold at a premium of 84.6%. This is quite steep a reflection of the nature of the house market in Nairobi that is skewed to high end properties. Nairobi has witnessed growth in construction and purchases in upper middle and wealthy segment of the property market. The price premiums established in this study seem to corroborate the heightened activity in this market segment. The price premium also reveals the strong preference for a suitable location in the decision-making process of real estate investors. Government of Kenya is providing impetus in the affordable housing market segment by funding construction and giving incentives to the private sector. This intervention by government is likely to spur growth in the hitherto neglected segment of the property market. Finally, an additional bedroom would result in a house price increase by 18.6% on average in Nairobi.

House surface area, location and number of bedrooms had significant and positive effect on house prices. While house type had a significant negative effect on house prices. This agreed with Wolverton and Senteza (2000) who found that house size, house type, age and

location significantly affect house price. In addition, the study findings agree with Choy, Mak and Ho (2007) who researched house prices in Hong Kong. They found size, age and location significantly affect house prices. However, location was measured in terms of access to transport, sea view and the apartment floor number. Zietz, Sirmans and Smersh (2008) studied single-family home sales in Florida, US. They found that home prices are significantly influenced by size, location, and age of the homes. This is in congruence with the current study. 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 was different from what was reported in Dubin (1998) who studied Baltimore, US and found no effect. While the findings of this study on the effect of number of bedrooms concur with literature, Zheng (2014) found otherwise. She studied Singapore market and found no effect.

The exponents of the coefficients of the dummy time variables were extracted resulting to the price index in Figure 4.1:

Figure 4.1: Residential real estate price index



Source: Author, 2023

Figure 4.1 shows the residential real estate prices over the years from 2011 Q1 to 2020 Q4. The prices have been up and down between 2011 and 2016. In addition, prices have been on an upward trajectory between 2017 and 2019 with a drop in 2020 possibly due to covid -19.

4.4 Residential Rent Index

Rent value was operationalised using a rent index. The rent index was useful in capturing the changes in rent paid for residential real estate in Nairobi over time.

The rent value index was constructed based on actual rent paid for houses in Nairobi as provided by property developers, agents, and commercial banks in Kenya. The Hedonic model was used as it controls for change of quality thus minimizing quality bias (Sirmans, Macpherson & Zietz, 2005; Malpezzi, Ozanne & Thibodeau, 1987). The hedonic price model calculated the average house rent changes having controlled for the characteristics of the house namely house surface area, location, number of bedrooms and house type. Data used in the construction of the housing rent index included house selling price, house surface area, location, number of bedrooms and house type. This data was collected for a sample residential property sold over the ten years under study. The following model was used.

$$Ln\ Rent_i = \propto + \beta_1 Ln\ Area_i + \beta_2\ Hse\ Type_i + \beta_3 Location_i + \beta_4 Bed_i + \sum_{t=2}^{T} \theta_{it} D_{it} + e_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (3.2)$$

Where:

$Ln\ Rent_i$ = Log of the rent for house i

Area = House surface area in squared meters

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

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

Bed = Number of bedrooms

D_{it} = The dummy variables for time denoting the 40 quarters in the study period

e_{it} = error term

The rent index was derived based on the exponents of the co-efficient (θ_{it})of the dummy time variable for the 40 quarters under study. The base period (2010 Q3) index value was set at 100. The rent index for the subsequent quarters were derived (2010 Q4 to 2020 Q4). The period of the study was 40 quarters starting 2011 Q1 to 2020 Q4. As such the rent index values relating to that period were used in hypothesis testing.

The results of the cross-sectional regression analysis based on the hedonic model was as follows in Table 4.3 and the details in appendix 4:

Table 4.3: Regression results for rent index

Rent	**Coef.**	**St. Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
Area	.614	.036	16.87	0	.542	.685	***
HseType	-.051	.03	-1.68	.094	-.11	.009	*
Location	.663	.026	25.48	0	.612	.714	***
Bedroom	.152	.019	8.07	0	.115	.188	***
Constant	5.592	.247	22.63	0	5.107	6.077	***
R^2	0.806	Number of obs				1073	
F-test	94.934	Prob > F				0.000	
AIC	916.464	BIC				1145.462	

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

Source: Author, 2023

The overall model was significant (F-statistic – 94.934; Prob > F = 0.000). Therefore, the model was fit calculating the rent index. The R^2 was 80.6% indicating that the independent variables explain 80.6% of the rent value changes. House size (Area), Location, Number of bedroom (Bed) significantly affect house price ($p<0.05$).

The results indicate that a 1% increase in the house surface area will result in 0.614% increase in house rent. Also, rent on apartments were on average priced 5.1% below the stand-alone houses such as bungalows, maisonettes etc. This underscores the tenants' preference for stand-alone houses regardless of location. An additional bedroom would result in a house rent increase by 16.4% on average in Nairobi. Houses located in upmarket areas were on average rented at a premium of 94.1%. This rent premium indicates that location the most important consideration in determining the amount of rent a tenant is willing to pay. Government of Kenya is providing impetus in the affordable housing market segment. Government initiatives include actual construction of affordable housing and other incentives given to private developers. As such, affordable housing project by government may achieve two objectives. The first is intervention on the supply side to ease pressure on rising house prices. This assertion is supported by the study's findings. Secondly, is to improve ownership rate in Nairobi which is very low (9%). The hope is to increase supply up to an inflection point that will provide feedback effect on the rent.

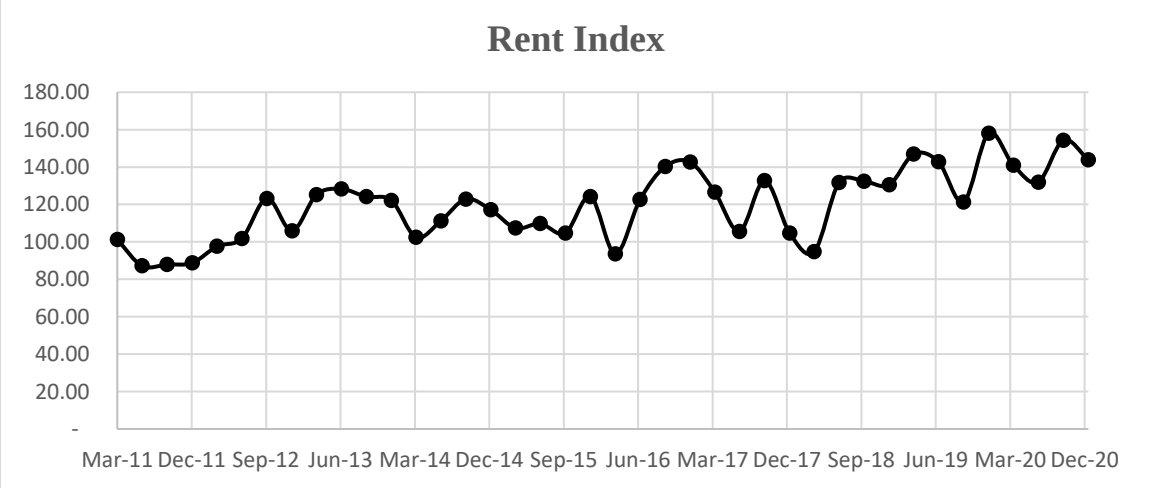
House surface area, location and number of bedrooms had positive significant effect on rent value. House type had negative but insignificant effect on rent value. The findings of this study agreed with past studies in respect of number of bedrooms (Zisheng, Mats & Zan, 2020; Malpezzi, Belete & Yilma, 2020); Ozanne & Thibodeau, 1987). However, other

studies reported that number of bedrooms had no effect (Darfo-Oduro, 2020; Rezaeian, Asgari, & Heshmatolah, 2019).

Location was found to be significant in the current study as was the case in Belete and Yilma (2020), Kimani, Kuria, and Ngigi (2021), and Wickramaarachchi (2016). Zisheng, Mats and Zan (2020) and Hoffmann and Kurz, 2002 found that house type had significant effect on rent value in Beijing and Germany, respectively. Whereas this study found no effect in Nairobi thus agreeing with Rezaeian, Asgari, and Heshmatolah (2019).

The exponents of the coefficients of the dummy time variables were extracted resulting to the rent index in Figure 4.2:

Figure 4.2: Residential real estate rent index



Source: Author, 2023

Figure 4.2 shows the residential rent values over the years from 2011 Q1 to 2020 Q4. The rent values have been up and down but relatively stable between 2011 and 2016. Rent value has been on an upward trajectory between 2017 and 2019 with a drop in 2020 possibly due to covid -19.

4.5 Descriptive Statistics

The house price index and rent index for the forty quarters as modelled in the preceding sections together with the economic factor variables and property supply variable were collated and descriptive statistics presented in Table 4.4:

Table 4.4: Overall descriptive statistics analysis

Variables	Obs	Mean	Std. Dev.	Min	Max	Skew.	Kurt.	JB Pr)
Price Index	40	107.747	15.674	76.644	142.761	.077	2.547	.8264
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	59.991	-.209	2.698	.8018
Inflation Index (Quarterly CPI)	40	167.157	29.769	114.62	219.019	.058	1.781	.2866
Interest (%)	40	15.2	2.5	11.9	20.2	.333	1.938	.2702
Rent Index	40	119.781	18.849	87.197	158.091	.035	2.133	.5321

Source: Author, 2023

The price index minimum value was 76.644 and the maximum 142.761. The average being 107.747. The base index value was 100. The standard deviation 15.674. Therefore, the real estate prices in Nairobi have experienced significant changes over the years. The kurtosis is 2.547. The Jarque-Bera (JB) normality test indicate normality (p-0.8264>0.05).

Real GDP growth rate peaked at 7.6% with lowest rate at negative 4.1%. The negative growth rate of 4.1% was in the second quarter of 2020 after the lockdown owing to COVID-19. Kenya's economy recorded impressive growth averaging 5.3% quarterly pre-corona pandemic. Overall, the mean quarterly real GDP growth rate was 4.7% with a standard deviation of 0.023. The kurtosis is quite high at 10.873 an indication of non-normality.

Property supply was operationalised by the value of building plans approved each quarter by Nairobi City County. This provided an indication of the ongoing developments that are likely to affect the residential real estate prices. 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 kurtosis of 2.698 and skewness of -0.209 approximate normal distribution. The Jarque-Bera (JB) normality test indicate 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 appearance of structural break in the time series data. The inflation index minimum value was 114.6 and the maximum 219. The average being 167. The base index value was 100. The average quarterly change in inflation was 1.76% over the ten years. The standard deviation 29.769. The JB normality test indicate normality (p-0.2866>0.05).

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% with a standard deviation of 0.025. The interest rates in Kenya have been stable. The JB test also support normal distribution (p-0.2702>0.05).

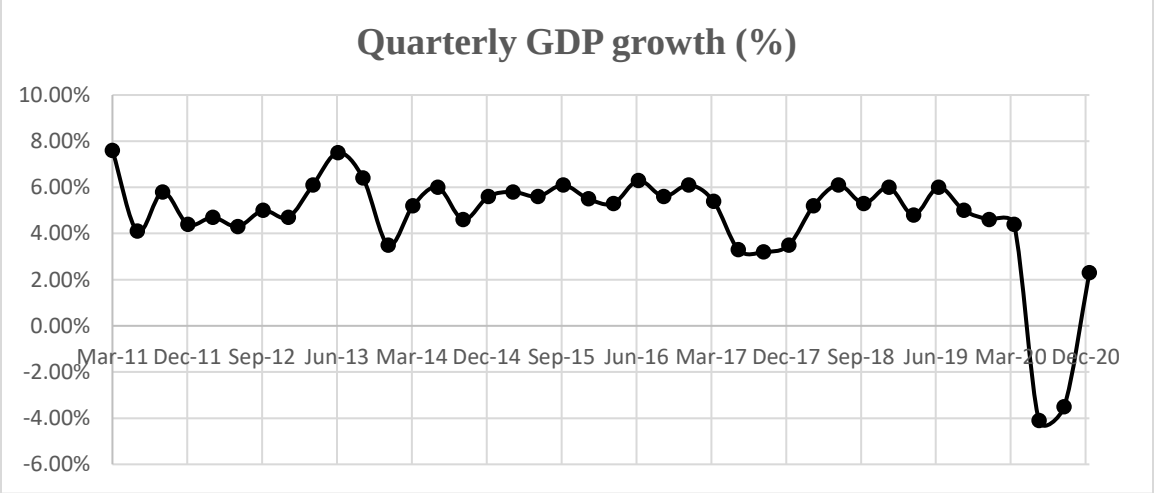
The rent index minimum value was 87.197 and the maximum 158.091 The average being 119.781. The base index value was 100. The standard deviation was 18.849. Therefore, the residential rent values in Nairobi have experienced significant changes over the years The

kurtosis is 2.133 depicting a normally distributed data. This is also confirmed by JB normality test (p-0.5321>0.05).

4.6 Trend Analysis

Figure 4.3 depicts GDP trend over the study period. Real GDP quarterly growth rate has averaged about 4.7%. However, in 2020 Kenya's economy experienced negative GDP growth rate on two consecutive quarters. This was occasioned by the COVID-19 that resulted in unprecedented lockdowns.

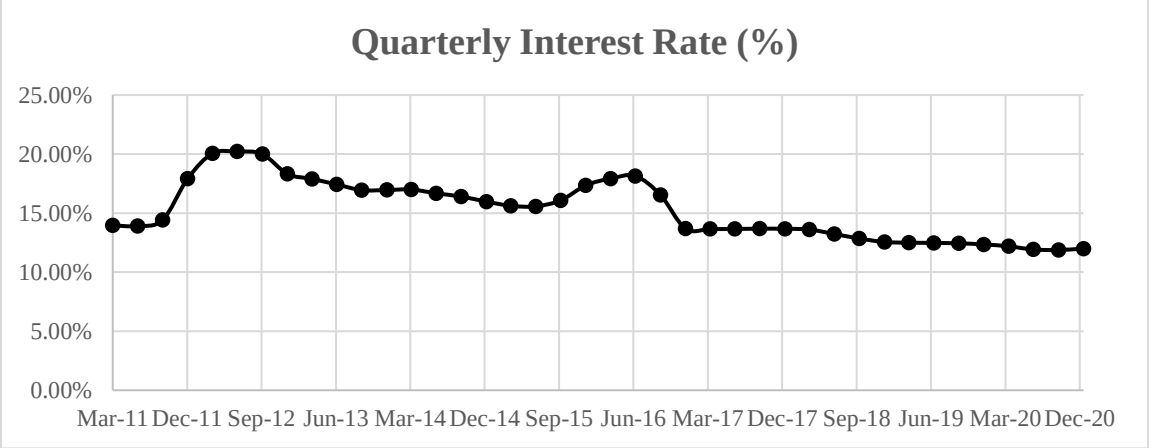
Figure 4.3: Trend analysis - GDP



Source: Author, 2023

Figure 4.4 captures the changes in interest rates. The average commercial bank lending interest rates have been on a downward trajectory over the study period. There were spikes in 2012 and 2016. However, interest rates have stabilised since 2017. The stable interest rates are attributed to the interest rate capping that was introduced in Kenya in 2016 but lifted in 2019.

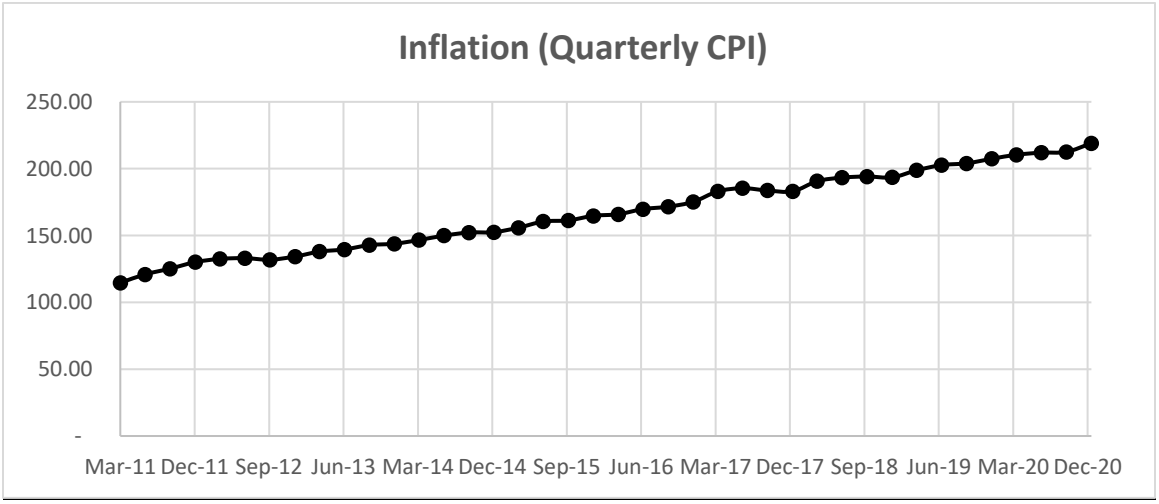
Figure 4.4: Trend analysis – interest



Source: Author, 2023

Figure 4.5 depicts the inflation trends in Kenya over the ten-year period under study. Inflation was measured by the consumer price index. 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 appearance of structural break in the time series data. Inflation has been trending upwards throughout the period under study. This persistent upward trend may have implication on asset prices.

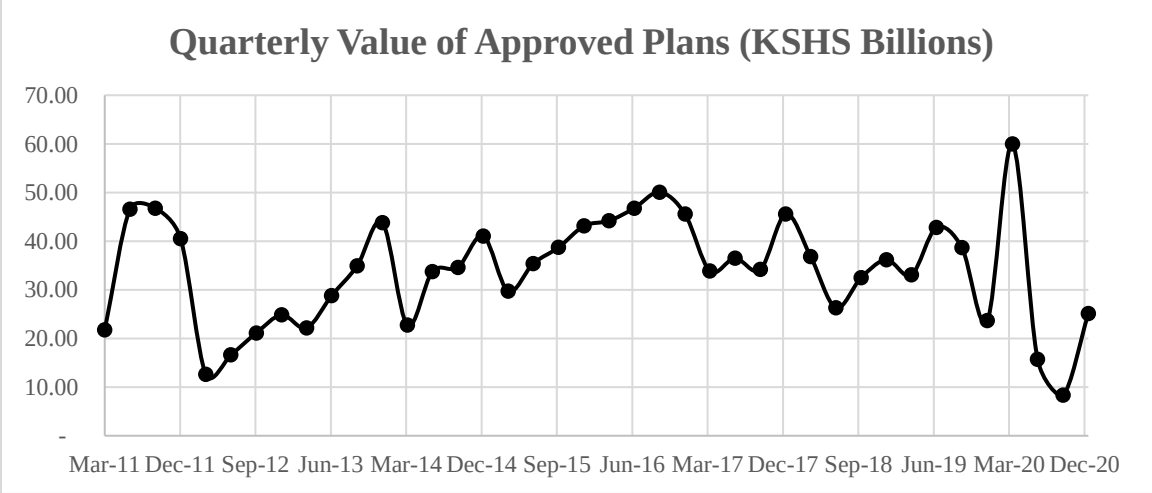
Figure 4.5: Trend analysis - inflation index



Source: Author, 2023

Figure 4.6 shows the trend in property supply. Value of approved building plans by Nairobi City County provided an indication of the property supply. The value of supply pipeline has been volatile. However, the values seem to oscillate around a certain average despite the spikes. As such, there are indications of property supply being mean reverting.

Figure 4.6: Trend analysis – value of approved plans



Source: Author, 2023

4.7 Diagnostic Tests

Diagnostic tests were carried out to ensure the series do not violate any of the assumptions of classical ordinary least squares and other models. Diagnostic tests included stationarity tests, serial dependence tests, heteroscedasticity tests and multicollinearity tests.

4.7.1 Stationarity Test

The ADF unit root test was used to test for stationarity. A series is stationary if it has a constant mean, variance and autocovariance (Brooks, 2019). Non-stationarity may lead to certain problems. Firstly, any unexpected change in the variables or shocks may not be corrected or revert to the long-run mean. Secondly, nonstationary data can lead to spurious

regressions. Finally, the standard assumptions for asymptotic analysis may not be valid. The test statistics will not follow the t-distribution and F-distribution. The results of the stationarity test had an important implication on the choice of model for hypotheses testing.

The null hypothesis was that the series are not stationary. The summary of the results of the test are as per Table 4.5:

Table 4.5: Summary of stationarity test

Variable	**Reference**	**I (0)**	**I (1)**
Price Index	Table 4.6 & Table 4.7		✔
Interest	Table 4.8 & Table 4.9		✔
GDP	Table 4.12	✔	
LN Value of Approved Plans	Table 4.13	✔	
Inflation Index	Table 4.10 & Table 4.11		✔
Rent Index	Table 4.14 & Table 4.15		✔

Source: Author, 2023

GDP and log of the value of approved building plans were stationary at levels [(I (0)]. On the other hand, price index, interest, inflation index and rent index were not stationary at levels. However, the series became stationary at first difference [1 (1)]. The stationarity test resulted in mixed stationarity. GDP and value of approved building plans are stationary at levels while the rest are stationary at first difference. This implied the use of ordinary least squares (OLS) regression was not suitable as it would potentially lead to spurious inferences (Granger & Newbold, 1974; Nkoro & Uko, 2016). Therefore, literature proposes a dynamic model that factors in lagged variables of both the dependent and independent variables.

The study therefore adopted Autoregressive Distributed Lag Model (ARDL). ARDL has several advantages including its suitability in the presence of mixed stationarity. Also,

ARDL is more efficient with small samples (Kripfganz & Schneider, 2020; Pesaran, Shin, & Smith, 2001).

ARDL model is specified as follows:

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

The value of the dependent variable is determined by the lagged values of itself and the lagged values of the independent variables. The optimal number of lagged variables for the dependent variables is denoted by "p" while "q" is for the independent variables. This results in ARDL (p, q). The optimal lags are chosen to minimise the effect of multicollinearity. Dynamic models such as ARDL as opposed to static models such as OLS provide a framework for modelling inertia. For example, in this study the past values of approved building plans are likely to affect the current real estate prices. The ensuing tables provide the detailed stationary test results.

Table 4.6 shows the stationary test for price index. The absolute test statistic 2.162 was less than the critical value of 2.964 at 5% significance. Also, the p=0.2203 was greater than 5% hence the null hypothesis of non-stationarity could not be rejected.

Table 4.6: Stationarity test at levels - Price index

Variable: Price Index	
N	38
Number of lags = 1	
Test statistic	-2.162
p-value	0.2203.

Source: Author, 2023

However, at first difference as shown in Table 4.7, the price index series become stationary ($p<0.05$ and test-statistic within the rejection region).

Table 4.7: Stationarity test at first difference - Price index

Variable: D. Price Index	
N	37
Number of lags = 1	
Test statistic	-5.517
p-value	0.0000

Source: Author, 2023

Table 4.8 depict the stationary test for interest rates. The absolute test statistic 2.014 was less than 2.964 at 5% significance. Also, the $p=0.2806$ was greater than 5% hence the null hypothesis of non-stationarity could not be rejected.

Table 4.8: Stationarity test at levels - Interest

Variable: Interest	
N	37
Number of lags = 1	
Test statistic	-2.014
p-value	0.2806

Source: Author, 2023

However, at first difference as shown in Table 4.9, the interest series become stationary ($p<0.05$ and test-statistic within the rejection region).

Table 4.9: Stationarity test at first difference - Interest

Variable: D. Interest	
N	37
Number of lags = 1	
Test statistic	-4.019
p-value	0.0013

Source: Author, 2023

The outcome of the stationary test for inflation index is in Table 4.10. The absolute test statistic 0.157 was less than 2.964 at 5% significance. Also, the p=0.9698 was greater than 5% hence the series was not stationary.

Table 4.10: Stationarity test at levels – Inflation index

Variable: Inflation Index	
N	38
Number of lags = 1	
Test statistic	0.157
p-value	0.9698

Source: Author, 2023

However, at first difference as depicted in Table 4.11, the inflation index series become stationary ($p<0.05$ and test-statistic within the rejection region).

Table 4.11: Stationarity test at first difference - Inflation index

Variable: D. Inflation Index	
N	37
Number of lags = 1	
Test statistic	-6.56
p-value	= 0.000

Source: Author, 2023

In Table 4.12, the absolute test statistic 3.077 was greater than 2.964 at 5% significance. Also, the p=0.0283 was less than 5%. GDP series was therefore stationary at levels.

Table 4.12: Stationarity test at levels - GDP

Variable: GDP	
N	38
Number of lags = 1	
Test statistic	-3.077
p-value	0.0283

Source: Author, 2023

Table 4.13 shows the results for value of approved plans. The absolute test statistic 3.451 was greater than 2.964 at 5% significance as per Table 4.13. Also, the p=0.0093 was less than 5% hence the null hypothesis of non-stationarity was rejected. Log of Value of Approved Plans series was therefore stationary at levels.

Table 4.13: Stationarity test – LN value of approved plans

Variable: LN Value of Approved Plans	
N	38
Number of lags = 1	
Test statistic	-3.451
p-value	0.0093

Source: Author, 2023

Table 4.14 captures the stationary test results for rent index. The absolute test statistic 2.285 was less than 2.964 at 5% significance. Also, the p=0.1806 was greater than 5% hence the null hypothesis of non-stationarity was not rejected.

Table 4.14: Stationarity test – Rent Index

Variable: Rent Index	
N	38
Number of lags = 1	
Test statistic	-2.285
p-value	0.1806

Source: Author, 2023

However, at first difference as depicted in Table 4.15, the rent index series become stationary ($p<0.05$ and test-statistic within the rejection region).

Table 4.15: Stationarity test at first difference – Rent Index

Variable: D. Rent Index	
N	37
Number of lags = 1	
Test statistic	-7.505
p-value	= 0.000

Source: Author, 2023

4.7.2 Autocorrelation Test

Linear regression model assume that the errors are uncorrelated (Brooks, 2019). If the errors are correlated, then then autocorrelation is detected or there is serial dependence. Autocorrelation may lead to incorrect standard errors of estimates hence wrong inferences made. LM test of autocorrelation was used to detect serial dependence. Breusch Godfrey LM test has null hypothesis of no serial correlation. The resulting p-value of 0.6232 is greater than 5%. As such, the null hypothesis of no serial correlation could not be rejected. The test was based on the fitted data of all variables in the study.

Table 4.16: Autocorrelation test – Breusch Godfrey LM test

Lags(p)	Df	chi2	Prob>Chi2
4	4	2.620	0.6232

H0: no serial correlation

Source: Author, 2023

4.7.3 Heteroscedasticity Test

Classical linear regression model requires the variance of the errors to be constant (Green, 2002). This is the assumption of homoskedasticity. The errors are said to be heteroscedastic if the variance is not constant. The consequence of heteroscedasticity may lead to incorrect standard errors of the estimates hence wrong conclusion of the hypothesis test. Breusch-Pagan test for heteroskedasticity was used to detect heteroscedasticity.

Breusch-Pagan test has null hypothesis of constant variance. The resulting p-value of 0.2985 is greater than 5% (Table 4.17). As such, the null hypothesis of constant variance could not be rejected. The test was based on all the independent variables in the study. Therefore, the model does not suffer from heteroscedasticity.

Table 4.17: Heteroscedasticity test

Source	chi2	df	p
Heteroskedasticity	22.80	20	0.2985
Skewness	7.42	5	0.1916
Kurtosis	0.00	1	0.9619
Total	**30.22**	**26**	**0.2585**

Source: Author, 2023

4.7.4 Multicollinearity Test

Multicollinearity problem exists when the independent variables are correlated (Brooks, 2019). This may inflate the standard errors of estimate. The incorrect standard errors may lead to wrong inferences. Multicollinearity tests was carried using variance inflation factors (VIF). VIF of not more than ten is acceptable threshold. Table 4.18 summarises the test results.

Table 4.18: Multicollinearity test

	VIF	1/VIF
Inflation Index	3.956	.253
Interest	2.452	.408
GDP	2.059	.486
LN Value of Approved Plans	1.928	.519
Rent Index	1.641	.609
Mean VIF	2.407	.

Source: Author, 2023

Based on Table 4.18, all the variables had VIF within the acceptable threshold. Hence, presence of multicollinearity was not detected.

4.7.5 Normality Test

The errors are also assumed to be normally distributed ($ut \sim N(0, \sigma 2)$). This is an important requirement for hypothesis testing of the model parameters. 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 may be assumed if the sample is large by invoking the central limit theory.

Jarque-Bera null hypothesis is normality, and the alternative is non-normality. The test results were as per Table 4.19:

Table 4.19: Normality test

JB test: .2434 Chi (2) .8854 Ho: normality:

Source: Author, 2023

The null hypothesis of normality was not rejected ($p>0.05$). Therefore, the model parameters were suitable for hypothesis testing and prediction.

4.8 Correlation Analysis

The objective of the study was to establish the relationship among economic factors, property supply, rent value and residential real estate prices. Economic factors were measured by GDP, interest rates, and inflation index. Property supply was measured by the logs of the value of approved building plans. Rent value was measured by rent index and residential real estate prices operationalised by a price index. The rent and price indexes were constructed using the hedonic model using a sample of houses in Nairobi over a ten-year period.

A correlation analysis was carried out among all the study variables to establish the strength of association. The level of association was indicated by the magnitude of the correlation coefficient parameter. The strength of association was based on the significance test evaluated by p-values. The results are as per Table 4.20:

Table 4.20: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Price Index	1.000					
(2) GDP	-0.1907	1.000				
	(0.238)					
(3) LN Value of Approved Plans	-0.1201	0.501*	1.000			
	(0.460)	(0.001)				
(4) Inflation Index	0.714*	-0.437*	0.010	1.000		
	(0.000)	(0.005)	(0.951)			
(5) Interest	-0.442*	0.341*	-0.104	-0.759*	1.000	
	(0.004)	(0.031)	(0.522)	(0.000)		
(6) Rent Index	0.822*	-0.25	-0.136	0.683*	-0.473*	1.000
	(0.000)	(0.121)	(0.404)	(0.000)	(0.002)	

Source: Author, 2023

The values in parenthesis are the p-values while the others are the correlation coefficients. The correlation between price index and GDP is negative, weak, and insignificant (corr. = -0.1907; p>0,05). This seemed out of step with literature but agrees with Zhou (2021). The expected relationship was positive. GDP growth rate is expected to affect positively housing prices due to increased economic activity and demand. Price index is negatively and insignificantly related to value of approved plans (corr.= -0.1201; p>0,05). This agrees with theoretically expected relationship since increase in property supply is likely to reduce real estate prices. The correlation between price index and inflation is positive, strong, and significant (corr.=0.714; p<0,05). The empirical evidence on the relationship between inflation and real estate prices is mixed. Hence the resulting correlation agreed with some past studies.

Price index is negatively related to interest rates albeit moderate (corr. = -0.442). However, the level of association is significant (p<0.05). The correlation results agree with the theoretically expected relationship. High interest rates increase required rate of return which in turn affects property prices downwards. Besides, high interest rates may constrain

property supply which may push property prices upwards. The correlation between Price index and rent index is positive, strong, and significant (corr.=0.822; $p<0.05$). This tends to agree with theoretically expected relationship. Increase in rent is likely to increase real estate prices. However, an argument against this is that high rent may result in increased supply that may cause real estate prices to plummet. The results of the correlation analysis underscore the need for understanding the interplay of economic factors, property supply and rent values in the way the influence house prices.

4.9 Chapter Summary

This chapter presented the results of data analysis and the discussion of the findings. The overall objective of the study was to establish the relationship among economic factors, property supply, rent value and residential real estate prices in Nairobi. Besides, the study had five specific objectives.

The first and second objectives of developing Nairobi house price index and rent value index were achieved. The indices were developed using data collected for 1,073 houses in Nairobi. The model used passed the test of good fit.

Diagnostic tests were carried out and the data was found to be fit for hypothesis testing. There were no serial dependence, heteroscedasticity, and multicollinearity. The fitted data also passed the normality test. However, only GDP and value of approved plans series were found to be stationary at levels. The other variables namely price index, interest, inflation and rent index were stationary at first difference. The implication of the mixed stationarity was that the static OLS would not be suitable (Granger & Newbold, 1974). As such a dynamic model that incorporates lagged values of both the dependent and independent

variables would be suitable to avert spurious regression. Therefore, the study adopted ARDL model. The optimal number of lags was determined, and the model implemented to determine the relationship among the variables in the study.

CHAPTER FIVE: HYPOTHESES TESTING AND DISCUSSION OF FINDINGS

5.1 Introduction

This chapter presents the results of hypotheses tests. The objective of the study was to establish the relationship among economic factors, property supply, rent value and residential real estate prices. The main objective was divided into five specific objectives. The stationarity test showed that some variables were stationary at levels while others became stationary at first difference. This resulted into mixed stationarity. As such, the OLS which is a static model was not deemed appropriate. Therefore, ARDL which is a dynamic model was adopted. In this model, the dependent variable is regressed against its lagged values, independent variables at levels and lagged independent variables. The study had three hypotheses and ARDL was used to test the hypotheses.

ARDL was implemented in five steps. The first was to establish the optimal number of lags given that model incorporates lagged values. Bayesian Information Criterion (BIC) was used since it provides parsimonious results (Kripfganz & Schneider, 2020; Schwarz, 1978). The second was to test the model's significance through F-test. The third was to test whether the variables under study had long-run relationship or are cointegrated. Bounds test was used to test for cointegration (Kripfganz & Schneider, 2020; Pesaran, Shin, & Smith, 2001). The fourth was to specify and run the error correction model (ECM) to determine both the long-run and short-run relationships between the dependent and independent variables. The study used R^2 to determine the extent to which all the independent variables explain the variation in the dependent variable. The specific contribution of each predictor variable was determined using the t-test. Also, p-values were

utilised to test for the significance of the relationship. The fifth and last step was to carryout postestimation tests to confirm the validity of the hypothesis tests done. The post estimation tests included autocorrelation, heteroskedasticity, normality and parameter stability.

The following sections capture the results of each hypothesis that was tested. This was in line with methodology outlined in chapter three and as summarised in the preceding paragraph.

5.2 Economic Factors, Property Supply and Residential Real Estate Prices

This section addresses the first two objectives of the study. The first objective of the study was to establish the effect of economic factors on residential real estate prices. The second objective of the study was to establish the effect of property supply on residential real estate prices. Economic factors were GDP, inflation, and interest. Property supply was operationalised by the value of the building plans approved by Nairobi County. Real estate prices were operationalised by price index constructed in this study. The null hypotheses was (H_1) the effect of economic factors on residential real estate prices was not significant and (H_2) the effect of property supply on residential real estate prices was not significant. ARDL model was used to test these hypotheses. The following sub sections present the results.

5.2.1 Model Specification

The mixed stationarity of the variables under study necessitated the use of ARDL model. The ARDL model is generally specified as follows (Kripfganz & Schneider, 2020):

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

Where:

y_t = dependent variable
X = vector of independent variables
p = optimal number of lags - dependent variable
q = optimal number of lags - independent variables
$\emptyset$ = coefficient of the dependent variables
β = coefficient of the independent variables
u = error term

The dependent variable was residential real estate prices (price index). The independent variables were economic factors (GDP, inflation index, interest) and property supply (LN of value of approved plans). Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) were used to determine the optimal number of lags. BIC was chosen as it provides parsimonious results (Kripfganz & Schneider, 2020; Schwarz, 1978) and the outcome was as per Table 5.1:

Table 5.1: Optimal lags - Economic factors, property supply and real estate prices

Model	N	ll (null)	ll (model)	df	AIC	BIC
.	36	-145.1738	-127.8625	7	269.725	280.8096
Price Index					2	1
GDP					2	1
Inflation Index					0	0
Interest					1	0
LN of Value of Approved Plans					0	0

Source: Author, 2023

Having determined the optimal number of lags, the ARDL (1,1,0,0,0) was specified as follows:

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

The ARDL was run to test for overall model significance. Table 5.2 summarises the result:

Table 5.2: Model Summary - Economic factors, property supply and real estate prices

ARDL (1,1,0,0,0) regression
Sample: 2011q2 thru 2020q4

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

Source: Author, 2023

The model's R^2 was 0.7111 indicating that economic factors and property supply explain about 71.11% of the variation in residential real estate prices. The adjusted R^2 was 0.6369. The model was significant ($F=13.13$; $p<0.05$) at 5% of level of significance. Therefore, the specified ARDL (1,1,0,0,0) model was robust enough to test for the significance of the effect of each independent variable.

5.2.2 Cointegration Test

The next step was to determine whether long-run relationship among the variables exists. If long-run relationship exists, then error correction model (ECM) must be specified and run. Otherwise, then only the short run ARDL model would suffice. Bound test was used to determine cointegration.

The model is specified such that the first difference of the dependent variable is related to the lagged value of its first difference, differenced independent variables, and the lagged independent variables at levels. The following model was run to test for cointegration.

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

The terms with β and ∅ are coefficients associated with the differenced variables and they indicate short-run relationships. While δ indicate the long run relationships (Pesaran, Shin, & Smith, 2001). The null hypothesis for the cointegration test was as follows:

Ho: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$: No cointegration

H1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$: Presence of cointegration

Table 5.3 provides the summary of the cointegration test results:

Table 5.3: Cointegration test - Economic factors, property supply and real estate prices

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)

	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

Source: Author, 2023

The null hypothesis of no cointegration was rejected at 5% significance level [F=8.129 > 3.236 (I (0) and 4.587 (I (1)]. Also, p<0.05 hence residential real estate prices have long run relationship with economic factors and property supply.

5.2.3 Model Estimates Results

The results of the bound test indicated that residential real estate prices are cointegrated with economic factors and property supply. Therefore, error correction model (ECM) must be specified to determine the significance of the long run relationships. Also, the significance of the short-run relations was tested using short run ARDL model.

The ECM is generally specified as follows:

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

Where ECT is the error correction term being the residuals from the estimated long run model. ($ECT_t = y_t - \hat{y}t$)

Considering the optimal lags, the specific ECM was specified as follows:

$$\Delta PriceIndex_t = C_0 + \emptyset \Delta PriceIndex_{t-1} + \beta_1 \Delta GDP_t + \delta ECT_{t-1} + u_t$$

The ECM was run to test for overall model significance. Table 5.4 summarises the result:

Table 5.4: ECM Model summary - Economic factors, property supply and real estate prices

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's R^2 was 0.5599 indicating that economic factors and property supply explain about 55.99% of the variation in residential real estate prices. The adjusted R^2 was 0.4774. The model was significant (F=6.79; p<0.05) at 5% of level of significance. Therefore, the specified ECM model was robust enough to test for the significance of the effect of each independent variable. ECM was implemented and the output summary is in Table 5.5:

Table 5.5: ECM Regression results - Economic factors, property supply and real estate prices

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 real estate prices as indicated by R^2 of 0.4774. GDP (β = 484.34; t =2.74; p<0.05), Inflation (β = 0.706; t =4.88; p<0.05) and Value of approved plans (β = -18.722; t = -2.33; p<0.05) were found to have significant long run effect on real estate prices. A

1% growth in GDP will lead to 4.84% increase in real estate prices in the long run. While 1% change in Value of approved plans will lead to 0.187% decline in real estate prices (price index) in the long run. Besides, 1% change in inflation will lead to 0.706% increase in real estate prices (price index) in the long run. Interest (β = 242.373; t =1.48; p>0.05) had insignificant long run effect on prices.

The adjustment factor of negative 0.719 is significant (β = -0.719; t= -5.15; p<0.05). This indicates that 71.9% of the deviations from the long run equilibrium due to short run shocks in a particular quarter will be corrected in the subsequent period. Therefore, short run shocks will be corrected within two quarters (71.9% per quarter). The speed of adjustment of two quarters may seem slow but confirms the illiquid nature of the real estate market. Overall, this tends to agree with EMH and stock flow model. Even if the shocks are caused by irrational behaviours as espoused in behavioural finance, the market eventually experiences correction. The resulting equation is as follow:

$$Price\ Index = 88.785 + 484.34\ GDP + 0.706\ Inflation\ Index - 18.722\ Ln\ Valueof Approved\ Plans$$

In the short run, changes in GDP (β = -221.910; t = -2.40; p<0.05) have significant effect on real estate prices. A 1% increase in GDP will lead to a 2.21% decline in real estate prices in the short run. This seems to be out of step with the theoretically expected relationship. However, the finding agrees with Zhou (2021). The resulting short run equation is:

$$\Delta PriceIndex = -221.91\Delta GDP - 0.719ECT_{t-1}$$

5.2.4 Postestimation diagnostics

The results of the hypotheses tests indicate that economic factors (GDP, inflation) and property supply (value of approved plans) have long run significant effect on real estate prices. The validity of the outcome of the hypothesis test is subject to post estimation tests. The post estimation tests conducted included autocorrelation, heteroskedasticity, normality and parameter stability. The model passed all the four tests. Specifically, there was no autocorrelation (Table 5.6) and heteroscedasticity (Table 5.7) on the fitted model. The errors were also normally distributed (Table 5.8), and model parameters were found to be stable (Table 5.9).

Autocorrelation may lead to incorrect standard errors of estimates hence wrong inferences made. LM test for autocorrelation was used to test serial dependence. The null hypothesis being no serial correlation. The resulting p-value of 0.4032 is greater than 5% (Table 5.6). As such, the null hypothesis of no serial correlation could not be rejected. The test was based on the fitted model.

Table 5.6: Postestimation autocorrelation test - Economic factors, property supply and real estate prices

Lags (p)	chi2	Df	Prob>Chi2
4	4.021	4	0.4032

H0: no serial correlation

Source: Author, 2023

The errors are said to be heteroscedastic if the variance is not constant. The consequence of heteroscedasticity may lead to incorrect standard errors of the estimates hence wrong conclusion of the hypothesis test. Breusch-Pagan test for heteroskedasticity was used to detect heteroscedasticity.

Breusch-Pagan test has null hypothesis of constant variance. The resulting p-value of 0.2994 is greater than 5% (Table 5.7). As such, the null hypothesis of constant variance could not be rejected. The test was based on fitted model. Therefore, the model does not suffer from heteroscedasticity.

Table 5.7: Postestimation heteroscedasticity test - Economic factors, property supply and real estate prices

Source	chi2	df	P
Heteroskedasticity	30.33	27	0.2994
Skewness	7.01	6	0.3201
Kurtosis	0.99	1	0.3199
Total	**38.33**	**34**	**0.2795**

Source: Author, 2023

The errors are also assumed to be normally distributed ($ut \sim N(0, \sigma 2)$). This is an important requirement for hypothesis testing of the model parameters. Jarque-Bera null hypothesis is normality, and the alternative is non-normality. The test results were as per Table 5.8:

Table 5.8: Postestimation normality test - Economic factors, property supply and real estate prices

JB test: .3953 Chi (2) .8206 Ho: normality:

Source: Author, 2023

The null hypothesis of normality was not rejected ($p>0.05$). Therefore, the errors of the fitted model were normally distributed.

The fitted model assumes that the estimated parameters will remain stable over time. The expected value of the errors is zero. As such, the cumulative sum of errors is plotted to check whether they will deviate outside of the 95% confidence bands. Cumulative sum

(Cusum) test for parameter stability was used (Green, 2002). The null hypothesis is that there is no structural break. The cusum test result are as per Table 5.9 for recursive and Table 5.10 for OLS:

Table 5.9: Postestimation model stability test Recursive- Economic factors, property supply and real estate prices

Sample: 2011q2 thru 2020q4	Number of	obs = 39
H0: No structural break		
	-------- Critical value--------	
	statistic	5%
Recursive	**0.3952**	**0.9479**

Source: Author, 2023

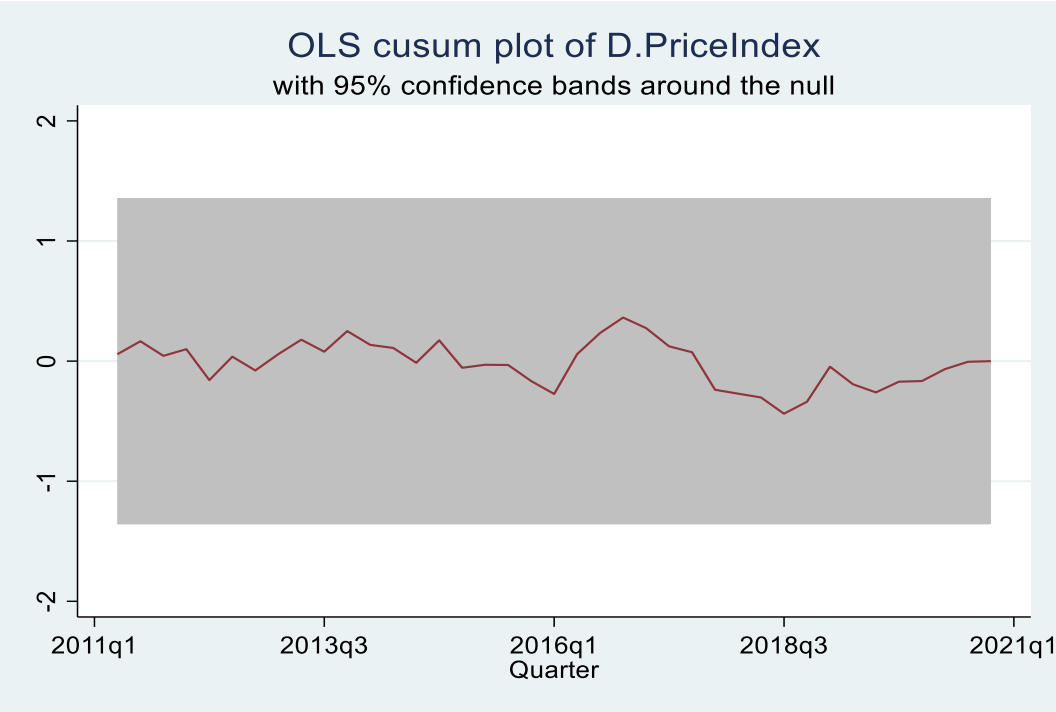
Table 5.10: Postestimation model stability test OLS- Economic factors, property supply and real estate prices

Sample: 2011q2 thru 2020q4	Number of	obs = 39
H0: No structural break		
	Test	---- Critical value--------
	statistic	5%
OLS	**0.4381**	**1.3581**

Source: Author, 2023

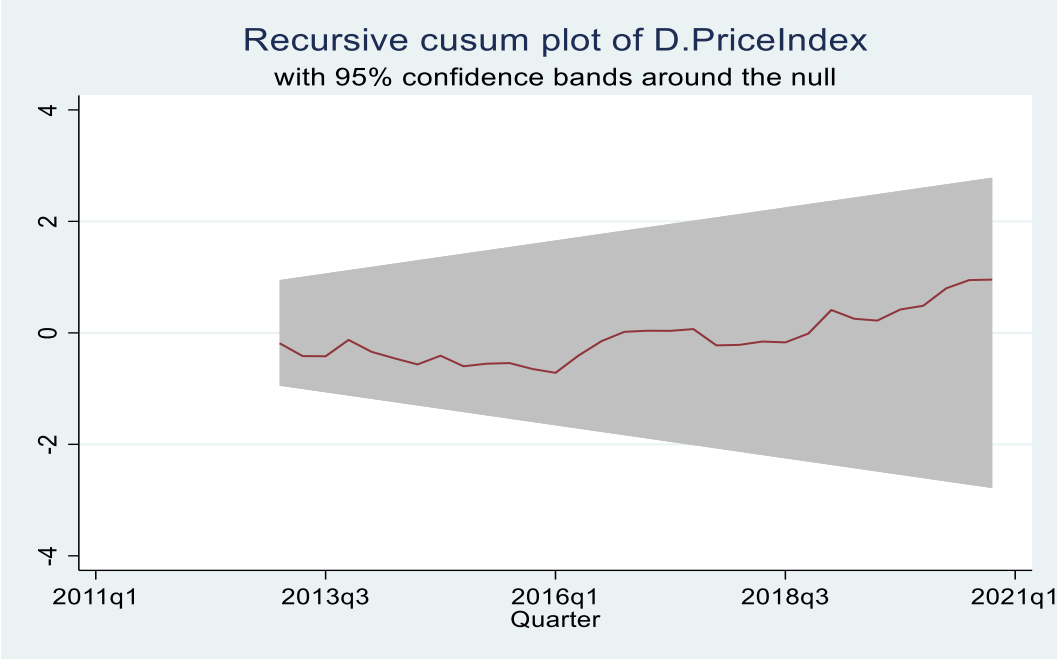
The null hypothesis of no structural break could not be rejected ($p>0.05$). Therefore, the model parameters were stable. Figure 5.1 and Figure 5.2 also depict the absence of structural break as the cumulative sum of the errors are within the 95% confidence bands.

Figure 5.1: OLS Cusum plot - Economic factors, property supply and real estate prices



Source: Author, 2023

Figure 5.2: Recursive Cusum plot - Economic factors, property supply and real estate prices



Source: Author, 2023

5.3 Mediating Effect of Rent Value on Economic Factors, Property Supply and Residential Real Estate Prices

This section addresses the third and fourth objectives of the study. The third objective of the study was to establish the mediating effect of rent value on the relationship between economic factors and residential real estate prices in Nairobi. While the fourth objective of the study was to establish the mediating effect of rent value on the relationship between property supply and residential real estate prices in Nairobi. Economic factors were measured by real GDP growth rate, inflation index and interest rates. Property supply was measured by the value of approved building plans by Nairobi City County. Rent value was measured by the rent index and real estate prices were measured by the price index constructed using the hedonic model. The null hypothesis was that (H_3) the mediating effect of rent value on the relationship between economic factors and residential real estate prices is not significant and (H_4) the mediating effect of rent value on the relationship between property supply and residential real estate prices is not significant. The mixed stationarity of the variables under study necessitated the use of ARDL model. ARDL model was used to test this hypothesis.

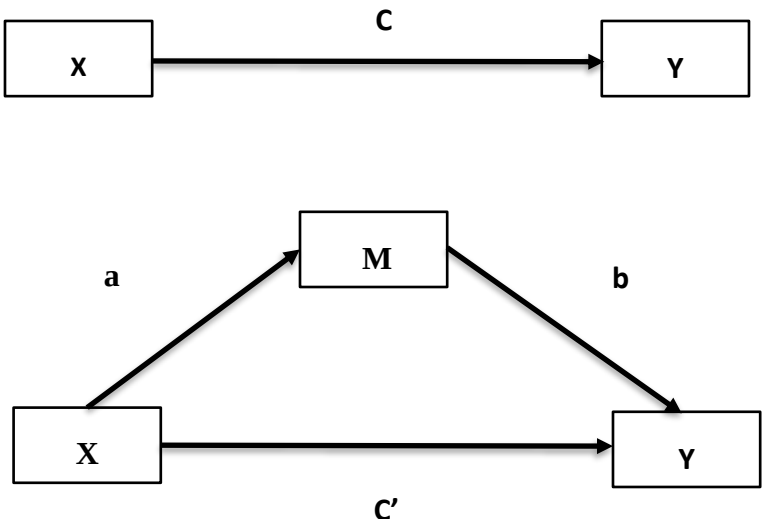
The mediating effect of rent value on the effect of economic factors and property supply on residential real estate prices was tested using the framework developed by Baron and Kenny (1986) and Sobel (1982).

5.3.1 Model Specification

The mediating effect of rent value on the effect of economic factors and property supply on residential real estate prices was be tested using the framework developed by Baron and

Kenny (1986) and Sobel (1982). The framework stipulates four steps that follow four paths as captured in Figure 5.3:

Figure 5.3: Mediation effect test framework



Step 1: This is denoted by path [C] in Figure 5.3. The relationship between independent variables (X) and dependent variable (Y) is tested.

Step 2: This is denoted by path [a] in Figure 5.3. The relationship between independent variables (X) and mediating variable (M) is tested. For mediation to exist, the independent variable (X) must have a significant effect on the mediator (M).

Step 3: This is denoted by path [b] in Figure 5.3. The relationship between the mediator (M) and dependent variable (Y) is tested. For mediation to exist, the mediator (M) must have a significant effect on the dependent variable (Y) controlling for independent

variables (X). This means under path [b] the dependent variable (Y) will be regressed against both the mediator and independent variables.

Step 4: The outcome of step three above is used to test for mediation. There is mediation if the coefficient of the mediator is significant having controlled for independent variables as denoted by path [b]. Mediation is partial if the coefficients of the independent variables remain significant in the presence of the mediator which is denoted by path [C'] Otherwise, if [C'] is insignificant while [b] is significant then there is full mediation.

Baron and Kenny (1986) test for mediation entails running the three regressions (steps 1 to 3) separately. Iacobucci et al. (2007) have shown that this results into larger standard errors. They therefore proposed estimating the coefficients and other parameters simultaneously through Structural Equation Modelling (SEM). The parameters associated with the direct effect (path c`) and the indirect effect (path a and path b) are estimated simultaneously using SEM. The indirect effect (mediation effect) parameter is [a*b]. "a" and "b" are like those obtained through Baron and Kenny steps save for estimation technique which is through SEM. The SEM estimated parameters were then tested for mediation effect using Sobel, and Aroian tests (Aroian, 1944; Sobel, 1982)

Zhao, Lynch and Chen (2010) discussed the shortcoming of the Sobel (1982) test. The shortcoming stems from the assumption that [a*b] is normally distributed. This may not be the case even when the individual distributions of [a] and [b] are symmetrical. They therefore proposed bootstrapping method to generate a sampling distribution for [a*b] which is then tested independently. In this study we have used Monte Carlo simulation

with 2,000 replacements to generate distribution for [a*b] and tested it for its significance (Jose, 2013).

In summary, the study employed three tests for mediation. The first approach was based purely on Baron and Kenny (1986). The second, was the extension proposed by Iacobucci et al. (2007). Here, the model parameters were estimated using SEM. Then Sobel and Aroian tests were carried to establish the mediation effect (Sobel, 1982; Aroian, 1944). The third approach was bootstrapping. This was done in keeping with the work of Zhao, Lynch and Chen (2010) and Jose (2013). The outcome of the mediation test is presented in the following sections in keeping with the four steps and paths.

5.3.2 Step One: Economic Factors, Property Supply and Residential Real Estate Prices

This first step was to first determine whether the effect of economic factors and property supply on residential real estate prices was statistically significant. This is exactly what was done in section 5.2 as part of the first and second objectives of the study. The dependent variable was residential real estate prices (price index). The independent variables were economic factors (GDP, inflation index, interest) and property supply (LN of value of approved plans).

ARDL was implemented in five steps. Firstly, optimal number of lags was determined using BIC. The optimal lags were Price index (1), GDP (1), Inflation index (0), Interest (0), and LN of value of approved plans (0). Therefore ARDL (1,1,0,0,0) was specified. Secondly, the overall significance of the ARDL (1,1,0,0,0) model was tested and was found to be significant ($F=13.13$; $p<0.05$). Thirdly, Cointegration test was carried out to

determine existence of long run relationships among the variables under study. The bound test for cointegration indicated that cointegration existed [F=8.129 > 3.236 (I (0) and 4.587 (I (1)].

Fourthly, error correction model was specified and the short run ARDL model to determine both the long-run and short-run relationships between the dependent and independent variables. The outcome of the test indicated that economic factors (GDP and inflation) and property supply had significant effect on residential real estate prices in the long run. Also, GDP had short run effect on the changes in residential real estate prices. The short run deviation from the equilibrium long run relationship was corrected at the speed of 71.9% in the subsequent quarter. This was captured by the adjustment factor that was significant at 5% (β=-0.719; t= -5.15; p<0.05). Economic factors and property supply explained 55.99% of the variation in the residential real estate prices.

Lastly, postestimation tests were carried out to confirm the validity of the outcome of the hypothesis tests. The fitted model passed all the four tests. Specifically, there was no autocorrelation [p: 0.4032>0.05] and heteroscedasticity [p: 0.2994 >0.05]. The errors were also normally distributed [p: 0.8206>0.05], and model parameters were found to be stable [t (0.3952) < critical value (0.9479)].

In summary, the ECM model specified was:

$$\Delta PriceIndex_t = C_0 + \emptyset \Delta PriceIndex_{t-1} + \beta_1 \Delta GDP_t + \delta ECT_{t-1} + u_t$$

The ECM was run to test for overall model significance. Table 5.11 summarises the result:

Table 5.11: ECM Model summary – Step one of mediation test

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's R^2 was 0.5599 indicating that economic factors and property supply explain about 55.99% of the variation in residential real estate prices. The model was significant ($F=6.79$; $p<0.05$) at 5% of levels of significance. Therefore, the specified ECM model was robust enough to test for the significance of the effect of each independent variable. Table 5.12 provides the output the ECM:

Table 5.12: ECM Regression results – Step one of mediation test

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 real estate prices as indicated by R^2 of 0.4774. GDP (β = 484.34; t =2.74; $p<0.05$), Inflation (β = 0.706; t =4.88; $p<0.05$) and Value of approved plans (β = -18.722; t = -2.33; $p<0.05$) were found to have significant long run effect on real estate prices. A 1% growth in GDP will lead to 4.84% increase in real estate prices in the long run. While 1% change in Value of approved plans will lead to 0.187% decline in real estate prices (price index) in the long run. Besides, 1% change in inflation will lead to 0.706% increase in real estate prices (price index) in the long run. On the other hand, Interest (β = 242.373; t =1.48; $p>0.05$) had insignificant long run effect on house prices.

The adjustment factor of negative 0.719 is significant (β = -0.719; t= -5.15; $p<0.05$). This indicates that 71.9% of the deviations from the long run equilibrium due to short run shocks in a particular quarter will be corrected in the subsequent period. Therefore, short run shocks will be corrected within two quarters (71.9% per quarter). The speed of adjustment of two quarters may seem slow but confirms the illiquid nature of the real estate market. Overall, this tends to agree with EMH and stock flow model. Even if the shocks are caused by irrational behaviours as espoused in behavioural finance, the market eventually experiences correction. The resulting equation is as follow:

$$Price\ Index = 88.785 + 484.34\ GDP + 0.706\ Inflation\ Index - 18.722\ Ln\ Valueof Approved\ Plans$$

In the short run, changes in GDP (β = -221.910; t = -2.40; $p<0.05$) have significant effect on real estate prices. A 1% increase in GDP will lead to a 2.21% decline in real estate prices in the short run. This seems to be out of step with the theoretically expected relationship. However, the finding agrees with Zhou (2021). The resulting short run equation is:

$$\Delta PriceIndex = -221.91\Delta GDP - 0.719ECT_{t-1}$$

In summary, the first step and path [C] of the mediation test was completed. The results indicated that economic factors (GDP and inflation) and property supply (value of approved plans) had significant effect on residential real estate prices. The next step was to determine whether these variables (GDP, Inflation and Value of approved plans) have significant effect on the mediator (Rent value). This is step two and path [b].

5.3.3 Step Two: Economic Factors, Property Supply and Rent Value

In step two (path [a]), the effect of independent variables (GDP, inflation, interest and value of approved plans) on the mediating variable (Rent index) was tested. The null hypothesis was that economic factors (GDP, inflation, interest) and property supply (Value of approved plans) do not have a significant effect on rent value (Rent index). ARDL was implemented in multiple steps to test this hypothesis.

The first was to establish the optimal number of lags given that model incorporates lagged values. BIC was used since it provides parsimonious results. The second was to test the model's significance through F-test. The third was to test whether the variables under study had long-run relationship or are cointegrated. Bounds test was used to test for cointegration. The fourth was to specify and run the error correction model to determine both the long-run and short-run relationships between the dependent and independent variables. The study used R^2 to determine the extent to which all the independent variables explain the variation in the dependent variable. The specific contribution of each predictor variable was determined using the t-test. Also, p-values were utilised to test for the significance of the relationship. The fifth and last step was to carryout postestimation tests to confirm the

validity of the hypothesis tests done. The post estimation tests included autocorrelation, heteroskedasticity, normality and parameter stability. The results are as presented in the ensuing sections.

BIC and AIC were used to determine the optimal number of lags. BIC was chosen as it provides parsimonious results (Kripfganz & Schneider, 2020; Schwarz, 1978). The outcome of the test is as per Table 5.13:

Table 5.13: Optimal lags - step two of mediation test

Model	N	ll (null)	ll (model)	df	AIC	BIC
.	36	-152.5638	-140.5074	7	295.0149	306.0995
Rent Index					2	1
GDP					4	0
Inflation Index					4	0
Interest					3	1
LN of Value of Approved Plans					4	0

Source: Author, 2023

Having determined the optimal number of lags, the ARDL (1,0,0,1,0) model was specified as follows:

$$RentIndex_t = C_0 + \emptyset RentIndex_{t-1} + \beta_1 GDP_t + \beta_2 InflationIndex_t + \beta_3 Interest_t + \beta_4 Interest_{t-1} + \beta_5 Ln\,Valueof ApprovedPlans_t + u_t$$

The ARDL was run to test for overall model significance. Table 5.14 summarises the result:

Table 5.14: Model summary - step two of mediation test

ARDL (1,0,0,1,0) regression
Sample: 2011q2 thru 2020q4

Source	SS	df	MS			
Model	8138.46546	6	1356.410910	Number of obs	=	39
Residual	5364.52127	32	167.641290	F (6, 32)	=	8.09
Total	**13502.98673**	**38**	**355.341756**	Prob > F	=	0.0000
				R-squared	=	0.6027
				Adj R-squared	=	0.5282
				Root MSE	=	12.948

Source: Author, 2023

The model's R^2 was 0.6027 indicating that economic factors and property supply explain about 60.27% of the variation in rent value. The model was significant (F=8.09; p<0.05) at 5% level of significance. Therefore, the specified ARDL (1,0,0,1,0) model was robust enough to test for the significance of the effect of each independent variable.

The next step was to determine whether long-run relationship among the variables exists. If long-run relationship exists, then error correction model (ECM) must be specified and run. In the absence of long-run relationship, then only the short run ARDL model would suffice. Bound test was used to determine cointegration.

The model is specified such that the first difference of the dependent variable is related to the lagged value of its first difference, differenced independent variables and the lagged independent variables at levels. The following model was run to test for cointegration.

$$\begin{aligned}\Delta RentIndex_t = {} & C_0 + \emptyset \Delta RentIndex_{t-1} + \beta_1 \Delta Interest_t + \delta_1 RentIndex_{t-1} \\ & + \delta_2 GDP_{t-1} + \delta_3 InflationIndex_{t-1} + \delta_4 Interest_{t-1} \\ & + \delta_5 LNValueofApprovedPlans_{t-1} + u_t\end{aligned}$$

The terms with β and ∅ are coefficients associated with differenced variables and they do indicate short-run relationships. While δ terms indicate the long run relationships.

The results of the cointegration test are as per Table 5.15:

Table 5.15: Cointegration test - step two of mediation test

Pesaran, Shin, and Smith (2001) bounds test	
H0: no level relationship	F = 7.262
Case 3	t = -5.079
Finite sample (4 variables, 39 observations, 1 short-run coefficients)	

	5%		p-value	
	I (0)	**I (1)**	**I (0)**	**I (1)**
F	3.236	4.587	0.001	0.004
t	-2.909	-4.074	0.000	0.007

Source: Author, 2023

The null hypothesis was rejected at 5% significance level [F=7.262 > 3.236 (I (0) and 4.587 (I (1)]. Also, p<0.05 hence rent value have long run relationship with economic factors and property supply. Having determined existence of cointegration, the following ECM was specified:

$$\Delta RentIndex_t = C_0 + \emptyset \Delta RentIndex_{t-1} + \beta_1 \Delta Interest_t + \delta ECT_{t-1} + u_t$$

The overall significance of the ECM was tested, and results summarised in Table 5.16:

Table 5.16: ECM Model Summary - step two of mediation test

ARDL (1,0,0,1,0) regression
Sample: 2011q2 thru 2020q4

Source	**SS**	**df**	**MS**			
Model	6087.58316	6	1014.597193	Number of obs	=	39
Residual	5364.52127	32	167.641290	F (6, 32)	=	6.05
Total	**11452.1044**	**38**	**301.371169**	Prob > F	=	0.0003
				R-squared	=	0.5316
				Adj R-squared	=	0.4437
				Root MSE	=	12.948

Source: Author, 2023

The model's R^2 was 0.5316 indicating that economic factors and property supply explain about 53.16% of the variation in rent value. The model was significant (F=6.05; p<0.05) at 5% level of significance. Therefore, the specified ECM model was robust enough to test for the significance of the effect of each independent variable. Table 5.17 provides a summary of the ECM output:

Table 5.17: ECM Regression Results - step two of mediation test

ARDL (1,0,0,1,0) regression
Sample: 2011q2 thru 2020q4 — Number of obs = 39
R-squared = 0.5316
Adj R-squared = 0.4437
Log likelihood = -151.35662 — Root MSE = 12.9476

D. Rent Index	Coefficient	Std. err.	t	P>t
ADJ				
Rent Index				
L1.	-0.864	0.170	-5.080	0.000
LR				
GDP	151.873	164.729	0.920	0.363
Inflation Index	0.533	0.155	3.430	0.002
Interest	125.052	185.641	0.670	0.505
LN Value of Approved Plans	-13.289	9.024	-1.470	0.151
SR				
Interest				
D1.	-546.614	256.034	-2.130	0.041
_cons	122.638	90.489	1.360	0.185

Source: Author, 2023

Inflation (β=0.533; t=3.43; p<0.05) was found to have significant long run effect on rent value. The findings are in line with the theoretically expected relationships. They also support generally the arguments of EMH. 1% growth in inflation will lead to 0.53% increase in rent value in the long run. GDP (β=151.873; t=0.92; p>0.05), Value of approved plans (β= -13.289; t= -1.47; p>0.05) and Interest (β= 125.052; t= 0.670; p>0.05) had insignificant long run effect on rent value.

The adjustment factor of negative 0.864 is significant (t= -5.08; p<0.05). This indicates that 86.4% of the deviations from the long run equilibrium due to short run shocks in a particular quarter will be corrected in the next quarter. Therefore, short run shocks will be

quickly corrected. This supports the notion that real estate market may be efficient despite its illiquid nature. The resulting equation is:

$$RentIndex = 122.638 + 0.533\ InflationIndex$$

In the short run, changes in Interest (β= -546.614; t= -2.13; p<0.05) have significant effect on rent value. The negative interest effect may be associated with liquidity signalling. However, the long run positive relationship is regained quickly. A 1% increase in interest rates will lead to a 5.46% decline in rent value in the short run. The resulting equation is:

$$\Delta RentIndex = -546.614\ \Delta Interest - 0.864 ECT_{t-1}$$

The results of the hypotheses tests indicate that inflation has long run significant effect on rent value. The validity of the outcome of the hypothesis test is subject to post estimation tests. The post estimation tests conducted included autocorrelation, heteroskedasticity, normality and parameter stability. The model passed all the four tests. Specifically, there was no autocorrelation (Table 5.18), heteroscedasticity (Table 5.19) on the fitted model. The errors were also normally distributed (Table 5.20), and model parameters were found to be stable (Table 5.21).

An important assumption of the linear regression model is that the errors are uncorrelated with one another. Autocorrelation may lead to incorrect standard errors of estimates hence wrong inferences made. Breusch Godfrey LM test for autocorrelation was used to detect serial dependence.

Table 5.18: Postestimation autocorrelation test - step two of mediation test

Lags (p)	LM test for autocorrelation chi2	Df	Prob>Chi2
4	7.06 H0: no serial correlation	4	0.1328

Source: Author, 2023

Breusch Godfrey LM test has null hypothesis of no serial correlation. The resulting p-value of 0.1328 is greater than 5% (Table 5.18). As such, the null hypothesis of no serial correlation could not be rejected. The test was based on the fitted data of all variables in the study.

Classical linear regression model requires the variance of the errors to be constant. This is the assumption of homoskedasticity. The consequence of heteroscedasticity may lead to incorrect standard errors of the estimates hence wrong conclusion of the hypothesis test. Breusch-Pagan test for heteroskedasticity was used to detect heteroscedasticity.

Table 5.19: Postestimation heteroscedasticity test - step two of mediation test

White's test			
Source	**chi2**	**Df**	**P**
Heteroskedasticity	27.59	27	0.4325
Skewness	6.95	6	0.3255
Kurtosis	0.39	1	0.5346
Total	**34.92**	**34**	**0.4240**

Source: Author, 2023

Breusch-Pagan test has null hypothesis of constant variance. The resulting p-value of 0.4325 is greater than 5% (Table 5.19). As such, the null hypothesis of constant variance could not be rejected. The test was based on all the independent variables in the study. Therefore, the model does not suffer from heteroscedasticity.

The errors are also assumed to be normally distributed ($ut \sim N(0, \sigma 2)$). This is an important requirement for hypothesis testing of the model parameters. Jarque-Bera test was used to test for normality. Jarque-Bera null hypothesis is normality, and the alternative is non-normality. The test results were as per Table 5.20:

Table 5.20: Postestimation normality test - step two of mediation test

JB test: 2.132 Chi (2) .3445
Ho: normality:

Source: Author, 2023

The null hypothesis of normality was not rejected ($p>0.05$). Therefore, the model parameters were suitable for hypothesis testing and prediction.

The fitted model assumes that the estimated parameters will remain stable over time. The expected value of the errors is zero. As such, the cumulative sum of errors is plotted to check whether they will deviate outside of the 95% confidence bands. Cumulative sum (Cusum) test for parameter stability was used. The null hypothesis is that there is no structural break. The recursive cusum test result is as per Table 5.21 and Table 5.22 for OLS.

Table 5.21: Postestimation model stability recursive test – step two of mediation test

Sample: 2011q2 thru 2020q4 Number of obs = 39
H0: No structural break

	Test statistic	-------- Critical value --------- 5%
Recursive	**0.3257**	**0.9479**

Source: Author, 2023

Table 5.22: Postestimation model stability OLS test – step two of mediation test

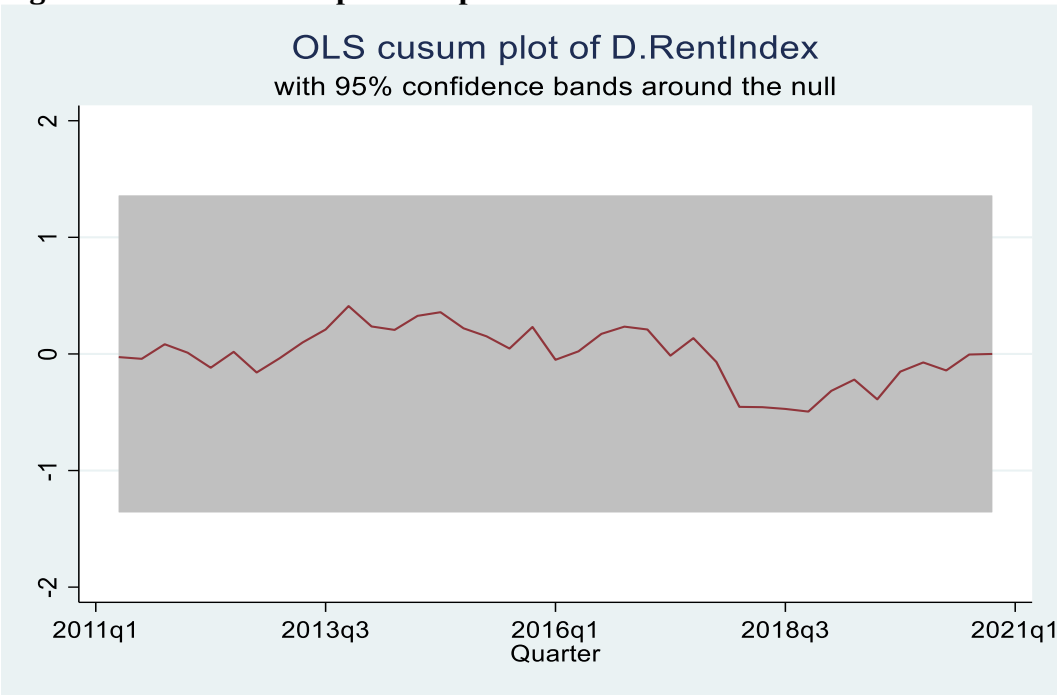
Sample: 2011q2 thru 2020q4 Number of obs = 39
H0: No structural break

	Test statistic	-------- Critical value --------- 5%
OLS	**0.4942**	**1.3581**

Source: Author, 2023

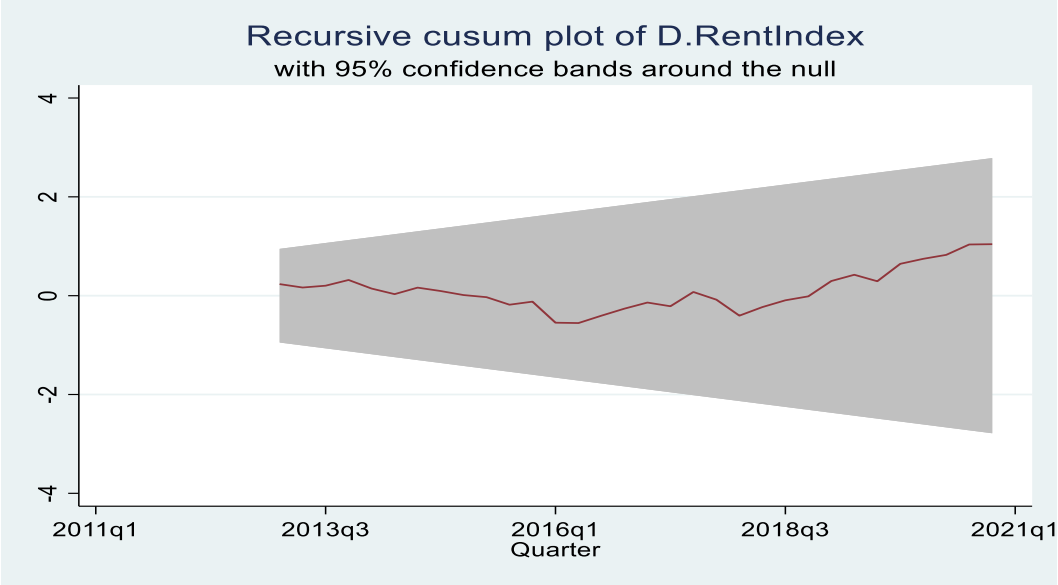
The null hypothesis of no structural break could not be rejected (p>0.05). Therefore, the model parameters were stable. Figure 5.4 and Figure 5.5 also depict the absence of structural break as the cumulative sum of the errors are within the 95% confidence bands.

Figure 5.4: OLS Cusum plot – step two of mediation test



Source: Author, 2023

Figure 5.5: Recursive Cusum plot – step two of mediation test



Source: Author, 2023

In summary, the second step and path [a] of the mediation test was completed. The results indicated that inflation had significant effect on rent value. The next step was to determine whether the mediator (rent value) controlling for (economic factors and property supply) have significant effect on the real estate prices (Price index). This is step three and path [b].

5.3.4 Step Three: Effect of Rent Value on Residential Real Estate Prices

In step three (path [b]), the effect of mediator the mediator (rent value) controlling for (economic factors and property supply) on the real estate prices (Price index) was tested. The null hypothesis was that the effect of rent value on residential real estate prices is not significant. ARDL was implemented through multiple steps to test this hypothesis.

The first was to establish the optimal number of lags given that model incorporates lagged values. BIC was used since it provides parsimonious results. The second was to test the model's significance through F-test. The third was to test whether the variables under study had long-run relationship or are cointegrated. Bounds test was used to test for cointegration. The fourth was to specify and run the error correction model to determine both the long-run and short-run relationships between the dependent and independent variables. The study used R^2 to determine the extent to which all the independent variables explain the variation in the dependent variable. The specific contribution of each predictor variable was determined using the t-test. Also, p-values were utilised to test for the significance of the relationship. The last step was to carryout postestimation tests to confirm the validity of the hypothesis tests done. The post estimation tests included autocorrelation, heteroskedasticity, normality and parameter stability. The results are as presented below.

BIC and AIC were used to determine the optimal number of lags. BIC was chosen as it provides parsimonious results (Kripfganz & Schneider, 2020; Schwarz, 1978). The outcome of the test was as per Table 5.23:

Table 5.23: Optimal lags – step three of mediation test

Model	N	ll (null)	ll (model)	df	AIC	BIC
.	36	-145.1738	-117.0959	8	250.1918	262.86
Price Index					1	1
GDP					3	1
Inflation Index					4	0
Interest					3	0
LN of Value of Approved Plans					3	0
Rent Index					4	0

Source: Author, 2023

Having determined the optimal number of lags, the ARDL (1,1,0,0,0,0) was specified as follows:

$$PriceIndex_t = C_0 + \emptyset PriceIndex_{t-1} + \beta_1 GDP_t + \beta_2 GDP_{t-1} + \beta_3 InflationIndex_t + \beta_4 Interest_t + \beta_5 Ln\ Valueof ApprovedPlans_t + \beta_6 RentIndex_t + u_t$$

The ARDL was run to test for overall model significance. Table 5.24 summarises the result:

Table 5.24: Model summary – step three of mediation test

ARDL (1,1,0,0,0,0)
regression
Sample: 2011q2 thru 2020q4

Source	SS	df	MS			
Model	7727.31713	7	1103.90245	Number of obs	=	39
Residual	1723.11139	31	55.584238	F (7, 31)	=	19.86
Total	**9450.4285**	**38**	**248.695487**	Prob > F	=	0.0000
				R-squared	=	0.8177
				Adj R-squared	=	0.7765
				Root MSE	=	7.4555

Source: Author, 2023

The model's R^2 was 0.8177 indicating that economic factors and property supply and rent value explain about 81.77% of the variation in residential real estate prices. The model was significant (F=19.86; p<0.05) at 5% level of significance. Therefore, the specified ARDL

(1,1,0,0,0,0) model was robust enough to test for the significance of the effect of each independent variable.

The next step was to determine whether long-run relationship among the variables exists. If long-run relationship exists, then error correction model (ECM) must be specified and run. In the absence of long-run relationship, then only the short run ARDL model would suffice. Bound test was used to determine cointegration.

The model is specified such that the first difference of the dependent variable is related to the lagged value of its first difference, differenced independent variables and the lagged independent variables at levels. The following model was run to test for cointegration.

$$\Delta PriceIndex_t = C_0 + \emptyset\Delta PriceIndex_{t-1} + \beta_1\Delta GDP_t + \delta_1 PriceIndex_{t-1} + \delta_2 GDP_{t-1} + \delta_3 InflationIndex_{t-1} + \delta_4 Interest_{t-1} + \delta_5 LNValueofApprovedPlans_{t-1} + \delta_6 RentIndex_{t-1} + u_t$$

The terms with β and ∅ are coefficients associated with the differenced variables and they do indicate short-run relationships. While δ terms indicate the long run relationships. The results of the cointegration test are as per Table 5.25:

Table 5.25: Cointegration test – step three of mediation test

Pesaran, Shin, and Smith (2001) bounds test

H0: no level relationship — F = 13.418

Case 3 — t = -7.666

Finite sample (5 variables, 39 observations, 1 short-run coefficient)

	5%		p-value	
	I (0)	**I (1)**	**I (0)**	**I (1)**
F	3.022	4.424	0.000	0.000
t	-2.901	-4.277	0.000	0.000

Source: Author, 2023

The null hypothesis was rejected at 5% significance level [F=13.418 > 3.022 (I (0) and 4.424 (I (1)]. Also, p<0.05 hence residential real estate prices have long run relationship with economic factors, property supply and rent value.

Having determined existence of cointegration, the following ECM was specified:

$$\Delta PriceIndex_t = C_0 + \emptyset\Delta PriceIndex_{t-1} + \beta_1\Delta GDP_t + \delta ECT_{t-1} + u_t$$

The overall significance of the ECM was tested, and results summarised in Table **5.26**.

Table 5.26: ECM Model summary – step three of mediation test

ARDL (1,1,0,0,0,0)
regression
Sample: 2011q2 thru 2020q4

Source	**SS**	**df**	**MS**			
Model	4480.39576	7	640.056537	Number of obs	=	39
Residual	1723.11139	31	55.584238	F (7, 31)	=	11.52
Total	**6203.5072**	**38**	**163.250188**	Prob > F	=	0.0000
				R-squared	=	0.7222
				Adj R-squared	=	0.6595
				Root MSE	=	7.4555

Source: Author, 2023

The model's R^2 was 0.7222 indicating that economic factors, property supply and rent value explain about 72.22% of the variation in real estate prices. The model was significant (F=11.52; p<0.05) at 5% level of significance. Therefore, the specified ECM model was robust enough to test for the significance of the effect of each independent variable. The ECM output is as per Table 5.27:

Table 5.27: ECM Regression Results – step three of mediation test

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

Sample: 2011q2 thru 2020q4 — Number of obs = 39
R-squared = 0.7222
Adj R-squared = 0.6595
Log likelihood = -129.21094 — Root MSE = 7.4555

D. Price Index	Coefficient	Std. err.	t	P>t
ADJ				
Price Index				
L1.	-1.069	0.139	-7.670	0.000
LR				
GDP	258.999	95.403	2.710	0.011
Inflation Index	0.372	0.089	4.170	0.000
Interest	139.597	87.685	1.590	0.122
LN Value of Approved Plans	-7.372	4.406	-1.670	0.104
Rent Index	0.449	0.085	5.260	0.000
SR				
GDP				
D1.	-236.670	74.774	-3.170	0.003
_cons	36.435	54.733	0.670	0.511

Source: Author, 2023

GDP (β=258.999; t=2.71; p<0.05), Inflation (β= 0.372; t= 4.17; p<0.05) and rent value (β= 0.449; t= 5.26; p<0.05) were found to have significant long run effect on real estate prices. A 1% growth in GDP will lead to 2.58% increase in real estate prices in the long run. While 1% change in rent value will lead to 0.449% increase in real estate prices (price index) in the long run. Besides, a 1% rise in inflation will lead to 0.372% rise in real estate prices in the long run. The established long run relationship between rent and real estate prices is supported by literature and theory (Ambrose, Eichholtz & Lindenthal, 2013; Belke & Keil, 2018); McNamara & Paul, 1997; Malpezzi, 1999). On the other hand, value of approved plans (β=-7.372; t=-1.67; p>0.05) and Interest (β= 139.597; t= 1.59; p>0.05) had insignificant long run effect on real estate prices. These insignificant effects have implications on the last step in the mediation test.

The adjustment factor of negative 1.06 is significant (t= -7.67; p<0.05). This indicates that about 100% of the deviations from the long run equilibrium due to short run shocks in a particular quarter will be corrected in the next quarter. The quick correction of discrepancies from equilibrium relationship speaks to the efficiency of the real estate market. It also supports the stock flow model given that prices are determined by fundamental factors. The resulting equation is:

$$PriceIndex = 36.435 + 258.999\, GDP + 0.372\, Inflation + 0.449\, RentIndex$$

In the short run, changes in GDP (β= -236.670; t= -3.17; p<0.05) had significant effect on real estate prices. The negative GDP effect may seem out of step with theory. It agrees with empirical findings of Zhou (2021). However, these short run deviations from equilibrium are corrected in full in the subsequent quarter.

The results of the hypotheses tests indicate that rent value, GDP and inflation have long run significant effect on real estate prices. The validity of the outcome of the hypothesis test is subject to post estimation tests. The post estimation tests conducted included autocorrelation, heteroskedasticity, normality and parameter stability. The model passed all the four tests. Specifically, there was no autocorrelation (Table 5.28), heteroscedasticity (Table 5.29) on the fitted mode. The errors were also normally distributed (Table 5.30), and model parameters were found to be stable (Table 5.31 and Table 5.32).

An important assumption of the linear regression model is that the errors are uncorrelated with one another. If the errors are correlated, then then autocorrelation is detected or there is serial dependence. Autocorrelation may lead to incorrect standard errors of estimates hence wrong inferences made. Breusch Godfrey LM test for autocorrelation was used.

Table 5.28: Postestimation autocorrelation test – step three of mediation test

Lags (p)	LM test for autocorrelation chi2	Df	Prob>Chi2
4	1.916	4	0.7512

H0: no serial correlation

Source: Author, 2023

Breusch Godfrey LM test has null hypothesis of no serial correlation. The resulting p-value of 0.7512 is greater than 5% (Table 5.28). As such, the null hypothesis of no serial correlation could not be rejected. The test was based on the fitted data of all variables in the study.

Classical linear regression model requires the variance of the errors to be constant. This is the assumption of homoskedasticity. The errors are said to be heteroscedastic if the variance is not constant. The consequence of heteroscedasticity may lead to incorrect standard errors of the estimates hence wrong conclusion of the hypothesis test. Breusch-Pagan test for heteroskedasticity was used to detect heteroscedasticity.

Table 5.29: Postestimation heteroscedasticity test – step three of mediation test

White's test			
Source	**chi2**	**df**	**p**
Heteroskedasticity	38.32	35	0.3214
Skewness	6.20	7	0.5170
Kurtosis	0.12	1	0.7253
Total	**44.64**	**43**	**0.4028**

Source: Author, 2023

Breusch-Pagan test has null hypothesis of constant variance. The resulting p-value of 0.3214 is greater than 5% (Table 5.29). As such, the null hypothesis of constant variance

could not be rejected. The test was based on all the independent variables in the study. Therefore, the model does not suffer from heteroscedasticity.

The errors are also assumed to be normally distributed ($ut \sim N(0, \sigma 2)$). This is an important requirement for hypothesis testing of the model parameters. Jarque-Bera test was used to test for normality. Jarque-Bera null hypothesis is normality, and the alternative is non-normality. The test results were as per Table 5.30:

Table 5.30: Postestimation normality test – step three of mediation test

JB test: .1873 Chi (2) .9106
Ho: normality:

Source: Author, 2023

The null hypothesis of normality was not rejected ($p>0.05$). Therefore, the model parameters were suitable for hypothesis testing and prediction.

The fitted model assumes that the estimated parameters will remain stable over time. The expected value of the errors is zero. As such, the cumulative sum of errors is plotted to check whether they deviate outside of the 95% confidence bands. Cumulative sum (Cusum) test for parameter stability was used. The null hypothesis is that there is no structural break. The cusum test result is as per Table 5.31 for recursive and Table 5.32 for OLS.

Table 5.31: Postestimation model stability recursive test – step three of mediation test

Sample: 2011q2 thru 2020q4		Number of obs = 39
H0: No structural break		
	Test statistic	-------- Critical value --------- 5%
Recursive	**0.7830**	**0.9479**

Source: Author, 2023

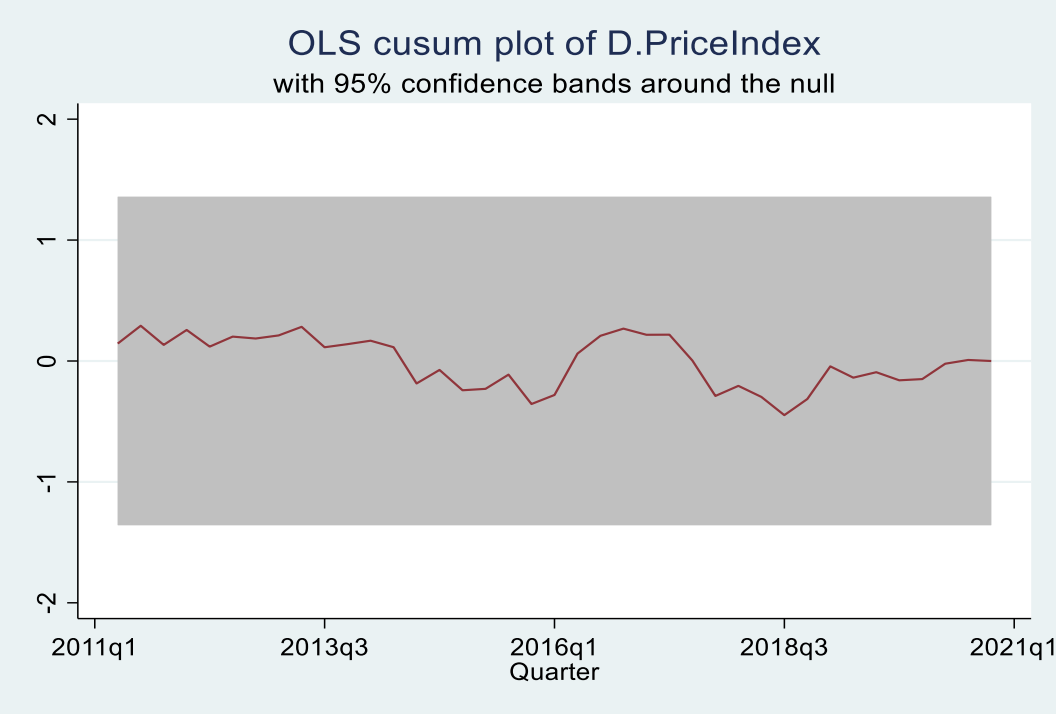
Table 5.32: Postestimation model stability OLS test – step three of mediation test

Sample: 2011q2 thru 2020q4		Number of obs = 39
	Test statistic	-------- Critical value --------- 5%
OLS	**0.4478**	**1.3581**

Source: Author, 2023

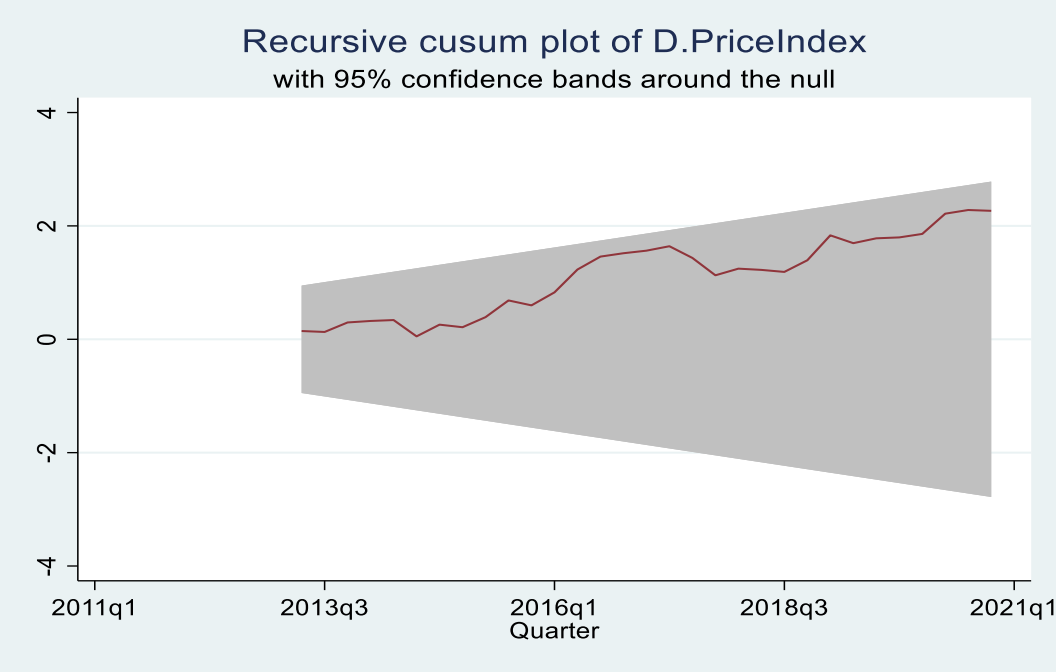
The null hypothesis of no structural break could not be rejected at 5% levels of significance [t (0.7830) < critical value (0.9479)] as per recursive cusum test. The OLS cusum test also confirmed parameter stability [t (0.4478) < critical value (1.3581)]. Therefore, the model parameters were stable. Figure 5.6 and Figure 5.7 also depict the absence of structural break as the cumulative sum of the errors are within the 95% confidence bands.

Figure 5.6: OLS Cusum plot – step three of mediation test



Source: Author, 2023

Figure 5.7: Recursive Cusum plot – step three of mediation test



Source: Author, 2023

In summary, the third step and path [b] of the mediation test was completed. The results indicated that rent value, GDP and inflation had significant effect on real estate prices. This confirms that the mediator has significant effect on real estate prices controlling for economic factors (GDP, inflation & interest) and property supply. The next step was to determine whether the mediator (rent value) mediates the effect of inflation on real estate prices fully or partially.

5.3.5 Step Four: Results of Mediation Tests

The third objective was to establish whether rent value mediates the effect of economic factors on real estate prices while the fourth objective was to establish whether rent value mediates the effect of property supply on real estate prices. Property supply did not have significant effect on rent value (mediator) as such the mediation test was stopped. The

mediation test following the works of Baron and Kenny (1986) and Sobel (1982) has four steps. The results of the first three steps are summarised below.

Mediation Effect

Step 1: Denoted by path [C]. The relationship between independent variables (X) and dependent variable (Y) is tested. Inflation (β= 0.706; t=4.88; $p<0.05$) had long run significant effect on real estate prices. Property supply had significant negative long-run effect on real estate price (β= -18.722; t= -2.33; $p<0.05$).

Step 2: Denoted by path [a]. The relationship between independent variables (X) and mediating variable (M) was tested. For mediation to exist, the independent variable (X) must have a significant effect on the mediator (M). Property supply (value of approved plans) did not have significant effect (β= -13.289; t= -1.47; $p>0.05$) on rent value (mediator). Therefore, the mediation test was terminated. GDP (an economic) factor did not affect the mediating variable. However, Inflation an economic factor (β=0.533; t=3.43; $p<0.05$) had long run significant effect on rent value (mediator). Therefore, we proceeded to test the mediating effect of rent value on the relationship between inflation and real estate prices.

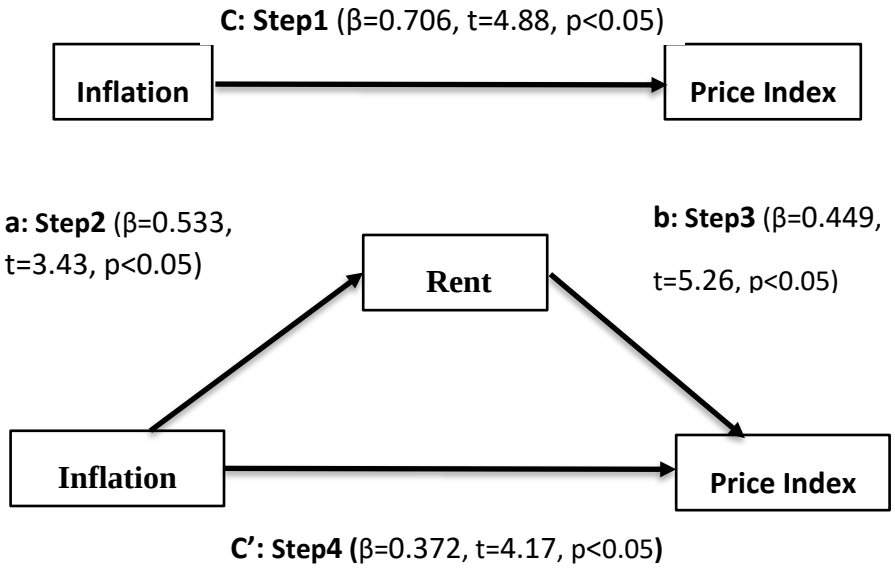
Step 3: Denoted by path [b]. The relationship between the mediator (M) and dependent variable (Y) was tested. For mediation to exist, the mediator (M) must have a significant effect on the dependent variable (Y) controlling for independent variables (X). This means under path [b] the dependent variable (Y) is regressed against both the mediator and independent variables. Rent value (mediator) had long run significant effect on real estate price (β= 0.449; t= 5.26; $p<0.05$).

Considering the outcome above, then step four tested whether rent value mediates fully or partially the effect of inflation on real estate prices.

Step 4: The outcome of step three above was used to test for mediation. There is mediation if the coefficient of the mediator is significant having controlled for independent variables as denoted by path [b]. Mediation is partial if the coefficients of the independent variables remain significant in the presence of the mediator which is denoted by path [C'] Otherwise, if [C'] is insignificant while [b] is significant then there is full mediation.

Rent value (β= 0.449; t= 5.26; p<0.05) had significant long run effect on real estate prices – path [b]. While the effect of Inflation (β=0.372; t=4.17; p<0.05) on real estate prices is still significant. Therefore, rent value partially mediates the effect of inflation on real estate prices. The results are further presented in Figure 5.8 for economic factors (inflation):

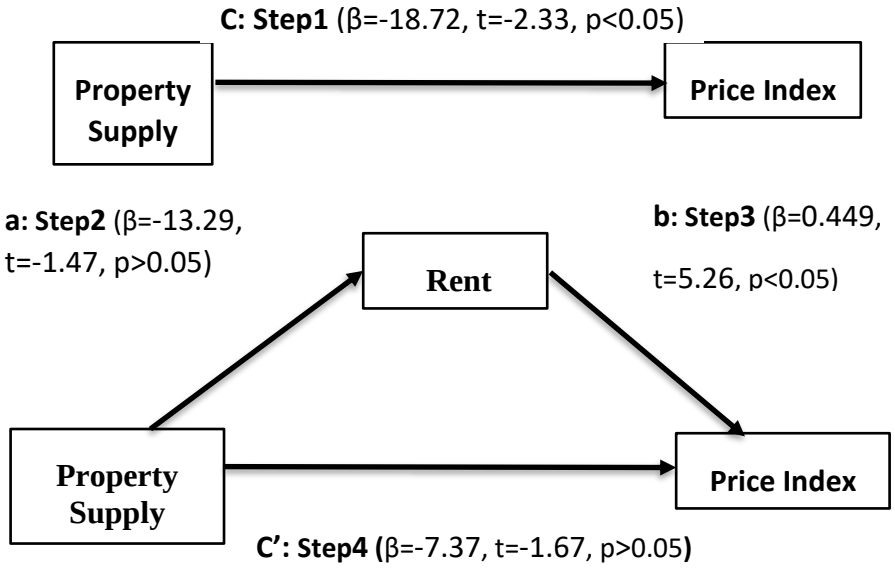
Figure 5.8: Mediating effect of Rent value on effect of Inflation on real estate prices



Source: Author, 2023

Property supply had significant negative long-run effect on real estate price (β= -18.722; t= -2.33; p<0.05) – path [C]. However, property supply did not influence rent value (β= -13.289; t= -1.47; p>0.05)– path [a]. Therefore, rent value does not mediate the effect of property supply on real estate prices. The results are further presented in Figure 5.9 for property supply:

Figure 5.9: Mediating effect of Rent value on effect of property supply on real estate prices



Source: Author, 2023

Baron and Kenny (1986) test for mediation entails running the three regressions (steps 1 to 3) separately. Iacobucci et al. (2007) have shown that this results into larger standard errors. They therefore propose estimating the coefficients and other parameters simultaneously through Structural Equation Modelling (SEM). The parameters associated with the direct effect (path c`) and the indirect effect (path a and path b) are estimated simultaneously using SEM. The indirect effect (mediation effect) parameter is [a*b]. “a” and “b” are like

those obtained through Baron and Kenny steps save for estimation which is through SEM. The results of the SEM estimation are in Table 5.33

Table 5.33: Structural Equation Model Results

Endogenous variables
Observed: Price Index, Rent Index
Exogenous variables
Observed: GDP Inflation Index, Interest, LN Value of Approved Plans
Fitting target model:
Iteration 0: log likelihood = -293.45778
Iteration 1: log likelihood = -293.45778
Structural equation model Number of obs = 40
Estimation method: ml
Log likelihood = -293.45778

Structural	Coefficient	std. err.	z	P>z
Price Index				
Rent Index	0.467	0.094	4.970	0.000
GDP	136.767	75.545	1.810	0.070
Inflation Index	0.277	0.082	3.360	0.001
Interest	88.527	77.125	1.150	0.251
LN Value of Approved Plans	-5.181	3.907	-1.330	0.185
_cons	39.322	45.888	0.860	0.391
Rent Index				
GDP	177.865	124.129	1.430	0.152
Inflation Index	0.515	0.112	4.590	0.000
Interest	34.717	129.822	0.270	0.789
LN Value of Approved Plans	-11.479	6.327	-1.810	0.070
_cons	138.864	74.127	1.870	0.061
Var (e. Price Index)		59.278	13.255	
Var (e. Rent Index)		168.256	37.623	

The test indicated that inflation has significant effect on rent. However, the effect of inflation on real estate prices is still significant in the presence of rent. The mediating effect of rent value on the relationship between inflation and real estate prices was tested. The parameter [a*b] was tested for its significance using the Sobel (1982) and Aroian (1944) tests. The z-values and the corresponding p-values for each test were computed to determine the significance of the estimates. The z-tests were computed as follows:

Sobel:
z-value = $a*b/\sqrt{(b^2*s_a^2 + a^2*s_b^2)}$

Aroian:
z-value = $a*b/\sqrt{(b^2*s_a^2 + a^2*s_b^2 + s_a^2*s_b^2)}$

Where:

a = the coefficient of Inflation (β=0.515 - path (a))

Sa = the standard error of Inflation (0.112 - path (a))

b = the coefficient of the mediating variable, Rent value (β= 0.467 - path (b))

Sb = the standard error of the mediating variable, Rent value (0.094 - path (b))

The null hypothesis for Sobel and Aroian tests is that there is no mediation. Table 5.34 shows the outcome of the Sobel and Aroian tests:

Table 5.34: Sobel, Aroian tests – Inflation step four of mediation test

Estimates	Aroian	Sobel
Indirect effect	0.24	0.24
Std. Err.	0.071	0.071
z-value	3.372	3.372
p-value	0.001	0.001
Conf. Interval	[0.101 - 0.380]	[0.101 - 0.380]

Baron and Kenny approach to testing mediation
STEP 1 – Rent Index: Inflation Index (X -> M) with B=0.515 and p=0.000
STEP 2 – Price Index: Rent Index (M -> Y) with B=0.467 and p=0.000
STEP 3 – Price Index: Inflation Index (X -> Y) with B=0.277 and p=0.001
As STEP 1, STEP 2 and STEP 3 as well as the Sobel's test above are significant the mediation is partial!

Source: Author, 2023

The null hypothesis of no mediation was rejected ($p<0.05$) for Sobel and Aroian tests. The tests indicate that rent partially mediates the effect of inflation on real estate prices. As such, the effect of inflation on real estate prices is partially channelled through rent.

Zhao, Lynch and Chen (2010) discussed the shortcoming of the Sobel (1982) test. The shortcoming stems from the assumption the [a*b] is normally distributed. This may not be the case even when the individual distributions of [a] and [b] are symmetrical. They therefore proposed bootstrapping method to generate a sampling distribution for [a*b] which is then tested independently. In this study we have used Monte Carlo simulation with 2,000 replacements to generate distribution for [a*b] and tested it for its significance (Jose, 2013). The results are captured in Table 5.35:

Table 5.35: Bootstrapping tests – Inflation step four of mediation test

Estimates	Monte Carlo
Indirect effect	0.241
Std. Err.	0.072
z-value	3.325
p-value	0.001
Conf. Interval	[0.110 - 0.389]

Zhao, Lynch & Chen's approach to testing mediation
STEP 1 – Price Index: Inflation Index (X -> Y) with B=0.277 and p=0.001
As the Monte Carlo test above is significant, STEP 1 is
significant and their coefficients point in same direction,
hence complementary mediation (partial mediation)!

RIT = (Indirect effect / Total effect)
(0.240 / 0.517) = 0.465
46 % of the effect of Inflation Index
on Price Index is mediated by Rent Index!
RID = (Indirect effect / Direct effect)
(0.240 / 0.277) = 0.869
The mediated effect is about 0.9 times as
large as the direct effect of Inflation Index on Price Index!

Source: Author, 2023

The null hypothesis of no mediation was rejected ($p<0.05$) for bootstrapping tests. The tests indicate that rent partially mediates the effect of inflation on real estate prices. As such,

about 46% of the effect of inflation on real estate prices is partially channelled through rent. The balance of 54% represents the direct effect of inflation on residential real estate prices. Also, the mediated effect of inflation on real estate prices is about 0.9 times as large as the direct effect of inflation on house prices.

In summary, the third objective was to establish whether rent value mediates the effect of economic factors on real estate prices. Mediation was tested in keeping with the work of [Baron and Kenny (1986); Sobel (1982); Aroian (1944); Iacobucci et al. (2007); Zhao, Lynch and Chen (2010); Jose (2013)]. The results indicate rent value partially mediates the effect of Inflation on real estate prices. This was also confirmed by Sobel, Aroian and Bootstrapping tests. The fourth objective was to establish whether rent value mediates the effect of property supply on real estate prices. The results indicate rent value does not mediate the effect of property supply on real estate prices.

5.4 Joint Effect: Economic Factors, Property Supply, Rent Value and Residential Real Estate Prices

The fifth and last objective of the study was to establish the joint effect of economic factors and property supply, rent value on residential real estate prices in Nairobi. Economic factors were measured by real GDP growth rate, inflation index, and commercial banks' lending interest rates. Property supply was measured by the value of approved building plans by Nairobi City County. Rent value was measured by the rent index developed using hedonic model as per the second objective of the study. Real estate prices were measured by the price index developed using hedonic model as per the first objective of the study.

The null hypothesis was the joint effect of selected economic factors, rent value, and property supply on residential real estate prices is not significant. Hierarchical regression analysis was used to test for joint effect.

Model 1: Economic factors and Real estate prices

$$PriceIndex = \beta_0 + \beta_1 GDP + \beta_2 Interest + \beta_3 InflationIndex + \varepsilon$$

Model 2: Economic factors, Property Supply and Real estate prices

$$PriceIndex = \beta_0 + \beta_1 GDP + \beta_2 Interest + \beta_3 InflationIndex + \beta_4 LNValueofApprovedPlans + \varepsilon$$

Model 3: Economic factors, Property supply, Rent value and Real estate price.

$$PriceIndex = \beta_0 + \beta_1 GDP + \beta_2 Interest + \beta_3 InflationIndex + \beta_4 LNValueofApprovedPlans + \beta_5 RentIndex + \varepsilon$$

Model 1 tested the extent to which economic factors (GDP, inflation, and interest) explain the changes in real estate prices (price index). This was captured by R^2. Besides, the model's significance as captured by F-statistic was determined. The significance of the β_{1-3} estimates was also determined by t-test and corresponding p-values.

Model 2 tested the extent to which economic factors (GDP, inflation, and interest) with addition of property supply (LN of value of approved plans) explain the changes in real estate prices (price index). This was captured by R^2. Besides, the model's significance as captured by F-statistic was determined. The significance of the β_{1-4} estimates was also determined by t-test and corresponding p-values. In addition, the significance of changes in R^2 with introduction of property supply relative to the outcome in model 1 was determined.

Model 3 tested the extent to which economic factors (GDP, inflation and interest), property supply (LN of value of approved plans) with addition of rent value (rent index) explains the changes in real estate prices (price index). This was captured by R^2. Besides, the model's significance as captured by F-statistic was determined. The significance of the β_{1-5} estimates was also determined by t-test and corresponding p-values. In addition, the significance of changes in R^2 with introduction of rent value relative to the outcome in model 2 was determined.

The null hypothesis of no significant joint effect is upheld if R^2 does not increase progressively through Model 1 to Model 3. Besides, $p>0.05$ of the change in R^2 in model 2 and 3 confirms upholding of the null hypothesis. Otherwise, the null is rejected. The results of the analysis are in Table 5.36.

Table 5.36: Hierarchical regression results – Joint effect of economic factors, property supply and rent value on real estate price.

Model 1:

Variables in Model:
Adding: GDP Inflation Index Interest

Source	**SS**	**Df**	**MS**	**Number of obs = 40**
Model	5278.589	3	1759.53	Prob > F = 0
Residual	4302.415	36	119.512	R-squared = 0.551
Total	9581.004	39	245.667	Root MSE = 10.932

Price Index	**Coefficient**	**Std. err**	**t**	**P>t**
GDP	101.79	85.91	1.18	0.244
Inflation Index	0.503	0.094	5.33	0
Interest	145.913	107.409	1.36	0.183
_cons	-3.371	30.727	-0.11	0.913

Model 2:

Variables in Model: GDP Inflation Index Interest
Adding: LN Value of Approved Plans

Source	SS	df	MS	Number of obs = 40
Model	5745.164	4	1436.29	Prob > F = 0
Residual	3835.84	35	109.595	R-squared = 0.6
Total	9581.004	39	245.667	Root MSE = 10.469

Price Index	Coefficient	Std. err	t	P>t
GDP	219.744	100.181	2.19	0.035
Inflation Index	0.517	0.091	5.71	0
Interest	104.723	104.775	1	0.324
LN Value of Approved Plans	-10.536	5.107	-2.06	0.047
_cons	104.104	59.825	1.74	0.091

R^2 Difference. Model 2 - Model 1 = 0.049 F (1,35) = 4.257 p = 0.046

Model 3:

Variables in Model: GDP Inflation Index Interest LN Value of Approved Plans
Adding: Rent Index

Source	SS	Df	MS	Number of obs = 40
Model	7209.894	5	1441.98	Prob > F = 0
Residual	2371.11	34	69.739	R-squared = 0.752
Total	9581.004	39	245.667	Root MSE = 8.351

Price Index	Coefficient	Std. err	t	P>t
GDP	136.767	81.94	1.67	0.104
Inflation Index	0.277	0.089	3.1	0.004
Interest	88.527	83.654	1.06	0.297
LN Value of Approved Plans	-5.181	4.238	-1.22	0.23
Rent Index	0.467	0.102	4.58	0
_cons	39.322	49.772	0.79	0.435

R^2 Difference Model 3 - Model 2 = 0.153 F (1,34) = 21.003 p = 0.000

Model	R^2	F(df)	p	R2 change	F(df) change	p
1:	0.551	14.723(3,36)	0.000			
2:	0.600	13.105(4,35)	0.000	0.049	4.257(1,35)	0.046
3:	0.753	20.677(5,34)	0.000	0.153	21.003(1,34)	0.000

Source: Author, 2023

Model 1 tested the extent to which economic factors (GDP, inflation, and interest) explain the changes in real estate prices (price index). The results indicate that 55.1% of the variation in real estate prices is explained by economic factors. The model is significant ($F=14.723$; $p<0$).

Model 2 tested the extent to which economic factors (GDP, inflation, and interest) together with property supply (value of approved plans) explain the changes in real estate prices (price index). The results indicate that 60% of the variation in real estate prices is explained by economic factors and property supply. The model is significant ($F=13.105$; $p<0$). Also, the increase in R^2 by 4.9% from 55.1% in model 1 to 60% in model 2 is significant ($F=4.257$; $p<0$).

Model 3 tested the extent to which economic factors (GDP, inflation, and interest) and property supply (Value of approved plans) together with rent value (rent index) explain the changes in real estate prices (price index). The results indicate that 75.3% of the variation in real estate prices is explained by economic factors, property supply and rent value. The model is significant ($F=20.677$; $p<0$). Also, the increase in R^2 by 15.3% from 60% in model 2 to 75.3% in model 3 is significant ($F=21.003$; $p<0$).

In summary, the hierarchical regression tested for the joint effect of economic factors, property supply and rent value on real estate prices. The increase in R^2 by 4.9% from 55.1% in model 1 to 60% in model 2 was significant ($F=4.257$; $p<0$). Also, the increase in R^2 by 15.3% from 60% in model 2 to 75.3% in model 3 was significant ($F=21.003$; $p<0$). The significance of changes in R^2 from model 1 through to model 3 confirm the joint effect. As such the null hypothesis is rejected. Therefore, the joint effect of economic factors,

property supply and rent value on real estate prices is significant. The resulting equation is:

$$PriceIndex = 39.322 + 0.467\ RentIndex + 0.277\ inflation$$

5.5 Summary of Statistical Tests

The goal of this research was to establish the relationship among economic factors, rent value, property supply and residential real estate prices in Nairobi. The objective was divided into five specific objectives. Hypotheses were formulated based on the research objectives. The analytical models were specified to aid in achieving the set objectives. Finally, data was collected, analysed and hypotheses tested. Table 5.37 provides a summary of the results:

Table 5.37: Summary of results

Objective	Hypothesis	Results	Remarks
Objective (a): To establish the effect of economic factors on residential real estate prices	**H_1:** The effect of economic factors on residential real estate prices is not significant.	GDP had positive long run significant effect on real estate prices: **GDP** (β 484.34; t 2.74; p < 0.05)	Rejected null hypothesis of no significant relationship between GDP and real estate prices.
		Inflation had positive long run significant effect on real estate prices: **Inflation** (β 0.706; t 4.88; p < 0.05)	Rejected null hypothesis of no significant relationship between inflation and real estate prices.
		Interest had positive but insignificant effect on real estate prices:	Null hypothesis of no significant relationship between interest rates and real estate prices was not rejected.

Objective	Hypothesis	Results	Remarks
		Interest (β= 242.373; t=1.48; p > 0.05)	
Objective (b): To establish the effect of property supply on residential real estate prices	**H_2:** The effect of property supply on residential real estate prices is not significant.	Property supply (Value of approved plans) had negative long run significant effect on real estate prices: **Value of approved plans** (β -18.722; t -2.33; p < 0.05)	Rejected null hypothesis of no significant relationship between property supply and real estate prices.
Objective (c): To establish the mediating effect of rent value on the relationship between economic factors and residential real estate prices	**H_3:** The mediating effect of rent value on the relationship between economic factors and residential real estate prices is not significant.	Multiple regression analysis-Stepwise: **<u>Step 1:</u>** **GDP** (β= 484.34; t=2.74; p < 0.05) **Inflation** (β= 0.706; t=4.88; p < 0.05) **<u>Step 2:</u>** **Inflation** (β=0.533; t=3.43; p < 0.05) **GDP, and Interest** did not have significant effect on rent value. **<u>Step 3:</u>** **Rent value** (β= 0.449; t= 5.26; p < 0.05). **<u>Step 4:</u>** ***Inflation:*** **Rent value** (β 0.449; t 5.26; p < 0.05) **Inflation** (β 0.372; t 4.17; p < 0.05)	GDP and inflation have significant effect on real estate prices. Inflation has significant effect on rent value. Rent value has significant effect on real estate prices. Inflation controlling for mediator has significant effect on real estate prices. While rent controlling for inflation and other variables has significant effect

Objective	Hypothesis	Results	Remarks
		and (Sobel test: $p < 0.05$; Aroian test: $p < 0.05$; Bootstrapping test: $p < 0.05$)	Sobel, Aroian and Bootstrapping tests were significant hence rent value partially mediates the effect of inflation on residential real estate prices.
Objective (d): To establish the mediating effect of rent value on the relationship between property supply and residential real estate prices	**H_4:** The mediating effect of rent value on the relationship between property supply and residential real estate prices is not significant.	Multiple regression analysis-Stepwise: **<u>Step 1:</u>** **Value of approved plans** (β= -18.722; t= -2.33; $p < 0.05$) **<u>Step 2:</u>** **Property supply** did not have significant effect on rent value. (β= -13.289; t= -1.47; $p > 0.05$)	Property supply (value of approved plans) has significant effect on real estate prices. Mediation test was terminated. Therefore, rent value does not mediate the relationship between property supply and residential real estate prices.
Objective (e): To establish the joint effect of selected economic factors, property supply and rent value on residential real estate prices	**H_5:** The joint effect of selected economic factors, property supply and rent value on residential real estate prices is not significant.	Hierarchical regression analysis **Model 1: Economic factors and real estate prices** 55.1% of the variation in real estate prices is explained by economic factors. The model is significant (R^2 = 55.1%; F=14.723; $p<0$).	The significance of changes in R^2 from model 1 through to model 3 confirm the joint effect. As such the null hypothesis is rejected. Therefore, the joint effect

Objective	Hypothesis	Results	Remarks
		Model 2: Economic factors, Property supply and real estate prices The model is significant (R^2 = 60%; F=13.105; p<0). Also, the increase in R^2 by 4.9% from 55.1% in model 1 to 60% in model 2 is significant (F=4.257; p<0). **Model 3: Economic factors, Property supply, Rent value and real estate prices.** The model is significant (R^2 =75.3%; F=20.677; p<0). Also, the increase in R2 by 15.3% from 60% in model 2 to 75.3% in model 3 is significant (F=21.003; p<0).	of economic factors, property supply and rent value on real estate prices is significant.

Source: Author, 2023

5.6 Discussion of Findings

The goal of this research was to establish the relationship among economic factors, property supply, rent value, and residential real estate prices in Nairobi. The objective was divided into five specific objectives. The first specific objective was to establish the effect of economic factors on residential real estate prices. The second was to establish the effect of property supply on residential real estate prices. The third was to determine the effect of rent value on the relationship between economic factors and residential real estate prices. The fourth was to determine the effect of rent value on the relationship between property

supply and residential real estate prices. The fifth and last specific objective was to establish the joint effect of economic factors, property supply and rent value on residential real estate prices.

Hypotheses were formulated based on the research objectives. The analytical models were specified to aid in achieving the set objectives. Finally, data was collected, analysed and hypotheses tested.

5.6.1 Economic Factors and Residential Real Estate Prices

The first objective was to establish the effect of economic factors on residential real estate prices. The selected economic factors were GDP, inflation, and interest rates. Residential prices were measured by the price index. The results indicated that GDP had positive and significant long run effect on residential real estate prices. This agreed with theory. Also, the findings are like those of past local studies (Kibunyi et al. 2017; Omboi & Kigige, 2011; Makena, 2012).

Inflation also had a significant positive long run effect on real estate prices. This agreed with the findings of Quan (1999). Al-Marwani (2014) who studied the UK market. However, the finding was different from Al-Marwani (2014) who studied the UK market and found no significant effect. Whereas Kearl (1979) and Kibunyi et al. (2017) found that inflation negatively affects 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), and Belke and Keil (2018) who reported positive significant effect. Keith (2007) and Mwololo (2014) reported negative effect. The varied findings in relation to inflation and interest rates continues to persist. High interest rates may increase opportunity costs of fund

thus reducing house prices. Alternatively, high interest rates may constrain property supply thus increasing house prices. Therefore, the varied results seem to reflect the net effect in different study contexts.

5.6.2 Property Supply and Residential Real Estate Prices

The second goal was to establish the effect of property supply on residential real estate prices. Property supply was proxied by the value of approved building plans. Residential prices were measured by the price index. The results indicated that property supply had significant negative long run effect on residential real estate prices. This conforms to the Stock Flow Model in that an increase in supply is expected to reduce house prices (Paradkar, 2013; Keith, 2007; Keynes, 1936). The finding agrees with Glaeser, Gyourko and Saiz (2008) who studied the US market. However, Belke and Keil (2018) reported that supply of newly constructed houses had a positive effect on house prices in Germany. This could be an indication of excess demand not satisfied with increase in supply. The mixed findings underscore the importance of studying demand and supply factors together to determine the overall effect.

5.6.3 Mediating Effect of Rent Value on Economic Factors and Residential Real Estate Prices

The third objective was to determine the effect of rent value on the relationship between economic factors and residential real estate prices. The selected economic factors were GDP, inflation, and interest rates. Rent value was measured by the rent index. Residential real estate prices were measured by the price index. The mediating effect was tested following the works of Baron and Kenny (1986), Sobel (1982) and Aroian (1944).

Including improvements by Iacobucci et al. (2007) who incorporated SEM and Zhao, Lynch and Chen (2010) who implemented bootstrapping.

Inflation had a positive and significant effect on residential real estate prices and on rent value. In addition, rent value controlling for other variables had positive significant effect on real estate prices. However, in the presence of rent value, inflation still had a significant effect on real estate prices. Thereby confirming that rent value partially mediates the relationship between inflation and real estate prices. Sobel test, Aroian test, and Bootstrapping test also independently confirmed the mediation effect of rent value. The finding implies that property owners can pass inflation risk to tenants by through rent escalations. In addition, property prices increase with inflation therefore cushioning property investors against inflation risk.

GDP had a positive and significant effect on residential real estate prices. However, the effect of GDP on rent value was insignificant. In addition, in the presence of rent value, GDP still had a significant effect on real estate prices. This indicates that GDP has a direct effect on residential real estate prices. The relationship is not mediated by rent value. The finding implies that the effect of economic growth is adjusted in the property market through price adjustment and not rent.

The finding on the positive and significant long run relationship between rent value and real estate prices agrees with theory and empirical literature. Ambrose, Eichholtz, and Lindenthal (2013), Belke and Keil (2018), Malpezzi (1999) and Larson (2011) found positive long run effect on real estate prices. The theoretically expected positive effect of rent value on property valuation is also discussed in Keith (2007). This current study has

expanded on the current knowledge by testing the mediating effect of rent value on the relationship between economic factors and real estate prices. Indeed, the research has confirmed that the effect of economic factors on real estate prices is transmitted through rent value. Rent as an important determinant of house prices confirms property market is driven by fundamentals and therefore negating the notion of random price movements or bubbles.

5.6.4 Mediating Effect of Rent Value on Property Supply and Residential Real Estate Prices

The fourth objective was to determine the effect of rent value on the relationship between property supply and residential real estate prices. Property supply was proxied by the value of approved building plans. Rent value was measured by the rent index. Residential real estate prices were measured by the price index. The mediating effect was tested following the works of Baron and Kenny (1986), Sobel (1982) and Aroian (1944). Including improvements by Iacobucci et al. (2007) who incorporated SEM and Zhao, Lynch and Chen (2010) who implemented bootstrapping.

Value of approved plans, an indicator of property supply had a negative and significant effect on residential real estate prices. However, the effect of value of property supply on rent value was insignificant. The finding agrees with Stock Flow Model (Paradkar, 2013) and Sorina (2014). The results indicate that the effect of property supply on residential real estate prices in Nairobi is not mediated by rent value. Therefore, property supply has a direct effect on residential real estate prices. The finding implies that the effect of property supply is adjusted in the property market through price adjustment and not rent.

5.6.5 Joint Effect of Economic Factors, Property Supply and Rent Value on Residential Real Estate Prices

The fifth and last specific objective was to establish the joint effect of economic factors, property supply, and rent value on residential real estate prices. The selected economic factors were GDP, inflation, and interest. Property supply was proxied by the value of approved building plans. Rent value was measured by the rent index. Residential real estate prices were measured by the price index. Hierarchical regression analysis was used to test for joint effect. Three regression models were run progressively increasing the independent variables. In the first model, real estate price was regressed against economic factors (GDP, inflation, interest). Property supply (value of approved plans) was added in the second model. Finally, rent value was added in the third model.

The increase in R^2 by 4.9% from 55.1% in model 1 to 60% in model 2 was significant ($F=4.257$; $p<0$). Also, the increase in R^2 by 15.3% from 60% in model 2 to 75.3% in model 3 was significant ($F=21.003$; $p<0$). The significance of changes in R^2 from model 1 through to model 3 confirm the joint effect. As such the null hypothesis is rejected. Therefore, the joint effect of economic factors, property supply and rent value on real estate prices is significant.

The finding agrees with Case and Shiller (1990) in the US context. Also, Sorina (2014) in Spain and Germany where they considered macroeconomic factors together with property supply. Belke and Keil (2018) reported similar findings in the German context save for property supply which had positive effect on house prices. However, the current study looked at rent value in addition to economic and supply factors. The mediating effect was

confirmed. Also, the study provides empirical evidence from Nairobi, a local emerging market.

CHAPTER SIX: SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the summary of findings and conclusions based on the previous chapter. Besides, the chapter documents contribution to knowledge and practice which may be valuable to relevant entities. The limitations of the study are highlighted and areas for further studies suggested.

6.2 Summary of Findings

The main goal of the research was to establish the effect of economic factors, property supply, rent value on real estate prices. The context of the study was Nairobi, and the unit of analysis was the Nairobi's residential real estate market. Nairobi is the capital city of the republic of Kenya and is home to the biggest real estate market in the country. The study adopted the positivism research philosophy that lends itself to empirical test of relationships based on theory. Besides, quantitative research design was used. The study period was ten years broken in calendar quarters beginning 2011 Q1 to 2020 Q2. Hypotheses were formulated in line with the objectives. Data was collected and analysed, and hypotheses tested before findings were documented. The main objective was divided further into five specific objectives whose findings are summarised below.

The first objective was to determine the effect of economic factors on residential real estate prices. The selected economic factors were GDP, inflation, and interest. Residential real estate prices were measured by the price index. The study adopted the hedonic pricing model in constructing the price index using house data in Nairobi. The results showed that

GDP had a positive and significant effect on residential real estate prices. Therefore, growth in GDP will positively influence house prices. Inflation also exhibited a significant positive effect on real estate prices. Therefore, rising inflation has an effect of increasing real estate prices. The study also found that any deviations from the long-run equilibrium relationships in particular quarter is quickly corrected in the subsequent quarter. This denotes the level of efficiency of the Nairobi residential real estate market supporting EMH. Interest was found not to statistically influence residential real estate price.

The second objective was to determine the effect of property supply on residential real estate prices. Property supply was measured by the value of approved building plans. Residential real estate prices were measured by the price index. The results showed that property supply, measured by value of approved plans had a negative and significant effect on residential real estate prices. As such, increased supply of houses will reduce house prices. The study also found that any deviations from the long-run equilibrium relationships in particular quarter is quickly corrected in the subsequent quarter. This denotes the level of efficiency of the Nairobi residential real estate market supporting EMH.

The third objective was to determine the effect of rent value on the relationship between economic factors and residential real estate prices. The objective focused on mediation effect of rent value. Rent value was measured by the rent index. The study adopted the hedonic pricing model in constructing the rent index using house data in Nairobi. The outcome indicated that the effect of inflation on residential real estate prices was partially mediated by rent value. Therefore, changes in inflation are partially transmitted to prices through rent value. The mediation effect may indicate that investors are able to pass inflation risk to tenants through rent adjustment. GDP had a direct effect on real estate

prices and therefore non-mediated. As such the effects GDP is adjusted through house prices resulting in capital gains and not rent income for investors.

The fourth objective was to determine the effect of rent value on the relationship between property supply and residential real estate prices. The objective focused on mediation effect of rent value. Rent value was measured by the rent index. The results indicated that property supply had a direct effect on real estate prices and therefore non-mediated. As such the effects property supply is adjusted through house prices resulting in capital gains and not rent yield for investors.

The fifth objective was to establish the joint effect of economic factors, property supply and rent value on residential real estate prices. Hierarchical regression analysis was used where three regression models were run progressively increasing the independent variables. In the first model, real estate price was regressed against economic factors (GDP, inflation, interest). Property supply (value of approved plans) was added in the second model. Finally, rent value was added in the model. Model was significant based on F-test, and it had R^2 of 75.3%. The increase in R^2 by 4.9% from 55.1% in model 1 to 60% in model 2 was significant ($F=4.257$; $p<0$). Also, the increase in R^2 by 15.3% from 60% in model 2 to 75.3% in model 3 was significant ($F=21.003$; $p<0$). The significance of changes in R^2 from model 1 through to model 3 confirm the joint effect. As such the null hypothesis is rejected. Therefore, the joint effect of economic factors, property supply and rent value on real estate prices is significant. The import from this finding is that the interplay of economic factors, property supply and rent value aid in understating better the variation in residential real estate prices.

6.3 Conclusions

The study achieved the main and five specific objectives that it had sought to achieve. The study concludes that economic factors, property supply and rent value have significant effect on residential real estate prices. The study developed quarterly real estate price index spanning ten years (2011Q1 – 2020 Q4). In addition, the study constructed the rent index over the same period. The conclusion on the five objectives was as follows.

Firstly, the null hypothesis that the effect of economic factors on residential real estate prices is not significant, was rejected. Therefore, the study confirms specifically that GDP and inflation have positive and significant effect on real estate prices. However, the effect of interest on real estate prices was found to be insignificant. Secondly, the null hypothesis that the effect of property supply on residential real estate prices is not significant, was rejected. Therefore, the study confirms property supply has negative and significant effect on real estate prices.

Thirdly, the null hypothesis that the mediating effect of rent value on the effect of economic factors on residential real estate prices is not significant, was rejected. As such, the study confirmed specifically that the effect of inflation on real estate prices was partially mediated by rent value. The study concludes that the effect of inflation on real estate prices is partially transmitted through rent value coupled with residual direct effects. However, GDP had a direct non-mediated effect on real estate prices.

Fourthly, the null hypothesis that the mediating effect of rent value on the effect of property supply on residential real estate prices is not significant, could not be rejected. The study concludes that rent value does not mediate the relationship between property supply and

real estate prices. Fifthly, the null hypothesis that the joint effect of economic factors, property supply and rent value on residential real estate prices is not significant, was rejected. Therefore, the study confirms joint effect as demonstrated by progressive increase in explanatory power of the predictor variables based on hierarchical regression analysis.

6.4 Contribution of the Study Findings

The findings of the study were posited to contribute to knowledge, practice, and policy formulation. The different stakeholders interested in factors affecting housing prices stood to benefit from the study. This section presents the benefits of the findings to theory, practice, and policy formulation. Specifically, how the study may have contributed to knowledge, investment decision, regulation, and policy formulation.

6.4.1 Contribution to Knowledge

The empirical findings of this study have contributed to the body of knowledge and furthered academic pursuits in several ways. The study empirically tested the interplay of a host of factors in influencing residential real estate prices. Specifically, the study incorporated property supply as an addition to the commonly used economic variables. Economic factors characterise demand side, therefore introduction of property supply provided better insight into how real estate prices evolve. The study findings indicated that property supply had negative but significant effect on house prices in Nairobi.

Besides, the study delved into the role of rent value in influencing real estate prices. Valuation theory tends to agree that rent value positively affects real estate prices. Most studies have looked independently how economic variables or rent values affect real estate

prices. The study has contributed to knowledge by expanding the understanding of the interlinkages of these factors in explaining house prices. Rent value was found to partially mediate inflation in explaining real estate prices. As such, inflation has both direct and indirect effect on house prices. This has implications for investment strategy.

The study tested the short run and long run relationships among the variables of interest which in the author's view has expanded the boundaries of knowledge. Firstly, GDP had 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 supply. In addition, this may be deemed to agree with behavioural finance models since it is a departure from standard theory. However, the speed of adjustment towards equilibrium was high at 71.9% meaning any deviations from the equilibrium relationship is corrected within two quarters. This tends to support the standard theory as espoused in stock flow model and EMH. Since the long run relationships based on the study indicated that GDP and inflation had positive effect while property supply had negative effect as expected. The findings also indicate departure from the tenets of random walk models. Real estate prices are influenced by economic factors, property supply and rent values as opposed to random evolution of prices. The study also concluded that interest rates have negative short run effect on rent value. As interest rates rise, rent value falls in the short run. However, the speed of adjustment was quite high at 86.4%. This implies that the bulk of the correction takes place within one quarter.

The study also contributed to the continuing controversy as relates to the effect of inflation and interest rates on real estate prices. Mixed findings persist some depicting positive while others negative effect. The study concluded that inflation had significant positive effect on

real estate prices while interest rates did not significantly affect real estate prices. There is a plausible argument for both positive and negative effect. For example, an increase in interest rates may reduce prices because of the high discount rates used in valuation. On the hand, an increase in interest rates may constrain supply which push up prices if there is no corresponding fall in demand. Therefore, it is plausible to conclude that mixed findings are a result of the differing net effect. The controversy may cease once the net effect which may differ from one context to another is accepted.

The study developed residential real estate price index using hedonic model. The model controlled for property characteristics namely size, location, house type and number of bedrooms. As such the price index only depicted pure price changes. This is a first for the local context in different ways. Firstly, the period extended slightly over ten years from 2010Q3 to 2020Q4. Secondly, actual transaction prices for houses were used and not ask prices by sellers. Thirdly, the data source span banks, property developers and agents and not just restricted to banks. The developed index put the study on a firm footing in testing the other hypotheses relating to house prices.

The study also developed rent index using hedonic model to capture the movement in rent value over time. The model controlled for property characteristics namely size, location, house type and number of bedrooms. As such the rent index carried pure rent changes. This was novel for the local context. The index spans slightly over ten years. In addition, actual rent paid was used as opposed to asking rent by property owners. Also, the data source was diverse including mortgaged properties and those ordinarily let by agents.

6.4.2 Contribution to Policy and Practice

The outcome of this study is projected to help practitioners and investors both individual and institutional when making investment decisions and in portfolio management. Banks and mortgage institutions will find the determinants of housing prices useful in mortgage pricing. Most banks either issue mortgage loans or hold real estate as collateral for lending. Performance of the mortgage loan and the collateral is closely tied to the performance of the real estate sector. This performance can be captured by the price index and rent index. The pricing of mortgage and policy decisions around size of collateral and loan to value ratio may be anchored on price and rent indices.

Policy makers in National and County governments may also find basis for formulating policy from the study findings. Real estate price index and rent index may inform property taxes levied by County governments. Currently, property taxes are based on old valuation rolls and any attempt to update them through valuation appraisals has proven to be difficult. As a practical intervention, County governments can adjust house values by the amount of the price index and then apply property tax rate. The national government may use the price and rent indices as a barometer for the state of the economy. Hence, the need to develop those indices nationally and in the Counties by building and improving on the findings of the study.

Regulators are likely to benefit from the study. Regulators in real estate market include Capital Market Authority, Retirement Benefit Authorities, Insurance Authorities and Central Banks whose licensees are heavy investors in real estate. These regulators prescribe investment guidelines, capital adequacy, liquidity thresholds and risk metrics to their

licensees. These guidelines may be informed by the performance of the real estate market as depicted by the price and rent indices. Any vulnerabilities and weaknesses in the real estate sector as evidenced by the index, supply and economic factors can call for adjustment in investment guidelines issued.

The study concluded that rent value, economic factors and property supply significantly affect real estate prices. The turning points in these fundamental factors may inform real estate investment strategies. Also, price and rent indices can be used as benchmarks for portfolio performance attribution. The returns by active real estate trading strategies may be evaluated against the house price index returns. This will assist investors in determining whether active portfolio managers outperform or underperform the benchmark passive portfolio proxied by the price index or rent index. Besides, the indices can herald new securities products in the market such as real estate index funds. Such products can offer investors indirect exposure to real estate market plus hedging opportunities. Therefore, the need for developing these indices for Kenya.

Besides, Central Banks will benefit because of implication of housing price movements on monetary and fiscal policy. Real estate market may affect consumer price index (CPI). In pursuit of the expansionary or contractionary monetary policy, CBK may be guided by the metrics (economic, supply factors and rent) that track real estate market. As such the finding of the study that rent value is a key factor in influencing real estate prices will provide impetus to Kenya National Bureau of Statistics (KNBS) to develop these indices.

6.5 Limitations of the Study

The study achieved all the set objectives and has provided a raft of recommendations in the form contribution to knowledge, practice, and policy. The findings and conclusion of the study were not in any way affected by the limitations of the study. However, the study had a couple of limitations. In developing the real estate price index and the rent index, hedonic model requires specification of various house characteristics or attributes. This 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 the availability of data. The choice of fewer but key attributes such as size, house type and location was the sweet spot for the study. More attributes can be incorporated in the hedonic model to develop rent and price indices. Lack of a database containing property sale transactions is a problem in Nairobi and Kenya at large. KNBS in conjunction with Ministry of Lands and County governments can create a robust database for property market that can expand future studies.

The study focused on the residential property market in Nairobi. Nairobi is the principal property market in Kenya by scale and vibrancy. However, generalisation of the findings of the study to the country, or region or in Africa should be cautioned. Besides, the study was limited to 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 with the chosen variables in the study. The study sought to find the effect of economic factors, property supply, rent value on property prices. There are many variables that were not included such as household income, employment rate,

exchange rate etc. Also, there could be additional indicators of property supply that may be of interest to future research as guided by theory or practice.

Finally, the study employed a structural multivariate model. Atheoretical models that are not necessarily anchored on economic theory were not pursued in the study. Such models may be augmented, and their explanatory power compared to the structural models.

6.6 Suggestions for Further Research

In as much as the study achieved all the objectives set out, further studies can be pursued. Such studies can be conceptualised around the limitations of the study. Firstly, a study can be done to develop price and rent index by incorporating additional attributes beyond what was considered in this study. Such attributes may include age of house, amenities, greenspace, quality of finishing, other measures of location etc. Also, an expanded database of properties can be used to run the hedonic model.

Secondly, the study focused only on residential properties in Nairobi. A different study can look at other property sectors such as office space, hotels, retail, industrial etc. Besides, such studies can be extended to cover other counties or the country.

Thirdly, other studies can be done by incorporating other variables and indicators of property supply, demand factors etc. Future research may seek to add other factors that may moderate real estate prices as guided by theory. Such factors may include, investor characteristics, regulation etc.

Lastly, atheoretical models that are not necessarily supported by economic, or finance theory were not considered in the study. Future studies may incorporate atheoretical models

to test their effectiveness in explaining or predicting real estate prices. Besides, structural models such as was used in this study may augment atheoretical models to determine real estate prices.

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APPENDICES

Appendix One: Data Collection Sheet – Macro data

Period	Value of approved building plans	GDP (%)	Inflation rate	Lending rate
2010 Q3				
2010 Q4				
2011 Q1				
2011 Q2				
2011 Q3				
2011 Q4				
2012 Q1				
2012 Q2				
2012 Q3				
2012 Q4				
2013 Q1				
2013 Q2				
2013 Q3				
2013 Q4				
2014 Q1				
2014 Q2				
2014 Q3				
2014 Q4				
2015 Q1				
2015 Q2				
2015 Q3				
2015 Q4				
2016 Q1				
2016 Q2				
2016 Q3				
2016 Q4				
2017 Q1				
2017 Q2				
2017 Q3				
2017 Q4				
2018 Q1				
2018 Q2				
2018 Q3				
2018 Q4				
2019 Q1				

Period	Value of approved building plans	GDP (%)	Inflation rate	Lending rate
2019 Q2				
2019 Q3				
2019 Q4				
2020 Q1				
2020 Q2				
2020 Q3				
2020 Q4				

Appendix Two: Data Collection Sheet – House data

Period	Sn. Of Houses (each quarter)	Selling price	Sale date (Month and Year)	Size (surface area sq. ft or Sq. m)	Location of house	Number of bedrooms	House type (Apartment or standalone)	Monthly Rent
2010 Q3	1. 2. 3. . . . 20.							
2010 Q4	1. 2. 3. . . . 20.							
2011 Q1	(continued as above)							
2011 Q2								
2011 Q3								
2011 Q4								
2012 Q1								
2012 Q2								
2012 Q3								
2012 Q4								
2013 Q1								

Period	Sn. Of Houses (each quarter)	Selling price	Sale date (Month and Year)	Size (surface area sq. ft or Sq. m)	Location of house	Number of bedrooms	House type (Apartment or standalone)	Monthly Rent
2013 Q2								
2013 Q3								
2013 Q4								
2014 Q1								
2014 Q2								
2014 Q3								
2014 Q4								
2015 Q1								
2015 Q2								
2015 Q3								
2015 Q4								
2016 Q1								
2016 Q2								
2016 Q3								
2016 Q4								
2017 Q1								
2017 Q2								
2017 Q3								
2017 Q4								
2018 Q1								
2018 Q2								
2018 Q3								
2018 Q4								

Period	Sn. Of Houses (each quarter)	Selling price	Sale date (Month and Year)	Size (surface area sq. ft or Sq. m)	Location of house	Number of bedrooms	House type (Apartment or standalone)	Monthly Rent
2019 Q1								
2019 Q2								
2019 Q3								
2019 Q4								
2020 Q1								
2020 Q2								
2020 Q3								
2020 Q4								

Appendix Three: Price Index Regression Output

P	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
Area	0.72	0.037	19.42	0	0.647	0.793	***
HseType	-0.114	0.031	-3.68	0	-0.174	-0.053	***
Location	0.613	0.026	23.14	0	0.561	0.665	***
Bedroom	0.171	0.019	8.91	0	0.133	0.208	***
Q42010	-0.121	0.133	-0.91	0.365	-0.382	0.141	
Q12011	-0.036	0.115	-0.31	0.758	-0.262	0.191	
Q22011	-0.197	0.12	-1.64	0.101	-0.433	0.038	
Q32011	-0.243	0.147	-1.65	0.098	-0.531	0.045	*
Q42011	-0.266	0.14	-1.9	0.058	-0.541	0.009	*
Q12012	0.042	0.122	0.34	0.733	-0.198	0.281	
Q22012	-0.094	0.115	-0.82	0.414	-0.321	0.132	
Q32012	0.088	0.112	0.78	0.434	-0.132	0.308	
Q42012	-0.065	0.113	-0.57	0.566	-0.286	0.157	
Q12013	0.073	0.113	0.64	0.52	-0.149	0.294	
Q22013	0.113	0.113	1	0.316	-0.108	0.334	
Q32013	0.004	0.115	0.04	0.971	-0.222	0.231	
Q42013	0.041	0.109	0.38	0.706	-0.172	0.254	
Q12014	-0.054	0.113	-0.47	0.635	-0.275	0.168	
Q22014	-0.022	0.11	-0.2	0.844	-0.238	0.194	
Q32014	-0.068	0.116	-0.58	0.56	-0.295	0.16	
Q42014	0.052	0.113	0.46	0.648	-0.17	0.274	
Q12015	-0.077	0.147	-0.52	0.602	-0.365	0.212	
Q22015	0.037	0.119	0.31	0.759	-0.197	0.271	
Q32015	0.055	0.122	0.45	0.652	-0.184	0.294	
Q42015	0.014	0.115	0.12	0.905	-0.212	0.24	
Q12016	0.014	0.124	0.11	0.911	-0.23	0.258	
Q22016	0.256	0.14	1.82	0.068	-0.019	0.532	*
Q32016	0.235	0.121	1.94	0.053	-0.003	0.473	*
Q42016	0.184	0.126	1.47	0.142	-0.062	0.431	
Q12017	0.132	0.118	1.11	0.265	-0.1	0.363	
Q22017	0.046	0.138	0.34	0.737	-0.224	0.316	
Q32017	0.032	0.119	0.27	0.788	-0.201	0.265	
Q42017	-0.179	0.138	-1.3	0.195	-0.449	0.091	
Q12018	0.036	0.144	0.25	0.801	-0.246	0.318	
Q22018	0.178	0.141	1.26	0.207	-0.098	0.454	
Q32018	0.147	0.125	1.18	0.24	-0.098	0.393	
Q42018	0.225	0.141	1.6	0.109	-0.05	0.501	
Q12019	0.356	0.14	2.54	0.011	0.081	0.632	**

P	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
Q22019	0.18	0.125	1.43	0.152	-0.066	0.425	
Q32019	0.192	0.135	1.42	0.156	-0.073	0.458	
Q42019	0.308	0.124	2.49	0.013	0.065	0.552	**
Q12020	0.207	0.117	1.76	0.078	-0.023	0.437	*
Q22020	0.277	0.121	2.29	0.022	0.04	0.515	**
Q32020	0.206	0.122	1.69	0.091	-0.033	0.445	*
Q42020	0.135	0.117	1.15	0.25	-0.095	0.364	
Constant	10.274	0.252	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
Akaike crit. (AIC)	956.213	Bayesian crit. (BIC)	1185.211

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

Appendix Four: Rent Index Regression Output

Rent	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
Area	0.606	0.033	18.12	0	0.541	0.672	***
HseType	-0.093	0.027	-3.49	0.001	-0.145	-0.041	***
Location	0.702	0.023	30.36	0	0.656	0.747	***
Bed	0.135	0.017	7.8	0	0.101	0.169	***
Q42010	-0.081	0.122	-0.66	0.509	-0.321	0.159	
Q12011	0.005	0.105	0.05	0.959	-0.201	0.211	
Q22011	-0.121	0.111	-1.09	0.278	-0.339	0.098	
Q32011	-0.126	0.136	-0.93	0.353	-0.393	0.14	
Q42011	-0.09	0.121	-0.74	0.457	-0.326	0.147	
Q12012	-0.005	0.108	-0.05	0.961	-0.217	0.207	
Q22012	0.02	0.105	0.19	0.853	-0.187	0.226	
Q32012	0.201	0.101	1.99	0.047	0.003	0.399	**
Q42012	0.062	0.102	0.61	0.543	-0.138	0.263	
Q12013	0.236	0.103	2.29	0.022	0.034	0.439	**
Q22013	0.269	0.101	2.66	0.008	0.071	0.468	***
Q32013	0.285	0.106	2.69	0.007	0.077	0.493	***
Q42013	0.173	0.098	1.76	0.079	-0.02	0.366	*
Q12014	-0.001	0.102	-0.01	0.993	-0.2	0.199	
Q22014	0.112	0.1	1.12	0.262	-0.084	0.308	
Q32014	0.199	0.104	1.91	0.057	-0.006	0.404	*
Q42014	0.148	0.102	1.45	0.148	-0.052	0.347	
Q12015	0.185	0.109	1.7	0.09	-0.029	0.399	*
Q22015	0.163	0.1	1.62	0.105	-0.034	0.359	
Q32015	0.195	0.099	1.96	0.05	0	0.39	*
Q42015	0.266	0.106	2.51	0.012	0.058	0.474	**
Q12016	0.205	0.103	1.99	0.047	0.003	0.408	**
Q22016	0.27	0.108	2.49	0.013	0.057	0.483	**
Q32016	0.324	0.109	2.97	0.003	0.11	0.538	***
Q42016	0.385	0.109	3.53	0	0.171	0.599	***
Q12017	0.219	0.106	2.08	0.038	0.012	0.427	**
Q22017	0.354	0.106	3.33	0.001	0.146	0.563	***
Q32017	0.276	0.108	2.55	0.011	0.064	0.488	**
Q42017	0.37	0.108	3.42	0.001	0.157	0.582	***
Q12018	0.18	0.106	1.71	0.088	-0.027	0.387	*
Q22018	0.343	0.108	3.19	0.001	0.132	0.554	***
Q32018	0.375	0.11	3.42	0.001	0.16	0.59	***
Q42018	0.452	0.107	4.21	0	0.241	0.662	***
Q12019	0.457	0.106	4.33	0	0.25	0.664	***
Q22019	0.477	0.112	4.25	0	0.257	0.698	***
Q32019	0.345	0.105	3.29	0.001	0.139	0.551	***

Rent	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
Q42019	0.49	0.106	4.62	0	0.282	0.698	***
Q12020	0.31	0.104	2.98	0.003	0.106	0.515	***
Q22020	0.331	0.111	2.97	0.003	0.112	0.549	***
Q32020	0.461	0.113	4.09	0	0.24	0.683	***
Q42020	0.407	0.107	3.81	0	0.197	0.617	***
Constant	5.695	0.226	25.19	0	5.252	6.139	***

Mean dependent var	11.131	SD dependent var	0.825
R-squared	0.825	Number of obs	1318
F-test	133.338	Prob > F	0
Akaike crit. (AIC)	1026.977	Bayesian crit. (BIC)	1265.435

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