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Housing Price and Interest Rate in South Africa: An Empirical Investigation in a Nonlinear Framework

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Abstract:
This study aims to investigate the nonlinear connection between housing prices and interest rates by analyzing monthly data from January to March 2023. Initial assessments of variable integration, cointegration, Granger causality, and impulse response analyses were conducted using linear models. Nonlinear methods were applied to identify asymmetrical relationships between housing prices and interest rates. A threshold vector autoregressive model was employed to uncover the dynamic asymmetric relationship. The Markov switching model was used to assess the persistence of interest rate effects on housing prices in both regimes. Empirical findings suggest a nonlinear causal relationship between housing prices and interest rates. The results indicate that the impact of interest rates on housing prices tends to persist in both regimes. This study underscores the significance of interest rates as a key driver of housing prices in the South African economy.

Keywords:
Housing price,
Interest rate,
Granger causality,
Nonlinearity,
South Africa

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南非的房價與利率：非線性架構下的實證研究

摘要:

本研究旨在透過分析2023年1月至3月的每月資料來調查房價與利率之間的非線性關係。評估。應用非線性方法來識別房價和利率之間的不對稱關係。採用閾值向量自迴歸模型來揭示動態不對稱關係。馬可夫轉換模型用於評估兩種制度下利率對房價影響的持續性。實證研究結果顯示房價與利率之間存在非線性因果關係。結果表明，利率對房價的影響在兩個制度下往往都會持續存在。這項研究強調了利率作為南非經濟房價關鍵驅動因素的重要性。

关键词：房價、利率、非線性、南非

1. Introduction

Since the global financial crisis of 2008, there has been an increase in the body of research investigating the factors that influence housing prices (Mian & Sufi, 2009, 2014; Gimeno & Martinez-Carrascal, 2010; Antipa & Lecat, 2010; Gerlach & Peng, 2005). The proportion of income allocated to housing increases as housing prices increase, which could lead to low effective demand. An increase in housing costs may also encourage the real estate sector to grow, which would increase reliance on investment. Both social and financial stability are negatively affected by a sharp increase in housing prices (Kim et al., 2017). Researchers and policymakers must investigate the factors that influence housing prices to make necessary policy modifications to stabilize housing prices. The debate on the drivers of housing prices is far from settled. Conventional theories on housing price fluctuations place a strong emphasis on cost- or demand-push variables such as household income, construction, and development of land cost.

However, empirical studies have shown that housing prices are far beyond cost- or demand-push variables. Macroeconomic fundamentals are assumed to play a dominant role in housing price movement. Among these macroeconomic factors is the interest rate. The cost of borrowing is represented by the interest rate, which is an important factor to consider when deciding on savings, investments, and consumption. Housing consumption is affected by interest rates in two ways: directly and indirectly. An increase in interest rates immediately affects homeowners and prospective buyers by raising the interest that they must pay for their mortgages now and in the future. As a result, there may be a decrease in both present and future consumer spending since the household's disposable income decreases after deducting mortgage interest payments. The income effect plus the substitution effect compensates for the direct effect. An increase in interest rates, according to the substitution effect, makes savings more profitable than current spending, which means that current household consumption is likely to decline. The income impact states that, while households obtain interest on a portion of their assets, they pay interest on the bulk of their obligations. Changing interest rates may alter the disposable income available for immediate expenditure and affect household consumption in the near run. An increase in interest rates indirectly lowers the demand for housing, which decreases home values and, ultimately, the housing wealth of economic actors and current consumption. Recently, many studies have focused on the relationship between interest rates and house price changes (Lim & Tsiaplias, 2018; Piazzesi & Schneider, 2016; Leamer, 2015; Bernanke, 2010). The interest rate is an important monetary policy tool that has been viewed differently as the monetary policy tool that can affect housing prices. For instance, some studies have found that monetary policy shocks have a negligible effect on home prices (Glaeser et al., 2014; Goodhart & Hofmann, 2008).

On the other hand, some argue that there is a direct correlation between interest rates and the housing price boom (Jorda et al., 2015; Taylor, 2009). In particular, the latter authors contend that rising housing prices are a direct result of lax monetary policies. Hence, the correlation between interest rates and aggregate home prices is an important concern for policymakers. The majority of research that has been done in the literature thus far has used the Johannsen cointegration technique and Granger causality within the standard VAR system to operate within a linear framework, even though real life is not linear. Therefore, the empirical time series was not likely to be linear. This may explain why various empirical contributions have been made in the literature. Apart from the few studies on housing price and interest rate dynamics in the literature, no study has been conducted on housing price and interest rate dynamics in a nonlinear framework. This study examines the relationship between housing prices and interest rates in a nonlinear framework to add to the body of literature. The current empirical effort contributes to the discussion on the housing price and interest rate nexus in the South African economy as empirical studies on the housing prices and interest rates nexus in the South African economy are still very lean.

Additionally, using a nonlinear framework, this study examines the dynamic relationship between housing prices and the interest rate nexus. After establishing the nonlinearity in the structure of the housing price and interest rate nexus in the South African economy, we conducted a threshold vector autoregressive (TVAR) model.

2. Literature Review

The housing market functions as a crucial economic indicator, impacting various stakeholders, such as home buyers, sellers, real estate agents, financial institutions, and policymakers. Understanding the intricate relationship between housing prices and interest rates is essential for predicting market conditions, making informed investment decisions, and formulating effective monetary and fiscal policies. However, comprehending this relationship is challenging, if not impossible, without considering the pivotal role of banks and housing loans in the housing market (Azwan & Masih, 2019).

Bank loans significantly influence housing prices through various mechanisms. Considering housing prices as asset prices, they are more likely to be determined by the discounted future stream of cash flow. Improvements in credit availability empower banks to offer loans at lower rates, thereby stimulating economic activity. Conversely, in a scenario where borrowing costs or interest rates rise, potential housing buyers may be discouraged, resulting in diminished demand for houses (Alkali et al., 2018). Conversely, a decrease in borrowing costs or interest rates tends to boost the demand for housing, consequently leading to an increase in housing prices (Panagiotidis & Printzis, 2016). Building on the preceding discussion, it can be inferred that housing prices are intricately linked to the dynamics of housing demand and supply, both of which are influenced by interest rates. Following the principles of the economic law of demand and supply, high prices are associated with ample supply, whereas low prices correlate with heightened demand. However, the elevated cost of housing involves increased demand for financial resources or loans, subsequently leading to higher interest rates. In a scenario of high interest rates, the accessibility of loans diminishes, imposing monetary constraints on potential housing buyers and reducing demand for housing. Essentially, on the supply side, an inverse relationship exists between interest rates and housing supply. Similarly, a negative correlation is observed between interest rates and housing demand. Low interest rates facilitate loan access and bolster demand for houses (Almutairi, 2016; Zhang et al., 2016). Consequently, the equilibrium between supply and demand is determined intricately by the pricing mechanism mediated by interest rates.

Interest rates play a direct role in influencing housing demand. A decrease in interest rates reduces the cost of borrowing and enhances the affordability and appeal of home purchase. Lower interest rates lead to reduced monthly mortgage payments, enabling potential buyers to afford larger loans. Consequently, housing demand has experienced an upswing, contributing to an escalation in prices (Zhu et al., 2017).

It is crucial to acknowledge that interest rates not only exert a direct impact on housing prices through buying transactions but also have an indirect effect through the construction process. When investors are willing to invest in building houses, the cost of materials and construction remains high due to elevated building loan costs, and the number of investors may decline, leading to a reduction in new housing development. Consequently, housing supply diminishes, causing finished house prices to increase to cover construction costs and ensure investors' profitability (Mosha, 2011; Napier, 2011).

Numerous studies conducted in different countries and regions have aimed to identify the factors influencing housing price fluctuations with a specific focus on the relationship between interest rates and housing prices. This section presents selected studies and their findings, recognizing that housing prices are influenced by multiple factors.

Stepanyan (2010) analyzed and compared the effects of various macroeconomic factors on housing prices in former Soviet Union countries. This study identifies interest rates as a key determinant of short-term fluctuations in housing prices. Similarly, Alkali et al. (2018) investigated the determinants of housing prices in Nigeria and found that interest rates played a significant role in determining the price level of housing in the country. In another study conducted in Nigeria, Elile & Raju (2021) revealed a positive relationship between interest rates and housing prices, suggesting that higher interest rates lead to increased demand for housing and, subsequently, result in higher house prices.

Shi et al. (2014) explored the effects of the central bank policy and retail mortgage rates on housing prices in New Zealand. These findings indicate a positive relationship, suggesting that an increase in interest rates is associated with higher housing prices. This aligns with the results of various other studies that have highlighted the sensitivity of housing prices to changes in interest rates, including those by Agnello & Schuknecht (2011), Panagiotidis & Printzis (2015), and Xu & Tang (2014). These studies collectively emphasize the significant impact of interest rates on housing prices across different countries and regions.

In contrast to theoretical arguments and some empirical findings suggesting a significant relationship between interest rates and housing prices, other studies have reported the absence or minimal effect of macroeconomic variables, including interest rates, on housing prices. For instance, Borowiecki's (2009) found a small effect of interest rates on housing prices in Switzerland. Additionally, Zhu et al.'s (2017) research on housing market stability, mortgage market structure, and monetary policy in the Euro area revealed instances in which interest rates were not statistically significant in influencing housing prices.

Given the conflicting effects of interest rates on housing prices as demonstrated by these studies, it becomes crucial to analyze the relationship between housing prices and interest rates in South Africa using an asymmetric approach. This approach considers potential nonlinearities or variations in the impact of interest rates on housing prices, acknowledging that the relationship may not follow a uniform pattern and may be influenced by specific conditions or contexts.

3. Methodology – Empirical Approach

The study implemented a structural VAR model and bivariate Granger causality test to investigate the dynamic responses and direction of causation between housing prices and interest rates. Following this, the TVAR, TVEC, and Markov switching models were used to assess each variable's nonlinear analysis.

3.1. SVAR and Causal Analysis

The SVAR model is stated as follows:

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}\begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{yt} \\ \epsilon_{xt} \end{bmatrix} \quad (1)$$

The coefficients are b and γ, and ∈ is a stochastic term. In the SVAR system, a contemporaneous relationship exists between Y_t and X_t. Thus, housing prices and interest rates are associated contemporaneously.

$$\text{Let} \quad B = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \quad (2)$$

The SVAR model can be restated in the traditional VAR model by multiplying both sides of (1) by B^{-1},

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} \frac{b_{10}-b_{12}\,b_{20}}{1-b_{12}\,b_{21}} \\ \frac{b_{20}-b_{10}\,b_{21}}{1-b_{12}\,b_{21}} \end{bmatrix} + \begin{bmatrix} \frac{\gamma_{11}-b_{12}\gamma_{21}}{1-b_{12}\,b_{21}} & \frac{\gamma_{12}-b_{12}\gamma_{22}}{1-b_{12}\,b_{21}} \\ \frac{\gamma_{21}-\gamma_{11}b_{21}}{1-b_{12}\,b_{21}} & \frac{\gamma_{22}-\gamma_{12}b_{21}}{1-b_{12}\,b_{21}} \end{bmatrix}\begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} \frac{\epsilon_{yt}-b_{12}\,\epsilon_{xt}}{1-b_{12}\,b_{21}} \\ \frac{-b_{12}\,\epsilon_{yt}+\epsilon_{xt}}{1-b_{12}\,b_{21}} \end{bmatrix} \quad (3)$$

Put differently,

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}\begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \quad (4)$$

In a typical VAR model, the stochastic term can be written as a linear combination of shocks to Y_t and X_t that are independently distributed.

$$\begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} = \frac{1}{1-b_{12}\,b_{21}}\begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}\begin{bmatrix} \epsilon_{yt} \\ \epsilon_{xt} \end{bmatrix} \quad (5)$$

Iteration can be performed on the typical VAR equation in (4) backward while substituting equation (5) into the model and re-stating equation (4) in terms of a vector moving average. Y_t and X_t can be contemporaneously stated in terms of the previous values of the disturbances to ϵ_{yt} and ϵ_{xt}

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \sum_{i=0}^{\infty}\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \frac{1}{1-b_{12}\,b_{21}}\sum_{i=0}^{\infty}\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}\begin{bmatrix} \epsilon_{yt-1} \\ \epsilon_{xt-1} \end{bmatrix} \quad (6)$$

We express the RHS of equation (6) as follows

$$\frac{1}{1-b_{12}\,b_{21}}\sum_{i=0}^{\infty}\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}\begin{bmatrix} \epsilon_{yt-1} \\ \epsilon_{xt-1} \end{bmatrix} = \sum_{i=0}^{\infty}\begin{bmatrix} \emptyset_{11}(i) & \emptyset_{12}\ (i) \\ \emptyset_{21}(i) & \emptyset_{22}(i) \end{bmatrix}\begin{bmatrix} \epsilon_{yt-1} \\ \epsilon_{xt-1} \end{bmatrix} \quad (7)$$

A Cholesky decomposition method is applied to address the identification challenge in VAR analysis by orthogonalizing the shocks. If it is presumed that $b_{21}$to is 0 in equation (2), based on structural model (1), it is implied that Y_ti.e housing price has no contemporaneous effects on interest rate X_t, only the previous value of the housing price can exert an influence on the interest rate, that is, X_t.

Equation (5) is restated as follows:

$$e_{yt} = \epsilon_{yt} + b_{12}\,\epsilon_{xt} \quad (8)$$

$$e_{xt} = \epsilon_{xt} \quad (9)$$

If the ordering of variables changes, the responses may also be altered unexpectedly. To establish the second order, the following limitation was imposed: b_{12}= 0. This implies that interest rates, X_t, are influenced by housing prices, Y_t and that the only factors affecting the contemporaneous values of government expenditure are shocks to ϵ_{yt}.

Subsequently, equation (5) can be written as:

$$e_{yt} = \epsilon_{yt} \quad (10)$$

$$e_{xt} = b_{21}\,\epsilon_{yt} + \epsilon_{xt} \quad (11)$$

3.2. Causal Relationship

The bivariate VAR model is specified as:

$$\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}\begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \quad (12)$$

where a_{i0} signifies the intercept terms while the a_{ij} is the lag operator.

The interest rate X_t, does not Granger-cause housing prices Y_t if $a_{12} = 0$. Similarly, Housing prices, Y_t, do not Granger-cause interest rate, X_t as long as $a_{21} = 0$. In the case of bidirectional causality, a_{12} and a_{21} are not equal to zero. Otherwise, if $a_{12} = a_{21} = 0$.

3.3. Threshold Vector Autoregressive (TVAR) Model

Before implementing a nonlinear model, it is essential to establish the presence of nonlinearity. In this study, BDS and McLeod-Li tests were employed for this purpose. The TVAR model was utilized to examine the nonlinear relationship between variables. When threshold cointegration is detected, the threshold vector error correction model (TVECM) is used to analyze short-term disequilibrium correction.

$$r_t = \begin{cases} \beta_{1,\,0} + \beta_{1,1} r_{t-1} + \ . \ . \ . + \beta_{p_1,1}\, r_{t-p_1} + \varepsilon_{1t}; & If\ r_{t-d} \le u \\ \beta_{2\,0} + \beta_{1,2} r_{t-1} + \ .. \ . \ + \beta_{p_2,2}\, r_{t-p_2} + \varepsilon_{2t}; & If\ r_{t-d} > u \end{cases} \qquad (13)$$

where u is the unknown threshold and d is delay.

The model offers a method for identifying nonlinearities between interest rates and housing prices. First, the cointegration technique developed by Hansen & Seo (2002) is employed to determine whether threshold cointegration exists. Following this, the asymmetric adjustment of the relationship between the variables was assessed using the threshold vector error correction model (TVECM).

3.4. Markov Regime-switching Model

This study aligns with Hamilton (1989). In a Markov switching model, the probability of transitioning between regimes is calculated as noted by Tong (1983) and Hamilton (1989).

The estimated model is as follows:

$$y_t = \begin{cases} c_1 + \sum_{i=1}^{p} \varphi_{i,1} y_{t-i} + \varepsilon_{1t}\ ;\ If\ s_t = 1, \\ c_2 + \sum_{i=1}^{p} \varphi_{i,2} y_{t-i} + \varepsilon_{2t}\ \ ; If\ s_t = 2 \end{cases} \qquad (14)$$

s_t takes values in $\{1,\ or\ 2\}$ which is a first-order Markov chain with transition probabilities.

The transition probabilities are as follows:

$P(S_t = 2 \setminus S_{t-1} = 1) = p_{11}$, $\quad (S_t = 1 \setminus S_{t-2} =$ *2=p22* (15)

where $0 < p_{ii} < 1$.

Specifically, the transition probability matrix is given as:

$$P = \begin{bmatrix} p_{11} & 1 - p_{22} \\ 1 - p_{11} & p_{22} \end{bmatrix} \qquad (16)$$

The steady-state probabilities are stated as follows:

$$p_1 = {(1 - p_{22})}\Big/{(2 - p_{11} - p_{22})} \qquad (17)$$

$$p_2 = {(1 - p_{11})}\Big/{(2 - p_{11} - p_{22})} \qquad (18)$$

This study utilizes monthly data on the housing price index (HPI) and interest rates, covering the period from January 2003 to March 2023. Data on the HPI were obtained from the First National Bank (FNB) database, whereas data on interest rates were sourced from the South African Reserve Bank (SARB) Statistics.

4. Results and Discussion

Table 1 shows the summarized statistics. The variables exhibited strong internal consistency within the range of their maximum and minimum values, as shown in table. Low standard deviations indicate that the variances are not excessively large, which is further supported by the slight skewness and kurtosis of the variables. The Jarque-Bera statistics assess the normality of the data. At the 1% significance level, the Jarque-Bera statistics for all variables accepted the null hypothesis of normality. This is reinforced by the closeness of the mean and median values, which suggests that the series is likely to be normally distributed.

Table 1. Summary statistics of the variables (Developed by the authors)

Statistics	HPI	IR
Mean	4.079	3.507
Median	3.995	3.453
Maximum	4.391	3.843
Minimum	3.817	3.0982
Std. Dev.	0.174	0.225
Skewness	0.456	0.141
Kurtosis	1.718	1.843
Jarque-Bera	3.711	2.125
Probability	0.156	0.345
Observs	243	243

Figure 1 shows how the variables varied throughout the study period. The graphical depiction demonstrates the growing trend in housing prices, while interest rates fluctuated during this time.

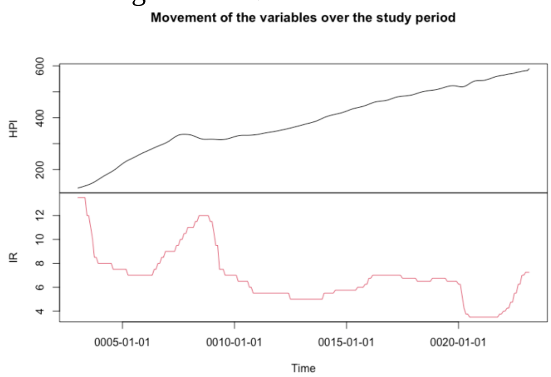

Figure 1. Graphical presentation of the variables (Developed by the authors)

Table 2 presents the time-series properties of government housing prices and interest rates, including the p-values for the stationarity tests with and without trends. The results indicate that the variables are non-stationary in their level form but become stationary after the first differencing. Given that the variables achieve stationarity after first differencing, a cointegration test is performed to determine the existence of a long-term relationship between them.

Table 2. Stationary test results (Developed by the authors)

Variable	ADF Test(Trend)	ADFTest(NoTrend)	PP(Trend)	PP(No Trend)
HPI	0.6010	0.4172	0.1156	0.2941
IR	0.2870	0.7121	0.5161	0.5167
D(HPI)	0.0000	0.0001	0.0000	0.0000
D(IR)	0.0000	0.0002	0.0000	0.0000

Table 3 presents the cointegration results. Lag selection was performed to determine the optimal lag length before conducting a cointegration test. Based on the Akaike information criterion, a lag order of 6 is recommended. The analysis concludes that long-term relationships exist between housing prices and interest rates in the South African economy, as indicated by the parameter values of the eigenvalue and trace statistics. This finding implies that at least one causal relationship exists between these two variables. Consequently, a Granger causality test was implemented.

Table 3. Cointegration test results (Developed by the authors)

	Trace Stat	10%	5%	1%	Eigen Value Stat	10%	5%	1%
r<=1	26.1	7.9	7.8	13.6	24.4	7.6	10.3	23.71
r=0	92.6	92.6	12.65	19.9	27.8	23.5	12.95	23.3

Table 4 presents the findings of the linear Granger causality test, indicating unidirectional causality from interest rates to housing prices in South Africa, with no reverse relationship. This finding suggests that interest rates Granger-cause housing prices in the South African economy.

Table 4. Linear Granger causality test results (Developed by the authors)

	F-Test	p-value
HPI⟶ IR	1.1086	0.3562
IR⟶ HPI	6.4623	0.0010

The SVAR impulse response between housing prices and interest rates is shown in Figures 2a and 2b, respectively. Evidence from the structural VAR analysis reveals that shocks to interest rates trigger sharp responses in housing prices, with the response diverging because the effects of the shock do not dissipate quickly. This finding supports the causality findings, indicating that interest rates Granger-cause housing prices.

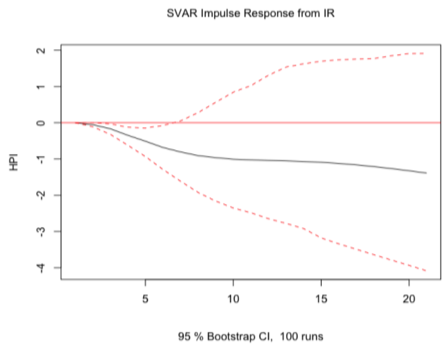

Figure 2a. Impulse response graph of housing price (Developed by the authors)

Figure 2b. Impulse response graph of interest rate (Developed by the authors)

BDS and McLeod-Li tests were applied to confirm the presence of nonlinearity in the variables. Given that the corresponding p-values were significant, the null hypothesis of linearity was rejected, thereby providing evidence of nonlinearity in the variables. The results of the BDS and McLeod-Li tests are presented in Tables 5 and 6, respectively.

Table 5. BDS nonlinearity test (Developed by the authors)

BDS Statistic		
eps /Dimension	HPI	IR
1(2)	200.7.00000)***.	53.1(0.000)***
1(3)	398.2(0.0000)***	86.2(0.000)***
2(2)	112.9(0.001)***	33.7(0.05)***
2(3)	151.5(0.000)***	9.2(0.000)***
3(2)	64.77(0.01)***	30.7(0.000)***
3(3)	70.68(0.000)***	31.8(0.000)***
4(2)	55.25(0.04)***	28.9(0.000)***
4(3)	53.60(0.00)***	28.2(0.000)***

*** indicates parameter is significant at 5%

Table 6. Mcleoad-Li nonlinearity test (Developed by the authors)

	Mcleod-Li Statistic	p-value
HPI	1351.3	0.00000***
IR	1018.5	0.00000***

After identifying the nonlinearity of the variables, a nonlinear Granger causality test was conducted; the results are listed in Table 7. The findings reveal a bidirectional causality between interest rates and housing prices. This finding contrasts with the linear Granger causality results, which indicate unidirectional causality. The nonlinear test shows that both housing prices and interest rates Granger cause each other.

Table 7. Nonlinear Granger causality test results (Developed by the authors)

	F-Test	p-value
HP1⟶ IR	19.81	0.0001***
IR⟶ HPI	1.4847	0.000***

*** indicates parameter is significant at 5%

After confirming the bidirectional causal relationship between the two variables, the next step was to examine their asymmetric impact. A TVAR model was employed to capture these relationships. The TVAR model allows for additive simulation of nonlinearity, as it is a nonlinear multivariate system. Before estimating TVAR, the LR test was conducted to assess nonlinearity in the VAR model under the assumption of linearity. Table 8 presents the LR test results, which reject the null hypothesis of the linear VAR, indicating at least one threshold in the data. These findings support the acceptance of a TVAR model with a single threshold. Consequently, we estimate the TVAR model with one threshold, using the interest rate as the threshold variable.

Table 8. LR test (Developed by the authors)

	LR statistic	p-value
Linear VAR vs 1 threshold TVAR	90.63	0.000***
Linear VAR vs 2 threshold TVAR	168.36	0.000***
1 threshold vs 2 threshold TVAR	9.12	0.161

*** indicates parameter is significant at 5%

The threshold values and variables of the TVAR model are shown in Figure 3. The top panel shows the threshold variables for government revenue, while the ordered threshold variables and threshold value, determined by the Sum of Squared Residuals (SSR), are also depicted in Figure 3. The threshold value was 7.0, which corresponded to the lowest SSR value.

Based on this threshold, the relationship between housing prices and interest rates varies depending on the regime, which is split into two. When the interest rate is less than or equal to 7.0, this represents the first regime, accounting for 72.6% of the observed values, and is referred to as the "low interest rate regime." The second regime, where the interest rate exceeds 7.0, covers 27.4% of the observations and is known as the "high interest rate regime."

Table 9 presents the empirical findings, showing that in the low interest rate regime, housing prices are significantly influenced by both their autoregressive component and the interest rate, while the interest rate is primarily affected by its autoregressive component. In this regime, the interest rate has a significant impact on housing prices but not vice versa. Similarly, in the high-interest rate regime, housing prices are strongly influenced by the interest rate, while the interest rate is again driven by its autoregressive component. However, the magnitude of the effect is greater in the high interest rate regime.

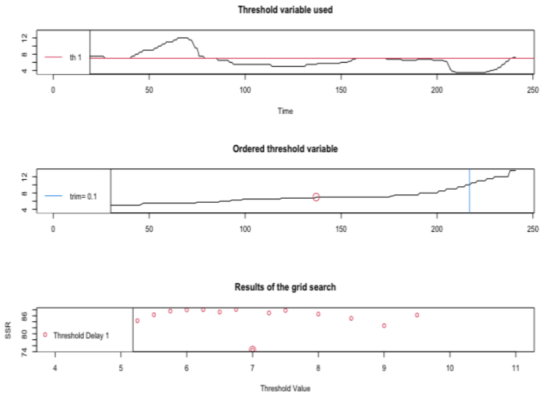

Figure 3. Threshold values of TVAR model (Developed by the authors)

Table 9. TVAR results test (Developed by the authors)

	Regime1 (IR≤ 7.0)		Regime2 (IR>7.0)	
	IR	HPI	IR	HPI
C	-0.4839	1.4267	-08909	1.5199
IR_{t-1}	1.1590*	0.0016***	-0.9611***	0.1710**
HPI_{t-1}	-0.5084	1.9183*	-0.0043	2.0150***
IR_{t-2}	-0.1751*	-0.0391	-0.0048***	0.0010***
HPI_{t-2}	0.5208	-0.9256	0.001441	-1.0266***
Percentage of Observation	72.26%		27.4%	

*** Indicate parameter significance at 1%
** Indicate parameter significance at 5%
* Indicate parameter significance at 10%

A multivariate Markov switching regime analysis was conducted to assess the impact of interest rates on housing prices across the two regimes, and the results are shown in Table 10. The findings reveal that the interest rate significantly affects housing prices in both regimes. In regime one, the low regime, the impact of the interest rate on housing prices is less pronounced than that in regime two, as reflected in the coefficients. The transition probabilities, also presented in Table 10, indicate the persistence of these effects. The probability that the influence of interest rates on housing prices will persist in both regimes is very high, confirming that the interest rate is a key driver of housing prices in the South African economy. This result is further corroborated by the smoothed probabilities illustrated in Figure 4.

Table 10. Markov regime switching results (Developed by the authors)

Dependent Variable= HPI	Regime 1		Regime 2		Transition Probabilities	
	coefficient	P-values	Coefficient	P-values	0.9940	0.0108
Intercept	0.3562	0.0000	1.3107	0.00000***	0.0059	0.9891
Interest Rate	0.0097	0.0017**	0.1033	0.0005		

** denotes significance at 5% ***denotes significance at 1%

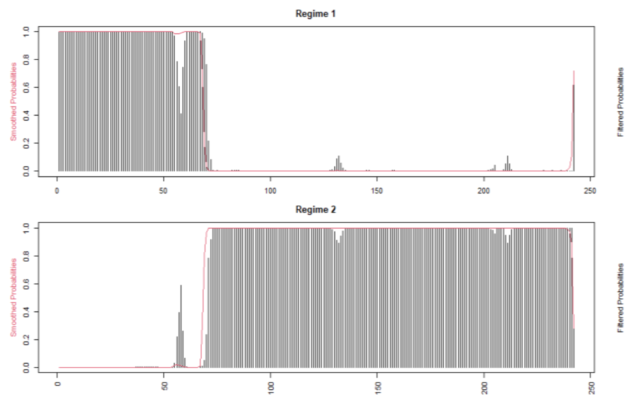

Figure 4. Smoothened probabilities (Developed by the authors)

5. Conclusion

This study investigates the relationship between housing prices and interest rates in South Africa within a nonlinear framework. Monthly data from 2003 (M1) to 2023 (M3) were used, with interest rate data sourced from the South African Reserve Bank (SARB) and housing price data from the FNB database. The findings reveal a cointegration relationship between housing prices and interest rates in South Africa. The linear Granger causality test indicates unidirectional causality from interest rates to housing prices. The BDS and McLeod-Li tests suggested the presence of nonlinearity. The nonlinear Granger causality test demonstrates a bidirectional causal relationship between interest rates and housing prices.

This study examined the nonlinearity in the VAR model using the LR test to assess the null hypothesis of linearity in VAR. The significance of the LR statistics led to the rejection of the linearity hypothesis.

Consequently, a single threshold for the threshold vector autoregressive (TVAR) model was estimated, with the interest rate serving as the threshold variable owing to its nonlinear causal relationship. The findings indicate that the threshold value is 7.0 when the Sum of Squared Residuals is at its lowest. The empirical results show that in the low interest rate regime, housing prices are mainly influenced by the interest rate and the housing price's autoregressive component. However, in the same regime, only the autoregressive component of the interest rate significantly influences it.

The results suggest that in a low interest rate environment, interest rates primarily drive housing prices with little feedback effect. Similarly, in the high-interest-rate regime, the interest rate significantly affects housing prices, with a more pronounced impact in a high-rate environment.

The Markov switching model further reveals that the influence of interest rates on housing prices tends to persist in both regimes, confirming that interest rates are a key driver of housing prices in the South African economy.

These findings offer valuable insights for governments and monetary policymakers for managing interest rates to promote affordable housing. For example, during periods of high interest rates, the government could introduce housing subsidy schemes to prevent housing crises, especially when interest rate hikes are necessary to control excess liquidity in the economy.

6. Limitations and Further Study

This study is limited in scope, particularly in terms of the number of variables considered. Future research should incorporate additional variables and expand to include more emerging economies for broader insights.

Author Contributions

Conceptualization, K.A.S. and Z.D.-K.; methodology, K.A.S.; validation, S.J.F.-S. and Z.D.-K.; investigation, K.A.S.; formal analysis, Z.D.-K.; resources, Z.D.-K.; data curation, Z.D.-K.; writing—original draft preparation, all authors contributed equally; writing—review and editing, K.A.S. and Z.D.-K.; visualization, S.J.F.-S.; supervision, K.A.S. and S.J.F.-S.; project administration, K.A.S. and S.J.F.-S. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors on request.

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Conflicts of Interest

The authors declare no conflicts of interest.

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