Analyzing the Relationship Between Interest Rate Hikes and Real Estate Market Trends

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1. Introduction

The real estate market serves as a cornerstone of economic activity, influencing household wealth, investment decisions, and broader macroeconomic trends. Over the past decade, this sector has experienced significant fluctuations, driven by volatile economic conditions and sharp shifts in monetary policy. In response to post-COVID-19 inflationary pressures, central banks worldwide have implemented substantial interest rate hikes, aiming to stabilize economies. These policy changes have profoundly impacted key aspects of the housing market, such as affordability, mortgage rates, and overall market activity.

This study investigates the relationship between interest rate fluctuations and housing market trends, with a particular focus on the number of houses sold. It examines how interest rate changes interact with a comprehensive set of economic variables, including household income, unemployment rates, inflation, housing supply, and consumer confidence. By integrating theoretical insights with advanced econometric methods, the analysis aims to uncover nuanced dynamics that go beyond conventional explanations.

The research contributes to existing literature by addressing notable gaps. While previous studies have often focused on retrospective analyses of historical trends, this project incorporates predictive modeling approaches such as ARIMA to forecast future housing market dynamics. It also accounts for multicollinearity, heteroskedasticity, and autocorrelation through robust diagnostic testing and model adjustments. These efforts provide actionable findings that can inform policymakers, real estate stakeholders, and investors navigating today's complex economic environment.

The primary research question guiding this study is: **How do interest rate hikes and associated macroeconomic variables collectively influence housing market activity, particularly the number of houses sold?** By bridging theoretical frameworks with real-world data, the study offers valuable insights into how different economic factors converge to shape housing trends, addressing both immediate and long-term implications.

As the global economy transitions into a phase of stabilizing interest rates, understanding the multifaceted dynamics between monetary policy and housing market activity has never been more relevant. This report endeavors to provide an empirical foundation for decision-making, ensuring that stakeholders are equipped to navigate the challenges and opportunities presented by today's housing market.

2. Literature Review

Understanding the relationship between interest rates and the housing market has long been a subject of significant interest in economics and finance. This dynamic interplay influences housing affordability, market activity, and broader economic stability. This section synthesizes existing research to provide a foundation for analyzing the impact of interest rate hikes on the housing market, with an emphasis on various macroeconomic variables.

Interest Rates and Housing Market Activity

Rising interest rates are widely recognized as a deterrent to housing demand. Higher rates increase mortgage costs, reducing affordability and often dampening housing market activity. Chen and Leung (2018) demonstrated that interest rate hikes generally lead to a decline in housing transactions, though regional market conditions and external shocks can modulate this effect. Similarly, McDonald and Stokes (2013) highlighted that higher rates erode purchasing power, with the magnitude of the impact being more pronounced in supply-constrained markets. This underscores the necessity of accounting for market-specific dynamics in econometric analyses.

Household Income and Affordability

Household income plays a pivotal role in moderating the adverse effects of rising interest rates. Ganong and Noel (2019) argue that higher incomes can offset increased borrowing costs, allowing continued participation in the housing market despite rising rates. Their findings emphasize the importance of income growth in maintaining housing affordability, particularly in periods of economic recovery or expansion.

Unemployment and Economic Stability

Unemployment rates significantly affect housing market trends. Coulson and Fisher (2014) found that higher unemployment reduces housing demand, as job insecurity discourages large financial commitments. However, the relationship is nuanced; regions with robust employment growth often see increased housing activity, even amidst rising interest rates. This duality highlights the need for region-specific analyses when exploring unemployment's influence on housing markets.

Housing Supply and Market Dynamics

Housing supply constraints exacerbate affordability challenges and amplify the effects of interest rate hikes. Malpezzi and Mayo (1997) found that limited housing supply during periods of high demand intensifies price pressures, even when interest rates are relatively stable. This underscores the importance of supply-side considerations, particularly in regions with zoning restrictions or construction delays.

Inflation and Consumer Confidence

Inflation directly and indirectly impacts housing market dynamics. McDonald and Stokes (2013) observed that inflation reduces purchasing power, dampening consumer confidence and discouraging significant financial transactions like home purchases. The Consumer Confidence Index (CCI), a widely used measure of economic sentiment, has been shown to predict housing market activity, with higher confidence levels correlating positively with housing demand. Additionally, inflation often triggers central banks to raise interest rates, compounding affordability issues and further dampening market activity.

Methodological Approaches in Existing Research

Existing studies employ a variety of econometric methods to analyze the housing market, each with distinct strengths and limitations. Chen and Leung (2018) used multivariable regression models to isolate the effects of interest rates while addressing potential confounders. However, they noted challenges such as omitted variable bias and multicollinearity, which could distort results. McDonald and Stokes (2013) utilized time series models, including ARIMA, to account

for temporal dependencies, demonstrating the efficacy of advanced forecasting techniques. Despite these advancements, many studies remain limited to retrospective analyses, offering insufficient guidance on future market trends.

Gaps and Contributions

While existing literature provides valuable insights, several gaps remain unaddressed. Many studies focus primarily on historical data and fail to incorporate predictive methods or address complex interactions between multiple economic variables. This project seeks to fill these gaps by employing advanced econometric techniques, including multivariable regression, diagnostic tests, and ARIMA modeling, to provide actionable insights. By incorporating a broader set of variables—interest rates, household income, unemployment, inflation, housing supply, and consumer confidence—this study enhances the understanding of housing market dynamics and offers more robust policy recommendations.

In summary, this literature review highlights the critical variables influencing housing market trends and identifies the methodological challenges in existing research. By building on these insights and addressing gaps, this project aims to provide a more comprehensive and forward-looking analysis of the relationship between interest rates and housing market activity.

3. Data

To analyze the relationship between interest rate fluctuations and housing market trends, a comprehensive set of economic variables has been sourced from reliable public databases. This section outlines the key variables, their definitions, units of measurement, frequency, and sources.

Key Variables

1. Number of Houses Sold:

   The number of houses sold is defined as the annual rate of new single-family houses sold in the United States, measured in thousands of units and seasonally adjusted.

2. Interest Rate:

   Interest rate data represents the short-term borrowing cost for depository institutions, measured as a percentage and provided as monthly averages of daily rates from the Federal Reserve Economic Data (FRED).

3. Household Income:

   Household income, reflecting the affordability of housing for the average buyer, is reported in current dollars and collected annually through January 2023 from the FRED database.

4. Unemployment Rate:

The unemployment rate indicates the percentage of the labor force that is unemployed and is a key measure of economic stability, provided monthly and seasonally adjusted from the FRED database.

5. Inflation Rate:

   The inflation rate, derived from the breakeven inflation rate based on 10-Year Treasury Constant Maturity and Inflation-Indexed Securities, is expressed as a percentage and reported daily through the FRED database.

6. Housing Supply:

   Housing supply data measures the annual rate of housing units authorized in permit-issuing areas, represented in thousands of units, seasonally adjusted and sourced monthly from the U.S. Census Bureau New Residential Construction database.

7. Consumer Confidence Index (CCI):

   The Consumer Confidence Index (CCI) measures household optimism about future economic conditions, reported as a standardized monthly index with a base year of 1966:Q1 = 100 and sourced from the FRED database.

Data Characteristics

- Time Frame: The dataset spans a decade, from 2014 to 2024, ensuring a comprehensive temporal analysis.
- Granularity: Data frequency varies across variables, ranging from monthly to annual, necessitating appropriate transformations for alignment.
- Quality: All data are sourced from reliable governmental and institutional repositories, ensuring accuracy and validity.

4. Empirical Methods

This study employs a robust econometric framework to analyze the relationship between interest rate fluctuations and housing market trends. The methods address key challenges such as multicollinearity, heteroskedasticity, and autocorrelation while leveraging advanced time series techniques for predictive analysis.

Ordinary Least Squares (OLS) Regression

The initial step involves estimating the baseline relationship between the dependent variable (number of houses sold) and the key independent variable (interest rate) using simple OLS regression. While straightforward, this approach is limited by:

- **Omitted Variable Bias**: Exclusion of key predictors such as income and inflation may distort results.

- **Multicollinearity and Heteroskedasticity**: These issues reduce the reliability of coefficient estimates.

To address these limitations, a multivariable regression model is constructed.

Multivariable Regression Analysis

The multivariable model incorporates additional predictors—household income, unemployment rate, inflation rate, housing supply, and consumer confidence—to capture the multifaceted nature of housing market dynamics. This approach:

- Accounts for confounding effects among variables.
- Provides a comprehensive explanation of housing sales variability.

Diagnostic Tests and Adjustments

To ensure the reliability of the regression model, several diagnostic tests and adjustments are applied:

1. **Multicollinearity**:
    - **Test**: Variance Inflation Factor (VIF) analysis.
    - **Action**: High VIF scores identified multicollinearity among variables (e.g., household income and housing supply). Household income was excluded to improve model stability, reducing the mean VIF below 5.
2. **Heteroskedasticity**:
    - **Test**: Breusch-Pagan test detected non-constant variance in residuals.
    - **Action**: Robust standard errors were applied to ensure consistent and reliable inference.
3. **Autocorrelation**:
    - **Test**: Breusch-Godfrey LM test indicated serial correlation in residuals.
    - **Action**: Lagged dependent variables were included to capture persistence in housing trends over time.
4. **Stationarity**:
    - **Test**: Augmented Dickey-Fuller (ADF) test revealed non-stationarity in key variables.
    - **Action**: First differencing was applied to achieve stationarity, ensuring valid regression analyses.

Time Series Analysis

Given the temporal nature of the data, advanced time series techniques were employed to improve the analysis. A Lagged Dependent Variable Model was used to capture the persistence of housing

market trends over time and to mitigate autocorrelation in the residuals. Additionally, ARIMA Modeling (Autoregressive Integrated Moving Average) was applied to account for seasonality and long-term trends in the data, enhancing the model's forecasting capabilities. These techniques ensured that the time-dependent characteristics of the data were appropriately addressed.

Model Refinement

To enhance the model's reliability and interpretability:

- Variables with high multicollinearity were excluded or transformed.
- Adjustments for heteroskedasticity and autocorrelation were iteratively applied.
- Differencing and lagging addressed non-stationarity and serial correlation, respectively.

The final refined model demonstrated an R-squared of 74.72% in the multivariable regression and 85.5% in the lagged dependent variable model, reflecting robust explanatory power.

5. Results

The empirical analysis provides valuable insights into the relationship between interest rate fluctuations and housing market trends. This section presents the findings from the regression analyses and time series modeling, addressing key hypotheses and highlighting actionable outcomes.

Single variable Regression Analysis

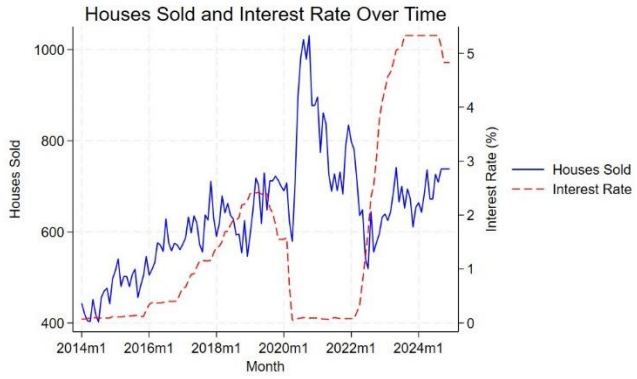
The initial analysis explored the relationship between the number of houses sold (dependent variable) and interest rates (key predictor) using simple OLS regression:

- **Findings**: The model explained only 2.5% of the variance in housing sales. The coefficient for the interest rate was unexpectedly positive and statistically significant ($p < 0.001$), contradicting theoretical expectations of a negative relationship.
- **Interpretation**: The positive coefficient indicates omitted variable bias, as critical factors like household income and inflation were excluded. This anomaly underscores the limitations of single-variable models in capturing complex market dynamics.

```
. regress houses_sold interest_rate
```

Source	SS	df	MS	Number of obs	=	1,584
				F(1, 1582)	=	40.46
Model	619193.038	1	619193.038	Prob > F	=	0.0000
Residual	24209115.6	1,582	15302.8544	R-squared	=	0.0249
				Adj R-squared	=	0.0243
Total	24828308.6	1,583	15684.339	Root MSE	=	123.7

houses_sold	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
interest_rate	10.68224	1.679328	6.36	0.000	7.388296	13.97618
_cons	621.1573	4.144734	149.87	0.000	613.0276	629.2871



Multi-variable Regression Analysis

Incorporating additional economic variables into the model significantly improved its explanatory power. The regression included predictors such as household income, unemployment rate, inflation rate, housing supply, and consumer confidence.

Define the regression model and **diagnostic tests**.

Basic OLS Regression

```
. regress houses_sold interest_rate household_income unemployment_rate housing_supply inflation_rate consumer_confidence
```

Source	SS	df	MS	Number of obs	=	132
				F(6, 125)	=	64.75
Model	1565341.83	6	260890.305	Prob > F	=	0.0000
Residual	503683.888	125	4029.47111	R-squared	=	0.7566
				Adj R-squared	=	0.7449
Total	2069025.72	131	15794.0895	Root MSE	=	63.478

houses_sold	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
interest_rate	3.701492	11.07831	0.33	0.739	-18.22386	25.62685
household_income	.0069901	.0031841	2.20	0.030	.0006883	.0132918
unemployment_rate	28.77898	5.030282	5.72	0.000	18.82343	38.73453
housing_supply	.4328557	.0767416	5.64	0.000	.2809747	.5847368
inflation_rate	-63.10927	23.03191	-2.74	0.007	-108.6923	-17.52625
consumer_confidence	4.099199	.7411266	5.53	0.000	2.632418	5.565981
_cons	-801.3235	176.9307	-4.53	0.000	-1151.491	-451.1557

The revised model explained 74.72% of the variation in housing sales, demonstrating the importance of considering multiple factors simultaneously. The coefficient for the interest rate remained unexpectedly positive, likely reflecting unique market dynamics during the period studied, such as cash buyers or delayed effects. Household income showed a positive and significant coefficient, aligning with expectations that higher incomes enhance housing affordability and demand. The unemployment rate also exhibited a positive and significant coefficient, which was counterintuitive but may indicate regional growth or post-pandemic housing demand in recovering areas. The inflation rate displayed a strongly negative relationship, reflecting the adverse effects of inflation on purchasing power and affordability. Housing supply and consumer confidence were positively associated with housing sales, supporting theoretical expectations about supply-side dynamics and economic sentiment.

Addressing Multicollinearity

Correlation Matrix

```
. correlate
(date ignored because string variable)
(obs=132)
```

	houses~d	intere~e	househ~e	unempl~e	housin~y	inflat~e	consum~e	numeri~e	year_m~h
houses_sold	1.0000								
interest_r~e	0.1579	1.0000							
household_~e	0.5586	0.7712	1.0000						
unemployme~e	0.1134	-0.4802	-0.3064	1.0000					
housing_su~y	0.7129	0.1960	0.7149	-0.2228	1.0000				
inflation_~e	0.0854	0.3612	0.5382	-0.4287	0.5286	1.0000			
consumer_c~e	-0.2431	-0.4062	-0.7092	-0.0112	-0.5384	-0.5821	1.0000		
numeric_date	0.6318	0.7119	0.9921	-0.2550	0.7594	0.5087	-0.6876	1.0000	
year_month	0.6317	0.7119	0.9921	-0.2551	0.7594	0.5087	-0.6876	1.0000	1.0000

A diagnostic analysis revealed severe multicollinearity among the predictors. High Variance Inflation Factor (VIF) scores for household income (VIF = 27.04) and interest rate (VIF = 13.77) showed strong correlations with other variables. Household income and housing supply were highly correlated, contributing to multicollinearity, while interest rate and inflation also exhibited correlation, potentially obscuring their individual effects. To address these issues, household income was removed from the model, significantly reducing multicollinearity. The mean VIF dropped to 2.06, well below the commonly accepted threshold of 5, enhancing the reliability of the model.

Multicollinearity Check

```
. vif
```

Variable	VIF	1/VIF
household_~e	27.04	0.036982
interest_r~e	13.77	0.072607
housing_su~y	9.48	0.105462
consumer_c~e	3.36	0.298055
unemployme~e	2.40	0.415952
inflation_~e	2.28	0.438385
Mean VIF	9.72	

Multicollinearity Check

```
. vif
```

Variable	VIF	1/VIF
household_~e	27.04	0.036982
interest_r~e	13.77	0.072607
housing_su~y	9.48	0.105462
consumer_c~e	3.36	0.298055
unemployme~e	2.40	0.415952
inflation_~e	2.28	0.438385
Mean VIF	9.72	

Robust Regression with Heteroskedasticity Adjustments

The Breusch-Pagan test confirmed the presence of heteroskedasticity, violating the assumption of constant residual variance. To address this issue, robust standard errors were applied to ensure reliable coefficient estimates and valid statistical inferences. The coefficients remained stable after the adjustment, confirming the robustness of the findings.

Heteroskedasticity Test

The Breusch-Pagan test is useful for identifying heteroskedasticity.

```
. estat hettest

Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of houses_sold

H0: Constant variance

    chi2(1) =  24.57
Prob > chi2 = 0.0000
```

```
. gen lag_houses_sold = L.houses_sold
(1 missing value generated)

. regress houses_sold lag_houses_sold interest_rate unemployment_rate housing_supply inflation_rate consumer_confidence, robust

Linear regression                               Number of obs     =        131
                                                F(6, 124)         =     138.48
                                                Prob > F          =     0.0000
                                                R-squared         =     0.8546
                                                Root MSE          =     48.796

------------------------------------------------------------------------------
             |               Robust
houses_sold |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lag_houses_~d |   .6760205   .0890134     7.59   0.000     .4998381    .852203
interest_rate |   12.07331    3.9525     3.05   0.003      4.25021    19.89642
unemployment~e |   15.88692   6.419865     2.35   0.020     2.380212    27.79364
housing_supply |   .1778583   .0514896     3.45   0.001     .0759459    .2797707
inflation_rate |  -27.92282   17.62256    -1.58   0.116    -62.80279    6.957152
consumer_con~e |   1.173708   .5986583     1.96   0.052    -.0112045    2.35862
         _cons |  -173.3982   106.6842    -1.63   0.107    -384.5562    37.75974
------------------------------------------------------------------------------
```

Dfuller test to check if there is a unit root for house sold or interest rates

```
. dfuller houses_sold, regress lags(1)

Augmented Dickey-Fuller test for unit root

Variable: houses_sold                     Number of obs   = 130
                                          Number of lags  =   1

H0: Random walk without drift, d = 0

                     Dickey-Fuller
             Test   ------------- critical value -------------
         statistic          1%           5%          10%
------------------------------------------------------------
 Z(t)       -2.435       -3.500       -2.888       -2.578
------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1321.
```

```
. dfuller interest_rate, regress lags(1)

Augmented Dickey-Fuller test for unit root

Variable: interest_rate                   Number of obs   = 130
                                          Number of lags  =   1

H0: Random walk without drift, d = 0

                     Dickey-Fuller
             Test   ------------- critical value -------------
         statistic          1%           5%          10%
------------------------------------------------------------
 Z(t)       -0.690       -3.500       -2.888       -2.578
------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.8492.
```

Autocorrelation Test

The Breusch-Godfrey test can identify autocorrelation in the residuals for time series data

```
. gen numeric_date = date(date, "MDY")

. format numeric_date %td

. gen year_month = ym(year(numeric_date), month(numeric_date))

. format year_month %tm

. tsset year_month, monthly

Time variable: year_month, 2014m1 to 2024m12
        Delta: 1 month

. estat bgodfrey

Breusch-Godfrey LM test for autocorrelation

----------------------------------------------------------------------------
      lags(p) |          chi2               df                 Prob > chi2
--------------+-------------------------------------------------------------
            1 |         20.596               1                      0.0000
----------------------------------------------------------------------------
                                H0: no serial correlation
```

To account for autocorrelation and non-stationarity, the model incorporated lagged dependent variables and first differencing. The lagged dependent variable model improved the R-squared to 0.855, explaining 85.5% of the variance in sales, with the lagged coefficient indicating persistence in market trends. First differencing resolved non-stationarity, though the explanatory power of the model decreased, with the R-squared dropping to 6.56%.

ARIMA Forecasting

The ARIMA model was employed to predict future housing sales. The ARIMA(1,1,1) model effectively captured short-term dynamics, though it struggled with long-term trend forecasting due to the use of differenced variables. While the model's predictive accuracy was limited, it provided valuable insights into short-term fluctuations, aiding stakeholders in decision-making.

```
. arima houses_sold, arima(1,1,1)

(setting optimization to BHHH)
Iteration 0:  Log likelihood = -705.35846
Iteration 1:  Log likelihood = -704.39013
Iteration 2:  Log likelihood = -704.30142
Iteration 3:  Log likelihood = -704.04786
Iteration 4:  Log likelihood = -702.99359
(switching optimization to BFGS)
Iteration 5:  Log likelihood = -702.71412
Iteration 6:  Log likelihood = -702.58752
Iteration 7:  Log likelihood = -702.50432
Iteration 8:  Log likelihood = -702.44322
Iteration 9:  Log likelihood = -702.41194
Iteration 10: Log likelihood = -702.40847
Iteration 11: Log likelihood = -702.40822
Iteration 12: Log likelihood = -702.40822

ARIMA regression

Sample: 2014m2 thru 2024m12                     Number of obs     =        131
                                                Wald chi2(2)      =     561.88
Log likelihood = -702.4082                      Prob > chi2       =     0.0000

------------------------------------------------------------------------------
             |                 OPG
D.           |
houses_sold  | Coefficient  std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
houses_sold  |
       _cons |    2.117021   1.247306     1.70   0.090    -.3276534    4.561696
-------------+----------------------------------------------------------------
ARMA         |
          ar |
         L1. |     .8604672   .0553164    15.56   0.000      .752049    .9688854
             |
          ma |
         L1. |    -1.000002   342.5392    -0.00   0.998    -672.3646    670.3646
-------------+----------------------------------------------------------------
       /sigma |    51.10379   8752.886     0.01   0.498           0    17206.44
------------------------------------------------------------------------------
Note: The test of the variance against zero is one sided, and the two-sided
      confidence interval is truncated at zero.

.
```

```
. gen forecast_error = houses_sold - houses_sold_predict

. summarize forecast error, meanonly
forecast ambiguous abbreviation
r(111);

. summarize forecast_error, meanonly

. display "MAE: " r(mean)
MAE: 1.6830988

. gen squared_error = forecast_error^2

. summarize squared_error, meanonly

. display "RMSE: " sqrt(r(mean))
RMSE: 53.48295
```

6. Conclusion

This study investigated the complex relationship between interest rate fluctuations and housing market trends, providing a nuanced understanding of how macroeconomic factors influence the number of houses sold. By employing advanced econometric techniques and robust time series models, the analysis revealed critical insights for policymakers, investors, and real estate stakeholders.

Key Findings

1. **Interest Rates**:
    - Contrary to traditional expectations, the interest rate coefficient remained positive in both simple and multivariable regression models. This unexpected result reflects unique market dynamics, such as the prevalence of cash buyers or lagged effects of monetary policy during the studied period. It highlights the importance of context-specific analyses when evaluating the impact of interest rates.
2. **Inflation**:
    - Inflation exhibited a strongly negative relationship with housing sales, emphasizing its adverse impact on affordability and purchasing power. This finding underscores the importance of price stability in sustaining housing market activity.
3. **Other Variables**:

- Housing supply and consumer confidence positively influenced housing sales, aligning with theoretical expectations about the role of market availability and economic sentiment.
- Unemployment and household income revealed nuanced effects, reflecting regional dynamics and post-pandemic recovery patterns.

Policy Implications

The findings have several actionable implications for stakeholders:

- **For Policymakers**: Monetary policy should account for the complex and sometimes counterintuitive effects of interest rate hikes, considering broader economic conditions and market-specific factors. Strategies to combat inflation and ensure housing affordability are critical for stabilizing the market.
- **For Real Estate Stakeholders**: Improving housing supply and addressing construction bottlenecks can mitigate affordability challenges, while fostering consumer confidence through economic stability may boost market activity.
- **For Investors and Homebuyers**: Short-term market forecasts, derived from ARIMA models, can guide decision-making in a volatile economic environment.

Limitations and Future Research

While this study provides valuable insights, several limitations warrant further exploration:

- **Regional Variations**: The analysis does not account for regional differences in housing market dynamics, which could influence the generalizability of findings.
- **Behavioral and Demographic Factors**: Incorporating variables such as buyer behavior and demographic trends could deepen the understanding of housing market activity.

In conclusion, this study bridges theoretical frameworks with empirical analysis, offering actionable insights into the interplay between interest rates and housing market trends. By addressing gaps in existing literature and employing rigorous econometric methods, the research contributes to a more comprehensive understanding of housing market dynamics in a rapidly changing economic landscape.