Proceedings of the 8th International Conference on Economic Management and Green Development
DOI: 10.54254/2754-1169/120/20242519

Macro Indicators and Housing Prices in the U.S.

Yuming Zhang[1,a,*]

[1]*College of LSA, University of Michigan, Ann Arbor, Michigan, U.S.*
a. alexxzz@umich.edu
**corresponding author*

Abstract: This study examines the influence of macroeconomic indicators—U.S. GDP, tax rates, population, and interest rates—on housing prices across the United States, utilizing data from 1982 to 2018 sourced from the Federal Reserve Economic Data (FRED). Employing a comprehensive analytical framework, including multiple linear regression, time series analysis, and a mixed-effects model, the research identifies GDP and tax rates as significant factors affecting housing prices. GDP positively correlates with housing prices, whereas higher tax rates have a negative impact. The study highlights the importance of accounting for regional variations through mixed-effects modeling, which captures the diverse impacts of economic indicators across different states. This approach offers nuanced understandings to the real estate market's dynamics, emphasizing the role of economic growth and fiscal policies. The findings aid policymakers in understanding the economic forces shaping housing markets and suggest further research avenues, particularly in incorporating recent global economic events like the COVID-19 pandemic.

Keywords: Macroeconomics, Real Estate, U.S, Econometrics

1. Introduction

This paper examines the effect of U.S. GDP, tax rates, population, and interest rates on housing prices in the United States. The selection of the research question is informed by two primary considerations. Firstly, housing prices serve as a crucial economic indicator, reflecting the health of the real estate market and its correlation with the overall economic condition. Variations in housing prices can indicate broader economic trends such as growth, recession, or inflation. For instance, the subprime mortgage crisis and the subsequent burst of the 2008 housing bubble precipitated a significant economic downturn, severely affecting living conditions [1]. Consequently, the profound impact of housing prices on the economy motivates this inquiry. Secondly, the issue of housing prices is intimately connected to housing affordability. As a forthcoming graduate entering the workforce, the reality of housing costs and affordability is increasingly pertinent. Additionally, for many individuals and families, housing constitutes a substantial portion of their expenditures. Analysis of housing prices is essential, enabling more informed decisions regarding living arrangements, including whether to buy or rent [2-6].

2. Previous Research

The Bank for International Settlements' research paper, "Interest rates and house prices in the United States and around the world", suggests that there's a significant relationship between interest rates

DOI: 10.54254/2754-1169/120/20242519

and housing prices in the U.S., with short-term interest rates playing a notable role in influencing house prices. The impact of these rates on housing prices unfolds gradually over several years, reflecting substantial inertia in the housing market. This means that changes in interest rates do not immediately translate into significant shifts in housing prices. Specifically, the study estimates that a 1% decline in U.S. short-term interest rates causes house prices to increase by 5% after three years. Although the effect is more modest than some theoretical models suggest, it still represents a considerable impact. Additionally, it's crucial to note that U.S. interest rates also have spillover effects on global housing markets, highlighting the interconnected nature of financial markets. These findings underscore the crucial role of monetary policy, particularly the management and regulation of short-term interest rates, in influencing housing prices in the U.S., and suggest that policymakers need to consider the delayed effects of interest rate adjustments when planning monetary interventions [7].

Investopedia's research paper, "4 Key Factors That Drive the Real Estate Market", illustrates that real estate is a major component of wealth in the U.S., where the homeownership rate stood at 66% in early 2023. The market's attractiveness is affected by four key factors: demographics, interest rates, the economy, and government policies. Demographic shifts, like the aging of baby boomers, significantly shape real estate trends and demand for different types of properties. Interest rates directly affect real estate affordability and market demand; lower rates decrease mortgage costs and boost demand, driving prices up, while higher rates do the opposite. The overall economic health, indicated by GDP, employment data, and other economic indicators, also impacts the real estate market, with different property types affected differently by economic cycles. Lastly, government policies such as tax incentives can temporarily increase demand. For instance, the U.S. government's first-time homebuyer's tax credit in 2009 significantly spurred home sales, illustrating the impact of policy on real estate demand. Understanding these factors can help investors make informed decisions in the real estate market [8].

3. Description of Dataset

The dataset used in this research was sourced from the Federal Reserve Economic Data (FRED), an extensive repository maintained by the Federal Reserve Bank of St. Louis. This database provides a comprehensive collection of economic data gathered from multiple sources.

The macroeconomic variables compiled for this study include the average sales price of houses sold (the dependent variable), U.S. GDP, tax rates at both the higher and lower bounds, population, and the 10-year real interest rate (all independent variables). The decision to collect both upper and lower tax rate bounds was driven by the hypothesis that individuals with higher incomes may exhibit different sensitivities to changes in housing prices compared to those with lower incomes.

Data were collected for the period from 1982 to 2018, intentionally omitting the years affected by the COVID-19 pandemic due to its extraordinary economic impact. This timeframe allows for the analysis of housing price trends under more typical economic conditions.

To better understand the dynamics of housing price changes, a logarithmic transformation was applied to all data points. This transformation focuses on the rate of change in housing prices, emphasizing periods of rapid increase or decrease. Notably, housing prices showed a consistent upward trend from 1982 until 2018, with an exception in 2008, when prices declined sharply due to the subprime mortgage crisis.

4. Empirical Strategy and Models

The empirical strategy is designed to analyze the influence of macroeconomic factors on housing prices using statistical models and tests that ensure the results to be significant and reliable. The

DOI: 10.54254/2754-1169/120/20242519

primary analytical tool employed is multiple linear regression ($Y=\beta0+\beta1X1+\beta2X2+\cdots+\beta kXk+\epsilon$; $\beta0$ is the intercept; $\beta1$ to βk are the parameter estimates; ϵ is the error term), which will enable the examination of how independent variables such as U.S. GDP, tax rates, population, and interest rates relate to the dependent variable—housing prices. This approach will facilitate the assessment of direct correlations and the magnitude of their impact.

In addition to regression analysis, the Phillips-Perron test will be utilized to check for the presence of unit roots in the time series data, ensuring that the results are not compromised by non-stationarity, which could lead to spurious regression results. The Variance Inflation Factor (VIF) test will also be operated to test multicollinearity among the independent variables, safeguarding the integrity of the regression coefficients by confirming that each variable provides unique information.

Furthermore, the analysis will incorporate a mixed-effects model ($yij=\beta0+\beta1Xij+uj+eij$; i and j represents the i-th observation in the j-th group; the dependent variable is the house price index, the independent variables are tax rates, GDP, population, and interest rates) to account for potential random effects across different states or regions within the U.S. This model is particularly useful for handling data that may exhibit group-specific variability, which is common in economic data collected across diverse geographic areas. The inclusion of mixed-effects modeling allows for more accurate inferences by acknowledging and adjusting for these variations, thereby enhancing the overall analysis [9].

Together, these methodologies form a comprehensive empirical strategy that underpins the research objective of this paper, providing a thorough investigation into the factors influencing housing prices in the United States.

5. Results

5.1. Multiple Linear Regression

A linear regression was conducted on the dependent variable, housing prices, against all the independent variables. The results, presented in Table 1, reveal that changes in GDP and tax rates are statistically significant, while changes in population and real interest rates are not statistically significant. To be specific, when GDP increases by 1%, housing prices increase by 1.2%. Conversely, a 1% increase in the higher bound of tax rates results in a 0.25% decrease in housing prices, and a 1% increase in the lower bound of tax rates leads to a 0.22% decrease in housing prices.

Table 1: Linear Regression Results

	(1)
VARIABLES	ln_housing_price
ln_GDP	1.2184
	(0.0001)
ln_tax_high	-0.2504
	(0.0056)
ln_tax_low	-0.2243
	(0.0019)
ln_pop	-2.0579
	(0.152)
ln_real_interest	0.0285
	(0.1080)
Constant	28.305

DOI: 10.54254/2754-1169/120/20242519

Table 1: (continued).

	(0.0669)
Observations	37
R-squared	0.988

However, the presence of a large constant in the regression output suggests a significant unexplained proportion within the model. Moreover, this constant is statistically insignificant under a 95% confidence interval. Consequently, a time series analysis was initiated to investigate whether time serves as a contributing factor to these dynamics.

5.2. Time Series Analysis

The stationarity of the dependent variable (change in housing price) was assessed using the Phillips-Perron test. The initial results indicated that the dependent variable is not stationary, as the test statistics did not exceed the critical values and the p-value (0.4859) exceeded the 0.05 threshold (see Table 2).

To address this issue, the dependent variable was transformed by taking the first difference. A subsequent Phillips-Perron test on this differenced variable confirmed stationarity, evidenced by test statistics that were more negative than the critical values and a p-value (0.0019) below 0.05.

Table 2: Phillips–Perron Test

Phillips–Perron test for unit root	Number of obs = 36			
Variable: ln_housing_price	Newey–West lags = 3			
H0: Random walk without drift, d = 0				
	Dickey–Fuller			
	Test statistic	critical value 1%	critical value 5%	critical value 10%
Z(rho)	-1.469	-17.948	-12.852	-10.420
Z(t)	-1.595	-3.675	-2.969	-2.617
p-value for Z(t)	0.4859			
Phillips–Perron test for unit root	Number of obs = 35			
Variable: diff_ln_housin~e	Newey–West lags = 3			
H0: Random walk without drift, d = 0	Dickey–Fuller			
	Test statistic	critical value 1%	critical value 5%	critical value 10%
Z(rho)	-22.778	-17.880	-12.820	-10.400
Z(t)	-3.916	-3.682	-2.972	-2.618
p-value for Z(t)	0.0019			

This differencing process was then applied to each independent variable to ensure consistency in stationarity across the dataset. It was confirmed that all differenced variables exhibited test statistics more negative than the critical values, and the p-values were less than 0.05, indicating that they too were stationary.

DOI: 10.54254/2754-1169/120/20242519

5.3. Regression with Stationary Variables

After eliminating the effect of time, a linear regression was conducted using the stationary variables. Surprisingly, it was found that all coefficients of the independent variables are not statistically significant except for GDP (see Table 3).

Table 3: Linear Regression with stationary variables

	(1)
VARIABLES	diff_ln_housing_price
diff_ln_GDP	1.1369
	(0.0044)
diff_ln_tax_high	-0.140
	(0.187)
diff_ln_tax_low	-0.0046
	(0.963)
diff_ln_pop	-4.084
	(0.394)
diff_ln_real_interest	0.0185
	(0.234)
Constant	0.0244
	(0.616)
Observations	36
R-squared	0.356

This unexpected outcome prompted an investigation into potential collinearity among the independent variables. Consequently, a Variance Inflation Factor (VIF) test was conducted to determine the extent of correlation among the variables. This test is crucial for diagnosing multicollinearity, which can obscure the individual effects of predictors in a regression model.

5.4. Test for Collinearity

Table 4: VIF Test

Variable	VIF	1/VIF
diff_ln_ta~h	1.28	0.7826
diff_ln_ta~w	1.18	0.8455
diff_ln_pop	1.13	0.8863
diff_ln_GDP	1.04	0.9594
diff_ln_re~t	1.03	0.9682
Mean VIF	1.13	

The results presented in Table 4 illustrate that the VIF values for the independent variables are relatively low, averaging around 1. This indicates that the level of correlation among the variables is within acceptable limits, suggesting that multicollinearity is not a significant concern in this analysis.

DOI: 10.54254/2754-1169/120/20242519

Given the low VIF values and the non-significance of the coefficients in the linear regression model, further investigation may be needed to explore other potential reasons for the lack of significance.

5.5. Preliminary Conclusion

Despite initial analyses failing to confirm the hypothesized relationships, it became apparent that housing prices might respond differently across geographic locations. For instance, the dynamics of housing price changes in New York City are likely distinct from those in Ann Arbor. To address this geographic variability, the panel data method was employed, leveraging data variation across different states and time periods.

Additional data were collected for four U.S. states—Maryland, New York, Texas, and Mississippi—covering the years from 1982 to 2018. These states were selected based on their economic standings as identified in Dr. Ted Jones' paper, "The Richest (and Poorest) States in America." Maryland represents one of the wealthiest states, while New York and Texas have median income levels, and Mississippi ranks among the poorest [10]. This selection provides a diverse and representative sample of the U.S. economic spectrum, which is crucial for examining the nuanced impacts of economic variables on housing prices across different economic contexts.

By using panel data analysis, this study aims to capture both temporal and spatial variations in housing prices, potentially offering more precise insights into how economic factors influence housing markets at the state level.

5.6. Panel Data Analysis

Recognizing that different states may have unique characteristics influencing housing prices—such as varied regulatory environments, cultural attitudes towards property ownership, and geographic desirability—a Mixed Effects Model was selected to capture these diverse impacts more accurately. This model is particularly useful for addressing unobserved heterogeneity among states, which might otherwise skew the analysis.

In the Mixed Effects Model, each state is allowed to have its own baseline level (intercept) for housing prices, accommodating the idiosyncratic factors unique to each state. This random intercept approach accounts for the unseen variables that can affect housing prices. The term "random" refers to the model's treatment of these intercepts: rather than assigning a fixed value, they are estimated from the data, assumed to be distributed around a central mean applicable across all states.

This modeling strategy enhances the robustness of the analysis by permitting variations between states while still drawing general conclusions about the influence of economic factors on housing prices. Such an approach is crucial for understanding the complex dynamics of real estate markets across different geographic and socio-economic contexts.

Table 5: Mixed-effects Model Regression

Performing gradient-based optimization:						
Iteration 0:	Log likelihood	82.5615				
Iteration 1:	Log likelihood	82.5615				
Computing standard errors:						

DOI: 10.54254/2754-1169/120/20242519

Table 5: (continued).

Mixed-effects ML regression	Number of obs = 148					
Group variable: state	Number of groups = 4	Obs per group:	min = 37	avg = 37.0	max = 37	Wald chi2(5) = 1283.43
Log likelihood	82.5615		Prob > chi2	0.000 0		
ln_House_Price_Index	Coefficient	Std. err.	z	P>|z|	[95% conf. interval]	
ln_GDP	0.9011	0.3390	2.66	0.008	0.2365	1.5656
ln_tax_high	-0.2566	0.1025	-2.50	0.012	-0.4576	-0.0556
ln_tax_low	-0.4295	0.0809	-5.31	0.000	-0.5881	-0.2710
ln_pop	-1.2602	1.7051	-0.74	0.460	-4.6023	2.0817
ln_real_interest	0.0244	0.0210	1.16	0.246	-0.0168	0.0656
_cons	14.9865	18.1562	0.83	0.409	-20.5989	50.5720
Random-effects parameters	Estimate	Std. err.	[95% conf. interval]			
state: Identity						
sd(_cons)	0.3149	0.1118	0.157 0	0.631 7		
sd(Residual)	0.1287	0.0075	0.114 7	0.144 5		
LR test vs. linear model: chibar2(01) = 266.02 Prob >= chibar2 = 0.0000						

Table 5 performed a mixed-effects model regression that focused on analyzing the impact of various economic factors on the house price index, using data grouped by state. The model includes GDP, higher tax rate bounds, lower tax rate bounds, population, and real interest rate as predictors. The results show a statistically significant positive association between GDP and the house price index (coefficient = 0.9011187, p = 0.008), indicating that increases in GDP are associated with increases in house prices. Both the higher tax rate (coefficient = -0.2566408, p = 0.012) and the lower tax rate (coefficient = -0.4295706, p = 0.000) are negatively associated with the house price index, suggesting that higher tax rates are linked to lower house prices. However, population and real interest rates did not show a statistically significant impact on house prices (p-values of 0.460 and 0.246, respectively). The random effects parameters indicate variation in the house price index across states, with a standard deviation for the intercepts across states of 0.314945. The Wald chi-squared statistic of 1283.43 with a p-value of 0.0000 confirms the model fits the data significantly well, justifying the inclusion of random effects to capture unobserved heterogeneity across states. The findings suggest that economic factors like GDP and tax rates play significant roles in influencing house prices across different regions.

6. Conclusion

This research paper has explored the effect of U.S. GDP, tax rates, population, and interest rates on housing prices in the U.S. and across various states. The selection of these variables was based on their critical roles as economic indicators and their potential impacts on the real estate market, which

DOI: 10.54254/2754-1169/120/20242519

is a major component of the national economy. The empirical analysis utilized multiple linear regression, time series analysis, and a mixed-effects model to rigorously test the hypothesized relationships.

The findings indicate that GDP and tax rates have statistically significant impacts on housing prices, affirming part of the initial hypothesis. Specifically, an increase in GDP tends to increase housing prices, which aligns with the general economic theory that a stronger economy boosts real estate values. Conversely, higher tax rates are associated with lower housing prices, suggesting that fiscal policy can influence the affordability and attractiveness of real estate investments. These results were consistent across the mixed-effects model, which also highlighted the importance of considering regional differences when analyzing economic impacts on housing markets. The use of a mixed-effects model was particularly enlightening, as it allowed for the accommodation of unobserved heterogeneity across states. This method provided a better understanding of the dynamics at play and emphasized the complexity of the real estate market, which is influenced by a myriad of factors that can vary significantly from one region to another.

The study's significance is its contribution to the understanding of how macroeconomic variables affect housing prices in different economic and regional contexts. The insights gained can aid policymakers in crafting strategies that consider both national economic indicators and regional specifics to effectively manage the real estate market. Furthermore, the methodology and findings can work as a reference for further studies that seek to find similar relationships in other sectors or regions. While this study has provided valuable insights, it is not without limitations. One significant limitation is the scope of economic indicators analyzed. Including additional variables such as consumer confidence, employment rates, or international economic trends could potentially yield a more comprehensive understanding of what drives housing prices. Moreover, the dataset used, covering the period from 1982 to 2018, excludes the latest economic events such as the COVID-19 pandemic, which could have provided further insights into the resilience and dynamics of the housing market under extraordinary circumstances. The study's reliance on available data from only four states, while practical, may also limit the generalizability of the findings. A larger dataset encompassing more states or even international data could enhance the robustness and applicability of the results to different economic contexts.

In conclusion, this paper examines the complex connection between economic indicators and housing prices, enhanced by a sophisticated analytical approach that incorporates regional variations. While the study achieves its objectives by identifying key economic factors affecting housing prices, it also opens avenues for further research to build on these findings and explore additional variables. The limitations noted are a catalyst for future research to expand the scope and depth of understanding in this vital area of economic study.

References

[1] *Demyanyk, Y., & Van Hemert, O. (2011). Understanding the subprime mortgage crisis. The Review of Financial Studies, 24(6), 1848-1880.*

[2] *Anari, A., & Kolari, J. (2002). House prices and inflation. Real Estate Economics, 30(1), 67-84.*

[3] *G. Donald, J., & Winkler, D. (2002). The dynamics of metropolitan housing prices. Journal of Real Estate Research, 23(1-2), 29-46.*

[4] *Kahn, J. A. (2008). What drives housing prices?. FRB of New York Staff Report, No. 345.*

[5] *Glaeser, E. L., Gyourko, J., & Saks, R. E. (2005). Why have housing prices gone up?. American Economic Review, 95(2), 329-333.*

[6] *Conefrey, T., & Whelan, K. (2013). Supply, demand and prices in the US housing market. UCD Centre for Economic Research Working Paper Series, No. WP13/07.*

[7] *Sutton, G. D., Mihaljek, D., & Subelyte, A. (2017). Interest rates and house prices in the United States and around the world. BIS Working Paper, No. 665.*

DOI: 10.54254/2754-1169/120/20242519

[8] *Nguyen, J. (2023). 4 key factors that drive the real estate market. Investopedia. Retrieved from https://www.investopedia.com/articles/mortages-real-estate/11/factors-affecting-real-estate-market.asp.*

[9] *Fox, J. (2002). Linear mixed models. Appendix to an R and S-plus Companion to Applied Regression, 16, 2349-2380.*

[10] *Jones, T. C. The real richest state in America: A cost-of-living adjusted income ranking. The Real Richest State in America: A Cost-of-Living Adjusted Income Ranking. May 15, 2021. Retrieved on May 2, 2024. Retrieved from https://www.stewart.com/en/insights/2021/05/14/the-richest-and-poorest-states-in-america-before-and-after-comparative-cost-of-living-adjustments.*