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THE ROLE OF U.S. REAL ESTATE AS AN INFLATION HEDGE

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Abstract: This study evaluates the ability of the U.S. real estate sector to mitigate inflation using NPCRE, FNRE, and DWRTF indices from 1998 to 2023. By applying Fama and Schwert models, cointegration tests, and causality tests, detailed insights into the potential of real assets as an inflation hedge are revealed. The findings challenge existing assumptions by showing varying effectiveness across different segments of real estate in protecting against inflation. Additionally, the inclusion of macro variables highlights their influence on inflation and how it impacts the hedging abilities of real estate segments differently. Cointegration tests demonstrates persistent connections between real estate returns and inflation emphasizing long-term associations.

Keywords: Real Estate Returns, Inflation Hedge, U.S. Economy, Investment Strategies

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1. Introduction

Real estate plays a significant role in investment portfolios, offering promising returns and diversification benefits. It is important to comprehend the connection between real estate returns and inflation for effective portfolio management and mitigating investment impacts, as emphasized by (Quan 1999).

Inflation, the gradual rise in prices of goods and services over time, reduces the value of money. It has significant impact on different types of assets, including real estate, making it an important consideration for investors. Initial studies by (Fama 1977) proposed that residential real estate provided full protection against both anticipated and unforeseen inflation. However, later research presented varied viewpoints, influencing our comprehension of real estate's function in safeguarding against inflation. Several studies have delved into the relationship between real estate and inflation, offering a range of perspectives (Simpson 2007).

Studies on Real Estate Investment Trusts and Commercial Real Estate in Korea have shown differing perspectives on the correlation between real estate investments and inflation rates. This indicates that these assets may potentially serve as an effective hedge against inflation, a point emphasized by (Hoesli 2008). However, research conducted in Ireland, Turkey, and Taiwan has presented challenges to this traditional view of real estate's ability to mitigate inflationary effects. Some studies suggest that it only provides partial protection against inflation, while others argue that it does not offer significant safeguarding from erosive impacts of rising prices as highlighted by (Liu 2009).

Given the current economic landscape market by escalating inflation rates, there is growing need to reevaluate the role of real estate as an inflation hedge. Recent surges in inflation emphasize the importance of exploring how tangible assets like real estate can shiel against adverse effects caused by rising prices. In light of evolving economic conditions influencing investment portfolios, updated research and analysis are essential for understanding the relationship between real estate returns and high levels of inflation today, providing crucial insights for investors and policymakers alike.

The paper initiates an exploration of real estate's role in hedging against inflation, commencing with a thorough examination of existing literature in Section 2. Through the use of various methodologies such as OLS regression, cointegration tests, and Granger causality, it aims to reveal insights and detailed data structures outlined respectively in Section 3 and 4. Section 5 presents challenging findings that unveil varying effectiveness of inflation hedging across different real estate segments, considering the diverse impacts pf macroeconomic variables and inflation's influence within these segments. The study uncovers enduring connections between real estate returns and inflation while observing bidirectional temporal influences. Finally, Section 6 concludes the study.

2. Literature Review

The research on the connection between real estate in the United States and inflation encompasses various approaches and results. (Adrangi 2004) questioned the proxy hypothesis for REITs, emphasizing macroeconomic connections to understand the inverse relationship between real REIT returns and inflation. Conversely, (Park 2012) emphasized the positive ability of commercial real estate in Korea to hedge against inflation, underlining the significance of diverse asset types in strategies for hedging against inflation.

(Ganesan 1998) Highlighted the superiority of financial assets compared to real assets as inflation hedges in Hong Kong, emphasizing the contextual nature of inflation hedging effectiveness. Amonhaemanon's study in (2013) explored the Thai market and revealed a positive connection between real estate returns and inflation, underscoring the significance of economic environments in shaping this relationship. Wurstbauer's research in (2015) emphasized direct infrastructure's ability to provide short-term and long-term protection against inflation, highlighting the potential of infrastructure investments for safeguarding against inflation. Hoesli's Swiss study conducted in (1994) indicated that real estate has superior abilities for hedging against inflation compared to stocks, underlining the importance of asset selection strategies for managing inflation risks.

The study by (Le Moigne 2008) demonstrated that residential properties in Hong Kong are effective as a hedge against inflation, outperforming financial assets and common stocks. Li's research in (2008) on the Shanghai housing market also showed partial long-term inflation hedging, emphasizing the importance of geographical factors.

National's findings in (2000) underscored the sector-specific nature of inflation hedging in Singapore, with industrial property proving to be the most effective hedge. Hoesli (2008) discovered that stocks offered a complex form of hedge against inflation, highlighting the nuanced dynamics across different asset classes.

(Stevenson 1999) conducted a study on the inflation hedging ability of Irish real estate and found it to be not very robust, emphasizing the importance of market-specific factors. Despite extensive investigation into the connection between real estate and inflation, there is still no clear agreement on the effectiveness of real estate as a hedge against inflation, Li (2012)

(Bond 1998) stressed that residential real estate serves as a significant hedge against both expected and unexpected inflation and highlighted the need to asset-specific analyses. (Chu 2004) discovered that real estate returns in most Chinese cities did not effectively hedge against inflation, underscoring the necessity for complex analyses in diverse economic contexts.

Fang's findings in (2008) revealed a negative correlation between housing returns and anticipated inflation in Taiwan, demonstrating how asymmetric leverage effects impact inflation hedging. Hamelink's work from (1996) concluded that compared to stocks and bonds Switzerland, real estate did not offer superior protection against inflation while emphasizing how complex it is to hedge against inflation across different asset classes.

The extensive literature on real estate returns and inflation is varied, but encounters limitations due to country-specific data restrictions. This makes it difficult to definitively establish whether real estate serves as an effective hedge against inflation. To address this gap, my research focuses on examining this relationship within the U.S. market. Drawing from these studies, I have chosen methodologies such as Ordinary Least Squares regression to assess the short-term inflation hedging capabilities of real estate assets. I will perform three regressions to analyze the impact of actual inflation and split inflation into expected and unexpected components. Additionally, cointegration analysis will investigate longer-terms connections between real estate returns and inflation in order to gain a deeper understanding of how real estate values react to prolonged periods of inflationary pressures. Granger causality tests will explore cause-and-effect light on potential directional relationships. The objective is to ascertain if U.S. real estate returns genuinely offer protection against inflation by aiming toward providing new insights or evidence that adds value for existing research efforts.

3. Data

This study undertakes a comprehensive analysis spanning 25 years, from 1998 to 2023, utilizing both quarterly and yearly data (refer to Graph 1 and Graph 2 in the Appendix). The primary objective within this extensive temporal range is to systematically collect data at regular intervals, enabling the capture of short-term fluctuations and long-term trends. This approach aligns with the research's fundamental goals.

The dataset complied for U.S. markets encompasses variables drawn from prior studies and recommendations sourced from official sources. Notably, the selection process for inflation rate proxy involves utilizing the Consumer Price Index (CPI). (Fama 1977) highlighted its suitable as an investor-facing price level proxy, leading to the choice of CPI Urban Consumer Less Food & Energy YoY NSA. This particular CPI variant, recommended by the Federal Reserve Bank of St. Louis (FRED) for its focus on core inflation, ensures a more precise identification of inflation and deflation periods. The data is retrieved from Bloomberg, but it is also accessible from FRED data. Additionally, one of the proxies created to forecast expected inflation, involving lagged short-term interest rates, will be the Federal Funds Effective Rate (DFF), which, according to FRED, is the central interest rate in the U.S. financial market.

Three indices are selected as real estate return proxies to enable a comprehensive analysis. The NCREIF Property Index (FNRE Index) directly represents institutional-grade commercial properties, drawing insights from property appraisals. In contrast, the FTSE NAREIT Equity REIT Index (NPNCRE) and Dow Jones U.S. Selected REIT Index (DWRTF) offer indirect exposure to real estate via traded securities, providing insights into overall market sentiment. Data for these indices is sourced from Bloomberg.

Crucial macroeconomic variables influencing real estate returns, such as stock market real returns, U.S. GDP growth rate, money supply, and interest rates, are incorporated. The chosen proxies and their respective data sources are as follows: S&P 500 Index (SPX Index) for stock market real returns, the GDP CQOQ Index for the U.S. GDP growth rate, M1 for money supply, all obtained from Bloomberg. Regarding the interest rates, the data for the Federal Funds Effective Rate (DFF) is retrieved from the FRED platform.

The table below provides a comprehensive summary of descriptive statistics for each variable under consideration:

Variables	Obs	Mean	Std.Dev.	Min	Max	Kurtosis	Skewness	Average Annual Return
CPI	99	0,37	0,17	0,00	1,00	3,09	1,26	-0,73
Return FNRE	98	0,01	0,11	-0,51	0,28	6,55	-1,78	0,04
Return NPNCRE	98	0,02	0,02	-0,09	0,06	7,03	-2,23	0,08
Return DWRTF	98	0,01	0,11	-0,53	0,29	6,98	-1,83	0,04
S&P 500	99	0,28	0,25	0,00	1,00	0,68	1,28	0,07
M1	99	0,17	0,30	0,00	1,00	2,89	2,14	0,18
Interest Rate	99	1,87	1,99	0,04	6,86	-0,56	0,86	
GDP rate	99	0,27	0,29	0,00	1,00	-0,56	0,86	2,80

Table 1 - Descriptive Statistics of the Variables

To guarantee consistent scaling across all chosen variables, the CPI, S&P 500, GDP rate, M1, and interest rate have been adjusted to standardized value of 1.00. This adjustment removes any discrepancies in scaling and enable a more accurate comparative analysis among the selected variables.

4. Methodology

Understanding the potential of U.S. real estate to mitigate inflation is contingent on various methodological approaches that encompasses a wide array of analytical tools for comprehensive examination.

4.1. OLS Regression Models

The use of Ordinary Least Squares regression method takes forefront in short-term evaluations, providing a foundational approach to assess real estate's ability to hedge against inflation within a limited timeframe. This preliminary analysis offers essential insights into short-term relationships and sets the stage for deeper exploration.

The **first model** examined is the **Actual Inflation Model by Equation (1)**, which investigates whether real estate and financial asset returns can effectively hedge against actual inflation:

$$\textbf{(1)}\ \boldsymbol{R_{jt}} = \boldsymbol{\alpha_t} + \boldsymbol{\beta_j}\Delta_{\boldsymbol{t}} + \boldsymbol{\varepsilon'_{jt}}$$

In this model, three simple linear regressions are constructed using $\boldsymbol{R_{jt}}$ as the dependent variable representing real estate returns. Three distinct proxies will be used as dependent variable. The regression utilizes the actual inflation rate $(\Delta_{\boldsymbol{t}})$ consistently sourced from CPI data as the independent variable in this initial model. The intercept $\boldsymbol{\alpha_t}$ signifies the real rate of return while the coefficient $\boldsymbol{\beta_j}$ reflects how asset returns impact observable fluctuations in inflation.

Moving on to **Fama and Schwert Model** based on Fisher's concepts introduced by Fama's in (1977), Equation (2) presents an Ordinary Least Squares model aiming to evaluate assets' efficacy at safeguarding against both expected and unexpected inflation:

$$\textbf{(2)}\ \boldsymbol{R_{jt}} = \boldsymbol{\alpha_t} + \boldsymbol{\beta_j}\mathbf{E}(\Delta_t|\boldsymbol{\phi_{t-1}}) + \boldsymbol{\gamma_j}[\Delta_t - \mathbf{E}(\Delta_t|\boldsymbol{\phi_{t-1}})] + \boldsymbol{\eta'_{jt}}$$

The equation includes $\boldsymbol{\beta_j}$ multiplied by conditional expectation **E** of a change (Δ_t, representing inflation) based on the information set $\boldsymbol{\phi}$ available until time $t-1$, it determines expected future rates deduced from past data accessible up until $t-1$. Additionally, $\boldsymbol{\gamma_j}$ represents deviations between actual changes symbolizing unexpected inflations. If an asset serves as a hedge against expected or unexpected inflations sums up normally close coefficients $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ tend statistical closeness one denotes that complete hedging occurs if these consistent. Conversely when each stand statistically significant notation could close correlations respective terms other provide extents indicate effectiveness absorption combined influences varying levels hedges comparative comprehensive standpoint partial greater than zero more integrative higher significantly presence signals also points redirected exposure compared alternatives.

(Chu 2004) presents an advanced Equation (3) model that aims to address the complexities of financial markets by integrating macroeconomic elements denoted by [X].The model's objective is to illustrate the intricate relationship between these variables and the behaviour of the dependent variable:

$$\textbf{(3)}\ \boldsymbol{R_{jt}} = \boldsymbol{\alpha_t} + \boldsymbol{\beta_j}\mathbf{E}(\Delta_t|\boldsymbol{\phi_{t-1}}) + \boldsymbol{\gamma_j}[\Delta_t - \mathbf{E}(\Delta_t|\boldsymbol{\phi_{t-1}})] + \boldsymbol{\xi}\mathbf{X} + \boldsymbol{\eta_{jt'}}$$

The component $\boldsymbol{\xi}\mathbf{X}$ in the equation signifies the influence of macro-economic variables (X) on the dependent variable, with $\boldsymbol{\xi}$ representing their associated coefficients. These include real stock market returns, real GDP growth rate, money supply correlated with inflation, and interest rates.

Additionally, $\boldsymbol{\eta_{jt}}$, represents the error term in the regression equation, capturing unexplained variations or factors not encompassed in the model.

The justification for incorporating these variables as independent factors in the equation is supported by various research. (Park 2012) highlights an economic process that makes commercial real estate a viable safeguard against inflation. With the growth of household income, there is an increase in demand for goods and services, which generally leads to inflation. This increased demand also applies to commercial real estate services, resulting in an appreciation of commercial property values. Additionally, this rise in households income has a positive effect on listed stocks, indicating that both real estate and stocks serve as protection against inflation.

Additionally, findings from research by (Suparti 2019), (Akalpler 2018) and Van (2020) emphasize the significant role of the money supply in affecting inflation rates. These studies demonstrate a direct relationship between an increase in the money supply and subsequent elevation in inflation rates. Furthermore, (Sean 2019) highlights the evident interaction between economic growth and inflation, indicating that excessively lor or high inflation can hinder economic growth or purchasing power respectively. Factors such as interest rates and the money supply have a substantial impact on inflation, with research showing a positive correlation between interest rates and economic growth, as well as the influence of the money supply on inflation rates.

In particular, an increase in the money supply often leads to lower interest rates, which can potentially benefit the real estate sector by reducing borrowing costs. This stimulates demand for real estate assets and may enhance investor returns.

Moreover, research conducted across various countries such as China, Vietnam, Nigeria, and Zimbabwe, as outlined by (Suparti 2019) and (Akalpler 2018), consistently shows positive connections between money supply growth and inflation rates. By incorporating these variables into the model, a more comprehensive understanding of the complex relationship between macroeconomic factors, inflation, and real estate returns is attained, thus illuminating broader economic forces shaping the U.S. real estate market.

This study specifically examines the issue of non-stationarity time series data, which has often been overlooked in Fama's approach. The stationarity[i] test is conducted before regression estimation to eliminate potential spurious[ii] regressions and addresses the persistent autocorrelation in regression residuals. Furthermore, the model is enhanced by incorporating four important macroeconomic factors, real return of the stock market, the real GDP growth rate, inflation-linked money supply, and interest rates, thereby relaxing the constraints imposed by a constant real return term in the regression equation.

4.2. Forecasting Expected Inflation

In the analysis of inflation hedging ability, the choice of an anticipated inflation proxy carries substantial importance and can greatly influence results. This research utilizes four different proxies to reduce dependence one single option. While main focus is not on comparing these proxies, their diverse inclusion reduces the risk associated with relying solely on proxy.

The main indicator, based on the work of (Fama 1977), relies on lagged short-term interest rates, specifically using the yield on Federal Funds Effective Rate as the proxy for interest rates. Fama considered Treasury bill rates to be a reliable proxy for expected inflation in the

U.S. Another proxy uses a simple first-order autoregressive model, while the other two methods are based on autoregressive moving average models: ARIMA 1,1,1 and ARIMA 1,1,3 from Park's study in (2012). Stevenson (2000) noted that short-term yields and the method proposed by Fama and Gibbson (1982) outperformed ARIMA models. On the other hand, Hoesli's research in (2008) revealed that three-and-four-point moving average of inflation were more effective in both the U.K. and U.S when compared across different models.

This diverse set of proxies aims to reduce dependence of any single choice. Importantly, the analysis involves computing unexpected inflation, a crucial factor obtained from the difference between actual and projected expected inflation rates. By incorporating various proxies, this comprehensive strategy strengthens the credibility of the analysis, guaranteeing a detailed assessment of the investment's ability to hedge against inflation.

4.3. Cointegration Tests

In order to assess the long-term inflation-hedging abilities of real estate assets, there is a need for a crucial shift from static to dynamic analysis. Static methods such as the traditional Ordinary Least squares tend to focus only on short-term dynamics, potentially overlooking important underlying long-term connections between assets and inflation. Understanding the district characteristics of real estate investments, including illiquidity and extended transactions periods, it is important to differentiate between short-term fluctuations and lasting effects. To accomplish this, cointegration methodology emerges as a fundamental tool that enables a comprehensive evaluation of real estate's enduring potential in hedging against inflation.

The method is based on the Engle-Granger two-step process. In contrast to prior research, this analysis focuses on real inflation without distinguishing between expected and unexpected inflation, which aligns with the perspective recommended by Tarbert (1996). The purpose of cointegration testing is to identify a long-term equilibrium relationship between the time series variables, actual inflation, and real estate returns.

To begin, the first step involves performing the widely used Augmented Dickey-Fuller test in time series analysis. This test is utilized to determine whether the time series variables contain unit roots, which suggests a long-term relationship between them.

ADF Equation without Trend:

$$(4)\ \boldsymbol{\Delta Y_t = \alpha Y_{t-1} + \varepsilon_t}$$

H_0: Unit Root Present

H_1: No Unit Root Present

ADF Equation with Trend:

$$(5)\ \boldsymbol{\Delta Y_t = \alpha Y_{t-1} + \beta T + \varepsilon_t}$$

H_0: Unit Root Present

H_1: No Unit Root Present

Where $\boldsymbol{\Delta Y_t}$ represents the differenced time series variables for the three proxies of real estate returns, and $\boldsymbol{Y_{t-1}}$ is the lagged variable with a two-period lag, the **T** signifies a time trend. The ADF test examines stationary within the time series data to determine if future observations are dependent on past realizations. Its outcome serves as a critical indicator for further employing time series analysis methods.

Once stationarity is verified, residuals are calculated by taking the differencing between the observed data and the estimated values from the cointegration equation. Analysing these residuals is crucial to assess the adequacy of the model in explaining the long-term relationship between real estate returns and inflation.

4.4. Granger Causality Tests

After conducting comprehensive co-integration analyses, the granger causality tests play a crucial role in revealing the directional relationship between real estate returns and inflation. This analytical process uncovers causal connections, elucidating whether changes in real estate returns impact inflation, vice versa, or if there is a mutual relationship. This conclusive evaluation enhances the analysis by unveiling the temporal complexities of the interaction between real estate returns and inflation.

In these empirical tests, the Granger causality principle is employed to gauge if past values of a variable, such as X, explain variations observed in another variable, Y. To undertake this analysis, an initial regression of Y on its lagged values captures any autoregressive aspects and sets up the equation:

$$\textbf{(4)}\ \boldsymbol{R_{jt} = \alpha_0 + \alpha_1 R_{t-1} + \alpha_2 R_{t-2} + \cdots + \alpha_j R_{t-j} + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \cdots + \beta_j X_{t-j} + u_t}$$

The lag count is often determined using Bayesian or Akaike Information Criterion (BIC/AIC). The Granger causality test examines the collective hypothesis that previous values of X do not have statistical significance:

$$\textbf{(5)}\ \boldsymbol{H_0 \colon \beta_1 = \beta_2 = \cdots = \beta_j = 0}$$

while the alternative hypothesis involves at least one non-zero value among them:

$$\textbf{(6)}\ \boldsymbol{H_0 \colon \beta_j \neq 0, for\ at\ least\ one\ value\ of\ j}$$

Causality bidirectionally is examined by comparing the restricted model, which excludes historical X values, with the full model. An F-test assesses the difference between their Sum of Squared Errors to determine if omitting past X values is valid:

$$(7)\ \boldsymbol{F}^{*} = \frac{(\boldsymbol{SSE_r} - \boldsymbol{SSE_u})/\boldsymbol{m}}{\boldsymbol{SSE_u}/(\boldsymbol{n}-\boldsymbol{k})}$$

Here, (m) represents the number of restrictions, (n) denotes observations, and (k) indicates parameters estimated in the full model.

It's important to note that this analysis exclusively focuses on actual inflation rates while excluding examination of expected and unexpected inflation. This approach aligns with testing long-term relationships under the assumption of equality between actual and expected inflation rates for analytical purposes.

5. Results and Analysis

5.1. Summary Analysis

In investing the links between different economic indicators and real estate profits, the main goal is to determine whether real estate can be considered a dependable safeguard against inflation. The associations revealed by the data present an interesting scenario, as depicted in Table 2:

	CPI	FNRE Return	NPNCRE Return	DWRTF Return	S&P 500	M1	Interest Rate	GDP rate
CPI	1,000							
FNRE Return	-0,081	1,000						
NPNCRE Return	0,305	0,291	1,000					
DWRTF Return	-0,076	0,998	0,304	1,000				
S&P 500	0,424	0,030	0,003	0,025	1,000			
M1	0,528	0,013	-0,085	0,007	0,890	1,000		
Interest Rate	0,314	0,004	0,140	0,016	-0,125	-0,133	1,000	
GDP rate	0,067	0,195	0,258	0,209	0,088	0,054	0,057	1,000

Table 2 - Correlation Analysis

CPI demonstrated mild negative correlations with FNRE Return (-0,081) and DWRTF Return (-0,076) suggesting a slight opposite trend between inflation and these market returns. In contrast, it shows moderate positive connections with the S&P 500 (0,424), M1 (0,528), and Interest Rate (0,314), indicating alignment with these factors. However, its associations with FNRE Return (0,305) and GDP rate (0,067) are relatively weaker.

The NPNCRE Return shows modest positive associations with FNRE Return (0,291), suggesting some coherence in their trends. However, its connections with other variables, such as S&P 500 (0.030) and Interest Rate (0.004), indicate relatively minor direct impact.

Meanwhile, the NPNCRE Return shows moderately positive associations with DWRTF Return (0,304) and GDP rate (0,258), indicating a somewhat synchronous movement with these variables. However, its relationships with other indicators like S&P 500 (0,003) and Interest Rate (0,140) seems to be less pronounced.

DWRTF Return is significantly correlated with both FNRE Return (0.,998) and moderately correlation with NPNCRE Return (0,304), demonstrating a strong alignment with these market return variables. However, its connections to other financial indicators are comparatively less substantial.

The S&P 500 shows modest positive associations with the CPI (0,424) and M1 (0,890), indicating a relatively stronger link compared to its relationships with other financial indicators. Interestingly, it exhibits slight adverse correlations with Interest Rate (-0,125) and GDP rate (0,088).

M1 exhibits a moderate positive relationship with CPI (0,528) and a significantly strong connection with S&P 500 (0,890), while its associations with other factors are comparatively less robust. This suggests that although the expansion of money supply may align with increased stock market returns, its influence on real estate seems to be less prominent.

Based on the provided sources, real estate returns show a mild positive correlation with interest rates, FNRE Returns (0,004) and NPNCRE Return (0,140), indicating the potential for higher interest rates to correspond with increased real estate returns. This suggests that real estate may serve as a hedge against inflation, particularly through its connection with movements in interest rate.

Analysing the correlation between real estate returns and CPI reveals complex relationships. The FNRE Return demonstrates a slight negative correlation (-0,080) with CPI, indicating a modest inverse trend with inflation, but not clearly representative of a simple hedge.

Additionally, the high correlation between NPNCRE, FNRE, and DWRTF Returns, particularly between FNRE and DWRTF Returns (0,998), suggests their nearly identical reactions to inflationary pressures or market changes. This could potentially impact each other's performance and indicates a stable alignment within the real estate market itself.

While the observed correlations offer interesting insights, they are not consistently strong. However, the significant positive connections with interest rates suggest a possible way for real estate to serve as an inflation hedge, mainly through its interactions with fluctuations in interest rates. Further analysis and considerations will be necessary to draw definitive conclusions on real estate's efficacy as an inflation hedge.

5.2. Econometric Analysis

Based on the results of the OLS regression, particularly in the initial equation with only actual inflation as the independent variable, a variety of responses were revealed within the indices to changes in the Actual Inflation Rate. The coefficient for FNRE Returns stands at -0,005, suggesting a slight adverse association with actual inflation, however, with a t-statistic of -0,791, it does not exhibit statistical significance. Similarly, like FNRE Return, the coefficient for DWRTF Return is also -0,005 and lacks statistical significance.

For NPNCRE Returns, the coefficient is 0,004, along with a substantial t-statistic of 3,141, suggesting a statistically notable correlation between NPNCRE Return and actual inflation. The F-statistic of 9,864 additionally reinforces the general importance of the model.

Simple Linear Regression: 1998-2023				
Dependent Variable	α	β	**F-Statistic**	**Adjusted R Square**
FNRE Return	0,022	-0,005	0,626	-0,004
Std.Err.	0,019	0,006		
t-Statistic	1,149	-0,791		
NPNCRE Return	0,010	0,004	9,864	0,084
Std.Err.	0,004	0,001		
t-Statistic	2,549	3,141		
DWRTF Return	0,022	-0,005	0,553	-0,005
Std.Err.	*0,020*	*0,006*		
t-Statistic	1,088	-0,744		

Table 3 - Actual Inflation Model

In summary, although the FNRE and DWRTF Return do not show a substantial correlation between their coefficients and actual inflation, the NPNCRE Return indicates a modest but statistically significant connection. This suggests its potential as a partial inflation hedge.

Table 4 demonstrates findings based on Fama's methodology from a study in (1977). Regression analyses utilizing different indicators offer understanding into the relationship among different returns and indicators for anticipated inflation. Four proxies: Short-Term Interest Rates, First-order Autoregressive Model, and ARIMA models (ARIMA 1,1,1 and ARIMA 1,1,3) reveal varied impacts on the examined returns.

Proxy 1: Short-Term Interest rates: 1998-2023		
Dependent Variable	β	**F-Statistic**
FNRE Return	0,004	4,921
t-Statistic	2,972	
NPNCRE Return	0,004	4,921
t-Statistic	2,972	
DWRTF Return	-0,004	0,304
t-Statistic	0,008	
Proxy 2: Simple First Order Autoregressive Model: 1998-2023		
Dependent Variable	β	**F-Statistic**
FNRE Return	-0,010	3,611
t-Statistic	-1,515	
NPNCRE Return	0,003	11,419
t-Statistic	2,186	
DWRTF Return	-0,010	3,647
t-Statistic	0,011	
Proxy 3: ARIMA(1,1,1): 1998-2023		
Dependent Variable	β	**F-Statistic**
FNRE Return	0,004	0,747
t-Statistic	0,321	
NPNCRE Return	0,010	9,828
t-Statistic	4,308	
DWRTF Return	0,005	0,806
t-Statistic	0,436	
Proxy 4: ARIMA(1,1,3): 1998-2023		
Dependent Variable	β	**F-Statistic**
FNRE Return	-0,010	1,211
t-Statistic	-0,450	
NPNCRE Return	0,024	16,309
t-Statistic	5,711	
DWRTF Return	-0,010	1,244
t-Statistic	-0,411	

Table 4 - Fama and Schwert Model

In Proxy 1, which concentrated on short-term interest rates, revealed that both FNRE and NPNCRE returns demonstrated comparable coefficients of 0,004, with corresponding t-statistics of 2,972. These findings suggest a statistically significant positive correlation between these real estate indices and short-term interest rates, while DWRTF displayed relatively minor significance. Additionally noteworthy is the F-statistic, indicating that both FNRE and

NPNCRE returns exhibited an F-statistic of 4,921, further underlining the importance of their connection to short-term interest rates.

Employing Proxy 2, the first-order autoregressive model, FNRE return displays a negative coefficient of -0,010 with a t-statistic of -1,515, suggesting a potential inverse relationship between FNRE and the variables. On the other hand, NPNCRE return shows a positive coefficient of 0,003 with a t-statistic of 2,186, indicating a positive association. While DWRTF also demonstrates relationships, they were notably weak in comparison. The F-statistics for FNRE and NPNCRE returns in this model were 3,611 and 11,419 respectively, further supporting the significance of their associations within this structure.

Utilizing an ARIMA 1,1,1 model in Proxy 3 reveals a weak relationship for FNRE and DWRTF. However, NPNCRE exhibited a more meaningful coefficient of 0,010 with a significant t-statistic of 4,308, highlighting a string and positive connection with the economic indicators. Remarkably, the F-statistic for NPNCRE return was 9,828, indicating a substantial overall association within this model.

Using an ARIMA 1,1,3 model in proxy 4 confirmed the lack of significance of FNRE and DWRTF while emphasizing a strong positive correlation with NPNCRE. The significant coefficient of 0,024 and the high t-statistic of 5,711 for NPNCRE return in this model were supported by a notably high F-statistic of 16,309, highlighting the robustness and importance of the relationship between NPNCRE and the economic indicators.

I can infer that, although FNRE and DWRTF returns generally display a weak or insignificant correlation with the economic indicators across the models, NPNCRE return consistently demonstrated a stronger and more resilient positive connection, particularly in Proxy 2 and Proxy 4. These outcomes not only suggest but also confirm the possibility for NPNCRE to function as an inflation hedge compared to the other indices examined here, further reinforced by the notably higher F-statistics observed, especially in Proxy 4.

The regression analysis from 1998 to 2023 reveals interesting findings regarding the connection between real estate returns and economic indicators. Specially, upon examining statistically significant values, it becomes apparent that certain economic factors demonstrate noteworthy associations with real estate returns, particularly in terms of acting as a hedge against inflation, as shown in Table 5:

Multiple Regression: 1998-2023							
Dependent Variable	α	β	γ	$\xi X1$	$\xi X2$	$\xi X3$	$\xi X4$
FNRE Return	0,022	-0,049	-0,011	0,012	0,009	0,039	0,004
t-Statistic	0,839	-2,194	-1,383	0,128	0,105	1,946	1,723
NPNCRE Return	0,001	0,003	0,007	0,042	-0,064	0,002	0,001
t-Statistic	0,273	0,835	4,567	2,324	-3,833	0,596	2,429
DWRTF Return	0,021	-0,051	-0,011	0,013	0,006	0,021	0,004
t-Statistic	0,757	-2,194	-1,345	0,127	0,070	1,984	1,861

Table 5 - Recognizing the dynamic nature of the markets

The data highlights, the importance of Money Supply (X2) as a key factor for NPNCRE returns, indicating a significant negative coefficient (-0,064) with a high t-Statistic (-3,833). This association implies that an increase in the money supply is linked to decreases in NPNCRE, potentially serving as a hedge against inflation. Higher levels of money supply, often associated with inflationary pressures, are connected to lower NPNCRE returns.

The intricate connection between real estate returns and inflation protection appears to be complex, as evidenced by the significant negative rcorrelation between Money Supply and NPNCRE returns. This suggests these findings underscore the need for a comprehensive understanding of the interplay between economic factors and real estate returns when assessing real estate's potential as an inflation hedge.

5.3. Cointegration and Causality Tests

During the period of 1998 to 2023, Cointegration Regressions were conducted using Augmented Dickey-Fuller (ADF) tests on residuals for NPNCRE, FNRE, and DWRTF indices. Each index was subjected to two variations of ADF tests, one with a trend and one without. These tests produced alpha (α) and beta (β) coefficients along with associated t-statistics based on critical values provided in the calculations by Stevenson (1999). A more negative t-statistic indicates stronger evidence for stationarity, which is essential in time series analysis. Comparing these statistics against their critical values helps determine non-stationarity and aids in evaluating the stationary nature of residuals.

Cointegration Regressions: 1998-2023				
Dependent Variable	α	β	**Trend**	**T-Stat**
ADF Test on Residuals FNRE				
No Trend	-1,115	0,019		-6,399
With Trend	-1,110	0,029	0,251	-6,389
ADF Test on Residuals NPNCRE				
No Trend	*-0,240*	*0,002*		*-3,797*
With Trend	-0,246	0,004	0,206	-3,862
ADF Test on Residuals DWRTF				
No Trend	-1,083	0,018		-6,342
With Trend	-1,091	0,031	0,251	-6,348
Note: Critical Value: No trend = -3.052 and With trend = -3.50				

Table 6 - Cointegration Tests

The results of these examinations showed substantial stability within the leftover data, which is essential in assessing the potential for real estate to function as a safeguard against inflation. Remarkably low t-statistics were noted across all three indicators, particularly noticeable in the versions that did not include a trend. The range of t-statistic was from -3,797 to -6,399, indicating string evidence of stability without a trend.

The findings suggest a stable connection between the real estate indicators and real inflation, indicating the possibility for these indicators to serve as efficient protections against the effects of inflation. The following Granger causality tests aim to further explore this relationship by seeking to establish the causal link between real estate returns and inflation, presented in Table 7:

Asset	F-Statistic	P-Value
CPI->FNRE	5	1%
FNRE->CPI	2	13%
CPI->NPNCRE	4	3%
NPNCRE->CPI	11	0%
CPI->DWRTF	5	1%
DWRTF->CPI	2	9%

Table 7 - Granger Causality Tests

The outcomes indicate a notable one-way causal connection between CPI and NPNCRE, demonstrated by a substantial F-statistic of 11 and negligible p-value of 0%. This suggests that

CPI effectively anticipates NPNCRE returns, indicating that fluctuations in real inflation have a significance influence on the NPNCRE index.

Similarly, the analyses show a significant causal connection between CPI and DWRTF, illustrated by an F-statistic of 5 and p-value of 1%. This indicates that CPI has a statistically substantial predictive influence on DWRTF returns.

Conversely, for FNRE, there is a one-way causality from CPI to FNRE with an F-statistic of 5 and a p-value of 1%, suggesting that CPI may significantly forecast FNRE returns.

The Granger causality test from FNRE, DWRTF, and NPNCRE to CPI does not show a significant predictive relationship as indicated by the higher p-values (FNRE $\Rightarrow$ CPI: 13%, DWRTF $\Rightarrow$ CPI: 9%, NPNCRE $\Rightarrow$ CPI: 3%)

These collective results suggest a potential predictive association between actual inflation and the indices. The findings imply that fluctuations in actual inflation could potentially predict returns in these real estate indices, indicating the possibility of real estate serving as a hedge against inflationary pressures.

The results I obtained are consistent with some aspects of the existing literature while also demonstrating certain differences.

Several studies in the literature review explored the relationship between real estate and inflation hedge across different regions and economic contexts. Similar to my findings, some previous research highlighted the potential for real estate to serve as a protection against inflation. For example, insights form markets such as Hong Kong and Thailand, as documented in existing literature, coincide with my study's identification of consistent NPNCRE return associations across different models. This indicates a promising possibility for real estate to act as a partial hedge against inflation.

However, my research differed in certain causal relationships and regional specific compared to the existing literature. While my findings showed a predictive link from actual inflation to specific real estate indices (NPNCRE, DWRTF, FNRE), some studies indicated different influences or even no significant causal connections at all. Additionally, my emphasis on the U.S. market differs from the broader geographical like Taiwan, Switzerland, and Singapore. These discrepancies may contribute to the variations observed in conclusions regarding real estate's ability to hedge against inflation.

In summary, my results provide valuable perspective on the potential of the U.S. real estate market to serve as hedge against inflation. While there were consistent correlations in specific indices, the differences underscore the need for context-specific examinations to fully grasp the intricacies of using real estate for hedging inflation in varied economic environments.

6. Discussion

The research conducted a thorough investigation of the complex connection between real estate returns in the United States and inflation, using various methods like OLS regression, cointegration tests, and Granger causality tests. These analytical techniques were utilized to reveal the possible function of real estate as a hedge against inflation in the American market. The findings form the OLS regression models provided detailed insights, questioning existing theories by demonstrating differing effectiveness within different real estate sectors in protecting against inflation. The incorporation of macroeconomic variables illuminated their impact on inflation and their diverse effects on the ability of different real estate segments to hedge against it. This highlighted the importance of comprehending market dynamics and the complex nature of hedging against inflation in real estate.

Cointegration tests revealed lasting links between real estate returns and inflation, emphasizing the presence of long-term associations that enhance the comprehension of how these variables interact over extended periods. At the same time, Granger causality tests shed light on temporal complexities, clarifying the intricate dynamics of how fluctuations in real estate returns or inflation influence each other, frequently demonstrating mutual causal relationships.

Comparison with the broader global literature accentuates the contextual nature of inflation hedging with the wider international literature highlights the contextual aspect of inflation hedging in the US real estate market. The intricate connections among various assets, different geographic regions, and economic circumstances underscore the importance of customizing investment strategies within the American real estate sector.

This thorough method not only contributes to the comprehension of inflation hedge in the U.S. real estate market but also emphasizes the intricate and multifaceted connection between real estate returns and inflation, requiring a sophisticated and flexible strategy to navigate this intricate area.

7. Conclusion

This research explored the complex correlation between inflation and real estate returns in the United States, using various approaches to examine the potential of real estate as a hedge against inflation. The study employed diverse methods such as OLS regression, cointegration tests, and Granger causality analyses to uncover the intricate dynamics influencing inflation hedging across different sectors of the American real estate market.

The results indicated different levels of effectiveness in combating inflation within various real estate sectors, challenging traditional beliefs and emphasizing the contextual aspect of inflation hedging. The influence of macro variables on inflation and their varied impacts across real estate segments underscored the necessity for customized investment strategies in this intricate environment.

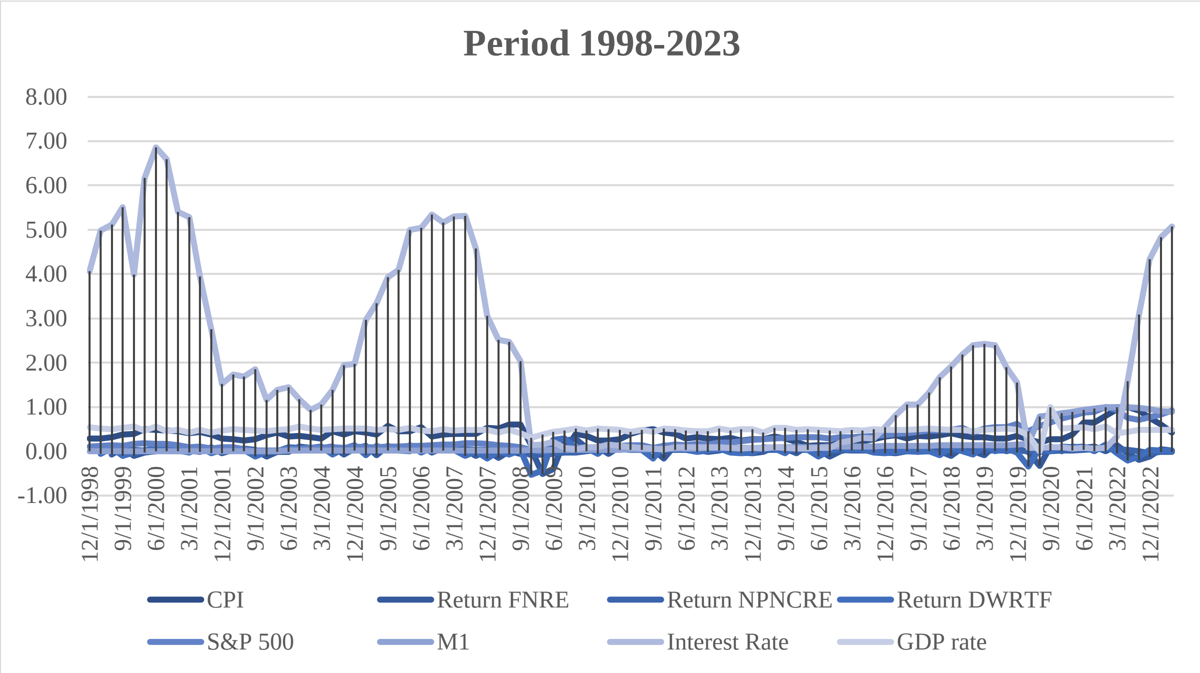
The study, however, is limited in scope as it focused on a specific time frame and geographic region. This may restrict the generalizability of the findings. The complexity of real estate markets suggests that additional variables and more refined models are necessary to ensure a thorough analysis.

Future academic investigations could potentially broaden their geographical focus or consider different time frames to enhance the comprehension of real estate's inflation hedging capabilities. Expanding the analysis to integrate additional economic indicators or delving into more specific subcategories within the real estate sector, may yield deeper insights into strategies for hedging against inflation.

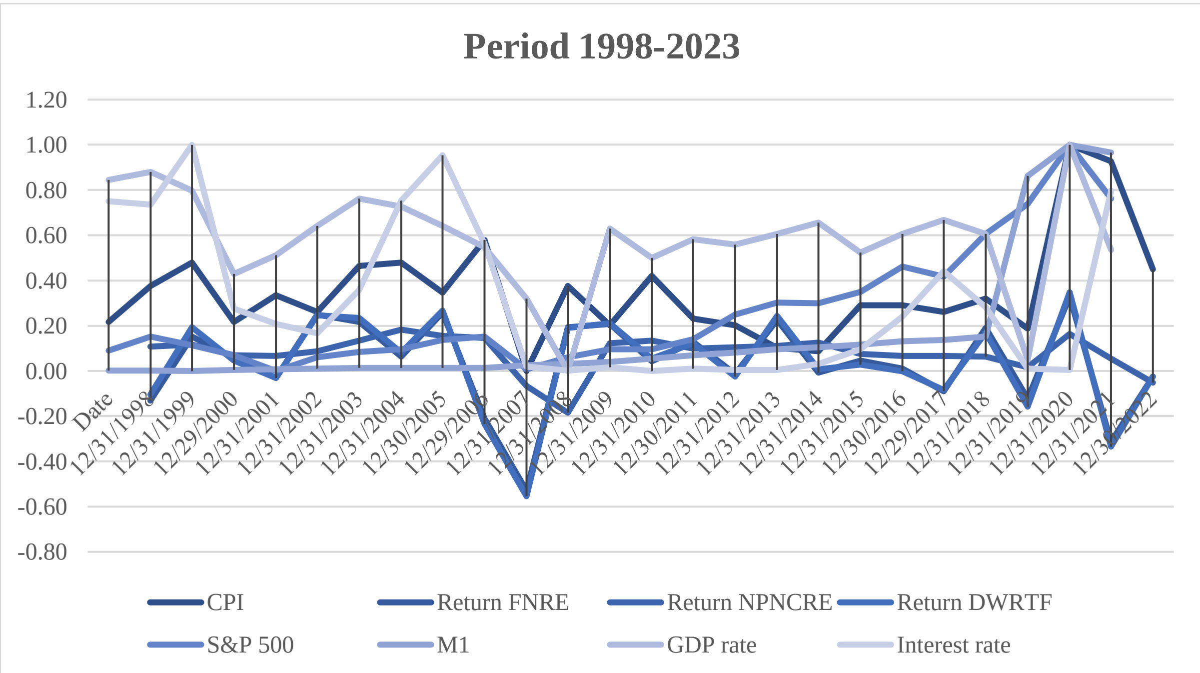
Moreover, qualitative research could supplement numerical investigations by examining investors conduct, attitudes, and market outlooks pertaining to real estate and inflation hedging. It is also essential to explore developing patterns like technological advancements or environmental concerns to comprehend their potential influence on inflation hedging in the real estate sector.

In conclusion, this research offers valuable insights into the correlation between inflation and U.S. real estate returns. However, there is still much to explore in this area. Overcoming these limitations and exploring future research avenues will enhance our understanding of real estate's effectiveness as an inflation hedge in evolving economic settings.

Appendix



Graph 1 - Variables of the Study Data (Quarterly Data)



Graph 2 - Variables of the Study Data (Yearly Data)

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[i] Stationarity is a crucial prerequisite for conducting empirical tests with time-series data. When data lack stationarity, it breaches the assumptions of Ordinary Least Squares (OLS) by disrupting the consistent mean variance in residual errors. This breach also alters the time-invariant nature of inter-temporal correlation in error terms, leading to potentially misleading regression outcomes.

[ii] Spurious results, stemming from non-stationary time-series in regression models, are deceptive and do not accurately reflect the genuine economic relationships. Despite demonstrating a high R^2, these results lack time-invariance, making them unsuitable for making reliable long-term predictions.