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Title The inflation hedging properties of gold, stocks, and real estate: A comparative analysis

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Abstract

This study is a comparative analysis of inflation hedging properties of stocks, gold and real estates for the US. It is hypothesized that the assets have varying market characteristics and thus should respond differently to high inflation. The Fisher's hypothesis for asset-inflation hedging is constructed both within the bivariate and multivariate modelling frameworks. Thereafter, some salient features typical of predictive models such as asymmetry, time-variation and structural breaks are incorporated in the estimation process for completeness. The results show that inflation hedging tendencies of assets are heterogeneous across the considered assets. The real estates and stocks prove to be good hedges against inflation, while gold investment defies Fisher's hypothesis. Also, the results are sensitive to the decomposition of data for pre- and post-GFC periods, indicating that asset-inflation hedging relationship for the US is time-varying. The results are robust to alternative data frequencies

Keywords Inflation hedging; Gold; Stocks; Real estate; United States

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Research Highlights:

- The inflation hedging of heterogeneous asset classes is examined.
- Only real estates and stocks were confirmed to provide hedge against inflation.
- The former produces a higher potential for inflation hedging than the latter.
- The result is robust to alternative specifications and data frequencies.
- It is however sensitive to sub-periods of pre- and post-global financial crisis.

The inflation hedging properties of gold, stocks and real estate: a comparative analysis

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JEL Classification: E44, G11, G15

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1.0 Introduction

The aim of a rational investor is to maximise returns and reduce risk. However, inflation has been found to impede these objectives (Wang et al., 2011; Arnold and Auer, 2015; Yeap and Lean, 2017). The influence of inflation on financial matters has raised significant concern among academics, investors, and policymakers since 1970.[1] For instance, Linter (1975) argues that fewer issues are more important than inflation's effect on financial institutions, markets, and investment policies. Theoretical arguments show that inflation reduces purchasing power and the standard of living of economic agents in addition to causing a potential reduction in returns on investment assets (Anari and Kolari, 2002; Iacoviello, 2012; Case et al., 2012; Yeap and Lean, 2017; Christou et al., 2018). In an attempt to mitigate the detrimental effects of inflation, a strand of literature has designed ways to hedge against inflation based on the Fisher (1930) theory, which states that the expected nominal interest rate should move in sync with expected inflation. Fama and Schwert (1977) demonstrated that the Fisher thesis can be inferred for all classes of assets where nominal returns of the said asset should move in sync with inflation, indicating that the asset has a full (short-run) hedge against inflation risks (see Arnold and Auer, 2015). Hence, the dynamics of hedging against inflation require that the return on investments should be at least equal to the rate of inflation (see Fang et al., 2008; Obereiner and Kurzrock, 2012; Amonhaemanon et al., 2013; Hoang et al., 2016; Taderera and Akinsomi, 2020).

This study seeks to identify and quantify the extent to which returns on selected financial assets could hedge against inflation. By extension, the study provides answers to the inquiry of whether different asset classifications react in the same manner or differently to inflation. Thus, this study is a comparative analysis of inflation hedging properties of gold, stocks, and real estates. The study's objective of undertaking a comparative analysis inclusive of real estate has theoretical

[1] One of the monetary objectives of the government is price stabilisation. Hence, governments and policymakers try to find the best approach to achieve minimal inflation. Investors seek to protect their wealth by diversifying their portfolio to include those assets considered to be a good hedge against the vagaries of inflation.

backing[2]. Real estate is an investment and a consumption good. While rising general prices are transmitted to real estate price via construction input prices, tight monetary policy in times of inflation reduces liquidity flow to the real estate market to cause lower prices and hence returns on real estate investment (Breitenfellner et al. 2015; Christou et al., 2018).

Empirical validation of the Fisher hypotheses is inconclusive for a wide range of financial assets. Arnold and Auer (2015) justified this stance on the intuition that studies have employed different methodologies, sample sizes, scopes, and measurements. We extend this argument, on the cause of the mixed result, to the inability of previous studies to account for some inherent properties of either or both assets and inflation. Specifically, features such as asymmetry and structural breaks have been ignored.[3] When these extant features are unaccounted for, it could bias results and lead to wrong policy formulation. The norm in literature is to assume that there is systematic relationship between assets and inflation. This implies that both assets and inflation move in the same direction. However, realities have suggested otherwise. Frey and Manera (2007) offer insight on how to observe asymmetry in the assets-inflation nexus. It has also been documented that the relationship between macroeconomic and financial variables are nonlinearly related (Atil et al, 2014; Bahmani-Oskooee and Ghodsi, 2016). Based on the aforementioned, we argue that assets react differently during inflation and deflationary periods.

Assets react differently to inflation due to their varying characteristics. A common characteristic of most financial variables is their susceptibility to breaks and high reaction to structural changes in the economy. The boom and bust features have implication on the ability of assets to hedge against inflation. Prior to the recent global financial crisis, it was evident that asset prices were trending. Thus, assets could easily hedge against inflation. However, when the bubble bursts, not only were assets unable to hedge against inflation, but they also significantly lost their price valuation. There is empirical validation of this stance based on the argument that the inflation hedging potential of some of these assets considered individually could be time-varying,

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[2] This objective is confronted in this paper by considering the inflation risk hedging potential of each of stock, gold, and real estate returns in distinct analysis. In order to properly observe the inflation hedging power of real estate, we conduct further analysis with firm-level data to isolate real estate from the broad stock prices. Hence, in addition to the main analysis, which uses aggregated data, we conduct robustness with firm-level data for stock returns with and excluding real estate sector. We have an anonymous reviewer to thank for this insight.

[3] For inflation, Bahmani-Oskooee and Ghodsi (2016) and Shahbaz et al. (2018) are exemptions.

indicating, for instance, that gold may function as a hedge against inflation only in specific economic conditions or data ranges (see Beckmann and Czudaj, 2013; Batten et al., 2014; Hoang et al., 2016; Aye et al., 2017; Shahzad et al., 2018). There is also evidence of regime dependence in stock-inflation hedging (Li et al., 2010; Kim and Ryoo, 2011; Oxman, 2012; Rushdi et al., 2012; Spierdijka and Umar, 2015). The real estate hedging potential may also be episodic (Wu and Pandey, 2012; Obereiner and Kurzrock, 2012; Amonhaemanon et al. 2013); time varying (Christou et al., 2018); asymmetric (Yeap and Lean, 2017); and differ across sectors (Taderera and Akinsomi 2020). The significant effect of structural shifts in the economy (i.e. structural breaks) and its effect on financial assets has been registered in the literature (Su et al., 2009; Eraslan and Ali, 2018). Studies have also confirmed cyclicality in asset prices (Mayer, 2011).

Numerous studies have examined assets-inflation hedging nexus (see Mayer, 2011; and Arnold and Auer, 2015; for literature surveys). We make two contributions to the literature. First, studies have largely examined single asset-inflation hedging properties. We expand on this notion by capturing multiple assets. This is to shed more light on which asset(s) best preserve the wealth of investors. Second, we account for some features that characterise high frequency data: asymmetry and structural break. As far as literature guides us, this is the first study to capture these two features simultaneously in the asset-inflation hedging framework.

As a prevue, we show that inflation hedging is asset-specific. Real estate and stock returns were confirmed to be a good hedge against inflation, while nominal returns on gold investments defy Fisher’s hypothesis. These results are valid even after accounting for asymmetry and structural breaks and several robustness checks. Our result is sensitive to the decomposition of the dataset to pre- and post-financial crisis periods, which suggests that the considered inflation hedging potential of assets changes after the global financial crisis.

Following this introduction, we structure the rest of this paper as follows. The methodology and theoretical framework informing it are presented in section two. Data and preliminary analysis are discussed in the third section. In section four, empirical results are presented and the last section concludes the paper.

2.0 Theoretical framework and methodology

The inflation hedge of any asset class is usually predicated on the Fisher hypothesis (see Fisher, 1930) which renders the first attempt to formally state the hypothetical relationship between asset returns and inflation. Under this hypothesis, the nominal interest rate is expressed as the sum of real returns and inflation rate. Fama and Schwert (1977) point out that the proposition that expected nominal returns contain market assessments of expected inflation rates can be applied to all assets (Arnold and Auer, 2015). Thus, with a suitable measure for inflation, we can specify a generalised Fisher hypothesis framework for the inflation hedging of a particular asset class as follows:

$$r_t = \alpha + \beta\pi_t + \varepsilon_t; \qquad \varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right) \tag{1}$$

where r_t is the asset return computed as the first difference of the natural log of the asset price in question and π_t is the inflation rate computed as $\log\left(cpi_t / cpi_{t-1}\right)$. The coefficient β measures the inflation hedge of a particular asset and there are three possible outcomes in this regard—partial hedge, full hedge, and superior performance. Partial hedge requires that $0 < \beta < 1$; full hedge implies that $\beta = 1$; and there is superior performance if $\beta > 0$. However, the asset in question has no inflation hedging potential if $\beta \le 0$.

Note that equation (1) is specified in a manner to circumvent the problem of unit root and consequently avoid reporting relationships which do not exist due to spurious regressions (see Granger et al., 2001). Nonetheless, formal unit root tests such as the ADF-type and the GARCH-based unit root test of Narayan and Liu (2015) and Narayan et al. (2016a) are conducted to validate the absence of unit root in the relevant series (see the preliminary analyses). However, another important feature of equation (1) particularly for the predicted series is that it is more likely to exhibit conditional heteroscedasticity effect which may have implications on the predictability analyses (Westerlund and Narayan, 2012, 2015).[4] Thus, we follow the approach of WN (2012, 2015) |to resolve the problem in the estimation process.

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[4] Several recent papers have validated the need to account for this effect when dealing with high frequency series. Examples include studies focusing on inflation predictability (see Salisu and Isah, 2018; Salisu et al., 2018; Tule et al., 2019); stock returns predictability (see Bannigidadmath and Narayan, 2015; Narayan and Bannigidadmath, 2015; Narayan and Gupta, 2015; Phan et al., 2015; Westerlund and Narayan, 2015; Narayan et al., 2016b; Devpura et al., 2018; and Salisu et al., 2019a) and exchange rate predictability (Salisu et al., 2019b).

Consequently, we consider equation (1) as the baseline model and extend the same to account for other important considerations when analysing inflation hedging. First, we allow for the asymmetric reaction of asset prices to changes in inflation. Note that equation (1) assumes that the relationship between the asset price and inflation is symmetric, whereas, as aforementioned, a new strand of the literature—albeit limited—suggests that it should be asymmetric (see for example, Ahmed and Cardinale, 2005; Knif et al., 2008; Kim and Ryoo, 2011; Wang et al., 2011; Yeap and Lean, 2017). To accommodate such asymmetries in analyses, we decompose π_t into positive $\left(\pi_t^+\right)$ and negative $\left(\pi_t^-\right)$ changes using the Shin et al. (2014) approach[5] and thereafter replace the π_t factor in equation (1) with the π_t^+ and π_t^-. Technically, the π_t^+ and π_t^- are respectively decomposed as:

$$\pi_t^+ = \sum_{j=1}^{t} \Delta\pi_j^+ = \sum_{j=1}^{t} \max\left(\Delta\pi_j, 0\right) \tag{2}$$

$$\pi_t^- = \sum_{j=1}^{t} \Delta\pi_j^- = \sum_{j=1}^{t} \min\left(\Delta\pi_j, 0\right) \tag{3}$$

Therefore, π^+ and π^- can be defined as the positive and negative partial sum decompositions of π, respectively. Thus, equation (1) can be re-specified to account for asymmetries as follows:

$$r_t = \alpha + \beta^+\pi_t^+ + \beta^-\pi_t^- + \varepsilon_t \tag{4}$$

where equation (4) captures the role of positive and negative changes in inflation which can equally be described in this context as high and low levels of inflation respectively. It is hypothesised that r_t can be used to hedge against inflation if both β^+ and β^- are positive although it is expected that $\beta^- > \beta^+$. In other words, regardless of the level of inflation, whether high or low, its relationship with returns on the selected assets is expected to be positive in order to classify such assets as inflation hedging.

[5] An alternative approach is proposed by Kilian and Vigfusson (2011); however, the approach by Shin et al. (2014) is favoured because of its computational simplicity as well as its suitability for the analysis of long-run and short-run asymmetric effects in economic relationships.

We also allow for significant structural breaks in the baseline model following the Narayan and Liu (2015) [NL (2015) hereafter] test.[6] There are two reasons for considering structural breaks. First, based on their Monte Carlo simulations, Devpura et al. (2019) reveal that a structural break-based predictive regression model fits the data reasonably well in predicting stock price returns. Devpura et al. (2018) and Salisu et al. (2019a,b) had previously offered empirical support for a structural break-based predictive regression model before it was formalised by Devpura et al. (2019) using both Monte Carlo simulations and empirical datasets. Second, literature is replete with evidence of the time-varying behaviour of the inflation hedging of asset classes (see Li et al., 2010; Kim and Ryoo, 2011; Oxman, 2012; Rushdi et al., 2012; Beckmann and Czudaj, 2013; Bampinas and Panagiotidis, 2015; Spierdijka and Umar, 2015; Aye et al., 2016; Hoang et al., 2016; Lucey et al., 2017; Christou et al., 2018). Essentially, the procedure is to first determine any significant structural shift in equation (1) and thereafter create a dummy variable for each break as an additional regressor in the same equation. Since the NL (2015) test is a multiple break-point test, we can identify more than one significant structural break in the estimation process. Thus, equation (1) is extended to include dummy variables for structural breaks:

$$r_t = \alpha + \beta\pi_t + \sum_{i=1}^{k}\phi_i D_{i,t} + \varepsilon_t \qquad (5)$$

where the inclusion of structural shift in the model is denoted by $D_t = 1$ if $t \geq$ Break Date and zero otherwise for all $i = 1, 2, ..., 5$ depending on the number of breaks obtained from the NL test. In addition to the endogenously determined structural breaks, we also allow for exogenous breaks determined by the global financial crisis. This consideration is motivated by the evidence of episodic inflation hedging for selected asset classes (see Li et al., 2010; Kim and Ryoo, 2011; Lucey, 2011; Oxman, 2012; Rushdi et al., 2012; Wu and Pandey, 2012; Batten et al., 2014; Spierdijka and Umar, 2015; and Lucey et al., 2017). Thus, the full sample is further partitioned into pre-Global Financial Crisis (GFC) and post-GFC periods and thereafter distinct analyses are rendered for them. Additionally, we consider an alternative data frequency for the analyses of the

[6] Other unit root tests that account for structural breaks include Lumsdaine and Papell (1997), Lee and Strazicich (2003), Perron (2006), and Narayan and Popp (2010, 2013). However, these unit root tests do not account for the conditional heteroscedasticity effect in their respective test regressions—a salient feature of stock returns and inflation (see Table 1). Cook (2008) and Narayan and Liu (2015) noted that if a unit root test regression follows a GARCH process and is ignored, the test is subject to size distortions. The GARCH-based unit root test has been extensively used in the recent literature (Salisu and Adeleke, 2016; Salisu et al., 2016; Salisu et al., 2019c; and Salisu et al., 2019d).

inflation hedge of the considered asset classes to verify if the choice of data frequency has any implication on the analyses. The predictability results may be sensitive to data frequency (see for example, NL, 2015 for the predictability of energy prices; Narayan and Sharma, 2015, for exchange rates; Salisu et al., 2016 for stock prices; Salisu and Adeleke, 2016 for sovereign bond yield; and Narayan et al., 2018 for oil and stock prices).

3.0 Data and preliminary analysis

As stated and justified in the introduction, this study is limited to the US. We built a monthly dataset for three classes of assets (real estate, gold, and stock returns). Real estate is measured by real estate investment trust (REIT). The US S&P500 is used to measure stock prices, while gold prices are captured using afternoon price-fixings of the London gold market denominated in USD. Consumer price index data is sourced from the FRED website, while other variables are collected from the Bloomberg terminal. Investment returns and month-on-month CPI inflation are computed as the percentage log difference of the respective variables.

Table 1 presents descriptive statistics. The average inflation rate is about 0.17% while investments in stock markets yield a return of about 0.3%. Investments in gold yield over 0.7%, bringing it in sync with investment returns among the considered assets. The average return on real estate is about 2.7%. On average, real estate yields the highest returns relative to other asset classes over the period under consideration. It is therefore not surprising to see real estate returns as being the most volatile, judging by the standard deviation. We conducted an autocorrelation test using Ljung-Box test Q and Q2 statistics. Series in the model were found to be serially correlated. The conditional heteroscedasticity is examined using the autoregressive conditional heteroscedasticity Lagrangian multiplier (ARCH-LM) test F-statistic. The analysis is based on two lags. Results show the existence of an ARCH effect at different lag lengths. This suggests that serial correlation and heteroscedasticity consistent modelling should be adopted.

There are two unit root tests conducted in this study. The first is the traditional ADF test. The second is the GARCH-based unit root test of NL (2015). The latter is superior to the former because of its ability to account for series that are trending, to exhibit structural breaks, and to display conditional heteroscedasticity (see Salisu and Adeleke, 2016). Results from these tests show that the series are stationary at level. This might be connected to the fact that the series are measured in returns and there are high probabilities of mean reversion.

Table 1: Preliminary analyses

Variable	Mean	StDev	LB^2 (2)	LB^2 (4)	ARCH(2)	ARCH(4)	ADF	NL (2015)	
Inflation	0.1789	0.3016	33.347[a]	34.430[a]	19.631[a]	10.1224[a]	-9.959[a#]	-9.7342 [a#]	[-]
Stock returns	0.3010	4.2398	21.267[a]	51.387[a]	9.959[a]	10.3081[a]	-13.35 [a#]	-12.624 [a#]	[2002M11; 2009M03]
Gold returns	0.7134	3.7944	8.7580[a]	15.692[a]	3.8550[a]	2.8770[a]	-11.14[a#]	-10.517 [a#]	[2011M09]
Real Estate	2.7239	11.7234	21.647[a]	22.432[a]	11.5153[a]	5.5572[a]	-15.76[a#]	-8.1940[a#]	[2009M03]

Note: The computed inflation used here is the month-on-month inflation computed as 100*log(cpi/cpi(-1)) where cpi is the consumer price index. The asset return is also computed using monthly frequency and is computed as 100*log(p/p(-1)) where p is the asset price. The NL unit root test follows the GARCH-based unit root test developed by NL (2015) with the underlying test equation $\Delta y_t = \lambda_0 + \lambda_1 t + \delta y_{t-1} + \sum_{i=1}^{k} D_i B_{it} + \varepsilon_t$ where y_t denotes the series under consideration; t is a time trend; $B_{it} = 1$ if $t \geq T_{B_i}$ and $B_{it} = 0$ otherwise. Values in the square brackets "[…]" are the break dates from the NL test. The null hypothesis of unit root given as $H_0 : \delta = 0$ is tested against the alternative hypothesis of stationarity denoted as $H_1 : \delta < 0$. # represents a trend in the unit root test equation. Superscripts a, b, c denote 1%, 5%, and 10% levels of significance, respectively. LB is the Ljung-Box serial correlation test with null hypothesis of no serial correlation. ARCH is the conditional heteroscedasticity test with the null hypothesis of no heteroscedasticity. Lags 2 and 4 are reported for both tests.

4. Presentation and Discussion of Results

4.1 Empirical Results

The main objective of this study is to analyse inflation hedging potentials of gold, stocks, and real estates in the US. In other words, the study seeks to investigate whether holding of gold, stocks, or real estate will enable rational economic agents in the US to avoid risk of investment returns losses due to higher inflation. The change in gold, stocks, or real estate returns as a result of change in inflation rate, β, in equation (1) is expected to be positive for gold, stocks, or real estate to serve as a good hedge against inflation. The hedging is partial if $0 < \beta < 1$, full if $\beta = 1$, and extraordinary (superior performance) if $\beta > 1$ (see Bampinas and Panagiotidis, 2015 and Arnold and Auer, 2015).

The main empirical results are presented in Table 2. The baseline result is the main result while accounting for structural breaks and asymmetry is expected to improve the baseline result if structural breaks and asymmetry matter. The summary of the result is presented on the column for “Hedge?” in Table 2, where the remark is indicated ‘Yes’ if gold serve as a hedge against inflation and ‘No’ if otherwise. This decision was made not only when the coefficient of inflation rate is positive but also when it is significant. A positive relationship implies that high inflation rate correlate with high gold, stocks, or real assets returns in the US.

It could be deduced from Table 2 that there is evidence of Fishers’ effect in the case of real estates and stock returns, as these assets provide a good hedge against inflation. Specifically, stock and real estate returns exhibit superior performance in hedging against inflation. Notably, this result holds irrespective of whether or not asymmetry and structural breaks are accounted for. It is noticeable that positive and negative coefficients of inflation rate are not significantly different. This indicates that there is no inflation asymmetry in the asset-inflation hedging nexus for the US.

Literature has supported the US stock hedging-inflation tendencies (see for example, Barnes et al., 1999; Amenc et al., 2009; Kim and Ryoo, 2011). There are two common factors attributed to the stock-inflation hedging tendencies: (i) stabilisation of the US inflation rate, especially in the post “Great Moderation” era; (ii) series of innovations implemented in the US stock market. Hence, investors have ample options to diversify their portfolio without incurring loss to wealth.

Table 2: Inflation hedging results for gold, real estate and stock returns

	Baseline	With SB	With Asymmetry		Hedge?
Assets			Positive	Negative	
Gold	0.772	0.772	0.932	0.916	No
Real Estate	15.715[a]	6.947[a]	16.155[a]	15.722[a]	Yes
Stock	6.264[a]	3.306[a]	6.490[a]	6.438[b]	Yes

Note: The gold/stock/real estate return is considered to be an inflation hedge if its real return is independent of the rate of inflation, implying a positive correlation between asset returns and inflation. Thus, given the following $r_t = \alpha + \beta\pi_t + \varepsilon_t$ where r_t represents returns for respective assets and π_t is inflation; hence, gold/stock/real estate is a good hedge against inflation if $\beta > 0$; otherwise it is not. Superscripts a, b, c denote 1%, 5%, and 10% levels of significance respectively.

Similarly, real estate exhibits extraordinary performance in providing hedge against inflation as the real estate-inflation beta coefficient is exceedingly greater than one. This suggests that returns on real estate increase more than a proportionate increase in inflation rate. This result is similar to those previously obtained (see Anari and Kolari, 2002; Glascock et al., 2002; Lee and Lee, 2012; Hofman and Aalbers, 2019). There are two main arguments to support this stance: first, in a bid to meet one of three essential human needs (shelter), there will always be demand for real estate among individuals and professionals, indicating that there will always be market for real estate investment. Theoretically, it is expected that returns on real estate would increase as a result of the positive relationship between demand and price. Second, the higher the returns on investment in real estate, the higher the inflation. However, the rate of increase in return is higher than that of inflation.

Observing the gold-inflation hedging relationship, our result suggests that gold does not provide a good hedge for inflation in the US, given that the beta coefficient in gold-inflation hedging model is not significant (although positive). This result holds even when asymmetry and structural breaks are accounted for. This stance is similar to the findings of Wang et al. (2011) and Erb and Harvey (2013) who concluded that there is no evidence to confirm Fisher's effect in the gold-inflation relationship. It is however against the finding of Greer (1997) about the inflation hedging capability of gold. Meanwhile, Beckmann and Czudaj (2013) obtained mixed results on the gold-inflation relationship. Batten et al. (2014) concluded that gold could not hedge against inflation because the former is seen as monetary easing fuels fears of higher inflation, which in turns affect gold prices. Hoang et al. (2014) advised investors not to use gold to hedge against inflation in the long-run.

In sum, an overview of results in Table 2 shows that inflation hedging tendencies are heterogeneous to various classifications of assets. While stock prices and real estate validate Fishers hypothesis, the same cannot be said of the price of gold. It is also instructive to note that these results hold after accounting for features such as structural breaks and asymmetry.

Further, owing to the importance of the 2007/2008 financial crisis, which affected assets' returns, we partition our sample size into pre- and post-GFC periods. The results, presented in Table 3, show that gold does not provide a good hedge against inflation in the US both before and after the GFC. This is consistent with our earlier result about gold. The result further shows that stock does not become a good hedge against inflation until after the GFC; this suggests that our result about stock-inflation hedging under the full sample is significantly influenced by the post-GFC stock-inflation hedging relationship. This finding would not have been revealed without this systematic period segmentation. Meanwhile, there is consistency in the full and partial sample analyses for real estate-inflation hedging relationship, as the partial analysis result shows that holding of real estate is a good hedge against inflation both before and after the GFC.

Table 3: Asset-inflation hedging nexus in the Pre- and Post-GFC periods

Pre GFC			Post-GFC		
Gold	Real Estate	Stock	Gold	Real Estate	Stock
0.528	11.811[b]	-0.477	1.773	16.1443[a]	6.489[a]

Source: Authors' computation
Note: The gold/stock/real estate return is considered to be an inflation hedge if its real return is independent of the rate of inflation, implying a positive correlation between the nominal gold/stock/real estate return and inflation. Thus, given the following $r_t = \alpha + \beta\pi_t + \varepsilon_t$ where r_t is the gold/stock/real estate return and π_t is the inflation; hence, gold/stock/real estate is a good hedge against inflation if $\beta > 0$; otherwise it is not. Superscripts a, b, c denote 1%, 5%, and 10% levels of significance respectively. Statistics presented are coefficients of the baseline regression.

4.2 Robustness and Sensitivity Analysis

We conducted various robustness checks to examine the sensitivity of our results to different data frequencies and the inclusion of additional regressors in the asset- inflation hedging model. First, we conducted the analysis using quarterly data to examine whether our result is sensitive to data frequencies (see Narayan and Sharma, 2015 for insights suggesting that the predictability model may be sensitive to data frequency). The result for this exercise, presented in Table 4, shows that the use of quarterly frequency does not alter the aforementioned conclusion. By implication, our result that stocks and real estate provide a good hedge for inflation in the US but gold does not is robust to data frequency, as it holds irrespective of whether monthly or quarterly data frequency is used.

Table 4: Robustness Check 1 (Quarterly series)

Assets	Baseline	With SB	With Asymmetry		Hedge?
			Positive	Negative	
Gold	2.009	-3.165	0.022	0.433	No
Real Estate	10.671[a]	7.019[a]	10.553[a]	10.862[a]	Yes
Stock	4.141[a]	4.862[a]	4.241[a]	4.035[a]	Yes

Note: The gold/stock/real estate return is considered to be an inflation hedge if its real return is independent of the rate of inflation, implying a positive correlation between the nominal gold/stock/real estate return and inflation. Thus, given the following $r_t = \alpha + \beta\pi_t + \varepsilon_t$ where r_t is the gold/stock/real estate return and π_t is the inflation; hence, gold/stock/real estate is a good hedge against inflation if $\beta > 0$; otherwise it is not. Superscripts a, b, c denote 1%, 5%, and 10% levels of significance respectively.

Second, our asset-inflation hedging model was expanded to account for the influence of industrial production. This is aimed at analysing the inflation hedging potential of gold, real estate, and stocks in a multivariate modelling framework. The newly introduced variable, Industrial Production Index (IPI), has been extensively used in literature as a proxy for economic activities (see for example, Kilian, 2009; Salisu et al., 2019a). Apparently, an increase in economic activities will lead to an increase in interest rates, and, by implication, a fall in investment returns. This suggests that a negative relationship is expected between IPI and asset (gold, real estates, and stocks) returns.

Table 5: Robustness check II (Model Augmented with Industrial Production Index)

Variables	Gold Hedging	Real Estate Hedging	Stock Hedging
INFC	1.798	6.824[a]	3.111[b]
IPIG	-0.727	-7.325[a]	-0.486

Note: INFC is inflation while IPIG is the industrial production growth. The gold/stock/real estate return is considered to be an inflation hedge if its real return is independent of the rate of inflation, implying a positive correlation between the nominal gold/stock/real estate return and inflation. Thus, given the following $r_t = \alpha + \beta\pi_t + \gamma IPIG_t + \varepsilon_t$ where r_t represents returns for respective assets and π_t is the inflation; hence, gold/stock/real estate is a good hedge against inflation if $\beta > 0$; otherwise it is not. γ is the coefficient of IPIG which is expected to be negative. Superscripts a, b, c denote 1%, 5%, and 10% levels of significance respectively. The statistics presented are coefficients of the baseline regression.

Table 5 presents results of the multivariate, economic activities-augmented asset-inflation hedging model. From the result, we confirm that our main result that stocks and real estate provide a good hedge for inflation in the US but gold does not, is a robust choice of bivariate or multivariate modelling framework. The coefficient of economic growth is negative in the gold, real estate, and stock hedging models. This implies that as there is an increase in economic growth, returns on investments decrease, which conforms to the theoretical economic expectation. Meanwhile, the coefficient of IPIG is only significant for real estate returns; this suggests that reduction in stocks and gold returns as a result of increase of economic activities is not significant.

Table 6: Robustness Check III (Asymmetry and augmenting model with IPI)

Variable	Gold returns	Real Estate returns	Stock returns
INFC_p	1.798	16.833[a]	6.498[a]
INFC_n	-0.727	16.451[a]	6.446[a]
IPIG	-0.712	-5.082[a]	0.031

Source: Authors' computation

Note: INFC_p and INFC_n are the positive and negative partial sum decomposition, respectively. IPIG is the industrial production growth. Superscripts a, b, and c imply the level of statistical significance at 1%, 5%, and 10%, respectively. Statistics presented are coefficients of the baseline regression. Coefficients that are significant imply there is evidence of hedging.

With regards to the third robustness analysis conducted, the industrial production augmented model was allowed to account for the influence of inflation asymmetry on asset returns. We present this result in Table 6. Statistics continue to confirm our earlier results. In addition, however, it confirms our previous result on inflation asymmetry—that inflation has no asymmetric effect asset returns in the US. Further accounting for structural breaks obtained from the NL test (see Table 2), we estimate with a single regressor (i.e. inflation) for the bivariate model and an additional regressor (i.e. inflation and industrial production growth) for the multivariate model. The results are consistent with previous findings. Real estate displays the strongest inflation hedging prowess, followed by stocks, but the 'beta' coefficients associated with gold equation are statistically insignificant, indicating the inability of the asset to provide cover against inflation risk (see Table 7 for details). Lastly, in Table 8, we employ firm-level stock price data for the S&P 500 to conduct panel analyses. The ensuing analysis compares results for comprehensive data (stock price panel data involving all firms) and the exclusion of firms belonging to the real estate sector. This takes care of the possible fusion of effects of real estate with the stock market. The results of pooled panel data regression in Table 8 confirm earlier findings that stocks are good inflation hedges and their inflation hedging powers are not influenced by the inclusion of real estate firms. In fact, 'beta' coefficients improved in magnitude when stock prices of real estate firms were excluded from the overall analyses.

Table 7: Robustness check IV (Accounting for NL (2015) break dates)

Model	Gold	Real Estate	Stock
Bivariate	0.237	10.036[a]	4.860[a]
Multivariate	0.624	10.286[a]	4.373[a]

Note: 'Bivariate' is the baseline model, while 'multivariate' is the model with industrial production growth as an additional regressor. The gold/stock/real estate return is considered to be an inflation hedge if its real return is independent of the rate of inflation, implying a positive correlation between asset returns and inflation. Thus, given the following $r_t = \alpha + \beta\pi_t + \varepsilon_t$ where r_t represents returns for respective assets and π_t is the inflation; gold/stock/real estate is a good hedge against inflation if $\beta > 0$; otherwise it is not. Superscripts a, b, c denote 1%, 5%, and 10% levels of significance respectively.

Table 8: Robustness check V (Using firm level stock data)

Model	Stocks (full)	Stock (less real estate)
Bivariate	0.756[a]	1.060[a]
Multivariate	0.714[a]	1.014[a]

Note: The 'bivariate' is the baseline model in panel form while 'multivariate' is the extended panel model with industrial production growth as additional regressor. The gold/stock/real estate return is considered to be an inflation hedge if its real return is independent of the rate of inflation, implying a positive correlation between the asset returns and inflation. Thus, given the following $r_{it} = \alpha + \beta\pi_{it} + \varepsilon_{it}; i = 1,...N; t = 1,...T,$ where r_{it} represents returns for the respective assets and π_{it} is the inflation; gold/stock/real estate is a good hedge against inflation if $\beta > 0$; otherwise it is not. Superscripts a, b, c denote 1%, 5%, and 10% levels of significance respectively.

5. Conclusion

This study analysed asset-inflation hedging nexus in the US with the aim of determining inflation hedging characteristics of selected assets; stocks, gold, and real estates. We hypothesised that stock, gold, and real estate have varying market characteristics; hence, should react differently to inflation. Thus, these assets exhibit some features (asymmetry and structural breaks) that need to be accounted for when estimating inflation hedging models. The analysis was conducted under four different scenarios. The first is the baseline model under which the relationship between inflation and asset returns was estimated without accounting for structural breaks or asymmetry. The second is a situation where structural breaks are accounted for in the analysis of the relationship between inflation and asset returns; and the third is a situation where we account for asymmetry in analysing the relationship. In the fourth scenario, we employ firm-level data in order to isolate the stock price for the real estate sector from overall stock prices for the US. Hence, we compare analysis for all-inclusive stock returns and for the stock less real estate sector. Our full sample period was partitioned into pre- and post-GFC periods to examine the possible time varying relationship. As a form of sensitivity analysis, our baseline model was augmented into a multivariate model using an indicator of economic activities. Sensitivity to changes in data frequency were also conducted by the use of quarterly frequency.

Our results show that inflation hedging tendencies of assets are heterogeneous across the considered assets. Specifically, real estates and stocks were confirmed to hedge against inflation, while gold investment defies Fisher’s hypothesis. These results are valid in accounting for asymmetry and structural breaks. This indicates that inflation has no asymmetric effect asset returns in the US. More so, the result is not sensitive to the use of either the bivariate or multivariate model, but it was found to be sensitive to the decomposition of the dataset to pre- and post-financial crisis, which suggests that the asset-inflation hedging relationship is time varying. The use of firm-level data where the real estate sector price is excluded reinforce the finding that stock truly hedges inflation in the US, and such a characteristic for real estate is not accidental. In terms of investment policy implication, our results suggest that US investors will have a good hedge against inflation by holding stock asset and real estate, and not by holding gold.

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AUTHOR STATEMENT

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

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