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Asymmetric Causality Analysis of the Interactions Between Gold and REIT Returns

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This study examines the causal relationship between gold and real estate investment trust (REIT) returns. In particular, the paper uses a nonparametric causality-in-quantile approach to explore whether gold could serve as a hedging tool against movements in REIT returns. The results provide supportive evidence of bidirectional and asymmetric causality-in-variance between gold and REIT returns. There is evidence of asymmetric causality-in-mean between gold and All REITs, and equity REIT returns. The results from the full sample nonlinear Granger causality test indicate that gold and REIT returns have a causal influence on each other. Taken together, the results imply that gold investment could serve as a hedge against volatilities in the REIT market and vice versa.

Keywords

Gold, REITs, Causality-in-Mean, Causality-in-Variance, Hedging

1. Introduction

Portfolio managers and institutional investors alike, frequently seek avenues to reduce risk exposure associated with asset returns. Gold and real estate investment trusts (REITs) are touted in the financial literature as effective hedging instruments. It is then not surprising that many studies have examined the abilities of these instruments to hedge against volatilities in the financial markets. REITs, as a long-term investment asset class, provide all the benefits associated with real estate. They are also a passive means of investment, and offer cash flow and liquidity to investors. The REIT indices are value weighted aggregates and classified by the National Association of Real Estate Investment Trusts, Inc. (NAREIT) into three categories; namely equity REITs, mortgage REITs and All REITs. Equity REITs typically invest in or own real estate. They generate returns for investors through rent collection. Mortgage REITs in contrast are intended to lend money to owners and developers or invest in financial instruments that are secured by mortgages. All REITs include both equity and mortgage REITs. Unlike the equity and mortgage indexes, the All REIT index is not free float adjusted. In addition, its components are exempt from the requirements of minimum size and liquidity criteria.

Like REITs, gold is highly liquid and often used as a hedging instrument against volatilities in financial markets. The price of gold is viewed by some analysts as a leading indicator of inflation because gold is extensively held as a store of value. It has been suggested in the financial literature that gold is one of the best investment instruments for diversification. Since gold is frequently traded, its price and relationship with other financial assets have received increased attention from investors, traders, policy makers and academicians. Kumar (2014) suggests that unlike other physical investment assets, gold is more durable and easily transacted. Arouri *et al*. (2015) contend that these qualities make gold a precious metal that has gained the attention of researchers and practitioners in finance. Dee *et al*. (2013) suggest that as a financial asset, gold has served as a financial or economic standard, foreign exchange reserve and even the main payment instrument in some countries.

As a contribution to the literature, this paper examines the relationship between gold and REIT returns by using a quantile-based causality test proposed in Nishiyama *et al.* (2011) and Jeong *et al.* (2012) and modified by Balcilar *et al.* (2017). This procedure is adopted because it has several attractive features. First, it can detect nonlinearity. Second, it is robust even in the presence of extreme values in the data. Third, it can detect both causality-in-mean and in-variance. To the best of the knowledge of the author, this is the first study to use this approach to investigate the relationship between gold and REIT returns. The results from the study reveal that the relationship between gold and REIT returns is asymmetric and that the two series have causal influence on each other.

The remainder of the paper is organized as follows. Following the introduction, Section 2 provides the literature review. Section 3 furnishes the methodology. Section 4 discusses the empirical results. Section 5 provides the conclusions and the implications of the study.

2. Brief Literature Review

Ciner *et al.* (2013) examine the relationships among stocks, bonds, gold, oil and exchange rates for both the United States and the United Kingdom. They find that gold acts as a safe haven when exchange rates depreciate in both countries. Kleiman *et al*. (2002) examine the relationship between real estate markets for Europe, Asia and North America. They find that the three real estate markets are random walk processes and above all, cointegrated. They therefore conclude that the three real estate markets are driven by common shocks and as such, investors in international real estate markets cannot derive diversification benefits in the long run. Newell and Webb (1996) examine the performance of real estate, stocks and bonds in several major international markets. They find that international investors garner portfolio diversification benefits by incorporating real estate investments in their portfolios. Capie *et al*. (2005) and Hammoudeh *et al.* (2009) examine the relationship between gold and the US dollar. They find that gold serves as a hedge against fluctuations in the dollar. Lee *et al*. (2011) investigate the ability of real estate stocks to serve as hedging instruments against inflation in the long run for Malaysia, the Philippines and Taiwan. They find that real estate stocks lack the ability to hedge against inflation in the long run in these three East Asian emerging markets. Liang *et al*. (1998) examine the ability of futures contracts to hedge REIT returns. They find from the various hedging strategies used that futures contracts do not hedge REIT returns. They conclude that REIT returns may remain unhedgeable pending the development of futures contracts strictly written on REITs.

Shahzad *et al.* (2019) reexamine the nexus between gold and inflation by using the quantile-on-quantile and the causality-in-quantiles approaches for China, India, Japan, France, the United Kingdom and the United States. They find that gold and inflation are positively related in the sample countries. They further find that the ability of gold to hedge against inflation varies between booms and recessions. In addition, they find evidence of asymmetric Granger causality in mean and variance from inflation to gold in the cases of China, Japan, France and the United Kingdom in the mid-quantile ranges. Based on these results, they conclude that gold may serve as an effective hedge against inflation only in normal economic conditions. Salisu *et al*. (2019) examine the inflation hedging potential of gold and palladium for Organisation for Economic Co-operation and Development (OECD) countries by using both a time series analysis and a panel data approach. They find that gold and palladium hedge against inflation in the OECD countries. Tarbert (1996) uses both annual and quarterly data for the United Kingdom to examine whether real estate could serve as a hedge against inflation. She finds that real estate does not hedge against inflation in the United Kingdom. Park and Bang (2012) use quarterly data from 2002 to 2010 to examine the ability of commercial real estate to hedge against inflation for Korea. They find supportive evidence that commercial real estate hedges against inflation in Korea. Obereiner and Kurzrock (2012) use a cointegration analysis and monthly data from 1992 to 2009 to explore the relationships among real estate funds, special funds and real estate stocks for Germany. They find that real estate returns do not have implications for inflation in the short run given that all three real estate investment means do not hedge against anticipated and unanticipated inflation at different lags in time. In contrast, the results from their cointegration tests reveal that the three investment vehicles serve as a hedge against inflation in the long run. Similarly, the results from the Granger causality tests indicate that movements in real estate are significantly affected by inflation in the long run.

Ziaei (2012) uses a generalized method of moment (GMM) model to examine the effect of gold prices on equity, bond and domestic credit for ASEAN +3 countries, which include Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Japan and South Korea. While he finds a significantly negative relationship between gold prices and equity, there is no significant relationship between domestic credit and gold price. He concludes that gold can act as a hedge against equity. He suggests that this result is evidence that gold prices cannot be considered a safe haven in the case of the ASEAN+3 countries. Hoesli *et al.* (2004) conduct a study on the benefits of adding real estate assets in mixed-asset portfolios by using unhedged and hedged indexes. They find that domestic and international real estate assets are effective portfolio diversifiers. Brounen and Eichholtz (2003) examine the diversification potential of property shares for the United Kingdom and United States from 1986 to 2002. They find that the correlations between these asset classes have decreased over this time frame. Erola and Tirtiroglub (2008) examine the ability of REITs to hedge against inflation in Turkey from December 1999 to December 2004. They find that Turkish REITs could serve as a hedge against both actual and expected inflation. The results from split samples show that the hedging ability of REITs is better under a high inflation regime than under a moderate inflation regime. Robiyanto (2018) use both the ordinary least square (OLS) and quantile regression (QREG) approaches to explore the function of gold as a safe haven and hedge for Sharia stocks in Indonesia and finds that gold can indeed serve as both a hedge and safe haven asset. Fleischmann *et al.* (2019) use an autoregressive integrated moving average (ARIMA) model to examine whether real estate, stocks and bonds offer a deflation hedge for Hong Kong and Japan from 1986 to 2009 and find that real estate is not an effective hedge against deflation.

Adrangi *et al.* (2004) examine the relationship between equity and mortgage REIT returns and inflation. They find that real REIT returns are negatively correlated with unexpected inflation and subsequently conclude that these two real estate investments are not safe haven assets in times of inflation. Chatrath and Liang (1998) examine the relationship between inflation and REITs and find that REITs are not a hedge for unanticipated inflation. Park *et al.* (1990) find that inflation and REITs are negatively correlated and conclude that REITs cannot be used to hedge against inflation. Chua *et al.* (1990) explore the ability of gold to reduce portfolio risks and find that gold offers significant portfolio diversification benefits. They attribute this result to the fact that gold tends to retain its value especially during periods of financial crises. Shakil *et al.* (2018) examine the relationship among gold, interest rate, the consumer price index (CPI) and oil prices for Saudi Arabia and find that these factors have a long run relationship. They further find that gold prices have significantly negative impacts on oil prices. In all, they conclude that gold could serve as a hedge against movements in inflation, the Saudi riyal and oil prices in Saudi Arabia.

From the preceding literature, it is obvious that research on the nexus between gold and REIT returns is not robust. Indeed, most of the studies in the literature have focused on the abilities of gold and REITs to hedge against risks. Unlike earlier studies that focus on the abilities of gold and REITs to serve as either a safe haven or a hedge against fluctuations in the financial markets, this study focuses on the relationship between these two variables.

3. Methodology and Data

This section discusses the various tests applied in this study. The empirical analysis commences with the application of unit root tests. Specifically, the study uses augmented Dickey and Fuller (ADF) (Elliot et. al., 1996), Phillips and Perron (P-P; Phillips and Perron,1988) and Zivot and Andrews (Z-A; Zivot and Andrews 1992) unit root tests. The study next uses the linearity test in Luukkonen *et al.* (1988) and the Brock–Dechert–Scheinkman (BDS; Brock *et al.*, 1996) test to look for the presence of linearity in the series. For structural breaks, the study applies the Bai-Perron (Bai and Perron 1998) multiple break tests and the parameter stability tests in Andrews (1993) and Andrews and Ploberger (1994). Details on these various diagnostic tests have been extensively discussed in the literature and as such will not be revisited in this study. Finally, the study implements the full sample nonlinear Granger causality test in Diks and Panchenko (2006).

3.1 Causality-in-Quantiles Testing

This paper applies the quantile-based causality tests developed by Nishiyama *et al.* (2011) and Jeong *et al.* (2012) and modified by Balcilar *et al.* (2017). In the spirit of Jeong *et al.* (2012), the hypothesis is that gold returns (y_t) do not Granger-cause REIT returns (x_t) in the Q-quantile relative to the lag-vector (y_{t-1}, …, y_{t-p}, x_{t-1}, …, x_{t-p}), given:

$$Q_\theta\big(y_t \big| y_{t-1}, \dots, y_{t-p,} x_{t-1}, \dots, x_{t-p}\big) = Q_\theta\left(y_t \big| y_{t-1}, \dots, y_{t-p}\right) \qquad (1)$$

x_t causes y_t in the θ-th quantile relative to $(y_{t-1}, \dots, y_{t-p}, x_{t-1}, \dots, x_{t-p})$ if

$$Q_\theta\big(y_t \big| y_{t-1}, \dots, y_{t-p}, x_{t-1}, \dots, x_{t-p}\big) \neq Q_\theta\left(y_t \big| y_{t-1}, \dots, y_{t-p}\right) \qquad (2)$$

where $Q_\theta(y_t | \quad)$ stands for the θ-th quantile of y_t. The conditional quantiles of y_t, $Q_\theta(y_t | \quad)$ which depend on t and the quantiles are restricted between zero and one (i.e. $0 < \theta < 1$).

The vector is defined as $Y_{t-1} \equiv (y_{t-1}, \dots, y_{t-p}), X_{t-1} \equiv (x_{t-1}, \dots, x_{t-p})$ and $Z_t = (X_t, Y_t)$, and the let functions $F_{y_t|Z_{t-1}}(y_t \mid Z_{t-1})$ and $F_{y_t|Y_{t-1}}(y_t \mid Y_{t-1})$ are Z_{t-1} and Y_{t-1}, respectively. In the conditional distribution $F_{y_t|Z_{t-1}}(y_t \mid Z_{t-1})$ which defines $Q_\theta(Z_{t-1}) \equiv Q_\theta(y_t \mid Z_{t-1})$ and $Q_\theta(Y_{t-1}) \equiv Q_\theta(y_t \mid Y_{t-1})$ and it can be seen that $F(y_t \mid Z_{t-1})\,\{Q_\theta(Z_{t-1}) \mid Z_{t-1}\} = \theta$, which holds with a probability equal to one. As a result, the non-causality in the θ-th quantile hypothesis can be tested as follows:

$$\text{H}_0\text{:}\ F(y_t \mid Z_{t-1})\,\{Q_\theta(Y_{t-1}) \mid Z_{t-1}\} = 1 \qquad (3)$$

$$\text{H}_1\text{:}\ F(y_t \mid Z_{t-1})\,\{Q_\theta(Y_{t-1}) \mid Z_{t-1}\} < 1 \qquad (4)$$

Jeong *et al.* (2012) advance the distance measure given by $J = \{\varepsilon_t\, E(|Z_{t-1}) f_z\,(Z_{t-1})\}$, where ε_t is a regression error term and $f_z(Z_{t-1})$ stands for the marginal density function of Z_{t-1}.

The regression error term ε_t is obtained based on the null hypothesis in Equation (3), which can only be true if and only if $E[\mathbf{1}\{y_t \leq \theta_0(Y_{t-1} \mid Z_{t-1})\}] = 0$, or $\mathbf{1}\{y_t \leq \theta_0(Y_{t-1})\} = \theta + \varepsilon_t$, where$\mathbf{1}\{\cdot\}$ represents an indicator function. According to Jeong *et al.* (2012), the feasible kernel-based sample analogue of J has the following form:

$$\hat{J}_T = \frac{1}{T(T-1)h^{2p}} \sum_{t=p+1}^{T} \sum_{s=p+1, s\neq 1}^{T} k\left(\frac{Z_{t-1} - Z_{s-1}}{h}\right) \hat{\varepsilon}_t \hat{\varepsilon}_s. \qquad (5)$$

where $k(\,)$ stands for the kernel function with a bandwidth h, T represents the sample size, p is the lag order, and $\hat{\varepsilon}_t$ is the estimate of the unknown regression error, which is based on:

$$\hat{\varepsilon}_t = \mathbf{1}\{y_t \leq Q_\theta(Y_{t-1})\} - \theta \qquad (6)$$

$\hat{Q}_\theta(Y_{t-1})$ is an estimate of the θ-th conditional quantile of y_t given Y_{t-1} and we estimate $\hat{Q}_\theta(Y_{t-1})$ by using the nonparametric kernel method as follows:

$$\hat{Q}_\theta(Y_{t-1}) = F^{-1}_{y_t|y_{t-1}(\theta|Y_{t-1})} \qquad (7)$$

where $\hat{F}_{y_t|y_{t-1}}(Y_t \mid Y_{t-1})$ is the Nadaraya-Watson kernel estimator given by:

$$\hat{F}_{y_t|y_{t-1}}(Y_t \mid Y_{t-1}) = \frac{\sum_{s=p+1,s\neq t}^{T} L(Y_{t-1} - Y_{s-1}/h)1(y_s \leq y_t)}{\sum_{s=p+1,s\neq t}^{T} L(Y_{t-1} - Y_{s-1}/h)} \quad (8)$$

where $L(\,)$ denotes the kernel function and h the bandwidth.

The study next tests for causality-in-variance (second moment) from gold to REIT returns and vice versa. This test involves the application of the higher order quantile causality test advanced by Nishiyama *et al.* (2011) which is given by:

$$y_t = g(X_{t-1}, Y_{t-1}) + \varepsilon_t \quad (9)$$

The higher order causality-in-quantiles can be tested based on Equation (9) as follows:

$$\text{H}_0\text{:}\ P\{F_{y_t}^{k}|Z_{t-1}\{Q_\theta(Y_{t-1}) \mid Z_{t-1}\} = \theta = 1\} \quad \text{for } k = 1,2,3, \ldots, K \quad (10)$$

$$\text{H}_1\text{:}\ P\{F_{y_t}^{k}|Z_{t-1}\{Q_\theta(Y_{t-1}) \mid Z_{t-1}\} = \theta < 1\} \quad \text{for } k = 1,2,3, \ldots, K \quad (11)$$

In the spirit of Jeong *et al.* (2012), the null hypothesis that x_t Granger-causes y_t in quantile θ up to the K-th moment can be tested by using Equation (9) to frame the feasible kernel-based test statistic for each k. The causality-in-variance test is carried out by replacing y_t in Equations (5) and (6) with y_t^2. However, combining the different statistics for each k=1,2,3, …, K into one statistic for the joint null is complicated by the fact that the statistics are mutually correlated (Nishiyama *et al.* 2011). The sequential testing procedure suggested by Nishiyama *et al.* (2011) is used to address this weakness. The first step under this methodology involves testing for nonparametric Granger causality in the 1st moment (i.e. k=1). The acceptance of the null hypothesis of non-causality in the 1st moment does not preclude the existence of causality in the 2nd moment (i.e. k=2). This necessitates the testing for nonparametric Granger causality in the 2nd moment. In essence, this methodology allows the researcher to sequentially test for the existence of causality in the mean (k=1) and causality in the variance (k=2).

In applying the nonparametric causality-in-quantile test, it is important for the researcher to specify the lag order (p), bandwidth value (h), and kernel type for $k(\,)$ and $L(\,)$. To this effect, this study utilizes the Schwartz information criterion in selecting the appropriate lag length. Regarding the selection of the bandwidth value, this study relies on least squares cross-validation. The study finally determines the appropriate kernel functions for $k(\,)$ and $L(\,)$ by relying on the leave-one-out least-squares cross validation technique proposed by Racine and Li (2004) and Li and Racine (2004).

3.2 Data and Descriptive Statistics

The study employs monthly data on All REITs, equity and mortgage REITs and gold (per troy ounce). The data on REITs were obtained from the NAREIT website at https://www.reit.com/data-research/reit-indexes/monthly-index-values-returns. The data span the time period from January 1972 through to December 2018. The data on gold were retrieved from the World Gold Council website at https://www.gold.org/goldhub/data/gold-prices. The return series were calculated as percentage changes in the gold prices and REIT indexes. Table 1 displays the summary statistics for gold and REIT returns. The mean values for All, equity and mortgage REIT returns are 0.88, 0.44 and 0.60 percent, respectively. The mean value for gold returns is 0.77 percent. From the minimum and maximum statistics, it can be seen that all of the return series have greatly fluctuated in the time period under study. For instance, the returns for All REITs ranged from a minimum of -30.23 to a maximum of 30.81 percent. The standard deviations reveal that among the REIT returns, mortgage returns have the greatest variability (5.67%) from the mean. In contrast, equity REIT returns with a standard deviation of 4.86 percent have the least deviation from the mean. The standard deviation for gold returns stand at 5.67 percent. The statistics presented in Table 1 reveal that all three REIT return series are negatively skewed, while gold returns are positively skewed. The kurtosis statistics for all of the return series exceed 3, which suggests the presence of a heavy tail in the distributions. The Jarque-Bera statistics for the return series overwhelmingly reject the null hypothesis of normality. The presence of heavy tails in the distributions of the return series serves as an initial justification for the application of the quantile causality approach.

Table 1 Descriptive Statistics

	ALLR	EQR	GR	MOR
Mean	0.88	0.44	0.77	0.60
Maximum	30.81	30.50	28.79	38.40
Minimum	-30.23	-31.91	-22.37	-24.11
Std. Dev.	5.01	4.86	5.86	5.67
Skewness	-0.39	-0.63	0.84	-0.27
Kurtosis	10.40*	10.67*	7.14*	8.51*
Jarque-Bera	1302.31*	1419.61*	469.19*	719.55*
Probability	0.00	0.00	0.00	0.00

Note: * indicates level of significance at 1%. Kurtosis > 3. ALLR = All REIT returns, EQR =Equity REIT returns, MOR= Mortgage REIT returns, and GR=Gold returns

Table 2 presents the Pearson's correlation coefficients between gold and REIT returns. The results show that the correlation coefficients between the REIT returns are statistically significant at least at the 10 percent level of significance. For instance, the correlation coefficient (0.92) between All and equity REIT returns is positive and statistically significant at the 1 percent level. However, the correlation coefficients between gold and REIT returns are positive, but only statistically significant in the case of the mortgage REIT returns. Although these results provide acursory evidence that gold could serve as a hedging instrument against the volatilities in the REIT markets, a more rigorous analysis grounded in a theoretically consistent model is needed before a valid conclusion can be drawn.

Table 2 Pearson's Correlation Coefficient

	ALLR	EQR	GR	MOR
ALLR	1.00			
EQR	0.92*	1.00		
GR	0.04	0.04	1.00	
MOR	0.70*	0.53*	0.07***	1.00

Note: * and *** indicate significance at the 1% and 10% levels, respectively. ALLR = All REIT returns, EQR =Equity REIT returns, MOR= Mortgage REIT returns, and GR=Gold returns

4. Empirical Results

Prior to applying the nonparametric quantile-in-causality tests, the study first ascertained the time series properties of gold and REIT returns by using the ADF, the P-P and Z-A unit root tests. The unit root tests were undertaken given that the nonparametric causality-in-quantile test requires the series in the model to be stationary. A modified Akaike information criterion (MAIC) was used to determine the appropriate lag lengths for the ADF and P-P unit root tests. The null hypothesis of nonstationarity was tested against the alternative hypothesis of stationarity. The results from the various unit root tests are presented in Table 3. The results from the ADF and P-P unit tests show that all of the return series are stationary in their levels. The results from the Z-A test also show that the three-return series are level stationary with structural breaks. The structural breaks for All REITs and gold returns occurred in May 1973. For mortgage REIT returns, the structured break occurred in August 1973. However, for equity REIT returns, the structural break occurred in February 2009. The 1973 breaks correspond to the 1973 oil crisis while the 2009 break parallels the 2008 housing market crash in the United States.

To ensure completeness and comparability, the study applied a standard linear Granger causality test, nonparametric quantile-in-causality test and the full sample nonlinear Granger causality test in Diks and Panchenko (2006). Table 4 displays the results from the standard linear Granger causality between gold and REIT returns. The optimal lags determined by the MAIC are shown in Column 2 of Table 4. The results show that there is no evidence of causality from gold to REIT returns and vice versa. For instance, the null hypothesis that gold returns do not Granger-cause All REIT returns can not be rejected as the

F-statistic (0.75) is statistically insignificant. Similarly, the null hypothesis that All REIT returns do not Granger-cause gold returns can not be rejected as the *F*-statistic (1.75) is statistically insignificant. Comparable results are indicated between gold and the other REIT returns (i.e. equity and mortgage REIT returns). The results from the standard Granger causality tests should be taken with caution as they do not account for nonlinearity and structural breaks that may be present in the relationship between gold and REIT returns. In other words, failure of the linear Granger causality to consider nonlinearity and structural breaks may likely lead to misspecification and hence biased inferences.

Table 3 Unit Root Tests with and without Breakpoints

Series	*DF_GLS*	*k*	*P-P*	*k*	*Z-A*	*k*	Break Date
ALLR	-8.49^{*}	4	-23.86^{*}	3	-22.28^{*}	0	1973M05
EQR	-8.16^{*}	4	-22.74^{*}	5	-22.74^{*}	0	2009M02
GR	-7.22^{*}	3	-29.48^{*}	4	-23.27^{*}	0	1973M05
MOR	-7.73^{*}	5	-25.74^{*}	5	-25.74^{*}	0	1973M08

Note: * indicates significance level at 1%. The 1% critical values for the ADF, P-P and Z-A unit root tests are -3.48, -3.97 and -5.35, respectively. ALLR = All REIT returns, EQR =Equity REIT returns, MOR= Mortgage REIT returns, and GR=Gold returns

Table 4 Linear Granger Causality Test Results

Null Hypothesis	Lags	*F*-Statistic	*P*-value
Panel A: Gold Versus All REIT Returns			
GR does not Granger cause ALLR	4	0.75	0.56
ALLR does not Granger cause GR	4	1.75	0.14
Pane B: Gold Versus Equity REIT Returns			
GR does not Granger cause EQR	5	0.72	0.61
EQR does not Granger cause GR	5	1.77	0.12
Panel C: Gold Versus Mortgage REIT Returns			
GR does not Granger cause MOR	4	1.52	0.20
MOR does not Granger cause GR	4	1.91	0.11

Note: ALLR = All REIT returns, EQR =Equity REIT returns, MOR= Mortgage REIT returns, and GR=Gold returns

To this effect, the paper implements the linearity test in Luukkonen *et al*. (1988) and the BDS test (Brock *et al*., 1996). For structural breaks, the study applies the Bai-Perron (2003) multiple structural break tests and the parameter stability tests in Andrews (1993) and Andrews and Ploberger (1994). Table 5A shows the linearity test results in Luukkonen *et al.* (1988). The appropriate lag lengths (k) and the delay parameters (d) are determined by using the AIC. The results show that the null hypothesis of linearity should be rejected in all of the cases.

For example, the test statistic for All REIT returns is 5.08 (*p*-value = 0.00) and statistically significant at the 1 percent level. Similar results are implicated for the other return series. Table 5B presents the results from the BDS nonlinearity test. The BDS tests are implemented for various dimensions which range from 2 to 6. The results suggest that the null hypothesis that the residuals of the return series are independently and identically (*iid)* distributed should be rejected at the conventional levels. For instance, the BDS test statistics for equity are 4.00, 4.99, 5.61, 6.08 and 6.87, for 2, 3, 4, 5, and 6 dimensions respectively. These test statistics are statistically significant at the 1 percent level. These results provide evidence of the nonlinearities of all the return series and corroborate those from the linearity test in Luukkonen *et al.* (1988).

Table 5A Linearity Test Results

Series	*K*	*D*	*F*-stat	*p*-value
ALLR	2	2	5.08*	0.00
EQR	2	1	9.49*	0.00
GR	2	3	4.14*	0.00
MOR	2	3	7.22*	0.00

Note: * indicates rejection of the null hypothesis of linearity at the 1% level of significance. ALLR = All REIT returns, EQR =Equity REIT returns, MOR= Mortgage REIT returns, and GR=Gold returns

Table 5B BDS Nonlinearity Test Results

	ALLR		EQR		GR		MOR	
Dimension	*z*-stat	*p*-value	*z*-stat	*p*-value	*z*-stat	*p*-value	*z*-stat	*p*-value
2	5.51*	0.00	4.00*	0.00	6.07*	0.00	6.55*	0.00
3	6.61*	0.00	4.99*	0.00	6.51*	0.00	7.41*	0.00
4	7.38*	0.00	5.61*	0.00	7.13*	0.00	7.99*	0.00
5	8.10*	0.00	6.08*	0.00	7.88*	0.00	8.73*	0.00
6	8.80*	0.00	6.87*	0.00	8.55*	0.00	9.10*	0.00

Note: * indicates level of significance at the 1% level. The null hypothesis is that the residuals are independent and identically distributed (iid). ALLR = All REIT returns, EQR =Equity REIT returns, MOR= Mortgage REIT returns, and GR=Gold returns.

The paper then applies the structural break tests. Tables 6A presents the results from the Bai-Perron multiple break tests. The tests are conducted by using a maximum of 5 breaks and trimming factor of 10 percent. The results reveal that there are two structural breaks for all the return series. In each of these cases, the scaled *F-stat* exceeds the critical value at least at the 5 percent level of significance. For instance, in terms of the relationship between gold and All REIT returns, the scaled *F-stat* for two structural breaks (2 versus 3) is 10.44 while the 5 percent critical value is 17.97 in Panel A. This result indicates that the null hypothesis of three structural breaks should be rejected in favor of the alternative hypothesis of two structural breaks. The results presented in Table 6A show the presence of two structural breaks for all of the return series. The first structural break occurred in September 1977, while the second break occurred in February 1980 in all of the cases. Table 6B provides the parameter stability test results which reject the null hypothesis of stability in all of the cases. The *Sup-F*, *Exp-F* and *Ave-F* test statistics are 53.64, 20.86 and 25.04, respectively. These test statistics are significant at the 1 percent level. Similar results are found for gold, equity and mortgage REIT returns. The results from the parameter stability test are consistent with those found with the Bai-Perron multiple break test. Taken together, the results from the various diagnostics tests indicate the presence of nonlinearity and structural breaks, and hence, justify the application of the nonparametric quantile-in-causality tests.

Table 6A Bai-Perron Multiple Structural Break Test Results

Break-Test	*F*-stat	Scaled *F*-stat	Critical Value†	TB1	TB2
Panel A: Equation for Gold and ALL REIT Returns					
0 vs 1**	11.46	34.38	15.37	1977M09	1980M02
1 vs 2**	8.89	26.67	17.15	1977M09	1980M02
2 vs 3	3.48	10.44	17.97	1977M09	1980M02
Panel B: Equation for Gold and Equity REIT Returns					
0 vs 1**	13.18	39.54	15.37	1977M09	1980M02
1 vs 2**	7.69	23.07	17.15	1977M09	1980M02
2 vs 3	3.32	9.96	17.97	1977M09	1980M02
Panel C: Equation for Gold and Mortgage REIT Returns					
0 vs 1**	10.98	32.93	15.37	1977M09	1980M02
1 vs 2**	8.42	25.26	17.15	1977M09	1980M02
2 vs 3	5.30	15.89	17.97	1977M09	1980M02

Notes: ** Indicates 5% level of significance
† The critical values are based on Bai-Perron (2003).

Table 6B Parameter Stability Test Results

Series	Max. Wald *F*-Stat	*P*-value	Exp Wald *F*-stat	*P*-value	Ave Wald *F*-stat	*P*-value
ALLR	53.64*	0.00	20.86*	0.00	25.04*	0.00
EQR	77.87*	0.00	32.72*	0.00	31.03*	0.00
MOR	57.43*	0.00	22.54*	0.00	12.02	0.59

Note: * indicates rejection of the null hypothesis of linearity at the 1% level of significance. Parameter stability tests by Andrews (1993) and Andrews and Ploberger (1994) with the null of parameter stability. Probabilities calculated by using method in Hansen (1997). ALLR = All REIT returns, EQR =Equity REIT returns, MOR= Mortgage REIT returns, and GR=Gold returns

Given the findings of nonlinearity and structural breaks, the study then conducted the nonparametric quantile-in-causality tests. The results from the quantile causality- in-mean (1st moment) and in-variance (2nd moment) are shown in Figures 1a to 3b. The horizontal axis denotes the quantiles while the vertical axis displays the test statistics which correspond to the quantile in the horizontal axis. The horizontal solid lines represent the 5 percent critical value (1.96). Figures 1a and 1b show the causality in the mean and variance between gold and All REIT returns. From Figure 1a, it can be observed that there is evidence of causality- in-mean and in-variance from gold to All REIT returns. The results show evidence of causality- in-mean from gold to the All REIT returns between quantiles of 0.20 and 0.70. However, the results reveal evidence of causality- in-variance from gold to All REIT returns for the entire quantile range (i.e. 0.10 to 0.90). These results suggest that the null hypothesis that gold returns do not Granger-cause All REIT returns in-mean and in-variance should be rejected, thus implying that gold has predictive power on All REIT returns.

Figure 1a Causality in Mean and Variance from Gold to All REIT Returns

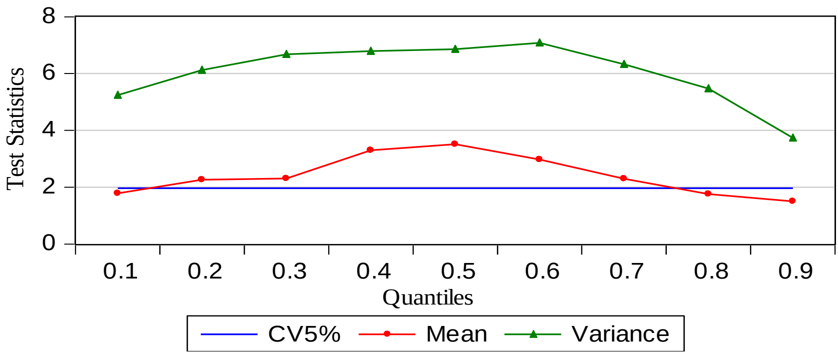


Figure 1b Causality in Mean and Variance from All REITs to Gold Returns

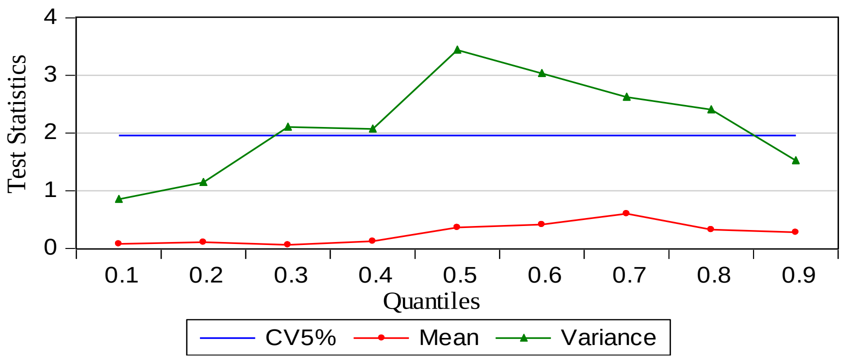


Figure 1b shows the quantile causality- in-mean (1st moment) and in-variance (2nd moment) tests from All REIT to gold returns. The results indicate that the null hypothesis of non-causality in- mean from All REIT to gold returns should not be rejected at the 5 percent level of significance. The test statistics at the various quantiles are less than the 5 percent critical value. However, the results reveal evidence supportive of causality- in-variance from All REIT to gold returns over the quantile range of 0.30 - 0.80. In the lower and highest quantiles (0.10, 0.20 and 0.90), the null hypothesis of non-causality in-variance from All REIT to gold returns is not rejected at the 5 percent level of significance. Taken together, the results in Figures 1a and 1b show evidence of unidirectional causality-in-mean from gold to All REIT returns but not vice versa. However, the evidence supports the existence of bidirectional causality-in-variance between gold and All REIT returns. These results imply that gold and All REIT returns have predictive power on each other.

Figures 2a and 2b show the results for causality- in-mean and in-variance between gold and equity REIT returns. In Figure 2a, there is supportive evidence of causality- in-mean and in-variance from gold to equity REIT returns. The results show evidence of causality- in-mean from gold to equity REIT returns for the quantiles that range from 0.10 to 0.80. The results further show evidence supportive of causality- in-variance from gold to equity REIT returns for the entire quantile range (i.e. 0.10 - 0.90). These results indicate that the null hypothesis that gold returns do not Granger-cause equity REIT returns in-mean and in-variance should be rejected, thus implying that gold has predictive power on equity REIT returns and vice versa.

Figure 2b presents the test results for the quantile causality- in- mean and in-variance from equity REIT to gold returns. The results show that the null hypothesis of non-causality in-mean from equity REIT to gold returns should not be rejected at the 5 percent level of significance. As can been seen from Figure 2b, the test statistics are statistically insignificant at the 5 percent level at the different quantiles. However, the results reveal evidence supportive of causality- in-variance from equity REIT to gold returns over the quantile range between 0.30 and 0.80. In the lower and highest quantiles (0.10, 20 and 0.90), the null hypothesis of non-causality in-variance from equity REIT to gold returns is not rejected at the 5 percent level of significance. Taken together, the results in Figures 2a and 2b provide evidence of unidirectional causality-in-mean from gold to equity REIT returns but not vice versa. However, the evidence supports the existence of bidirectional causality-in-variance between gold and equity REIT returns. These results imply that gold and equity REIT returns have predictive power on each other.

Figures 3a and 3b show the test results for the causality-in-mean and in-variance between gold and mortgage REIT returns. According to the results reported in Figure 3a, the null hypothesis that gold returns do not Granger-cause mortgage REIT returns is rejected only for a 0.30 quantile. However, the null hypothesis of non-causality in-mean from the gold returns and to the mortgage REIT returns is not rejected for the rest of the quantiles. The results also show supportive evidence of causality- in-variance from gold to mortgage REIT returns for the quantiles that range from 0.30 through to 0.90. These results suggest that the null hypothesis that gold returns do not Granger-cause equity REIT returns in-mean and in-variance should be rejected thus implying that gold has predictive power on mortgage REIT returns and vice versa.

Figure 2a Causality in Mean and Variance from Gold to Equity REIT Returns

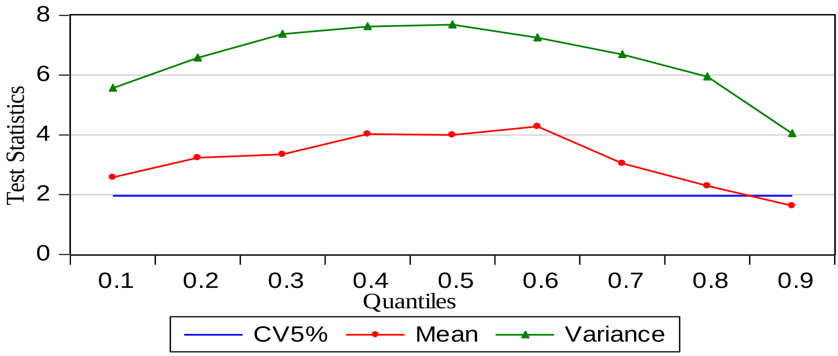


Figure 2b Causality in Mean and Variance from Equity REIT to Gold Returns

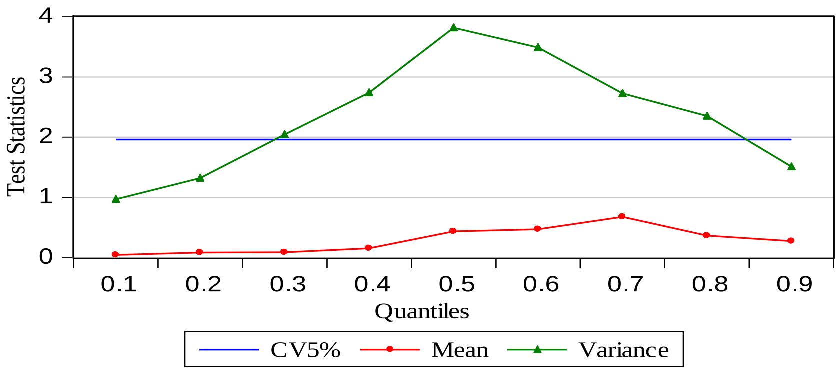


Figure 3b depicts the test results for the quantile causality- in-mean and in-variance from mortgage REIT to gold returns. The results show that the null hypothesis of non-causality in-mean from mortgage REIT to gold returns should not be rejected at the 5 percent level of significance. The test statistics are statistically insignificant at the 5 percent level at all the different quantiles. However, the results reveal evidence supportive of causality- in-variance from mortgage REIT to gold returns for the quantiles of 0.50, 0.60 and 0.80. In the lower and highest quantiles (0.10-0.40 and 0.90), the null hypothesis of non-causality in-variance from mortgage REIT to gold returns is not rejected at the 5 percent level of significance. Taken together, the results in Figures 3a and 3b provide evidence of unidirectional causality-in-mean from gold to mortgage REIT returns but not vice versa. However, the evidence supports the existence of bidirectional causality-in-variance between gold and mortgage REIT returns. These results imply that gold and mortgage REIT returns have predictive power on each other.

Figure 3a Causality in Mean and Variance from Gold to Mortgage REIT Returns

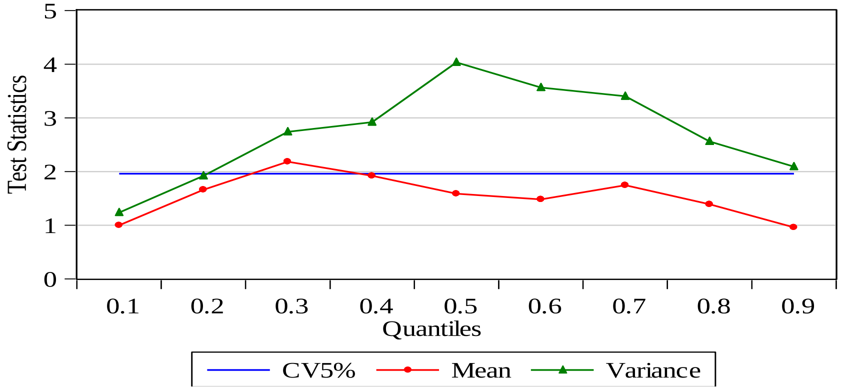
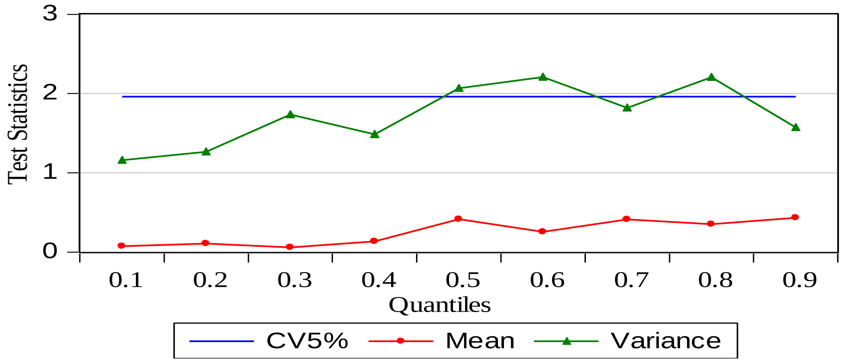


Figure 3b Causality in Mean and Variance from Mortgage REITs to Gold Returns



To shed additional light on the relationship between the gold and REIT markets, this study applies the nonlinear Granger causality test in Diks and Panchenko (2006). For robustness, nonlinear Granger causality is implemented for different embedding dimensions (i.e. m = 2, 3, and 4). Table 7 presents the results of the nonlinear Granger causality test. The results in Panel A suggest that the null hypothesis of no full sample nonlinear Granger causality from gold to All REIT returns should be rejected at the conventional levels. The test statistics of 3.20, 2.91, and 2.32 for m=2, m=3 and m=4, respectively, are statistically significant at the 1 percent level. Similarly, the null hypothesis of no full sample nonlinear Granger causality from All REIT to gold returns is rejected since the test statistics of 3.11, 3.06 and 2.44, for m=2, m=3 and m =4 respectively are statistically significant at the 1 percent level. These results provide evidence of bidirectional nonlinear causality between gold and All REIT returns. Panel B shows the nonlinear causality test results between gold and REIT returns, which are evidence of full sample nonlinear Granger causality from gold to equity REIT returns and vice versa. Panel C reveals the nonlinear causality test results between gold and mortgage REIT returns, which indicate that the null hypothesis of no full sample nonlinear Granger causality from gold to mortgage REIT returns should be rejected and vice versa. In all of the cases, the test statistics are statistically significant at least at the 10 percent level. Taken together, the results presented in Table 7 provide supportive evidence of full sample bidirectional nonlinear Granger causality among gold and the various REIT returns. The finding that gold and REIT returns have a causal influence on each other is consistent with the results from the nonparametric quantile-in-causality tests. In all, the results from the various nonlinear Granger causality tests suggest that a gold investment could serve as an effective hedge against volatilities in the REIT market and vice versa. This finding contradicts that in Liang *et al.* (1998) who in a related study find that gold futures contracts do not offer the means to effectively hedge REIT returns. The differences in results could be attributed to the methodologies used by the studies, data frequency and time periods studied.

Table 7 Nonlinear Granger Causality Test Results in Diks and Panchenko (2006)

	M=2		*M=3*		*M=4*	
	Stat	*P*-value	Stat	*P*-value	Stat	*P*-value
Panel A: Gold Versus ALL REIT Returns						
GR $\nrightarrow$ ALLR	3.20^{*}	0.00	2.91^{*}	0.00	2.32^{*}	0.01
ALLR $\nrightarrow$ GR	3.11^{*}	0.00	3.06^{*}	0.00	2.44^{*}	0.01
Panel B: Gold Versus Equity REIT Returns						
GR $\nrightarrow$ EQR	2.56^{*}	0.01	2.50^{*}	0.01	2.48^{*}	0.01
EQR $\nrightarrow$ GR	2.33^{*}	0.01	2.47^{*}	0.01	1.79^{**}	0.04
Panel C: Gold Versus Mortgage REIT Returns						
GR $\nrightarrow$ MOR	1.74^{**}	0.04	1.77^{**}	0.04	1.45^{***}	0.07
MOR $\nrightarrow$ GR	2.44^{*}	0.01	1.75^{**}	0.04	1.95^{**}	0.03

Note: *,** and ***indicate significance at the 1%, 5% and 10% levels, respectively. m denotes the embedding dimension. ALLR = All REIT returns, EQR =Equity REIT returns, MOR= Mortgage REIT returns, and GR=Gold returns. Full sample nonlinear Granger causality test.

5. Summary and Implications

This paper has examined the relationships between gold and REIT returns for the United States. Specifically, the study has used the ADF, P-P and Z-A unit root tests to ascertain the time series properties of gold and the various REIT returns. The study conducts a battery of diagnostic tests such as the linearity test in Luukkonen *et al.* (1988) and the BDS test for linearity, the Bai-Perron (2003) multiple break tests, and the parameter stability techniques in Andrews (1993) and Andrews and Ploberger (1994) for structural breaks. The study conducts nonparametric quantile-in-causality tests to ascertain the causal relationship between gold and REIT returns. To check the robustness of the results of the nonparametric causality-in-quantile tests, the study implements the full sample nonlinear Granger causality test in Diks and Panchenko (2006).

The results of the various diagnostic tests suggest that the gold and REIT return series are nonlinear and as such, structurally unstable. The results from the nonparametric causality-in-quantile tests show evidence of causality-in-mean that run from gold to All REIT returns. Similar results are found among gold, and equity and mortgage REIT returns. The results further provide evidence of causality-in-variance from gold to All, equity and mortgage REIT returns. The results fail to reject the null hypothesis of nonlinear causality- in-mean from the All, equity and mortgage REIT returns to gold returns. However, the results support evidence of causality-in-variance that is derived from All, equity and mortgage REIT returns to the gold returns. The results from the Diks and Panchenko (2006) test indicate that nonlinear causality runs from gold to REIT returns and vice versa. The results from this study suggest that gold and REIT markets are integrated rather than segmented. In short, it can be concluded that volatility in one market can be quickly transferred to another based on the causality-in-variance results between gold and REIT returns. From an investment perspective, the results indicate that gold could serve as a hedge against turmoil in the REIT market and vice versa.

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