

Causality between Real Estate Market and Stock Market: Evidence from REIT Index in Taiwan

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Abstract. This paper investigates short-run dynamic interactions between real estate investment trust (REIT) index and stock market index in Taiwan over the 2006-2015 periods. In addition to traditional linear analysis, the recently developed models are applied to explore the possible short-run non-linear linkage between the two indexes. The results of linear Granger causality tests show weak evidence of linear causality from REIT index to stock index. Further analysis from non-linear Granger causality test reveals no causality between the two indexes. These findings have important implication for investors.

Introduction and Literature Review

Diversification of a portfolio is an important issue of great concern for investors and researchers. To construct a well-diversified portfolio, investors usually need to look for a group of assets whose returns have low correlation or move in the unlike direction. The Real Estate Investment Trust (REIT) created in the 1960s is a unique investment asset with a mixed characteristic of both the real estate market and the stock market. In recent years, the REIT is favored by investors in their investment decision-making process, typically because the REIT has stable high dividends with a moderate risk compared to stock market investment. The REIT also has advantages of an inflation hedge, good liquidity, and tax preference. Since the REIT could help investors share the benefit of real estate growth and build the more broad and optimal investment strategy, understanding the linkages between REIT and other assets is of the utmost importance to investors seeking to make a well-diversified portfolio.

Numerous studies on the real estate market have been devoted to recognizing the factors affecting the REIT returns. These studies have documented that the size of the REIT [1,5], interest rate [3, 20], money policy [8,20], and economic growth [17] have a significant impact on REIT returns. Recently, some other researchers highlight and confirm the momentous shock of the global financial crisis on the REIT returns [21]. In a more recent paper, Loo et al. [19] study the short-run and long-run linkage between the Asian REIT markets and seven macroeconomic variables. The results show that the influence of the macroeconomic variables on the REIT return varies across countries.

Empirical studies on the REIT also have investigated the dynamic interactions between REIT and other assets because of its implication for portfolio allocation and risk management. Most of these studies focus on the US market and show that the change in the REIT prices is closely related to the change in the stock prices [2,9,15,16,17,18,26]. The early study by Liu et al. [18] documents that the US securitized real estate market is integrated with the stock market but the US commercial real estate market is segmented from the stock market. Ling and Naranjo [16] find evidence of integration between the US real estate securities and the stock market and that the degree of integration increases significantly during the 1990s. Analyzing the dynamic conditional correlation of REIT, stock, and direct real estate returns, Fei et al. [9] reveal strong correlation between US REIT returns and stock market returns over 1987-2008. Liow [17] applies fractional integration vector error

correction model to explore long-run co-memories and short-run adjustment between REIT and stock indexes in the four Asian-Pacific markets. Results show cointegration relationship, accompanied by significant adjustment speed, only exists in the case of Hong Kong and Singapore. Apergis and Lambrinidis[2] study dynamics of stock and securitized real estate markets in the US and the UK over the period 1985-2006. They find that the two markets are highly integrated and that the stock returns cause REIT returns. Tsai and Chiang[26] apply the threshold error correction model to examine the relationship between REIT and stock indexes and their asymmetric adjustment behaviors in six Asian-Pacific financial markets. The authors report a two-way causality for Australia, Japan, and Singapore, and a one-way causality for Hong Kong and Taiwan.

Most of the existing literature focuses the developed REIT markets and empirical investigation into the case of emerging REIT markets is limited¹. Moreover, most of the empirical evidence is based on the linear statistical tool which might ignore the possible non-linear information. Since there exists significant evidence in the non-linear dynamics of stock and REIT indexes[4,26], it is inappropriate to assume that relationship between REIT and stock indexes is linear. Therefore, in addition, to exploring the linear association between REIT market and the stock market, this paper especially focuses on their non-linear associate onto provide further highlight the linkage between these two markets in the literature.

The objective of this paper is to analyze whether there are significant dynamic relations between REIT market and the stock market in Taiwan. The analysis employs linear and non-linear time series techniques, including unit root tests and Granger causality tests, to access the short-run linkage between the two markets. The analysis from linear Granger causality tests shows that REIT index returns cause stock returns but not vice versa, suggesting that investors could use the REIT price to predict stock market price. However, non-linear Granger causality tests fail to detect the existence of causality between REIT market and the stock market. These findings provide useful insight to investors and policy maker in Taiwan since they demonstrate that there are potential gains of asset allocation when investors hold REIT and stocks at the same time.

The remainder of the article is organized as follows. The next section describes the econometric methodology employed to analyze the short-run linkage between REIT market and the stock market. Section 3 presents the data and empirical results. The final section offers a conclusion.

Methodologies

The empirical methods used in this paper are introduced as follow.

Conventional Linear Unit Root Tests

To avoid spurious regression problem, various unit root tests are developed to examine the stationary of time series in the literature. In this paper, first, we test for stationarity of variables by employing three linear unitroot test techniques, namely, ADF [6], and KPSS[12]. Since these standard unit tests are known to suffer potentially finite sample power and size problems, we use the NP[23] test to improve this problem. The NP test constitutes of four tests statistics: MZ_{α} , MZ_t , MSB, and MP_t . Due that the estimation of unit root model might be biased if the lag length and bandwidth are pre-designated without rigorous determination, the modified Akaike information criterion (MAIC) and the Bartlett kernel based criterion proposed by Newey and West [22] are utilized to determine the optimal number of lags and optimal bandwidth, respectively.

Advanced ESTAR non-linear Unit Root Test

To capture non-linearity in data generating process, Kapetanios et al. [11] (henceforth, KSS) design a powerful test for the presence of non-stationarity against a non-linear but globally stationary exponential smooth transition autoregressive (ESTAR) process. Recently, Sollis[25] extends the KSS ESTAR model by allowing for asymmetric non-linear adjustments under the

alternative hypothesis. The extended model is given as:

$$\Delta Y_t = (1 - \exp(-\gamma_1 Y_{t-1}^2)) \{ (1 + \exp(-\gamma_2 Y_{t-1}))^{-1} \rho_1 + [1 - (1 + \exp(-\gamma_2 Y_{t-1}))^{-1}] \rho_2 \} Y_{t-1} + v_t \quad (1)$$

where Y_t is the demeaned or/and a detrended series, $[1 - \exp(-\gamma_i Y_{t-1}^2)]$ are exponential transition function, v_t is an independently and identically distributed (i.i.d.) error with zero mean and finite variance σ^2 . The parameter $\gamma_1 \geq 0$ determines the speed of the transition between two regimes, while $\gamma_2 \geq 0$ controls the degree of asymmetric. The assumption $\rho_1 \neq \rho_2$ reflects asymmetric adjustment process.

The unit root null hypothesis can be tested against the alternative hypothesis of globally stationary asymmetric ESTAR non-linearity by testing the null of $\gamma_1 = 0$. Under this null, the parameters γ_2, ρ_1 and ρ_2 are unidentified. By replacing the exponential and logistic function in Eq. 3 by their first-order Taylor's approximations around $\gamma_1 = 0$ and $\gamma_2 = 0$, respectively, with allowing for higher-order dynamics, Sollis [25] obtains the following regression

$$\Delta Y_t = \phi_1 Y_{t-1}^3 + \phi_2 Y_{t-1}^4 + \sum_{i=1}^{p-1} \beta_i \Delta Y_{t-i} + \eta_t, \quad t = 1, 2, \dots, T \quad (2)$$

Here the unit root null hypothesis becomes $H_0 : \phi_1 = \phi_2 = 0$ and a standard F-test can be applied to test this null.

Linear Granger Causality Testing

The linear Granger causality test is a test for bivariate causality, which involves estimating a reduced form of the unrestricted vector autoregression (VAR) model. Suppose that there are two stationary time series X_t and Y_t ($t = 1, \dots, T$), then the VAR model can be expressed in the following two-equation system:

$$X_t = \alpha_1 + \sum_{i=1}^{L_x} \beta_{1,i} X_{t-i} + \sum_{j=1}^{L_y} \beta_{2,j} Y_{t-j} + u_{x,t} \quad (3)$$

$$Y_t = \alpha_2 + \sum_{i=1}^{L_x} \beta_{3,i} X_{t-i} + \sum_{j=1}^{L_y} \beta_{4,i} Y_{t-j} + u_{y,t} \quad (4)$$

where α and β are parameters for estimation, and L is the lag order. The error term u_t is i.i.d. error with zero mean and constant variance.

To test the null hypothesis that Y does not cause X , a standard joint test (F or χ^2 test) of exclusion restrictions is used to determine whether all the lagged values of Y are insignificant in the equation of X . The null hypothesis that Y does not cause X is rejected if $\beta_{2,j}$ ($j = 1, \dots, L_y$) are jointly significantly different from zero. Bi-directional causality or feedback exists if Granger causality runs in both directions.

Test for the Non-linear Granger Causality

The test for non-linear Granger causality used in this study is based on a special type of non-linear structure, known as the bi-variate noisy Mackey-Glass (hereafter, MG) model ([13,14]). The MG model is expressed as follows:

$$X_t = \alpha_{11} \frac{X_{t-\tau_1}}{1 + X_{t-\tau_1}^{c_1}} - \delta_{11} X_{t-1} + \alpha_{12} \frac{Y_{t-\tau_1}}{1 + Y_{t-\tau_1}^{c_2}} - \delta_{12} Y_{t-1} + v_{x,t} \quad v_{x,t} \sim N(0,1) \tag{5}$$

$$Y_t = \alpha_{21} \frac{X_{t-\tau_1}}{1 + X_{t-\tau_1}^{c_1}} - \delta_{21} X_{t-1} + \alpha_{22} \frac{Y_{t-\tau_1}}{1 + Y_{t-\tau_1}^{c_2}} - \delta_{22} Y_{t-1} + v_{y,t} \quad v_{y,t} \sim N(0,1) \tag{6}$$

where X_t and Y_t are series of the system, $t = \tau, \dots, N, \tau = \max(\tau_1, \tau_2)$, α_{ij} and δ_{ij} are parameters to be estimated, τ_i are integer delays, and c_i are constants. This model can produce various types of dependence by adjusting the parameters c_i and τ_i . The main advantage of this model over simple VAR alternatives is that the MG terms are able to capture more complex dependent dynamics in a time series. The identification of significant MG terms reveals non-linear feedback interdependence between X_t and Y_t .

The MG based Granger causality test aims to detect whether past samples of Y_t have a significant non-linear effect on the current value of X_t . This test is similar to the linear Granger causality test, except that models fitted to the underlying series are MG processes. To test the null hypothesis that Y_t does not Granger cause X_t , the standard F statistics is computed as $F = ((S_r - S_{ur}) / r) / (S_{ur} / (N - k - 1))$, where S_r and S_{ur} are the sums of squared residuals of the unconstrained and constrained MG models respectively, k is the number of free parameters in the unconstrained M-G model and r is the number of parameters set to zero when estimating the constrained model. Under the null, the test statistic follows a standard $F_{r, N-k-1}$ distribution.

Data and Empirical Results

The data consists of the daily closing prices of the REIT98 index and Taiwan capitalization weighted stock index, which are traded on the Taiwan stock exchange (TSE). The REIT98 index is the market capitalization-weighted index which is calculated based on all publicly listed REIT securities in TSE². The sample period covers from January 2, 2006, to December 31, 2015, with a total of 2481 observations.

The two price series are obtained from the database of Taiwan Economic Journal (TEJ). In the following empirical analysis, the price series are expressed in natural logarithm. The related returns series are computed as 100 times the first difference of the daily original (log-) prices in the time period. The evolution of the two original (log-) series is shown in Fig. 1.

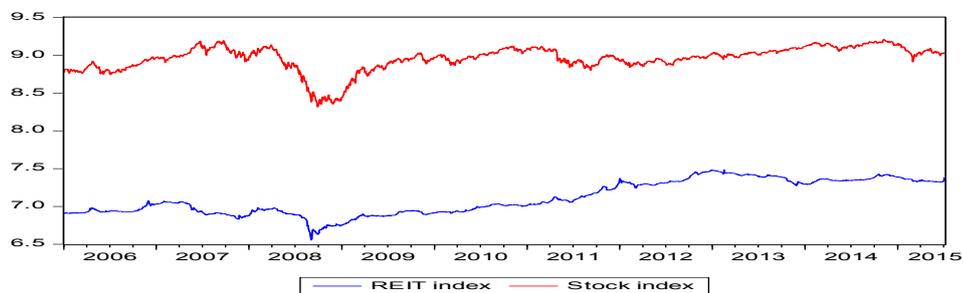


Figure 1 Time trend of the REIT index and stock index (in the log).

The summary statistics of daily returns of the REIT index and the aggregate stock index presented in Table 1 provides several preliminary insights into the data. The mean for both the returns suggest that the REIT market performs better than stock market during the sample period. The standard deviations seem to be more volatile over time, and as expected, the REIT returns have

the smallest standard deviations. Both the returns exhibit a positive mean return with significant skewness and kurtosis, suggesting fat-tailed behavior and possibly some extreme returns in the sample. The Jarque-Bera (JB) tests for normality indicate that the two returns are not normally distributed. The Ljung-Box Q tests with 10lags show strong autocorrelation in both the returns. These significant autocorrelations suggest the existence of non-linear dependence in these returns.

Table 1 summary statistics of daily returns of REIT index and stock index

| Variables | Mean | SD | Skew | Kurt | JB | JB prob | Q(10) |
|-------------|-------|-------|--------|--------|--------------|---------|-----------|
| REIT index | 0.019 | 0.531 | 0.935 | 21.157 | 46616.583*** | 0.000 | 187.02*** |
| Stock index | 0.010 | 1.256 | -0.398 | 3.419 | 1273.410*** | 0.000 | 26.524*** |

Notes: (1) The sampleperiod is from January 2,2006, to December 31, 2015, for 2481daily observations. (2) Q(10) represents the Ljung-Box Q statistics with 10lags for the return series. (3)*** denotes significance at the 1% level.

The beforehand work of empirical analysis is to examine whether the underlying index series are stationary. The stationary characteristic of returns of the REIT index and stock index is first checked by applying four linear unit root tests: ADF, PP, KPSS and NP tests. The ADF,PP and NP tests share the null hypothesis that a given series has a unit root, while the KPSS has a reversed null hypothesis of stationarity. The KPSS test is conducted to check the robustness of the other unit root tests. For the sake of parsimony, this paper uses the MAIC criterion with lag length up to 10 for ADF,PP and NP tests to gauge the optimal number of lags. The Bartlett kernel-based criterion proposed by Newey and West (1994) is used to determine the optimal bandwidth of KPSS test.

Panel A of Table 2lists the results of various linear unit root tests for the returns of REIT index and stock index. The ADF,PP and NP tests reject the null hypothesis of a unit root at the 5% significance level for both the return series. The KPSS test confirms the results of the above tests by accepting the null hypothesis of stationary for return series.

To detect the potentialnon-linear unit root, this paper applies KSS and Sollis test procedures based on the ESTAR models, respectively. The lag lengths of the two models are determined by Bayesian information criterion(BIC). The results of KSS and Sollis unit root tests listed in Table 2show the non-existence of a unit root in the REIT index return and stock index return since the test statistics are significant at the 1% level. Together with the results from linear and non-linear unit root tests, we there foreconclude that both the REIT index and the stock index are stationary.

Table 2 Results of unit root tests for returns of REIT index and stock index

| (a) ADF,PP,NP and KPSS tests | | | | | | | |
|------------------------------|---------------|------------|-------|---------------|------------|----------|----------|
| Variables | ADF | PP | KPSS | NP | | | |
| | | | | MZ α | MZt | MSB | MP |
| Stock index | -28.716*** | -40.102*** | 0.141 | -11.159** | -2.347** | 0.210*** | 9.177*** |
| REIT index | -46.965*** | -46.945*** | 0.053 | -685.93** | -16.839*** | 0.030*** | 0.061*** |
| (b) KSS and Sollis tests | | | | | | | |
| | KSS | | | Sollis | | | |
| Stock index | -17.005(1)*** | | | 109.533(1)*** | | | |
| REIT index | -25.266(1)*** | | | 120.414(1)*** | | | |

Notes: (1)The ADF,PP,NP and KPSS unit root tests are based on the regression model with an intercept term, whileKSS and Sollis tests are based on the ESTAR models. The lagsof the four linear tests areselected by MAIC, while the ones of KSS and Sollis tests are selected by BIC. (2) *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.(3) The critical value for the 10%, 5% and 1% significance level of ADF, PP and KPSS tests are (-2.568, -2.864, -3.435), (-2.568,-2.864, -3.435) and (0.347, 0.463, 0.739).The critical values for the NP,KSS and Sollis tests are tabulated inNg and Perron,Kapetanioset al. and Sollis, respectively.(4) The null hypothesis of ADF,PP, NP, KSS and Sollis tests are non-stationary (unit root), whilethe null hypothesis of KPSS test is stationary (no unit root).

This paper next explores the causality between the indexes. The results of the linear Granger causality test for returns of the REIT index and stock index are summarized in Table 3. The

standard Granger tests show weak evidence of Granger causality from the REIT to stock index returns but fail to provide evidence of reversed Granger causality. The F statistic, which tests the exclusion of the coefficients of the REIT index returns from the equation for the stock index returns, is significant at the 10% level. However, the F statistics in the equation for the REIT index returns is insignificant at the same confidence level. Therefore, the test results indicate that the REIT returns seem to have the weak linear predictive power to stock returns but not vice versa.

Table 3 Results of linear Granger causality tests between returns of REIT index and stock index

| Null Hypothesis | t statistics | p-value |
|---------------------------------------|--------------|---------|
| REIT index does not cause stock index | 1.728* | 0.084 |
| Stock index does not cause REIT index | 1.588 | 0.112 |

Notes:(1) The lag length of the VAR model is 2 selected by BIC. (2) *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

To avoid possible bias from filtering linear dependence among variables, this paper tests for short-term non-linear Granger causality using a noisy MG model. The estimation of the model requires a prior choice of values for the parameters c_1, c_2, τ_1, τ_2 . This paper uses the values $c_1 = c_2 = 2$ and $\tau_1 = \tau_2 = 1$ on the basis of BIC. Having these parameters, we next estimate the MG model by OLS and then conduct the non-linear Granger causality tests.

Table 4 illustrates the results of the MG non-linear Granger causality test between returns of the REIT index and the stock index. The F statistics fail to reject the null of no Granger causality from REIT returns to stock returns at the 5% significance level. The reversed causality from stock returns to REIT returns is also insignificant at the same significance level. These results indicate the non-existence of non-linear causality between REIT market and the stock market. This might be due to the fact that investors prefer the investment of direct real estate and the investment behavior of REIT companies is limited by the law in Taiwan. The finding demonstrates that market price information of these two markets cannot be transmitted to each other.

Table 4 Results of non-linear Granger causality tests between returns of REIT index and stock index

| Null Hypothesis | F statistics | p-value |
|---|--------------|---------|
| REIT returns do not cause stock returns | 0.617 | 0.537 |
| Stock returns do not cause REIT returns | 1.392 | 0.164 |

Notes: The parameters for the MG model are $\tau_1 = \tau_2 = 1$ and $c_1 = c_2 = 2$.

Conclusion

This paper examines the dynamic linkage between the REIT index and aggregate stock index in Taiwan. Linear and newly-developed non-linear test techniques are utilized to explore the short-run causality between the two indexes. The results find that the two indexes exert linear and non-linear stationarity. Further results from linear causality tests reveal that there exists weak causality from REIT index to stock index, indicating that price information from REIT index can be used to predict stock index. However, non-linear causality tests show no causality between the two indexes.

The findings of this paper are of particular interest to researchers, investors, and policymakers for some reasons. First, as the study findings show, REIT index can be used to predict stock index, therefore investors could use this information to earn profit. Second, the above findings also imply that the Taiwan stock markets could be inefficient in the short run since REIT prices tend to influence stock market prices. Third, the finding of no causality from the stock market to REIT market might arise from the smaller size and law limitations of the Taiwan REIT market and investors' preference on the direct real estates; therefore policymakers in Taiwan should design the proper policy to develop the REIT market.

Future research also can attempt to explore the international linkages of the REIT market and

other financial markets. The analysis of this paper also can further be extended to explore the non-linear dynamic association between financial markets and economic variables.

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