Integration between Real Estate market and Stock market: Evidence from Taiwan

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Abstract

This paper investigates long-run equilibrium relationship between real estate market and stock market in Taiwan using real estate investment trust (REIT) index. Linear cointegration model and recently developed time-varying vector error correction model are applied to explore possible long-run linear and non-linear linkage between the two indexes. The results of both the cointegration tests point to the existence of neither linear nor non-linear cointegration, suggesting that REIT markets are segmented from stock markets. These findings have important implication for investors and policy makers.

Key words: REIT, Stock index, Cointegration, Time-varying

Introduction and Literature Review

Portfolio investing is an important issue in the financial management. To construct a well-diversified portfolio, investors need to look for a group of assets whose returns have low correlation. Among investment assets, the REIT is a unique asset with a mixed characteristic of both the real estate market and the stock market. The REIT becomes popular among the investors in recent years, typically because it provides stable high dividends with a moderate risk compared to stock market investment. Moreover, the REIT has advantages of 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 practitioners, scholars, and policy makers.

Numerous studies have investigated the interactions between REIT asset and other assets, especially stock, 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. The early study by Liu et al. [12] document that the US securitized real estate market is integrated with the stock market but the US commercial real estate market is not. Li and Wang [9] conclude that the US REIT market is integrated with the general stock market. Ling and Naranjo [10] find evidence of integration between the US real estate securities, including REIT, and the stock market and that the degree of integration increases significantly during the 1990s. Glascock et al. [5] examine the causality and long-run linkages among US REIT, bond and stock returns. The results show that REIT is cointegrated with the bond market but after 1992, cointegration exists between REIT and stock returns. Apergis and Lambrinidis [1] study dynamics of stock and securitized real estate markets in the US and the UK. They find that the two markets are highly integrated. Analyzing the dynamic of US REIT, stock, and direct real estate returns, Fei et al. [4] reveal strong correlation between REIT and stock returns.

For the Asian-Pacific markets (Japan, Hong Kong, Singapore, and Malaysia), Liow and Yang [11] report that cointegration between REIT and stock indexes, accompanied by significant adjustment speed, only exists in the case of Hong Kong and Singapore. Tsai and Chiang [18] examine the relationship between REIT and stock indexes and their asymmetric adjustment behaviors in the six Asian-Pacific financial markets (Australia, Japan, Singapore, Taiwan, Korea, and Hong Kong). They find that there has been long-run equilibrium and causality between REIT and stock indexes in most of these markets.

The existing literature mainly focuses on the developed REIT markets and empirical investigation into the case of emerging REIT markets is limited. Moreover, most empirical evidence is based on the linear statistical tool which might ignore the possible non-linear information. Therefore, it might be biased to assume that relationship between REIT and stock indexes is linear. Thus, in addition to the linear association between REIT market and stock market, this paper also explores their non-linear association to provide further highlight the linkage between these two markets in the literature.

The objective of this paper is to analyze whether there exists significant relation between REIT market and stock market in Taiwan from the long-run perspectives. The analysis employs linear and non-linear time series techniques, including unit root tests and cointegration tests, to access the long-run equilibrium relationship between the two markets. The empirical results from linear and non-linear cointegration tests fail to find the existence of cointegration, indicating that the two markets are segmented. These findings provide useful insight to investors and policy maker in Taiwan since they demonstrate that there are potential gains of long-run diversification when investors hold REIT and stocks at the same time.

The remainder of the article is organized as follows. The next section describes the statistical tools. Section 3 presents the data and empirical results. The final section offers a conclusion.

Methodologies

A. Conventional Linear Unit Root Tests

To avoid the spurious regression problem, various unit root tests are developed to detect the stationary of time series in the literature. In this paper, first, we test for stationarity of variables by employing three linear unit root test techniques, namely, ADF [3], KPSS [8], and NP [14] tests. 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 model selection criterion and the Bartlett kernel are usually utilized to determine the optimal lag length and bandwidth, respectively.

B. Advanced ESTAR Non-linear Unit Root Test

To capture non-linearity in the time series, Kapetanios et al. [10] (henceforth, KSS) develop a powerful test for the presence of non-stationarity against a non-linear but globally stationary exponential smooth transition autoregressive (ESTAR) process. Recently, Sollis [17] extends the KSS model by allowing for asymmetric non-linear adjustments under the alternative hypothesis. The extended model is given as:

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

where Y_t is a demeaned or/and 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. 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 $\gamma_1 = 0$. However, the parameters γ_2, ρ_1 and ρ_2 are unidentified under this null. Replacing the exponential and logistic function in (1) by their first-order Taylor's approximations around $\gamma_1 = 0$ and $\gamma_2 = 0$, respectively, with allowing for higher-order dynamics, Sollis [17] obtains the following regression

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

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.

C. Gregory-Hansen (GH) cointegration test

Cointegration tests can be applied to capture the long-run equilibrium among variables. The Gregory and Hansen [6] expand conventional linear cointegration test to allow for the possibility of regime shifts. The GH test tests the null of no cointegration against the alternative of cointegration in the presence of a possible regime shift. The shift considered is a single break in the intercept and/or slope coefficients vector. Among four models of the GH tests, model (1) is the standard two-stage cointegration method, and the other three models are as follows:

Model 2(*C*) : $y_t = \mu_1 + \mu_2 D_t(\lambda) + \beta_1 X_t + e_t$ (3)

Model 3(*C/T*) : $y_t = \mu_1 + \mu_2 D_t(\lambda) + \gamma t + \beta_1 X_t + e_t$ (4)

Model4(*C/S*): $y_t = \mu_1 + \mu_2 D_t(\lambda) + \beta_1 X_t + \beta_2 X_t D_t(\lambda) + e_t$ (5)

where y_t is an univariate, and X_t is variate vector. The symbols of model specification, C, C/T and, C/S denote level shift, level shift with a trend, and regime shift models, respectively. If $t > T\lambda(t=1,\ldots,T)$, $D_t(\lambda)$ equals 1, and 0 otherwise. $\lambda = T_B / T$ and T_B is a possible break point. The test statistics for the ADF and Z_α and Z_t of Perron [15] are:

$$\text{ADF}^* = \inf_{\tau\in T} \text{ADF}(\tau) \quad Z_\alpha^* = \inf_{\tau\in T} Z_\alpha(\tau) \quad Z_t^* = \inf_{\tau\in T} Z_t(\tau)$$

D. Time-varying cointegration test

To test for the possible non-linear cointegration relationship, this paper adopts the time-varying vector error correction model (TV-VECM) of Bierens and Martins [2]. In the model, the cointegrating relationship varies smoothly over time and their adjustment process can be non-linear.

The TV-VECM(p) with Gaussian errors is written as:

$$\Delta Y_t = \mu + \alpha\beta_t' Y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta Y_{t-j} + \varepsilon_t,\ t = 1,2,3,\ldots,T \quad (6)$$

where Y_t is a $k\times 1$ time series vector, μ is a $k\times 1$ vector of intercepts, α is a fixed $k\times r$ matrix with rank r, β_t is a TV $k\times r$ matric with rank r, T is the number of observations, $\varepsilon_t \sim N_k(0,\Omega)$, and Γ_j and Ω are $k\times k$ matrices. For the time series vector Y_t, it is assumed that there are fixed $r<k$ linearly independent columns for the cointegrated matrix β_t. Our objective is to test the null hypothesis of time-invariant (TI) cointegration $\Pi_t' = \Pi' = \alpha\beta'$ against the alternative TV cointegration $\Pi_t' = \alpha\beta_t'$.

Under the assumptions of orthonormality and smoothness, Bierens and Martins [2] show that the TV cointegrating vector β_t can be approximated for some fixed m by a finite sum of Chebyshev time polynomials $P_{i,T}(t)$:

$$\beta_t = \beta_m(t/T) = \sum_{i=0}^{m} \xi_{i,T} P_{i,T}(t) \quad (7)$$

where $m < T-1$ and $\xi_{i,T} = \Sigma_{t=1}^{T} \beta_t P_{i,T}(t)/T$ are unknown matrices. The Chebyshev time polynomials are defined by:

$$P_{0,T}(t) = 1, P_{i,T}(t) = \sqrt{2}\cos(i\pi(t-0.5)/T), t=1,..,T, i=1,..,m$$

Here the standard model selection procedures can be used to choose the optimal value of *m*.

By substituting (7) into (6), the TV-VECM can be written as

$$\Delta Y_t = \mu + \alpha\xi' Z_{t-1}^{(m)} + \sum_{j=1}^{p-1} \Gamma_j \Delta Y_{t-j} + \varepsilon_t \quad (8)$$

where $\xi' = (\xi_0', \xi_1', \ldots, \xi_m')$ is a matrix of rank r and $Z_{t-1}^{(m)} = P_{i,T}(t) \otimes Z_{t-1}$. The null hypothesis of TI cointegration corresponding to ξ' so that $\xi' Z_{t-1}^{(m)} = \beta' Z_{t-1}$. Bierens and Martins [2] propose a likelihood ratio (LR) test for the null hypothesis of standard TI cointegration against the alternative TV cointegration. Under the null, the LR statistic is

ISBN 978-1-5090-4897-7

asymptotically distributed as a chi-squared distribution with $r \times m \times k$ degree of freedom.

Data and Empirical Results

A. The Data

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

The data 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-) price series is shown in Fig. 1.

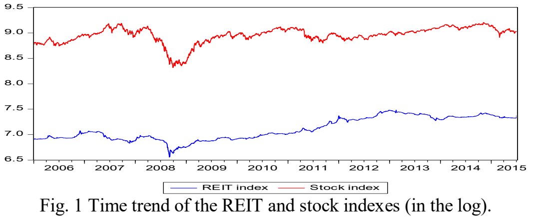

Fig. 1 Time trend of the REIT and stock indexes (in the log).

The summary statistics of daily returns of the REIT and stock indexes in Table 1 provides several preliminary insights into the data. The mean for both the index returns suggest that the REIT market performs better than stock market during the sample period. The standard deviations are more volatile over time, and as expected, the REIT returns have the smaller 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 10 lags show strong autocorrelation in both the returns. These significant autocorrelations suggest the existence of non-linear dependence in these index returns.

Table 1 summary statistics of REIT index and stock index

Vars.	Mean	SD	Skew	Kurt	JB	Q(10)
REIT index	0.02	0.53	0.94	21.16	46616.6***	187.02***
Stock index	0.01	1.26	-0.40	3.42	1273.4***	26.52***

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

B. Empirical Results

We first check the stationarity of the index series 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. For the sake of parsimony, we use the Akaike information criterion (AIC) with lag length of 10 for ADF, PP and NP tests to gauge the optimal number of lags. The Bartlett kernel-based criterion proposed by Newey and West [13] is used to determine the optimal bandwidth of KPSS test.

Table 2 lists the results of various linear unit root tests for the level and the first difference of daily prices of REIT index and stock index. The ADF, PP and NP tests fail to reject the null hypothesis of a unit root at the 5% significance level for both the index price series. After first differencing, however, these unit root tests show that there is no unit root for these prices series. The KPSS test confirms the results from the above tests by rejecting the null hypothesis of stationary for prices series and not rejecting the null for first-differenced prices series.

Table 2 Results of linear unit root tests

(A) ADF, PP and KPSS test

	Level			1st-difference		
Vars.	ADF	PP	KPSS	ADF	PP	KPSS
Stock Index	-1.65	-1.55	6.24***	-28.72***	-40.10***	0.14
REIT index	-2.30	-2.28	1.63***	-46.97***	-46.95***	0.05

(B) NP test

	Level			1st-difference		
Vars.	MZ_t	MSB	MP_t	MZ_t	MSB	MP_t
Stock index	-1.01	0.41	9.39	-2.347**	0.21***	9.18***
REIT index	0.23	0.74	36.09	-16.84***	0.03***	0.06***

Notes: (1) All unit root tests are based on the regression model with an intercept. The appropriate lag lengths are selected by AIC. (2) *, ** and *** denote significance at the 10%, 5% and 1% significance 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 tests are tabulated in Table 1 of Ng and Perron [14]. (4) The null hypothesis of ADF, PP and NP tests are non-stationary (unit root); the null of KPSS test is stationary (no unit root).

To detect the potential non-linear unit root, this paper applies KSS and Sollis test procedures based on the ESTAR models. The optimal lags of the two models are determined by Bayesian information criterion (BIC). The results listed in Table 3 support for the existence of a non-linear unit root in the REIT and stock indexes since the related test statistics are insignificant at the 10% level. After first differencing, both the KSS and Sollis tests reject the null hypothesis of no unit root for two returns series at the 1% level. Together with the results from linear and non-linear unit root tests, we therefore conclude that both the REIT index and the stock index are non-stationary and integrated of order one.

Table 3 Result of non-linear unit root test

	Level		1st diff.	
Vars.	KSS	Sollis	KSS	Sollis
REIT index	-1.54 (1)	1.01 (1)	-17.01(1)***	109.53 (1)***
Stock index	1.53 (2)	0.04 (1)	-25.27(1)***	120.41 (1)***

Notes: (1) The KSS and Sollis tests are based on the demeaned series. (2) The numbers in the parentheses are the lag lengths selected by BIC. (3) The simulated critical values for the KSS and Sollis tests are tabulated in Kapetanios et al. [7] and Sollis [17], respectively. (4) *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

We next examine the cointegration relationship between the REIT and stock indexes. To account for possible structural changes, GH cointegration test is used. Table 4 lists the results obtained from the three models, namely C, C/T and C/S, of the

GH cointegration test. The breakpoints detected by the models are also listed. The lag lengths are selected by BIC with the maximum lag of 8. The test results show no cointegration between REIT and stock indexes. Test statistics fail to reject the null hypothesis of no cointegration at the 10% significance level for all the three models. The finding indicates that there is not a stable linear long-term relationship or common stochastic trend between REIT and stock indexes.

Table 4 Results of Gregory-Hansen cointegration test

Model	ADF^*	Z_α^*	Z_t^*
C	-3.85 [0.58]	-3.85 [0.58]	-29.45 [0.58]
C/T	-3.74 [0.58]	-3.74 [0. 58]	-27.80 [0. 58]
C/S	-3.93 [0.59]	-3.92 [0.59]	-30.59 [0.59]

Notes: (1) The 5% critical values for models C, C/T and C/S are -4.92, -5.29, -5.50 for ADF^* and Z_α^* and -46.98, -53.92, -58.33 for Z_t^*, respectively. (2) Numbers in parentheses denote the break points represented by the percentage of the whole sample period.

To access the possible non-linear cointegration relationship, the TV-VECM of Bierens and Martins [2] are applied to determine whether the REIT and stock indexes are non-linearly cointegrated. Table 5 provides the results of TV cointegration test for different Chebyshev time polynomials m. The BIC select the optimal polynomial of 1 for the cases of 1 to 2 cointegration vectors. The LR test statistics suggest no cointegration relationship between REIT and stock indexes, consistent with the findings from GH cointegration tests. The evidence indicates the non-existence of long run relationship between REIT market and stock market.

Table 5 Results of time-varying cointegration test

(A) LR test for TV cointegration				
m	$r = 1$		$r = 2$	
	LR	p-value	LR	p-value
1	0.791	0.673	5.686	0.224
2	6.217	0.184	12.580	0.127
3	16.703	0.010	23.894	0.021
(B) BIC for TV cointegration model				
m	$r = 1$		$r = 2$	
1	-13.689		-14.366	
2	-13.685		-14.356	
3	-13.683		-14.348	

Conclusion

This paper explores the long-run linkage between stock index and REIT index using the Gregory-Hansen cointegration test and newly-developed non-linear test techniques. The results from the two cointegration tests show the non-existence of cointegration. The evidence indicates that there is no long-run equilibrium relationship between REIT market and stock market, suggesting the two markets could offer opportunities for long-run portfolio diversification for investors since they tend to be segmented in the long run.

The findings of this paper are of particular interest to researchers, investors, and policymakers for the two reasons. First, as the study findings show, the REIT market and stock market are segmented, therefore investors can apply this finding to gain long-run benefit from risk diversification. Second, the finding of no cointegration association 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.

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 ISBN 978-1-5090-4897-7