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Dynamic modelling of real estate investment trusts and stock markets

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ABSTRACT

Taiwan launched the first case of real estate securitization in 2005. The interrelationship between Taiwan Real Estate Investment Trusts (T-REITs) and the aggregate equity markets and segmented industries has drawn the interests of both investors and academia. This paper employs Toda and Yamamoto's (1995) procedure and the generalized impulse response approach to uncover the extent and the magnitude of the relationship between T-REITs and aggregate and segmented stock prices. We collected daily data of the first two issued T-REITs, Fubon No.1 and Cathay No. 1, from March 2005 to March 2010 and October 2005 to March 2010, respectively, to examine their causal relationships with aggregate stock markets, the financial sector, and the construction sector. The empirical results indicate that all variables have break points, reflecting shocks from the Subprime Mortgage Crisis or deregulation of the Qualified Domestic Institutional Investors (QDII) for Mainland Chinese to invest in Taiwan. We also discover that an individual T-REIT may lead or lag behind stock price indices due to its capitalization scale or business type. The transitory initial impacts of innovations in T-REITs on stock price indices are observed herein.

1. Introduction

Research studies have broadly explored the price, risk, and return of real estate markets, and the influential factors and interrelationships with other investment vehicles (Sing et al., 2006). The first strand of related research focuses on the influence of macroeconomic factors, such as interest rates and inflation on real estate investment trusts (REITs, hereafter). Gyourko and Keim (1992) found that important information about property market fundamentals is impounded in REIT returns, especially when they are adjusted to control for general market factors. Liang and Webb (1995) further stressed that the market risk of mortgage REITs (MREITs) is mostly interest rate risk, which is not diversified away. Mei and Gao (1995) also concluded that REITs' returns could be explained by a function of fundamental economic variables. Most of the research in this strand indicated that the returns of REITs are influenced by some macroeconomic factors, such as inflation, interest rates, and economic growth (Kim et al., 2007).

The second category of real estate literature engages in exploring the interrelationship between REITs. Nelling and Gyourko (1998) found that there is only weak evidence of predictability of REIT returns based purely on past performance. Subrahmanyam (2007) explored the existence of joint dynamics across the REIT and non-REIT sectors. Impulse response functions and Granger causality tests indicate the existence of persistent liquidity spillovers running from REITs to non-REITs. Moreover, Liow and Webb (2009) demonstrated that the magnitude to which correlations are shown in international securitized real estate markets might largely be through the increasing integrated nature of the world real economy, rather than a result of the globalization of financial markets.

The third group of related studies attempts to discover the interrelationship between real estate investment and other vehicles, particularly stock markets. He et al. (1996) examined the relationship between REITs' returns and bank stock returns. They found that MREIT explains the risks and returns of bank stocks better than equity REITs. Lizieri and Satchell (1997) explored that the wider equity economy leads the real estate market in the short term, however, positive real estate returns may point to negative future returns in the rest of the economy in the long run. Ling et al. (2000) indicated that an out-of-sample prediction of excess returns on an equity REIT has a lower power than an in-sample prediction. Hoesli and Camilo (2007) showed in an international analysis that securitized real estate returns are positively associated with stock and real estate returns, but negatively related to bond returns. More related studies also have shown that REITs and the general stock market are integrated (Ambrose et al., 2007; Laopodis, 2009; Liu et al., 1990). Some studies investigates the impacts of movements or volatilities of stock prices on REITs (Ambrose and Bian, 2010; Cotter and Stevenson, 2004, 2006; Devaney, 2001; Stevenson, 2002), but their conclusion regarding the direction of a causal relationship between real estate markets and stock markets tends to be weak.

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In Taiwan the "Real Estate Securitization Statute" was promulgated in 2003. As Lee and Stevenson (2005) noted, REITs to some extent provide a hybrid investment form, standing between equities and the fixed-income sector. In addition, the asset maintains strong links with the direct real estate market. These inter-linkages provide such assets with unique characteristics. Real estate in Taiwan is extremely important for people's belief in the traditional notion of 'land is wealth.'[1] With the introduction of this new mechanism, real estate can be transacted in the form of securities, which in turn increases its liquidity. Industries related to real estate in Taiwan have been eager to apply the securitization process for raising funds to liquidate real estate investments. These REITs provide a new alternative for investment in the property market, which is traditionally considered as a secured, scarce, and precious but low-liquid vehicle for most Taiwanese investors. In the Taiwan context, people believe real estate is the most valuable asset, providing an interesting case for the empirical model of REITs.

Prior to the initial public offering (IPO), Taiwan REITs (T-REITs, hereafter) are required to go through an appraisal board meeting held by the government to evaluate the net asset value (NAV) for investor protection. The appraisal meeting helps investors screen the fundamental value of the object's assets and also limits REITs' appreciation potential. This special characteristic draws our interest to examine the causal relationship of T-REITs with the equity markets, including the overall stock markets, the financial sector stocks, and the construction sector stocks.[2] The reason to examine the relationship of T-REITs with both the financial and construction sectors is that we want to discover what securitized real estate is like, or which of the following is related: financial vehicles, traditional construction, or direct real property investments.

This paper applies the Granger causality test of Toda and Yamamoto (1995; hereafter TY) to draw conclusions with regard to the causal relationships between T-REITs and weighted stock prices. The TY (1995) method is a modified Wald (MWALD) test in the VAR framework. The concept of causality is basically related to the topic of market integration/segmentation. The hypothesis for determining which direction the causal relationship flows is most likely from stocks to real estate, given the concept that the real estate market is not liquid and may be inactive in prices when compared to the stock market. These movements of asset prices may reflect the behaviors of arbitrageurs and investment managers balancing their portfolios. This information may also benefit investors who consider different prices as a part of their overall investment portfolios. Daily data of the first two issued T-REITs, Fubon No.1 and Cathay No.1, cover the periods March 2005-March 2010 and October 2005-March 2010, respectively, and we examine their causal relationships with the aggregate stock markets, and the financial sector and construction sector in Taiwan. The benefit from using the Granger causality test of TY (1995) is that it does not require knowledge as to the cointegration properties of the system and can be applied in the absence of cointegration (Lee and Chien, 2011).

The above method can also be used when stability and rank requirements are not satisfied. The model estimation procedures are indeed quite simple, particularly in cases where there are more than two cointegrating vectors and when the OLS is valid. This paper also examines the transmission mechanism between these variables by applying the generalized impulse response approach (GIRF) of Pesaran and Shin (1998). The impulse response analysis can trace a variable's directional responses to a one standard deviation shock in another variable. This achieves both direct and indirect effects of innovations on a variable of interest, thus enabling us to comprehensively estimate the dynamic linkages between T-REITs and the Taiwan Weighted Stock Index.

The remaining part of this paper is organized as follows. Section 2 introduces the development of real estate securitization in Taiwan. Section 3 briefly describes the econometric methodology. Section 4 presents the empirical results. Section 5 offers the conclusion.

2. Real estate securitization in Taiwan

Up until 2009, a few countries in the Asia-Pacific region have implemented a real estate securitization mechanism, including Australia, Malaysia, Japan, Singapore, South Korea, Taiwan, Hong Kong, Philippines and India, while the U.K. and Germany in Europe are on their way towards following the mainstream. The REITs provide these countries with a new alternative for direct investment in the property market, which is traditionally considered as a secured, scarce, and precious, but low-liquid vehicle for most Asian investors.

In Taiwan the "Real Estate Securitization Statute" was promulgated in 2005. There are two types of vehicles for real estate securitization in Taiwan: real estate investment trust (T-REIT) and real estate asset trust (T-REAT). T-REITs are similar to REITs in other countries and involve raising funds first and then acquiring real estate targets. Like stocks, T-REITs have no specific investment period, while the structuring of T-REATs is very similar to that of asset securitization. T-REATs are established to first hold defined real estate with rental or operating income for specific periods and then to raise funds in exchange for the particular properties. Capital gains are distributed to investors after the sale of the target properties for T-REATs. Both T-REITs and T-REATs are only allowed to operate as closed-end funds, and at least 75% of the funds must invest in existing properties or related rights that generate steady income as follows: asset-backed securities (ABS), bank deposits and acceptance, short-term commercial papers, and treasury bonds. Real estate development activities, although under discussion, are still prohibited for both portfolios of T-REITs and T-REATs.

Unlike the U.S. and Japan, Taiwan only allows the operation of an investment trust (special-purpose trust) instead of an investment corporation (special-purpose corporation). The minimum capital requirement for establishing a T-REIT is NT$1 billion and for a T-REAT is NT$300 million. (US$1 = NT$30 in 2010 on average). For both T-REITs and T-REATs, any five certificate holders cannot own more than 50% of the total value of the issued certificates. The T-REIT is allowed to leverage financially for the purpose of operation or dividend payout, but the maximum percentage has not been regulated. The income of T-REITs is only required to be distributed within six months after every fiscal year, but the ratio is not specifically regulated.

After the enactment of the "Real Estate Securitization Statute" in 2003, Taiwan introduced the first case of REIT to the public market in early 2005. Up through 2010, the accumulated market capitalization of T-REITs has reached US$1.8 billion, indicating the popular trend of real estate securitization for both investors and issuers in Taiwan. As stated above, T-REITs are required to go through an appraisal board meeting prior to IPO for evaluating the NAV for investor protection. The appraisal meeting helps investors screen the objective assets' fundamental value and also limits REITs' appreciation potential. Therefore, the price fluctuation of T-REITs is smaller than those in the U.S. or in Japan. The low-risk and low-return characteristics of T-REITs also provide investors a secured vehicle in Taiwan, together with the tax-free incentive for the dividends of T-REIT investors. The incentives above have resulted in over 60% of investors being individuals, according to Fubon No.1, the first T-REIT introduced to the markets.

The trend of real estate securitization indicates that REITs have successfully drawn investors' interests in this region, where real estate is

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[1] According to the census of Taiwan's Ministry of Interior in 2006, the average home ownership rate is over 87% and the average housing unit vacancy rate is 17.6%. These two figures are far above the average of other countries (Lee and Chien, 2011; Chen et al., 2011).

[2] There are some paper discussing the volatility of REITs and stock prices. Most of these papers aim to utilize the GARCH model to analyze the volatility dynamics of REITs, including Devaney (2001), Stevenson (2002), and Cotter and Stevenson (2004. 2006). A few of them utilize data on REITs to examine the role of stock market volatility on earnings management (Ambrose and Bian, 2010). However, the aim of this paper is to examine the characteristics of T-REITs that lead or lag the stock price index. We focus on the price relationships of these two markets, not the volatility linkages, and the volatility in daily stock market index data is not discussed herein.

traditionally considered as an asset that appreciates in the long run. Despite the popularity of the REIT mechanism in Asia, some unique characteristics of Asian REITs are worth noting. First, most REITs in Asia do not allow funds to invest in properties abroad. This restriction may lead these REITs to become less regional diversified and eventually encounter significant concentration risk and currency risk as the domestic macro economy declines. Second, the economic scale of the Asian REITs, which are relatively smaller than those in the U.S., might face liquidity limitations in the future, especially as real estate markets stagnate or the rental or operating income streams shrink. Third, most of these countries have no regulations upon the minimum lease term of the properties for REIT investment. The uncertainty over continuity in rental contracts, especially for anchor tenants, may imply a significant variation between the predicted and realized incomes, and consequently the forecast and fundamental NAVs of the invested properties. Fourth, some Asian countries do not provide tax advantages for investing in REITs, and some impose restrictions on REITs of minimum holding periods for the properties. Relative to the experience in the U.S. and Australia, these features may lead to limited liquidity and marketability of REITs. International investors or researchers will need to take into account the basic differences of REITs among various countries for assessing potential risks.

3. Methodology

In line with Toda and Yamamoto (1995), we consider the *n*-vector time series Z_t generated by the *k*-th order VAR model:

$$Z_t = \Phi_0 + \Phi_1 t + \Phi_2 t^2 + \Phi_3 t^3 + \Pi_1 Z_{t-1} + \ldots + \Pi_k Z_{t-k} + E_t,\ t = 1, \ldots T, \tag{1}$$

where $E_t \sim N(0, \Omega)$; $Z_t = (REIT_t', SP_t')$, where $REIT_t$ and SP_t represent T-REIT and stock price, respectively; and t represents a deterministic time trend. Economic hypotheses can be expressed as restrictions on the coefficients in the model in accordance with the following:

$$\mathrm{H_0 : F}(\pi) = 0,$$

where $\pi=$ vec(P) is a vector of the parameters in Eq. (1); $\mathrm{P} = (\Pi_1 \ldots \Pi_k)$; and F(.) is a twice continuously differentiable m-vector valued function.

TY (1995) set up a simple procedure to facilitate testing for Granger non-causality in level VARs, which is estimated by the OLS with integrated variables. The test essentially involves two stages. First, the augmented $(k+d)$ VARs are estimated, where d is the maximal order of integration. Second, we apply the Wald test to the first k VAR coefficient matrix to test for Granger causality. For testing the null hypothesis, TY (1995) confirmed that the Wald statistic converges in distribution to an χ^2 random variable with m degrees of freedom regardless of whether the process Z_t is stationary, possibly around a linear trend, or whether it is cointegrated. This methodology minimizes the risks perhaps associated with misidentifying the orders of integration of the series, or the presence of cointegration, while additionally it minimizes the possibility of distorting the test size that frequently results from pretesting.

This paper applies the advanced generalized impulse response techniques of Pesaran and Shin (1998) to examine the relationships between T-REITs and the aggregate equity markets and segmented industries. The results are expected to draw interests from investors and academia. We consider the two-dimensional VAR model as follows:

$$Z_t = A \sum_{i=1}^{p} \psi_i Z_{t-1} + \varepsilon_t, \tag{2}$$

where Z_t is a (2×1) vector of jointly determined endogenous variables; ψ_1 through ψ_p are (2×2) coefficient matrices; A is a vector of constants; and ε_t is a (2×1) vector of well-behaved disturbances with covariance $\Sigma = \sigma_{ij}$ $(i, j = 1, 2)$. The generalized impulse response of Z_{t+n} with respect to a unit shock to the jth variable at time t is represented by $(G_n \Sigma e_j)(\sigma_{ij})^{-1}$, where $G_n = \psi_1 G_{n-1} + \psi_2 G_{n-2} + \cdots + \psi_p G_{n-p}$, $n = 1, 2, \ldots$, $G_0 = I$, $G_n = 0$ for $n < 0$, and e_j is a (2×1) selection vector with unity as its jth element and zero elsewhere.

Our methodology has two advantages over the standard impulse response analysis (Chen et al., forthcoming). First, it does not presuppose any ordering that has theoretical implications. Second, the methodology provides a meaningful interpretation of the initial impact of shocks - a feature that is missing in the traditional methodology, but might be important in the analysis of Taiwan Real Estate Investment Trusts where information is transmitted quickly.

4. Empirical investigations

We use two different stock prices of T-REITs' data, including Fubon No.1 and Cathay No.1 for empirical analysis. Properties in the portfolios of these two T-REITs are all located in Taipei City, and both T-REITs are ranked over twA. Fubon No. 1, market capitalization of US $0.25 billion, includes three office buildings and one commercial building that are 10 years old or newer. Cathay No. 1, market capitalization of US$0.43 billion, has two office buildings and one hotel, all of which are over 40 years old. The sample period for Fubon No.1 is from March 10, 2005 to March 15, 2010. The sample data of Cathay No.1 covers the period from October 3, 2005 to March 15, 2010. Other data are daily prices for three different weighted indices: the Taiwan Weighted Stock Index (*SPT*), the Weighted Price Index of the Financial Sector (*SPF*), and the Weighted Price Index of the Construction Sector (*SPC*). All the data are collected from the Taiwan Economic Journal (TEJ) database. All of the variables used are in natural logarithms.

Figs. 1–5 present the price movements of Fubon No.1, Cathay No. 1, and the SPT, SPF, and SPC series, respectively. The figures show that these prices are non-stationary and exhibit similar patterns. In Fig. 1 the price of Fubon No.1 shows more variation since March 2007 and seems to be breaking around April 2007 and June 2008. As to Cathay No. 1, its price also presents more variations after July 2007 and is breaking around April 2009.

4.1. Case 1 — REIT of Fubon No.1

For a comparison, we apply the unit-root tests, including the ADF (Dickey and Fuller, 1979), the PP (Phillips and Perron, 1988), the KPSS (Kwiatkowski et al., 1992), the DF-GLS (Elliott et al., 1996), and the NP (Ng and Perron, 2001), from March 10, 2005 to March 15, 2010 to detect stationarity of these variables. Table 1 presents the results of the classic unit-root tests. We follow the determining rule of Doldado et al. (1990) to establish the appropriate model for the unit-root tests. Aside from this, we adopt the newly-developed Modified Akaike's Information Criterion (MAIC) suggested by Ng and Perron (2001) to select the optimal number of lags based on the principle of parsimony. The results in Table 1 clearly indicate that all series are integrated of order one (I(1)) at the 5% level of significance for all unit-root tests without structural breaks.

All of the above unit-root tests are not appropriate for testing the stationarity of a series that encounters a structural change. Thus, we further take the structural break into account when employing the unit-root test. Ever since the renowned paper offered by Perron (1989),[3] previous literature has been aware of the importance of allowing for a structural break when testing for a unit root. Interestingly, subsequent

[3] These are: Model A (the crash model), which allows for a one-time change in the intercept of the trend function; Model B (the changing growth model), which allows for a change in the slope; and Model C (the crash-cum-growth model), which allows for a change in both intercept and slope (please see a detailed discussion in Lee and Strazicich, 2003; Perron, 1989; Smyth and Inder, 2004).

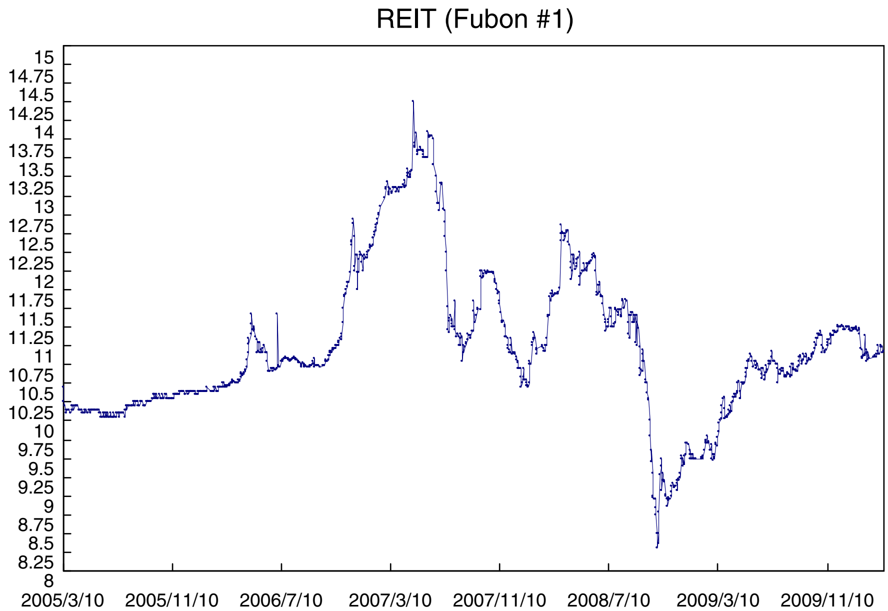

Fig. 1. Price movement of the REIT of Fubon No. 1(March 10, 2005–March 15, 2010).

studies changed the test to allow for one unknown break point that is determined endogenously from the data. Without allowing for structural breaks, traditional ADF type tests could cause a wrong decision when the null hypothesis is not rejected. To improve the default of ADF type tests without allowing for possible breaks in the series, Perron (1989) proposed allowing for one known, or "exogenous," structural break in the ADF unit-root test. Following Perron (1989), Zivot and Andrews (1992) offered to determine the break point "endogenously" from the data.

A structural break essentially corresponds to an intermittent shock with a permanent effect on the series (Hendry, 1996). The opposite can also happen if the break occurs at the beginning of the sample (Leybourne et al., 1998). In order to take this possible regime shift in the unit-root tests into account, Zivot and Andrews (1992, hereafter ZA) developed a new category of tests that allow for a structural break.

A potential problem common to the ADF-type endogenous break unit-root tests is that they derive their critical values assuming no break(s) under the null. This assumption leads to size distortions in the presence of a unit root with a break as Nunes et al. (1997) showed. As Lee and Strazicich (2004) suggested, if we lose the power from ignoring one break, then it may let us extend that the query has a similar loss of power from ignoring two or more breaks in the one-break test (Smyth and Inder, 2004). To avoid problems of bias and spurious rejections, Lee and Strazicich (2003) derived the endogenous two-break LM unit-root test.

Lee and Strazicich (2003) held that the two-break LM unit-root test statistic can be estimated by regression according to the LM (score) principle as follows:

$$\Delta y_t = \eta' \Delta R_t + \varphi \tilde{S}_{t-1} + u_t, \tag{3}$$

where $\tilde{S}_t$ is a de-trended series, $\tilde{S}_t = y_t - \tilde{\Psi}_x - R_t \tilde{\eta}, t = 2, \ldots, T; \tilde{\eta}$ is a vector of coefficients in the regression of Δy_t on $\Delta R_t; \tilde{\Psi}_x$ is given by $y_1 - R_1 \tilde{\eta}$; and y_1 and R_1 denote the first observations of y_t and R_t, respectively. Corrections for autocorrelated errors are accomplished

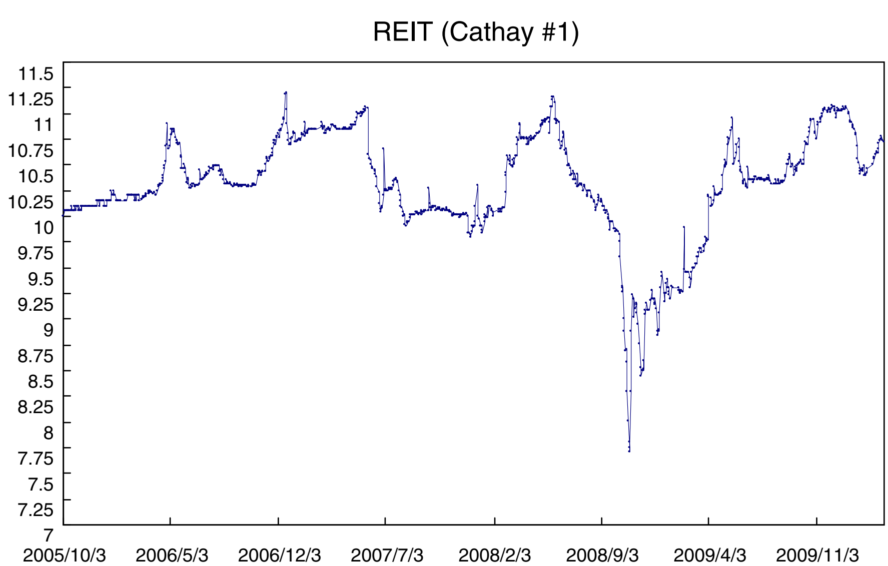

Fig. 2. Price movement of the REIT of Cathay No. 1 (October 8, 2005–March 15, 2010).

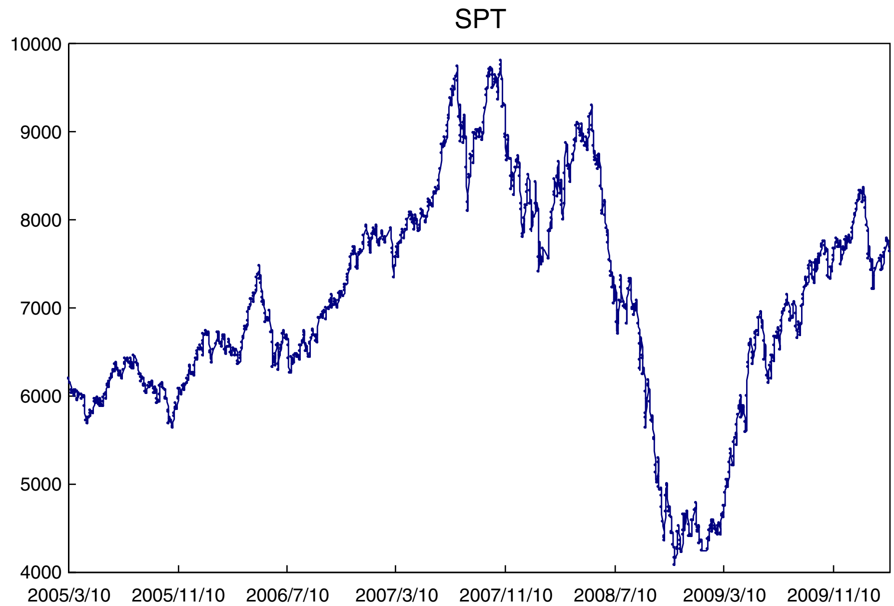

Fig. 3. Movement of the weighted price index of Taiwan Stock Exchange (SPT) (March 10, 2005–March 15, 2010).

via augmented terms $\Delta\tilde{S}_{t-j}, j=1, \ldots, k$, in Eq. (3), as with the ADF test. For Model C, where $B_{jt}=\Delta D_{jt}$ and $BT_{jt}=\Delta DT_{jt}^*$ (j = 1, 2), the unit-root null hypothesis is described by $\varphi=0$ (implying a unit root with two breaks), and the LM test statistics are given by:

$$\tilde{\tau} = \text{t}-\text{statistic for the null hypothesis } \varphi = 0. \tag{4}$$

From this, the LM unit-root test can endogenously determine the two breaks by utilizing a grid search as follows:

$$LM_{\tau} = \inf_{\lambda} \tilde{\tau}(\lambda). \tag{5}$$

There is a repeated procedure at each combination of break points, $\lambda_j=T_{Bj}/T, j=1, 2$. As shown in Lee and Strazicich (2003), the critical values for Models A and C depend on the location of the breaks (λ). Therefore, we utilize critical values that correspond to the location of the breaks.

We list the null and alternative hypotheses of Model C as:

$$\begin{aligned}&\text{Null}:\ y_t = \mu_0 + d_1 B_{1t} + y_{t-1} + v_{1t}\\&\text{Alternative}:y_t = \mu_1 + \gamma t + d_1 D_{1t} + \omega_1 DT_{1t} + y_{t-1} + v_{2t}\end{aligned} \tag{6}$$

However, if the vector of exogenous variables shows $R_t=[1, t]'$, then the DGP is the same as that shown in the no break LM unit-root test of Schmidt and Phillips (1992).

Tables 2 and 3 respectively present the results of the ZA (1992) tests and Lee and Strazicich's (2003) unit-root tests. Both these two tests show that all series carry a unit root in the level and reject the null of "non-stationarity" in the first difference. This insures the I(1) type series for all series considered. The results of the ZA test and Lee and Strazicich's (2003) tests indicate that the estimated break

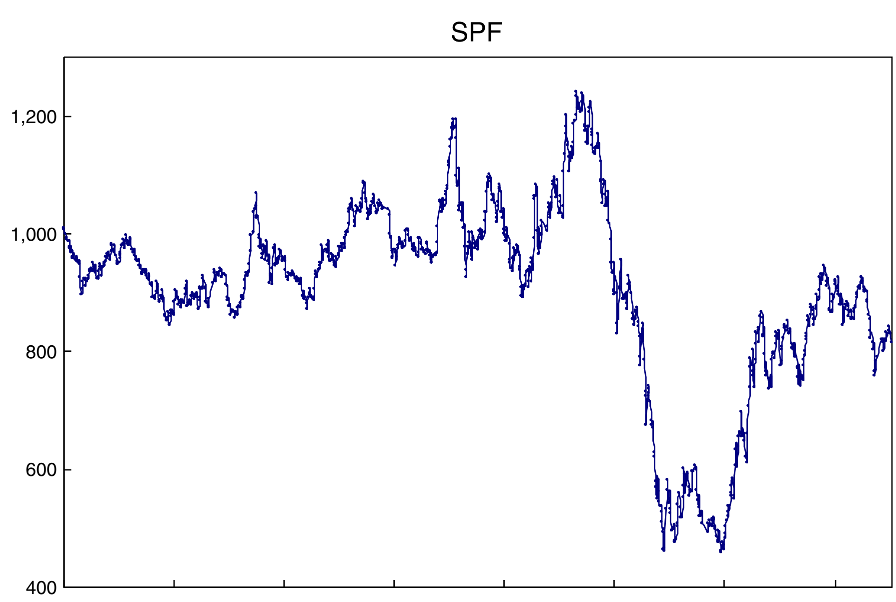

Fig. 4. Movement of the weighted price index of the financial sector (SPF) (March 10, 2005–March 15, 2010).

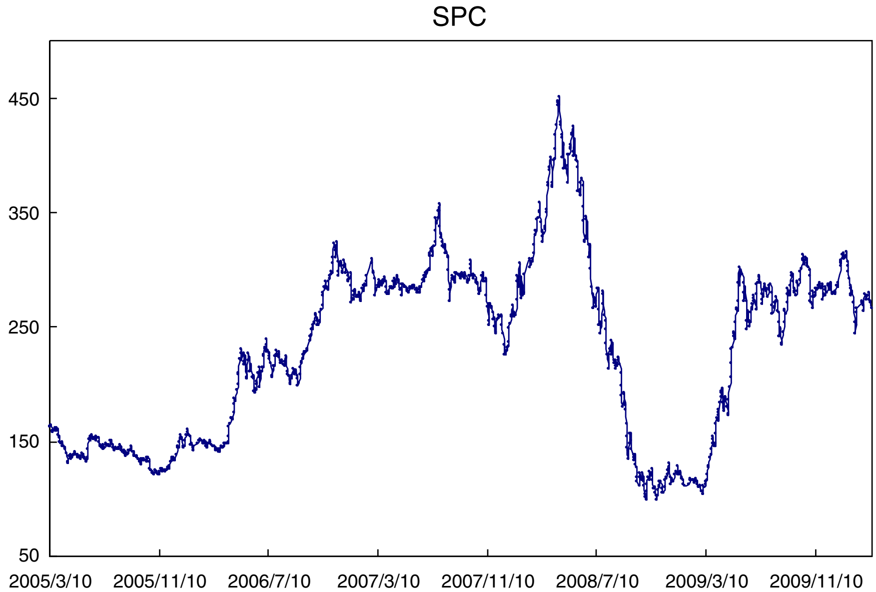

Fig. 5. Movement of the weighted price index of the construction sector (SPC) (March 10, 2005–March 15, 2010).

points occur around three periods, from April to September 2007, from May to November 2008, and from February to May 2009. We find critical economic incidents that match with the structural breaks of these series.

First, what is the reason causing the estimated break point from April to September 2007? On April 2, 2007, New Century Financial Corporation filed voluntary petitions for relief of bankruptcy, which was before the start of the Subprime Mortgage Crisis. Second, what is the reason causing the break points over the period from May to November 2008? Rescuing Bear Stearns with an emergency cash infusion, JP Morgan agreed to buy Bear Stearns for U$240 million in March 2008. Fueled by rumors and speculations, a drop in financial stocks was very likely. On September 7, 2008, it was announced that two government-sponsored agencies, Fannie Mae and Freddie Mac, would be nationalized to ensure financial stability. One week later, Lehman Brothers filed for bankruptcy, whereas around the same time, Bank of America announced that it would purchase Merrill Lynch. Events in October 2008 involved the collapse of all three of Iceland's major banks, which suffered the largest of all countries in economic history. For the above factors, there was major instability in global stock markets with major drops in market value over the period from May to November 2008.

The estimated break points from February to May 2009 are caused by the deregulation of the Qualified Domestic Institutional Investors (QDII) for Mainland Chinese to invest in Taiwan. According to Regulations on QDIIs Investing in Taiwan issued by the Taiwan Authority in April 2009, QDIIs approved by related mainland China economic authorities are permitted to invest in Taiwan. It is expected to bring in over NT$25 billion investment into Taiwan's stock markets under the 10% ceiling. The improvement in the cross-strait political relationship caused the break point.

Based on the test procedure of TY (1995), the test essentially involves two stages. First, the augmented $(k+d)$ VARs are estimated. We employ Akaike's Information Criterion (AIC) to select the lag-lengths of the VARs. Table 4 reports the optimum order of the VARs(k). Second, we apply the Wald test to test for Granger causality between variables. Table 5 shows TY's (1995) results, which provide convincing evidence of a uni-directional causality running from *SPT*,

Table 1
Results of unit-root test without breaks (Fubon No.1 and SP; 2005/3/10–2010/03/15).

Variable	ADF	PP	KPSS	DF-GLS	NP
Level					
Fubon #1	−2.149 [8]	−1.922[13]	0.504 [29]**	−2.027[8]	−8.496[8]
SPT	−1.752[14]	−1.439[8]	0.447 [29]**	−1.653[14]	−5.822[14]
SPF	−2.274[14]	−1.929[5]	0.303 [29]**	−2.273[14]	−11.425[14]
SPC	−1.951[14]	−1.454[8]	0.448 [29]**	−1.937[14]	−8.172[14]
First difference					
Fubon #1	−24.069 [1]**	−37.482 [13]**	0.065[13]	−2.426[14]	−251.646 [1]**
SPT	−7.901 [13]**	−33.452 [10]**	0.131[9]	−7.244 [13]**	−65.541 [13]**
SPF	−8.095 [14]**	−33.678 [8]**	0.071[7]	−7.427 [13]**	−109.734 [14]**
SPC	−7.195 [13]**	−30.127 [5]**	0.115[8]	−6.464 [13]**	−43.150 [13]**

Notes: The regressors include an intercept and a time trend. For the ADF and PP tests the 5% critical values are −3.413. For the DF-GLS test the 5% critical value is −2.890. For the KPSS test the 5% critical value is 0.146. For the NP test the 5% critical value is −17.30. The numbers in parentheses are the lag order in the ADF, DF-GLS, and NP tests. The lag parameters are selected on the MAIC. Truncation lags are for the Newey–West correction of the PP test in parentheses. The numbers in parentheses are the bandwidth for the KPSS test.
** Indicates significance at the 5% level.

Table 2
Zivot and Andrews test for unit roots with one break (Fubon No. 1 and SP; 2005/3/10–2010/03/15).

Variable	Statistic	Estimated break
Level		
Fubon #1	−3.065[2]	2008/06/09
SPT	−4.364[0]	2008/05/20
SPF	−4.282[0]	2008/06/09
SPC	−4.856[1]**	2008/05/23
First difference		
Fubon #1	−24.845[1]**	2007/04/30
SPT	−34.095[0]**	2008/11/20
SPF	−34.583[0]**	2008/10/28
SPC	−15.999[4]**	2008/04/18

Notes: The critical value for the 5% level is −4.80 for Model A from Zivot and Andrews (1992). Model A allows for a change in the level of the series. The lag parameters are selected based on the MAIC.
** Indicates significance at the 5% level.

Table 3
Two-break minimum LM unit root test for model C (Fubon No. 1 and SP; 2005/3/10–2010/03/15).

Variable	$\hat{k}$	$\hat{T}_B$	Test statistic	$\hat{d}_1^*$		$\hat{d}_2^*$	
Level							
Fubon #1	8	2006/12/26, 2008/10/13	−4.038	0.003**	(2.535)	−0.001	(−1.442)
SPT	1	2008/5/19, 2009/2/5	−3.889	−0.005**	(−4.377)	0.011**	(5.853)
SPF	2	2008/6/5, 2009/3/25	−4.676	−0.007**	(−4.232)	0.017**	(5.415)
SPC	1	2008/5/19, 2009/2/5	−2.997	−0.008**	(−4.143)	0.015**	(4.237)
First difference							
Fubon #1	1	2007/7/10, 2007/9/28	−38.721**	−0.112**	(−7.915)	−0.125**	(−8.838)
SPT	1	2008/3/11, 2008/7/14	−33.926**	2.761**	(19.740)	−1.312**	(−10.546)
SPF	1	2009/4/21, 2009/5/6	−34.608**	12.670**	(2.364)	−1.271	(−0.234)
SPC	4	2008/5/15, 2009/5/26	−17.074**	−12.445**	(−14.935)	15.873**	(14.867)

Notes: Term $\hat{k}$ is the optimal number of lagged first-differenced terms included in the unit root test to correct for serial correlation. $\hat{T}_B$ denotes the estimated break points. The 5% critical value for the minimum LM test with two breaks (Model C) is −5.286. Standardized coefficients ($\hat{d}_i^* = \hat{d}_i/\hat{\sigma}$) are reported. *T*-statistics for $d_i = 0$ are given in parentheses. Term *d* is the coefficient of dummy variables under the unit root null in Lee and Strazicich (2003).
** Denotes significance at the 5% level.

SPF, and *SPC* to Fubon No.1 at the 5% level of significance. The leading effects, of the other three stock price indices to Fubon No.1, may show that investors of this REIT are less sensitive to fluctuations in the stock markets. This result also indicates that changes in other three stock price indices are a good signal to make an investment decision for investors of Fubon No.1.[4]

The TY (1995) method is one way to explore the Granger causality relationship among the series. Nevertheless, it does not provide information about the responses of each variable to innovations in other variables, or whether the shock is eternal or temporary. Applying the GIRF analysis, as in Pesaran and Shin (1998), can explain this. Different from the standard approach, the GIRF solves the orthogonality problem inherent in traditional out-of-sample Granger causality tests.[5]

We execute the GIRF approach to find out which variable takes priority over the other. How lasting and intense are these effects?[6] The mutual impacts of shocks between Fubon No.1 and *SPT*, *SPF*, and *SPC* are shown respectively in Figs. 6–8. As the horizontal axis presents the days past the unanticipated innovations, the vertical axis is the extent of the response, scaled such that 1.0 equals 1 standard deviation. Using confidence intervals representing ±2 standard deviations is significant. We use a Monte Carlo simulation procedure with 1,000 replications to acquire error bands. The GIRF presents how long and to what extent each variable responds to unanticipated changes in other variables.

A shock from Fubon No.1 initially has significantly positive impacts on the other three stock price indices (in Figs. 6–8), but the shocks fade away within three days. Similarly, the shocks from the other three variables also have significant positive impacts on Fubon No.1, but diminish within one day. The point estimate shows that the impact effects from Fubon No.1 are all roughly 0.02 for the other three variables, while the impact effects from the others on Fubon No.1 vary, and the largest impact effect is from SPF at about 0.05.

Table 4
Selection of the order of the VARs(k) (Fubon No. 1 and SP; 2005/3/10–2010/03/15).

Lag	AIC		
	SPT	SPF	SPC
1	−12.334	−11.761	−11.267
2	−12.347	−11.773	−11.299#
3	−12.347#	−11.774#	−11.297
4	−12.342	−11.769	−11.293
5	−12.340	−11.764	−11.288
Optimal (k^*)	3	3	2

Notes: AIC stands for the Akaike Information Criteria. Term k^* is the selected order of the VARs. AIC results are suggested by Stock (1994). # indicates lag order selected by the criterion.

4.2. Case 2 — REIT of Cathay No. 1

Table 6 presents the results of the unit-root tests without structural breaks for the period covering from October 3, 2005 to March 15, 2010, indicating that all series are I(1) at the 5% level of significance. To consider structural breaks, Tables 7 and 8 respectively report the results of the ZA (1992) tests and Lee and Strazicich's (2003) tests. Both these tests show that all series carry a unit root in the level and reject the null of "non-stationarity" in the first difference, which insures the I(1) type series for all series considered. The ZA test and Lee and Strazicich's (2003) test results also indicate that the break point occurs for three periods in the last section, as in the case for the REIT of Fubon No.1.

We next employ AIC to select the lag-lengths of the VARs. Table 9 report the optimum order of the VARs(k), while Table 10 shows TY's (1995) test results. At the 5% significant level, we observe a bi-directional relationship between Cathay No.1 and other stock price indices, *SPT*, *SPF*, and *SPC*.

Table 5
Results of the Granger causality test based on the TY procedures (Fubon No.1 and SP; 2005/3/10–2010/03/15).

Variable	SP Granger causes REIT	REIT Granger causes SP	Direction of causality
SPT	7.314**	0.9109	*SPT*=>*REIT*
	[0.000]	[0.435]	*REIT*≠>*SPT*
SPF	6.446**	1.314	*SPF*=>*REIT*
	[0.000]	[0.269]	*REIT*≠>*SPF*
SPC	10.796**	0.140	*SPC*=>*REIT*
	[0.000]	[0.869]	*REIT*≠>*SPC*

Note: The $[k+d_{max}]$*th*-order level VAR is estimated with d_{max} being 1. The reported estimates are asymptotic Modified Wald statistics. The values in parentheses are *p*-values. ≠> denotes statistical insignificance and hence fails to reject the null hypothesis of non-causality. ⇒ denotes the rejection of the null hypothesis of non-causality.
** Indicates significance at the 5% level.

[4] In future research, we may utilize the estimating and testing procedures of multiple structural changes in the multivariate regressions proposed by Qu and Perron (2007) to examine whether structural breaks exist among variables.

[5] In the traditional (orthogonalized) impulse response function (IRF) the shocks to the VAR model are orthogonalized by using the Cholesky decomposition before computing the impulse response. The IRF is not invariant to the variables' ordering in the VAR (Pesaran and Shin, 1998), which may lead to the wrong results. Contrary to the IRF, the GIRF is invariant to variables' reordering in the VAR, and thus the GIRF could solve the orthogonality problem to make the results more accurate.

[6] In a stable economy an unexpected shock only has a temporary effect — that is, it may cause positive or negative impacts on economy, but these impacts will decrease as time goes. All results of the GIRF tend to converge to the equilibrium in the long run. Thus, positive or negative directions of the GIRF are very meaningful. However, using the Granger causality test is for mainly finding out and discussing the lead-lag relationship between variables. We can understand the interactions between variables through the impacts for the previous period's data of the variables in the systems. Thus, Granger causality and GIRF provide different information and different results in estimating the relationship between variables.

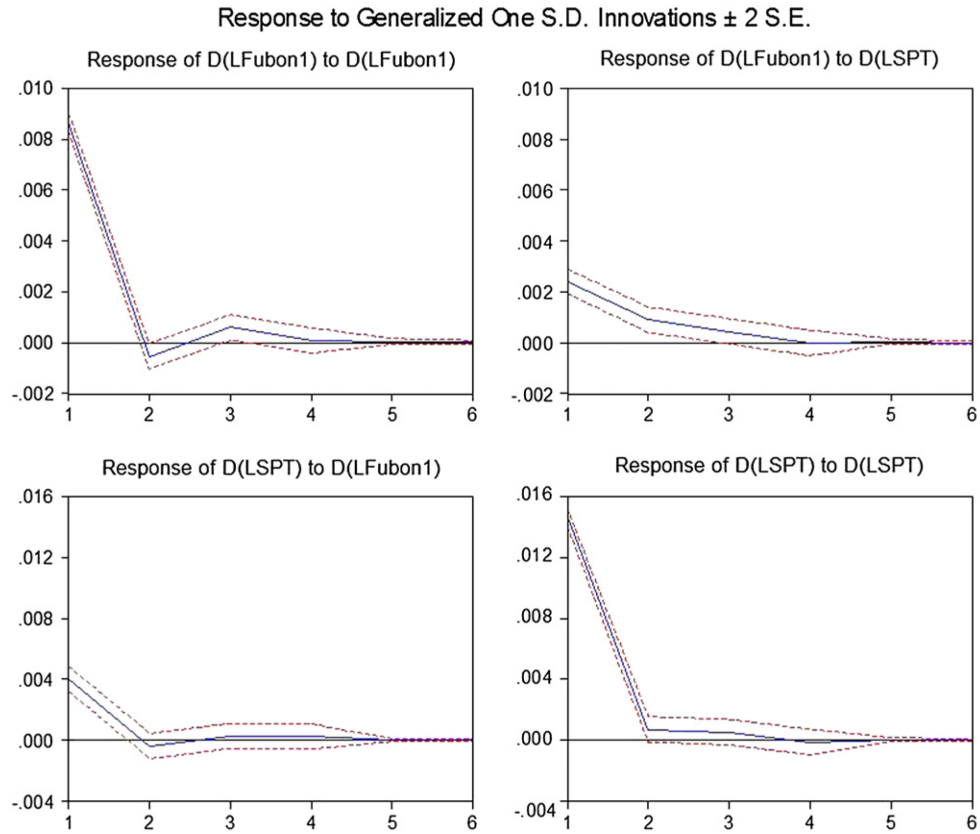

Fig. 6. Generalized impulse responses (a shock from Fubon No. 1 and SPT).

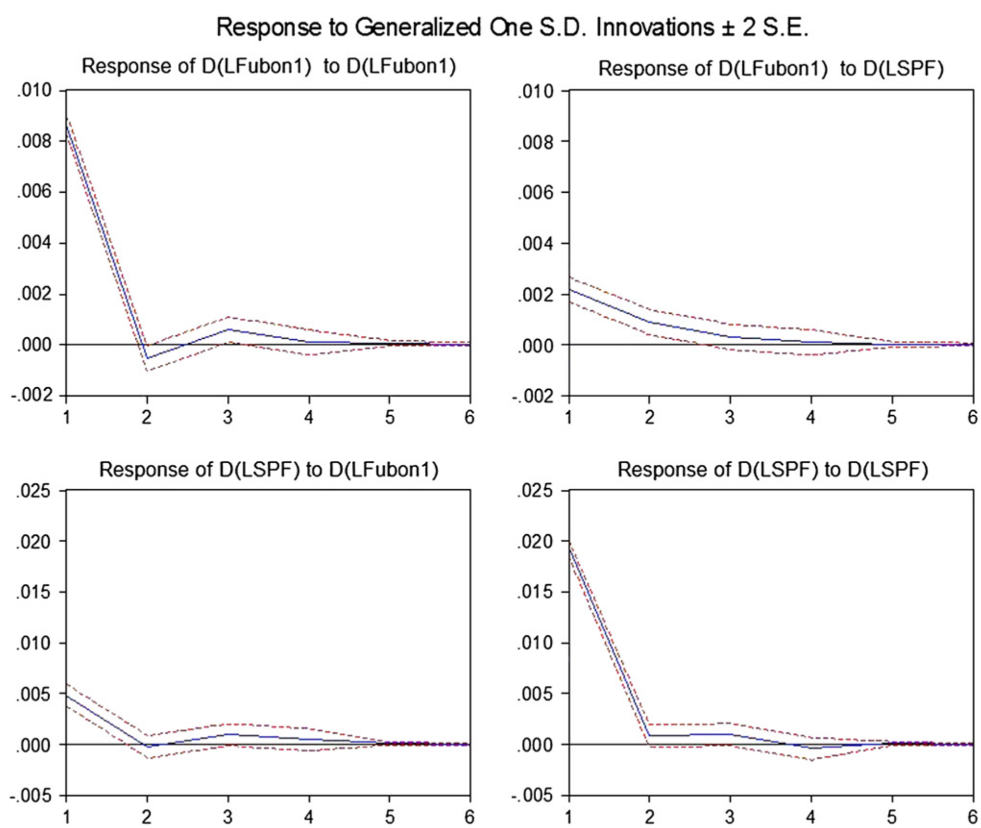

Fig. 7. Generalized impulse responses (a shock from Fubon No. 1 and SPF).

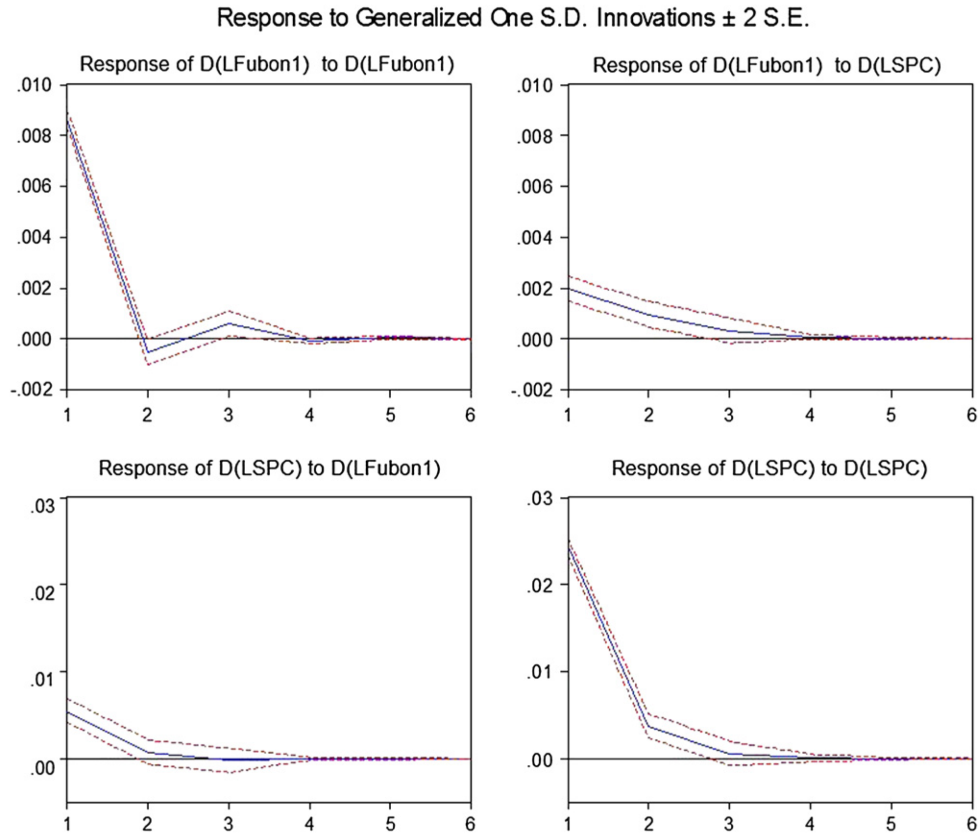

Fig. 8. Generalized impulse responses (a shock from Fubon No. 1 and SPC).

Being different from TY's (1995) results for Fubon No.1, there exist two-way lead-lag relationships between Cathay No.1 and the other stock price indices. In light of the reasons causing the bi-directional relationships, investors treat Cathay No.1 as a more common part of an investor's portfolio and a closer substitute for other stocks. Reasons for this include that the Cathay Group is the largest conglomerate as well as a financial holding corporation in Taiwan, and Cathay No.1 accounts more than 20% of all Taiwan REITs.

Figs. 9 to 11 respectively show the GIRF results among Cathay No.1 and *SPT*, *SPF*, and *SPC*. A shock from Cathay No.1 initially has significantly positive impacts on the other three stock price indices, but the shocks die out within three days. Similarly, the shocks from the other three variables also have significant positive impacts on Cathay No.1 and also weaken within two days. The point estimate shows that the impact effects from Cathay No.1 are all roughly 0.02 for the other three variables, while the impact effects from the others on Cathay No.1 are from 0.005 to 0.05, and the largest impact effect is from *SPF* at about 0.05.

4.3. Further discussions of Case 1 and Case 2

These two cases, Fubon No. 1-T-REIT and Cathay No. 1-T-REIT, present two different results of TY's (1995) causality. Why are they different? The reason is that the capitalization scale or business type of the individual T-REIT may lead or lag behind stock price indices. We will further demonstrate this as follows.

First, the reason why stock price index returns (*SPT*, *SPF*, and *SPC*) show only one way Granger causality on Fubon No. 1 may be due to the fact that the Fubon Group mainly focuses on financial services (e.g., insurance, banking, and securities). Although Fubon also has a construction

Table 6
Results of unit-root test without breaks (Cathay No.1 and SP; 2005/10/3–2010/03/15).

Variable	ADF	PP	KPSS	DF-GLS	NP
Level					
Cathay #1	−2.904[2]	−2.641[7]	0.256[25]**	−2.788 [2]	−15.835[2]
SPT	−1.867[14]	−1.456[11]	0.440[25]**	−1.533[14]	−4.885[14]
SPF	−2.243[14]	−1.838[7]	0.331[25]**	−2.079[14]	−9.494[14]
SPC	−2.176[14]	−1.604[4]	0.425[25]**	−1.609[14]	−5.579[14]
First difference					
Cathay #1	−15.523[4]**	−29.509[12]**	0.044[9]	−9.849[6]**	−971.577[4]**
SPT	−7.382[13]**	−31.530[13]**	0.153[11]**	−6.747[13]**	−52.828[13]**
SPF	−7.488[13]**	−31.676[10]**	0.083[9]	−6.435 [13]**	−61.004[13]**
SPC	−6.782[13]**	−28.312[3]**	0.142[3]	−5.807[13]**	−37.387[13]**

Note: The regressors include an intercept and a time trend. For the ADF and PP tests the 5% critical values are −3.413. For the DF-GLS test the 5% critical value is −2.890. For the KPSS test the 5% critical value is 0.146. For the NP test the 5% critical value is −17.30. The numbers in parentheses are the lag order in the ADF, DF-GLS, and NP tests. The lag parameters are selected on the MAIC. Truncation lags are for the Newey-West correction of the PP test in parentheses. The numbers in parentheses are the bandwidth for the KPSS test.
** Indicates significance at the 5% level.

Table 7
Zivot and Andrews test for unit roots with one break (Cathay No. 1 and SP; 2005/10/3–2010/03/15).

Variable	Statistic	Estimated break
Level		
Cathay #1	−3.464[2]	2009/04/02
SPT	−4.329[0]	2008/05/20
SPF	−4.345[0]	2008/06/09
SPC	−4.655[5]	2008/05/23
First difference		
Cathay #1	−21.466[1]**	2008/10/28
SPT	−32.202[0]**	2008/11/20
SPF	−32.604[0]**	2008/10/28
SPC	−15.068[4]**	2008/04/18

Note: The critical value for the 5% level is −4.80 for Model A from Zivot and Andrews (1992). Model A allows for a change in the level of the series. The lag parameters are selected based on the MAIC.
** Indicates significance at the 5% level.

Table 9
Selection of the order of the VARs(k) (Cathay No. 1 and SP; 2005/10/3–2010/03/15).

Lag	AIC		
	SPT	SPF	SPC
1	−12.576	−12.000	−11.505
2	−12.599	−12.025	−11.544
3	−12.601[a]	−12.030[a]	−11.545[a]
4	−12.596	−12.025	−11.542
5	−12.592	−12.020	−11.538
Optimal (k^*)	3	3	3

Note: AIC stands for the Akaike Information Criteria. Term k^* is the selected order of the VARs. AIC results are suggested by Stock (1994).
[a] Indicates lag order selected by the criterion.

company, it mainly constructs buildings for its own group. Therefore, Fubon No.1 is one-way affected by the three stock price index returns. This result of causality from stock price indices to REIT is consistent with that of Okunev and Wilson (1997), who also showed a lag time from the S&P 500 to Equity REITs in the U.S. This is intuitive since stock markets usually serve as the leading indicator of an economy's performance. Stock markets therefore usually lead the E-REIT markets.

Second, the underlying reasons for Cathay No.1 to lead the three stock price indices may be explained by the structure of the company's industry. The Cathay Group has a very strong market base and vast scale in Taiwan's construction industry. The assets of Cathay No. 1-T-REIT (NT $13.93 billion) are 1.7 times larger than the assets of Fubon No. 1-T-REIT (NT$8.09 billion). The Cathay Group not only builds residential and commercial properties, but also releases the "Cathay Index for Newly-Built Houses" (newly-built housing index in Taiwan) for investors' and homebuyers' references.

The Cathay Group is the largest private conglomerate in Taiwan, and its wealth is ranked within the top 100 in the Forbes global list. The capitalization of Cathay No.1 accounts more than 20% of all Taiwan REITs. Therefore, Cathay No. 1 is not just affected by the three stock price index returns, but its performance may also play a leading indicator for Taiwan's real estate, construction, and stock markets. For example, the Cathay Group bids for a parcel of real estate at a high price in Taipei City's central business district in 1986, thereafter introducing a massive wave of price appreciation for the local real estate market. The appreciation in real estate prices gained three-fold from 1986 to 1991 in Taiwan. Therefore, the results show that all three stock price index returns and Cathay No. 1 T-REIT have two-way Granger causal relationships.

The different capitalization scale or business type of these two REIT groups (Fubon and Cathay) causes different TY (1995) test results of causalities. Compared with other research findings, most studies have ascribed the different relationships to the time span of the sample data or economic situation. For example, Glascock et al. (2000) also found different relationships between the stock market and REIT market. They attributed the difference to the sample subperiods, structural changes, and economic environments. Clayton and MacKinnon (2003) also discovered different relationships between stock markets and REITs, imputing the difference to the scale of the REITs as well as the sample periods. Ling and Naranjo (1999) presented the integration relationship between stock markets and REITs, but the appraisal-based real estate returns failed to support the integration hypothesis. However, our finding herein is the first to discuss that the capitalization scale and business type of the REIT business group may also play a role in leading stock markets.

5. Conclusions and implications

The advent of the real estate securitization mechanism provides increased liquidity for traditional real estate investment. Taiwan promulgated the "Real Estate Securitization Statute" in 2003 and issued the first T-REIT in 2005. The special feature of a T-REIT – that all the target properties in the REIT portfolio require a board meeting for appraisal assessment by the government – was lifted in early 2007. Thus, this characteristic prompted us to examine whether it influences the performance of a T-REIT. We collected two T-REITs with the longest duration, Fubon No.1 and Cathay No.1, to test their causal relationships with the overall equity market, and the financial sector and construction sector indices. We apply TY's (1995)

Table 8
Two-break minimum lm unit root test for model C (Cathay No. 1 and SP; 2005/10/3–2010/03/15).

Variable	$\hat{k}$	$\hat{T}_B$	Test statistic	$\hat{d}_1^*$		$\hat{d}_2^*$	
Level							
Cathay #1	2	2008/10/6, 2009/4/6	−4.895	−0.004**	(−3.577)	0.004**	(3.196)
SPT	1	2008/5/16, 2009/2/12	−3.795	−0.007**	(−5.046)	0.012**	(5.558)
SPF	2	2008/6/25, 2009/3/25	−4.700	−0.011**	(−4.817)	0.018**	(5.300)
SPC	1	2008/6/18, 2009/3/31	−3.064	−0.013**	(−4.145)	0.016**	(4.064)
First difference							
Cathay #1	1	2008/9/11, 2008/10/23	−32.248**	0.098**	(6.789)	−0.026	(−1.845)
SPT	1	2007/8/10, 2007/8/14	−32.298**	−2.278**	(−3.093)	3.433**	(4.652)
SPF	1	2009/4/27, 2009/5/6	−32.898**	16.805**	(2.242)	−8.525	(−1.129)
SPC	4	2008/5/15, 2009/5/26	−16.137**	−12.658**	(−14.089)	15.986**	(14.089)

Notes: Term $\hat{k}$ is the optimal number of lagged first-differenced terms included in the unit root test to correct for serial correlation. $\hat{T}_B$ denotes the estimated break points. The 5% critical value for the minimum LM test with two breaks (Model C) is −5.286. Standardized coefficients ($\hat{d}_i^* = \hat{d}_i/\hat{\sigma}$) are reported. T-statistics for $d_i = 0$ are given in parentheses. Term d is the coefficient of dummy variables under the unit root null in Lee and Strazicich (2003).
** Denotes significance at the 5% level.

Table 10
Granger causality test results based on the TY procedures (Cathay No. 1 and SP; 2005/10/3–2010/03/15).

Variable	SP Granger causes REIT	REIT Granger causes SP	Direction of causality
SPT	3.836**	5.173**	*SPT=>REIT*
	[0.001]	[0.002]	*REIT=>SPT*
SPF	3.554**	7.809**	*SPF=>REIT*
	[0.014]	[0.000]	*REIT=>SPF*
SPC	4.913**	3.669**	*SPC=>REIT*
	[0.002]	[0.012]	*REIT=>SPC*

Note: The $[k+d_{max}]$*th*-order level VAR is estimated with d_{max} being 1. The reported estimates are asymptotic Modified Wald statistics. The values in parentheses are *p*-values. ≠> denotes statistical insignificance and hence fails to reject the null hypothesis of non-causality. ⇒ denotes the rejection of the null hypothesis of non-causality.
** Indicates significance at the 5% level.

procedure to draw conclusions regarding the causal relationship between T-REITs and other stock prices and further assess the relative strengths of the T-REITs and other stock prices by applying GIRF of Pesaran and Shin (1998). The main findings in our empirical results are as follows.

First, we find that all variables have the phenomena of a break point. The unit-test results from using the models of ZA (1992) and Lee and Strazicich (2003) indicate that the break points occurred around three periods: from April to September 2007, from May to November 2008, and from February to May 2009. We note critical economic incidents that match with these structural breaks of these series. The estimated break points over the period from April to September 2007 and the period from May to November 2008 are due to the global financial crisis. The break point from February to May 2009 is caused by the deregulation of Qualified Domestic Institutional Investors (QDII) for Mainland Chinese to invest in Taiwan.

Second, the results of TY's (1995) causality test indicate that there is uni-directional causality from the three stock price indices to REIT Fubon No.1, and there are bi-directional relationships between REIT Cathay No.1 and the three stock price indices. The different business types and scales of the REIT groups – Fubon Group and Cathay Group – cause different TY (1995) test results of causalities. Compared with other research findings, most studies have ascribed the different relationships to the time span of the sample data or economic situation. Our finding is the first to discuss that the capitalization scale and business type of the REIT group may also play a role in leading stock markets.

Third, according to the results of the GIRF between the two T-REITs and three stock price indices, a shock from both T-REITs initially has significantly positive impacts on the other three stock price indices, and vice versa.

The contribution of this study is that we are the first to employ the TY (1995) and the GIRF methods in the analysis of T-REITs' causal and dynamic linkages and discover that an individual REIT may lead or lag behind stock markets due to its various characteristics, business types, or scale of its mother company. Moreover, in the Taiwan context, people believe real estate is the most valuable asset and provides an interesting case for the empirical model of the REITs. The objectives of a generalization or international comparison may be achieved if data on many countries are collected for further empirical analysis.

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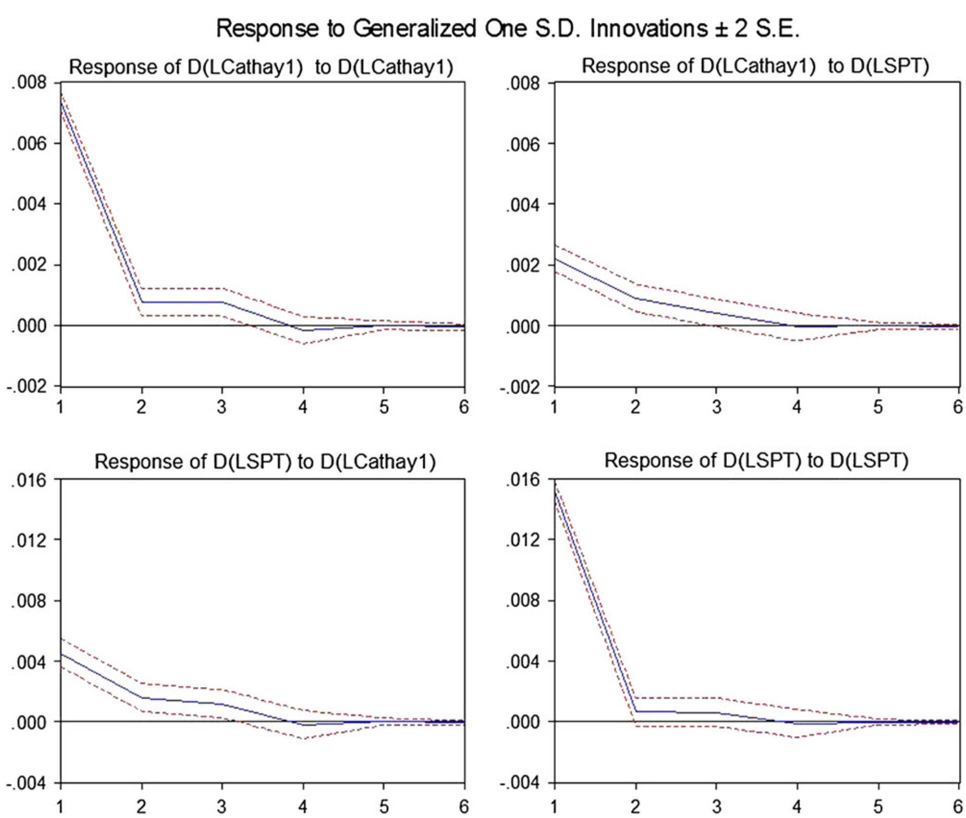

Fig. 9. Generalized impulse responses (a shock from Cathay No. 1 and SPT).

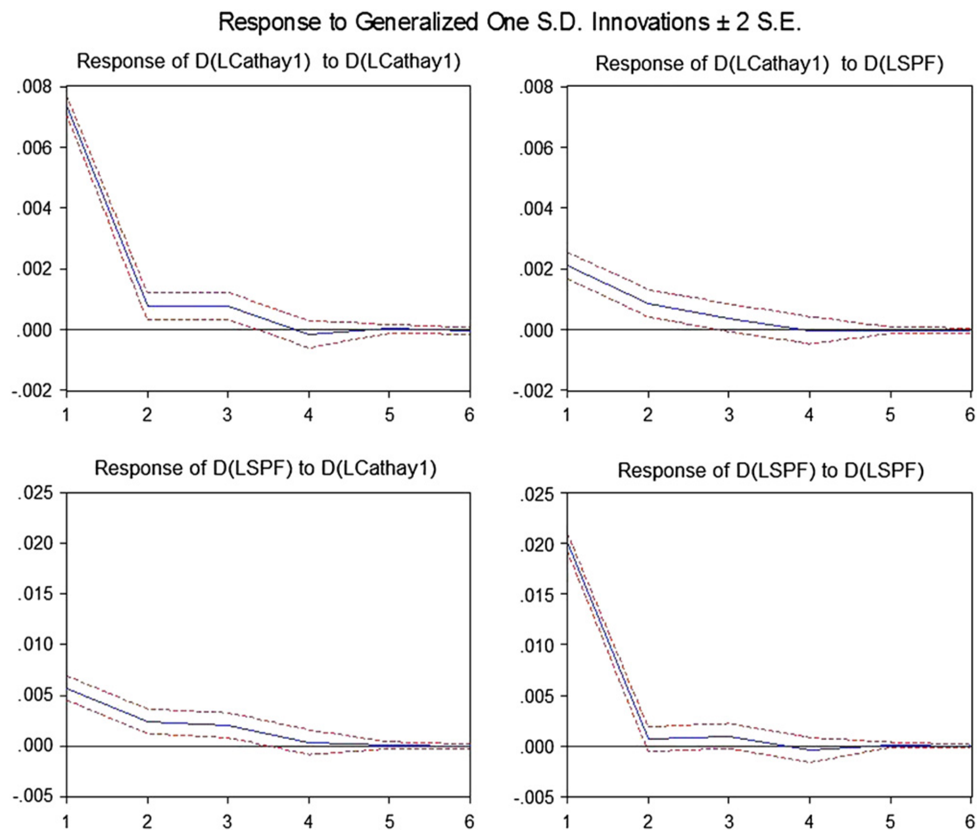

Fig. 10. Generalized impulse responses (a shock from Cathay No. 1 and SPF).

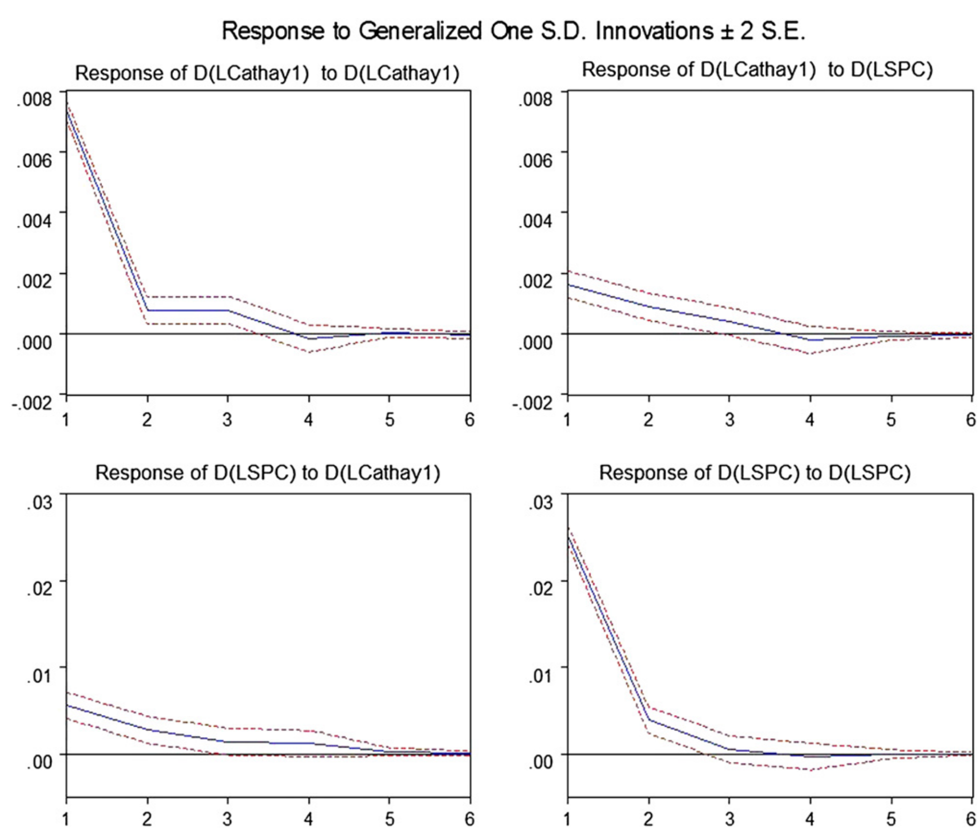

Fig. 11. Generalized impulse responses (a shock from Cathay No. 1 and SPC).

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