Economic Modelling 29 (2012) 291–298

Contents lists available at SciVerse ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Examining the stochastic behavior of REIT returns: Evidence from the regime switching approach

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ARTICLE INFO

Article history:
Accepted 19 October 2011

Keywords:
REITs
Markov switching model
Permanent component
Transitory component

ABSTRACT

In this paper the stochastic behavior of the returns on real estate investment trusts (REITs) is examined by using the unobserved component Markov switching (UC-MS) model. This approach endogenously permits the volatility to switch as the date and regime change and allows us to decompose the permanent and transitory components in REIT returns at monthly frequencies. The empirical evidence clearly shows that, for all of the REIT returns, the overall variance of the transitory component is significantly smaller than the corresponding variance for the permanent component. The durations of the high-variance regimes for both the fundamental and transitory components are short-lived and revert to normal levels quickly.

1. Introduction

Real estate investment trusts, known as REITs, are entities that invest in different kinds of real estate or real estate-related assets, including shopping centers, office buildings, hotels, and mortgages secured by real estate. The Real Estate Investment Trust Act of 1960 authorized the creation of REITs which permits small investors to pool their investments in commercial real estate in order to obtain the same economic benefits as might be obtained by direct ownership. The National Association of Real Estate Investment Trusts (NAREIT) classifies REITs into three categories: equity, mortgage, and hybrid. Equity REITs, the most common type of REIT, invest in or own real estate and make money for investors from the rents they collect. Mortgage REITs lend money to owners and developers or invest in financial instruments secured by mortgages on real estate. Hybrid REITs are a combination of equity and mortgage REITS.

The appealing aspect of REITs is that at least 90% of their taxable income must be distributed to shareholders annually in the form of dividends. Lee and Stevenson (2005) point out that REITs to some extent provide a hybrid form of investment, standing between equities and the fixed-income sector. The inclusion of REITs into the S&P's mainstream benchmark indices has also induced more investors to participate in this sector in recent years. The growth in investor awareness and interest in the REIT sector has encouraged the development of a large literature that examines the characteristics of the asset. For instance, many studies delve into the relationship between REITs and the broader capital markets. Studies such as Liu et al. (1990), Mei and Lee (1994), Ling and Naranjo (1999) and Glascock et al. (2000) all report strong relationships, often in terms of cointegration, between REITs and mainstream equities. A number of studies, however, have found contrasting evidence (see, for example, Clayton and MacKinnon, 2001; Okunev and Wilson, 1997).

A growing number of studies have examined the relationships among domestic REIT markets and the transmission of shocks across them (see, for example, Payne, 2006; Payne and Mohammadi, 2004) and have looked into the influence of macroeconomic state variables on the excess returns of REITs (see, for example, Chandrashekaran, 1999; Chen et al., 1986; Ewing and Payne, 2005; Karolyi and Sanders, 1998; Payne, 2003, 2006; Peterson and Hsieh, 1997). Another group of researchers (see, for example, Bredin et al., 2007; Cotter and Stevenson, 2006, 2008; Devaney, 2001; Najand and Lin, 2004; Stevenson, 2002) has focused on the return and/or volatility behavior of REITs.

The aim of this study is to investigate the issue regarding the stochastic behavior of REIT returns. The recent studies on asset prices have relied on decomposing the asset returns into the permanent and transitory components. Following this line of research, we adopt the unobserved component Markov-switching model (UC-MS) to achieve this goal. The reasons for adopting the UC-MS model in this study are as follows. First of all, an important feature of this model is the incorporation of the shocks in the permanent and transitory components. Each component is affected by the large and small volatilities, of which the shift between the two volatility regimes depends on a "transition probability". Furthermore, the volatility regime shift is decided by a stochastic process, which nests the determinant shift.

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doi:10.1016/j.econmod.2011.10.006

In addition, the shift itself is unknown a priori but lets the data speak for themselves.

Second, while there are many models that could help us examine the influences of large and small volatilities on both components, we hope that our model is general enough to nest different specifications. For example, Lastrapes (1989) and Lamoureux and Lastrapes (1990) showed that failure to allow for regime shifts may lead to an overstatement of the persistence of the variance of a series. This also justifies the use of a regime shifting model. Third, this approach is suitable at the monthly frequency. Hamilton and Susmel (1994) propose a switching ARCH model in which they allow the parameters of the ARCH process to come from one of several different regimes. Although the ARCH process controls the short-run dynamics, the long-run dynamics is governed by regime shifts in the unconditional variance, while an unobserved Markov-switching process drives the regime changes. These authors apply the model to weekly return data and show that the ARCH effects almost completely diminish after a month. This tends to indicate that when modeling monthly returns an ARCH term may not be necessary.

Our methodological approach parallels Kim and Kim (1996), Bhar and Hamori (2004) and Hammoudeh and Choi (2007). In particular, Kim and Kim (1996) examine the relative importance of the permanent and transitory components within the framework of the state-space model with Markov-switching heteroskedasticity. Bhar and Hamori (2004) study the behavior of stock returns of four G-7 countries. Chen and Shen (2004) examine the price and volume volatilities for Taiwan stock and foreign exchange markets. Hammoudeh and Choi (2007) examine the volatility of the decomposed stock returns of the Gulf Cooperation Council (GCC) countries and compare it to that for Mexico. Wilson et al. (2007) employ the unobserved component approach to examine interdependence across securitized property markets.

The major findings from this study are as follows. First, the results confirm the validity of using the unobserved component Markov-switching model in examining the REIT returns. Second, the evidence clearly shows that, for the three REIT returns, the overall variance of the transitory component is significantly smaller than the corresponding variance for the permanent component. Third, the graphs of filtered probabilities show that transitory component of returns switch between low- and high-variance regimes more frequently than that of the permanent component of returns. Finally, the existence of a correlation among REIT returns proves the inefficiency of portfolio diversification strategies for investors or speculators.

The rest of this paper is organized as follows. The methodological review and econometric modeling used in this paper are described in Section 2, and the empirical results and implications are presented in Section 3. Our concluding remarks are summarized in Section 4.

2. Econometric modeling

2.1. Methodological review

The decomposing of a series into permanent and transitory components starts from GDP studies. This literature includes the influential papers by Nelsson and Plosser (1982), Watson (1986), Campbell and Mankiw (1987), and Cochrane and Sbordone (1988). At this early stage, the concept is straightforward in a time series framework. For example, Nelsson and Plosser (1982) matched a model consisting of transitory and permanent components to an autocorrelation function to determine the relative sizes of these two components. Cochrane (1988) focused on how large the random walk is in GDP. His GDP series incorporates an arbitrary serial correlation in the transitory components and the random walk process. All this research, however, has assumed either that there is only one disturbance perturbing the time series under study, or that the underlying permanent component has a very special structure, for instance, that it has serially uncorrelated increments.

The methodology has soon been applied to the study of stock returns since it helps us understand the sources of the mean-reverting process and the resulting predictability. Typically, the permanent component is described by a random walk process and the transitory one is an autoregressive stationary process. If only the former exists, no mean-reverting phenomenon exists and the stock return is non-predictable. Alternatively, if only the latter exists, the stock return displays a strong mean-reverting pattern and is predictable. However, in reality, either the polar cases do not exist because the stock return is commonly found to be a mixture of the two processes. Thus, it becomes interesting to identify which component dominates. In particular, the dominance may be different in the short and the long terms. Simply put, when or how can the stock returns be predictable?[1]

Fama and French (1988) found that the mean-reverting process, which is estimated by the autocorrelation coefficient, displays a U-shaped pattern against the time horizon. For example, within a year, the autocorrelations are close to zero but they become negative for 2-year returns, reach minimum values for 3–5-year returns, and then move back toward 0.0 for longer return horizons. Thus, the hypothesis is that the mean-reverting process increases as the time horizon increases up to three years.[2] Hence, the permanent component dominates the variation of returns in the short and longer terms, whereas the transitory component dominates the mild-term. See also Poterba and Summers (1988) for a similar discussion.

In the earlier literature, the permanent and transitory components are simply assumed to be autoregressive processes. However, asset price returns are typically found to be affected by the volatilities. For example, REIT series may be hit by external shocks such as the 1987 US market crash, the 1994 Mexican crisis, the 1997 Asian financial crisis and the 2008 financial tsunami, among others. In these crashes or crises the observed stock prices experienced a dramatic change in volatilities. Thus, it needs to be asked whether these observed huge volatility changes result from either permanent or/and transitory components. Furthermore, large and small shocks impact the capital market in a mixed or rotated way, creating the turbulent and tranquil volatility periods in the economies. Thus, each component may not only be influenced by the volatility, but these volatilities could be further classified into two regimes, large and small volatility regimes. These new patterns should be incorporated into the model to reflect the change in the real world.

2.2. Permanent and transitory decomposition of returns

Following Fama and French (1988), let p_t be the natural log of a REIT price at time t. It is assumed that p_t is the sum of a random walk or the fundamental component, p_t^*, and a stationary (transitory) component, z_t:

$$p_t = p_t^* + z_t \tag{1}$$

$$p_t^* = \mu + p_{t-1}^* + e_t, \quad e_t \sim N\left(0,\ \sigma_e^2\right) \tag{2}$$

$$z_t = \phi_1 z_{t-1} + \phi_2 z_{t-2} + v_t, \quad v_t \sim N\left(0,\ \sigma_v^2\right) \tag{3}$$

The REIT return is given by

$$r_t = p_t - p_{t-1} = \mu + e_t + (z_t - z_{t-1}). \tag{4}$$

[1] There are many researchers, for example, to name a few, Li and Wang (1995), Kleiman et al. (2002), Stevenson (2002), Payne and Sahu (2004) and Belaire-Franch et al. (2007), that employ different approaches to study the predictability of REIT returns.

[2] The estimates for industry portfolios suggest that predictable variation due to mean reversion is about 35% of 3–5-year return variances.

When the transitory component z_t has a root close to, but not equal to, unity, a given change in price tends to be reversed over a long period of time by a predictable change in the opposite direction (Fama and French, 1988). Kim and Kim (1996) assume that z_t follows an AR(2) process and rewrite the model in state space form as follows:

$$r_t = \mu + [1 \quad -1] \begin{bmatrix} z_t \\ z_{t-1} \end{bmatrix} + e_t \tag{5}$$

$$\begin{bmatrix} z_t \\ z_{t-1} \end{bmatrix} = \begin{bmatrix} \phi_1 & \phi_2 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} z_{t-1} \\ z_{t-2} \end{bmatrix} + \begin{bmatrix} v_t \\ 0 \end{bmatrix}. \tag{6}$$

Eqs. (5) and (6) are called, respectively, the measurement equation and the transition equation. We can rewrite those equations in matrix form:

$$y_t = \mu + H\beta_t + e_t, \tag{7}$$

$$\beta_t = F\beta_{t-1} + v_t, \tag{8}$$

In Fama and French (1988), it is assumed that the error terms e_t and v_t are regime-invariant. However, the Markov-switching variances are assumed for the two shocks in this study. One is related to the permanent (σ_e^2) component and the other is related to the transitory (σ_v^2) component.

$$\sigma_e^2 = (1 - S_{1t})\sigma_{e0}^2 + S_{1t}\sigma_{e1}^2 \tag{9}$$

$$\sigma_v^2 = (1 - S_{2t})\sigma_{v0}^2 + S_{2t}\sigma_{v1}^2. \tag{10}$$

The two independent unobserved state variables, S_{1t} and S_{2t}, are assumed to be governed by a first-order Markov chain with a transition probability described by Eqs. (11) and (12), respectively:

$$\Pr[S_{1t} = 0 | S_{1t-1} = 0] = p_{00}, \qquad \Pr[S_{1t} = 1 | S_{1t-1} = 1] = p_{11}, \tag{11}$$

$$\Pr[S_{2t} = 0 | S_{2t-1} = 0] = q_{00}, \qquad \Pr[S_{2t} = 1 | S_{2t-1} = 1] = q_{11}, \tag{12}$$

where p_{00} and p_{11} are the transition probabilities for the low and high variance regimes of the permanent component, and q_{00} and q_{11} are defined similarly for the transitory component. We use a logistic transformation in formatting the transition probabilities and coding the Gauss program accordingly.[3]

Hammoudeh and Choi (2007) point out that there are two benefits from adopting this specification. First, we can incorporate regime shifts in variance structures within the permanent and transitory framework. Second, Kim and Nelson (1998) have shown that the Markov-switching heteroskedasticity model of stock returns is a good approximation of the underlying data generating process. In a GARCH framework, the unconditional variance does not change, whereas in a Markov-switching specification it changes depending on the state of volatility. This is the main difference between these two approaches used to capture the empirical characteristics of the stock return volatility. In addition to the fundamental differences between the ARCH-type and Markov-switching heteroskedasticity, an important motivation for considering a state-space model with Markov-switching heteroskedasticity is due to Lastrapes (1989) and Lamoureux and Lastrapes (1990), who show that failure to allow for regime shifts may lead to an overstatement of the persistence of the variance of a series.

To identify the permanent and transitory components and characterize their relationships within the REIT *returns*, as in Bhar and Hamori (2004) and Hammoudeh and Choi (2007), we set the model as follows:

$$r_t = \tau_t + c_t, \tag{13}$$

$$\tau_t = \mu + (Q_0 + Q_1 S_{1t})e_t, \tag{14}$$

$$c_t = \phi c_{t-1} + (h_0 + h_1 S_{2t})v_t, \tag{15}$$

where τ_t is the permanent part and c_t is the transitory (or temporary) part of the total return which is assumed to follow an AR(1) process. It is noted that in Fama and French (1988) the permanent component of the return is $\tau_t = \mu + e_t$, whereas the transitory component of the return is $c_t = \phi c_{t-1} + v_t$. The parameters h_1 and Q_1 represent the additional variance resulting from the economy entering the transitory high-variance state and permanent high-variance state periods, respectively. Eqs. (13)–(15) are labeled as the unobserved component Markov-switching (UC-MS) model.

We can estimate the unknown parameters using Kalman filter and Kim's (1993) mixed collapsing method. This involves generating a probability-weighted likelihood function and a recursive algorithm to update the probabilities as new observations become available. The estimation results will help us comment on the time series behavior of returns for a particular REIT. The nature of the model given by Eqs. (13) to (15) suggests that unobserved component modeling takes place in a state space framework. For a general understanding of the issues in unobserved component modeling, Harvey (1991) is an excellent reference. The modification to the standard estimation of state space models needed due to the presence of the Markov-switching variables is developed in Kim (1993).

3. Data and results

3.1. Data description and basic statistics

The sample period was determined primarily based on the availability of the data. Monthly data on the price indices for the three broad classifications of REITs in the US, namely, the Equity, Mortgage, and Hybrid REITs covering the period from 1971:12 to 2009:05 are used in the analysis.[4] The original data were obtained from the National Association of Real Estate Investment Trusts (NAREIT).[5] We do not consider the All REIT indices in this study. This is based on the following fact: at the end of 2003, out of a total of 171 REITs, 144 were classified as Equity REITs, with this sector accounting for 91% of the total REIT market capitalization. Therefore, the Equity and All REIT indices are effectively one and the same (Cotter and Stevenson, 2006). Rates of return were obtained by first-differencing the corresponding natural logarithms of the price indices.

Some descriptive statistics of the respective return series are outlined in Table **1**, which details the first four moments of each series and presents tests for normality and serial correlation. Several interesting facts are found from Table **1**. First, the coefficients of skewness of all of the series are negative, implying that returns are flatter to the left compared to the normal distribution. The coefficients of excess kurtosis for the raw returns are much higher than 0, indicating that the empirical distributions of these samples have fat tails. The coefficients of skewness and excess kurtosis reveal non-normality in the data. This is confirmed by the Jarque–Bera normality

[3] The transition probabilities are, of course, allowed to be time-varying, which are dependent on exogenous factors. Chang (2011) states that the transition probabilities may be affected by monetary policy and that the persistence (duration) of the regime also depends on the monetary policy. Chen and Shen (2007) consider the transition probabilities to be duration-dependent and examine this feature of five Pacific Rim stock returns.

[4] Based on an anonymous referee's suggestion, we update the data to 2011:07 for the Equity and Mortgage REITs. However, the sample periods retain from 1971:12 to 2009:05 for the Hybrid REIT since it is no longer available in the NAREIT.

[5] For more information on the data, please refer to the following website: `http://www.reit.com`.

Table 1
Summary statistics.

	Equity	Mortgage	Hybrid
Mean	0.00	−0.00	−0.00
S.D.	0.05	0.06	0.06
SK	−1.63	−0.81	−0.83
EK	12.34	4.59	5.58
JB	3054.15**	445.62**	636.30**
LB(24)	74.60**	41.46**	98.48**
ARCH(4)	25.34**	5.71**	59.50**
ADF	−15.47**	−19.72**	−6.97**

(1) Mean and S.D. refer to the mean and standard deviation, respectively.
(2) SK is the skewness coefficient.
(3) EK is the excess kurtosis coefficient.
(4) JB is the Jarque–Bera statistic.
(5) LB(24) is the Ljung–Box Q statistic calculated with twenty-four lags.
(6) ARCH(4) is the ARCH test calculated with four lags on raw returns.
(7) ADF is the Augmented Dickey–Fuller unit root test for returns.
** Denotes significance at the 5% level.

Table 2
p-values for a battery of non-linear tests.

	Equity	Mortgage	Hybrid
RESET1	0.0000[a]	0.0155	0.0824
RESET2	0.0001	0.0155	0.0000[a]
KEENAN	0.0000[a]	0.8102	0.0223
TSAY	0.0000[a]	0.8100	0.0015
MCLEOD	0.0000[a]	0.0000[a]	0.0000[a]
BDS	0.0000[a]	0.0000[a]	0.0000[a]
WHITE1	0.0902	0.0372	0.2340
WHITE2	0.0000[a]	0.0000[a]	0.0000[a]
NEURAL1	0.0000[a]	0.0063	0.1122
NEURAL2	0.0000[a]	0.0069	0.0488

(1) RESET1: Ramsey and Schmidt (1976). RESET 2: Thursby and Schmidt (1977).
(2) KEENAN: Keenan (1985). TSAY: Tsay (1986).
(3) MCLEOD: McLeod and Li (1983). BDS: Brock et al. (1996).
(4) WHITE1 and WHITE2 are White's (1987) information matrix tests.
(5) NEURAL1 and NEURAL2 are the neural network tests proposed in White (1989a,b).
(6) 0.0000[a] denotes the figure is less than 0.00001.

test as shown in Table 1. Second, the Ljung–Box Q-statistics, LB(24), indicate significant autocorrelations for all of the series. We also report a standard ARCH test for the raw returns. The test results indicate a significant ARCH effect. Finally, in order to avoid spurious conclusions due to the mis-specification of the data, stationarity tests are conducted with the Augmented Dickey Fuller (ADF) unit root tests for all of the series analyzed. The findings show that the price data cannot reject the null hypothesis of non-stationarity. However, once first differenced, the return series are stationary.

3.2. Results from the UC-MS model

In order to validate the Markov-switching model used in this paper, we first conduct several non-linear tests for all of the REIT returns. Psaradakis and Spagnolo (2002) examine the relative performance of some popular non-linearity tests when applied to time series generated by Markov-switching autoregressive models. The nonlinearity tests considered include RESET-type tests, the Keenan test, the Tsay test, the McLeod-Li test, the BDS test, the White dynamic information matrix test, and the neural network test. Their simulation studies suggest that these non-linear tests are, in general, helpful to discriminate the linearity from the Markov-switching model.[6] The results are reported in Table 2. Table 2 shows that most of the *p*-values of these non-linear tests are smaller than the 5% significance level or better, indicating that all of the REIT returns are better characterized by the Markov-switching model.

As outlined in the Introduction, asset returns are typically found to be affected by the volatilities. Thus, it needs to be asked whether these observed volatility changes result from either permanent or/and transitory components. Each component may not only be influenced by the volatility, but these volatilities could also be further classified into two regimes, namely large and small volatility regimes. These new patterns should be incorporated into the model to reflect the change in the real world and thereby help us to correctly evaluate the mean-reverting process. In order to achieve this goal, we estimate the unobserved-component model with Markov-switching heteroskedasticity developed by Kim and Kim (1996).

In estimating the model, we initially did not impose any constraints on any of the parameters except for (i) non-negativity constraints on standard errors (Q_0, Q_1, h_0, h_1), (ii) transition probabilities $0 \leq p_{11}$, p_{00} q_{11}, $q_{00} \leq 1$, and (iii) the stationarity condition for the fad component. One of these unrestricted MLEs fell on the boundary h_0, which violates the regularity condition. Therefore, to calculate the standard errors we imposed $Q_0 = 0$ and treated this parameter as a known constant for the purpose of calculating the second derivatives of the log likelihood. Several different specifications for each of the series were estimated, including the AR(1) and AR(2) processes. The finally chosen model is based on the likelihood ratio statistic of the AR (k) with respect to the alternative of the additional autoregressive coefficient, i.e., the AR ($k+1$), at the 5% level of significance. We perform a numerical estimation of the unknown parameters using the OPTIMUM module of GAUSS 3.2 with a combination of the Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm.

Table 3 shows the estimation results of Eqs. (13)–(15), i.e., the Markov-switching heteroskedasticity model. The first question we ask is whether each series' dynamics is well-characterized by the UC-MS model. The results show that the low variance estimates of the transitory component, i.e., h_0, is not significantly different from zero at the 5% level for all of the returns of the REITs. The additional measure of high variance estimates of the transitory component, i.e., h_1, are statistically significant at the 5% level for the three REITs (Equity, Mortgage, Hybrid). In other words, as these markets enter the high-variance state, the variance of the transitory component of these REIT returns increases.

The results for the variance state of the permanent component are somewhat different from those for the transitory component. The estimates of the UC-MS model suggest that the high-variance (Q_1) and low-variance (Q_0) regimes of the permanent components of the total return are respectively statistically significant at the 5% level for the three REITs (Equity, Mortgage, Hybrid). Thus, as these markets enter the high-variance state, the variance of the permanent component

Table 3
Estimation of permanent and transitory components.

	Equity	Mortgage	Hybrid
p_{00}	0.9960** (0.0036)	0.9816** (0.0091)	0.9945** (0.0048)
p_{11}	0.7900** (0.1601)	0.8909** (0.0524)	0.9573** (0.0507)
Q_0	0.0475** (0.0052)	0.0417** (0.0063)	0.0301** (0.0018)
Q_1	0.1875** (0.0596)	0.0897** (0.0138)	0.1273** (0.0261)
q_{00}	0.9627** (0.0405)	0.8309** (0.1619)	0.9574** (0.0251)
q_{11}	0.9456** (0.0234)	0.8284** (0.2681)	0.9145** (0.0606)
h_0	0.00003 (0.0005)	0.0003 (0.0011)	0.0001 (0.0014)
h_1	0.0287** (0.0020)	0.0296** (0.0044)	0.0697** (0.0083)
φ	0.0037 (0.0121)	0.1878 (0.1043)	0.1904** (0.0695)
μ	0.0059** (0.0017)	−0.0004 (0.0026)	0.0028 (0.0022)
RCM_p	2.951	20.855	9.597
RCM_t	55.455	86.358	46.441
LL	−840.4539	−733.622	−708.0022

Figures in parentheses are standard errors.
RCM_p is the regime classification measure for permanent component.
RCM_t is the regime classification measure for transitory component.
** Denotes significance at the 5% level.

[6] Readers are referred to Psaradakis and Spagnolo (2002) for detailed descriptions of these tests.

of these REIT returns increases. All in all, the findings generally confirm the validity of using the unobserved component Markov-switching model in examining the return variance.

The existence of the high-variance state for permanent and transitory components is important to both investors and speculators. Since the empirical results show that there exist two possible variance regimes in the two components of all REIT returns, then risk-averse investors should ask for higher compensation when the economy enters into the high-variance state regardless of whether the increase in variance is coming from a shock in the fundamentals or in the transitory component.

The estimates of transition probability p_{11} (the high-variance state of the permanent component) and the probability p_{00} (the low-variance state of the permanent component) are both highly significant at the 5% level for every REIT. This is also true for the estimates of the transition probabilities of the high variance (q_{11}) and low variance (q_{00}) states of the transitory components. The low-variance state permanent probability p_{00} is higher than the high-variance state probability p_{11}, suggesting that the low-variance state dominates the high-variance state for quite a long time. This result implies that the high-variance state for a permanent shock is not long-lived. This phenomenon is confirmed by the filtered probabilities as shown in Figs. **1**–**3**. In addition, the transition probability of the high-variance state of the transitory component q_{11} is smaller than the low-variance state probability q_{00}, which is indicative of the fact that the low-variance state dominates. In other words, the high-variance state for the transitory shock is short-lived and confirmed by the filtered probabilities in Figs. **4**–**6**. One thing worth noting is that in 2008 the permanent and transitory components enter the high-variance regime simultaneously. This suggests that, for all of the REIT returns, the shock from the 2008 financial tsunami is not only temporary, but also permanent.

To assess the quality of regime switching in our model, we calculate the regime classification measure (RCM) proposed by Ang and Bekaert (2002). It is defined as

$$\mathrm{RCM} = 400 \times \frac{1}{T} \times \sum_{t}^{T} p_t(1-p_t)$$

where p_t is the filtered probability of being in a certain regime at time t. Basically, this is a sample estimate of the variance of the probability series. It is based on the idea that perfect classification of regime would infer a value of 0 or 1 for the probability series and be a Bernoulli random variable. Good regime classification is associated with low RCM statistic values. A value of 0 means perfect regime classification and a value of 100 indicates that the two-regime model simply assigns each regime a 50% chance of occurrence throughout the sample. Weak regime inference implies that the model cannot successfully distinguish between regimes from the behavior of the data and may indicate misspecification. Consequently, a value of 50 is often used as a benchmark (Chan et al., 2011). The RCM measures are reported in the bottom of Table **3**. In the case of the permanent component, it is found that the RCM values for all the series are reasonably low, especially for the Equity REIT. In the case of the transitory component, it is found that the value of RCM of the Mortgage REIT is higher than the other two REITs. The high RCM value is consistent with frequently switch between regimes as shown in Fig. **5**. The RCM values show that the UC-MS model is able to confidently distinguish which regimes are occurring at each point in time, especially for the permanent component of returns.

Table **4** provides the total variances of the returns, permanent and transitory components. The variance is a permanent component derived by adding up the variances of the low and high states. The variance for the transitory component is calculated in the same way. The magnitude of the overall variance of return is derived by adding the variances of the permanent and transitory components. For all

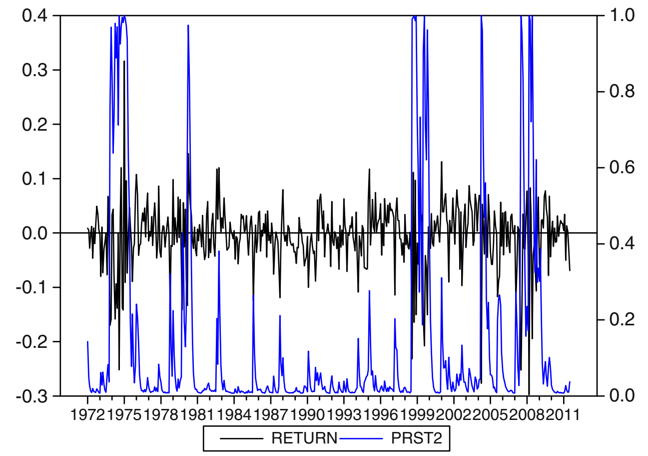

Fig. 2. Permanent component of Mortgage return (black line) and probability of high variance state for permanent component (blue line).

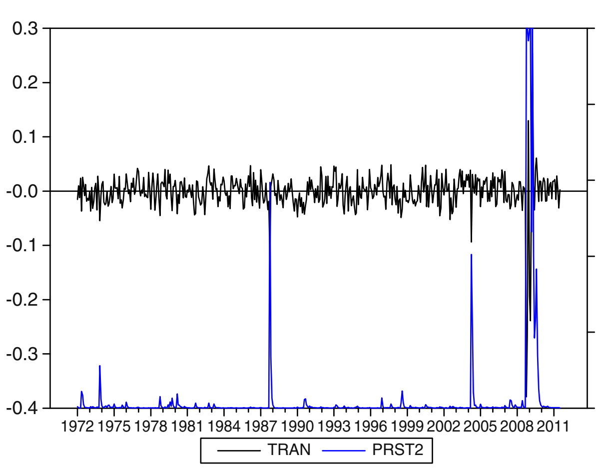

Fig. 1. Permanent component of Equity return (black line) and probability of high variance state for permanent component (blue line).

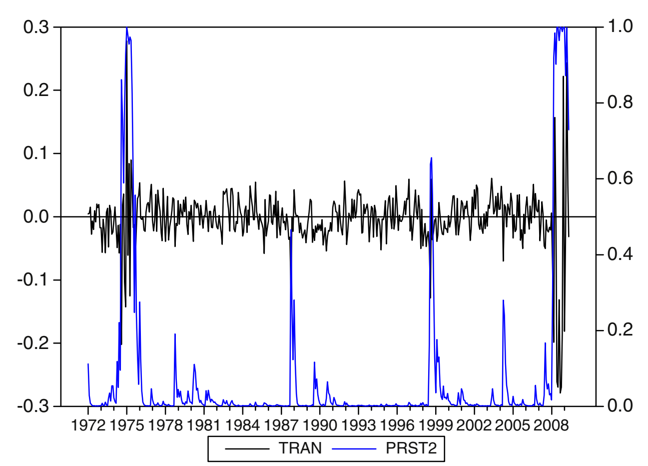

Fig. 3. Permanent component of Hybrid return (black line) and probability of high variance state for permanent component (blue line).

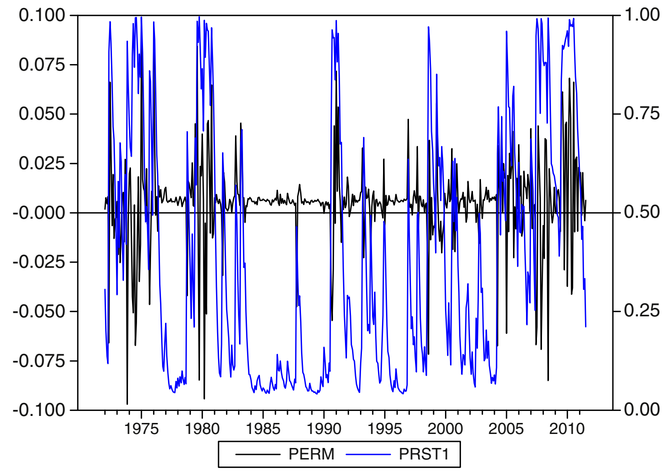

Fig. 4. Transitory component of Equity return (black line) and probability of high variance state for transitory component (blue line).

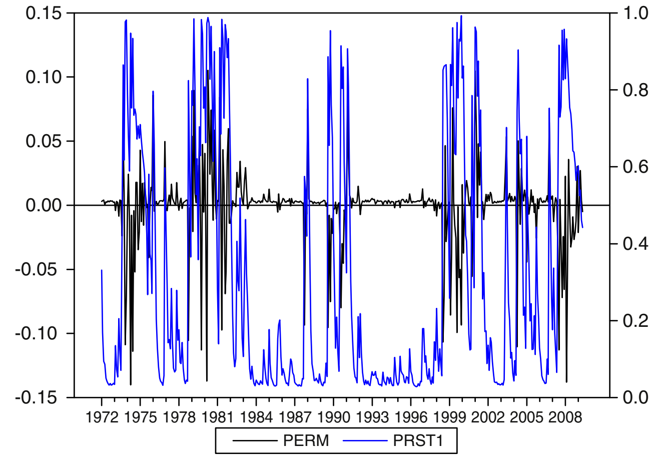

Fig. 6. Transitory component of Hybrid return (black line) and probability of high variance state for transitory component (blue line).

of the REIT returns, the overall variance of the transitory component is significantly smaller than the corresponding variance for the permanent component. This finding is unlike that of Hammoudeh and Choi (2007), who found that the overall variance for the transitory component is expected to be much higher than the corresponding variance for the permanent component of GCC stock returns. Our results show that the variance due to shocks in the fundamentals is much higher than the variance during fad times regardless of the state of the economy. Thus rational investors or speculators should ask for much higher premiums not only during turbulent times but also normal periods.

Table **5** gives the variance duration for the permanent and transitory components. Because the expected duration is calculated from the transition probabilities, the duration of the variance differs considerably among the REITs and also across the components. Several interesting facts can be extracted from that table. First, the overall duration for the permanent component is much longer than for the transitory component. Second, the durations of the high-variance state for the transitory and permanent components are shorter than those of the low-variance state. This result gives general support to the following fact: the variance of the high-variance regimes of both the fundamental and transitory components is short-lived and they revert to normal levels quickly. The investment implication of this fact is that risk-averse investors and traders should opt for a “buy and hold” strategy instead of a “chasing the wind” strategy in order to ride out the fundamental risk. As suggested by Hammoudeh and Choi (2007), monetary authorities and financial policy-makers should also be aware of the longer-lasting variance in the fundamentals' states for these markets. They should encourage the introduction of sophisticated financial instruments (e.g., options, futures) to reduce risk and volatility.

Table **6** shows the monthly contemporaneous correlation patterns for the return itself and for its permanent and transitory components between the Equity, Mortgage, Hybrid REITs. We can easily find that the correlation patterns are positive for the return itself and for its permanent and transitory components between these REIT returns, indicating that these returns move together in the short run and long run. This finding should not be surprising because these REITs are issued in the US and are located in the same geographical region and share many common social and economic characteristics. In terms of the movements of the returns, all REIT returns move in the same direction whether in terms of total return, fundamentals or fads under both variance regimes, suggesting that they are co-moved by a common factor such as political stability, liquidity and/or the financial tsunami in the short run and long run. This makes these markets the least eligible candidates, relatively speaking, for portfolio diversification.

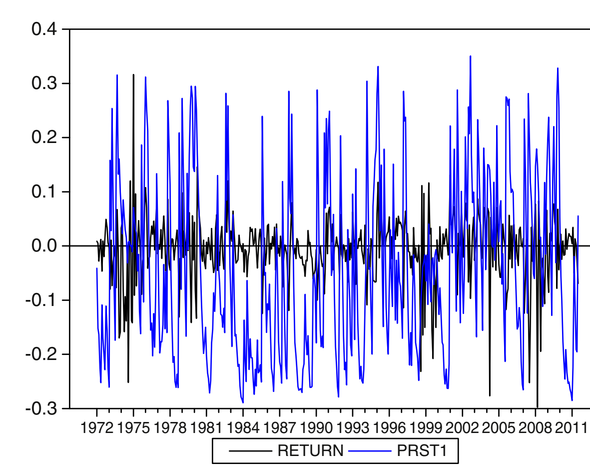

Fig. 5. Transitory component of Mortgage return (black line) and probability of high variance state for transitory component (blue line).

Table 4
Total variance of returns and permanent and transitory components.

	Equity	Mortgage	Hybrid
Permanent			
Low variance	0.0475	0.0417	0.0301
High variance	0.1875	0.0897	0.1273
Total	0.2350	0.1314	0.1574
Transitory			
Low variance	0.00003	0.0003	0.0001
High variance	0.0287	0.0296	0.0697
Total	0.02873	0.0299	0.0698
Return overall	0.26373	0.1613	0.2272

Table 5
Variance duration for permanent and transitory components.

	Equity	Mortgage	Hybrid
Permanent			
Low variance	250.00	51.55	181.82
High variance	4.76	8.94	23.42
Total	254.76	60.49	205.24
Transitory			
Low variance	26.81	12.06	23.47
High variance	18.38	8.53	11.70
Total	45.19	20.59	35.17

Duration is measured in months as 1/(1-probability).

4. Concluding remarks

This paper examines the stochastic behavior of the returns of real estate investment trusts (REITs) in the US. In doing so, we employ the Fama and French (1988) approach with modification. That is, we decompose the permanent and transitory components in the REIT returns at monthly frequencies using the unobserved component Markov-switching model, which builds upon the ideas set forth by Kim and Kim (1996) and Bhar and Hamori (2004). We estimate an unobserved component Markov-switching model for a vector of REIT returns. This approach allows us to decompose returns into permanent and transitory components and to analyze the impact of shocks of the permanent and transitory components. In addition, we can examine their impact on the overall return variance. Our empirical results lead to several interesting conclusions. First, the results confirm the validity of using the unobserved component Markov-switching model in examining the REIT returns. The evidence clearly shows that, for all of the REIT returns, the overall variance for the transitory component is significantly smaller than the corresponding variance for the permanent component. Second, the variances of the high-variance regimes of both the fundamental and transitory components are short-lived and revert to normal levels quickly. Finally, there is a positive correlation between these REIT returns and for the investors or speculators, the existence of a correlation proves the inefficiency of portfolio diversification strategies.

Acknowledgments

We would like to thank the editor, Professor Hall, and two anonymous referees of this journal for the helpful comments and suggestions. The usual disclaimer applies.

Table 6
Contemporaneous correlations.

	Equity	Mortgage	Hybrid
Return			
Equity	1		
Mortgage	0.512	1	
Hybrid	0.614	0.699	1
Permanent			
Equity	1		
Mortgage	0.343	1	
Hybrid	0.536	0.602	1
Transitory			
Equity	1		
Mortgage	0.439	1	
Hybrid	0.568	0.466	1

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