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# Time-Varying Betas of US REITs from 1972 to 2013

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**Abstract** This study estimates the time-varying REIT betas with a structural time series model using monthly REIT return data for the periods from 1972 to 2013. Based on the FTSE-NAREIT return indices for the equity REIT (EREIT) and mortgage REIT (MREIT), we found corroborative evidence of the temporal declines in the betas of the two REITs up to 1999. The time-varying beta characteristics of the two REIT betas are fundamentally different in the 2000s. While the MREIT betas continued to decline, the EREIT betas showed a sharp reversal of the downward trend. Coinciding with the low interest regime in the US, EREITs used more external debt to fund new acquisitions and development activities, and as a result, the EREIT betas increased sharply in 2000s. The EREIT betas hit the peak in 2009; and declined thereafter when active deleveraging occurred in the market. Using firm level data, we construct two leverage-sorted EREIT portfolios, and our empirical results do not reject the leverage effects on time-varying EREIT betas. However, we find that the leverage effect is not triggered by the declines in stock prices as proposed in the finance literature.

**Keywords** Time-varying beta · Systematic risk · Leverage effects · Deleveraging · Equity REITs and Mortgage REITs

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**JEL Classification** G1

## Introduction

REIT betas are dynamic and not static. Like the declining stock market betas,[1] equity real estate investment trust (EREIT) betas have declined since the 1970s. [2] Many empirical studies showed that US REIT betas are return-dependence (asymmetry)[3] and time-dependence.[4] However there are two gaps in the earlier studies. First, most of the earlier studies did not cover the late 1990s and 2000s periods, where significant transformation and modernization have taken place in the US REIT markets. The periods witnessed the Greenspan's low interest regime in the early 2000s, and also the period of "deleveraging" after the subprime crisis (Kawaguchi et al. 2012). REITs used more external debt to fund aggressive acquisitions and development activities (Bai et al. 2011). A rapid expansion in commercial credit in the 2000s has driven real estate booms in the US. Therefore, extending the data to cover the periods beyond 2000s allows us to better understand the US REIT beta behavior.

Second, using constant beta (OLS) models could not fully capture the dynamics of REIT betas (Harvey, 1989; Ferson and Harvey, 1991 and 1993).[5] Based on the time-varying coefficient (TVC) approach of Engle and Watson (1987), we propose to estimate changing REIT betas using a structural time series model consisting of a stochastic level term and a stochastic beta. Estimated using the Kalman filter technique, the model corrects for possible parameter instability and eliminates arbitrariness in having to a-priori fixing different break points.

The study uses new data sets covering the periods in the late-1990s and 2000s, and also new estimation methodology. We collect two sources of REIT data, which include the index-level data published by the European Public Real Estate Association-National Association of REITS (EPRA-NAREIT) and the stock-level data obtained from Center for Research in Security Prices (CRSP) database. The study covers the period from January 1972 to December 2013. Our empirical results show three important characteristics of the time-varying REIT betas. First, we find corroborative evidence showing temporal declines in EREIT and MREIT betas in the pre-2000s period, which are consistent with the findings in the earlier studies. However, a clear divergence in the two time-varying betas was observed in the 2000s, which suggests some fundamental changes to the two REIT markets. We find that EREITs in the 2000s are more sensitive to stock market shocks relative to the earlier periods including the 1990s.

[1] Franzoni (2002 and 2008) found that the market betas of value and small-cap stocks in the US decreased by more than 75 % in the second half of the last century.

[2] See the studies such as Ghosh et al. (1996); McIntosh et al. (1991); Khoo et al. (1993); Liang et al. (1995); and Lee et al. (2008).

[3] Sagalyn (1990), Goldstein and Nelling (1999) and Chatrath et al. (2000) found that REIT betas are high in declining markets than in advancing markets. However, Chiang et al. (2004) rejected the asymmetric beta hypothesis after controlling for the three Fama and French (1993) factors.

[4] EREIT betas were correlated with different risk factors over time starting with large-cap stock risk factors in the 1970s, small-cap stock risk factors in the 1980s, and the real estate risk factors in the post-1993 periods. Clayton and MacKinnon (2001, 2003) attribute the changing risk behavior to the maturation of REIT industry.

[5] Jagannathan and Wang (1996) and Lettau and Ludvigson (2001) also showed that constant beta unconditional CAPM model underestimate time-varying beta in the stock markets.

Second, could the “leverage effect” of Black (1976) and Christie (1982) explain the sharp increases in EREIT betas in the 2000s? In their hypothesis, stock price declines trigger an increase in the leverage ratio, and consequently, result in high stock price volatility. We construct two leverage-sorted portfolios of equity REITs and test if the betas of high leverage EREITs and low leverage EREITs behave differently over time. Our results do not reject the “leverage” effects; but our results are fundamentally different from that hypothesized by Black (1976) and Christie (1982), because the condition of stock price declines as assumed in the “leverage hypothesis” was not found in the 2000s period. Third, we did not find significant effects of REIT size (asset value) on dynamics of EREIT betas.

The remainder of the paper is organized as follows. Literature Review – Time-varying characteristics of REIT betas section reviews the literature on time-varying betas of REITs. Data Analysis section explains the TVC framework and the structural time series model. Empirical Results section covers the data analysis and empirical methodology. Conclusion section analyzes the empirical results. Section 6 concludes the paper.

## Literature Review – Time-varying characteristics of REIT betas

There are three strands of literature that have examined the characteristics of the REIT beta over different periods. The earliest strand of literature found evidence of declining REIT betas using empirical data that may not cover the important periods of the REIT modernization in the US. [6] McIntosh et al. (1991) Khoo et al. (1993) and Ghosh et al. (1996) are among the earliest researchers attempting to explain the declining REIT beta phenomenon. McIntosh et al. (1991) showed that REIT betas share similar characteristics of small-cap stocks, but their results showed no small stock return anomaly in REITs, which is inconsistent with the finance literature. Khoo et al. (1993) then argued that increases in the number analysts following REITs improve information efficiency in the market. In contrary to the hypothesis that increased analysts’ coverage reduces variations between REITs and stock markets, they however, argue that price discovery occur in the direct real estate market. The same reason was also cited by Ghosh et al. (1996) who showed that REIT returns were more correlated with real estate market fundamentals after the 1980s.

The second strand of literature examines the cyclical characteristics of REITs. Different market cycle definitions were used by the literature. Sagalyn (1990) Goldstein and Nelling (1999) identified booms and busts based on positive and negative excess market returns, respectively; whereas Glascock (1991) used the definition of the National Bureau of Economic Research (NBER) to identify the recession periods. The studies showed contrasting results when the two different definitions were used when testing cyclical behaviors of REIT betas. Sagalyn (1990) and Goldstein and Nelling (1999) showed that equity REIT betas were higher in declining markets than in advancing markets. However, Glascock (1991) showed that REIT beta was pro-cyclical that increased in the up-markets.

[6] Except for Ghosh et al. (1996), the two earlier studies did not cover the period beyond 1993, which is known as the strong growth phase of US REITs.

Chatrath et al. (2000) tested the REIT beta behaviors in two different sub-periods: 1972–1985 and 1986–1998, and found that the asymmetric REIT betas were significant in the two periods, but the effect was weakened in the second period (1986–1998) relative to the first period (1972–1985). Their results were consistent with those found in Sagalyn (1990) and Goldstein and Nelling (1999). They described the results that were usually linked to the small-cap stocks as the "asymmetric REIT-beta puzzle", because the asymmetry in REIT beta effects could not be explained away when the small-cap index was used as the proxy of market return in the models. The asymmetric REIT-beta hypothesis was challenged by Chiang et al. (2004), who found that asymmetry in REIT betas disappeared after controlling for the three Fama-French factors in the models.

The third strand of literature seeks to explain the questions of what drive changing REIT beta behavior. Have REIT betas become more real estate-like or more stock-like? Clayton and MacKinnon (2001, 2003) found that REIT betas were correlated with the large-cap stock risk factor in the 1970s and the small-cap stock risk factor in 1980s. However, REIT betas become more real estate-like after 1992,[7] of which Clayton and MacKinnon (2001 and 2003) called the period of maturation of REIT. The real estate risk factor story was rejected by Peterson and Hsieh (1997) who showed that variations in EREIT returns were fully explained by the three Fama-French risk factors. Glascock et al. (2000) showed that REIT returns were more stock-like than real estate-like in the post-1992 period.

The post-1990s period witnessed significant structural shift in the REIT betas. The large influx of institutional capital into the US REIT market not just propelled an explosive growth in the US REIT markets; a new breed of more sophisticated institutional investors (Wang et al. 1995; Chan et al. 1998; Ling and Naranjo, 2003)[8] could have transformed the REIT beta characteristics. "New REITs" entering the market in the post-1992 periods were significant different from "old REITs". Ott et al. (2005) showed new REITs were generally larger; have higher leverage; and invested more. They adopt complex financing structure to support high Tobin's Q investments and acquisitions. The 2000s represents another interesting period, during which REITs switched from "leveraging" in 2000–2006 to "deleveraging" after 2007. Bai et al. (2011) argued that REITs use the cheap credit supply to expand their real estate portfolios in the 2000s driving significant real estate price inflation. Kawaguchi et al. (2012) found significant "leverage effects", where the REIT variances increases significantly in the post-Greenspan era (after 2007).

How has the transformation of modern REITs, especially in the 2000s, changed their beta behavior? We may expect modern REIT betas to have less defensive attributes,[9] but be more correlated with growth-related market risks. However, the empirical evidence verifying the time-varying characteristic of REIT betas in the

[7] Mei and Lee (1994) and Ziering et al. (1997) found a significant real estate risk factor in REIT pricing.

[8] The relaxation of the rules restricting institutional holdings of REITs through the "look-through" provisions in 1993 Tax Reform has been the single most important policy change that has caused the surge in institutional investments into the REIT market.

[9] Being conceived as a defensive vehicle, REITs distribute 90 % of more income generated from their real estate portfolios backs to investors as dividends.

1990s and 2000s is scarce, if there exists. This motivates our study to test the changing REIT beta behavior using the TVC model.

### Time-Varying Coefficient (TVC) Framework

Based on the three-factor model proposed by Fama and French (1993), the excess REIT return is defined as a function of an excess market risk and two additional risk factors ("SMB" and "HML" factors):

$$R_{i,t} - R_{f,t} = \alpha + \beta_t\left(R_{m,t} - R_{f,t}\right) + \gamma\ SMB + \lambda\ HML + \varepsilon_t, \varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right) \quad (1)$$

where $R_{i,t}$ denotes the asset return of REIT $i$, where the subscript $t$ indicates the time; $R_m$ denotes the market return; $R_f$ is the risk-free rate of return; SMB captures the size risk computed as the difference in returns between small and large stock portfolios; and HML captures the growth risk factors computed as the differences in returns of portfolios of high B/M ratio (book to market value ratio) stocks and low B/M ratio stocks. The three estimated parameters $\alpha$, $\beta$ and $\varepsilon$ represent intercept term, REIT beta, and regression error, respectively.

Based on the TVC framework proposed by Engle and Watson (1987), we extend the static CAPM model as in Eq. (1) to allow for a stochastic level term ($\alpha$) and a stochastic beta term ($\beta$), where the two terms are driven separately by random walk processes. The model, which is known as a local trend transition model, is augmented with a stochastic beta term, and represented below:

$$\alpha_{t+1} = \alpha_t + \zeta_t, \zeta_t \sim N\left(0, \sigma_\zeta^2\right) \quad (2)$$

$$\beta_{t+1} = \beta_t + \eta_t, \quad \eta_t \sim N\left(0, \sigma_\eta^2\right) \quad (3)$$

where $\zeta_t$ and $\eta_t$ are uncorrelated irregular terms that are *i.i.d* with zero means and constant variances ($\sigma_\zeta^2$ and $\sigma_\eta^2$). The beta in Eq. (3) is time-varying, if $\beta_t$ and $\sigma_\eta^2$ are significantly different from zero. We estimate the time-varying beta with a stochastic trend term using the Kalman filter estimator. [10]

## Data Analysis

### Data Sources and Descriptive Statistics

We use two sources of aggregate-level data in our empirical tests. First, we obtained the total monthly return indices published by the FTSE and the National Association of Real Estate Investment Trusts (NAREIT) for the period from January 1972 to December 2013. The monthly series total returns of equity REIT (EREIT) and mortgage REIT (MREIT), are used in the study. Like the earlier studies, we model the behavior of the two REIT betas separately using the three-factor Fama-French CAPM

[10] Refer to Harvey (1996) for technical details.

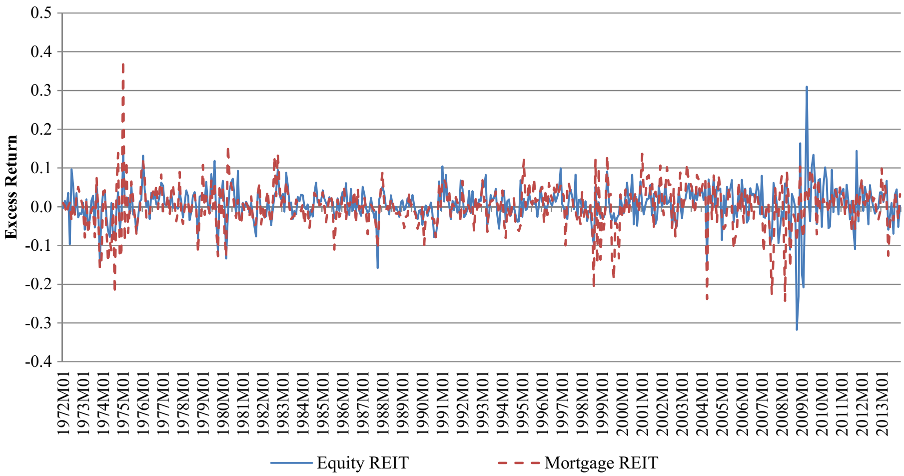


**Fig. 1** Excess returns of equity REITs and mortgage REITs. Note: The figure plots the excess returns of equity REITs (*EREITs*) and mortgage REITs (*MREITs*) for the sample period from January 1972 to December 2013, where "M" in the figure denotes the month of the year. The excess return of REIT is computed as the different between total return of REIT index and the risk free rate of return. The total return indices of EREITs and MREITs are obtained from FTSE-NAREIT, and risk-free rate is the 1-month T-bill rate obtained from Professor French's website

models, which are also augmented with the return-dependence (asymmetric) and time-dependence (up and down markets) dummies. We then extend the model to capture the time-varying characteristics of beta using the structural time series models (the local trend with stock beta model as in the previous section).

The three Fama-French benchmark risk factors included in the model are an excess market return, [$R_m$-$R_f$ ], which is constructed from the value-weighted return on all NYSE, AMEX, and NASDAQ stocks (from CRSP) minus the 1-month Treasury bill rate (from Ibbotson Associates); a size risk factor, "SMB" (Small minus Big), which is the average return on three small portfolios minus the average return on three large portfolios; and a growth risk factor, "HML" (High minus Low), which is the average return on two value portfolios minus the average return on two growth portfolios.[11] The monthly data on the three risk factors are obtained from Professor French's website Fig. 1.

The descriptive statistics on the excess market return, risk-free return, and excess returns of EREITs and MREITs are summarized in Table 1. The means and standard deviations of the two benchmark risk factors (SMB and HML) are also included. We present the statistics for the full sample period (1972M1-2013M12) and also three sub-periods (1972M1-1989M12; 1990M1-1999M12 and 2000M1-2013M12). The full sample period results show that the average monthly excess returns of the EREIT and MREIT were estimated at 0.6 and 0.2 %, respectively. Both REIT returns outperformed the excess market return of 0.05 % and the risk-free rate of return of 0.4 %. In term of volatility, the risks of the two REITs, EREITs (0.050) MERITs (0.059) were higher than the stock market risk (0.046).

[11] See Fama and French, 1993, "Common Risk Factors in the Returns on Stocks and Bonds," *Journal of Financial Economics*, for a complete description of the factor returns.

**Table 1** Descriptive statistics

| | Excess return of equity REIT | Excess return of mortgage REIT | Risk-free return | Excess stock market return | Size risk factor | Growth risk factor |
|---|---|---|---|---|---|---|
| Symbol | EEQRET | EMGTRET | RF | MKT_RF | SMB | HML |
| 1972M1-2013M12 | | | | | | |
| Mean | 0.006 | 0.002 | 0.004 | 0.005 | 0.002 | 0.004 |
| Std. Dev. | 0.050 | 0.059 | 0.003 | 0.046 | 0.031 | 0.030 |
| Observations | 504 | 504 | 504 | 504 | 504 | 504 |
| 1972M1-1989M12 | | | | | | |
| Mean | 0.005 | −0.001 | 0.006 | 0.004 | 0.002 | 0.006 |
| Std. Dev. | 0.041 | 0.059 | 0.002 | 0.049 | 0.029 | 0.028 |
| Observations | 216 | 216 | 216 | 216 | 216 | 216 |
| 1990M1-1999M12 | | | | | | |
| Mean | 0.004 | −0.001 | 0.004 | 0.011 | −0.001 | −0.001 |
| Std. Dev. | 0.037 | 0.057 | 0.001 | 0.040 | 0.029 | 0.028 |
| Observations | 120 | 120 | 120 | 120 | 120 | 120 |
| 2000M1-2013M12 | | | | | | |
| Mean | 0.010 | 0.007 | 0.002 | 0.003 | 0.004 | 0.005 |
| Std. Dev. | 0.066 | 0.060 | 0.002 | 0.047 | 0.036 | 0.034 |
| Observations | 168 | 168 | 168 | 168 | 168 | 168 |

This table reports the descriptive statistics of excess returns of Equity REIT (*EREITs*) and Mortgage REITs (*MREITs*), which are based on the total return indices of the FTSE-NAREIT (National Association of REIT). The risk-free interest rate (*RF*), the excess value-weighted stock market returns, (*MKT_RF*), the size (*SMB*) and growth (*HML*) benchmark risk factors are obtained from Professor Kenneth French's website. The statistics including mean, standard deviation and observation for the full sample period and different sub-periods are reported in the table

When we analyze the sub-period statistics, we found a marginal decline in the excess monthly EREIT returns from 0.5 % for the period 1972M1-1989M12 to 0.4 % for the period 1990M1-1999M12; and MREIT excess return remained constant at −0.01 in the two sub-periods. The two REITs showed strong performance in the 2000s with excess returns of 1.0 and 0.7 % for EREITs and MREITs, respectively. In comparison, the stock market registered the strongest performance of 1.1 % in the 1990s compared with the two sub-periods in the 1970s–1980s (0.4 %) and the 2000s (0.3 %). EREIT and MREIT excess returns in the 2000s (20001M-2013M12) were the most volatile with the standard deviations estimated at 6.6 and 6.0 %, respectively. The volatilities for MREITs vary within a narrow range of between 5.7 and 6.0 % in the three sub-periods; whereas we observe a slight decline in the volatilities of the EREIT excess returns from 4.1 % in the 1972M1-1989M12 period to 3.7 % in the 1990M1-1999M12 period. The volatility of EREIT excess returns in the 2000s, however, increased significantly to 6.6 %. The high volatility in 2000s has been puzzling; and thus studying this period that was closely linked with Greenspan's low interest regime is likely to contribute new information to the REIT literature.

## Constructing Leverage- and Size-Sorted EREIT Indices

Do REIT beta behaviors vary by their firm-specific characteristics? The total return indices of FTSE-NAREIT [12] benchmark the industry-level performance; they are, however, not suitable to test the variations in REIT betas by different firm characteristics. Therefore, we propose to construct REIT indices that reflect differences in leverage and size characteristics of REITs using monthly stock data series in the Center for Research in Security Prices (CRSP) file and selected annual financial data of REITs from the CRSP/Compustat merged file. REITs are identified in the two data files based on the standard industry code (SIC) 6798.

We obtain the annual financial data on total debt ("DEBT") and total asset ("ASSET") of the REIT samples identified by SIC 6798 from the CRSP/Compustat merged files. We then compute the debt ratio ("LEVERAGE") as ("LEVERAGE = DEBT/ASSET") for each REIT. To avoid "survival bias" of REIT samples in our proposed indices, we use only 157 equity REITs[13] with an "active" status as in 2013 in our portfolio construction process. The index construction methodology is described as follows:

Based on the average "LEVERAGE" of the full sample as in 2013, we sort a REIT into a "High Leverage" portfolio ("HDebt"), if its debt ratio REIT is higher than the average; and otherwise, it is sorted into of a "Low Leverage" portfolio ("LDebt"). Based on the same average approach, we also sort the REIT samples by "ASSET" into a "large size" portfolio ("BSize") consisting of REITs that have total asset value that is higher than the average; and a "Small Size" portfolio ("SSize") that include all other REITs that has smaller than or equal to the average total asset. Figure 2 shows the plot of the average debt ratios ("LEVERAGE") for the "HDebt" and "LDebt" portfolio alongside with the sample averages. The average leverage ratios of the "HDebt" and the "LDebt" portfolios are estimated at 60.26 and 27.80 %, respectively. The average debt ratios of both "HDEbt" and "LDebt" portfolios have been moving up steadily since 1992. The "deleveraging" effects that caused slight dips in the average debt ratios in the two REIT portfolios were observed in 2009 and 2010. We also plot the average total asset value for the two size-sorted portfolios in Fig. 3. There were significant uptrends in average total asset value of REITs after 1994, and sharper increases were found in the "BSize" portfolio.

We then collect the historical return series of the identified REITs from the CRSP monthly data file, and then construct monthly return indices of the leverage- and size-sored REIT portfolio, ($R_p$), using an equal weighted approach, such that $R_{p|HDebt} = \frac{\sum_i^N R_i}{N}$, where $R_i$ is the monthly stock return of REIT *i*, and N is the number of REIT sample in the "HDebt" portfolio. We then compute the monthly return series for the "LDebt" REIT portfolio, denoted as "$R_{p|LDebt}$", using the remaining REITs with below the average "LEVERAGE" ratios. Based on the same approach, we compute the monthly return series for the two size-sorted REIT portfolios ("BSize" and "SSize"). After the merging the two files, we could only construct the average monthly leverage- and size-sorted

[12] FTSE-NAREIT constructs its REIT indices using a selected sample of all publicly-listed EREITs and MREI Ts in major US exchanges, where the firm characteristics of the REIT samples are not undifferentiated.

[13] There were 200 firms (REITs) identified by SIC 6798 in the CRSP/Compustat merged file as in 2013, of which 162 were equity REITs and 38 were mortgage REITs. The mortgage REITs are not used due to the small number of MREITs. 5 of the equity REITs do not have debt information, and are dropped from the sample, and we end up with the final list of 157 equity REITs.

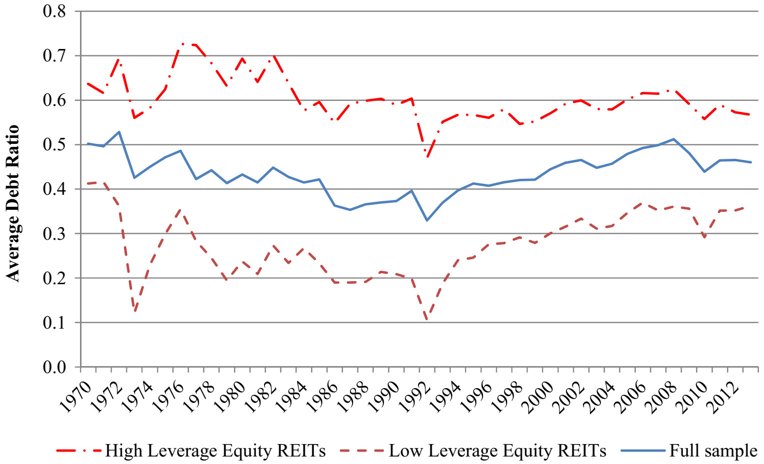


**Fig. 2** Average debt ratio of the leverage-sorted equity REIT portfolios. Note: The plot the average debt ratio using data of equity REITs obtained from CRSP/Compustat merged file, and the firms "survive" as in 2013. The equity REITs are then sorted based on the debt ratio into a high leverage portfolio that consists of equity REITs that have the above average debt ratios; and other equity REITs that have below the average debt ratios are sorted into a low leverage portfolio. The average monthly debt ratios of the two equity REIT portfolios are computed (high leverage portfolio is represented by the *dashed-dotted line*, and the low leverage portfolio is represented by the *dashed line*) and trends are shown alongside the full-sample average debt ratio (*darkened line*)

portfolio return series for the periods starting from August 1985 to December 2013, due to the sparse data and also "survival" elimination of some REIT samples.

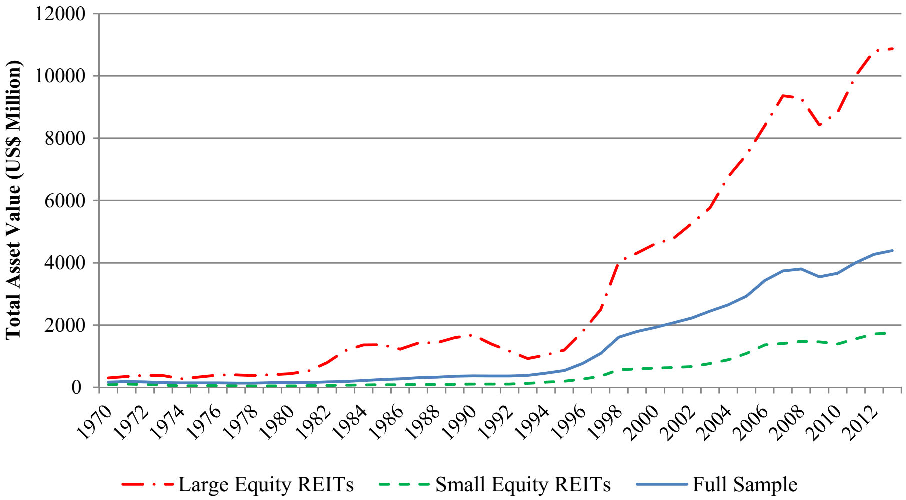


**Fig. 3** Average total asset value of large and small equity REIT portfolios. Note: The plot the average total asset values using data of equity REITs obtained from CRSP/Compustat merged file, and the firms "survive" as in 2013. The equity REITs are then sorted based on the total asset value into a large size portfolio that consists of equity REITs that have the above average asset values; and other equity REITs that have below the average asset values are sorted into a small size portfolio. The average monthly asset values of the two equity REIT portfolios are computed (large size portfolio is represented by the *dashed-dotted line*, and the small size portfolio is represented by the *dashed line*) and trends are shown alongside the full-sample average asset value (*darkened line*)

Based on the return series, we compute the excess returns for the respective REIT portfolios, ["$R_p - R_f$"], where $R_f$ is the 1-month T-bill rate of return obtained from Professor French's website, and the summary statistics are presented in Table 2. The statistics of the FTSE-NAREIT EREIT excess returns are included for comparison purposes. The results show that except for the small size portfolio, the other three portfolios outperformed the FTSE-NAREIT EREIT portfolio in term of the excess returns. The large size EREIT portfolio has the highest average excess return of 1.1 % for the full sample period. In the sub-period analyses, there were similar uptrends found in excess returns for the two leverage-sorted portfolios and the "SSize" portfolio in the three sub-periods; whereas the "LSize" portfolio shows a slightly different V-shaped excess return trend declining from 1.1 % in 1980s to 1.0 % in 1990s before recovering again to 1.3 % in 2000s. We also observe that the excess returns in the 2000s were the most volatile for all the four REIT portfolios; a trend, which again indicates the unique REIT market condition in the 2000s period and beyond.

**Table 2** Excess returns of equity REITs

| Sample | Equity REIT | High leverage equity REIT portfolio | Low leverage equity REIT portfolio | Large equity REIT portfolio | Small equity REIT portfolio |
|---|---|---|---|---|---|
| Symbol | EEQRET | EEQHDRET | EEQLDRET | EEQHARET | EEQLARET |
| 1985M9-2013M12 | | | | | |
| Mean | 0.007 | 0.009 | 0.009 | 0.011 | 0.007 |
| Std. Dev. | 0.053 | 0.059 | 0.050 | 0.058 | 0.052 |
| Observations | 340 | 340 | 340 | 340 | 340 |
| 1985M9-1989M12 | | | | | |
| Mean | 0.002 | 0.004 | 0.009 | 0.011 | 0.004 |
| Std. Dev. | 0.032 | 0.045 | 0.038 | 0.039 | 0.043 |
| Observations | 52 | 52 | 52 | 52 | 52 |
| 1990M1-1999M12 | | | | | |
| Mean | 0.004 | 0.005 | 0.007 | 0.010 | 0.004 |
| Std. Dev. | 0.037 | 0.047 | 0.036 | 0.044 | 0.038 |
| Observations | 120 | 120 | 120 | 120 | 120 |
| 2000M1-2013M12 | | | | | |
| Mean | 0.010 | 0.012 | 0.011 | 0.013 | 0.011 |
| Std. Dev. | 0.066 | 0.070 | 0.061 | 0.071 | 0.062 |
| Observations | 168 | 168 | 168 | 168 | 168 |

This table reports the descriptive statistics of excess returns for equity REIT (*EREITs*, and four different portfolios of equity REITs sorted by leverage ratio and total asset value. The REIT portfolios are constructed using financial data of REITs (SIC: 6798) obtained from CRSP/Compustat merged file, and the return data are obtained from CRSP monthly file. We created two set of indices, one based on the leverage ratio (*debt/total asset*) and another based on the total asset (*size*). The leverage- and size-sorted time series are only available for the period from 1985M9 to 2013M12, where "M" indicates the month of the year. The statistics including mean, standard deviation and observation for the full sample period and different sub-periods are reported in the table

## Empirical Results

### Baseline Three-factor CAPM Models

Based on the static three-factor CAPM model as in Eq. (1), we estimate the market beta for EREIT and MREIT and summarize the regression results in Table 3. The adjusted $R^2$ for the EREIT and MREIT excess return models are estimated at 0.543 and 0.341, respectively. The results show that the 3-factor models explain more variations in the ERIET excess returns (EQRET) than the MREIT excess returns (MGTRET). The coefficients of the market betas and the other two Fama-French benchmark risk factors (SMB and HML) are significant at a less than 1 % level. The beta coefficient of EREIT (0.715) is higher than the MREIT beta (0.669) for the full sample period 1972M-2013M12.

We also estimate the three-factor constant beta models for the leverage- and size-sorted equiety REIT portfolios using a shorter sample period from 1985M9 to 2013M12. The results as shown the last four columns of Table 3 show that the excess return model for the small-size equity REIT portfolio (EEQLARET) has the highest adjusted $R^2$ of 0.531, and the large-size equity REIT portfolio (EEQHARET) has the lowest adjusted $R^2$ of 0.395. The three Fama-French benchmark risk factors are all significant at less than 1 % level. The high-leverage equity REIT beta (EEQHDRET) is the highest estimated at 0.769; whereas the lowest beta of 0.618 was estimated for the low-leverage equity REIT beta (EEQLDRET).

### Asymmetric REIT Betas

We replicate the asymmetric REIT beta models with a declining market dummy variable, $d_m$, which follows the same definition as Sagalyn (1990) and Goldstein and Nelling (1999), where [$d_m$ =1], if the excess market return is zero or negative, [$(R_m\text{-}R_f)\leq 0$]; and otherwise, [$d_m$=0; if $(R_m\text{-}R_f)>0$]. The asymmetric beta model is defined as:

$$R_{nareit,t}-R_{f,t}=\alpha+\beta_i\left(R_{m,t}-R_{f,t}\right)+\ \beta_{im}d_m\left(R_{m,t}-R_{f,t}\right)+\gamma SMB+\lambda HML+\varepsilon_t \quad (4)$$

The results in Table 4 show that the coefficients on the interactive down-market and excess market return variables are significant in explaining variations in EREIT and MREIT excess returns at less than 5 and 10 % levels, respectively. However, the coefficients have opposite signs in the two models. The down-market beta for EREI Ts is positive at 0.243, which is consistent with the earlier literature on the asymmetric beta puzzle for EREIT. However, the down-market beta for MREITs is significantly negative at −0.276. The results imply that EREITs are more sensitive to the stock market shocks in down-markets; whereas, MREITs appear are counter-cyclical and more defensive against stock market volatility during recessions. When we add the down-market interactive term to the three-factor models for the leverage- and size-sorted Equity REIT portfolio, the results show no significant asymmetric effects in all the four portfolios.

**Table 3** Fama-French three-factor models

| Sample REITs | Equity REIT | Mortgage REIT | High leverage equity REIT portfolio | Low leverage equity REIT portfolio | Large equity REIT portfolio | Small equity REIT portfolio |
|---|---|---|---|---|---|---|
| Sample period: | 1972M01-2013M12 | | 1985M09-2013M12 | | | |
| Dependent Variable: | EQRET | EMGTRET | EEQHDRET | EEQLDRET | EEQHARET | EEQLARET |
| Constant | −0.001 | −0.005** | 0.001 | 0.003 | 0.004* | 0.000 |
| | -(0.578) | -(2.347) | (0.235) | (1.475) | (1.736) | (0.154) |
| Excess Stock Market Return | 0.715*** | 0.669*** | 0.769*** | 0.618*** | 0.700*** | 0.695*** |
| (Rm-Rf) | (20.255) | (13.324) | (14.656) | (12.875) | (12.257) | (15.594) |
| Size Risk | 0.418*** | 0.416*** | 0.551*** | 0.412*** | 0.428*** | 0.511*** |
| (SMB) | (8.233) | (5.767) | (7.237) | (5.916) | (5.162) | (7.904) |
| Growth Risk | 0.685*** | 0.601*** | 0.976*** | 0.739*** | 0.841*** | 0.858*** |
| (HML) | (12.793) | (7.890) | (11.974) | (9.914) | (9.480) | (12.387) |
| Adjusted R-squared | 0.543 | 0.341 | 0.501 | 0.424 | 0.395 | 0.531 |

This table report results of the 3-facctor CAPM models for equity REITs (*EREITs*), mortgage REITs (*MREITs*) and four leverage- and size-sorted equity REIT portfolios. The model specification is defined below:

$$R_{i,t}-R_{f,t}=\alpha+\beta_t(R_{m,t}-R_{f,t})+\gamma SMB+\lambda HML+\varepsilon_t$$

where $(R_i - R_f)$ denotes the excess returns of REIT *i*. where *i* includes excess return of equity REITs [EQREIT], excess return of mortgage REITs (*EMGTREIT*), excess return of for leverage- (high leverage equity REIT portfolio, EEQHDRET; and low leverage equity REIT portfolio, *EEQLDRET*) and size-sorted equity REIT portfolios (large size equity REIT portfolio, EEQH ARET; and small size equity REIT portfolio, *EEQLARET*) (constructed using data obtained from CRSP and CRSP/Compustat merged files); $(R_m$-$R_f)$ denotes the excess market return, where $R_f$ is 1-month T-Bill return obtained from Ibbotson and Associates, Inc.; "*SMB*" and "*HML*" are the two Fama-French factors that capture the size and growth effects, respectively. The regression coefficients are shown in the first row of each variable, and t-statistics are included in the parentheses. * denotes significance at 10 % level; ** denotes significance at 5 % level, and *** denotes significance at 1 % level

**Table 4** Asymmetric REIT betas

| Sample REITs | Equity REIT | Mortgage REIT | High leverage equity REIT portfolio | Low leverage equity REIT portfolio | Large equity REIT portfolio | Small equity REIT portfolio |
|---|---|---|---|---|---|---|
| Sample period: | 1972M01-2013M12 | | 1985M09-2013M12 | | | |
| Dependent Variable: | EEQRET | EMGTRET | EEQHDRET | EEQLDRET | EEQHARET | EEQLARET |
| Constant | 0.004 | −0.010*** | −0.001 | 0.000 | 0.002 | −0.001 |
| | (1.467) | −(2.942) | −(0.188) | −(0.089) | (0.445) | −(0.265) |
| Excess Stock Market Return (Rm−Rf) | 0.590*** | 0.811*** | 0.807*** | 0.720*** | 0.776*** | 0.729*** |
| | (9.276) | (8.947) | (7.813) | (7.640) | (6.908) | (8.321) |
| Excess Return and Down-Market Interactive (Rm-Rf)×dm | 0.243** | −0.276* | −0.068 | −0.185 | −0.137 | −0.062 |
| | (2.363) | −(1.878) | −(0.419) | −(1.255) | −(0.780) | −(0.455) |
| Size Risk (SMB) | 0.401*** | 0.435*** | 0.556*** | 0.425*** | 0.437*** | 0.516*** |
| | (7.857) | (5.988) | (7.210) | (6.041) | (5.217) | (7.875) |
| Growth Risk (HML) | 0.674*** | 0.614*** | 0.981*** | 0.751*** | 0.850*** | 0.862*** |
| Adjusted R-squared | 0.547 | 0.344 | 0.500 | 0.425 | 0.394 | 0.530 |

This table report results of the asymmetric 3-facctor CAPM models and the specification is defined below:

$$R_{nareit,t}-R_{f,t}=\alpha+\beta_t d_m(R_{m,t}-R_{f,t})+\gamma SMB+\lambda HML+\varepsilon_t$$

where $(R_i - R_f)$ denotes the excess returns of REIT *i*. where *i* includes excess return of equity REITs [EQREIT], excess return of mortgage REITs (EMGTREIT), excess return of for leverage- (high leverage equity REIT portfolio, EEQHDRET; and low leverage equity REIT portfolio, EEQLDRET) and size-sorted equity REIT portfolios (large size equity REIT portfolio, EEQHARET; and small size equity REIT portfolio, EEQLARET) (constructed using data obtained from CRSP and CRSP/Compustat merged files); $(R_m$-$R_f)$ denotes the excess market return, where $R_f$ is 1-month T-Bill return obtained from Ibbotson and Associates, Inc.; "*SMB*" and "*HML*" are the two Fama-French factors that capture the size and growth effects, respectively. In this Model, we include a down-market dummy, dm, which has a value of 1, if the excess market return is negative, *i.e.*, $[(R_m - R_f)<0]$, and 0 otherwise, to capture the asymmetry in the beta behavior. The regression coefficients are shown in the first row of each variable, and t-statistics are included in the parentheses. * denotes significance at 10 % level; ** denotes significance at 5 % level, and *** denotes significance at 1 % level

**REIT Betas in Different Growth Phases**

We next examine variations of REIT betas in different growth phases by adding discrete time dummy variables, $d_k$, to capture multiple structural breaks in the beta behavior over the full sample periods. The extended three-factor CAPM model is given as:

$$R_{i,t}-R_{f,t}=\alpha+\beta_i\left(R_{m,t}-R_{f,t}\right)+\sum_{k=1}^{2}\beta_{ik}d_k\left(R_{m,t}-R_{f,t}\right)+\gamma SMB+\lambda HML+\varepsilon_t \quad (5)$$

where $d_k$ is a discrete time dummy variable. For the EEQRET and MGTRET models, we use two sub-period dummies as indicated by the subscript $k$=[1, 2], such that [$d_1$= 1] for the period from January 1990 to December 1999, and [$d_2$=1] for the period from January 2000 to December 2013. The period from January 1972 to December 1989 is used as the reference period. If sub-period beta coefficient, $\beta_{ik}$, is significantly different from zero, discrete changes in the estimated beta are observed across the sub-divided periods; otherwise, the static beta assumption is not rejected across the sub-periods.

The results in Table 5 show that the adjusted $R^2$ of the EEQRET and EMGT RET models increase marginally to 0.548 and 0.352, respectively (compared to 0.543 and 0.341 as in the Model in Table 3). The three Fama-French benchmark risk factors ($R_m$-$R_f$, SMB and HML) are all significant at less than 1 % level. The EREIT beta coefficient decreases to 0.657, whereas the MREIT beta coefficient increases to 0.802 relative to the earlier estimates as in Table 3 (EEQRET=0.715 and EMGTRET=0.669). For the structural break effects, our results show that the coefficient on [$(R_m$-$R_f)\times D_1$] is negative but not significant at 10 % level. The results show no significant structural shifts or declines in EREIT betas in the 1990s relative to the beta in the 1970s and 1980s, which was inconsistent with the predictions by some of the earlier studies (Ghosh et al. 1996; McIntosh et al. 1991; Khoo et al. 1993; Liang et al. 1995; Chiang et al. 2004).

We extend our model to cover the period in 2000s using the discrete time dummy, $D_2$, and the results show that the EREIT beta increases significantly by 0.181 and MREIT beta declines by −0.338 in the 2000s relative to the baseline beta for the period 1972M1-1989M12. The divergence in EREIT and MREIT betas in the 2000s may suggest possible shifts in fundamentals that drive the two REIT markets.

We replicate the discrete time dummy models to estimate betas for the leverage- and size-sorted EREIT portfolios, and the results in the last four columns of Table 5 show consistent upward trends in EREIT betas in the 2000s relative to the earlier reference period 1985M9-2013M12, and the we found the betas of the low-leverage and the large-size REIT portfolios to have stronger incremental effects by 0.340 and 0.373 in the 2000s, respectively.

**Time-Varying EREIT Betas**

The results of return-dependence and time-dependence REIT beta as shown in the asymmetric beta models and the multiple structural break models clearly reject the hypothesis of constant REIT betas. Based on Engle and Watson's TVC framework, we add stochastic effects to the level term, $\alpha_i$, and the market beta, $\beta_i$, in

**Table 5** REIT betas at different growth phases

| Sample REITs | Equity REIT | Mortgage REIT | High leverage equity REIT portfolio | Low leverage equity REIT portfolio | Large equity REIT portfolio | Small equity REIT portfolio |
|---|---|---|---|---|---|---|
| Sample period: | 1972M01-2013M12 | | 1985M09-2013M12 | | | |
| Dependent Variable: | EEQRET | EMGTRET | EEQHDRET | EEQLDRET | EEQHARET | EEQLARET |
| Constant | −0.001 | −0.006** | 0.001 | 0.004* | 0.005** | 0.001 |
| | −(0.355) | −(2.523) | (0.510) | (1.922) | (2.146) | (0.444) |
| Excess Stock Market Return ($R_m$-$R_f$) | 0.657*** | 0.802*** | 0.642*** | 0.438*** | 0.503*** | 0.581*** |
| | (13.356) | (11.493) | (8.602) | (6.498) | (6.248) | (9.178) |
| Excess Return and 1990s Interactive ($R_m$-$R_f$)×$D_1$ | −0.035 | −0.066 | | | | |
| | −(0.400) | −(0.524) | | | | |
| Excess Return and 2000s Interactive ($R_m$-$R_f$)×$D_2$ | 0.181** | −0.338*** | 0.241** | 0.340*** | 0.373*** | 0.215** |
| | (2.476) | −(3.261) | (2.383) | (3.723) | (3.421) | (2.514) |
| Size Risk (SMB) | 0.407*** | 0.430*** | 0.522*** | 0.370*** | 0.382*** | 0.485*** |
| | (8.037) | (5.990) | (6.809) | (5.351) | (4.625) | (7.459) |
| Growth Risk (HML) | 0.660*** | 0.637*** | 0.934*** | 0.680*** | 0.776*** | 0.820*** |
| | (12.203) | (8.299) | (11.276) | (9.081) | (8.684) | (11.666) |
| Adjusted R-squared | 0.548 | 0.352 | 0.508 | 0.445 | 0.413 | 0.539 |

This table report results of the asymmetric 3-facctor CAPM models and the specification is defined below:

$$R_{i,t}-R_{f,t} = \alpha + \beta_i\left(R_{m,t}-R_{f,t}\right) + \sum_{k=1}^{2}\beta_{ik,t}d_k\left(R_{m,t}-R_{f,t}\right) + \gamma SMB + \lambda HML + \varepsilon_t$$

where ($R_i$ –$R_f$) denotes the excess returns of REIT *i*. where *i* includes excess return of equity REITs [EQREIT], excess return of mortgage REITs (EMGTREIT), excess return of for leverage- (high leverage equity REIT portfolio, EEQHDRET; and low leverage equity REIT portfolio, EEQLDRET) and size-sorted equity REIT portfolios (large size equity REIT portfolio, EEQHARET; and small size equity REIT portfolio, EEQLARET) (constructed using data obtained from CRSP and CRSP/Compustat merged files); ($R_m$-$R_f$) denotes the excess market return, where $R_f$ is 1-month T-Bill return obtained from Ibbotson and Associates, Inc.; "*SMB*" and "*HML*" are the two Fama-French factors that capture the size and growth effects, respectively. In this Model, we use two time dummies, $d_k$, where k=[2, 3], such that $d_2$ and $d_3$ represent the 1990s and 2000s sub-periods respectively. The regression coefficients are shown in the first row of each variable, and t-statistics are included in the parentheses. * denotes significance at 10 % level; ** denotes significance at 5 % level, and *** denotes significance at 1 % level

Eq. (1) by allowing the two variables to follow two uncorrelated random walk processes that have constant means and variances $\sigma_\zeta^2$ and $\sigma_\eta^2$ as defined in Eqs. (2) and (3). The two transition equations are jointly estimated with the baseline CAPM model using the Kalman filter technique. The estimated parameters for the time-varying 3-factor CAPM model are summarized in Table 6. From the variance of disturbances, the random walk component of the beta coefficient is positive, although the stochastic level effect is insignificant. Most of the time-varying effects come from the random excess market return and the irregular terms. The fixed coefficients on "SML" and "HML" are significant and positive, which are consistent with the earlier static CAPM models.

For the purpose of our analysis, we extract the time-varying betas for EREIT and MREIT from the local level model as in Eq. (3) and plot the two stochastic betas in

**Table 6** Estimation of the time varying beta models

| Sample REITs | Equity REIT | Mortgage REIT | High leverage equity REIT portfolio | Low leverage equity REIT portfolio | Large equity REIT portfolio | Small equity REIT portfolio |
|---|---|---|---|---|---|---|
| Symbol | EEQRET | EMGTRET | EEQHDRET | EEQLDRET | EEQHARET | EEQLARET |
| Variances of disturbances: value \| [q-ratio] | | | | | | |
| RW-coef on ($R_m$-$R_f$) | 0.004 | 0.001 | 0.004 | 0.004 | 0.007 | 0.003 |
| | [1.000] | [0.498] | [1.000] | [1.000] | [1.000] | [1.000] |
| Level | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | [0.000] | [0.001] | [0.000] | [0.000] | [0.000] | [0.000] |
| Irregular | 0.001 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 |
| | [0.270] | [1.000] | [0.433] | [0.302] | [0.250] | [0.390] |
| State vector analysis at period 2013 (12): value, prob. | | | | | | |
| Level | 0.001 | −0.002 | 0.002 | 0.004** | 0.006 | 0.001 |
| Regression effects in final state at time 2013 (12): coefficient, t-value, prob. | | | | | | |
| HML | 0.525*** | 0.654*** | 0.748*** | 0.484*** | 0.562*** | 0.638*** |
| | (9.370) | (8.115) | (8.357) | (6.089) | (5.887) | (8.472) |
| SMB | 0.383*** | 0.400*** | 0.477*** | 0.326*** | 0.335*** | 0.441*** |
| | (7.932) | (5.590) | (6.455) | (4.989) | (4.285) | (7.112) |
| Summary statistics: | | | | | | |
| $R^2$ | −1.095 | −0.212 | −0.749 | −1.353 | −1.849 | −0.707 |
| Standard error | 0.072 | 0.065 | 0.079 | 0.078 | 0.099 | 0.068 |

This table report results of the time-varying CAPM model, which include the return equation and transition equation that can be estimated using the state-space structure of Kalman filter techniques defined as:

$$R_{i,t}-R_{f,t} = \alpha + \beta_t\left(R_{m,t}-R_{f,t}\right) + \gamma SMB + \lambda HML + \varepsilon$$

$$\alpha_{t+1} = \alpha_t + \zeta_t, \zeta_t \sim N\left(0, \sigma_\zeta^2\right) \qquad \beta_{t+1} = \beta_t + \eta_t, \quad \eta_t \sim N\left(0, \sigma_\eta^2\right)$$

where ($R_i$ –$R_f$) denotes the excess returns of REIT *i*. where *i* includes excess return of equity REITs [EQREIT], excess return of mortgage REITs (EMGTREIT), excess return of for leverage- (high leverage equity REIT portfolio, EEQHDRET; and low leverage equity REIT portfolio, EEQLDRET) and size-sorted equity REIT portfolios (large size equity REIT portfolio, EEQHARET; and small size equity REIT portfolio, EEQLARET); ($R_m$-$R_f$) denotes the excess market return, where $R_f$ is 1-month T-Bill return obtained from Ibbotson and Associates, Inc.; "*SMB*" and "*HML*" are the two Fama-French factors that capture the size and growth effects, respectively. The estimated parameters $\alpha$ is the intercept term; $\beta$ is the stochastic REIT beta, and ε is the regression error. In the transition equations, $\zeta_t$ and $\eta_t$ are mutually uncorrelated irregular terms that are *i.i.d* with zero means and constant variances, $\sigma_\zeta^2$ and $\sigma_\eta^2$ respectively

Fig. 4. The two REIT betas show different time-varying patterns over the full sample periods. MREIT beta (as represented by the dashed line) show marked declines from a high of nearly 1.0 in 1972–1974 to below 0.4 in the period after 2009M5. However, EREIT betas show more cyclical patters with a steep increase in beta starting from 1972M1 and reaching a high of 0.837 in 1979M9. The results also verify the prediction of many earlier researchers that a clear temporal decline was observed in the time-varying EREIT betas in 1980s and 1990s. The declining trend in EREIT began after 1980M1, and the EREIT beta hit the lowest point of 0.298 in three consecutive months from May 2000 to July 2000.

The figure also shows that 2002M9 marks the start of the second strong upward movement of the time-varying EREIT beta in 2000s culminating to the peak of 1.421 in 2008M11. Coinciding with the subprime crisis occurring in 2007, EREI Ts entered into an aggressive "deleveraging" phase. The uptrend of EREIT beta was reverted after 2009, and the EREIT betas declined and reached a low of 0.541 at the end of the sample period of 2013M12. Unlike the static betas, the stochastic plot of the changing behavior EREIT betas that includes a sharp up-cycle followed by a strong reversion in the EREIT betas in 2000s was an interesting result that is new to the literature.

We compute the means and standard deviations of the time-varying beta series for EREIT and MREIT for the period 1985M9-2013M12 and two sub-periods (1985M9-1999M12 and 2000M1-2013M12) and present the results in Table 7. The statistics show that the time-varying EREIT beta has a higher mean of 0.684 and a volatility of 0.265, relative to the 0.586 and 0.128 estimated for time-varying MREIT beta for the period 1985M9-2013M12. The differences in means of EREIT beta and MREIT beta (0.98) are significant based on the pooled

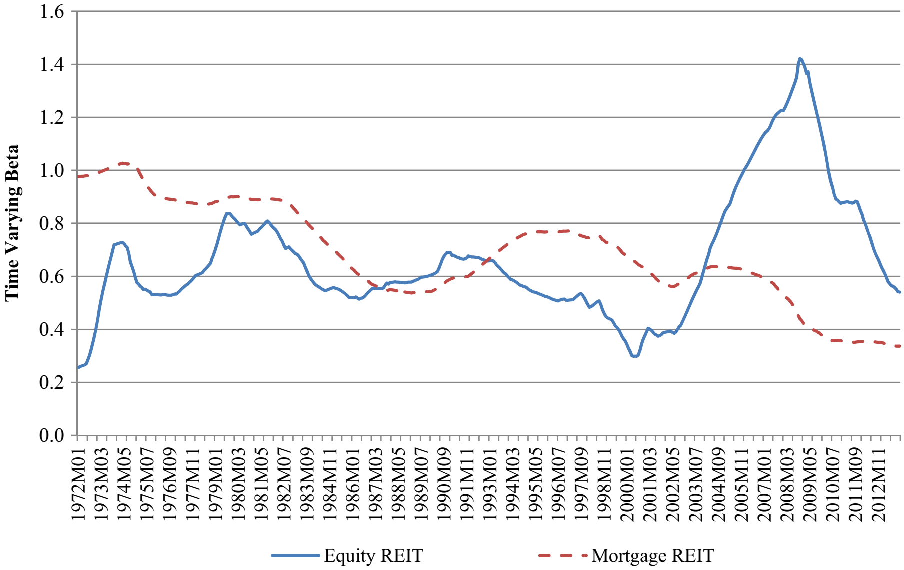


**Fig. 4** Time varying betas of equity REITs and mortgage REITs. Note: This figure plots the time varying beta of EREIT and MREIT as estimated using the time-varying coefficient (*TVC*) Model. The data cover the period from January 1972 to December 2013

**Table 7** Characteristics of time varying REIT betas

| Sample REITs | Equity REIT | Mortgage REIT | High leverage equity REIT portfolio | Low leverage equity REIT portfolio | Large equity REIT portfolio | Small equity REIT portfolio |
|---|---|---|---|---|---|---|
| Symbol | TVCEEQRET | TVCEMGTRET | TVCEEQHDRET | TVCEEQLDRET | TVCEEQHARET | TVCEEQLARET |
| 1985M9-2013M12 | | | | | | |
| Mean | 0.684 | 0.586 | 0.714 | 0.597 | 0.669 | 0.647 |
| Std. Dev. | 0.265 | 0.128 | 0.243 | 0.286 | 0.326 | 0.235 |
| Observations | 340 | 340 | 340 | 340 | 340 | 340 |
| *t*-test of difference | 0.098*** | | 0.116*** | | 0.022 | |
| | (6.173) | | (5.717) | | (1.003) | |
| 1985M9-1999M12 | | | | | | |
| Mean | 0.564 | 0.659 | 0.592 | 0.443 | 0.517 | 0.530 |
| Std. Dev. | 0.073 | 0.088 | 0.042 | 0.147 | 0.203 | 0.036 |
| Observations | 172 | 172 | 172 | 172 | 172 | 172 |
| *t*-test of difference | −0.095*** | | 0.150*** | | −0.013 | |
| | −(10.844) | | (12.823) | | −(0.795) | |
| 2000M1-2013M12 | | | | | | |
| Mean | 0.808 | 0.512 | 0.838 | 0.756 | 0.824 | 0.767 |
| Std. Dev. | 0.327 | 0.120 | 0.296 | 0.307 | 0.354 | 0.286 |
| Observations | 168 | 168 | 168 | 168 | 168 | 168 |
| *t*-test of difference | 0.296*** | | 0.083** | | 0.057 | |
| | (11.035) | | (2.509) | | (1.624) | |

The table summarizes of the time varying betas estimated using the TVC three-factor CAPM models. The statistics include mean and standard deviations (*in parentheses*) are summarized by the full sample periods and two sub-periods. We the time varying betas for the equity REITs [*EQREIT*], mortgage REITs (*EMGTREIT*), and also two leverage- (high leverage equity REIT portfolio, EEQHDRET; and low leverage equity REIT portfolio, *EEQLDRET*) and two size-sorted equity REIT portfolios (large size equity REIT portfolio, EEQHARET; and small size equity REIT portfolio, *EEQLARET*) (constructed using data obtained from CRSP and CRSP/Compustat merged files). We include the pooled variance *t*-test of the difference between the two sample means for the REIT type and also the leverage- and size-sorted REIT portfolio. The t-statistics are given in parentheses. * denotes significance at 10 % level; ** denotes significance at 5 % level, and *** denotes significance at 1 % level variance t-tests. When we split the period into two sub-periods: 1985M9-1999M12 and 2000M1-2013M12, we see a clear contrast in the means and standard deviations between the two REITs. The time-varying EREIT betas were smaller and less volatile in 1990s (difference=−0.095); but were higher and more volatile in 2000s compared to the time-varying MREIT betas (difference=0.296). The means EREIT beta increased from 0.546 in 1990s to 0.808 in 2000s; whereas the standard deviations of the EREIT beta increased from 0.073 in 1990s to 0.327 in 2000s.

There are two observations that can be made from the above results of the time-varying betas of EREIT and MREIT. First, the declining MREIT betas and its divergence from EREIT betas especially in the 2000ss have clearly indicated that MREITs have become structurally more defensive, and more insulated against stock market shocks; whereas, the Glascock et al. (2000) story of EREITs becoming more stock-like seems to become stronger moving into the 2000s. Second, the strong uptrend in the early 2000s is consistent with the high REIT stock price volatility observed during the Greenspan era (Kawaguchi et al. 2012); and also with the aggressive leverage-driven acquisitions and development activities by REIT in the 2000s (Bai et al. 2011). More robustness tests of the leverage and size effects on the time-varying beta behavior will be conducted in the following sections.

## Leverage Effects on EREIT Betas

Do "leverage effects" significantly influence time-varying beta characteristics of EREIT? We plot the time-varying betas of the two leverage-sorted EREIT portfolios in Fig. 5. We observe a strong divergence in the betas of the high-leverage EREIT portfolio and the low-leverage EREIT portfolio, especially in the 1980s; and the two betas converged in the earlier 1990s before they moved apart again in the period 1994M1-1999M12. In 2000M1-2013M12, we find that the time-varying betas of the two leverage-sorted portfolios follow closely the same cyclical patterns of the time-varying beta of the FTSE-NAREIT benchmark equity portfolio.

The descriptive statistics of the betas for the two EREIT portfolios are summarized in Columns 4 and 5 of Table 7. The means of the high-leverage EREIT betas were consistently higher than the means of the low-leverage EREIT beta in all periods. The average time-varying betas of the high-leverage EREIT portfolio and the low-leveraged EREIT beta is estimated at 0.714 and 0.597, respectively for the full period from 1985M9-2013M12. Based on the pooled variance *t*-test of difference in means (0.116), the results reject the null hypothesis that the mean betas for the two leverage-sorted portfolios of EREITs are the same. Although the means the two portfolio betas were lower in the early period 1985M9-1999M12 than the means in the period 2000M1-2013M12, but the differences in the two betas were bigger in the early period (0.85) relative to the early period (0.083). Our results could not reject the leverage effects on the time-varying EREIT betas. However, the result is not conditional on the stock price declines as assumed in Black's (1976) and Christie's (1982) hypothesis.

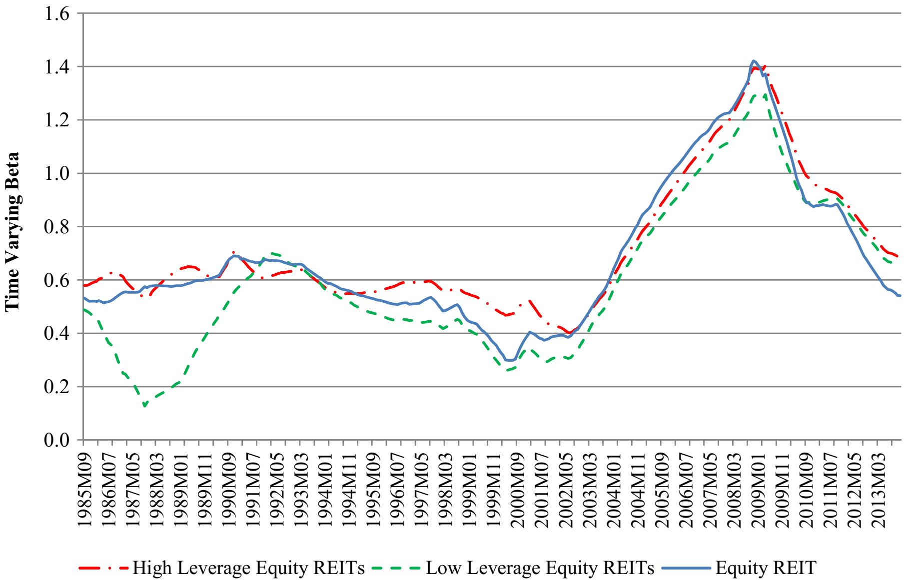


**Fig. 5** Effects of leverage and time varying betas of equity REITs. Note: This figure plots the time varying beta of EREIT (based on FTSE-NAREIT return index) alongside with two leverage-sorted portfolios constructed using data of Equity REITs (SIC 6798) obtained from CRSP and CRSP/Compustat merged files. The time varying beta of the high leverage Equity portfolio is represented by the *dashed-dotted line*, whereas the time varying beta of the low-leveraged Equity portfolio is represented by the *dashed line*. The estimation uses monthly index constructed using data covering the period from September 1985 to December 2013

## Size Effects on EREIT Betas

As a robustness check, we test if the time-varying betas are related to the size EREIT portfolios. We form a large EREIT portfolio and a small EREIT portfolio based on the total asset value, and the time-varying betas of the two size-sorted portfolios are plotted in Fig. 6. We saw more reversals in term of differences in the means of the time-varying betas of large EREIT portfolio relative to small EREIT portfolio. The large EREIT mean time-varying betas were higher than the mean time-varying betas of small EREI Ts in two sub-periods 1989–1994 and 2000–2010, but lower in other sub-periods. When we superimpose the FTSE-NAREIT benchmark EREIT betas onto the figure, we see similar cyclical trends in all three betas, except for large REIT betas in the periods before 1994.

We compute the means and standard deviations of the time-varying betas for the large and small EREIT portfolios in the last two columns of Table 7. The statistics of the pooled variance t-tests are also included. Compared to the results in the leverage-sorted portfolios, we find that the differences in means for the size-sorted EREIT betas are smaller in the full sample period (1985M9-2013M12) and the two sub-periods (1985M9-1999M12 and 2000M1-2013M12). The mean beta of the large EREIT portfolio (0.824) was higher than that of small EREIT portfolio (0.767) in the sub-period 2000M1-2013M12; but the large EREITs were relatively less risky in 1985M9-1999M12 period relative to small EREITs. However, the t-tests do not reject the null hypothesis that the two betas are significantly different for all the periods. The results imply that betas of small and large EREITs could

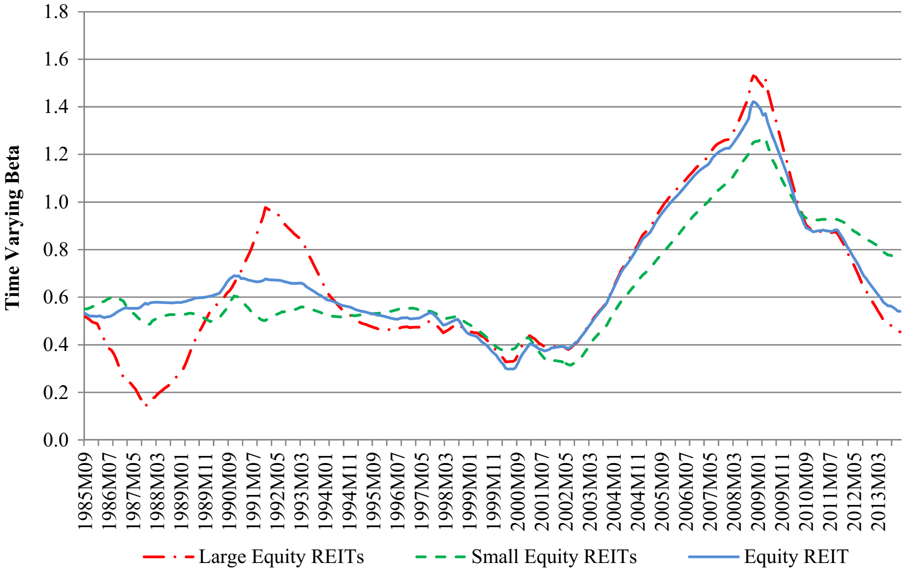


**Fig. 6** Effects of asset size and time varying betas of equity REITs. Note: This figure plots the time varying beta of EREIT (based on FTSE-NAREIT return index) alongside with two size-sorted portfolios constructed using data of Equity REITs (SIC 6798) obtained from CRSP and CRSP/Compustat merged files. We use total asset value of REITs as the proxy for size. The time varying beta of the large equity portfolio is represented by the *dashed-dotted line*, whereas the time varying beta of the small equity portfolio is represented by the *dashed line*. The estimation uses monthly index constructed using data covering the period from September 1985 to December 2013

fluctuate in the short-term, but the size of REIT shows no significant effects on the long-term averages of the betas. We could not find the size-induced effects of changing betas in EREIT portfolios; and one possible reason is that the size effect has been significantly explained in the Fama-French's SMB risk factor.

## Conclusion

There is limited empirical evidence found in the literature on how Greenspan's low interest regime has impacted the US REIT markets in the 2000s. The leverage-driven growth story of Bai et al. (2011) and the capital switching story of Kawaguchi et al. (2012) are among the two studies that have examined the changing risk behavior of EREIT in the US. This study adds to the understanding of REIT betas by modeling time-varying REIT betas using new empirical data in the 2000s and also with new methodology. We use the structural time series model with Kalman filter technique that could flexibly and directly extract beta dynamics from the data without having to a-priori identify the structural break points.

Our empirical results identify three important time-varying characteristics of REIT betas. First, we find corroborative evidence showing temporal declines in EREIT and MREIT betas in the pre-2000s period, which are consistent with the findings in the earlier studies. While our empirical results show a continuous declining trend of MREIT beta in the 2000s, we find a strong reversal in the EREIT beta trend after 2000s. The divergence in the two time-varying betas may suggest some fundamental changes to the two REIT markets. More interestingly, we find that EREITs in the 2000s are more sensitive to stock market shocks relative to the earlier periods including the 1990s.

We constructed portfolios of equity REITs with different financial attributes (leverage ratio and asset value) using data from CRSP and CRSP/Compustat merged file, and test if the betas of high leverage EREITs and low leverage EREITs behave differently over time. Our second finding suggests that the averages of high leverage EREIT betas are consistently higher than the averages of the low leverage EREIT betas. The *t*-test statistics affirm that the betas are significantly different in the two sub-periods 1985M9-1999M12 and 2000M1-2013M12. While we do not reject the "leverage" effects, our results are fundamentally different from that hypothesized by Black (1976) and Christie (1982), because the condition of stock price declines as assumed in the "leverage hypothesis" was not found in the 2000s period.

Third, we did not find significant effects of REIT size (asset value) on dynamics of EREIT betas. Large REIT betas were higher in the two periods: 1989–1994 and 2000–2010, whereas small REITs have higher systematic risks in all other periods. The Fama-French benchmark size risk factor could have had captured the size related effects in REIT betas; and our results did not show that small REITs are more risky than large REITs.

As the period of rising EREIT beta in our study was not coincided with REIT stock price decreases, our results could be correlated with the low interest rate factor that induces REITs to use more debt to fund new acquisitions and development activities. Empirical tests using micro data on firms' switching of equity for debt could be used in the future to directly test the causality of leverage ratio on increases in REIT beta.

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