An Empirical Examination of Jump Risk and Continuous Risk in U.S. REITs Market

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Abstract

This paper utilizes recent advances in econometric theory, developed by Anderson, Bollerslev, and Diebold (2007), Barndorff-Nielsen and Shephard (2004), and Tauchen and Zhou (2006), to effectively separate the continuous and jump components of all REITs. By this econometric technique, we investigate whether different types (equity, mortgage, and hybrid type) of U.S. REITs markets has significant jump phenomenon. In addition, we further decompose each of the volatility components into continuous systematic risk and jump systematic risk by extending CAPM and two-factor models. By decomposing, we intend to discuss that is the jump beta risk higher than continuous beta risk? Is the jump beta risk and continuous beta risk asymmetric? And we intend to investigate that is jump risk almost systematic or idiosyncratic (nonsystematic)?

Key words: asset price volatility, REITs, asymmetric continuous beta, asymmetric jump beta, idiosyncratic risk
1. Introduction

Asset price volatility is the most fundamental element of risk management. In order to properly model the asset price process, most of the discrete time models have been of the generalized autoregressive conditional heteroskedastic (GARCH) type, while the continuous time models begin with the jump-diffusion model of Merton (1976), which is a combination of a smooth and continuous process, along with a much less persistent jump process. A thorough understanding of both the continuous and jump components of volatility is required to manage risk effectively. The first goal of this paper is to investigate whether different types (equity, mortgage, and hybrid type) of U.S. REITs markets has significant jump phenomenon by utilizing econometric techniques developed by Anderson, Bollerslev, and Diebold (2007). By using high-frequency (daily) data, one can effectively separate the continuous and jump components of REITs returns.

When estimating parameters in a jump-diffusion model, it has been difficult for financial economists to separate jumps from the underlying diffusion process, in part because the actual jump is not readily observable from the time-series data of the underlying asset returns. Most jump parameter estimates are based on numerical simulations, since direct estimates are difficult to obtain in all but a few special cases (Ait-Sahalia 2004). Tauchen and Zhou (2006) pointed out that “the main message from the empirical literature seems to be that jumps are very important in asset pricing, but the estimation of jump parameters and the pricing of jump risk are not easy to implement”. This poses a serious practical challenge to risk managers. This paper uses econometric techniques provided by Anderson, Bollerslev, and Diebold (2007), Barndorff-Nielsen and Shephard (2004), and Tauchen and Zhou (2006) to accurately estimate the total volatility and the volatility of the underlying continuous-time process with measures they call the “Realized Volatility” (RV) and “Bi-power
Variation” (BV) measures, respectively. The difference between these two measures provides an unbiased estimate of the jump component of prices. Based on this technique, we further investigate whether REITs, stock and bond markets has significant jump risk phenomenon.

Moreover, many studies (e.g., Liu et al. (1990), Peterson and Hsieh (1997), Chiang, Lee and Wisen (2004)) have investigated the return association between equity REITs and the general stock market by using Capital Asset Pricing Model (CAPM, Sharpe 1964) and Fama-French (1993) three-factor model. Furthermore, betas of the stock market have responded asymmetrically in different market conditions. REITs beta was also found to have higher correlations with general market movements in declining markets than in rising markets (Goldstein and Nelling, 1999; Sagalyn, 1990; Chatrath, Liang and McIntosh, 2000; Chiang, Lee and Wisen, 2004). This asymmetric response of REITs returns reflect the risk preference of investors, who dislike downside risks. The second goal of this paper is to further decompose each of the volatility components into continuous beta risk and jump beta risk based on the (asymmetric) CAPM model and (asymmetric) Fama-French three-factor model. This decomposition is interesting because traditional standard factor models of risk implicitly assume that an asset’s systematic risk is uncorrelated with jumps in the market (i.e., that the asset’s beta does not change on days when the market experiences a jump). By decomposing we intend to discuss that is the jump beta risk higher than continuous beta risk? Is the jump beta risk and continuous beta risk asymmetric? And we intend to investigate that is jump risk almost systematic or idiosyncratic (nonsystematic)?

The difference between continuous betas and jump betas has important implications for risk management. With a total beta, one knows only the average level of systematic risk. However, given an asset’s continuous and jump betas, one can
explicitly calculate the asset’s systematic risk conditional on whether or not the market experiences a jump. This is important for risk managers: if REITs behaves differently during a severe market downturn than it does at other times, this information offers the potential to significantly improve on calculations such as Value at Risk (VaR). Moreover, if REITs are combined in a well-diversified portfolio, then the REIT’s systematic jump risk is more relevant than the REIT’s total jump risk. This highlights the importance of decomposing total jump risk into its systematic and idiosyncratic components.

2. Literature Reviews

The relationship between real estate securities and general financial markets has been extensively explored, with much of the literature focusing on the bivariate relationship between REITs and general stock markets. As reviewed below, existing studies can be generally divided into two categories, which are based on time series analysis or asset pricing models.

Some discrete time series techniques were employed to examine the dynamic relationship between real estate and general financial markets. Kallberg, Liu, and Pasquariello (2002) conducted structural break tests and reported regime shifts in returns and volatility relationships between real estate and stock markets in eight Asian markets. Based on a bivariate GARCH model, Cotter and Stevenson (2006) found that daily REIT-stock correlations generally increased during the period from 1999 to 2005. Applying a multivariate DCC-GARCH model to a seven asset system, Huang and Zhong (2006) argued that during the period from 1999 to 2005, daily conditional correlation between REITs and US equity was always positive but had a positive trend and daily correlations between REIT and US bond fluctuated around zero. Also using a DCC-GARCH model, Case, Yang, and Yildirim (2009) examined
monthly conditional correlations between US stock and REIT markets from 1972 to 2008 and explored the implications for portfolio allocation.

Instead of using time series models, many studies have investigated the return association between equity REITs and the general stock market based on asset pricing models. Gyourko and Linneman (1988), Giliberto (1993), Myer and Webb (1993), Han and Liang (1995), Liang, Chatrath and McIntosh (1996), and Oppenheimer and Grissom (1998), among others, showed that REITs are exposed to beta risk. The asset pricing models have been applied to investigate integration versus segmentation between the real estate market and the general financial markets since the first study of Liu et al. (1990) on this topic. Liu et al. (1990) used a single-factor model and reported that the US securitized real estate market integrates with the stock market, while the US private commercial real estate market is segmented from the stock market. Peterson and Hsieh (1997) showed that the risk premiums on equity REITs are significantly related to three Fama-French factors driving common stock returns, while mortgage REIT risk premiums are significantly related to two bond market factors as well as the three stock market factors. Using a series of commonly used multi-factor asset pricing models, Ling and Naranjo (1999) confirmed that US REITs are integrated with the stock market and the degree of such integration has significantly increased during the 1990s, while there is little evidence for integration between the real estate and stock markets when appraisal-based real estate returns are used. Using a multi-factor model where stock, bond, and direct real estate returns as proxies for underlying state variables determining these asset prices, Clayton and Mackinnon (2003) reported that while through 1970s and 1980s the US NAREIT returns were driven largely by the same economic factors that drive large cap stocks, they are more closely related to both small cap stock and real estate-related factors in 1990s. Downs and Patterson (2005) employed a generalized asset pricing model (i.e.,
a discount factor model) and showed that US REIT returns from 1972 to 1991 cannot be fully explained by stock and bond returns.

The standard equilibrium asset pricing model theorizes a positive and linear trade-off between return and systematic risks of capital assets. However, empirical evidence in small capitalization stocks and REITs seems to contradict the theoretical relationship. Betas of these stocks have responded asymmetrically in different market conditions. REIT beta was also found to have higher correlations with general market movements in declining markets than in rising markets (Goldstein and Nelling, 1999; Sagalyn, 1990; Chathrath, Liang and McIntosh, 2000; Chiang, Lee and Wisen, 2004). This asymmetric response of REIT returns reflect the risk preference of investors, who dislike downside risks. The results have significant implications for the portfolio management, in particular, the allocations of REIT in a mixed asset portfolio. The results imply that REITs are not an effective risk diversifier for a mixed asset portfolio in recessionary periods. Chathrath, Liang and McIntosh (2000) argues that asymmetry in beta is caused by the combined effects of decaying relationships between REIT returns and general market returns and higher stock market returns in the recent decade. The dividend yield spread hypothesis was also rejected, because the asymmetric beta responses were not found in utilities stocks, which share the same high dividend payout characteristics as REITs. They found similarity in the pattern of asymmetry in beta, but the variance effects (Glosten, Jagannathan and Runkel, 1993; Jagannathan and Wang, 1996) that drive the small capitalization stock beta asymmetry were not significant in REITs. Thus, the asymmetric beta hypothesis remains a puzzle.
3. Theoretical Framework and Empirical Methodology

3.1 Jump Detection Theoretical Framework

This section describes the jump detection methodology which is developed by Andersen, Bollerslev and Diebold (2007).

Let \( p(t) \) denote a logarithmic asset price at time \( t \). The continuous–time jump diffusion process traditionally used in asset pricing is expressed as a stochastic differential equation as follows:

\[
dp(t) = \mu(t)dt + \sigma(t)dW(t) + \kappa(t)dq(t), \quad 0 \leq t \leq T, \tag{3.1}
\]

where \( \mu(t) \) denotes a continuous and locally bounded variation process, \( \sigma(t) \) denotes a strictly positive stochastic volatility process, \( W(t) \) is a standard Brownian motion, \( q(t) \) is a counting process and \( \kappa(t) \) is a measure of the size of the jump which conditional on a jump occurring. When jump occurs at time \( t \), the value of \( dq(t) \) is equal 1; otherwise the value of \( dq(t) \) is equal 0. The quadratic variation for the cumulative return process, \( r(t) \equiv p(t) - p(0) \), is then

\[
[r, r] = \int_0^t \sigma^2(s)ds + \sum_{0 < s \leq t} \kappa^2(s). \tag{3.2}
\]

If the jumps do not occur (\( q(t) = 0 \)), then the quadratic variation simply equals the continuous volatility (integrated volatility) because that the second return on right-hand side disappears (discounituous jump).

Let \( r_{t,\Delta} \equiv p(t) - p(t - \Delta) \) denotes the discretely sampled \( \Delta \)-period returns. And we define the monthly realized volatility (RV) by the summation of the corresponding \( 1/\Delta \) daily squared returns.

\[
RV_{t+1}(\Delta) = \sum_{j=1}^{1/\Delta} r_{t+j\Delta,\Delta}^2. \tag{3.3}
\]

For notational simplicity and without loss of generality, \( 1/\Delta \) is assumed to be an integer. Hence, follow Anderson and Bollersleve (1998), the realized volatility converges uniformly in probability to the increment in the quadratic variation process.
by the theory of quadratic variation, as the sampling frequency of the underlying returns increase. That is

\[ RV_{i+1}(\Delta) \rightarrow \int_0^\Delta \sigma^2(s)ds + \sum_{0<\tau<\Delta} \kappa^2(s). \] (3.4)

Obviously, the realized volatility can be separated into two processes: the continuous sample path process and the jump process. Thus, the quadratic variation is consistent for the continuous volatility without jumps. Define the standardized realized bi-power variation (BV) as:

\[ BV_{i+1}(\Delta) \equiv \mu_i^{-2} \sum_{j=2}^{1/\Delta} \left| r_{i+j, \Delta}^2 \right| \left| r_{i+1+j, \Delta}^2 \right| \] (3.5)

where \( \mu_i^{-2} = \sqrt{\pi/2} \). Then, as \( \Delta \rightarrow 0 \) the equation (3.5) is possible to show.

\[ BV_{i+1}(\Delta) \rightarrow \int_0^\Delta \sigma^2(s)ds. \] (3.6)

Hence, the contribution to the quadratic variation process is a result of the jumps may be consistently estimated by

\[ RV_{i+1}(\Delta) - BV_{i+1}(\Delta) \rightarrow \sum_{0<\tau<\Delta} \kappa^2(s). \] (3.7)

This is fundamental theory and empirical for this article.

According to Dunham and Friesen (2008), the ratio statistic defines as follow:

\[ RJ_T = \frac{RV_i - BV_i}{RV_i}. \] (3.8)

With the absence of jumps, the equation (3.8) will converge to a standard normal distribution. Then
\[ ZJ = \frac{RJ_t}{\sqrt{\left(\frac{\pi}{2}\right)^2 + \pi - 5} \frac{1}{m} \max(1, \frac{TP}{BV_t^2})} \rightarrow N(0,1), \quad (3.9) \]

where \( m = 1/\Delta \) and \( TP_t \) as shown in the following:

\[ TP_t = m \mu_{4/3} \frac{m}{m-2} \sum_{j=3}^{m} r_t^{4/3} \left| r_{t,j-1} \right| \left| r_{t,j} \right|^{4/3} \rightarrow \int_{t-1}^{t} \sigma_4^4 ds^{3}, \quad (3.10) \]

where \( \mu_{4/3} = 2^{4/3} \Gamma((4/3 + 1)/2)/\Gamma(1/2) \).

We choose a value which is significant at the 5% critical value to confirm of jumps. Hence, the actual jump calculates as \( J_t = \text{sign}(r_t) \times \sqrt{(RV_t - BV_t) \times I_t} \), where \( I_t \) is equal to one when jump occurs and zero otherwise.

### 3.2 Decomposing Systematic Risk into Continuous and Jump Components

The distinction between systematic and nonsystematic risk has been explicitly recognized at least since Sharpe (1964), and jumps have been explicitly recognized in stochastic volatility and option pricing models for many years (Merton 1976; Bates 1991). To date, little work has examined the systematic and nonsystematic characteristics of jumps for REITs market. This section first develops an empirical methodology that decomposes total jump risk into systematic and nonsystematic components based on the CAPM model and two-factor model. Next, we test the asymmetric jump and continuous beta effects based on the CAPM model and

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\[ \text{According to Andersen, Bollerslev and Diebold (2007), the realized power variation (for } \Delta \rightarrow 0 \text{) follows that in general for } 0 < p < 2, \]

\[ \text{PRV}_{\Delta,p} = \mu_{p}^{\Delta-p/2} \sum_{j=3}^{\Delta} \left| r_{t,j} \right|^{p} \rightarrow \int_{t-1}^{t} \sigma_{p}^{p} (s) ds, \]

where \( \mu_{p} = 2^{p/2} \Gamma(\frac{1}{2} (p+1))/\Gamma(1/2) = E[|Z|^{p}] \). Therefore, the \( \text{PRV}_{\Delta,p} \) diverges to infinity for \( p > 2 \). And the impact of the discontinuous jump process disappears in the power variation measures with \( 0 < p < 2 \), while \( \text{PRV}_{\Delta,2} = RV_{\Delta,2} \) converges to the continuous volatility plus the jump volatility.

\[ \text{TP} \] denotes the tri-power quarticity robust to jumps from Barndorff-Nielsen and shephard (2004).
two-factor model.

**The modified CAPM model**

It is common to express daily returns for an asset in terms of a factor model. Without loss of generality, consider the standard single-factor model (such as the CAPM) for REIT $i$ returns:

$$R_{it} = \alpha_i + \beta_{it} R_{Mt} + \eta_{it}, \quad i = 1, 2, ..., 168$$

(3.11)

Equation (3.11) does not distinguish between the continuous and jump components of total return, but does decompose total return into systematic ($\beta_{it} R_{Mt}$) and nonsystematic ($\alpha_i + \eta_{it}$) components. Any market jump is embedded in $R_{Mt}$, while any nonsystematic jump unique to REIT $i$ is included in the error term.

In this section, we further decompose each REIT’s systematic risk into its continuous and jump components. This decomposition is interesting because standard factor models of risk implicitly assume that an asset’s systematic risk is uncorrelated with jumps in the market (i.e., that the asset’s beta does not change on days when the market experiences a jump). The modified CAPM model is as follows:

$$R_{it} = \alpha_i + \beta_{it}(R_{Mt} - J_{Mt}) + \beta_{2i} J_{Mt} + \eta_{it}, \quad (3.12)$$

where $J_{Mt} = \text{sign}(R_{it}) \times \sqrt{(RV_{it} - BV_{it}) \times I_t}$ is the signed magnitude of the jump return for the stock market, and $I_t$ is equal to one when jump of stock market occurs and zero otherwise. $\beta_{it}(R_{Mt} - J_{Mt})$ represents continuous systematic risk and $\beta_{2i} J_{Mt}$ represents jump systematic risk of REIT $i$. The value of $\eta_{it}$ is nonsystematic risk. The equation (3.12) is built up to test whether the return on REIT market is influenced by jump beta of the stock market.

The existing literature views REITs as a hybrid of stocks and bonds in terms of
return and risk exposure in the short-run (e.g., Ling and Naranjo (1997), Peterson and Hseih (1997), Karolyi and Sanders (1998)), with increased exposure to real estate revealed in longer term price dynamics (e.g., Mei and Lee (1994), Geltner and Rodriguez (1998)). Intuitively, REIT returns should be related to returns on stocks because REITs are influenced to some degree by the same macroeconomic variables that affect stock returns. The relatively fixed nature of the cash flows derived from income-property with long-term leases and high credit quality tenants, together with the high dividend yield REITs provide to investors, implying that REIT returns and risks should also be related to macroeconomic variables that affect bond returns. Essentially, this means that returns to stock and bond indices can act as proxies for the unobservable state variables that are common both to REITs, stocks and bonds. Hence, we expand the modified CAPM model to include the bond market factor, as follows:

\[
R_t = \alpha_i + \beta_{i1}(R_{Mt} - J_{Mt}) + \beta_{i2}J_{Mt} + \beta_{i3}(R_{Bt} - J_{Bt}) + \beta_{i4}J_{Bt} + \eta_{it}
\]  

(3.13)

where \( J_{Bt} = \text{sign}(R_t) \times \sqrt{(RV_t - BV_t)} \times I_t \) is the signed magnitude of the jump return for the bond market, and \( I_t \) is equal to one when jump of bond market occurs and zero otherwise.

**The Asymmetric Response Model**

Different versions of asymmetric response models have been used by researchers to test the asymmetric beta hypothesis, (e.g., Glascock (1991) and Goldstein and Nelling (1999)). We decompose systematic risk into continuous and jump components and include a dummy variable for declining market state to test the asymmetry continuous beta hypothesis. Furthermore, we include a dummy variable for down-jump signal to test the asymmetry jump beta hypothesis. Based on a CAPM model, in which the return on a individual REIT, \( R_{it} \), is specified as a linear function of stock, as follows:
\[ R_u = \alpha_i + \beta_{i1}(R_{Mt} - J_{Mt}) + \beta_{i2}J_{Mt} + \beta_{i3}D(R_{Mt} - J_{Mt}) + \beta_{i4}D_JJ_{Mt} + \eta_{it}, \] (3.14)

where \( \beta_{ji} \) is the comparable continuous systematic risk coefficient of stock markets represented by a market dummy \( D \), which has a value 1 when the excess market return is negative; and 0 otherwise. If the estimated value of \( \beta_{ji} \) is significantly non-zero, the asymmetric continuous beta exists. If the coefficient is positive, we have the similar results as Goldstein and Nelling (1999), which imply a higher systematic risk in declining markets than in rising markets. However, if \( \beta_{ji} \) is significant and negative, we have the Glascock (1991) results, which imply that REITs provide effective risk diversification in non-recessionary periods. Furthermore, \( \beta_{ji} \) is the comparable jump systematic risk coefficient of stock markets represented by a market dummy \( D_J \), which has a value 1 when the jump magnitude is negative; and 0 otherwise. If the estimated value of \( \beta_{ji} \) is significantly non-zero, the asymmetric jump beta exists. If the coefficient is positive, it implies a higher jump systematic risk in bad signal than in good signal.

The expanded empirical asymmetric response CAPM framework, in which the return on an individual REIT, \( R_{it} \), is specified as a linear function of stock and bond, is defined as follows:

\[ R_{it} = \alpha_i + \beta_{i1}(R_{Mt} - J_{Mt}) + \beta_{i2}J_{Mt} + \beta_{i3}D(R_{Mt} - J_{Mt}) + \beta_{i4}D_JJ_{Mt} \\
+ \beta_{i5}(R_{Bt} - J_{Bt}) + \beta_{i6}J_{Bt} + \beta_{i7}D(R_{Bt} - J_{Bt}) + \beta_{i8}D_JJ_{Bt} + \eta_{it} \] (3.15)

where \( \beta_{ji} \) is the continuous systematic risk coefficient of bond markets represented by a market dummy, \( D \), which has a value 1 when the excess market return is negative; and 0 otherwise. \( \beta_{ji} \) is the jump systematic risk coefficient of bond markets represented by a market dummy \( D_J \), which has a value 1 when the jump magnitude is negative; and 0 otherwise.
4. Empirical Results

4.1 Data Description

Our sample contains the U.S. three markets: the real estate market, the bond market and stock market over the period from January 1, 2000 to December 31, 2008, including 2263 daily observations. The REITs data of real estate market are taken from the Center for Research in Security Price (CRSP) database. The S&P 500 index and the Treasury bond futures Contract on a daily interval over the same sample periods are used to compute the general stock market returns and the bond market returns. These data are available in the Global Financial Data database (GFD). Before testing for jump risk, we first check whether the series is stationary using the Augmented Dickey and Fuller method (ADF). The tests do not reject the null hypothesis. Hence, all data are converted into the form of rates of change by calculating them as the difference of the natural logarithms of the data series.

4.2 Empirical Properties of the Data

Table 1 shows the cross-sectional summary statistics for realized volatility (RV) and bi-power variation (BV) for all samples including 168 firms of U.S. REITs, S&P 500 index and interest rate on mid-term bond. In panel A, the variable of RV approximates the total monthly return variance, while the BV estimates the continuous return variance. The standard deviations are calculated as the square root of these variables. The average value of $RV^{1/2}$ in U.S. REITs, S&P 500 index and Treasury bond futures returns are 9.55, 5.24 and 2.71 percent, respectively. The results suggested that the real estate market has more volatility than equity and bond markets in U.S.. This reason maybe that the most U.S. REITs markets are equity type (shown in Figure 1) and thus have the maximum value of U.S. REITs is 33.357%. Next, in order to measure the proportion of continuous volatility to total volatility, we also
construct the ratio of BV/RV. For stock market, approximately 44.5 percent of the total variance is due to continuous variance. Continuous variance contributes approximately 45.1 percent of total variance for the real estate market.

Panels B and C presents risk measures and the characteristics of the jumps. Total risk is computed as the variance of the total monthly return, while jump risk is the variance in monthly jump returns. The difference between jump risk and total risk is continuous risk, which is defined as the variance of the continuous monthly return. The percentage of total risk attributable to jumps is calculated as the jump variance divided by the total variance. Jump contributes approximately 19 percent (0.015% ÷ 0.077%) of total variance for the real estate market, 9 percent of total variance for the stock market, while 40 percent of the total variance is due to jump component in the bond market. Furthermore, the ratio between jump months and total months is the jump frequency. On days when a jump occurs, the jump size is calculated as the square root of the difference between RV and the BV measure. As for the jump frequency, jumps in the real estate market occur on 5.71 percent of trading days, while the equity market and the bond market jumps occur on 3.18 and 10.37 percent of trading days. Therefore, the bond market has higher jump frequency than the other markets in U.S.. Here we find the interesting phenomena, although the bond market has higher jump frequency but it has smallest jump size than the other markets. Figure 2 shows the numbers of REITs with significant jump risk from January 1, 2000 to December 31, 2008. During the all period, we find that the average numbers of REITs with significant jump risk is approximately 10 numbers for each day. Practically, the average numbers of REIT with significant jump risk has approximately 20 numbers for each day during the period from year 2000 to year 2003. One possible explanation

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4 The value is equal to 1 on jump days; otherwise, the value is equal 0.
for this is that the transaction in real estate market behaves more active and makes the return and volatility (jump risk) of REITs markets increases. Hence, the dividends of equity REITs are higher than 10 year maturity U.S. treasury yield from year 2000 to year 2003 (shown in Figure 3).
Table 1
Summary Statistics of Return Data

<table>
<thead>
<tr>
<th>Panel A: Jump Model Parameters</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>Min</th>
<th>S&amp;P 500</th>
<th>Bond market</th>
</tr>
</thead>
<tbody>
<tr>
<td>$RV$</td>
<td>2.091%</td>
<td>1.280%</td>
<td>26.533%</td>
<td>0.480%</td>
<td>0.388%</td>
<td>0.082%</td>
</tr>
<tr>
<td>$RV^{1/2}$</td>
<td>9.548%</td>
<td>8.307%</td>
<td>33.357%</td>
<td>6.100%</td>
<td>5.236%</td>
<td>2.707%</td>
</tr>
<tr>
<td>$BV$</td>
<td>0.807%</td>
<td>0.562%</td>
<td>7.030%</td>
<td>0.199%</td>
<td>0.179%</td>
<td>0.037%</td>
</tr>
<tr>
<td>$BV^{1/2}$</td>
<td>6.257%</td>
<td>5.555%</td>
<td>20.151%</td>
<td>3.958%</td>
<td>3.506%</td>
<td>1.815%</td>
</tr>
<tr>
<td>$BV / RV$</td>
<td>45.114%</td>
<td>45.807%</td>
<td>48.886%</td>
<td>33.141%</td>
<td>44.580%</td>
<td>45.719%</td>
</tr>
<tr>
<td>$(BV / RV)^{1/2}$</td>
<td>66.571%</td>
<td>67.289%</td>
<td>69.599%</td>
<td>54.962%</td>
<td>66.342%</td>
<td>67.208%</td>
</tr>
</tbody>
</table>

Panel B: Risk Measures

| Total risk | 0.077% | 0.044% | 0.746% | 0.017% | 0.011% | 0.005% |
| Jump risk  | 0.015% | 0.004% | 0.204% | 0.000% | 0.001% | 0.002% |
| Continuous risk | 0.063% | 0.037% | 0.625% | 0.016% | 0.009% | 0.003% |

Panel C: Properties of Jump Risk

| Jump frequently | 5.705% | 5.141% | 15.361% | 2.298% | 3.181% | 10.366% |
| Jump size       | 0.0709 | 0.0609 | 0.2576 | 0.0459 | 0.0385 | 0.0199 |

Figure 1: Number of U.S. REITs Type from 1990 to 2008
(Source: Data available from NAREIT)
4.3 Empirical results

_jump beta vs. continuous beta_

The result is shown in Table 2. Panel A reports the coefficients of the traditional CAPM model for U.S. REITs. The total systematic risk in Panel A is estimated by regressing total monthly returns for REITs on the total monthly return for the stock
market. The average total beta for the firms in our sample is about 0.72, which suggests that systematic risk of stock market has a positive effect on real estate market. These findings are compatible with Giliberto (1993), Han and Liang (1995) and Oppenheimer and Grissom (1998), who indicated that the REITs are exposed to beta risk. However, if the stock price has jump risk, traditional CAPM model will fail to capture important characteristics of abnormal shock event. Hence, to investigate further whether the continuous components and jump components of the stock market have different effects on the real estate market, it further decomposes total systematic risk into its continuous and jump components, shown in Panel B. We find that the coefficients of $\beta_{1i}$ (the average continuous beta) and $\beta_{2i}$ (the average jump beta) are 0.76 and 0.74, and the difference between the continuous and jump beta is significant at the 1% level. Therefore, it will be meaningful to explore the jump and continuous components of the stock market based on the CAPM model. Next, considering the jump beta risk, the values of $\beta_{1i}$ and $\beta_{2i}$ are statistically significant for most U.S. REITs (with 139 numbers of REITs, $139/168=82.74$ percent), indicating that continuous beta risk and jump beta risk in the stock market has an effect on the real estate market. That is, the returns on real estate market are correlated with the stock market when the stock market experiences a jump.

Many studies have investigated the return association between equity REITs and the general stock market (e.g., Ambrose et al, 1992; Myer and Webb, 1993). However, one limitation of CAPM framework is that it ignores the common factors that could influence the observed market. For example, Glascock, Lu and So (2000) examines the integration of REITs, stock and bond returns. They show that REITs are cointegrated with the bond market. Therefore, a multi-factor return generating approach is utilized in order to capture the relationship of REITs, stock and bond returns. Table 3 shows the coefficients of the two-factor model of these variables. In
Panel A, the coefficients of total return beta of stock market are significant for most U.S. REITs (with 137 numbers of REITs, 137/168=81.55 percent). Comparing with stock market, most of the coefficients of total systematic risk are not significant in bond market (with 29 numbers of REITs, 29/168=17.26 percent). This indicates that most of the returns of REITs are not influenced by the U.S. bond market. One possible explanation is that most of U.S. REITs are equity types, and thus have lower relationship with the bond market. As mentioned above, similarly we decompose each stock systematic risk into its continuous and jump components in two-factor model. This decomposition is interesting because standard two-factor model of risk implicitly assume that an asset’s systematic risk is uncorrelated with jump in the stock market. The difference between the continuous and jump beta is significant in stock market, implying it is necessary to separate the continuous risk and jump risk from the systematic risk of stock return in two-factor model.

This paper further analyzes the explanatory power to the REIT return when we decompose bond market. The result is shown in Panel B. The significance of different value between the continuous and jump components in bond market, suggesting that continuous beta risk and jump beta risk explains the discrepancies between real estate and bond markets. Hence, to decompose systematic risk into continuous and jump components is important for stock and bond markets. We also find that continuous beta risks are higher than jump beta risks. Economically, this means the REITs returns are most correlated with the stock and bond markets returns on days when stock and bond markets do not experience a jump.

**Is continuous beta asymmetric?**

We further expand our model to include a dummy variable for declining market state to test the asymmetric continuous beta hypothesis, and include a dummy variable
for negative jump size to test the asymmetric jump beta hypothesis. The results are shown in Panel C of Table 2 and Table 3. In Table 2, the coefficients of $\beta_{3i}$ are used to infer the asymmetric in continuous risk exposures; In Table 3, the coefficients of $\beta_{5i}$ and $\beta_{7i}$ are used to infer the asymmetric in continuous risk exposures. The results of asymmetric continuous beta tests in Panel C are estimated similarly using Glascock (1991) approach that includes a dummy variable for bear market, which is defined by negative excess market returns, in the standard CAPM framework. We find the significant positive value of $\beta_{3i}$ in 44.64 percent of REITs (75÷168=44.64%) in Table 2 and 37.50 percent (63÷168=37.50%) in Table 3. In the bond market, there are approximately 47 percent in U.S. REITs to have significant positive $\beta_{7i}$ value in Table 3. Furthermore, we assumed that $\beta_{3i} = \beta_{3i}$ and $\beta_{5i} = \beta_{7i}$ to test the asymmetric relationship of continuous beta. The result shows the difference between the symmetry continuous and asymmetry continuous betas are significant at the 1% level in stock and bond market, suggesting that the results support the asymmetric continuous beta hypothesis and compatible with Sagalyn (1990), Goldstein and Neling (1999), that claim the REITs returns more track the stock returns in declining market than in rising market.

Is jump beta asymmetric?

Except the business cycle, the good news and bad news of the market could influence the relationship between different markets. This concept of leverage effect is first proposed by Black (1976). Many studies have widely used this concept to analyze the financial markets, e.g., Koutmos, 1998; Wu and Xiao, 2002; Chen, et al., 2003; Mohanty, 2006. When the markets was suffered by the positive (good news) and the negative (bad news) of the information shock, if the bad news of the information affect the volatility of asset price more large than the good news of the information,
namely the existence of the leverage effect in this market. For this reason, we want to
examine whether the asymmetric jump beta exists when markets suffer the shocks in
this subsection. The results of asymmetric jump beta tests are shown in Panel C of
Table 2 and Table 3. In Table 2, the coefficients of $\beta_{4i}$ are used to infer the
asymmetric in jump risk exposures; In Table 3, the coefficients of $\beta_{4i}$ and $\beta_{8i}$ are
defined as the asymmetric in jump risk exposures. We find that the values of $\beta_{4i}$ in
stock market in Table 2 are significant and positive in 72 numbers (42.86 percent) of
U.S. REITs. In Table 3, it still has 77 numbers (45.8 percent) of REITs to have
significant positive $\beta_{4i}$, indicating the jump beta risk with bad news is higher than
with good news. This result appears to be consistent with Huang, Lee and Tzou
(2009), that finds evidence of a strong asymmetric effect with respect to the impact of
past good and bad news in the U.S., Australia and Japan EREITs. In the bond market,
the significant value of $\beta_{8i}$ are approximately 46 percent in U.S. REITs. Moreover,
by applying a test to test the asymmetric relationship between bad news and good
news for stock market and bond market, it is assumed that $\beta_{2i} = \beta_{4i}$ and $\beta_{6i} = \beta_{8i}$.
The results show the difference between the symmetry jump and asymmetry jump
beta are significant at the 1% level in stock and bond market, suggesting that there is a
support for the asymmetric jump beta hypothesis. It indicates that important pieces of
bad news tend to increase the volatility in U.S. excess REITs returns. Hence,
separating the positive jump size and negative jump size is important when studying
the impact of news on financial markets. The bad shocks probably limit the wealth
and investment plans of the investors. Ignoring this phenomenon, the investor maybe
undervalues the relationship between assets and to work out the wrong decisions.
Furthermore, our result implies that when pricing the derivatives of the REITs, it is
necessary to distinguish between the positive and the negative of jump size of the
REITs and thus jump diffusion model maybe fail to capture the dynamic process of
REITs.

**Is jump risk nonsystematic?**

In the equation (3.13), it separates systematic risk into continuous and jump components. However, all nonsystematic risks do not separated continuous and jump risk. Therefore, in this section, we decompose nonsystematic risk into continuous and jump components. As mentioned above, the value of \( \eta_{it} \) is total nonsystematic risk. Define the nonsystematic jump return \( \text{NonJump} \) and nonsystematic continuous return \( \text{NonCon} \) as follows:

\[
\text{NonJump} = J_{it} - \hat{\beta}_2 J_{iB} - \hat{\beta}_4 J_{iB},
\]

\[
\text{NonCon} = \nu_{it} - (J_{it} - \hat{\beta}_2 J_{iB} - \hat{\beta}_4 J_{iB}).
\]

Hence, it can decompose total risk into systematic (jump and continuous) and nonsystematic risks (jump and continuous). This study defines total risk as the variance of total monthly returns and the systematic continuous (jump) risk as squared continuous (jump) systematic risk multiplied by the variance of continuous (jump) market returns. Nonsystematic jump risk is defined as the sample variance of \( \text{NonJump} \) and nonsystematic continuous risk is defined as the sample variance of \( \text{NonCon} \). The result is shown in Panel B of Table 2 and Table 3. It finds that most jump risk is nonsystematic, suggesting that accounting for jump risk is most important in a non-diversified context, where nonsystematic risk is present.

In Summary, our study results in several important findings. First, the continuous beta is higher than the jump beta in U.S. REITs market, thus the continuous beta is the most relevant measure of co-movement with the market on days when stock and bond markets do not experience a jump. The U.S. REITs seem to behave differently during a severe market downturn than it does at other times, and this information offers the potential to significantly improve on calculations such as Value at Risk (VAR).
Second, the asymmetric continuous betas are positive in stock and bond markets, indicating the continuous betas are higher during down markets and lower during up markets. Such behavior may imply that, REITs returns would be more affected during periods of significant market decline. Third, this evidence indicates that there is asymmetric/leverage effect in risk premia of stock and bond effects on REITs returns. Finally, most jump risk is nonsystematic, with systematic jump risk contributing less than 6% of total return variance. This would suggest that accounting for jump risk is most important in a non-diversified context where nonsystematic risk is present.
### Table 2: Results of decomposing systematic risk into continuous and jump components for CAPM model

<table>
<thead>
<tr>
<th>Panel A: Traditional CAPM</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev.</th>
<th>No.(Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.7225</td>
<td>0.6799</td>
<td>2.0705</td>
<td>-0.2093</td>
<td>0.4028</td>
<td>135(80.36%)</td>
</tr>
</tbody>
</table>

Total return beta(S)

<table>
<thead>
<tr>
<th>Panel B: Modify CAPM_ Continuous and Jumps Betas</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev.</th>
<th>No.(Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous beta(S)</td>
<td>0.7559</td>
<td>0.7037</td>
<td>2.4894</td>
<td>-0.0593</td>
<td>0.4421</td>
<td>139(82.74%)</td>
</tr>
<tr>
<td>Jump beta(S)</td>
<td>0.7410</td>
<td>0.6919</td>
<td>2.3024</td>
<td>-0.1263</td>
<td>0.4226</td>
<td>137(81.55%)</td>
</tr>
<tr>
<td>Difference(Con-jump)</td>
<td>0.0149</td>
<td>0.0169</td>
<td>0.187</td>
<td>-0.184</td>
<td>0.040</td>
<td></td>
</tr>
</tbody>
</table>

Percentage total risk

| Systematic jump risk(S)                         | 6.00% | 5.09%  | 16.54% | 0.01   | 4.91%    |
| Systematic continuous risk(S)                  | 4.53% | 4.01%  | 12.47% | 0.001% | 3.73%    |
| Nonsystematic jump risk(S)                     | 45.39%| 45.70% | 52.93% | 34.41% | 5.12%    |
| Nonsystematic continuous risk(S)               | 44.08%| 44.83% | 50.42% | 36.34% | 3.63%    |

Panel C: Modify CAPM_ Asymmetry Continuous and Jumps Betas

<table>
<thead>
<tr>
<th>Estimated parameter</th>
<th>Continuous beta1</th>
<th>Jump beta2</th>
<th>Continuous beta3</th>
<th>Jump beta4</th>
<th>Difference(Con1-jump2)</th>
<th>Difference(Con3-jump4)</th>
<th>Difference(Con1-con3)</th>
<th>Difference(Jump2-jump4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1477</td>
<td>0.2073</td>
<td>0.8952</td>
<td>0.8544</td>
<td>-0.0052</td>
<td>0.0408***</td>
<td>-0.7475***</td>
<td>-0.7015***</td>
</tr>
<tr>
<td></td>
<td>0.1529</td>
<td>0.2001</td>
<td>0.8112</td>
<td>0.8176</td>
<td>0.0009</td>
<td>0.0354</td>
<td>0.0408***</td>
<td>-0.6490</td>
</tr>
<tr>
<td></td>
<td>0.1477</td>
<td>0.2073</td>
<td>0.8952</td>
<td>0.8544</td>
<td>-0.0052</td>
<td>0.0408***</td>
<td>-0.7475***</td>
<td>-0.7015***</td>
</tr>
<tr>
<td></td>
<td>0.8544</td>
<td>0.0354</td>
<td>-0.7475***</td>
<td>-0.7015***</td>
<td>-0.6490</td>
<td>0.0408***</td>
<td>-0.7475***</td>
<td>-0.6446</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Asterisks denote statistical significance at the 1% (***) , 5% (**), or 10% (*) level, respectively.
The S denotes the stock market.
### Table 3: Results of decomposing jump risk into systematic and nonsystematic components for two-factor model

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev</th>
<th>No.(Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Traditional Three-Factor Model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{it} = \alpha_i + \beta_{it}R_{Mt} + \beta_{3i}D_{it}R_{Bt} + \eta_{it}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total return beta 1(S)</td>
<td>0.7990</td>
<td>0.7417</td>
<td>1.9484</td>
<td>0.2352</td>
<td>0.3781</td>
<td>137(81.55%)</td>
</tr>
<tr>
<td>Total return beta 2(B)</td>
<td>-0.2032</td>
<td>-0.5490</td>
<td>1.6869</td>
<td>-1.3793</td>
<td>0.8838</td>
<td>29(17.26%)</td>
</tr>
<tr>
<td><strong>Panel B: Modify Three-Factor Model <em>Continuous and Jumps Betas</em></strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{it} = \alpha_i + \beta_{it}(R_{Mt} - J_{Mt}) + \beta_{3i}J_{it} + \beta_{4i}(R_{Bt} - J_{Bt}) + \beta_{5i}J_{Pt} + \eta_{it}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated parameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous beta1(S)</td>
<td>0.8343</td>
<td>0.7929</td>
<td>2.3533</td>
<td>0.2181</td>
<td>0.4140</td>
<td>135(80.36%)</td>
</tr>
<tr>
<td>Jump beta2(S)</td>
<td>0.8142</td>
<td>0.7588</td>
<td>2.1588</td>
<td>0.2380</td>
<td>0.3977</td>
<td>134(79.76%)</td>
</tr>
<tr>
<td>Continuous beta3(B)</td>
<td>-0.3365</td>
<td>-0.5960</td>
<td>1.6143</td>
<td>-1.6276</td>
<td>0.9437</td>
<td>33(19.64%)</td>
</tr>
<tr>
<td>Jump beta4(B)</td>
<td>-0.2600</td>
<td>-0.5659</td>
<td>1.6365</td>
<td>-1.5374</td>
<td>0.9110</td>
<td>33(19.64%)</td>
</tr>
<tr>
<td>Difference(Con1-jump2)</td>
<td>0.0154***</td>
<td>0.0150</td>
<td>0.1944</td>
<td>-0.1910</td>
<td>0.0415</td>
<td></td>
</tr>
<tr>
<td>Difference(Con3-jump4)</td>
<td>-0.0230***</td>
<td>-0.0164</td>
<td>0.1060</td>
<td>-0.2143</td>
<td>0.0452</td>
<td></td>
</tr>
<tr>
<td><strong>Percentage total risk</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systematic jump risk(S)</td>
<td>5.55%</td>
<td>5.28%</td>
<td>15.89%</td>
<td>0.01%</td>
<td>4.50%</td>
<td></td>
</tr>
<tr>
<td>Systematic continuous risk(S)</td>
<td>4.20%</td>
<td>4.15%</td>
<td>11.62%</td>
<td>0.00%</td>
<td>3.42%</td>
<td></td>
</tr>
<tr>
<td>Systematic jump risk(B)</td>
<td>0.88%</td>
<td>0.29%</td>
<td>9.28%</td>
<td>0.00%</td>
<td>1.43%</td>
<td></td>
</tr>
<tr>
<td>Systematic continuous risk(B)</td>
<td>0.40%</td>
<td>0.16%</td>
<td>4.29%</td>
<td>0.00%</td>
<td>0.65%</td>
<td></td>
</tr>
<tr>
<td>Nonsystematic jump risk</td>
<td>45.13%</td>
<td>45.31%</td>
<td>52.78%</td>
<td>35.15%</td>
<td>4.97%</td>
<td></td>
</tr>
<tr>
<td>Nonsystematic continuous risk</td>
<td>43.85%</td>
<td>44.12%</td>
<td>49.18%</td>
<td>35.50%</td>
<td>3.46%</td>
<td></td>
</tr>
<tr>
<td><strong>Panel C: Modify Three- Factor Model <em>Asymmetry Continuous and Jumps Betas</em></strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R_{it} = \alpha_i + \beta_{it}(R_{Mt} - J_{Mt}) + \beta_{3i}J_{it} + \beta_{4i}D_{it}R_{Bt} + \beta_{5i}D_{it}J_{Bt} + \beta_{6i}(R_{Bt} - J_{Bt}) + \beta_{7i}D_{it}(R_{Bt} - J_{Bt}) + \beta_{8i}D_{it}J_{Bt} + \eta_{it}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated parameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous beta1(S)</td>
<td>0.7480</td>
<td>0.8197</td>
<td>1.8344</td>
<td>-1.5313</td>
<td>0.7472</td>
<td>15(8.93%)</td>
</tr>
<tr>
<td>Jump beta2 (S)</td>
<td>0.7381</td>
<td>0.8307</td>
<td>1.7952</td>
<td>-1.5408</td>
<td>0.7390</td>
<td>15(8.93%)</td>
</tr>
<tr>
<td>Continuous beta3(S)</td>
<td>1.7131</td>
<td>1.5517</td>
<td>5.1221</td>
<td>-1.2996</td>
<td>1.0127</td>
<td>63(37.50%)</td>
</tr>
<tr>
<td>Jump beta4(S)</td>
<td>1.6315</td>
<td>1.4455</td>
<td>4.6532</td>
<td>-1.2831</td>
<td>0.9375</td>
<td>63(37.50%)</td>
</tr>
<tr>
<td>Continuous beta5(B)</td>
<td>-1.4592</td>
<td>-1.2784</td>
<td>3.0210</td>
<td>-4.0426</td>
<td>1.2428</td>
<td>81(48.21%)</td>
</tr>
<tr>
<td>Jump beta6(B)</td>
<td>-1.4215</td>
<td>-1.2892</td>
<td>3.0090</td>
<td>-4.0719</td>
<td>1.2182</td>
<td>79(47.02%)</td>
</tr>
<tr>
<td>Continuous beta7(B)</td>
<td>2.6528</td>
<td>2.5211</td>
<td>8.3255</td>
<td>-3.3869</td>
<td>1.6583</td>
<td>78(46.43%)</td>
</tr>
<tr>
<td>Jump beta8(B)</td>
<td>2.5056</td>
<td>2.2132</td>
<td>8.4086</td>
<td>-3.3051</td>
<td>1.6928</td>
<td>77(45.83%)</td>
</tr>
<tr>
<td>Difference (Con1-jump2)</td>
<td>-0.0100**</td>
<td>-0.0029</td>
<td>0.0856</td>
<td>-0.3805</td>
<td>0.0542</td>
<td></td>
</tr>
<tr>
<td>Difference (Con3-jump4)</td>
<td>0.0486***</td>
<td>0.0387</td>
<td>0.4725</td>
<td>-0.2384</td>
<td>0.0970</td>
<td></td>
</tr>
<tr>
<td>Difference (Con5-jump6)</td>
<td>-0.0413***</td>
<td>-0.0360</td>
<td>0.1204</td>
<td>-0.3553</td>
<td>0.0671</td>
<td></td>
</tr>
<tr>
<td>Difference (Con7-jump8)</td>
<td>0.0480***</td>
<td>0.0447</td>
<td>0.3161</td>
<td>-0.1994</td>
<td>0.0865</td>
<td></td>
</tr>
<tr>
<td>Difference (Con1-con3)</td>
<td>-0.6434***</td>
<td>-0.5660</td>
<td>3.1472</td>
<td>-7.7591</td>
<td>1.5896</td>
<td></td>
</tr>
<tr>
<td>Difference (Con5-con7)</td>
<td>-0.5851***</td>
<td>-0.5865</td>
<td>3.0907</td>
<td>-6.9096</td>
<td>1.5286</td>
<td></td>
</tr>
<tr>
<td>Difference (Jump2-jump4)</td>
<td>-2.4136***</td>
<td>-2.0099</td>
<td>6.4079</td>
<td>-12.3681</td>
<td>2.7340</td>
<td></td>
</tr>
<tr>
<td>Difference (Jump6-jump8)</td>
<td>-2.3243***</td>
<td>-1.9073</td>
<td>6.3141</td>
<td>-12.4804</td>
<td>2.6603</td>
<td></td>
</tr>
</tbody>
</table>

Note: Asterisks denote statistical significance at the 1% (***) , 5% (**), or 10% (*) level, respectively.

The S denotes the stock market and the B denotes the bond market.
5. Conclusions

This paper uses an econometric technique which is developed by Andersen, Bollerslev and Diebold (2007) to verify the existence of jump in REITs, stock and bond markets in U.S.. This test shows that jump contributes approximately 62.4 percent of total variance for all REITs in Taiwan. Next, previous studies only know the average level of systematic risk (total beta). We extend the CAPM and three-factor models to decompose the stock and bond market’s systematic risk into the continuous beta risk and jump beta risk. Our empirical results find that jump beta risks are higher than continuous beta risks. Economically, this means the REITs co-move with the stock market much more on days when stock market experiences a jump. This implies that REITs behave differently during a severe market downturn than it does at other times, this information offers the potential to significantly improve on calculations such as Value at Risk (VAR). The R-squared of the model that decomposes jump risk into systematic and nonsystematic components improves in Taiwan REITs, compared with the traditional CAPM and three-factor model. Third, most of REITs in Taiwan do not have significantly asymmetric continuous beta effect and asymmetric/leverage effect. Forth, we decompose nonsystematic risk of systematic return in the stock and bond market into continuous and jump components, and we find that the most jump risk is nonsystematic. This suggests that accounting for jump risk is most important in a non-diversified context where nonsystematic risk is present.
References


