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The Interaction of Volatility, Volume and Skewness: Empirical Evidence from REITs

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Abstract

This paper considers how trading volume impacts upon the first three moments of REIT returns. Consistent with previous studies of the broader stock market, we find that volume is a significant factor with respect to both returns and volatility. We also find evidence supportive of the Hong & Stein's (2003) *Investor Heterogeneity Theory* with respect to the finding that skewness in REIT index returns is significantly related to volume. Furthermore, we also report findings that show the influence of the variability of volume with skewness.

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1. Introduction

Over the course of the last two decades, Real Estate Investment Trusts (REITs) have become established as the primary listed vehicle for property investment companies. REITs are distinguished from conventional corporate structures in that they are tax-transparent in relation to their dividend payments: if US REITs comply with certain requirements, dividend payments are exempt from corporate tax. The main rules that REITs have to observe are that 70 percent of assets and 70 percent of income are derived from real estate, and that a minimum of 90 percent its taxable income is distributed as dividends[1].

REITs were first launched in the US in 1960. However, it was not until the 1990s that the US REIT market grew and matured into a substantial asset class; the period since then is often referred to as the 'modern REIT' era. Two key regulatory events facilitated this development. *First*, the introduction of the UPREIT (Umbrella Partnership) structure, which allowed real estate investors to effectively indefinitely defer capital gains tax that had formerly been levied when a new REIT was created.[2] *Second*, the passing of the Omnibus Budget Reconciliation Act (1993), which increased the attractiveness of REITS to institutional investors.[3] There were 58 listed equity REITs in 1990; during 1993 and 1994 alone this number more than doubled, with 95 REIT initial public offerings (IPOs). By the end of 2012, the sector's market capitalization was $315bn – a more than 50-fold increase.

As the REIT market has matured, a burgeoning academic literature has observed and analyzed changes in various characteristics of the sector. A number of key factors have contributed to these changes; the most important being the growth in institutional investment. Chan et al. (2003) show that institutional shareholders' average holding of REIT shares – at 14 percent in 1992, grew to 39 percent in 1999[4]. In the 2000s, the inclusion of REITs in the Standard & Poor's (S&P) indices (from 2001) and the strong performance of the sector in the first half of the decade saw even greater institutional interest in the sector, so that by 2005 institutions owned 60 percent of the sector's shares (Lin et al., 2009).

Despite these developments, the number of REIT-specific papers to have considered the issue of trading volume is remarkably small. This is especially so when one considers both the increase in REIT trading volume during this period and the large general literature on trading volumes. With regard to trading volumes SNL Financial estimate that average REIT volume increased from 3 million shares per day in 1993 to over 50 million shares per day by 2006. In the context of the recent financial crisis, average daily volume was in excess of 100m shares from 2008 onwards, peaking at nearly 200m shares in 2009. The impact of the increase in volume from the early nineties onwards is the key issue under consideration in the current study.

The analysis in the current paper considers the impact of trading volume in the US REIT market, drawing draw upon a broad range of methodological frameworks. The first part of the empirical analysis utilizes daily data from 1991 through 2011, examining the relationship of volume with volatility using Granger Causality and GARCH-based tests. The results indicate that volume is a significant factor with respect to both returns and

volatility, and this as the REIT sector has matured an increased in volatility has also been observed. The second part of the paper draws upon the approach in Chen et al. (2001) and Hutson et al. (2008) in analyzing the differing moments of REIT returns and volume through the monthly estimation of the first three moments. The results provide evidence supportive of Hong & Stein's (2003) *Investor Heterogeneity Theory* with respect to the finding that skewness in REIT index returns is significantly related to volume. Furthermore, we also report findings that show the influence of the variability of volume with skewness. The remainder of the paper is laid out as follows. Section 2 provides a brief review of some of the pertinent literature. Section 3details the data used in the study and provides some initial results with respect to the relationship between volume and volatility. The empirical analysis is broken into two broad sections, which examine daily and monthly data respectively. The empirical results are correspondingly presented in Sections 4 and 5. Section 5 provides concluding comments.

2. Literature

The importance of volume has been long established in the general finance literature, in both a theoretical and empirical context[5]. Epps and Epps' (1976) *Mixture of Distributions Model* (MDM) hypothesizes a positive causal relation between volume and absolute returns. This positive volume-volatility relation arises because the volume of trading is positively related to the degree of dispersion of traders' opinion as to value[6]. One of the few studies of REIT volume is Cotter and Stevenson (2008), who report evidence of a significant positive relation between volume and volatility. The

implications of the link between trading volume and price volatility can also be seen in the momentum literature (Daniel et al., 1998; Hong and Stein, 1999; Lee and Swaminathan, 2000). Hung and Glascock (2010) illustrate the importance of trading volumes in REIT markets in the context of momentum, and find that turnover is a significant factor.

Chordia et al., (2001) provide evidence with respect to volume and returns, hypothesising that higher volume will lead to lower returns. Their rationale is based upon their view of volume as a measure of market liquidity; higher volume would lead traders to require a lower liquidity premium. In addition, this argument can be extended not only to the level of trading but also to the variability of volume. Higher volatility in volume can be indicative of the risk associated with changes in liquidity. In turn, higher variability in volume would be expected to result in higher expected returns, as traders would demand a greater liquidity premium. Whilst their findings are supportive of the first hypothesis, Chordia et al., (2001) find that the volatility of volume is negatively related to returns. Hutson et al. (2008) suggest that this finding is due to heterogeneity in investor opinion.

The increase in volume may not only affect prices and volatility, but also the skewness of returns. An explanation for this relation can be found in Hong and Stein (2003). They argue that because some investors have a limited ability to short-sell, information that was previously hidden becomes apparent during market declines, and resulting in negative skewness. The linkage with increased volume is based upon the large literature that has considered the relation between volume and volatility, which argues that the level of trading volume can act as a proxy for investor heterogeneity[7]. In comparison to the substantial literature that has analysed the impact of volume on price and volatility,

there is a limited literature devoted to examining the linkages between volume and the higher moments.

Chen et al. (2001) provide empirical evidence in relation to Hong and Stein's (2003) theoretical framework. In estimating a series of cross-sectional regressions, they find that negative skewness is most evident in stocks that have experienced an increase in trading volume. However, while this relation is significant at the firm level, it is not at the level of the stock market index[8]. The insignificance of this finding at the index level is confirmed by Charoenrook and Daouk (2004), who find only weak evidence that lagged volume is significantly related to future negative skewness. Hueng and Brooks (2003) report significant findings, although the relation tends not to be negative. Hueng and McDonald (2005) use a time-series approach, and their findings support those of Chen et al. (2001).

Hutson et al. (2008) adopt an alternative methodological framework, using both single-equation and Vector Auto Regression (VAR) models to analyse index-level stock price data. While their initial findings using a single equation framework generally confirm the existing evidence with respect to index data, the use of a VAR approach allows the authors to consider a broader range of 'channels of influence'. Hutson et al. (2008) find evidence of a strong volume-volatility relation, and in contrast to the findings of Chen et al., (2001), that skewness is significantly affected by trading volume at the market level.

In addition to the limited research on trading volume in REITs, few studies have examined third and fourth moments of REIT returns. Furthermore, the focus of the studies that have examined the issue vary considerably. Bond and Patel (2003) consider

the issue of time-variation in skewness in a GARCH framework. While they report evidence of skewness in a large proportion of their sample of 40 firms from both the US and UK, no evidence is found with respect to time variation. Vines et al. (1994) and Liow and Chan (2005) consider a similar issue, namely the relation between higher order co-movements and REIT returns. Vines et al. (1994) find no evidence that co-skewness affects equity REIT returns; in contrast, Liow and Chan's (2005) findings support the view that there is a relation between higher order co-movements and REIT returns. Their results are particularly strong when considering co-kurtosis. Lizieri et al. (2007) apply independent component analysis based on a kurtosis-maximizing algorithm to reveal return-generating factors in REIT returns. Hutson and Stevenson (2008) consider the measurement of skewness and find evidence of time-variation in the skewness of REITs both at an index and individual firm level. Furthermore, the reported results indicate that index level skewness is of the same sign as skewness at a REIT specific level.

The lack of studies to have considered asymmetry in REIT returns is somewhat surprising given the number of studies have shown that underlying property investment returns are general non-normal in their distribution (e.g. Young and Graff, 1995; Graff et al., 1997). Whilst there is no difference in the trading of REIT shares in comparison with stocks generally, the nature of the underlying assets may possibly play a role. In addition to the non-normality reported in the real estate literature, the illiquid nature of property investment may lead to implications in the share price returns. The illiquidity of the underlying assets does constrain the ability of a real estate portfolio manager, which effectively is what a REIT is, from adjusting their holdings in a timely manner in

response to changing market conditions. This is particularly so during market downturns as illiquidity often further increases in such periods.

3. Data and Initial Empirical Analysis

We use daily US Equity REIT index data from January 1991 to the end of April 2011, with Volume defined as dollar turnover as a percentage of market capitalization. Table 1 provides summary statistics of the raw data for the full sample period, and for four sub-periods: 1991-1995, 1996-2000, 2001-2005, and 2006 to 2011. Consistent with prior studies, we find a marked increase in REIT trading volume during the period. Average daily volume was about $32 million in the first half of the 1990s, and this increased to an average of $2,820 million in the period 2006 to 2011 – an almost 90-fold increase. Although this latter figure is exaggerated by the unusually high volume observed during the 2007/8 financial crisis, it is clear that trading volume had risen substantially before the crisis. This is not simply the result of a greater number of REITs in the sector. As can be seen by the last column of Table 1, turnover rose from an average of 0.26 percent of market capitalization in the early 1990s to 0.40 percent during 2001-2005, and to 1.33 percent in the 2006-2011 period[9].

The impact of this increase in volume on volatility is not straightforward. As seen in Table 1, REIT volatility (as measured by the standard deviation) fell in the second half of the 1990s, and then increased considerably during the 2001-2011 period. It is possible that thin trading in REIT stocks – as evident in the low trading volumes – in part contributed to the higher volatility observed. Then as the market matured during the

1990s trading levels approached more normal levels. Therefore, the impact of thin trading on volatility subsided. A recent paper by Ooi et al. (2009) notes that US REITs displayed heightened idiosyncratic risk during the early nineties. Ooi et al. (2009) show that reduced idiosyncratic risk was associated with increased integration as the market matured. As well as for the purpose of robustness testing, this pattern of apparent variation in the volume-volatility relation motivates our use of sub-periods in the empirical analysis.

As can be seen in Figure 1, which depicts raw daily turnover for the full period 1991-2011, the volume data is non-stationary. As noted by Lee and Rui (2002), many studies have observed that volume data can frequently display both linear and non-linear time-trends. For example, Hutson et al. (2008) find evidence of a positive drift in their volume data. We use two alternative methods to de-trend the turnover data. The first is an adaptation of the approach used in Hutson et al. (2008), whereby the log of turnover is regressed on a linear deterministic function of time. We add a quadratic term in order to account for any non-linear time-trends, as follows:

$$\log \left(TO_t \right) = \alpha + \beta_1 \text{TIME} + \beta_2 \text{TIME}^2 + \varepsilon_t \tag{1}$$

where *TO* is the original turnover series and TIME is a linear deterministic function. Whereas Hutson et al. (2008) extract the de-trended series by estimating the exponential of the error term from equation (1), we adopt a slightly different approach. In line with Connolly and Stivers (2005), we define the de-trended series as the residual, ε_t, less the minimum ε_t over the sample period. The two approaches are similar in that they ensure that non-negative estimates of de-trended turnover are obtained[10].

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The second measure of turnover is Market-Adjusted Relative Turnover (MRTO), as proposed by Connolly and Stivers (2003, 2005). In this measure, turnover is market-adjusted due to the positive relation between volume and absolute returns (Karpoff, 1987). In addition, any time-trend in the turnover data is controlled for based on its autoregressive behaviour. The model is as follows:

$$\log \left(TO \right) = \gamma_0 + \sum_{k=1}^{5} \gamma_k \log \left(TO_{t-k} \right) + \gamma_6 \left| R_{m,t} \right| + \gamma_7 D_t^- \left| R_{m,t} \right| + \upsilon_t \tag{2}$$

Where R_m is the return on the REIT index and D^- is a dummy variable equalling unity when the index return is negative. The de-trended series is estimated as the residual, υ_t, less the minimum υ_t over the sample period. The inclusion of the return term means this measure can be viewed as unexpected turnover, or shock in turnover, having accounted for market movements and the direction of those movements. Connolly and Stivers (2003, 2005) argue that estimating an unexpected turnover measure that is orthogonal to both the actual and absolute return means that any variation in the lagged/autoregressive element is not related to either the direction or the magnitude of the return.

The coefficients estimated from equations (1) and (2) are reported in Table 2. In relation to the pure time-trend variant of equation (1) (Panel A), both the time and time squared terms are significant at the 1 percent level. For the market-adjusted measure of equation (2) (Panel B), all of the coefficients, with the exception of γ_7, are significant at the 1 percent level, and are of the anticipated sign. Figures 2 and 3 depict the de-trended turnover series. The market-adjusted de-trending approach of equation (2) does a better job at de-trending the series than does the simpler time-trend approach of equation (1).

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This supports the arguments of Connolly and Stivers (2003, 2005) regarding the importance of incorporating both absolute market returns and market direction when estimating unanticipated turnover.

4. Empirical Results: Analysis of Daily Data

4.1 Granger Causality Tests

The first element of our empirical analysis involves standard Granger Causality tests as well as non-linear specifications. The tests are conducted with respect to the following relationships: Returns-Volume, Volatility-Volume, and Absolute Returns-Volume. We conduct these tests on the full period data set as well as the four sub-periods. The lag length used in the causality tests is based on the Schwartz Bayesian Criterion in each case.

We assume that our variables of interest – REIT returns R_t and volume V_t – are conditional on two information sets: $\mathbf{I}_{R,t-1}$ and $\mathbf{I}_{V,t-1}$ respectively. Therefore, consistent with Granger (1969), Hiemstra and Jones (1994), and Diks and Panchenko (2006), our strictly stationary variable V_t does not Granger cause another strictly stationary variable R_t if the past values of V_t provide no forecasting power in excess of the already incorporated past values of R_t :

$$R_{t+1},\ldots,R_{t+k} \mid \mathbf{I}_{V,t},\mathbf{I}_{R,t} \ \Box \ R_{t+1},\ldots,R_{t+k} \mid \mathbf{I}_{R,t} \quad \text{for some } k \geq 1 \tag{3}$$

A standard linear Granger non-causality procedure involves running a linear vector autoregressive model (VAR) of the following form:

$$R_t = a_0 + a_1 R_{t-1} + \ldots + a_n R_{t-n} + b_1 V_{t-1} + \ldots + b_n V_{t-n} + e_t \tag{4}$$

$$V_t = a_0 + a_1 V_{t-1} + \ldots + a_n V_{t-n} + b_1 R_{t-1} + \ldots + b_n R_{t-n} + u_t \tag{5}$$

The test of the Granger non-causality between variable V_t and R_t can be conducted through a simple test of the hypothesis of joint restriction of all the coefficients b equal to zero ($b_1 = b_2 = \ldots = b_n = 0$) for each variable in the VAR model. Linear tests may, however, have low power in cases where the relation between variables is of the non-linear form. Therefore, we also apply a non-linear non-parametric variation of the test, as suggested by Diks and Panchenko (2006). This approach is shown to be superior to that of Hiemstra and Jones (1994) since the latter procedure tends to over-reject the non-causal relationships between variables with the increase in sample size.

Following Diks and Panchenko (2006) and Bekiros and Diks (2008), assume Lv-length lagged vector of the trading volume variable V_t, $\mathbf{V}_{t-Lv}^{Lv} \equiv V_{t-Lv}^{Lv}, V_{t-Lv+1}^{Lv}, \ldots, V_{t-1}^{Lv}$ and Lr-length lagged vector of REIT returns R_t, $\mathbf{R}_{t-Lr}^{Lr} \equiv R_{t-Lr}^{Lr}, R_{t-Lr+1}^{Lr}, \ldots, R_{t-1}^{Lr}$. Therefore, for the variable R_{t+1}, the null hypothesis of no additional information from the variable V_t can be expressed as follows:

$$R_{t+1} \mid \mathbf{V}_t^{Lx}, \mathbf{R}_t^{Ly} \, \Box \, R_{t+1} \mid \mathbf{R}_t^{Ly} \tag{6}$$

$$H_0 : V_t \quad \text{does not Granger causing} \quad R_t \tag{7}$$

For a strictly stationary bivariate time series R_t, V_t, this expression provides a statement about the invariant distribution of the $Lv + Lr + 1$ – dimensional vector $\mathbf{W}_t = \mathbf{V}_t^{Lv}, \mathbf{R}_t^{Lr}, Z_t$, where $Z_t = R_{t+1}$. To make the notation compact, Diks and Panchenko (2006) let $Lv = Lr = 1$ and show that under the null, the conditional distribution of Z given $V, R = v, r$ is the same as that of Z given $R = r$. Further, equation (6) can be expressed in terms of ratios of joint distributions. Specifically, the joint probability density function $f_{V.R.Z}(v, r, z)$ and its marginals must satisfy the following relation:

$$\frac{f_{V.R.Z}(v,r,z)}{f_R(r)} = \frac{f_{V.r}(v,r)}{f_R(r)} \cdot \frac{f_{R.Z}(r,z)}{f_R(r)} \tag{8}$$

This explicitly states that V and Z are independent conditionally on $R = r$ for each fixed value of r. Diks and Panchenko (2006) show that this reformulated hypothesis H_0 implies:

$$q \equiv \mathrm{E}\left[f_{V.R.Z} \; V,R,Z \; f_R \; R \; - f_{V.R} \; V,R \; f_{R.Z} \; R,Z \right] = 0 \tag{9}$$

Diks and Panchenko (2006) and Bekiros and Diks (2008) further define a local density estimator of a d_W- variate random vector $\mathbf{W}$ at W_i as

$$\hat{f}_W \; W_i \; = \; 2\varepsilon_n^{-d_W} \; n-1^{-1} \sum_{j, j \neq i} I_{ij}^W \quad \text{where} \quad I_{ij}^W = I \; \left\| W_i - W_j \right\| < \varepsilon_n \quad \text{with} \quad I \cdot \quad \text{the}$$

indicator function and ε_n the bandwidth, depending on the sample size n. Given this estimator, the test statistic is the sample version of equation (9):

$$T_n\left(\varepsilon_n\right) = \frac{n-1}{n(n-2)}\sum_i \hat{f}_{V.R.Z}\left(V_i,R_i,Z_i\right)\hat{f}_R\left(R_i\right) - \hat{f}_{V.R}\left(V_i,R_i\right)\hat{f}_{R,Z}\left(R_i,Z_i\right) \tag{10}$$

For $Lv = Lr = 1$, if bandwidth $\varepsilon_n = Cn^{-\beta}\left(C>0,\dfrac{1}{4}<\beta<\dfrac{1}{3}\right)$ then Diks and Panchenko

(2006) prove that the test statistic in equation (10) satisfies

$$\sqrt{n}\,\frac{T_n\left(\varepsilon_n\right)-q}{S_n}\xrightarrow{D} N\left(0,1\right) \tag{11}$$

where $\xrightarrow{D}$ denotes convergence in distribution and S_n is an estimator of the

asymptotic variance of $T_n\left(\cdot\right)$. This is a one-tailed version of the test. It implies rejection

of the null hypothesis if the left-hand side of equation (11) is too large.

The results for the linear and non-linear models are reported in Table 3. We report

findings for both the DTO and MRTO adjusted volumes using data for the full period

(1991-2001), as well as the four sub-periods (1991-1995, 1996-2000, 2001-2005, and

2006-2011). Panel A reports on the return-volume relation, Panel B the volatility-volume

relation, and Panel C the absolute return-volume relation. For the return-volume relation,

Panel A shows that the direction of interaction is returns to volume, rather than the other

way around; and for the significant coefficients, the signs are universally positive,

indicating that when REIT prices rise, trading volume increases. In general, the findings

are stronger for the linear models than the non-linear.

There is also strong evidence of a volume-volatility relation, from volatility to volume and the reverse – volume to volatility, although the latter is in general weaker. There is particularly strong evidence of these interactions in the most recent period, 2006-2011. With the exception of this period, and commensurate with the findings reported in Panel A, fewer significant findings are reported for the most robust non-linear model than the linear. When absolute returns are used as the measure of volatility (Panel C), the findings are similar to those when squared returns are used (Panel B). Our findings on the relation between volume and volatility are consistent with studies of the volatility-volume relation in stock indexes. There is also evidence of a bi-direct relation between volume and volatility for REITs, and this is consistent with Hutson et al.'s (2008) findings for 11 developed country stock markets.

4.2 GARCH Analysis of Daily Data

For the second component of the analysis of the daily contemporaneous relation between volume and returns and volatility, we adopt two GARCH specifications, similar in form to those used in Lee and Riu (2002). GARCH models assume that the volatility of the series is a deterministic function of past returns and is therefore conditional on previous squared error terms. The GARCH (1,1) specification, as proposed by Bollerslev (1986), further allows the conditional variance of the series to be dependent on its own lags. A standard univariate GARCH (1,1) specification is as follows:

$$x_{i,t} = \mu + \varepsilon_{i,t} \tag{12}$$

$$\varepsilon_{i,t} \sim N(0, h_{ii,t}) \tag{13}$$

$$h_{ii,t} = \gamma_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{ii,t-1} \tag{14}$$

where the mean is described by a first order VAR, and univariate volatility follows a GARCH process. The specification is subject to $\gamma_i > 0, \alpha_i, \beta_i \geq 0, \alpha_i + \beta_i < 1$. The α and β coefficients determine the short-run dynamics of the resulting volatility time series. A large β indicates that shocks to conditional variance take a long time to dissipate; that is, volatility is said to be "persistent". A large α indicates that volatility reacts intensely to recent market movements. We use two alternative specifications. The first, which incorporates volume in the GARCH mean equation, is as follows:

$$R_t = b_0 + b_1 SP_t + b_2 V_t + \varepsilon_t \tag{15}$$

$$h_t = a_0 + a_1 \varepsilon_{t-1}^2 + a_2 h_{t-1} \tag{16}$$

The second includes volume in the variance equation:

$$R_t = b_0 + b_1 SP_t + \varepsilon_t \tag{17}$$

$$h_t = a_0 + a_1 \varepsilon_{t-1}^2 + a_2 h_{t-1} + a_3 V_t \tag{18}$$

In both specifications, we include the S&P 500 Composite Index to control for overall market movements. As for the Granger causality tests, we estimate the GARCH models using daily data and the adjusted volumes DTO (Table 4) and MRTO (Table 5). Our findings are broadly in line with previous work on equities. Volume is significantly

related to REIT index returns, and there is essentially no difference between the estimates using the two approaches to de-trending volume. When volume is included in the mean equation (Panel A in Tables 4 and 5), its coefficient b_2 is significant for the full sample period and for the first two sub-periods (1991-1995, 1996-2000), but not for the two later sub-periods (2001-2005 and 2006-2010). A plausible explanation for volume's lack of significance, at least in the later 2000s sub-period, relates to the 2007-2008 financial crisis. As can be seen in Table 1, during this period large volumes were accompanied by a small negative average return and very high volatility.

The coefficient on volume in the variance equation (Panel B in Tables 4 and 5), a_3, is significant in all periods, and using both de-trending methods. This is indicative of a strong and robust volume-volatility relation for REITs, and it is consistent with the findings for equities (Anderson, 1996; Lee & Riu, 2002). It is also consistent with Cotter and Stevenson (2008), who include volume in their GARCH models when examining long memory in REIT volatility, and find it significant.

5. Empirical Results: Analysis of Monthly Data

5.1 Single-equation estimates

The second stage of our analysis follows the methodological approach used in Chen et al. (2001), Charoenrook and Daouk (2004), and Hutson et al. (2008). Using our daily REIT data, we estimate unconditional monthly estimates of the average, standard deviation and skewness of returns and de-trended volumes. This approach enables us to create a time-

series for each of the three moments. The time series for the mean, standard deviation and skewness are then used in subsequent empirical analysis. The notation that we use is as follows: *R1* denotes the monthly average of daily REIT returns, and *R2* and *R3* denote the standard deviation and skewness of the returns respectively. For volume, *V1*, *V2* and *V3* denote the average, standard deviation and skewness respectively of the within-month daily de-trended turnover series.

With respect to the measurement of skewness, the conventional approach is as follows:

$$SK^i = \frac{\frac{1}{N} \sum_{t=1}^{N} \left(R_{i,t} - \bar{R}_i \right)}{\left(\sigma_i \right)} \qquad (19)$$

where R_{it} is the return on asset i at time t, σ_i is the sample standard deviation and N is the number of observations. Most studies of return distributions use this estimate of skewness, and strong inferences are commonly made about the nature of the underlying distribution from this measure. The conventional estimate, however, can lead to erroneous inferences about the nature of the distribution. In particular, the effect of outliers is greatly amplified in the skewness calculation due to the cubing of deviations from the mean. This can result in substantial bias in the presence of a small number of outliers, or even a single outlier (Kim and White, 2004). In addition, Peiró (1999, 2002) argues that the conventional test is a test of normality and not symmetry. This implies that researchers may incorrectly conclude that returns are asymmetric when the distribution is in fact symmetric, but not normal. In a REIT context, Hutson and Stevenson (2008) highlight a number of the problems and biases associated with the conventional measure of the third moment, at both the firm and the index level. We

follow Hutson et al. (2008) in using an alternative measure of skewness. The measure used is a derivative of the standard coefficient of skewness:

$$SKW_i = -\frac{N(N-1)^{3/2}\sum_{i=1}^{n}R_{i,t}^3}{(N-1)(N-2)\left(\sum_{i=1}^{n}R_{i,t}^2\right)^{3/2}}$$

(20)

Equation (20) is the negative of the third moment, scaled by the cubed standard deviation. This results in the skewness being standardized for differences in variance. Taking the negative of this ratio is a convention in the return-skewness literature; a higher value corresponds to a more negatively skewed return distribution[11].

Table 6 provides summary statistics for these series; returns (Panel A), and our two measures of de-trended volume DTO (Panel B) and MRTO (Panel C). The sub-period findings highlight the changing nature of REIT volatility over time, with the average of the monthly standard deviation of returns estimates (Panel A) falling from the first to the second half of the 1990s, and increasing in the 2000s. The average of the skewness of returns figures support the findings of Hutson and Stevenson (2008); we find negative figures for average skewness (indicating positive skewness) in the 1990s, and positive figures (indicating negative skewness) subsequently. Hutson and Stevenson (2008) suggest that this pattern may in part be due to the problems inherent in examining higher moments. As the skewness is the third moment, not only can it be biased by the presence of extreme observations (Peiro, 1999 and Kim and White, 2004); during a period with low average returns, these extreme observations are effectively given less weight in the skewness calculation. In a period with a high average returns, the potential bias induced

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by cubing extreme negative deviations from the mean are enhanced. As reported in Table 1, the average daily return in 1996-2000 was only 0.0232. This increased dramatically to 0.0468 in the subsequent period (2001-2005). It is of interest, in the context of our current analysis, that the 2006-2011 period was accompanied by higher turnover, with the average of the DTO series rising from 1.6761 in the 2000-2005 period to 1.7813 in 2006-2011. Even the average of the MRTO series rose – from 1.6890 to 1.7256[12].

We use two alternative single-equation empirical models, as proposed by Charoenrook and Daouk (2004) and Chen et al. (2001) respectively, to explain return skewness. These are as follows:

$$R3_t = \alpha + \beta_1 R1_{t-1} + \phi_1 V1_{t-1} + \varepsilon_t \tag{21}$$

$$R3_t = \alpha + \beta_1 R3_{t-1} + \beta_2 R2_{t-1} + \phi_1 V1_{t-1} + \sum_{j=1}^{5} \delta_j R1_{t-j} + \mu_t \tag{22}$$

Following Chen et al. (2001), we incorporate five lags in the specification of equation (22). Because we have created monthly data by taking the within-month mean, volatility and skewness figures for return and volume, we use only two sub-periods in this analysis, with the end of 2000 as the break point[13].

The results of our single-equation estimates can be found in Table 7. Previous studies that have used such specifications on index data (Chen et al., 2001, Charoenrook and Daouk, 2004, Hutson et al., 2008) have tended to find that skewness is not significantly related to the mean and volatility of returns and volumes – particularly the skewness of

volumes. In their time-series analysis, Chen et al. (2001) found little of significance, as did Charoenrook and Daouk (2004)[14]. Hutson et al. (2008) report some significant findings, but only for Japan and the UK (of their 11 international equity markets), and only when they replicate the model of Charoenrook and Daouk (2004) (equation 21).

Using the DTO series, volume is significant in the entire sample period and for the 1991-2000 period, when using the first model (equation (21)). Using the second model (equation (22)), volume is significant for the first sub-period. When the MRTO series is used, volume it is significant determinant of skewness for the full sample period using both model specifications, but not in the sub-periods. These findings are consistent with Hong and Stein's (2003) Investor Heterogeneity hypothesis, which argues that increased volume can be interpreted as a rise in investor heterogeneity. It may initially appear strange that no results are significant in the final sub-period, given that it contains the 2007-2008 financial crisis which saw not only extreme negative REIT returns but also a large increase in trading volume. However, it is important to note that the models are estimated using time-series data based on monthly estimates of the first three moments. Therefore, the skewness estimates for the periods of extreme movement will not be unduly biased as they are based on the deviations within the month.

5.2 VAR Model

The final specification is based upon the VAR framework, as used in Hutson et al. (2008). This approach effectively expands the single-equation model of Chen et al. (2001). By estimating the model in a VAR system, it allows for more complex

interaction mechanisms across the various series. Charoenrook and Daouk (2004) include only the *R1* and *V1* series at one lag, while Chen et al. (2001) add the second and third moments of returns (*R2* and *R3*) and an additional four lags for the *R1* series. Further, the VAR specification extends the number of variables considered. Hutson et al. (2008) incorporate not only average de-trended volume (*V1*) but also the standard deviation (*V2*) and the skewness (*V3*) of volume. The model therefore captures the evolution of return skewness in relation to variations in return volatility (*R2*), average returns (*R1*), de-trended volume (*V1*), the standard deviation of the volume series (*V2*) and its skewness (V3). The lag length of four is based upon the Akaike Information Criterion (AIC).

The results reported in Table 8 provide details of coefficients that are significantly related to the skewness of returns. The results confirm the findings found from the single equation models, with significant results for average volume series in each of the sub-periods. Using the MRTO turnover, there is no relation between the first moment of volume and return skewness. This is consistent with Hutson et al (2008), who found no evidence of a volume-skewness relation for the US market. However, there is a strong relation between the higher moments – standard deviation and skewness – of volume and return skewness. This demonstrates the importance of Hutson et al.'s (2008) innovation of including the second and third moments of volume rather than simply the first moment, as used by Chen et al (2001) and Charoenrook and Daouk (2004).

Table 9 summarizes the main interactions between the return and volume series. *First*, we find strong evidence of the volume-volatility relation. Using the MRTO measure of de-trended volume (Panel C), the volume volatility relation (that is, V1→R2) is significant in all periods. We also find that the relation also holds in the reverse direction for all periods (Panel D); the second moment of return significantly influences volume (R2→V1). *Second*, while there is no evidence of a (first moment of) volume-skewness relation as discussed above, we find evidence of a reverse causality in this relation (R3→V1) during the two sub-periods.

6. Conclusion

This paper aims to examine the interaction between volume and the first three moments of REIT returns. Not only do the initial findings provide support for the commonly found relationships between volume and returns and volatility but we also find significant results with respect to skewness. The findings are supportive of the *Investor Heterogeneity Theory* of Hong & Stein (2003). Skewness in REIT returns is found to be significantly related to not only volume but also the volatility of volume, its second moment.

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Endnotes:

[1] The US, in common with some other markets, also has regulations in place regarding ownership. While the exact nature of the regulatory structure differs across markets, most countries adopt a similar arrangement to the US.

[2] Prior to the introduction of the UPREIT structure, the US tax authorities considered that a transaction had taken place when a REIT was established. Therefore, even if the original owners simply transferred their ownership through the issuance of REIT shares, they were liable to capital gains tax.

[3] The act allowed greater flexibility concerning the 5/50 ownership rule. This states that no more than 50% of REIT shares can be held directly or indirectly by any group of five or fewer investors. Following the legislation as long as a REIT had a minimum of 100 shareholders, then pension funds could treat each contributor to the fund as an individual investor in the REIT.

[4] There was a corresponding decline in REIT share bid-ask spreads (Below et al., 1996; Bhasin et al., 1997), and an increase in the number of analysts following the sector (Wang et al., 1995).

[5] In relation to some of the earlier papers in the field to have considered the relation between volume and returns, see Granger and Morgenstern (1963), Crouch (1970), Tauchen and Pitts (1983) and Wood et al. (1985). Later papers extended this form of analysis to consider lagged/dynamic relationships; see, for example, Rogalski (1979), Smirlock and Starks (1988), Jain and Joh (1988), Hiemstra and Jones (1994), Wang (1994), Chordia and Swaminathan (2000), Lee and Rui (2002).

[6] See also Clark (1973), Tauchen & Pitts (1983), Andersen (1996), Andersen and Bollerslev (1998) and Xu et al. (2006).

[7] See, for example, Clark (1973), Epps and Epps (1976), Tauchen and Pitts (1983), Harris and Raviv (1993) and Shalen (1993).

[8] Chen et al. (2001) suggest that the lack of significant findings is due to bias introduced due to large market movements such as the 1987 crash.

[9] If one considers data extending back to the 1970s, the increase is even more stark. During 1973-1979, average daily volume was just $833,569, increasing to just over $6m in the 1980s. REIT data is available back to 1973; however, we only consider the post-1991 period for two key reasons. First, changes in the structure of the US REIT market in the early 1990s, such as the Omnibus Budget Reconciliation Act, led to substantial changes in the sector. The post-early 1990s period is frequently referred to as the 'Modern REIT era', and it is characterised by quite different investment dynamics. Second, no daily index of REIT performance pre-1991 isolates Equity REITs. Rather the indices available combine Mortgage and Hybrid REITs. Due to their different return, risk and other characteristics, 1991 is the most appropriate start date.

[10] While the results reported in the paper are those using the Connolly and Stivers (2005) approach, all of the empirical tests were also conducted using the exponential of the residuals. These results do not substantially differ from those reported, and are available from the authors on request.

[11] As with the use of alternative measures of turnover, all of the empirical results were estimated with all specifications. While the results reported and discussed in the paper refer to the scaled measure of skewness, all of the tests were also estimated using the conventional measure. These findings are available on request from the authors.

[12] The unadjusted turnover series saw a larger increase, as one would expect, with the average rising from 0.2467 (1996-200) to 0.4008 (2001-2005) to 1.3316 (2006-2011).

[13] It should be noted with respect to the skewness series R3 and V3, that their use does not violate the normality assumptions of OLS. Tests of normality (available from the authors on request) show no evidence of non-normality in the skewness data. It should be remembered that the data analysed is a time series of observations of within-month estimates of skewness. Therefore, it does not necessarily follow that this monthly time series is itself non-normal.

[14] As noted in the introduction, Chen et al.'s (2001) cross-sectional firm level analysis did report significant findings.