

Monetary Shocks and REIT Returns

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Abstract We investigate the influence of unanticipated changes in US monetary policy on Equity Real Estate Investment Trusts (REIT's). Although a number of studies have investigated the issue of interest rate changes, the effect of unanticipated changes has not previously been addressed in terms of possible effects on both REIT's returns and volatility. The results show a strong response in both the first and second moments of REIT returns to unexpected policy rate changes. The results for the impact of the shock on both mean and volatility of returns is consistent with results from studies addressing broader equity markets. However, we find evidence both against behavioral changes in volatility coincident to US monetary policy decisions and asymmetric responses to the monetary policy shock.

Keywords US monetary policy · Equity Real Estate Investment Trusts · Monetary shocks · REIT returns

Introduction

The interest in the recent appointment of Ben Bernanke as the Chairman of the Federal Reserve is a further indication of the primacy of monetary policy as a main

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tool used by US policy makers in the stabilization of inflation and output. The importance of monetary policy changes and the transmission of information contained therein to asset markets has been a subject of interest in a number of papers in recent years. This paper examines the impact of changes in the main monetary policy instrument in the United States, the Federal Funds Rate, on Equity Real Estate Investment Trusts (REITs). The rationale behind the examination of REITs is due to their unique structure in comparison to mainstream equities. In particular, the requirement that at least 75% of their assets be invested in real estate and the minimum 90% payout of their taxable earnings as dividends may lead to a different response in REIT prices in comparison with equities to changes in monetary policy.¹

The impact of policy rate changes on the general equity market can be viewed as occurring through three channels. Firstly, the impact on the expected level of future dividends of the firms, secondly, any associated change in the real interest rate used to discount these dividends and thirdly changes in the equity risk premium. Given the characteristics of not only REITs but also the underlying private real estate market, a number of aspects of these linkages may take on additional importance in the context of the traded real estate sector. With respect to dividends, the 90% dividend payout requirement will lead to more substantial income flows from REITs than common stocks.

Monetary policy changes will have an influence on general economic activity that feeds through to occupational demand in the underlying real estate market. This will impact upon rents obtainable by the REIT from the underlying property portfolio and hence will directly affect the dividend payments of the firm. In addition, rate changes will also influence the value of the underlying portfolio. Not only will changes in rental income impact on property values but furthermore, given the linkages between the space and capital markets (DiPasquale and Wheaton 1992; Fisher 1992), there is an impact through cap rates on the value of the underlying portfolio. These effects mean that REITs are far more heavily tied to their underlying asset base than both equities generally and other forms of real estate securities, such as corporate based vehicles in markets such as the UK and Hong Kong. It also means that the response of REITs to changes in monetary policy may differ from the general evidence regarding the stock market.

A further factor that may also lead to differences in the results for REITs in comparison to the overall equity market is the relative size and maturity of the sector. While REITs were established by Congress in 1960 their growth has largely occurred since the early nineties. In 1991, for example, the total market capitalization of the equity REIT sector was \$8,785 m according to NAREIT (National Association of Real Estate Investment Trusts). At the end of 2005 this had increased to over \$300bn, while the number of Equity REITs had increased from 86 to 152. Amongst other papers, Cotter and Stevenson (2006) note in their examination of REIT volatility that this growth in the sector has led, particularly in recent years, to changes in the dynamics in the sector. However, while substantial

¹Note that this paper solely examines the response of Equity REITs and does not consider the Mortgage REIT sector.

growth has occurred REIT's still mainly comprise of small and mid cap firms, with an average size of just under \$2bn.

Our methodological approach draws on the recent work of Bomfim (2003), Jones et al. (1998) and Andersen and Bollerslev (1997). The transmission of monetary policy information is assessed through an analysis of meetings of the Federal Open Market Committee (FOMC). As in papers such as Bomfim (2003) we proxy market expectations concerning changes in the Fed Funds Rate through changes in the Fed Funds Futures Contract. Our paper examines three key hypotheses. Firstly, we investigate the impact of unanticipated changes in monetary policy on both the returns and volatility of the REIT sector. Secondly, we test for asymmetry in the response with respect to a positive or negative unanticipated change in the policy rate. Finally, behavioral changes in REIT volatility around the time of FOMC meetings are considered. In particular, we investigate what is commonly referred to as the *calm before the storm* effect. This refers to the fact that volatility tends to fall immediately prior to an announcement. This effect has been noted by Jones et al. (1998), Li and Engle (1998) and Bomfim (2003) for the Treasury Bond, Treasury Bill and Stock markets respectively.

The remainder of the paper is laid out as follows. The following section briefly reviews the existing literature in relation to interest rate changes on REIT's, the effect of anticipated versus unanticipated changes and finally behavioral changes around event days. The "Data and Methodological Framework" section details the methodological approach and the data requirements. The "Empirical Results" section contains the main empirical findings and the concluding comments are provided in the final section.

Literature Review

Interest Rate Changes and REIT's

While there have been a number of recent studies that have analyzed the relationship between REITs and interest rate changes, no account has been explicitly taken for the degree to which these changes have been anticipated.² A number of papers have shown that the sensitivity of REITs to interest rates is both time-varying and also dependent on the rate used. Both Chen and Tzang (1988) and Liang et al. (1995) find evidence of instability in their findings dependent on the exact time period examined. This result has been corroborated by Devaney (2001) and He et al. (2003).³ He et al. (2003) also confirm previous findings showing that REITs are most sensitive to changes in long-term yields and low-grade corporate bonds

²See Allen et al. (2000), Chen et al. (1997), Chen and Tzang (1988), Devaney (2001), Liang and Webb (1995), Ling and Naranjo (1997), McCue and Kling (1994), Mueller and Pauley (1995) and Swanson et al. (2002).

³He et al. (2003) highlight the importance of proxies by illustrating the sensitivity of results to the interest rate proxy used. They also find further evidence concerning the time-varying nature of the linkages between interest rates and real estate securities. Using a Flexible Least Squares approach the paper highlights that all of the proxies tested have time-varying characteristics.

although, as with other proxies used, these findings are also time-varying. This is a finding that is consistent with the literature to have examined financial institutions (e.g. Kane and Unal 1988).

Devaney (2001) utilizes a GARCH-M model similar to that used in the broader interest rate sensitivity literature such as Elyasiani and Mansur (1998). This is one of the few papers to have extended the analysis to examine the impact of interest rates on REIT volatility. The results illustrate the difference in focus between the Equity and Mortgage REIT sub-sectors. While highly significant findings are reported with regard to the mortgage sector the results for Equity REITs differ. While the coefficients are largely of the anticipated sign they are generally insignificant. It should be noted however that Devaney (2001) analyzed monthly data.⁴ A recent paper by Cotter and Stevenson (2006) examines daily REIT volatility. While the focus of that paper is not concerned with interest rate sensitivity, Treasury Bills are incorporated into the multivariate GARCH model used to examine the underlying volatility dynamics of REITs. The results show that Treasury Bill movements are significant in terms of both returns and volatility for Equity REITs.

Anticipated versus Unanticipated Changes

Given that the current paper analyses the impact of official rate changes and decisions of the FOMC, the analysis here links in with the broader literature that has examined the impact of macroeconomic variables on equity markets. Flannery and Protopapadakis (2002) examine the effect of 17 different macroeconomic announcements on equity returns. They find evidence that six (CPI, PPI, a monetary aggregate, balance of trade, employment and housing starts) are priced. However, only unanticipated money supply announcements influence both the first and second moment of stock returns. Connolly and Wang (2003) examine the impact of monetary announcements in an international environment looking at the US, UK and Japan.⁵ One interesting result from this study is evidence supportive of an asymmetric response in terms of whether the announcement contained good or bad news. This is a similar finding to that reported by Bomfim (2003) and is consistent with the leverage effect noted by Black (1976).

A large literature has examined the specific impact of US monetary policy on equity markets.⁶ An important issue in any examination of rate changes by the Federal Reserve is that of technical and non-technical rate changes. Prior to 1979 the Federal Reserve effectively changed the discount rate to bring it into line with market rates.⁷ Both Smirlock and Yawitz (1985) and Pearce and Roley (1985)

⁴Stevenson et al. (2005) adopt a similar methodological approach in their analysis of UK property companies and do find significant sensitivity in both the mean and variance equations using daily data.

⁵Conover et al. (1999) also note the importance and influence of US monetary policy in an international context, while Lastrapes (1998) provides further international empirical evidence on the influence of monetary policy on equity markets.

⁶An early paper to examine this is Waud (1970).

⁷Roley and Troll (1984), Cook and Hahn (1988) and Dueker (1992) examine the issue of technical and non-technical rate changes in the context of the impact of policy rate changes on market interest rates.

provide evidence on the impact of rate changes on the stock market. Pearce and Roley (1985) is one of the first studies to split the rate change into its expected and unexpected component, through the use of survey data. Post 1979 and the change in rate change policy the authors show that stock prices react significantly to unanticipated changes in the discount rate. A further change in the operation of the Federal Reserve occurred in 1994. Prior to February 1994 the Federal Reserve would effectively release information on rate changes the day after a FOMC meeting through the Open Market Desk. However, post February 1994 rate changes have been publicly announced directly after each FOMC meeting.

Thorbecke (1997) provides empirical evidence concerning the influence of monetary policy on stocks. The paper utilizes the Federal Funds Rate and non-borrowed reserves. While the general results highlight that an expansionary monetary policy increases ex-post returns, an interesting element of the analysis is that asymmetries in the responses may also help to explain the findings of Fama and French (1995). The authors find that monetary shocks affect smaller firms to a greater extent than large firms. It is hypothesized that this is due to the impact on credit availability noted by Gertler and Gilchrist (1994). Given the relative size of REITs it may therefore be expected that this would lead to an enhanced sensitivity in comparison to the overall market. However, it should be remembered that the tax status of REITs also brings into question the tax advantages of debt issuance.

Kuttner (2001) assesses the influence of policy based rate changes by the Federal Reserve on market rates. Market rates are proxied by Treasury bill, note and bond yields. The results highlight the importance of decomposing expected and unexpected components of monetary policy changes. While expected rate changes are not statistically significant, unexpected rate changes result in a large and significant response in market rates. Patelis (1997) notes that monetary policy changes can also provide valuable predictive information on future stock market movements. Furthermore, Rigobon and Sack (2003) find that the relationship between interest rates and stock prices is a bilateral one, reporting evidence that stock market behavior influences future interest rate movements. A recent paper by Bernanke and Kuttner (2005) adopts both an event study methodology and a VAR model of the type proposed by Campbell (1991). The event study results show a significant response to unanticipated changes in the rate. The VAR analysis finds that the primary impact of rate changes onto prices is through their impact on expected future excess returns.⁸

Behavioral Effects around Event Days

The likely behavioral changes in the volatility of asset returns around particular event windows and tests of the *calm before the storm* effect have been investigated by Jones et al. (1998). The paper examines the impact of employment and PPI announcements on bond returns. They also examine what may cause

⁸Further papers to have examined issues concerned with macroeconomic data and stock movements include Berry and Howe (1994), Mitchell and Mulherin (1994), Ederington and Lee (1993) and Cutler et al. (1989).

volatility persistence. They find no evidence of persistence in volatility following a monetary announcement, concluding instead that volatility persistence may be a result of the clustering of news announcements. Using the Mitchell and Mulherin (1994) database of news events they illustrate that information announcements are positively autocorrelated at significant levels at a daily interval.⁹

Bomfim (2003) examines the S&P 500 Composite and its response to Fed Funds Rate changes. The author initially finds no evidence of the *calm before the storm* effect. While volatility is higher on the day of the announcement, there is no reduction in volatility on the day prior to the FOMC meeting. However, the sample examined in this paper extends back to 1989 and therefore pre-dates the change in Federal Reserve policy in February 1994. As noted by Bomfim (2003) between 1989 and 1994 only 24% of rate changes were taken at scheduled meetings of the FOMC. However, since the policy change in 1994 the vast majority of rate changes have coincided with FOMC meetings. In the Bomfim (2003) sample, ending in 1998, 85% of all rate changes occurred and were announced on meeting days. Once the author takes account of pre and post 1994, he finds significant evidence of a *calm before the storm* effect. Finally, Bomfim (2003) also finds evidence that the effect of the shock on volatility is asymmetric.

Data and Methodological Framework

Our methodology draws on the recent work of Bomfim (2003), Jones et al. (1998) and Andersen and Bollerslev (1997). Firstly, we examine the impact of FOMC announcements on both the returns and volatility of the REIT sector. Specifically, by splitting the rate change into its anticipated and unanticipated components the analysis allows an examination of the impact of unexpected rate changes. Secondly, the behaviour of REIT returns around the time of FOMC meetings is considered and we investigate the *calm before the storm* effect.

The data in this paper is daily and extends from 31st January 1996 through to March 1st 2005. A potential issue with the use of daily data is that it may mask the exact impact. In particular, it is hard to isolate the impact of Federal Funds Rate changes as other announcements may be made that day. However, as Bomfim (2003) notes, FOMC meetings do not systematically coincide with any one economic date release. The REIT market is proxied by the Dow Jones-Wilshire Equity REIT Index. As noted in the “Introduction,” this paper solely examines the Equity REIT sector and does not examine, either in aggregate or in isolation, the Mortgage REIT sector.

The change in the Federal Funds Target Rate was obtained from the Federal Reserve Board of Governors. The proxy used for the unanticipated change in the target rate is the 1-day change in the price of the 1-month ahead 30-day Federal Funds Futures Contract traded on the Chicago Board of Trade (CBOT). Previous papers to have utilized such a proxy for monetary policy changes include: Bomfim and Reinhart (2000), Kuttner (2001), Poole and Rasche (2000), Reinhart and Simin (1997), Roley and Sellon (1998) and Thornton (1998). Previous empirical work in

⁹Castanias (1979) provides an early study on the volatility of the markets surrounding the release of economic data.

the field such as Connolly and Wang (2003), Ehrmann and Fratzscher (2004), Flannery and Protopapadakis (2002) and Li and Engle (1998) use alternative measures of expectations. These alternatives include the growth rate of money supply and survey data, however, Gurkaynak et al. (2002) show that the fed funds futures contract provides the best available forecast of the Feds Fund Rate. In particular a number of advantages are evident in comparison to the use of survey data as used in papers such as Ehrmann and Fratzscher (2004). The use of the futures contract data provides a continuous time-series, rather than an occasional observation. In addition, the majority of papers to have used survey data rely on surveys taking prior to scheduled FOMC meetings. The use of the futures contracts allows us to also examine the impact of rate changes announced an unscheduled FOMC meetings.¹⁰

The modeling approach adopted here is based on that used by Bomfim (2003) and Jones et al. (1998). The GARCH model can be specified as follows:

$$REIT_t = \beta_0 + \beta_1\Delta FFF_t + \beta_2REIT_{t-1} + \beta_3SP_t + \beta_4Mon + \beta_5Tue + \beta_6Thu + \beta_7Fri + \mu_t \tag{1}$$

$$\mu_t = e_t\sqrt{s_t} \tag{2}$$

$$e_t = v_t\sqrt{h_t} \tag{3}$$

$$\begin{aligned} E(e_t|\Omega_{t-1}) &= 0 \\ E(e_t^2|\Omega_{t-1}) &= h_t \\ E(u_t^2|\Omega_{t-1}) &= s_t h_t \end{aligned} \tag{4}$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2 \tag{5}$$

The REIT series is the dependent variable in the conditional mean equation. The independent variables comprise of the 1-day change in the fed funds futures (FFF), the lagged 1-day REIT return and the S&P 500. Dummy variables for days of the week are also incorporated into the specification. The unexplained component (μ_{t+1}) comprises of a non-normal stochastic element (e_{t+1}) whose conditional variance is time-varying and a variable (s_{t+1}). The variable indicates the impact of particular day effects and can be expressed as:

$$s_t = 1 + \delta_0 I_t^{(F)} + \delta_1 I_{t-1}^{(F)} + \delta_2 I_{t+1}^{(F)} + \delta_3 Mon + \delta_4 Tue + \delta_5 Thu + \delta_6 Fri + \phi \Delta FFF_t \tag{6}$$

¹⁰We follow the approach used in Poole and Rasche (2000) and use the 1 month ahead contract (rather than the current month) to derive our surprise and so avoid making the adjustment as in Kuttner (2001).

Where $I_t^{(F)}$ is a dummy set to unity when there is FOMC meeting and zero otherwise. The model is estimated using the quasi-maximum likelihood procedure proposed by Bollerslev and Wooldridge (1992).

As previously mentioned, three key hypotheses are tested. The first hypothesis relates to a news effect and whether an unanticipated change in the fed funds rate has any effect on the REIT sector. This is examined through the conditional mean equation. The hypothesis would be supported if β_1 is negative and statistically significant. We also address whether the shock to monetary policy has any effect on the second moments, which would be highlighted by the statistical significance of ϕ in Eq. 6. The possibility that there may be an asymmetric volatility effect (that higher than expected changes in rates will lead to great volatility) will also be considered. The final hypothesis relates to the *calm before the storm* effect. This refers to a hypothesized lower level of volatility on the day before FOMC meetings and higher on the day of the announcement itself. This is tested based the results from Eq. 6. The hypothesis is confirmed if coefficient δ_0 is positive and significant and δ_1 is negative and significant at conventional levels.

Empirical Results

The model is estimated under a variety of different scenarios. The initial examination concentrates upon changes in the Fed Fund Futures on FOMC meeting days. We then extend this to also incorporate unscheduled rate changes that take place outside of scheduled FOMC meetings.¹¹ The initial analysis is reported in Table 1. From these results it can be seen that the change in Fed Funds Futures impacts significantly on both the mean and volatility of the Equity REIT sector. Furthermore, the signs of the coefficients in relation to the mean and volatility equations have the anticipated sign, i.e., negative and positive respectively. This alone is interesting given the frequent lack of consistent findings in previous studies of REIT sensitivity to interest rate movements. The Devaney (2001) paper adopts the most similar methodological approach, in that a GARCH based model, in this case a GARCH-in-Mean specification, is used. However, the analysis on market rates generally finds an insignificant response in either the mean or variance equations. Only when the Mortgage REIT sector is examined are significant coefficients reported. This divergence in findings highlights the importance of taking into account market expectations and incorporating into the model specification the unanticipated nature of the rate change. In addition, it should also be reiterated that the Devaney (2001) paper examined monthly not daily data.

As would also be expected, the coefficients relating to the lagged REIT sector and the market index, as proxied by the S&P 500, are positive and significant at conventional levels. There is also evidence of GARCH effects in the model, justifying the use of this form of specification. One issue relating to the day of the week dummies that deserves mention is that in both the mean and variance equations the coefficients referring to Friday are positively signed and significant at

¹¹Note that given the data period examined (1996–2005), it is not necessary to take into account the change in the operations of the Federal Reserve in 1994.

Table 1 Impact of US monetary policy shocks on the mean and volatility of REIT's (scheduled announcements)

Variable	Coefficient	t-statistic
Mean equation		
β_0	-0.03	-1.21
β_1	-0.84 ^a	-10.30
β_2	0.18 ^a	9.80
β_3	0.24 ^a	28.70
β_4	0.05	1.55
β_5	0.09 ^a	3.12
β_6	0.05	1.54
β_7	0.11 ^a	3.37
Variance equation		
α_0	0.01 ^a	4.92
α_1	0.13 ^a	9.06
α_2	0.80 ^a	14.81
δ_0	-0.40	-1.25
δ_1	-0.01	-0.07
δ_2	0.36	1.45
δ_3	0.10	1.21
δ_4	-0.13	-1.07
δ_5	0.10	0.85
δ_6	0.22 ^a	2.35
ϕ	0.47 ^a	2.04

$$REIT_t = \beta_0 + \beta_1 \Delta FFF_t + \beta_2 REIT_{t-1} + \beta_3 S\&P_t + \beta_4 Mon + \beta_5 Tue + \beta_6 Thu + \beta_7 Fri$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2$$

$$s_t = 1 + \delta_0 I_t^{(SA)} + \delta_1 I_{t-1}^{(SA)} + \delta_2 I_{t+1}^{(SA)} + \delta_3 Mon + \delta_4 Tue + \delta_5 Thu + \delta_6 Fri + \phi \Delta FFF_t$$

Using 1 day change in 1 month ahead federal funds future contract as unanticipated change. The t statistics are robust using the procedure from Bollerslev and Wooldridge (1992)

^a Indicates statistical significance at conventional levels

conventional levels. This indicates a Friday effect in both the first and second moments of daily REIT index data.

The second issue relates to the hypothesized *calm before the storm*. As noted, this is tested through an examination of coefficients δ_0 and δ_1 in the variance equation. Unlike previous empirical evidence such as Bomfim (2003) we find no evidence of such an effect. For the hypothesis to be supported, δ_0 should be positive and significant and δ_1 negative and significant. The results show that neither coefficient is statistically significant. Hence, our results indicate that while there is a reaction in terms of both REIT's returns and their volatility to new information, we find no behavioral change around the time scheduled interest rate changes.

The behavioral insignificance may occur for a number of reasons including issues related to REIT's returns or the use of scheduled interest rate changes. It is possible that non-synchronous and thin trading leads to the behavioral insignificance in the Wilshire REIT index thereby contributing to these findings. As noted previously, despite the increase in both the size of the REIT sector and the corresponding increase in trading volume in recent years, the sector is relatively small. While the average market cap in the sector was just under \$2bn as of the end of 2005, 46% of the firms had a market value less than \$1bn. The use of individual REIT returns and the separate examination of REITs of differing levels of both market value and

trading volume may produce more conclusive findings in this regard. In comparison to the findings of Bomfim (2003) in relation to the S&P 500, it should be emphasized that his initial lack of significant evidence was in relation to the sample pre-dating the change in Fed policy in 1994. Once this was accounted for in the analysis significant results were reported. As our sample dates only from 1996 the change in Fed policy cannot be a possible reason behind the lack of significant evidence.

In order to further examine possible causes behind the differences in these findings we re-estimate the model under two alternative scenarios. The first is to use a portfolio of large cap heavily traded REITs to check for possible non-synchronous trading effects. The portfolio is created using the largest percentile of Equity REITs in each year during our sample. As with the Dow Jones–Wilshire index the portfolio is value-weighted. The second scenario is to re-estimate the tests using the S&P 500 to check for consistency in the Bomfim (2003) results and to exactly match the sample period. The results for both the large-cap REIT portfolio and the S&P are contained in Table 2. The results are interesting in a number of respects. Firstly, with regard to the large cap REIT portfolio, there is no discernable difference in the results, indicating that the previously reported findings for the overall sector index were not unduly influenced by non-synchronous trading effects. In general there are no substantial changes in the coefficients reported with significant impacts on REIT volatility recorded, the significance of coefficients relating to the lagged REIT and S&P returns in the mean equation and the lack of significance in relation to the *calm before the storm*. One difference is that changes in the fed funds futures rate does not significantly impact upon REIT returns.¹²

This view is to some extent also supported in with respect to the results for the S&P 500. These findings, using a matching sample period, differ substantially from those contained in the Bomfim (2003) paper and suggest that his findings are sensitive to the exact sample used. As previously noted, Bomfim (2003) argues that the significant results obtained followed the change in Federal Reserve operating procedure in 1994, using a sample of data that ends in December 1998. The change in the fed funds futures does not impact significantly on either returns or volatility in the S&P.¹³ Furthermore, there is no evidence of a significant *calm before the storm* effect in this sample period. The lack of significance in the mean equation and the similar finding in relation to large cap REITs would suggest that the findings in the initial analysis are indeed driven by the enhanced exposure of smaller REITs with regard to changes in the fed funds rate.

In relation to the variance equation, the fact that both REIT series' reported significant responses in volatility whereas the S&P did not would suggest that it is more of a REIT specific issue rather than merely one of firm size. As noted in the introduction there is a strong intuitive argument as to why Real Estate Investment Trusts may display a higher degree of sensitivity to interest rate movements in

¹²One possible reason behind this is that the impact of fed funds rate changes is more pronounced in smaller REITs and that this is driving the overall findings. However, tests on a corresponding small cap REIT portfolio also find insignificant results.

¹³Our results may be considered to be consistent with the underlying thesis of the Bomfim (2003) study, i.e. that monetary policy transparency has increased dramatically post 1994.

Table 2 Impact of US monetary policy shocks on the mean and volatility of large cap REIT's and S&P 500 (scheduled announcements)

Variable	Large cap REITs		S&P 500	
	Coefficient	t-statistic	Coefficient	t-statistic
Mean equation				
β_0	-0.03	-1.14	0.05	1.14
β_1	-0.08	-0.22	-0.55	-1.06
β_2	0.12 ^a	6.49		
β_3	0.26 ^a	22.97	0.01	0.07
β_4	0.08 ^a	1.77	0.02	0.34
β_5	0.09 ^a	2.06	0.01	0.23
β_6	0.04	0.91	-0.02	-0.35
β_7	0.12 ^a	2.57	0.01	0.22
Variance equation				
α_0	0.02 ^a	5.59	0.01 ^a	3.38
α_1	0.10 ^a	8.57	0.06 ^a	7.45
α_2	0.89 ^a	13.79	0.77 ^a	11.60
δ_0	-0.07	-0.24	0.04	0.08
δ_1	0.04	0.22	-0.51	-1.40
δ_2	0.05	0.22	0.28	0.90
δ_3	-0.10	-1.16	0.27 ^a	2.49
δ_4	-0.18	-1.44	0.12	0.89
δ_5	-0.02	-0.19	0.24	1.62
δ_6	0.17 ^a	1.74	0.25 ^a	2.25
ϕ	0.84 ^a	2.67	0.23	1.49

$$LREIT_t = \beta_0 + \beta_1 \Delta FFF_t + \beta_2 LREIT_{t-1} + \beta_3 S\&P_t + \beta_4 Mon + \beta_5 Tue + \beta_6 Thu + \beta_7 Fri$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2$$

$$s_t = 1 + \delta_0 I_t^{(SA)} + \delta_1 I_{t-1}^{(SA)} + \delta_2 I_{t+1}^{(SA)} + \delta_3 Mon + \delta_4 Tue + \delta_5 Thu + \delta_6 Fri + \phi \Delta FFF_t$$

$$S\&P_t = \beta_0 + \beta_1 \Delta FFF_t + \beta_3 S\&P_{t-1} + \beta_4 Mon + \beta_5 Tue + \beta_6 Thu + \beta_7 Fri$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2$$

$$s_t = 1 + \delta_0 I_t^{(SA)} + \delta_1 I_{t-1}^{(SA)} + \delta_2 I_{t+1}^{(SA)} + \delta_3 Mon + \delta_4 Tue + \delta_5 Thu + \delta_6 Fri + \phi \Delta FFF_t$$

Using 1 day change in 1 month ahead federal funds future contract as unanticipated change. The t statistics are robust using the procedure from Bollerslev and Wooldridge (1992)

^a Indicates statistical significance at conventional levels

comparison to the general stock market. This comes from the multiple impacts of rate changes with regard to issues such as the effect on cap rates and the potential impact on underlying occupational demand in the property market.

The analysis contained in Table 1 is solely concerned with rate changes announced at scheduled meetings of the FOMC. In order to consider the sensitivity of our results we investigate the impact of rate changes on all announcement days, both scheduled and unscheduled. While the number of unscheduled announcements has fallen dramatically in recent years it is still an important issue to consider. This is particularly the case for the events of 2001. During the first half of 2001 there were two unscheduled rate changes (interest rate reductions), 3rd January and 18th April. These two particular unscheduled rate changes are noteworthy given the Fed's preference for scheduled rate changes in recent years and the fact that they were both 50 basis point reductions. In addition, the impact of 9/11 was also a major factor on

the markets interest rate expectations and the actions of the Federal Reserve. For this reason, we extend the analysis, as reported in Table 3, to include rate changes that occurred outside of the auspices of a scheduled FOMC meeting.¹⁴

There are relatively few changes in the results after this extension of the analysis. As with the original specification, GARCH effects are evident, there is the anticipated influence of both lagged REIT returns and the contemporaneous S&P 500 in the mean equation and evidence of a Friday effect on both returns and volatility. In addition, as with the results previously discussed there is no significant evidence of a *calm before the storm* effect. Finally, there is evidence that there is a significant response to the unanticipated component of the rate change in terms of both the mean and variance equation. As with the initial analysis we also re-run the analysis using the large-cap REIT portfolio and the S&P 500. The patterns in the findings are broadly similar to those in the initial tests with a lack of significance in the mean equation for the large cap REIT portfolio. One difference is however observed in relation to the S&P in that while volatility does not significantly fall the day preceding an interest rate announcement it does rise to a significant extent on the day of the announcement. This makes intuitive sense in that the sole difference in this analysis is that it incorporates unscheduled announcements and therefore any rate changes will not have been anticipated to the same extent as with those made at FOMC meetings.¹⁵

Given the consistent statistically significant effect of the shock on both the mean and the variance, in the final part of the analysis we investigate whether this effect is asymmetric. This analysis is based on the leverage effect noted by Black (1976) and the volatility feedback hypothesis of French et al. (1989). This has been supported empirically in papers such as French et al. (1989) and Nelson (1991) while asymmetry has also been reported in papers closely related to the current study such as Bomfim (2003) and Connolly and Wang (1998). To examine this issue the variance equation is adjusted to take the following form.

$$s_t = 1 + \delta_1 I_{t-1}^{(SA)} + \delta_2 I_{t+1}^{(SA)} + \delta_3 \text{Mon} + \delta_4 \text{Tue} + \delta_5 \text{Thu} + \delta_6 \text{Fri} \\ + \phi_1 \Delta \text{FFF}_t^+ + \phi_2 \Delta \text{FFF}_t^- \quad (7)$$

where positive and negative unexpected changes in the fed funds futures rate are separated.^{16,17} The results, contained in Table 4, show no evidence of any asymmetry with respect to the shock on REIT's volatility. The existing evidence on mainstream equity returns has largely found evidence of an asymmetrical response, with an enhanced rise in volatility following a negative shock, i.e. a higher than anticipated

¹⁴Given the events of the first 9 months of 2001, the unusually large changes in monetary policy and the events of 9/11, we also incorporate a dummy variable into both the mean and variance equations. As can be seen from Table 3, the dummy variable is not statistically significant.

¹⁵The detailed results for the large-cap REIT portfolio and the S&P 500 are available from the authors.

¹⁶Tests of any possible asymmetry in the impact on returns was tested, but found not to exist.

¹⁷When testing for possible asymmetry in the volatility response to shocks, we isolate positive and negative surprises on scheduled announcement days. In order to avoid potential multicollinearity in our results, we omit $I_t^{(sa)}$ from the regression.

Table 3 Impact of US monetary policy shocks on the mean and volatility of REIT’s (total announcements)

Variable	Coefficient	t-statistic
Mean equation		
β_0	-0.03	-1.27
β_1	-0.72 ^a	-5.02
β_2	0.18 ^a	9.89
β_3	0.24 ^a	28.76
β_4	0.05	1.53
β_5	0.09 ^a	3.10
β_6	0.05	1.53
β_7	0.11 ^a	3.35
β_8	0.02	0.54
Variance equation		
α_0	0.01 ^a	4.78
α_1	0.13 ^a	9.05
α_2	0.80 ^a	14.70
δ_0	0.31	1.14
δ_1	-0.02	-0.12
δ_2	-0.25	-1.19
δ_3	0.09	1.05
δ_4	-0.13	-1.06
δ_5	0.11	0.92
δ_6	0.23 ^a	2.36
δ_7	0.01	0.23
ϕ	0.57 ^a	2.01

$$REIT_t = \beta_0 + \beta_1 \Delta FFF_t + \beta_2 REIT_{t-1} + \beta_3 S\&P_t + \beta_4 Mon + \beta_5 Tue + \beta_6 Thu + \beta_7 Fri + \beta_8 2001$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2$$

$$s_t = 1 + \delta_0 I_t^{(TA)} + \delta_1 I_{t-1}^{(TA)} + \delta_2 I_{t+1}^{(TA)} + \delta_3 Mon + \delta_4 Tue + \delta_5 Thu + \delta_6 Fri + \delta_7 2001 + \phi \Delta FFF_t$$

Using 1 day change in 1 month ahead federal funds future contract as unanticipated change. The t statistics are robust using the procedure from Bollerslev and Wooldridge (1992)

^a Indicates statistical significance at conventional levels

rise in rates, in comparison to positive shocks. However, in the case of REITs both coefficients are of the same sign and are not statistically different, with a *p* value from the Wald statistic of 0.23. The results for the large-cap REIT portfolio and the S&P 500 also fail to report significant findings.¹⁸ Given the lack of significant findings in relation to either large-cap REIT portfolio or the S&P 500, it is impossible to state whether the overall REIT results are due to non-synchronous or thin trading issues or to a REIT specific issue. However, they do however indicate that previous general empirical evidence on asymmetry is perhaps sensitive to the sample period used.

¹⁸The detailed results for the large-cap REIT portfolio and the S&P 500 are available from the authors.

Table 4 Tests for Asymmetry in the response of REITs to monetary policy shocks

Variable	Coefficient	t-statistic
Mean equation		
β_0	-0.02	-1.05
β_1	-0.84 ^a	-7.83
β_2	0.18 ^a	9.80
β_3	0.24 ^a	28.62
β_4	0.05	1.54
β_5	0.09 ^a	3.15
β_6	0.05	1.59
β_7	0.11 ^a	3.37
Variance equation		
α_0	0.01 ^a	4.73
α_1	0.13 ^a	9.06
α_2	0.81 ^a	15.14
δ_1	-0.12	-0.73
δ_2	0.28	1.26
δ_3	0.10	1.18
δ_4	-0.12	-1.05
δ_5	0.09	0.81
δ_6	0.22 ^a	2.29
ϕ_1	-0.48	-1.35
ϕ_2	-0.07	-0.25
Hypothesis test (p values for Wald statistic)	$\phi_1 = \phi_2 = 0$	0.23

$$REIT_t = \beta_0 + \beta_1 \Delta FFF_t + \beta_2 REIT_{t-1} + \beta_3 S\&P_t + \beta_4 Mon + \beta_5 Tue + \beta_6 Thu + \beta_7 Fri$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2 e_{t-1}^2$$

$$s_t = 1 + \delta_1 I_{t-1}^{(SA)} + \delta_2 I_{t+1}^{(SA)} + \delta_3 Mon + \delta_4 Tue + \delta_5 Thu + \delta_6 Fri + \phi_1 \Delta FFF_t^+ + \phi_2 \Delta FFF_t^-$$

Using 1 day change in 1 month ahead federal funds future contract as unanticipated change. The t statistics are robust using the procedure from Bollerslev and Wooldridge (1992)

^a Indicates statistical significance at conventional levels

Conclusions

This study offers a number of important contributions in the analysis of the sensitivity of REITs to changes in interest rates. Firstly, it has, through the use of the fed funds futures, indicated the effect of unanticipated changes in interest rates on both REIT's returns and their volatility. Although there is an established literature addressing the influence of interest rate changes on REITS returns, this is the first paper to explicitly take account of the impact of unanticipated changes. Secondly, it has specifically tested for both asymmetric responses in volatility to interest rate movements and the *calm before the storm* effect. The analysis provides a number of interesting results, relative to previous studies on REIT's returns and volatility, but also relative to mainstream equities.

In comparison to previous studies of REIT interest rate sensitivity the main results do show significant responses in both returns and volatility to unanticipated rate changes. The importance of the specification of unanticipated changes in interest rates is critical in considering the previous results where interest rate changes were adopted. Although the effect of the shock is significant on both returns and volatility, there is no evidence of asymmetry. There is also no evidence of changing volatility

behavior coincident to Federal Reserve announcements, *calm before the storm*. While the lack of any behavioral effect may appear inconsistent with the previous results reported for equities we also report results for both large cap REIT's and equities that are consistent with an absence of a significant *calm before the storm* effect, which would indicate that previously reported results are sensitive to the exact sample analyzed.

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