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The Asymmetric Response of Equity REIT Returns to Inflation

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Abstract This paper posits that the failure of past studies to document a positive relationship between REIT (Real Estate Investment Trust) returns and inflation is an artifact of the empirical framework that has predominated in these studies. Applying a pooled estimation methodology to an expansive data set containing 195 publicly traded equity REITs for the period 1981–2002, the study documents a strong asymmetry in the response of equity REIT returns to inflation. Specifically, when expected and unexpected inflation are separated into positive and negative changes, results indicate that equity REIT returns rise in response to both increases and decreases in inflation. The evidence, which is partly contingent on the prevailing monetary policy environment, carries important policy implications for portfolio management and provides insights into the observed anomalous relationship between REITs and inflation.

Keywords REITs · Inflation · Asymmetry · Pooled estimation

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Introduction

The relationship between inflation and real estate returns has been the subject of extensive empirical examination. This interest is generated partly due to the fact that the perceived inflation-hedging ability of real estate is often used to justify its inclusion in efficient mixed-asset investment portfolios.

Evidence of a positive relationship between inflation and real estate returns is somewhat substantiated in studies that examine direct (unsecuritized) holdings of real estate [see, for example, Brueggeman, Chen, and Thibodeau (1984), Ibbotson and Seigel (1984), Rubens, Bond, and Webb (1989), and Miles and Mahoney (1997)]. In general, these studies report that real estate holdings represent, at least, a partial hedge against the expected and unexpected components of inflation, and furthermore, the hedging effectiveness of mixed-asset investment portfolios improves once real estate is included. However, these conclusions have come under question by later studies that attribute the perceived inflation-hedging effectiveness of real estate to the "smoothing bias" that seems inherent in appraisal-based data.

Meanwhile, several researchers examining securitized real estate have suggested that real estate investment trusts (REITs) tend to behave like shares of common stock. Specifically, these studies have documented either a negative or an insignificant relationship between the returns on REITs and inflation for various sample periods [see, for example, Murphy and Kleiman (1989), Chan, Hendershott, and Sanders (1990), Park, Mullineaux, and Chew (1990), Yobaccio, Rubens, and Ketcham (1995), Chatrath and Liang (1998), and Ewing and Payne (2005)]. In extending this line of research, Gyourko and Linneman (1988) and Chen and Tzang (1988) differentiate between expected and unexpected inflation, and find that, while REITs offer some protection against expected inflation, there appears to be a negative (and perverse) relationship between REIT returns and unexpected inflation.

In a recent attempt to re-examine the perverse inflation behavior, Glascock, Lu, and So (2002) test for the causal relationship among REIT returns, inflation, real activity, and monetary policy variables. They conclude that the observed negative relationship between REITS and inflation is spurious, and is explained once the monetary policy effects on the respective variables are specifically taken into account. They argue that higher inflation leads to higher interest rates, and this in turn leads to lower REIT returns. Using an impulse-response function derived from a vector error correction model, they show that a positive shock to inflation produces an increase in REIT returns, with a lag of about 1 month.

This study extends our current understanding of the topic by introducing the role of asymmetry (i.e., positive versus negative change in inflation) in explaining the perverse inflation behavior of REIT returns. Under the efficient markets paradigm, it is reasonable to expect real estate returns to adjust rapidly to changes in information or expectations. If, as theory posits, the value of real assets rise with inflation—the statement seems almost axiomatic—then, REIT returns should increase correspondingly with the general price level. Furthermore, when unexpected inflation is realized, there should be an adjustment to REIT returns, correcting for any expectational errors. However, the failure of early empirical work to document such a positive relationship may perhaps be an artifact of the methodologies that have predominated in these studies. These studies have implicitly assumed that increases and decreases in inflation have symmetric effects on nominal REIT returns and, consequently, the two types of changes have been assumed to evoke similar responses from the real estate market. However, this may not necessarily be true.

From an economic standpoint, the asymmetric response of REITs returns may be drawn in light of how markets process information relevant in forming inflationary expectations. For instance, when the Federal Reserve engages in monetary policy tightening, this action might result in higher *ex ante* real rates, but could also signal higher or lower inflation in the future depending on how credible the Fed is perceived to be in combating inflation. If lower inflation is expected, then its impact on REIT returns would be indeterminate because of the offsetting effects of higher real rates and lower inflationary expectations. Alternatively, when the Fed loosens, the partial effect of lower *ex ante* real rates may be reinforced by expectations of higher inflation, or offset by expectations of stable prices.

Furthermore, it is important to note that there is evidence from other asset markets that cast doubts on the symmetry implications of traditional return generating models. For example, Jensen, Mercer, and Johnson (1996) report that stock and bond returns vary asymmetrically across monetary policy environments. They argue that dividend yields and the default spread affect stock returns only in expansive policy cycles. Bonds returns, on the other hand, are affected by the term spread in restrictive policy periods and by the dividend yield during expansive periods. Madura and Schnusenberg (2000) report that bank equity returns rise significantly in response to Fed easing in both the pre-1979 and post-1987 funds rate targeting regimes, but do not respond significantly to Fed tightening.

Therefore, how real estate returns react to positive versus negative inflationary changes (both expected and unexpected) in the presence of tightening and easing monetary policy actions, may be enlightening, not only as a study of market efficiency and information processing, but may also be at the crux of understanding the oft-noted anomalous relationship between inflation and securitized real estate returns.

The present study makes several other contributions. First, a survey-based technique is used to estimate the *expected* percentage change in the announced consumer price index (CPI). This is combined with the actual CPI figures, as they are released, in order to estimate the unexpected change or surprise in the inflation indicator. This approach is somewhat consistent with studies that employ the *Livingston Price Expectations* series to measure expected inflation [see Park et al. (1990)]. The advantage of using a survey-based measure is that it circumvents the conceptual and econometric problems that are frequently associated with the estimation of the anticipated and unanticipated components of economic time series data.[1] However, in order to lend credibility to the results and draw comparison with prior evidence, the inflation series is bifurcated into expected and unexpected

[1] For instance, studies such as by Fama (1975), Fama and Schwert (1977) and Hartzell, Heckman, and Miles (1987) among others have used Treasury bill rate as a proxy for expected inflation. The measure of unexpected inflation, under this framework, is the difference between actual inflation and the bill rate as calculated on an *ex post* basis. Unfortunately, this approach does not accommodate for time-varying real rates. Still others, such as Yobaccio et al. (1995), have used autoregressive time-series techniques to separate the expected and unexpected components of inflation.

inflation components using an autoregressive integrated moving average (ARIMA) model.

Second, like Glascock et al. (2002), this study attempts to demonstrate that the documented negative relationship between inflation and REIT returns is spurious. However, the difference between the two studies lies in how the topic is approached. Glascock et al. attribute the perverse inflation behavior of REITs primarily to the influence of monetary policy variables. This study, on the other hand, advances the notion of asymmetry along with monetary policy effects to explain the anomaly. In doing so, the study provides added insights into the behavior of REITs return generating process. Under this methodological framework, if the hypothesis that REIT returns go down when inflation rises is rejected, then the documented negative relationship between inflation and REITs can be shown to be spurious at the outset, and an artifact of a methodology that assumes symmetrical responses. It should be also be noted that regardless of the results of our investigation into the asymmetric response of REIT's to inflation, the present results and those of Glascock et al. are not mutually exclusive.

Finally, the use of a pooled estimation technique along with an expansive data set containing 195 publicly traded equity REITs (EREITs) over an extended time period (1981 through 2002) enable this study to thoroughly investigate the asymmetric impact of inflation on EREITs in a robust manner.[2]

The analyses indicate that employing traditional methodologies, which assume a symmetric response to positive and negative shocks, yield results similar to those documented extensively in the literature thus far. However, when changes in the inflationary variables are separated into positive and negative changes, EREIT returns exhibit a tendency to rise in response to both increases and decreases in expected and unexpected inflation. The implications of this finding, which has never been documented in the extant literature, seem to be quite profound. These results, which are partly contingent on the monetary policy condition of the economy, suggest that not only do EREITs respond positively to expected and unexpected inflation, by rising when there is an increase in inflation, but they also tend to do so in a way that limits downside risk. That is, EREIT returns rise when inflation rises, but they do not decline when inflation subsides. These findings have obvious policy implications for the management of mixed-asset investment portfolios that include EREITs.

Theoretical Considerations

This section lays out the theoretical considerations that motivate the asymmetric model. Specifically, the discussion explains the conditions under which traditional (symmetric) OLS regression models may mask the true underlying asymmetric relationships between variables, thus providing misleading results.

[2] Panel studies are more robust than simple time-series or cross-sectional OLS regressions because they (a) control for individual heterogeneity via fixed-effects estimation, (b) provide data that is informationally rich, contain more variability, less multicollinearity and more degrees of freedom, and (c) enhance estimation accuracy [see Baltagi (1995), and Moulton (1986 and 1987)].

To understand how the assumption of a symmetrical response could yield such perverse results, consider the following two regression models:

$$\Delta\text{EREIT}_t = \alpha + \beta\pi_t + \varepsilon_t \tag{1}$$

$$\Delta\text{EREIT}_t = \mu + \beta_+\pi_t^+ + \beta_-\pi_t^- + \xi_t \tag{2}$$

Equation 1 is the traditional OLS methodology which assumes a symmetrical response of EREIT returns (ΔEREIT) to inflation (π_t) announcements, whereas Eq. 2 represents an asymmetric response to inflation announcements. Specifically, π_t^+ and π_t^- are vectors containing positive and negative changes in inflation, respectively and β_+ and β_- are their associated regression coefficients.

If EREIT returns respond symmetrically to changes in inflation, the following condition must hold: $\beta = \beta_+ = \beta_-$, and this relationship may be estimated as follows:

$$\Delta\text{EREIT}_t = \mu + \beta\left(\pi_t^+ + \pi_t^-\right) + \xi_t. \tag{3}$$

The OLS estimate of β is $\widehat{\beta}$:[3]

$$\widehat{\beta} = w_+\widehat{\beta}_+ + w_-\widehat{\beta}_-, \tag{4}$$

where,

$$w_+ = \frac{\text{Var}\left(\pi_t^+\right) + \text{Cov}\left(\pi_t^+, \pi_t^-\right)}{\text{Var}(\pi_t^+) + \text{Var}\left(\pi_t^-\right) + 2\text{Cov}\left(\pi_t^+, \pi_t^-\right)},$$

$$w_- = \frac{\text{Var}\left(\pi_t^-\right) + \text{Cov}\left(\pi_t^+, \pi_t^-\right)}{\text{Var}(\pi_t^+) + \text{Var}\left(\pi_t^-\right) + 2\text{Cov}\left(\pi_t^+, \pi_t^-\right)}, \text{ and}$$

$$w_+ + w_- = 1$$

If $\widehat{\beta}_+$ and $\widehat{\beta}_-$ are the OLS estimates of β_+ and β_-, respectively, then the expectation of Eq. 4 is:

$$E\left(\widehat{\beta}\right) = w_+\beta_+ + w_-\beta_-. \tag{5}$$

The expected value of the β coefficient in Eq. 1, then, is a weighted-average of the β_+ and β_- coefficients in Eq. 2.

In a situations where β_+ is positive and β_- is negative (as we have postulated) then β will be negative whenever $\frac{|\beta_-|}{\beta_+} > \frac{w_+}{w_-}$.

Notice that the denominator for each weights, w_+ and w_-, is simply the variance of $\pi_t^+ + \pi_t^-$. In other words, the denominator is the variance of π_t. Thus, if $Var\left(\pi_t^+\right) < Var\left(\pi_t^-\right)$ then $w_+ < w_-$, and β_- will have more influence in the estimation of β then will β_+, and vice versa. Finally, the absolute magnitudes of β_+ and β_- will

[3] For a proof, see Johnston (1972, pages 157–159).

also play a role in determining which of the two estimates will dominate the traditional OLS β.

Data and Methodology

Data Description

This study analyzes the relationship between monthly EREIT returns and changes in expected and unexpected inflation over two time periods—August 1981 through November 2002, and January 1990 through November 2002. The EREITs used in this study are those that had any price history in the *Center for Research on Stock Prices* (CRSP) database during the time period in question. This yielded a set of 195 EREITs.[4]

In order to distinguish between expected and unexpected changes in inflation, this study employs two measurement techniques. The first is to use the consensus (median) forecast of the CPI release provided by *Money Market Services* (MMS). Studies investigating the properties of MMS forecast data have found them to be unbiased and superior to estimates that are produced by autoregressive models by virtue of their lower mean squared errors [see McQueen and Roley (1993), and Almeida, Goodhard, and Payne (1998), among others]. Not surprisingly, survey data on macroeconomic forecasts have been used in several recent studies in a variety of contexts, such as the examination of currency markets [Andersen, Bollerslev, Diebold and Vega (2003)], yield curve modeling [Balduzzi, Elton, and Green (2001)], and Treasury futures prices [Simpson and Ramchander (2004)], among others.

Since it is only at the time of the CPI release that revisions of inflationary expectations are likely to be formed; changes in expected inflation are calculated as the difference in the value between the MMS forecast and the actual value of the CPI variable at its most recent announcement. That is,

$$\text{Expected}(\Delta\text{CPI}_t) = [\text{MMS Forescast of CPI}_t] - \text{CPI}_{t-1} \tag{6}$$

The unexpected inflation (also called the surprise), on the other hand, is the actual value of the CPI announcement at time t minus the MMS forecast of the variable:

$$\text{Unexpected}(\Delta\text{CPI}_t) = \text{CPI}_t - [\text{MMS Forecast of CPI}_t] \tag{7}$$

The second method for decomposing inflation into expected and unexpected components is the more traditional approach followed in the literature. Specifically, an ARIMA model is used to decompose the inflation rate into the expected and unexpected components. The ARIMA model is estimated over an extended time

[4] In order to determine which REITs to include in the sample, the information from CRSP on all of the firms carrying an SIC code of 6798 that had price history during this period was first downloaded. From this REITs dataset, information from the *National Association of Real Estate Investment Trusts'* (NAREIT) directory and searches within the *Lexis-Nexis* database were collected to determine which REITs were classified as equity REITs. This methodology avoids the survivorship bias, as all EREITs are included in the analysis regardless of when they come into or go out of existence (we thank the reviewer for this suggestion).

period, August 1981 through November 2002, in order to arrive at robust estimates. The announced monthly percent changes in inflation required to estimate the ARIMA model were obtained from various news reports within the *Lexis-Nexis* database. Most of these reports, and the date of the announcement, came from the *New York Times*. It must be noted that comparable inflation data using the MMS survey resource is available only for a subset of the overall period, specifically January 1990 through November 2002.

A complex ARIMA structure that included both AR and MA terms at lags of 1, 2, 3, 4, 5, 7, 14, 15, 20, and 23 is found to correctly specify the inflation series, as this is the model that minimized the *Akaike Information Criteria* (AIC). The fitted observations and the error terms from the ARIMA model are treated as proxies for the expected and unexpected components of inflation, respectively.

Table 1 reports several descriptive statistics on the inflation variables. For each type of inflation variable—i.e., expected inflation and unexpected inflation—the number of observations, mean values, and standard deviations are reported. In addition, summary statistics (mean and standard deviation) are reported for the positive and negative observations for each variable. For example, studying the MMS data for the period January 1990 through November 2002 in Panel A, there were a total of 154 expected changes in the CPI. Out of these, 68 were positive changes and 44 were negative changes. The mean (standard deviation) positive percent change in expected CPI was 0.17 (0.11), whereas, negative percent changes had a mean (standard deviation) of −0.23 (0.17). On the other hand, an observation

Table 1 Data description

	Expected change			Surprise		
	All	Positive	Negative	All	Positive	Negative
Panel A: MMS-based expected and unexpected inflation for the period January 1990 to November 2002						
Number	154	68	44	155	40	63
Mean	0.01	0.17	−0.23	−0.01	0.15	−0.13
Std. dev.	0.20	0.11	0.17	0.12	0.07	0.06
Panel B: ARIMA-based expected and unexpected inflation for the period January 1990 to November 2002						
Number	154	84	70	155	73	82
Mean	0.01	0.13	−0.14	−0.01	0.11	−0.11
St. dev.	0.17	0.08	0.13	0.15	0.11	0.09
Panel C: tests of the equality of means (*t*-test) and variances (*F*-test) of the MMS and the ARIMA series for the period January 1990 to November 2002						
Means (prob.)	0.31 (0.75)	2.98 (0.003)	2.83 (0.01)	0.43 (0.67)	2.21 (0.03)	1.47 (0.14)
Variance (prob.)	1.33 (0.04)	1.45 (0.05)	1.54 (0.05)	1.40 (0.02)	1.91 (0.01)	2.16 (0.001)
Panel D: correlation between MMS- and ARIMA-based inflationary measures for the period January 1990 to November 2002						
Correlation	0.82	0.81	0.66	0.64	0.62	0.57
Panel E: ARIMA-based expected and unexpected inflation for the period August 1981 to November 2002						
Number	254	132	122	255	124	131
Mean	4E−3	0.14	−0.14	−0.01	0.12	−0.12
St. dev.	0.18	0.12	0.12	0.16	0.11	0.11

For the MMS data the number of positive observations and negative observations do not sum to the number of all observations, because some observations are equal to zero of the surprise changes in CPI indicates that while only 40 of them were positive, 63 of the surprise changes were negative. Similar results are reported in Panel B for inflation variables that are obtained using the ARIMA methodology.

Panel C of Table 1 presents the test results of the equality of the means and the variances between the appropriate MMS and the ARIMA inflation series. The *F*-tests reject the hypothesis, in every case, that the variances of the respective series are equal. In the case of the means, however, the *t*-tests cannot reject the hypothesis that the two expected changes in the inflation series are equal, nor can they reject the hypothesis that the means of the two unexpected changes in the inflation series are equal.

Panel D of Table 1 presents the correlations between the inflation variables obtained from the MMS and the ARIMA. Before classifying the inflation variables into positive and negative changes, the expected changes in inflation derived from MMS and ARIMA have a correlation coefficient of 0.82. The two unexpected changes in inflation series have a correlation coefficient of 0.64. While there is evidently some differences between the two methods of determining the expected and unexpected components of the inflation, there are also points of similarity as demonstrated by the means of the series and the relatively high levels of correlation between the series.

Finally, Panel E provides the summary statistics of the ARIMA series for the extended period August 1981 through November 2002. These results are qualitatively similar to the results in Panels A and B.

Monetary Policy Classification

As noted earlier, an important consideration while interpreting the results is to account for the potential impact of the monetary policy environment in mediating the relationship between inflation and REIT returns. In particular, changes in the Fed's discount rate are used to model the change in monetary policy. The emphasis on discount rate changes has several merits. First, changes in discount rate are newsworthy events that attract a considerable amount of market attention. Second, there is an abundance of evidence to indicate that discount rate changes affect asset prices [see Batten and Thornton (1984), and Hakkio and Pearce (1992), for example]. Third, changes in the discount rates, which are infrequent, usually can be more easily interpreted since the Fed often prefers to target the federal funds rate indirectly by using the discount rate mechanism (see Cook and Hahn (1988), and Goodfriend (1991), among others]. Finally, and perhaps most relevant to our study, rate changes are regarded as either signaling or confirming a particular monetary policy stance and possibly real output growth (Laurent, 1988).

Periods during which the discount rate increases are classified as periods of restrictive monetary policy, while periods during which the discount rate decreases are classified as periods of expansionary monetary policy. Following Jensen et al. (1996), the Fed is assumed to be operating under the same monetary policy stance as long as the consecutive discount rate changes are all in the same direction. Applying this classification, the monetary policy conditions for the overall sample period, August 1981 through November 2002, have been identified as either expansionary or contractionary monetary environment. Table 2 shows the breakdown of the

Table 2 Contractionary and expansionary monetary periods

Type of period	Beginning month	Ending month	Δ in discount rate over the period (basis points)
Expansionary	August 1981	March 1984	−550
Contractionary	April 1984	October 1984	+50
Expansionary	November 1984	August 1987	−350
Contractionary	September 1987	November 1990	+150
Expansionary	December 1990	April 1994	−400
Contractionary	May 1994	December 1995	+225
Expansionary	January 1996	July 1999	−75
Contractionary	August 1999	December 2000	+150
Expansionary	January 2001	November 2002	−475

This table shows the monetary environment in the U.S. economy between August 1981 and November 2002

complete period into expansionary and contractionary sub-periods based on changes in the discount rate. A review of the table indicates that, for the entire period in question, there are five sub-periods that can be considered expansionary, as indicated by declining discount rates, and four sub-periods that can be considered contractionary, as indicated by increasing discount rates. The length of each expansionary period was, on average, about 34 months, while each contractionary period lasted about 20 months, on average.

Methodological Framework

In order to be able to compare the results across the different sets of analysis, each of the expected and unexpected inflation series is divided by its own standard deviation. The standardization is beneficial since it does not influence the fit or the significance of the regression results, and it allows for interpreting the coefficients in the regressions as the impact of a one standard deviation change in the independent variable on the EREIT returns.

The empirical examination is conducted in three steps. First, EREIT returns are regressed on the expected (π_t^e) and unexpected inflation (π_t^u) components after controlling for the lagged return of the EREITs and the return on a value-weighted market portfolio (*MKT*) as calculated by *CRSP*. This is done in order to better capture the unique influence of inflation and to minimize the omitted variable bias. A fixed-effect pooled regression methodology is estimated as follows:

$$\Delta \mathrm{EREIT}_t = \alpha + \gamma\, \Delta \mathrm{EREIT}_{t-1} + \beta\, \mathrm{MKT}_t + \lambda \pi_t^u + \varphi \pi_t^e + \varepsilon_t\,, \tag{8}$$

The fixed-effect methodology allows for a different intercept term (α) for each cross-section in the pooled analysis. That is, the α terms in the regression vary across the different EREITs thus enabling the model to accommodate firm-specific differences. The pooled regressions are estimated using cross-section weights that account for cross-equation heteroskedasticity by minimizing the weighted sum-of-squared residuals. The equation weights are the inverses of the estimated equation variances, and are derived from unweighted estimation of the parameters of the system. White's (1980) heteroskedasticity-consistent covariance procedure is used to

Table 3 Inflation and EREIT returns

Variable	Coefficient	*t*-Statistic
Panel A: MMS results of $\Delta \text{EREIT}_t = \alpha + \gamma\, \Delta \text{EREIT}_{t-1} + \beta\, \text{MKT}_t + \lambda \pi_t^u + \varphi \pi_t^e + \varepsilon_t$		
$\Delta \text{EREIT}_{t-1}$	−0.02	−2.76*
MKT	0.32	47.26*
Unexpected	0.24	6.58*
Expected	−0.16	−5.35*
Panel B: ARIMA results of $\Delta \text{EREIT}_t = \alpha + \gamma \Delta \text{EREIT}_{t-1} + \beta\, \text{MKT}_t + \lambda \pi_t^u + \varphi \pi_t^e + \varepsilon_t$		
$\Delta \text{EREIT}_{t-1}$	−0.02	−2.78*
MKT	0.32	46.95*
Unexpected	0.11	2.57*
Expected	−0.11	−3.23*

The fixed-effect pooled regressions are estimated with White's (1980) correction for heteroskedasticity
This table reports the fixed-effect pooled time-series regression results of the impact of inflation and its components on EREIT after controlling for autocorrelation and the market portfolio. The sample period is from January 1990 through November 2002 (18,284 observations)
*Indicates statistical significance at the 0.01 level

arrive at robust standard errors of the parameters. The results from estimating Eq. 8 is reported in Table 3 and discussed in the results section of the paper below.

In order to understand exactly how the current analyses fits into the existing literature, one must note that the CPI announcement in a given month pertains to the previous month's CPI number. For example, January's CPI figure will be announced in the middle of February, and so forth. Thus, by using the announcement dates to calculate returns, and matching these up with the expected and unexpected components of the announcement, this study is using the lag of the inflation series used in other studies. When the lead of the inflation series is used in the analysis, there is no qualitative difference in the results—the results are of the same sign as the current analysis, but there is more statistical significance in the sense that the p-scores are lower on the test statistics.

Given the emphasis on CPI announcements and the dates of these announcements, the current study has a lot in common with conventional event studies that seek to understand how information around specific events is incorporated into market prices. Further, given that there is no qualitative difference in the results reported here when the inflation series are leaded, this study also provides implication for hedging as well.

In the second set of analyses, measures of expected and unexpected inflation are separated into positive and negative values and the previously outlined estimation procedure (as specified in Eq. 8) is repeated. Specifically, in order to determine if the EREIT returns exhibit an asymmetric response to positive versus negative values of expected and unexpected inflation, the following pooled time series regression is estimated:

$$\Delta \text{EREIT}_t = \alpha + \gamma\, \Delta \text{REIT}_{t-1} + \beta\, \text{MKT}_t + \lambda^+ \pi_t^{u+} + \lambda^- \pi_t^{u-} + \varphi^+ \pi_t^{e+} + \varphi^- \pi_t^{e-} + \varepsilon_t \tag{9}$$

where, all of the variables are as defined in Eq. 8, except that π_t^{u+} is a vector that contains the value of the surprise in the inflation-related variable when the surprise is positive, and a zero otherwise; π_t^{u-} is a vector that contains the value of the surprise in the inflation-related variable, when the surprise is negative, and a zero otherwise, π_t^{e+} is a vector that contains the value of the expected change in the inflation-related variable when the expected change is positive, and a zero otherwise; and π_t^{e-} is a vector that contains the value of the expected change in the inflation-related variable, when the expected change is negative, and a zero otherwise. The results from estimating Eq. 9 are reported in Table 4.

Finally, to examine whether the prevailing monetary environment has any influence on the relationship between inflation and EREIT returns, Eq. 8 and 9 are re-estimated by taking the monetary policy regime into consideration. Results of these analyses are reported in Tables 5 and 6.

Results

Impact of Inflation on EREIT Returns

Table 3 reports the results from regressing EREIT returns on the expected and unexpected components of inflation which are derived from the MMS survey (see Panel A) and the ARIMA procedure (see Panel B), while controlling for the influence of the overall market return and any autocorrelation in the return series. Importantly, these results assume symmetric response of EREIT returns to the inflationary measures. The evidence from both Panels A and B indicate the presence of a perverse relationship between expected inflation and EREIT returns. On the

Table 4 Asymmetric impact of inflation on EREIT returns

Variable	Coefficient	*t*-Statistic
Panel A: expected and unexpected inflation measured via MMS survey		
$\Delta\text{EREIT}_t = \alpha + \gamma\Delta\text{REIT}_{t-1} + \beta\text{MKT}_t + \lambda^+\pi_t^{u+} + \lambda^-\pi_t^{u-} + \varphi^+\pi_t^{e+} + \varphi^-\pi_t^{e-} + \varepsilon_t$		
ΔREIT_{t-1}	−0.03	−3.53*
MKT	0.35	52.93*
Unexpected Inflation (+)	1.74	24.91*
Unexpected Inflation (−)	−1.10	−21.26*
Expected Inflation (+)	0.30	5.02*
Expected Inflation (−)	−0.39	−8.04*
Panel B: expected and unexpected inflation measured via ARIMA		
$\Delta\text{EREIT}_t = \alpha + \gamma\Delta\text{REIT}_{t-1} + \beta\text{MKT}_t + \lambda^+\pi_t^{u+} + \lambda^-\pi_t^{u-} + \varphi^+\pi_t^{e+} + \varphi^-\pi_t^{e-} + \varepsilon_t$		
ΔREIT_{t-1}	−0.03	−3.10*
MKT	0.34	49.93*
Unexpected Inflation (+)	0.89	11.10*
Unexpected Inflation (−)	−0.61	−10.25*
Expected Inflation (+)	0.34	4.91*
Expected Inflation (−)	−0.43	−7.25*

The fixed-effect pooled regressions are estimated with White's (1980) correction for heteroskedasticity

This table documents results of the fixed-effect pooled time-series regression of the impact of expected and unexpected increases and decreases in inflation on EREIT returns. The sample period is from January 1990 through November 2002 (18,284 observations)

*Indicates statistical significance at the 0.01 level

Table 5 The influence of monetary policy condition on the relationship between inflation and EREIT returns

Variable	Coefficient	*t*-Stat	Variable	Coefficient	*t*-Stat	
Expansionary periods			Contractionary periods			*F*-Test of coefficients
Panel A: expected and unexpected inflation measured via MMS survey						
$\Delta REIT_{t-1}$	−0.01	−0.83	$\Delta REIT_{t-1}$	−0.06	−3.89*	7.94*
MKT	0.35	45.86*	MKT	0.23	17.36*	67.29*
Unexpected	0.18	4.00*	Unexpected	0.28	4.65*	1.93
Expected	−0.07	−1.88**	Expected	−0.40	−7.53*	25.56*
Panel B: expected and unexpected inflation measured via ARIMA						
$\Delta REIT_{t-1}$	−0.01	−0.91	$\Delta REIT_{t-1}$	−0.07	−4.15*	9.06*
MKT	0.36	46.46*	MKT	0.20	15.53*	102.95*
Unexpected	0.34	5.93*	Unexpected	−0.30	−5.04*	58.24*
Expected	−0.23	−4.94*	Expected	−0.14	−2.39**	1.57

The fixed-effect pooled regressions are estimated with White's (1980) correction for heteroskedasticity
This table shows fixed-effect pooled time-series regression results of the impact of inflation on EREIT returns after controlling for the prevailing monetary policy environment. The sample period is from January 1990 through November 2002 (18,191 observations)
* and **Indicate statistical significance at the 0.01, and 0.05 levels, respectively

other hand, unanticipated inflation has a positive contemporaneous impact on returns. In addition, the results suggest the importance of the market returns in positively influencing EREIT returns. The conditional market beta coefficient is 0.32 and is statistically significant at the 1 percent level. Furthermore, there is evidence of a statistically significant negative autocorrelation in the EREIT returns.

Table 6 The influence of monetary policy condition on the asymmetric response of EREIT returns to inflation

Variable	Coefficient	*t*-Stat	Variable	Coefficient	*t*-Stat	
Expansionary periods			Contractionary periods			*F*-Test of coefficients
Panel A: expected and unexpected inflation measured via MMS survey						
$\Delta REIT_{t-1}$	−0.02	−1.73*	$\Delta REIT_{t-1}$	−0.08	−4.92*	9.99*
MKT	0.40	51.62*	MKT	0.26	20.37*	88.54*
Unexpected (+)	1.77	22.77*	Unexpected (+)	1.64	12.79*	0.83
Unexpected (−)	−1.19	−19.38*	Unexpected (−)	−0.89	−11.75*	11.67*
Expected (+)	0.67	9.13*	Expected (+)	−0.20	−2.32*	72.97*
Expected (−)	−0.56	−9.52*	Expected (−)	−0.36	−4.44*	4.08**
Panel B: expected and unexpected inflation measured via ARIMA						
$\Delta REIT_{t-1}$	−0.01	−1.25	$\Delta REIT_{t-1}$	−0.07	−4.75*	14.93*
MKT	0.38	48.33*	MKT	0.24	17.17*	101.75*
Unexpected (+)	2.54	26.38*	Unexpected (+)	−0.20	−2.04**	451.55*
Unexpected (−)	−0.89	−12.00*	Unexpected (−)	−0.12	−1.26	43.28*
Expected (+)	0.31	4.08*	Expected (+)	0.62	5.25*	5.63**
Expected (−)	−0.68	−8.19*	Expected (−)	−0.60	−7.90*	0.63

The fixed-effect pooled regressions are estimated with White's (1980) correction for heteroskedasticity
This table shows fixed-effect pooled time-series regression results of the asymmetric response of EREIT returns to inflation after controlling for the prevailing monetary policy environment. The sample period is from January 1990 through November 2002 (18,141 observations)
* and **Indicate statistical significance at the 0.01, and 0.05 levels, respectively

The asymmetric response of EREIT returns to inflation is examined in Table 4. A summary evaluation of the results indicates that EREIT returns have a significant relationship with inflation, and importantly, this relationship is asymmetric. This is evident in both Panels A and B which employ the survey- and ARIMA-based measures of inflation, respectively. A closer examination of Table 4 reveals that EREIT returns have a significant positive relationship with both expected and unexpected *increases* in inflation, but they have significant negative relationships with both expected and unexpected *decreases* in inflation. When interpreting the results for the negative changes in expected and unexpected inflation, one must bear in mind that these independent variables are, by construction, negative, therefore a negative coefficient means that the dependent variable rises in response to the negative changes in expected and unexpected inflation. Therefore, the results document that EREIT returns tend to significantly increase with *both* positive and negative expected and unexpected changes in inflation. The results here represent a significant departure from prior studies that report a negative relationship between inflation and REIT returns.

Furthermore, some interesting observations are noted with regards to the magnitude of the asymmetric relationship which highlights the economic information conveyed in the inflationary expectations process. For instance, unexpected inflation has a much greater impact on EREIT returns than expected inflation. Additionally, EREIT returns tend to rise more in response to unexpected *increases* in inflation than due to unexpected *decreases* in the inflation, and this relationship is reversed when examining expected changes in inflation.

This latter result is essentially an empirical observation. It is theoretically possible for either of the responses to be greater, the analysis, however, indicates that the type of information conveyed by unexpected increases in inflation have a greater impact than that conveyed by unexpected decreases in inflation; while the information conveyed by expected decreases have a greater impact than expected increases.

The Role of Monetary Policy

This section investigates whether the prevailing monetary policy environment has any influence on the relationship between inflation and EREIT returns. The evidence from Panel A in Table 5, indicates that during both expansionary and contractionary phases of the monetary cycle, expected inflation has a negative and perverse impact on EREIT returns; whereas, unexpected inflation is positively associated with EREIT returns. These results, which are qualitatively similar to those presented in Table 3, suggest that monetary policy, by itself, does not fully explain the negative relationship between inflation and REITs. This, however, does not negate the importance of monetary policy since the F-test rejects the null hypothesis that the expected inflation coefficients in the expansionary and contractionary sample periods are equal to each other. The ARIMA-based results presented in Panel B paint a similar picture, but with one notable exception. Specifically, during contractionary periods of the monetary cycle, the estimated value of a surprise increase in inflation is negative.

The question that the study now seeks to address is: if monetary policy cannot entirely explain the negative correlation between inflation and EREIT returns, does its explanatory power improve when taken in conjunction with asymmetric inflation effects. These results are provided in Table 6. The analysis, using MMS and ARIMA based data (see Panels A and B), indicates during expansionary periods, when expected inflation is divided into positive and negative values, EREIT returns have a significant positive relationship with positive changes, and a significant negative relationship with negative changes in expected inflation. This suggests that EREIT returns tend to rise with both expected increases and decreases in inflation. These results are consistent with the asymmetric explanation documented in Table 4.

A potential explanation for the asymmetric response of EREIT returns might revolve around the market's perception of the Fed's credibility in combating inflation. For instance, under an expansionary monetary policy, if the market perceives a decrease in the Fed discount rate as stoking inflation, then the returns of EREITs, whose underlying assets are predominantly real assets, would increase. On the other hand, as the Fed pursues a tightening policy, the market may perceive this as dampening inflationary pressures and REIT returns would go down. For example, rising interest rates will mitigate demand for housing and commercial property, thereby lowering the expected future rise in the value of the EREITs' assets.

By comparison, during periods of restrictive monetary policy the asymmetric evidence is less compelling. While asymmetry is still able to generally resolve the perverse relationship between inflation and EREIT, there are some isolated exceptions. For instance, results document that an increase in expected inflation (measured using MMS data—see Panel A) and unexpected inflation (measured using ARIMA—see Panel B) have a negative influence on returns.

Therefore, an overall study of the results reported indicates that by separating inflation into increases and decreases in expected/unexpected inflation, EREIT returns increase with both positive and negative changes in inflation. However, when the monetary policy factors are taken into account, this relationship continues to be maintained only during the expansionary monetary policy periods. During restrictive monetary policy periods, the evidence is somewhat mixed—there are some indications that inflation continues to share a perverse relationship with EREIT returns. Thus, the results imply that using the asymmetric market response to resolve the perverse inflation relationship is partially contingent upon the prevailing monetary environment.

In order to enhance the credibility and robustness of the existing results, two additional empirical tasks are undertaken. In the first level, the above estimation procedures are extended to a longer sample period, 1981 through 2002. Given the lack of MMS survey data for the pre-1990 period, the ARIMA model is used to provide estimates of expected and unexpected inflation. These results, shown in Tables 7 and 8, are consistent with what has been established so far. Without taking into account the effects of asymmetry and monetary policy conditions, the nature of the relationship between inflation (expected and unexpected) and EREIT returns is best described as being anomalous (see Panel A). Asymmetry is able to explain this anomaly since EREIT returns rises in response to both increases in expected and unexpected inflation, and decreases in expected and unexpected inflation (see Panel B). These results are, however, subject to further modification once the joint effects of monetary policy and asymmetry are considered (see Table 8). Specifically, the asymmetric explanation to the anomaly largely remains intact during the expansion-

Table 7 Impact of expected and unexpected inflation (measured using ARIMA) on EREIT returns for the sample period August 1981 through November 2002

Variable	Coefficient	*t*-Statistic
Panel A: EREIT, expected and unexpected inflation		
$\Delta\text{EREIT}_t = \alpha + \gamma\,\Delta\text{EREIT}_{t-1} + \beta\,\text{MKT}_t + \lambda\pi_t^u + \varphi\pi_t^e + \varepsilon_t$		
ΔEREIT_{t-1}	−0.03	−4.08*
MKT	0.33	49.31*
Unexpected inflation	0.03	0.87
Expected inflation	−0.06	−1.73
Panel B: asymmetric impact of expected and unexpected inflation EREIT returns		
$\Delta\text{EREIT}_t = \alpha + \gamma\,\Delta\text{REIT}_{t-1} + \beta\,\text{MKT}_t + \lambda^+\pi_t^{u+} + \lambda^-\pi_t^{u-} + \varphi^+\pi_t^{e+} + \varphi^-\pi_t^{e-} + \varepsilon_t$		
ΔEREIT_{t-1}	−0.03	−4.42*
MKT	0.35	51.74*
Unexpected inflation (+)	0.76	10.34*
Unexpected inflation (−)	−0.62	−10.70*
Expected inflation (+)	0.25	3.77*
Expected inflation (−)	−0.30	−5.25*

All of the above regressions are estimated via a fixed-effect pooled time-series procedure that uses White's (1980) correction for heteroskedasticity

* and **Indicate statistical significance at the 0.01, and 0.05 levels, respectively

ary periods of the economy. During the contractionary periods, however, the observation of EREIT returns behaving as a perverse inflation hedge—specifically, against unexpected inflation—remains even after accounting for the asymmetry

Secondly, the study attempts to link and compare the present results with those found by Glascock et al. (2002) who attribute the perverse relationship between inflation and REIT returns primarily to the role of monetary policy influences. However, in their investigation, the authors use time-series analysis (as opposed to the panel approach of this study) and do not distinguish between positive and negative changes in inflation. The present results are re-examined by employing a time-series of NAREIT index returns. Results, which are not shown, are generally supportive of an asymmetric response of REIT returns. However, owing to

Table 8 Influence of monetary policy on the asymmetric response of EREIT returns to expected and unexpected inflation (measured using ARIMA) for the sample period August 1981 through November 2002

Variable	Coefficient	*t*-Stat	Variable	Coefficient	*t*-Stat	
Expansionary periods			Contractionary periods			*F*-Test of coefficients
ΔREIT_{t-1}	−0.01	−1.17	ΔREIT_{t-1}	−0.07	−4.92*	15.97*
MKT	0.37	47.16*	MKT	0.29	22.33*	32.69*
Unexpected (+)	2.24	24.83*	Unexpected (+)	−0.15	−1.56	384.29*
Unexpected (−)	−0.97	−13.8*	Unexpected (−)	0.12	1.18	87.83*
Expected (+)	0.07	0.94	Expected (+)	0.59	4.96*	15.93*
Expected (−)	−0.29	−3.68*	Expected (−)	−0.39	−5.09*	0.91

All of the above regressions are estimated via a fixed-effect pooled time-series procedure that uses White's (1980) correction for heteroskedasticity

* and **Indicate statistical significance at the 0.01, and 0.05 levels, respectively

methodological differences, these results do not carry the same amount of robustness and reliability as the empirical approach followed in this study.

Concluding Remarks

Previous studies have documented evidence of a negative relationship between REIT returns and inflation. This result is counterintuitive in that the price of real assets should rise when inflation rises. While this puzzling result has been explained in Glascock et al. (2002) by accounting for the interaction between REIT returns and monetary policy, the results presented here, however, indicate that there is more to the spurious negative relationship than just a need to account for monetary policy effects.

This study documents an asymmetry in the response of the EREIT returns to inflation. What this means is that EREIT returns do display a negative relationship with inflation, but this is predominantly the case when inflation, itself, is going down. Therefore, EREIT returns are shown to rise when inflation rises and to also rise when inflation decreases. The counterintuitive result of previous studies have been shown to be an artifact of the methodology they employ, which implicitly assumes symmetrical responses in EREIT returns to inflation.

Furthermore, the evidence which survive a battery of robustness checks is partly contingent on the prevailing monetary policy environment. Specifically, during expansionary periods, EREIT returns go up with both increases and decreases in inflation. However, during restrictive monetary policy periods, the perverse relationship between inflation and EREIT returns cannot be fully explained using the asymmetric framework. In conclusion, it appears that the negative association between EREIT returns and inflation is a product of both asymmetry and the monetary policy expectations of market participants.

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