BGPE Discussion Paper

No. 251

REITs and Commercial Real Estate Uncertainty

Vanessa Dietl

Gabriel Lee

Binh Nguyen Thanh

October 2026

ISSN 1863-5733

Editor: Prof. Regina T. Riphahn, Ph.D.
Friedrich-Alexander-Universität Erlangen-Nürnberg
© Vanessa Dietl, Gabriel Lee, Bing Nguyen Thanh

B G P E Discussion Paper Series

REITs and Commercial Real Estate Uncertainty

Vanessa Dietl,[*] Gabriel Lee,[**] Binh Nguyen Thanh[***]

October 19, 2026

Abstract

We examine whether commercial real estate uncertainty (CREU) is related to U.S. REIT returns from 1994 to 2025, comparing the CREU index of Dietl and Lee (2026) with established real estate, macroeconomic, and financial uncertainty measures within the framework of Lotz et al. (2023). A temporal causality analysis identifies predictive relationships for CREU and macroeconomic uncertainty in individual property sectors, whereas real estate and financial uncertainty show no such relationships. The unconditional asset pricing analysis shows that CREU is the only uncertainty measure with a statistically significant negative coefficient when the measures are included individually. Rolling-window estimates reveal time variation in uncertainty exposures, with differences in the estimated CREU exposure across crisis episodes. Finally, we identify economic state variables associated with time-varying CREU exposures: the negative relationship is weaker when house price growth is high and stronger when financial market volatility is elevated.

JEL Classification: G11, G12, R33.

Keywords: commercial real estate uncertainty; REIT returns; conditional asset pricing

[*]University of Regensburg, 93053 Regensburg, Germany, or vanessa1.dietl@ur.de.

[**]University of Regensburg, 93053 Regensburg, Germany, and Institute for Advanced Studies, 1080 Vienna, Austria, or gabriel.lee@ur.de.

[***]Royal Melbourne Institute of Technology (RMIT), Vietnam Campus, Ho Chi Minh City, Vietnam, or binh.nguyenthanh@rmit.edu.vn.

1 Introduction

Recent developments in commercial real estate have renewed attention to the role of uncertainty in property markets. The monetary tightening cycle of 2022 and the regional banking stress of 2023 raised concerns about property valuations, refinancing conditions, and lenders' exposure to commercial mortgages. These developments are particularly relevant for real estate investment trusts (REITs), which combine the liquidity of publicly traded equity with exposure to underlying property markets. Their returns may therefore reflect uncertainty originating in both financial and real estate markets. This raises the question of whether uncertainty specific to commercial real estate contains information about REIT returns beyond that provided by broader uncertainty measures.

Lotz et al. (2023) provide a systematic study of the relationship between financial and real estate uncertainty and U.S. REIT returns. They document negative uncertainty exposures and identify economic state variables associated with their variation over time. Their analysis employs the financial uncertainty measure of Ludvigson et al. (2021) and the real estate uncertainty measure of Nguyen Thanh et al. (2020), which is constructed from residential housing market variables. However, neither measure specifically captures uncertainty originating in commercial property markets. Whether such uncertainty provides additional information about REIT returns remains an empirical question.

We address this question using the Commercial Real Estate Uncertainty (CREU) index developed by Dietl and Lee (2026). The index applies the predictability-based framework of Jurado et al. (2015) to commercial real estate variables and is estimated directly at the quarterly frequency. We compare CREU with established measures of Real Estate Uncertainty (REU), Macroeconomic Uncertainty (MU), and Financial Uncertainty (FU). Building on the empirical framework of Lotz et al. (2023), we examine temporal predictability, unconditional uncertainty exposures, their variation over time, and their dependence on economic conditions. Our analysis covers quarterly excess returns for the Nareit All Equity REITs Index and eight property-sector indices from 1994Q1 to 2025Q4.

As a motivation, Figure 1 illustrates the evolution of FU, REU, and CREU at the three- and twelve-month forecast horizons alongside the log Nareit All Equity REITs Index. The three measures identify different episodes of heightened uncertainty, defined as periods in which an index exceeds its sample mean by at least 1.64 standard deviations (Bloom 2009). FU exceeds this threshold during the global financial crisis, from 2008Q3 to 2009Q2, and again at the onset of the COVID-19 recession, from 2020Q1 to 2020Q2. REU exceeds its threshold in the same two episodes and additionally around the 2011 debt ceiling dispute. CREU, by contrast, exhibits a single, more prolonged episode of threshold exceedances. At the three-month horizon, this episode begins in 2008Q1, two quarters before the corresponding episodes for FU and REU, and lasts ten consecutive quarters. At the twelve-month horizon, CREU remains above its threshold for nine consecutive quarters, beginning in 2008Q2. Unlike FU and REU, CREU does not exceed its threshold during the COVID-19 recession. These comparisons concern the evolution and persistence of the series rather than their absolute levels, as the measures are scaled differently. The differences motivate examining whether the source of uncertainty also matters for its relationship with REIT returns.

There are several reasons why uncertainty may be relevant for REIT returns. In the intertemporal asset pricing framework of Merton (1973), investors' portfolio decisions reflect changes in the investment opportunity set and the demand for assets that hedge against unfavorable economic conditions. Uncertainty may consequently be associated with changes in asset prices and expected returns. A further channel operates through underlying property markets. Since real estate investment is costly to reverse, uncertainty can increase the option value of delaying investment (Titman 1985; Pindyck 1991). Related empirical research examines the role of uncertainty in commercial real estate investment (Holland et al. 2000). These considerations motivate examining whether uncertainty measured directly from commercial property markets is associated with REIT returns.

Our empirical analysis yields three main findings.

First, the uncertainty measures differ in the timing of their association with REIT returns. Financial uncertainty exhibits its strongest correlation with REIT excess returns contemporaneously across the return series considered. In contrast, the strongest correlations for real estate uncertainty and short-horizon commercial real estate uncertainty generally occur at lags of one or two quarters. A temporal causality analysis identifies predictive relationships for CREU and macroeconomic uncertainty in selected property sectors. Neither real estate nor financial uncertainty satisfies both predictive criteria in the benchmark specification. For CREU, the evidence is concentrated in individual property sectors rather than the aggregate REIT market.

Second, lagged changes in CREU are negatively associated with subsequent REIT excess returns after controlling for conventional asset pricing factors. In the unconditional analysis, CREU is the only uncertainty measure with a statistically significant negative coefficient when the measures are included individually. Its coefficient also remains negative and statistically significant when CREU, REU, and FU enter the regression jointly. However, the unconditional CREU association is sensitive to particular sample and measurement choices. The individual CREU coefficient loses statistical significance when the global financial crisis is excluded. When REU is estimated directly at the quarterly frequency, the CREU coefficient is no longer statistically significant in the joint specification.

Third, the estimated CREU exposure varies over time. Rolling-window estimates reveal differences in uncertainty exposures across crisis episodes. In the conditional analysis, the interaction between CREU and house price growth is positive, whereas the interaction with financial market volatility is negative. These results suggest that the negative relationship between CREU and subsequent REIT returns is weaker when house price growth is high and stronger when financial market volatility is elevated. However, neither interaction remains statistically significant when the exposures to REU and FU are also allowed to vary with the respective economic state variable. The evidence for state-dependent CREU exposures therefore depends on the model specification.

Our analysis relates to several strands of the literature. Research on real estate asset pricing investigates the relationship between real estate returns and financial and economic risk factors (Ling and Naranjo 1997; Karolyi and Sanders 1998), building on the macroeconomic factor framework of Chen et al. (1986). Lotz et al. (2023) extend this literature by examining uncertainty exposures and uncertainty risk premia in the U.S. REIT market. Related research investigates

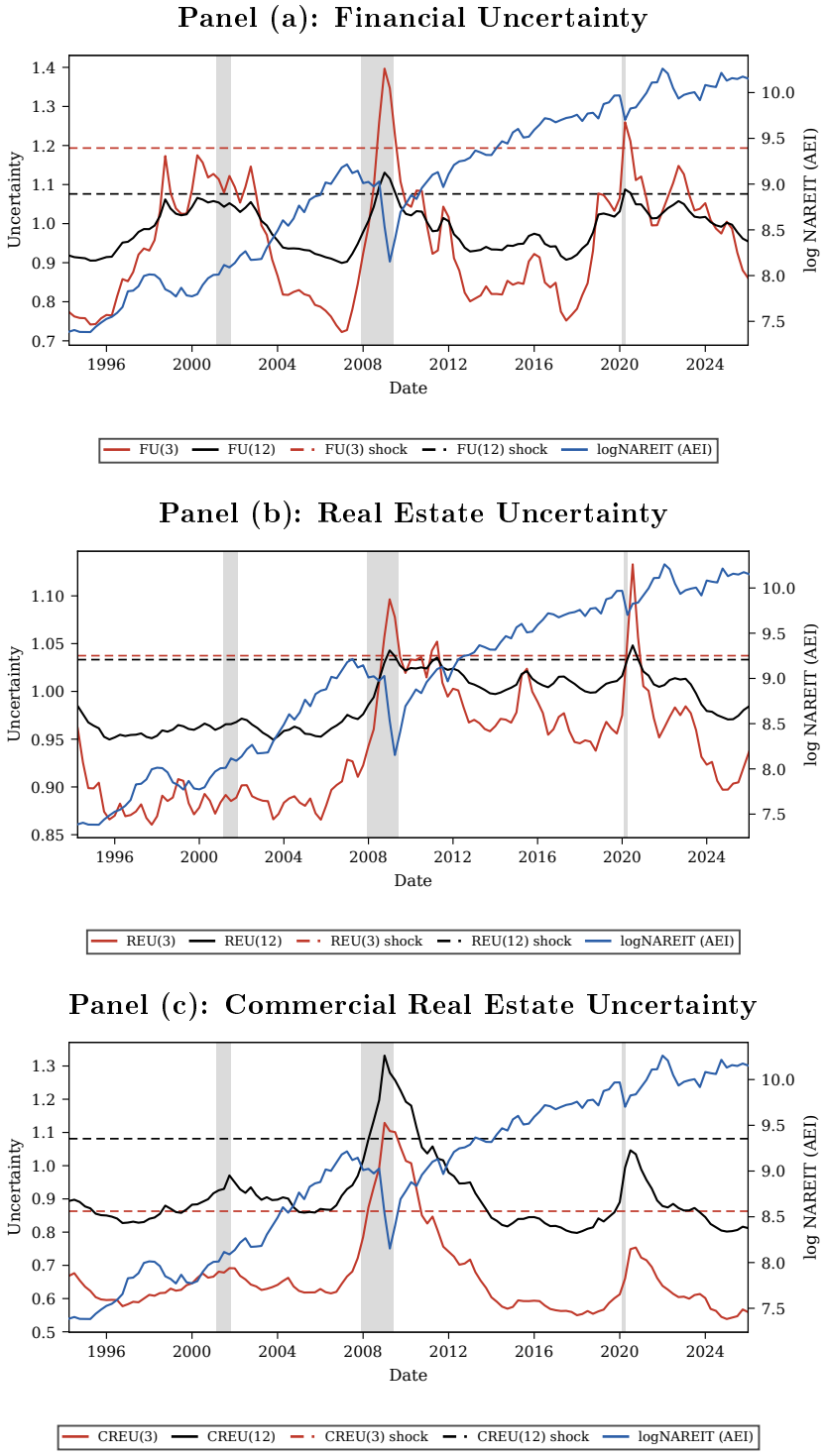


Figure 1: Uncertainty Measures and the Nareit All Equity REITs Index

Notes: Panels (a)–(c) show Financial Uncertainty (FU), Real Estate Uncertainty (REU), and Commercial Real Estate Uncertainty (CREU), respectively, at forecast horizons of three and twelve months, corresponding to one and four quarters for CREU (left axis). Each panel also displays the logarithm of the Nareit All Equity REITs Index (right axis). The sample covers 1994Q1 to 2025Q4. FU was developed by Ludvigson et al. (2021), REU by Nguyen Thanh et al. (2020), and CREU by Dietl and Lee (2026). The REU and CREU series used in the figure are taken from Dietl and Lee (2026). CREU is estimated directly at the quarterly frequency, whereas FU and REU are quarterly averages of their underlying monthly series. The Nareit index is measured at the end of each quarter.

Dashed horizontal lines indicate thresholds defined as 1.64 standard deviations above the respective sample means (Bloom 2009). The thresholds are 1.19 (FU(3)), 1.08 (FU(12)), 1.04 (REU(3)), 1.03 (REU(12)), 0.86 (CREU(3)), and 1.08 (CREU(12)). Shaded areas indicate NBER recession periods.

the relationship between uncertainty and real estate investment (Holland et al. 2000) and the responses of commercial property prices and REIT returns to uncertainty shocks (Gholipour et al. 2021). We extend this literature by examining uncertainty constructed specifically from commercial real estate variables.

Our analysis also relates to the literature on uncertainty measurement. Earlier approaches examine uncertainty in specific real estate settings. For example, Dorofeenko et al. (2014) investigate risk shocks in a model of housing production, while Miles (2009) examines the relationship between uncertainty and housing investment using a GARCH-in-mean model. The predictability-based framework of Jurado et al. (2015) has subsequently been applied to financial markets (Ludvigson et al. 2021), residential real estate (Nguyen Thanh et al. 2020), and commercial real estate (Dietl and Lee 2026). Rather than revisiting the construction of CREU, we investigate its relationship with publicly traded real estate returns relative to established uncertainty measures.

Our contribution is to extend the empirical analysis of uncertainty and REIT returns to uncertainty specific to commercial real estate. By comparing CREU with established uncertainty measures, we examine whether the source of uncertainty matters for its relationship with REIT returns. Our results provide evidence of a negative CREU association in the benchmark specification and show that its statistical significance in the joint regression depends partly on the construction of the competing uncertainty measures. Unlike Lotz et al. (2023), we do not estimate uncertainty risk premia. Our analysis concerns uncertainty exposures rather than the market price of uncertainty risk.

The remainder of the paper is organized as follows. Section 2 describes the data and uncertainty measures. Section 3 presents the empirical analysis. Section 4 reports the robustness analysis, and Section 5 concludes.

2 Data and Uncertainty Measures

2.1 Uncertainty measures

We use four measures of uncertainty to explain REIT returns: Real Estate Uncertainty (REU), Commercial Real Estate Uncertainty (CREU), Macroeconomic Uncertainty (MU), and Financial Uncertainty (FU). Table A9 in the Appendix lists all variables used in the analysis together with their definitions and sources. All four follow the methodology of Jurado et al. (2015) and are computed as the conditional volatility of the forecast error of a large set of economic variables. The measures are constructed to capture uncertainty about the predictability of economic developments rather than volatility as such. The conditional volatility of the unpredictable component of the h-period ahead forecast of a series $y_{j,t+h}$ is

$$\mathcal{U}^{y}_{j,t}(h) = \sqrt{E\left[(y_{j,t+h} - E(y_{j,t+h} \mid I_t))^2 \mid I_t\right]}, \tag{1}$$

where the forecast $E(y_{j,t+h} \mid I_t)$ uses only information available up to time t.[1] The individual series are then aggregated with weights ω_j into a single index,

$$UNC_t(h) = \sum_{j=1}^{n} \omega_j \, \mathcal{U}^y_{j,t}(h). \tag{2}$$

The four measures differ in the set of series entering Eq. (2). MU is based on a broad panel of macroeconomic series (Jurado et al. 2015), whereas FU is based on financial market variables, including valuation ratios, dividend and price information, and established stock market factors (Ludvigson et al. 2021). REU is derived from construction activity and supply-side variables of the residential housing market, such as housing starts and new built homes (Nguyen Thanh et al. 2020). CREU is derived from 22 quarterly commercial real estate series, each entering the index with equal weight (Dietl and Lee 2026). These series cover four aspects of the commercial property sector: construction spending and employment by property type, commercial mortgage lending and loan performance, commercial property prices and values, and credit and financing conditions. Its estimation draws on a predictor set of 253 additional macroeconomic and financial series, so that the information set underlying the forecasts in Eq. (1) is comparable in breadth to that of the established measures. Table A8 in the Appendix reports the correlations between the uncertainty factors. The two real estate measures are correlated at 0.53 at the three-month horizon, and CREU(3) is correlated at 0.26 with FU(3), so that the measures are not redundant. The correlation between CREU and MU is higher, at 0.58 at the three-month horizon and 0.71 between CREU(12) and MU(3), which is consistent with both measures drawing on partly overlapping predictor sets.

MU, FU, and REU are constructed at the monthly frequency and aggregated to quarterly averages, whereas CREU is estimated directly at the quarterly frequency. CREU is available for forecast horizons of one to four quarters (Dietl and Lee 2026). For comparability with the monthly uncertainty measures, we focus on horizons of one and four quarters, denoted $h = 3$ and $h = 12$ months, respectively. The one-month horizon used as the benchmark by Lotz et al. (2023) has no quarterly counterpart and is therefore omitted. We also exclude the six-month horizon because FU is available only for $h = \{1, 3, 12\}$.

Throughout the asset pricing analysis we convert the uncertainty measures into factors by taking log differences of the level series, expressed in percent:

$$\Delta UNC_t(h) = 100 \left[\ln UNC_t(h) - \ln UNC_{t-1}(h) \right], \tag{3}$$

where UNC denotes one of the four measures and h is the forecast horizon. This transformation mitigates concerns about the high serial correlation of the level series when studying the time-series relationship between uncertainty and REIT returns.[2] In the predictive regressions, we use uncertainty factors lagged by one quarter to explain REIT returns in period t, ensuring that the uncertainty measures precede the returns being explained.

[1] The conditional volatility is estimated using stochastic-volatility models at the shortest forecast horizon (one month for the monthly measures and one quarter for CREU). For longer horizons, a recursive procedure is applied.

[2] Figure A1 in the Appendix shows the partial autocorrelations of the uncertainty factors. All eight factors exhibit a substantial partial autocorrelation at the first lag and small or insignificant values at higher lags, which supports including them with a single quarterly lag.

2.2 REIT returns and sample period

We use the Nareit All Equity REITs Index as a proxy for the aggregate performance of the U.S. REIT market and compare eight property-sector indices to study sector-specific heterogeneity: Office, Industrial, Retail, Residential, Health Care, Lodging/Resorts, Self Storage, and Diversified. The index data are obtained from Nareit (2026). Quarterly excess returns are calculated as the sum of monthly logarithmic total returns within each quarter minus the corresponding sum of monthly returns on one-month Treasury bills, expressed in percent per quarter.

Our sample period ranges from 1994Q1 to 2025Q4, covering 128 quarters. The sample start follows Lotz et al. (2023) and coincides with the modern REIT era that began with the REIT boom of the 1990s; it is also the first quarter for which the uncertainty factors are available, since the CREU level series starts in 1993Q4 and enters the analysis in first differences. Relative to Lotz et al. (2023), whose sample ends in 2017, our period additionally covers the COVID-19 recession, the monetary tightening cycle of 2022, and the regional banking stress of 2023. The effective number of observations varies across specifications depending on the lag structure.

Table 1 reports summary statistics for the REIT excess returns and the uncertainty factors. Mean quarterly excess returns range from 0.31 percent for Lodging/Resorts to 2.62 percent for Self Storage, and their standard deviations from 9.69 percent for Residential to 16.78 percent for Lodging/Resorts. Among the uncertainty factors, FU exhibits the largest standard deviation at the three-month horizon, followed by MU, CREU, and REU. For each measure, the standard deviation of its quarterly log changes is lower at the twelve-month horizon than at the three-month horizon. The augmented Dickey–Fuller tests reject the null hypothesis of a unit root for all return series and all uncertainty factors at the 1 percent significance level.

2.3 Asset pricing factors and state variables

Lotz et al. (2023) show that a large share of the variation in REIT returns can be explained by the Carhart (1997) four-factor model extended by bond market risk. This specification serves as the benchmark for our asset pricing analysis. The stock market factor (Stocks) is the value-weighted excess return on the aggregate U.S. stock market and proxies for business cycle risk. The size factor (SMB) replicates a portfolio long in small and short in large stocks, while the value factor (HML) is long in stocks with a high and short in stocks with a low book-to-market ratio (Fama and French 1993). The momentum factor (MOM) takes a long position in stocks with the highest returns over the preceding twelve months and shorts losers (Carhart 1997). These four factors are obtained from Kenneth French's data library, and the risk-free rate is proxied by the one-month Treasury bill rate.

The bond market factor (Bonds) approximates the excess return on a ten-year Treasury bond. Since the corresponding CRSP bond return series is not available to us, we construct the factor from the ten-year Treasury constant maturity rate using a duration-based approximation of government bond returns and subtract the one-month Treasury bill rate.[3]

[3]The monthly total return is approximated as $r_t = y_{t-1}/12 - D_{t-1}(y_t - y_{t-1})$, where y_t is the ten-year Treasury constant maturity rate and D_t denotes the modified duration of a par bond with ten-year maturity and semi-annual coupons. The convexity term is neglected and yields are expressed in decimal units. Two series differ from the data used by Lotz et al. (2023): the bond market factor, which we approximate rather than take from CRSP,

Table 1: Summary Statistics of REIT Excess Returns and Uncertainty Factors

	Obs	Mean	SD	Min	Max	ADF
Panel A: REIT excess returns						
All Equity REITs (AEI)	128	1.58	9.92	−49.22	28.69	−8.50***
Office (OFF)	128	1.12	11.56	−51.15	37.23	−8.68***
Industrial (IND)	128	1.81	13.42	−83.12	29.50	−8.57***
Retail (RET)	128	1.51	12.95	−67.20	32.79	−8.04***
Residential (RES)	128	1.79	9.69	−44.50	31.44	−7.80***
Health Care (HC)	128	1.97	10.84	−46.19	23.99	−8.77***
Lodging/Resorts (LOD)	128	0.31	16.78	−72.33	55.69	−8.16***
Self Storage (STO)	128	2.62	10.17	−38.93	25.48	−8.11***
Diversified (DIV)	128	0.81	11.80	−54.01	33.22	−8.87***
Panel B: Uncertainty factors						
ΔREU(3)	128	0.00	2.03	−6.97	7.67	−9.88***
ΔREU(12)	128	0.00	0.57	−1.37	1.79	−7.40***
ΔCREU(3)	128	−0.13	3.36	−8.99	12.81	−4.97***
ΔCREU(12)	128	−0.07	2.50	−5.73	11.10	−5.16***
ΔMU(3)	128	0.01	4.88	−13.26	24.84	−8.52***
ΔMU(12)	128	0.00	2.23	−6.79	11.55	−8.15***
ΔFU(3)	128	0.10	5.21	−10.92	16.75	−7.57***
ΔFU(12)	128	0.03	1.68	−3.38	5.31	−6.95***

Notes: Summary statistics for the quarterly log excess returns of the Nareit All Equity REITs Index and eight property-sector indices, and for the uncertainty factors, from 1994Q1 to 2025Q4. Excess returns are calculated from monthly logarithmic total returns less the corresponding returns on one-month Treasury bills and are expressed in percent per quarter. Uncertainty factors are quarterly log differences of the respective uncertainty indices, expressed in percent, as defined in Eq. (3). REU and CREU are taken from Dietl and Lee (2026). REU, MU, and FU are quarterly averages of the underlying monthly indices, while CREU is estimated directly at the quarterly frequency. ADF denotes the augmented Dickey–Fuller test statistic with one lag. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

To examine whether uncertainty exposures depend on the state of the economy, we consider six state variables, each lagged by one quarter: house price growth, industrial production growth, consumer sentiment growth, the federal funds rate, the term spread between the ten-year Treasury rate and the federal funds rate, and the CBOE volatility index (VIX). The first three proxy for real economic conditions, the federal funds rate and the term spread for the monetary policy stance, and the VIX for financial market conditions. Growth rates are calculated as quarterly sums of monthly log differences in percent, while the remaining state variables enter in levels. All state variables are obtained from FRED; the corresponding series identifiers are reported in the notes to Table 7.

As additional controls in the robustness analysis we use changes in the CBOE volatility index (ΔVIX, VIXCLS) and in the news-based Economic Policy Uncertainty index of Baker et al. (2016) (ΔEPU, USEPUINDXD). Both are quarterly averages of the underlying daily series, entered as log differences in percent. Table A2 in the Appendix reports correlations of the REIT excess returns and the uncertainty factors with the common risk factors and the state variables.

3 Empirical Analysis

Our empirical analysis proceeds in four stages, each presented together with the corresponding results. After a descriptive correlation analysis, we first examine whether uncertainty contains predictive information for REIT excess returns. We then estimate the exposure of REIT returns to uncertainty using an unconditional asset pricing model, and subsequently investigate how this exposure varies over time. Finally, we examine whether uncertainty exposures depend on macroeconomic and financial conditions. Throughout, we follow the empirical framework of Lotz et al. (2023) and extend the analysis to commercial real estate uncertainty. Section 4 then assesses the robustness of these results.

3.1 Correlation Analysis

Table 2 reports contemporaneous and lagged correlations between the uncertainty factors and REIT excess returns. All 144 reported correlations are negative, although their magnitudes differ across uncertainty measures, forecast horizons, and property sectors.

Among the contemporaneous correlations in Panel A, FU exhibits the strongest association with the aggregate REIT index, at -0.46 for FU(3). CREU(12), MU(3), and REU(3) exhibit contemporaneous correlations of -0.39, -0.30, and -0.20, respectively. The sector-specific results reveal similar negative associations, although their magnitudes vary. CREU(12) exhibits particularly pronounced correlations with Retail (-0.46) and Lodging/Resorts (-0.51), whereas Self Storage generally exhibits weaker correlations. Within each uncertainty measure, the twelve-month horizon is more strongly correlated with aggregate REIT returns than the three-month horizon for CREU, while the correlations for the two FU horizons are similar.

Panel B reports the strongest correlation over lags of zero to four quarters. For FU, the strongest correlation is contemporaneous across all return series. By contrast, the strongest

and the federal funds rate, for which we use a quarterly average of monthly values rather than of end-of-month values. Both differences are documented in Table A9 in the Appendix.

correlations with REU and CREU(3) generally occur at lags of one or two quarters. For the aggregate index, CREU(3) exhibits its strongest correlation at a lag of one quarter (−0.30), whereas the strongest correlation with CREU(12) is contemporaneous (−0.39).

These differences in timing are suggestive but descriptive. A contemporaneous correlation is consistent with uncertainty and returns responding to the same underlying shock, whereas a correlation at a lag of one or two quarters is a necessary condition for uncertainty to contain predictive information. We therefore turn to a formal examination of temporal predictability.

Table 2: Correlation Analysis

	AEI	**OFF**	**IND**	**RET**	**RES**	**HC**	**LOD**	**STO**	**DIV**
Panel A: Contemporaneous correlations									
ΔREU(3)	−0.20	−0.23	−0.15	−0.26	−0.22	−0.19	−0.28	−0.14	−0.20
ΔREU(12)	−0.21	−0.21	−0.19	−0.28	−0.19	−0.13	−0.29	−0.13	−0.17
ΔCREU(3)	−0.25	−0.25	−0.22	−0.29	−0.28	−0.11	−0.30	−0.13	−0.23
ΔCREU(12)	−0.39	−0.38	−0.32	−0.46	−0.39	−0.24	−0.51	−0.19	−0.37
ΔMU(3)	−0.30	−0.28	−0.24	−0.40	−0.28	−0.28	−0.46	−0.16	−0.31
ΔMU(12)	−0.32	−0.30	−0.24	−0.42	−0.29	−0.30	−0.47	−0.18	−0.33
ΔFU(3)	−0.46	−0.41	−0.43	−0.45	−0.37	−0.36	−0.49	−0.26	−0.44
ΔFU(12)	−0.44	−0.39	−0.41	−0.44	−0.35	−0.35	−0.49	−0.25	−0.43
Panel B: Strongest correlations over lags 0–4									
ΔREU(3)	−0.24 [2]	−0.30 [1]	−0.31 [2]	−0.29 [1]	−0.25 [1]	−0.19 [0]	−0.28 [0]	−0.18 [2]	−0.21 [1]
ΔREU(12)	−0.32 [2]	−0.32 [1]	−0.37 [2]	−0.32 [1]	−0.26 [1]	−0.20 [2]	−0.29 [0]	−0.24 [2]	−0.24 [2]
ΔCREU(3)	−0.30 [1]	−0.28 [1]	−0.30 [1]	−0.31 [1]	−0.32 [1]	−0.16 [1]	−0.30 [0]	−0.25 [1]	−0.27 [1]
ΔCREU(12)	−0.39 [0]	−0.38 [0]	−0.39 [1]	−0.46 [0]	−0.39 [0]	−0.24 [0]	−0.51 [0]	−0.33 [1]	−0.37 [1]
ΔMU(3)	−0.34 [1]	−0.36 [1]	−0.35 [1]	−0.40 [0]	−0.34 [1]	−0.28 [0]	−0.46 [0]	−0.20 [1]	−0.34 [1]
ΔMU(12)	−0.37 [1]	−0.39 [1]	−0.35 [1]	−0.42 [0]	−0.37 [1]	−0.30 [0]	−0.47 [0]	−0.23 [1]	−0.36 [1]
ΔFU(3)	−0.46 [0]	−0.41 [0]	−0.43 [0]	−0.45 [0]	−0.37 [0]	−0.36 [0]	−0.49 [0]	−0.26 [0]	−0.44 [0]
ΔFU(12)	−0.44 [0]	−0.39 [0]	−0.41 [0]	−0.44 [0]	−0.35 [0]	−0.35 [0]	−0.49 [0]	−0.25 [0]	−0.43 [0]

Notes: Correlation coefficients between the uncertainty factors and the quarterly log excess returns of the Nareit All Equity REITs Index (AEI) and the property sectors, 1994Q1–2025Q4. Panel A shows contemporaneous correlations. Panel B shows the strongest correlation over lags of zero to four quarters, with the lag order in square brackets. The correlations are descriptive. The effective number of observations varies with the lag order; serial dependence and multiple comparisons are not accounted for by conventional correlation significance tests.

3.2 Temporal Causality

To examine temporal causality, we estimate the following model for each REIT return series:

$$x_t = \beta_0 + \sum_{j=1}^{L} \alpha_j x_{t-j} + \sum_{j=1}^{L} \beta_j \Delta UNC_{t-j}(h) + \varepsilon_t, \tag{4}$$

where x_t denotes the quarterly log excess return of the Nareit All Equity REITs Index or one of the eight property-sector indices, $\Delta UNC_t(h)$ is an uncertainty factor defined in Eq. (3), and $L = 3$ quarters in the benchmark specification.

Following Lotz et al. (2023), we employ two complementary tests. First, we conduct a Granger-causality test of the joint null hypothesis

$$H_0 : \beta_1 = \beta_2 = \cdots = \beta_L = 0. \tag{5}$$

Second, we test whether the sum of the coefficients on lagged uncertainty is zero. Following the terminology of Lotz et al. (2023), we refer to this coefficient sum as the long-term impact:

$$H_0 : \sum_{j=1}^{L} \beta_j = 0. \tag{6}$$

We classify an uncertainty factor as temporally predictive of REIT returns if both null hypotheses are rejected at the 5 percent significance level. Statistical inference is based on Newey and West (1987) standard errors with four lags.[4] For the All Equity REITs Index, we additionally examine alternative lag orders of $L = \{2, 4, 5, 6\}$ quarters. The tests establish temporal predictability rather than structural causality.

Tables 3 and 4 present the results of the temporal causality analysis. A predictive relationship is identified when both the test of the cumulative coefficients on lagged uncertainty and the Granger-causality test reject their respective null hypotheses at the 5 percent significance level.

Of the 72 combinations of uncertainty factors and return series, nine satisfy both criteria in the benchmark specification with three quarterly lags. Four involve CREU and five involve MU, whereas neither REU nor FU satisfies both criteria for any return series.

For the aggregate REIT index, none of the uncertainty factors satisfies both criteria at the benchmark lag order. CREU(12) is significant in the Granger-causality test ($p = 0.003$), while its cumulative coefficient is significant only at the 10 percent level ($p = 0.069$). Both criteria are satisfied when the lag order is reduced to two quarters.

The sector-specific results in Table 4 reveal more pronounced predictive relationships. For Retail, both CREU(3) and CREU(12) satisfy the two criteria, with p-values of 0.046 and 0.043 for the cumulative coefficients and 0.033 and below 0.001 for the Granger-causality tests, respectively. CREU(12) also satisfies both criteria for Lodging/Resorts and Diversified REITs. MU(12) satisfies both criteria for Office, Retail, Lodging/Resorts, and Diversified REITs, while MU(3) does so for Retail. All nine significant predictive relationships have negative cumulative coefficients.

Overall, the results indicate heterogeneity in the predictive information contained in uncertainty measures. In particular, the evidence for CREU is concentrated in selected property sectors rather than the aggregate REIT index. These findings concern temporal predictability and do not establish structural causality. They also do not account for the common risk factors known to drive REIT returns, which motivates the asset pricing specification we turn to next.

3.3 Unconditional Uncertainty Exposures

The coefficient β_i^{UNC} measures how strongly an index's excess return in period t is related to the change in uncertainty in period $t-1$. A negative estimate indicates that higher uncertainty in the preceding quarter is associated with lower subsequent returns, and a positive estimate the opposite. In an intertemporal asset pricing framework, a negative exposure would be associated

[4] Lotz et al. (2023) use six lags on monthly data. Four lags on quarterly data cover a comparable horizon of one year.

Table 3: Temporal Causality Analysis: All Equity REITs Index

	Lag order $L = 3$				Lag selection (L)			
	LTI		GC	C	C	C	C	C
Uncertainty	Sign	p-Value	p-Value		(2)	(4)	(5)	(6)
ΔREU(3)	(−)	0.082	0.336					
ΔREU(12)	(−)	0.059	0.199					
ΔCREU(3)	(−)	0.065	0.081					
ΔCREU(12)	(−)	0.069	0.003		+			
ΔMU(3)	(−)	0.151	0.223					
ΔMU(12)	(−)	0.077	0.154					
ΔFU(3)	(−)	0.160	0.175					
ΔFU(12)	(−)	0.106	0.117					

Notes: Causality analysis of the uncertainty factors on the quarterly log excess return of the Nareit All Equity REITs Index with lag order $L = 3$ quarters, estimated from Eq. (4) over 1994Q1–2025Q4. The long-term impact (LTI) refers to the significance of the sum of the coefficients β_j on lagged uncertainty, as defined in Eq. (6); the sign is reported in round brackets. Granger causality (GC) is the joint F-test of Eq. (5). The relationship is classified as temporally predictive (C, denoted +) if both tests are significant at the 5% level. The four right-hand columns report the sensitivity to lag selections $L = \{2, 4, 5, 6\}$. Newey–West standard errors with four lags. Property-sector results are reported in Table 4.

with a return compensation and a positive exposure with hedging benefits (Merton 1973; Lotz et al. 2023). Establishing this requires an estimate of the market price of uncertainty risk, which we do not provide; we therefore report exposures and do not interpret them as risk premia.

We examine whether uncertainty is associated with subsequent REIT returns after controlling for established asset pricing factors. Following Lotz et al. (2023), we augment the three-factor model of Fama and French (1993) and the momentum factor of Carhart (1997) with a bond market factor and lagged uncertainty:

$$\begin{aligned} er_{i,t} = \alpha_i + \beta_i^{UNC} \Delta UNC_{t-1}(3) + \beta_i^{stocks} er_t^{stocks} + \beta_i^{bonds} er_t^{bonds} \\ + \beta_i^{SMB} SMB_t + \beta_i^{HML} HML_t + \beta_i^{MOM} MOM_t + \varepsilon_{i,t}, \end{aligned} \tag{7}$$

where $er_{i,t}$ denotes the quarterly log excess return of REIT index i. The uncertainty factor enters with a one-quarter lag, while the stock market, bond market, size, value, and momentum factors enter contemporaneously. The coefficient β_i^{UNC} measures the relationship between lagged uncertainty and subsequent REIT returns, conditional on these factors.

We estimate separate specifications for each of the four uncertainty measures. The joint specification follows the structure of Lotz et al. (2023) and extends it by CREU, so that REU, CREU, and FU enter simultaneously; MU is estimated individually for comparison only. The analysis focuses on the three-month forecast horizon, corresponding to one quarter for CREU. We estimate the models for the aggregate REIT index and examine sector-specific exposures to CREU. All regressions are estimated by ordinary least squares using Newey–West standard errors with four lags.

Table 5 reports the unconditional asset pricing results. Panel A shows that the five common risk factors account for a substantial share of the variation in aggregate REIT excess returns, with an adjusted R^2 of 59.38 percent. Adding individual uncertainty factors produces relatively modest changes in explanatory power, with adjusted R^2 values ranging from 59.33 to 61.34

Table 4: Temporal Causality Analysis: Property Sectors

	Office (OFF)				Industrial (IND)			
	LTI		GC	C	LTI		GC	C
Uncertainty	Sign	*p*-Value	*p*-Value		Sign	*p*-Value	*p*-Value	
ΔREU(3)	(−)	0.015	0.078		(−)	0.121	0.278	
ΔREU(12)	(−)	0.006	0.059		(−)	0.090	0.181	
ΔCREU(3)	(−)	0.110	0.112		(−)	0.098	0.051	
ΔCREU(12)	(−)	0.099	0.000		(−)	0.092	0.123	
ΔMU(3)	(−)	0.101	0.077		(−)	0.197	0.390	
ΔMU(12)	(−)	0.039	0.046	+	(−)	0.157	0.372	
ΔFU(3)	(−)	0.189	0.007		(−)	0.135	0.445	
ΔFU(12)	(−)	0.132	0.003		(−)	0.102	0.382	
	Retail (RET)				Residential (RES)			
	LTI		GC	C	LTI		GC	C
Uncertainty	Sign	*p*-Value	*p*-Value		Sign	*p*-Value	*p*-Value	
ΔREU(3)	(−)	0.067	0.049		(−)	0.096	0.282	
ΔREU(12)	(−)	0.038	0.071		(−)	0.084	0.370	
ΔCREU(3)	(−)	0.046	0.033	+	(−)	0.090	0.075	
ΔCREU(12)	(−)	0.043	0.000	+	(−)	0.083	0.001	
ΔMU(3)	(−)	0.036	0.001	+	(−)	0.178	0.143	
ΔMU(12)	(−)	0.008	0.000	+	(−)	0.099	0.091	
ΔFU(3)	(−)	0.156	0.152		(−)	0.272	0.209	
ΔFU(12)	(−)	0.097	0.096		(−)	0.207	0.176	
	Health Care (HC)				Lodging/Resorts (LOD)			
	LTI		GC	C	LTI		GC	C
Uncertainty	Sign	*p*-Value	*p*-Value		Sign	*p*-Value	*p*-Value	
ΔREU(3)	(−)	0.154	0.490		(−)	0.054	0.145	
ΔREU(12)	(−)	0.057	0.201		(−)	0.027	0.112	
ΔCREU(3)	(−)	0.207	0.418		(−)	0.047	0.073	
ΔCREU(12)	(−)	0.328	0.000		(−)	0.041	0.000	+
ΔMU(3)	(−)	0.181	0.031		(−)	0.095	0.005	
ΔMU(12)	(−)	0.059	0.014		(−)	0.024	0.001	+
ΔFU(3)	(−)	0.267	0.020		(−)	0.068	0.246	
ΔFU(12)	(−)	0.172	0.012		(−)	0.035	0.155	
	Self Storage (STO)				Diversified (DIV)			
	LTI		GC	C	LTI		GC	C
Uncertainty	Sign	*p*-Value	*p*-Value		Sign	*p*-Value	*p*-Value	
ΔREU(3)	(−)	0.184	0.494		(−)	0.077	0.312	
ΔREU(12)	(−)	0.104	0.274		(−)	0.088	0.330	
ΔCREU(3)	(−)	0.151	0.142		(−)	0.033	0.106	
ΔCREU(12)	(−)	0.123	0.004		(−)	0.030	0.000	+
ΔMU(3)	(−)	0.431	0.187		(−)	0.105	0.015	
ΔMU(12)	(−)	0.287	0.086		(−)	0.042	0.010	+
ΔFU(3)	(−)	0.231	0.611		(−)	0.173	0.015	
ΔFU(12)	(−)	0.162	0.516		(−)	0.117	0.007	

Notes: As Table 3, for the eight property-sector indices. Across both tables, 9 of the 72 combinations of uncertainty factors and return series are classified as temporally predictive. Newey–West standard errors with four lags.

percent.

Among the four uncertainty measures, only CREU has a statistically significant coefficient in the individual specifications. The coefficient on lagged ΔCREU(3) is -0.40, with a t-statistic of -2.02. A one-percentage-point increase in the preceding quarter's log change in CREU is therefore associated with a 0.40-percentage-point reduction in current quarterly REIT excess returns, conditional on the contemporaneous asset pricing factors.

The coefficients on FU, REU, and MU are also negative, at -0.20, -0.27, and -0.31, respectively, but none is statistically significant. In the joint specification in column (6), which includes REU, CREU, and FU simultaneously, the CREU coefficient remains negative and significant at -0.37, while the coefficients on REU and FU are not significant.

The estimated loadings on the common risk factors are in line with the established REIT literature. The exposure to the stock market factor is positive and highly significant across all specifications, at around 0.75 to 0.78, as are the loadings on the size and value factors. The bond market exposure is likewise positive and significant, between 0.67 and 0.72, confirming the bond-like character of REIT returns (Van Nieuwerburgh 2019). The momentum loading is close to zero and never significant. The model-implied alpha, reported as the constant, is economically small and statistically insignificant in every specification. We note that the interpretation of alpha requires caution when non-tradeable uncertainty factors are included; the near-zero estimate, however, also holds in column (1), which contains only tradeable factors.

Panel B examines sector-specific exposures to CREU. The estimated CREU coefficients are negative for the aggregate index and all eight property sectors, although their statistical significance varies. They are significant at the 5 percent level for Retail (-0.54) and Residential (-0.53), and at the 10 percent level for Office, Lodging/Resorts, and Self Storage. The coefficients for Industrial, Health Care, and Diversified REITs are not statistically significant. Industrial exhibits the largest point estimate in absolute magnitude (-0.62), although this estimate is imprecise, which is consistent with its comparatively low adjusted R^2 of 43.72 percent.

The pattern is broadly consistent with differences in the sensitivity of property types to commercial real estate conditions. Lease structure is a plausible source of this heterogeneity: Van Nieuwerburgh (2019) notes that REIT cash flows depend on the tenancy periods of the underlying leases, which differ systematically across property types. Retail and Lodging/Resorts depend directly on consumer demand and operate with short lease terms or, in the case of hotels, with effectively daily repricing, which makes their cash flows responsive to changes in the commercial property environment. Health Care REITs, by contrast, typically operate under long-term leases whose revenues depend on demographics rather than on the commercial property cycle. For office markets, Lizieri et al. (2000) documents the interlocking between financial services firms as occupiers, investors, and lenders, which links office performance to financial rather than property market conditions. We report these as possible interpretations; our analysis does not test them.

These results indicate that lagged CREU retains a negative association with aggregate REIT excess returns after controlling for established asset pricing factors and the other uncertainty measures included in the joint specification. The unconditional specification, however, assumes that this exposure is constant over the entire sample period. Given that the sample contains several episodes of sharply elevated uncertainty, this assumption may be restrictive, and we relax

it next.

3.4 Time-Varying Uncertainty Exposures

The literature suggests that uncertainty exposures are strongest when the perceived level of uncertainty is highest (Bloom 2009; Ludvigson et al. 2021). An unconditional specification cannot capture such variation: if the exposure alternates between negative and positive values over the sample, a constant estimate will average over both. We therefore estimate Eq. (7) using rolling windows of 20 quarters, requiring a minimum of 16 observations. The resulting coefficients $\hat{\beta}_t^{UNC}$ represent estimated time-varying uncertainty exposures. We pay particular attention to episodes in which an estimated exposure changes sign, since a constant-exposure specification would average over such episodes.

We estimate separate rolling regressions for REU, FU, and CREU at the three-month forecast horizon. We subsequently relate the estimated betas to four episodes: the global financial crisis, the COVID-19 pandemic, the monetary tightening period of 2022, and the regional banking stress episode of 2023.

Following Lotz et al. (2023), the episode regressions are descriptive. Since successive rolling windows overlap substantially, the estimated betas are serially dependent. Moreover, the relatively small estimation windows introduce additional estimation uncertainty. We therefore focus primarily on the patterns and magnitudes of the estimated coefficients rather than on their statistical significance.

Figure 2 presents the rolling-window estimates of the uncertainty betas for the aggregate REIT index. Table 6 relates their variation to four crisis episodes.

During the global financial crisis, the estimated coefficient on the episode dummy is 1.017 for the CREU beta, compared with 0.173 for REU and 0.011 for FU. During the COVID-19 pandemic, the estimated coefficients are negative for CREU (-0.312) and REU (-0.401), but positive for FU (0.419).

During the monetary tightening episode of 2022 and the regional banking stress of 2023, the CREU beta is also lower relative to periods outside the specified episodes, with coefficients of -0.316 and -0.193, respectively. The corresponding coefficients for REU are close to zero.

The adjusted R^2 is 10.92 percent for the CREU beta regression, compared with -2.99 percent for REU and 0.02 percent for FU. The episode indicators are associated with more variation in the estimated CREU beta than in the other two beta series, although the overlapping rolling windows limit the precision of this comparison.

The episode regressions are descriptive and do not test for hedging properties. Adding the episode coefficients to the respective constants nevertheless yields the implied exposures within each episode. Outside the specified episodes the CREU exposure is -0.14, but during the global financial crisis it is $+0.88$. In these descriptive episode regressions, CREU is the only one of the three uncertainty measures whose estimated exposure changes sign during the global financial crisis. The FU exposure is positive throughout and becomes more strongly so during the COVID-19 recession, rising from 0.08 to 0.50, whereas the CREU exposure falls to -0.45. During the monetary tightening of 2022 and the regional banking stress of 2023, the CREU exposure is -0.45

Table 5: Unconditional Asset Pricing Analysis

Panel A: All Equity REITs (AEI)						
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.72	-0.65	-0.68	-0.78	-0.63	-0.74
	$[-0.96]$	$[-0.99]$	$[-0.98]$	$[-1.25]$	$[-0.96]$	$[-1.26]$
Stocks	0.78^{***}	0.77^{***}	0.77^{***}	0.76^{***}	0.75^{***}	0.75^{***}
	[4.87]	[5.57]	[5.31]	[5.79]	[5.78]	[6.23]
Bonds	0.67^{***}	0.69^{***}	0.67^{***}	0.70^{***}	0.71^{***}	0.72^{***}
	[3.39]	[3.65]	[3.45]	[3.51]	[3.99]	[3.69]
SMB	0.34^{**}	0.34^{***}	0.34^{**}	0.37^{***}	0.36^{**}	0.36^{***}
	[2.52]	[2.58]	[2.46]	[2.92]	[2.55]	[3.01]
HML	0.66^{***}	0.63^{***}	0.64^{***}	0.61^{***}	0.59^{***}	0.60^{***}
	[4.74]	[5.55]	[5.34]	[5.48]	[6.17]	[6.16]
MOM	-0.05	-0.04	-0.05	-0.05	-0.04	-0.05
	$[-0.56]$	$[-0.55]$	$[-0.53]$	$[-0.56]$	$[-0.54]$	$[-0.56]$
ΔFU(3)		-0.20				-0.16
		$[-1.21]$				$[-1.15]$
ΔREU(3)			-0.27			0.08
			$[-0.66]$			[0.20]
ΔCREU(3)				-0.40^{**}		-0.37^{**}
				$[-2.02]$		$[-2.19]$
ΔMU(3)					-0.31	
					$[-1.43]$	
Adj.R^2	59.38	60.14	59.33	61.34	61.19	61.37
Obs	128	128	128	127	128	127

Panel B: Property sectors, ΔCREU(3) as uncertainty factor									
	AEI	**OFF**	**IND**	**RET**	**RES**	**HC**	**LOD**	**STO**	**DIV**
Constant	-0.78	-1.87^{**}	-1.27	-1.34	0.01	-0.28	-2.56^{***}	0.86	-1.92^{***}
	$[-1.25]$	$[-2.47]$	$[-0.96]$	$[-1.44]$	[0.02]	$[-0.38]$	$[-3.42]$	[1.25]	$[-2.68]$
Stocks	0.76^{***}	0.95^{***}	1.03^{***}	0.91^{***}	0.59^{***}	0.62^{***}	1.16^{***}	0.48^{***}	0.87^{***}
	[5.79]	[7.03]	[3.90]	[4.90]	[4.59]	[4.96]	[9.53]	[4.21]	[6.94]
Bonds	0.70^{***}	0.75^{***}	0.51	0.72^{**}	0.55^{***}	1.19^{***}	-0.12	0.96^{***}	0.83^{***}
	[3.51]	[3.15]	[1.38]	[2.54]	[2.70]	[5.85]	$[-0.68]$	[4.20]	[4.21]
SMB	0.37^{***}	0.49^{***}	0.11	0.52^{***}	0.30^{***}	0.43^{***}	0.83^{***}	0.37^{**}	0.48^{***}
	[2.92]	[3.86]	[0.46]	[3.75]	[2.70]	[2.89]	[5.06]	[2.09]	[4.12]
HML	0.61^{***}	0.76^{***}	0.59^{***}	0.90^{***}	0.51^{***}	0.83^{***}	1.09^{***}	0.48^{***}	0.92^{***}
	[5.48]	[7.05]	[2.93]	[5.09]	[3.68]	[4.94]	[9.68]	[3.32]	[6.66]
MOM	-0.05	0.09	0.10	-0.05	-0.12	-0.12	-0.27^{**}	-0.05	-0.06
	$[-0.56]$	[0.80]	[0.75]	$[-0.54]$	$[-1.54]$	$[-1.27]$	$[-2.46]$	$[-0.44]$	$[-0.64]$
ΔCREU(3)	-0.40^{**}	-0.37^{*}	-0.62	-0.54^{**}	-0.53^{***}	-0.02	-0.49^{*}	-0.47^{*}	-0.30
	$[-2.02]$	$[-1.77]$	$[-1.60]$	$[-2.07]$	$[-2.79]$	$[-0.10]$	$[-1.92]$	$[-1.68]$	$[-1.19]$
Adj.R^2	61.34	62.83	43.72	60.14	48.12	51.31	77.31	32.31	65.54
Obs	127	127	127	127	127	127	127	127	127

Notes: Unconditional asset pricing analysis using the one-quarter lagged uncertainty factors, as specified in Eq. (7), 1994Q1–2025Q4. The dependent variable is the quarterly log excess return of the AEI in Panel A and of the property sectors in Panel B. The forecast horizon is $h = 3$ months throughout, since CREU is estimated at the quarterly frequency; REU, MU, and FU are quarterly averages of the underlying monthly series. Newey–West standard errors with four lags; t-statistics in brackets. Specifications including CREU lose one observation because the CREU level series starts in 1993Q4. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

and -0.33, in both cases more negative than outside the episodes. Since we do not estimate a market price of uncertainty, we refrain from translating these sign changes into implied return compensations.

These findings are descriptive. Successive rolling windows overlap substantially, and the relatively short estimation windows introduce additional estimation uncertainty. Moreover, the reported standard errors in the episode regressions do not fully account for the dependence induced by overlapping windows. The point estimates should therefore be interpreted as descriptive patterns rather than precise estimates of changes in uncertainty exposure. The variation in estimated uncertainty exposures nevertheless motivates the conditional analysis. We next examine whether macroeconomic and financial conditions are associated with these changes.

Table 6: Time-Varying Uncertainty Betas During Crisis Episodes

	(1) ΔREU(3)	(2) ΔFU(3)	(3) ΔCREU(3)
GFC 2008/2009	0.173	0.011	1.017^{***}
	[1.21]	[0.16]	[11.59]
Covid-19 pandemic 2020	-0.401^{***}	0.419^{***}	-0.312^{***}
	[−2.69]	[5.51]	[−3.21]
Monetary tightening 2022	−0.040	0.173^{**}	-0.316^{***}
	[−0.28]	[2.50]	[−3.54]
Regional banking stress 2023	−0.054	0.060	-0.193^{**}
	[−0.37]	[0.88]	[−2.01]
Constant	−0.117	0.077	−0.138
	[−0.82]	[1.13]	[−1.57]
Adj.R^2	−2.99	0.02	10.92
Obs	113	113	112

Notes: Regressions explaining the time variation of the estimated uncertainty betas of the Nareit All Equity REITs Index using dummy variables for four crisis episodes: the global financial crisis (2008Q4–2009Q2), the Covid-19 pandemic (2020Q1–2020Q2), the monetary tightening cycle of 2022 (2022Q1–2022Q4), and the regional banking stress of 2023 (2023Q1–2023Q2). The dependent variable is the quarterly uncertainty beta from the rolling window regressions described above. Betas are available from 1997Q4 onwards and from 1998Q1 for CREU.

Newey–West standard errors with four lags. The episode dummies cover between two and four quarters, and the dependent variable is constructed from overlapping 20-quarter windows, so the reported t-statistics overstate the precision of the estimates; the point estimates rather than the t-statistics should be interpreted. Following Lotz et al. (2023), these regressions are descriptive. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

3.5 Conditional Uncertainty Exposures

Following the conditional asset pricing literature, we examine whether uncertainty exposures vary with macroeconomic and financial conditions. The sign of the interaction coefficient indicates how the estimated uncertainty exposure changes with the respective state variable. For indicators of favorable economic conditions, a positive interaction would imply a less negative CREU exposure. For financial market volatility, a negative interaction would instead imply a stronger negative association when the VIX is elevated.

Our benchmark conditional specification is

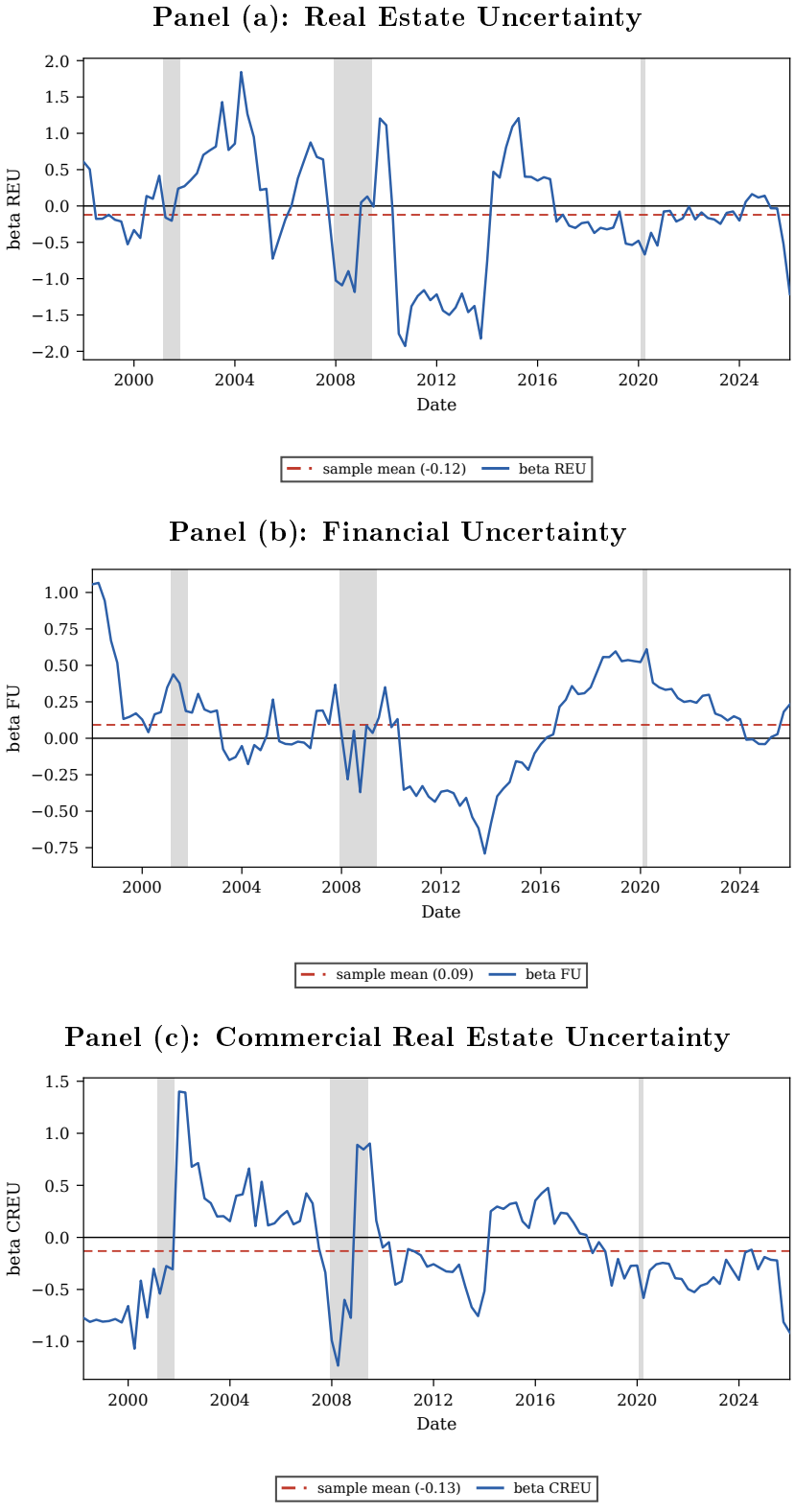


Figure 2: Time-Varying Uncertainty Betas of REITs

Notes: Estimated time-varying quarterly uncertainty betas of the Nareit All Equity REITs Index using the one-quarter lagged uncertainty factors ΔREU(3), ΔFU(3), and ΔCREU(3), from rolling window regressions over 20 quarters with a required minimum of 16 observations, controlling for the stock market, bond market, size, value, and momentum factors. Betas are available from 1997Q4 onwards and from 1998Q1 for CREU, whose level series starts in 1993Q4. The dashed horizontal line indicates the sample mean of the respective beta series. With seven parameters and estimation windows of 16 to 20 quarters, between 9 and 13 degrees of freedom remain, so part of the high-frequency variation reflects estimation uncertainty rather than genuine time variation in exposures. Shaded areas indicate NBER recession periods.

$$er_t = \alpha + \beta^{REU}\Delta REU_{t-1}(3) + \beta^{FU}\Delta FU_{t-1}(3) + \beta^{CREU}\Delta CREU_{t-1}(3) + \lambda c_{t-1} + \delta^{CREU}\left[\Delta CREU_{t-1}(3)c_{t-1}\right] + \boldsymbol{\gamma}'\mathbf{X}_t + \varepsilon_t, \tag{8}$$

where c_{t-1} denotes one of the six lagged state variables described in Section 2, and $\mathbf{X}_t$ contains the five contemporaneous asset pricing factors. The interaction coefficient δ^{CREU} measures how the relationship between CREU and REIT returns varies with the respective state variable. The corresponding conditional CREU coefficient is

$$\beta_t^{CREU} = \beta^{CREU} + \delta^{CREU}c_{t-1}. \tag{9}$$

Since β^{CREU} alone describes the association at a value of zero for the state variable, which is not economically meaningful for several of the state variables considered here, we interpret the interaction term and the implied conditional coefficient rather than the base coefficient in isolation.

We estimate separate specifications for house price growth, industrial production growth, consumer sentiment growth, the federal funds rate, the term spread, and the VIX. In the benchmark specification, only CREU interacts with the respective state variable, while REU and FU enter with constant coefficients. For the sector-specific analysis, we estimate a more parsimonious version of Eq. (8) that includes one uncertainty measure and its interaction with the state variable at a time, so that each estimate rests on nine parameters rather than eleven.

Table 7 reports the conditional asset pricing results. The benchmark specification includes REU, FU, and CREU jointly, while interacting CREU with each state variable in separate regressions.

The interaction coefficient is statistically significant for three of the six state variables. It is positive for house price growth (0.22) and industrial production growth (0.21), and negative for the VIX (-0.04). The interactions with consumer sentiment growth, the federal funds rate, and the term spread are not statistically significant.

The positive interactions with house price growth and industrial production growth indicate that the conditional CREU coefficient increases as these variables rise. Where the conditional CREU coefficient is negative, this implies a weaker negative association between commercial real estate uncertainty and REIT excess returns during periods of stronger real economic activity. Conversely, the negative interaction with the VIX indicates that the conditional CREU coefficient decreases as financial market volatility rises, which is consistent with a more negative association between CREU and REIT returns during periods of elevated market volatility.

Table 8 extends the conditional analysis to the aggregate index and the eight individual property sectors. Unlike the joint benchmark specification, these regressions include one uncertainty measure and its interaction with the respective state variable at a time.

Panel D summarizes the 54 index–state combinations for each uncertainty measure. FU exhibits the largest number of significant interactions, at 25, followed by CREU with 15 and REU with 14. For the base coefficients, CREU is significantly negative in seven combinations, compared with six for REU and two for FU.

These counts are descriptive, rely on unadjusted significance tests, and are not independent pieces of evidence. The nine return series have an average pairwise correlation of 0.79, and the estimated relationships may also be correlated across state variables. The results therefore illustrate heterogeneity in conditional uncertainty exposures without establishing a statistical ordering of the uncertainty measures.

The conditional relationships also differ across property sectors. Industrial, Lodging/Resorts, and Retail exhibit the largest interaction coefficients with house price growth, whereas Industrial, Diversified, and Retail exhibit the largest coefficients in absolute magnitude for the VIX interaction. Differences in lease structures, property market conditions, and sensitivity to consumer demand are possible sources of this heterogeneity, but our regressions do not examine these mechanisms and we report them as interpretations only.

Taken together, the conditional results indicate that the relationship between CREU and REIT returns is not uniform across economic conditions. Whether these patterns survive alternative specifications is the subject of the following section.

Table 7: Conditional Asset Pricing Analysis

State variable c_{t-1}	(1) Δhp	(2) Δip	(3) $\Delta SENT$	(4) ffr	(5) $term$	(6) VIX
ΔREU(3)	0.03	0.34	0.03	0.10	−0.01	0.13
	[0.10]	[1.17]	[0.08]	[0.26]	[−0.03]	[0.33]
ΔFU(3)	−0.09	−0.14	−0.16	−0.18	−0.17	−0.14
	[−0.71]	[−1.02]	[−1.04]	[−1.12]	[−1.20]	[−1.05]
ΔCREU(3)	−0.29	−0.30*	−0.45*	−0.52*	0.10	0.57*
	[−1.57]	[−1.77]	[−1.84]	[−1.85]	[0.35]	[1.89]
c_{t-1}	0.12	−0.35	−0.02	−0.07	0.19	−0.03
	[0.33]	[−0.65]	[−0.23]	[−0.28]	[0.57]	[−0.34]
ΔCREU(3)$\times c_{t-1}$	0.22**	0.21*	−0.02	0.09	−0.29	−0.04***
	[2.41]	[1.66]	[−0.55]	[0.95]	[−1.41]	[−3.47]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R^2	63.45	63.44	60.99	61.13	62.32	63.39
Obs	127	127	127	127	127	127

Notes: Conditional asset pricing analysis as specified in Eq. (8), in which only the commercial real estate uncertainty factor interacts with the state variable, while the levels of all three uncertainty factors are included. The dependent variable is the quarterly log excess return of the Nareit All Equity REITs Index, 1994Q1–2025Q4. As one-quarter lagged state variables c_{t-1} we use Case–Shiller house price growth (Δhp, CSUSHPISA), industrial production growth (Δip, INDPRO), consumer sentiment growth ($\Delta SENT$, UMCSENT), the effective federal funds rate (ffr, FEDFUNDS), the term spread ($term$, GS10 minus FEDFUNDS), and the CBOE volatility index (VIX, quarterly average of daily closing values). Growth rates are quarterly sums of monthly log differences in percent; the remaining state variables enter in levels. Stocks, Bonds, SMB, HML, and MOM are included as controls. Newey–West standard errors with four lags. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

4 Robustness Analysis

We assess the robustness of our results along four dimensions: the specification of the conditional model, the inclusion of alternative uncertainty proxies as controls, the forecast horizon and temporal aggregation of the uncertainty measures, and the construction of the uncertainty indices themselves. Throughout, statistical inference is based on Newey–West standard errors with four

Table 8: Conditional Asset Pricing Analysis for Different Property Sectors

	AEI	OFF	IND	RET	RES	HC	LOD	STO	DIV
Panel A: interaction with ΔREU(3)									
House price growth	0.602***	0.555***	1.012***	0.669***	0.411*	0.441***	0.681***	0.238	0.620***
	[2.92]	[2.83]	[2.64]	[2.77]	[1.83]	[2.99]	[3.30]	[0.99]	[2.98]
Industrial production	0.372**	0.453***	0.563*	0.314	0.314*	0.152	0.254*	0.204	0.307**
	[2.10]	[2.80]	[1.81]	[1.35]	[1.90]	[1.08]	[1.70]	[1.38]	[2.04]
Consumer sentiment	−0.009	0.002	0.007	−0.020	−0.027	−0.027	0.047*	0.024	0.006
	[−0.21]	[0.05]	[0.09]	[−0.48]	[−0.56]	[−0.79]	[1.79]	[0.50]	[0.20]
Fed funds rate	0.047	−0.017	0.168	0.217	0.127	0.065	0.065	−0.005	0.123
	[0.32]	[−0.10]	[0.70]	[1.36]	[0.97]	[0.40]	[0.40]	[−0.03]	[0.72]
Term spread	−0.423	−0.023	−0.799	−0.516	−0.456	−0.355	−0.058	−0.319	−0.509
	[−1.05]	[−0.05]	[−1.11]	[−1.21]	[−1.19]	[−1.34]	[−0.14]	[−0.90]	[−1.19]
VIX	−0.086**	−0.099***	−0.140**	−0.080	−0.098**	−0.032	−0.089*	−0.066	−0.112*
	[−2.02]	[−2.89]	[−2.47]	[−1.18]	[−2.47]	[−0.61]	[−1.84]	[−1.19]	[−1.90]
Panel B: interaction with ΔFU(3)									
House price growth	0.234**	0.206**	0.410**	0.280**	0.184*	0.102	0.197*	0.123	0.247**
	[2.36]	[2.20]	[2.37]	[2.25]	[1.74]	[1.21]	[1.68]	[1.14]	[2.45]
Industrial production	0.219**	0.214***	0.386***	0.202	0.186**	0.087	0.166***	0.229***	0.164**
	[2.50]	[2.94]	[2.58]	[1.47]	[2.21]	[1.07]	[2.88]	[4.15]	[2.16]
Consumer sentiment	−0.031**	−0.026*	−0.039*	−0.037**	−0.039***	−0.029**	0.007	−0.016	−0.015
	[−2.52]	[−1.76]	[−1.81]	[−2.35]	[−3.12]	[−2.55]	[0.54]	[−0.99]	[−1.31]
Fed funds rate	0.038	0.077	0.101	0.042	0.054	−0.010	0.003	0.052	0.091
	[0.49]	[0.97]	[0.92]	[0.55]	[0.72]	[−0.13]	[0.02]	[0.62]	[1.13]
Term spread	−0.178	−0.130	−0.322	−0.193	−0.168	−0.149	0.134	−0.104	−0.252*
	[−1.23]	[−0.92]	[−1.41]	[−1.22]	[−1.14]	[−1.17]	[0.65]	[−0.70]	[−1.73]
VIX	−0.046***	−0.047***	−0.068***	−0.049**	−0.041***	−0.031**	−0.052***	−0.062***	−0.056***
	[−4.27]	[−4.28]	[−5.16]	[−2.48]	[−3.48]	[−1.99]	[−3.89]	[−4.21]	[−3.25]
Panel C: interaction with ΔCREU(3)									
House price growth	0.235**	0.195**	0.469***	0.266***	0.182*	0.187**	0.338***	0.123	0.260**
	[2.56]	[2.31]	[3.23]	[2.60]	[1.90]	[2.05]	[3.91]	[0.83]	[2.01]
Industrial production	0.205	0.293***	0.356	0.228	0.184	0.084	0.157	0.073	0.222
	[1.50]	[2.92]	[1.52]	[1.30]	[1.39]	[0.72]	[1.18]	[0.43]	[1.52]
Consumer sentiment	−0.018	−0.013	0.001	−0.033	−0.030	−0.034*	0.027	−0.010	−0.006
	[−0.65]	[−0.43]	[0.02]	[−1.26]	[−1.06]	[−1.72]	[1.51]	[−0.38]	[−0.29]
Fed funds rate	0.073	0.056	0.247*	0.117	0.072	0.048	0.075	0.052	0.115
	[0.76]	[0.57]	[1.70]	[1.07]	[0.68]	[0.37]	[0.63]	[0.34]	[0.87]
Term spread	−0.278	−0.090	−0.673**	−0.347	−0.185	−0.177	−0.357	−0.293	−0.332
	[−1.32]	[−0.40]	[−2.16]	[−1.40]	[−0.84]	[−0.84]	[−1.60]	[−1.19]	[−1.15]
VIX	−0.036***	−0.026**	−0.066***	−0.044***	−0.029***	−0.021	−0.030*	−0.033	−0.057***
	[−3.35]	[−2.08]	[−4.62]	[−2.80]	[−2.63]	[−1.18]	[−1.85]	[−1.64]	[−3.97]

Panel D: summary across the 54 index–state combinations		
	Significant interactions	Significantly negative β^{UNC}
ΔREU(3)	14	6
ΔFU(3)	25	2
ΔCREU(3)	15	7

Notes: Interaction coefficient δ^{UNC} from the conditional asset pricing model, estimated separately for each combination of property sector, state variable, and uncertainty measure over 1994Q1–2025Q4. Each cell comes from a separate regression containing one uncertainty measure, its interaction with the state variable, and the controls, so that nine parameters are estimated. Specifications using CREU have 127 observations, while those using REU or FU have 128. State variables are defined as in Table 7. Stocks, Bonds, SMB, HML, and MOM are included as controls. Newey–West standard errors with four lags. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Panel D counts how many of the 54 index–state combinations yield an interaction coefficient significant at the 5% level and how many yield a base coefficient β^{UNC} that is significantly negative at the 5% level. These counts are descriptive: the nine return series have an average pairwise correlation of 0.79, so the effective number of independent tests is smaller than the nominal one. No multiple-testing correction is applied.

lags.

Table 9 reports a fully interacted specification in which REU, FU, and CREU each interact with the respective state variable. The interactions between CREU and house price growth and between CREU and the VIX are no longer statistically significant, whereas the interaction between FU and the VIX remains significant. The benchmark conditional CREU results are therefore sensitive to allowing the other uncertainty exposures to vary with the state variable. At the same time, this specification estimates thirteen parameters on 127 quarterly observations with potentially correlated uncertainty factors and interaction terms, which may affect the precision of the individual estimates.

Table 9: Conditional Asset Pricing Analysis, Fully Interacted Specification

State variable c_{t-1}	(1) Δhp	(2) Δip	(3) $\Delta SENT$	(4) ffr	(5) $term$	(6) VIX
ΔREU(3)	-0.56	0.43	0.10	0.31	0.33	0.17
	[-1.63]	[1.20]	[0.31]	[0.51]	[0.92]	[0.21]
ΔFU(3)	-0.19	-0.13	-0.23	-0.27	0.04	0.73^{**}
	[-1.40]	[-0.95]	[-1.45]	[-1.12]	[0.21]	[2.44]
ΔCREU(3)	-0.00	-0.27^{*}	-0.36	-0.58^{*}	-0.10	0.05
	[-0.00]	[-1.72]	[-1.56]	[-1.83]	[-0.48]	[0.12]
c_{t-1}	0.05	-0.34	-0.00	-0.06	-0.01	-0.03
	[0.13]	[-0.75]	[-0.02]	[-0.24]	[-0.04]	[-0.30]
ΔREU(3)$\times c_{t-1}$	0.40^{**}	0.01	0.01	-0.09	-0.28	0.00
	[2.32]	[0.05]	[0.29]	[-0.55]	[-1.25]	[0.04]
ΔFU(3)$\times c_{t-1}$	0.12	0.19^{**}	-0.04^{***}	0.04	-0.16	-0.04^{***}
	[1.47]	[2.36]	[-3.10]	[0.55]	[-1.50]	[-3.04]
ΔCREU(3)$\times c_{t-1}$	0.01	0.13	0.00	0.11	-0.18	-0.01
	[0.14]	[1.18]	[0.21]	[1.03]	[-1.34]	[-0.61]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R^2	66.33	68.14	63.27	60.70	63.19	64.64
Obs	127	127	127	127	127	127

Notes: As Table 7, but all three uncertainty factors interact with the state variable. State variables are defined as in Table 7. Stocks, Bonds, SMB, HML, and MOM are included as controls. Newey–West standard errors with four lags. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

These estimates should be interpreted with caution: thirteen parameters on 127 observations with strongly correlated uncertainty factors leave the individual interaction terms imprecisely identified.

Table 10 adds changes in the VIX and in economic policy uncertainty as additional controls. These are established uncertainty proxies, but unlike the predictability-based measures they are not constructed from conditional forecast errors. The VIX captures expected stock market volatility, whereas the EPU measures news-based economic policy uncertainty (Jurado et al. 2015; Baker et al. 2016). The conditional CREU results are unaffected: the interactions with house price growth and the VIX retain their signs and significance, and neither additional control is statistically significant.

Tables A4 and A5 vary the treatment of the uncertainty measures themselves. The first re-estimates the conditional model at the twelve-month forecast horizon, which tests whether the results are specific to short-horizon uncertainty. The second samples the last month of each quarter for the monthly measures rather than averaging within the quarter, which addresses the concern that averaging blurs the quarterly innovation of the monthly measures while leaving the

Table 10: Conditional Pricing Models with Alternative Uncertainty Measures as Controls

State variable c_{t-1}	(1) Δhp	(2) Δip	(3) $\Delta SENT$	(4) ffr	(5) $term$	(6) VIX
ΔREU(3)	−0.02	0.31	0.01	0.07	−0.03	0.13
	[−0.06]	[1.07]	[0.02]	[0.20]	[−0.09]	[0.32]
ΔFU(3)	0.01	−0.08	−0.11	−0.12	−0.11	−0.11
	[0.05]	[−0.57]	[−0.68]	[−0.79]	[−0.82]	[−0.75]
ΔCREU(3)	−0.32*	−0.34**	−0.47*	−0.57*	0.06	0.58*
	[−1.89]	[−2.19]	[−1.89]	[−1.84]	[0.24]	[1.95]
c_{t-1}	0.19	−0.36	−0.02	−0.03	0.05	−0.04
	[0.54]	[−0.70]	[−0.23]	[−0.12]	[0.14]	[−0.43]
ΔCREU(3)×c_{t-1}	0.25**	0.22*	−0.01	0.10	−0.30	−0.04***
	[2.43]	[1.65]	[−0.49]	[0.99]	[−1.46]	[−3.53]
ΔVIX	−0.05	−0.04	−0.03	−0.04	−0.04	
	[−1.32]	[−1.34]	[−1.12]	[−1.08]	[−1.04]	
ΔEPU	−0.02	−0.01	−0.01	−0.01	−0.01	−0.02
	[−1.01]	[−0.59]	[−0.58]	[−0.55]	[−0.70]	[−1.33]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R^2	63.97	63.45	60.75	60.99	62.22	63.42
Obs	127	127	127	127	127	127

Notes: As Table 7, with changes in the CBOE volatility index (ΔVIX, VIXCLS) and in the news-based Economic Policy Uncertainty index (ΔEPU, USEPUINDXD) added as controls; both are quarterly averages of the underlying daily series, entered as log differences in percent. In column (6) the VIX is itself the state variable, so ΔVIX is omitted there to avoid including the same series in levels, in differences, and in the interaction term. State variables are defined as in Table 7. Stocks, Bonds, SMB, HML, and MOM are included as controls. Newey–West standard errors with four lags. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

natively quarterly CREU unaffected. In both cases the interactions with house price growth and the VIX retain their signs and significance.

Table A1 re-estimates the unconditional specification excluding the global financial crisis. The individual CREU coefficient falls in absolute magnitude from −0.40 to −0.15 and is no longer statistically significant; in the joint specification it remains negative and significant at the 10 percent level. The unconditional association is therefore sensitive to the inclusion of the crisis, which is the episode in which CREU is most strongly elevated.

Table A6 reports the two alternative constructions of the uncertainty indices documented in Dietl and Lee (2026). The first estimates REU directly at the quarterly frequency rather than aggregating monthly observations, so that both real estate uncertainty measures are estimated at the same temporal frequency. Under this construction the individual CREU coefficient is unchanged at −0.40, but the individual REU coefficient rises in absolute magnitude from −0.27 to −0.55, and in the joint specification neither measure remains significant, with CREU at −0.21 ($t = -1.28$) and REU at −0.35 ($t = -1.25$). The statistical significance of the unconditional CREU association in the joint specification is therefore sensitive to the temporal frequency at which the competing REU measure is constructed.

The second alternative estimates CREU from 27 rather than 22 target series, which restricts the sample to 2007Q4–2025Q4. The unconditional CREU coefficient is larger in absolute magnitude than in the benchmark, at −0.54 individually and −0.52 jointly, and remains significant when the global financial crisis is excluded. Since this variant changes both the series set and the estimation period, the differences relative to the benchmark cannot be attributed to the selection of target series alone. The conditional interactions with house price growth and the VIX hold

under both constructions; the interaction with industrial production does not remain significant under the quarterly REU construction.

Table 11 reports the conditional specification with the Nareit Diversified REIT Index as the dependent variable. Lotz et al. (2023) motivate this specification as a test of whether the uncertainty exposure survives once idiosyncratic, sector-specific shocks are diversified away. As discussed in the notes to the table, that interpretation does not carry over to the Nareit Diversified index, which is a sector index rather than a diversified portfolio, so we read it as a ninth sector. The interaction with house price growth is 0.25 and the interaction with the VIX is -0.06, so that the signs correspond to those for the aggregate index.

Table 11: Conditional Pricing Model with the Diversified REIT Index

State variable c_{t-1}	(1) Δhp	(2) Δip	(3) $\Delta SENT$	(4) ffr	(5) $term$	(6) VIX
ΔREU(3)	0.15	0.56^{*}	0.20	0.24	0.06	0.29
	[0.48]	[1.94]	[0.62]	[0.75]	[0.22]	[0.86]
ΔFU(3)	-0.04	-0.10	-0.10	-0.14	-0.12	-0.09
	[-0.35]	[-0.75]	[-0.69]	[-0.89]	[-0.85]	[-0.72]
ΔCREU(3)	-0.25	-0.22	-0.32	-0.54	0.29	1.20^{***}
	[-1.11]	[-1.08]	[-1.49]	[-1.29]	[0.81]	[3.03]
c_{t-1}	-0.03	-0.19	0.05	-0.10	0.64	-0.02
	[-0.08]	[-0.37]	[0.70]	[-0.35]	[1.30]	[-0.19]
ΔCREU(3)$\times c_{t-1}$	0.25^{*}	0.25^{*}	-0.00	0.14	-0.34	-0.06^{***}
	[1.93]	[1.72]	[-0.15]	[1.00]	[-1.18]	[-4.33]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R^2	67.14	67.40	64.80	65.30	66.65	69.38
Obs	127	127	127	127	127	127

Notes: As Table 7, using the quarterly log excess return of the Nareit Diversified REIT Index as the dependent variable. State variables are defined as in Table 7. Stocks, Bonds, SMB, HML, and MOM are included as controls. Newey–West standard errors with four lags. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Lotz et al. (2023) motivate this specification as a test of whether the uncertainty exposure survives once idiosyncratic, sector-specific shocks are diversified away. That interpretation does not hold for the Nareit Diversified index, which is not a diversified portfolio of REITs but the sector index of those REITs that themselves hold several property types; its return volatility exceeds that of the All Equity REITs Index and is close to the average across the eight property sectors. The index is therefore best read as a ninth sector.

Finally, Table A7 reports residual diagnostics for the unconditional and conditional benchmark regressions. The Breusch–Godfrey tests provide no evidence of residual autocorrelation up to order four in any of the twelve specifications, and the Durbin–Watson statistics are close to two. Lotz et al. (2023) report the same two tests for their main regressions and likewise find no evidence of residual autocorrelation.

Overall, the robustness checks reveal a clear difference between the unconditional and the conditional results. The unconditional CREU association weakens when the global financial crisis is excluded and loses significance in the joint specification when REU is estimated at the same frequency as CREU. The conditional interactions with house price growth and the VIX retain their signs and significance under the additional controls, the alternative forecast horizon, end-of-quarter sampling, and both alternative index constructions, but not in the fully interacted specification. The evidence for state-dependent CREU exposures should therefore be interpreted as conditional on the model specification.

5 Conclusion

This paper examines whether uncertainty specific to commercial real estate provides information about U.S. REIT returns beyond that contained in established uncertainty measures. Using the Commercial Real Estate Uncertainty (CREU) index developed by Dietl and Lee (2026), we compare commercial real estate uncertainty with residential real estate, macroeconomic, and financial uncertainty. Building on the empirical framework of Lotz et al. (2023), we analyze quarterly excess returns for the Nareit All Equity REITs Index and eight property-sector indices from 1994Q1 to 2025Q4.

Our analysis yields three main findings. First, the uncertainty measures differ in the timing of their association with REIT returns. Financial uncertainty exhibits its strongest correlations contemporaneously across all return series, whereas residential real estate uncertainty and short-horizon CREU generally exhibit their strongest correlations at lags of one or two quarters. The temporal causality analysis identifies predictive relationships for CREU and macroeconomic uncertainty in selected property sectors, while neither residential real estate nor financial uncertainty satisfies both predictive criteria in the benchmark specification. For CREU, the evidence is concentrated in Retail, Lodging and Resorts, and Diversified REITs rather than the aggregate REIT market. These findings concern temporal predictability and do not establish structural causality.

Second, lagged changes in CREU are negatively associated with subsequent REIT excess returns after controlling for conventional asset pricing factors. CREU is the only uncertainty measure with a statistically significant negative coefficient when the measures are included individually. Its coefficient also remains negative and statistically significant when CREU, residential real estate uncertainty, and financial uncertainty enter the benchmark regression jointly. However, the robustness analysis qualifies these results. The individual CREU coefficient loses statistical significance when the global financial crisis is excluded. Moreover, its coefficient is no longer statistically significant in the joint specification when residential real estate uncertainty is estimated directly at the quarterly frequency rather than aggregated from monthly observations. The unconditional CREU association is therefore sensitive to both the sample period and the construction of the competing uncertainty measures.

Third, estimated uncertainty exposures vary over time. Rolling-window estimates reveal differences across crisis episodes. In the benchmark conditional specification, the interaction between CREU and house price growth is positive, whereas its interaction with financial market volatility is negative. These results suggest that the negative relationship between CREU and subsequent REIT returns is weaker when house price growth is high and stronger when financial market volatility is elevated. The interactions remain statistically significant in several alternative specifications, including additional uncertainty controls and alternative index constructions. However, neither interaction remains statistically significant when the exposures to residential real estate and financial uncertainty are also allowed to vary with the respective economic state variable. The evidence for state-dependent CREU exposures therefore depends on the conditional model specification.

Taken together, our findings suggest that the source of uncertainty matters for its relationship with REIT returns, but that its measurement matters as well. In the benchmark specifications,

uncertainty constructed directly from commercial real estate variables contains information about REIT returns that is not fully captured by established uncertainty measures. At the same time, the sensitivity of the joint regression to the construction of residential real estate uncertainty highlights the importance of accounting for differences in measurement frequency when comparing uncertainty measures.

Our findings also have implications for the assessment of uncertainty in publicly traded real estate. The differences in temporal predictability across property sectors suggest that aggregate REIT returns do not fully reflect the heterogeneity of sector-specific relationships with commercial real estate uncertainty. Moreover, the conditional results suggest that estimated uncertainty exposures may vary with prevailing economic conditions, although this evidence depends on the model specification.

Our analysis estimates uncertainty exposures rather than the market price of uncertainty risk. Unlike Lotz et al. (2023), we do not estimate uncertainty risk premia. Whether commercial real estate uncertainty constitutes a separately priced risk factor therefore remains an open question. Further research could also investigate the economic mechanisms underlying the sector-specific predictive relationships documented here. Differences in lease structures, property market conditions, and sensitivity to economic activity offer possible explanations, but their respective contributions remain to be established.

Appendix

Table A1: Unconditional Asset Pricing Analysis Excluding the Global Financial Crisis

	(1)	(2)	(3)	(4)	(5)
Constant	−0.06	−0.06	−0.04	−0.26	−0.25
	[−0.14]	[−0.12]	[−0.10]	[−0.55]	[−0.53]
Stocks	0.59***	0.58***	0.58***	0.60***	0.59***
	[6.92]	[6.91]	[6.96]	[7.09]	[7.12]
Bonds	0.81***	0.81***	0.82***	0.84***	0.85***
	[5.00]	[5.00]	[5.01]	[5.15]	[4.98]
SMB	0.44***	0.45***	0.45***	0.44***	0.46***
	[4.02]	[4.14]	[4.23]	[4.04]	[4.60]
HML	0.51***	0.51***	0.53***	0.50***	0.51***
	[6.70]	[6.92]	[6.54]	[6.75]	[6.83]
MOM	−0.03	−0.03	−0.04	−0.02	−0.03
	[−0.36]	[−0.37]	[−0.42]	[−0.26]	[−0.33]
ΔFU(3)		0.03			0.01
		[0.25]			[0.09]
ΔREU(3)			0.25		0.36
			[1.11]		[1.40]
ΔCREU(3)				−0.15	−0.26*
				[−1.06]	[−1.66]
Adj.R^2	57.20	56.86	57.22	58.01	57.91
Obs	120	120	120	119	119

Notes: As Table 5, excluding the global financial crisis period (2008Q1–2009Q4). The dependent variable is the quarterly log excess return of the Nareit All Equity REITs Index. Specifications without CREU contain 120 observations, while those including CREU contain 119 observations. Newey–West standard errors with four lags; t-statistics in brackets. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table A2: Correlations of REIT Returns and Uncertainty Factors with Risk Factors and State Variables

	AEI	**OFF**	**IND**	**RET**	**RES**	**ΔREU**	**ΔFU**	**ΔCREU**
Panel A: Common risk factors								
Stocks	0.612	0.632	0.575	0.573	0.523	−0.171	−0.526	−0.185
Bonds	−0.038	−0.057	−0.091	−0.086	−0.053	0.077	0.240	0.133
SMB	0.337	0.353	0.207	0.341	0.293	−0.031	−0.217	0.016
HML	0.330	0.327	0.222	0.392	0.318	−0.081	−0.117	−0.143
MOM	−0.350	−0.281	−0.216	−0.351	−0.359	0.183	0.378	0.122
Panel B: State variables								
House price growth	0.249	0.227	0.327	0.254	0.231	−0.253	−0.211	−0.319
Industrial production	0.258	0.275	0.324	0.275	0.260	−0.444	−0.160	−0.430
Consumer sentiment	0.341	0.358	0.279	0.318	0.320	−0.152	−0.215	−0.189
Fed funds rate	−0.059	0.036	−0.017	−0.040	−0.076	0.023	0.153	0.201
Term spread	0.087	0.047	0.003	0.091	0.096	−0.057	−0.114	−0.278
VIX	−0.407	−0.432	−0.469	−0.329	−0.379	0.172	0.129	0.271
Panel C: Lagged state variables ($L = 1$)								
House price growth	0.138	0.119	0.196	0.150	0.147	−0.127	−0.067	−0.272
Industrial production	0.196	0.263	0.233	0.225	0.211	−0.037	0.081	−0.351
Consumer sentiment	0.012	0.061	0.001	−0.008	0.037	−0.034	−0.049	−0.010
Fed funds rate	−0.087	0.016	−0.059	−0.067	−0.101	0.089	0.172	0.280
Term spread	0.116	0.063	0.044	0.115	0.122	−0.130	−0.123	−0.380
VIX	−0.047	−0.083	−0.106	0.027	−0.068	−0.095	−0.314	0.028

Notes: Pairwise correlations of quarterly REIT log excess returns and changes in uncertainty measures with common risk factors and state variables over 1994Q1–2025Q4. The table reports the All Equity REITs Index (AEI) and four selected property sectors. Panels A and B report contemporaneous correlations; Panel C reports correlations with state variables lagged by one quarter. The uncertainty measures refer to the three-month forecast horizon. State variables are defined in Table 7. The bond factor is approximated from the ten-year Treasury constant maturity rate, as described in Section 2. Correlations are descriptive and do not account for serial dependence or multiple comparisons.

Table A3: Sample Mean Returns of the Employed Factors

	Quarterly	Annualized
RF	0.60	2.41
Stocks	2.27	9.10
Bonds	0.44	1.74
SMB	0.05	0.21
HML	0.39	1.57
MOM	1.05	4.20
ΔREU(3)	—	—
ΔFU(3)	—	—
ΔCREU(3)	—	—

Notes: Quarterly sample means of the employed return factors over 1994Q1–2025Q4 and their annualized values. Annualized figures are calculated by multiplying quarterly means by four; minor differences may arise from rounding. RF denotes the average risk-free rate. All values are expressed in percent. The bond factor is the approximated bond excess return defined in Section 2.

Market prices of uncertainty risk are not estimated in this study. Unlike Lotz et al. (2023), we do not estimate cross-sectional risk prices using individual stock returns. The entries for REU, FU, and CREU are therefore left blank.

Table A4: Conditional Asset Pricing Analysis with a Four-Quarter Forecast Horizon

State variable c_{t-1}	(1) Δhp	(2) Δip	(3) $\Delta SENT$	(4) ffr	(5) $term$	(6) VIX
ΔREU(12)	0.66	1.18	0.53	0.54	0.07	0.43
	[0.51]	[1.17]	[0.39]	[0.37]	[0.05]	[0.28]
ΔFU(12)	−0.12	−0.07	−0.24	−0.22	−0.32	−0.18
	[−0.29]	[−0.18]	[−0.51]	[−0.46]	[−0.66]	[−0.41]
ΔCREU(12)	-0.73^{**}	−0.49	-0.92^{**}	-0.72^{*}	−0.02	0.69
	[−2.52]	[−1.47]	[−2.35]	[−1.68]	[−0.04]	[1.54]
c_{t-1}	0.17	−0.34	−0.04	−0.03	0.10	−0.02
	[0.48]	[−0.61]	[−0.38]	[−0.14]	[0.31]	[−0.29]
ΔCREU(12)×c_{t-1}	0.28^{***}	0.35^{*}	−0.03	−0.01	−0.43	-0.05^{***}
	[2.77]	[1.94]	[−0.72]	[−0.04]	[−1.35]	[−4.12]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R^2	64.82	65.98	62.13	61.62	63.27	64.73
Obs	127	127	127	127	127	127

Notes: As Table 7, using the twelve-month (four-quarter) forecast horizon for all uncertainty measures instead of the three-month horizon. The six-month horizon is not considered because FU is available only for $h = \{1, 3, 12\}$. State variables are defined in Table 7. Stocks, Bonds, SMB, HML, and MOM are included as controls. Newey–West standard errors with four lags; t-statistics in brackets. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table A5: Conditional Asset Pricing Analysis with End-of-Quarter Sampling

State variable c_{t-1}	(1) Δhp	(2) Δip	(3) $\Delta SENT$	(4) ffr	(5) $term$	(6) VIX
ΔREU(3)	−0.17	−0.06	−0.17	−0.15	−0.21	−0.13
	[−0.56]	[−0.23]	[−0.52]	[−0.48]	[−0.67]	[−0.41]
ΔFU(3)	−0.07	−0.13	−0.10	−0.13	−0.12	−0.14
	[−0.67]	[−1.09]	[−0.84]	[−1.01]	[−1.07]	[−1.25]
ΔCREU(3)	−0.26	−0.23	−0.44	−0.50	0.13	0.68**
	[−1.61]	[−1.33]	[−1.53]	[−1.57]	[0.54]	[2.31]
c_{t-1}	0.12	−0.43	−0.02	−0.08	0.18	−0.04
	[0.35]	[−0.74]	[−0.22]	[−0.33]	[0.48]	[−0.47]
ΔCREU(3)×c_{t-1}	0.23**	0.21	−0.02	0.10	−0.31	−0.04***
	[2.47]	[1.60]	[−0.56]	[0.96]	[−1.44]	[−3.58]
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R^2	63.58	63.30	60.85	61.05	62.32	63.66
Obs	127	127	127	127	127	127

Notes: As Table 7, using end-of-quarter observations rather than quarterly averages for the monthly REU and FU indices. CREU is unchanged because it is constructed directly at the quarterly frequency. This specification examines the sensitivity of the conditional results to temporal aggregation of the monthly uncertainty measures. State variables are defined in Table 7. Stocks, Bonds, SMB, HML, and MOM are included as controls. Newey–West standard errors with four lags; t-statistics in brackets. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

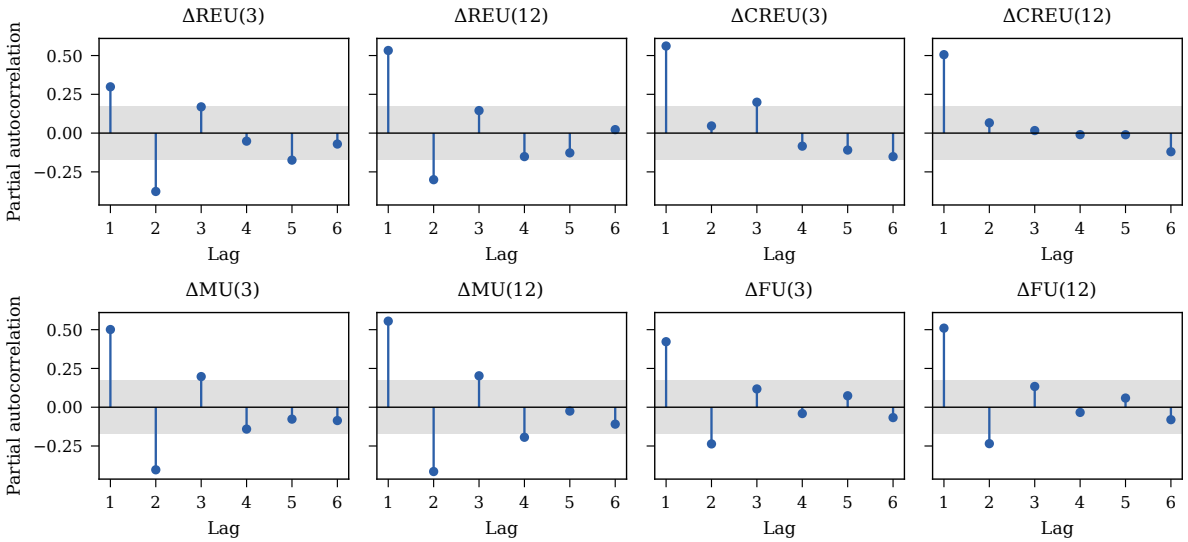


Figure A1: Partial Autocorrelations of the Uncertainty Factors

Notes: Partial autocorrelations of the uncertainty factors, defined as quarterly log differences of the respective uncertainty indices in Eq. (3), for lags of one to six quarters over 1994Q1–2025Q4. The shaded band indicates the approximate 95% confidence interval $\pm 1.96/\sqrt{T}$ with $T = 128$. All eight factors exhibit a substantial and significant partial autocorrelation at the first lag, between 0.30 and 0.56, and small or insignificant values at higher lags. This supports modelling the factors in first differences and including them with a single quarterly lag in the predictive regressions.

Table A6: Alternative Constructions of the Uncertainty Indices

	Benchmark 1994Q1–2025Q4	Quarterly REU 1994Q1–2025Q4	27 series 2007Q4–2025Q4
Panel A: Unconditional specification			
ΔCREU(3), individual	-0.40^{**}	-0.40^{**}	-0.54^{**}
	[−2.02]	[−2.02]	[−2.31]
ΔCREU(3), joint	-0.37^{**}	−0.21	-0.52^{**}
	[−2.19]	[−1.28]	[−2.24]
ΔREU(3), individual	−0.27	-0.55^{*}	−0.43
	[−0.66]	[−1.66]	[−1.39]
ΔREU(3), joint	0.08	−0.35	0.07
	[0.20]	[−1.25]	[0.18]
ΔCREU(3), excluding GFC	−0.15	−0.15	-0.21^{**}
	[−1.06]	[−1.06]	[−2.13]
Panel B: Conditional specification			
ΔCREU(3)× house price growth	0.22^{**}	0.23^{***}	0.24^{***}
	[2.41]	[2.62]	[3.09]
ΔCREU(3)× industrial production growth	0.21^{*}	0.19	0.22^{*}
	[1.66]	[1.43]	[1.71]
ΔCREU(3)× VIX	-0.04^{***}	-0.03^{***}	-0.05^{***}
	[−3.47]	[−3.24]	[−4.23]

Notes: Selected coefficients from the unconditional specification in Eq. (7) and the conditional specification in Eq. (8), estimated for the Nareit All Equity REITs Index. The benchmark column reproduces the corresponding estimates from Tables 5 and 7.
In the second column, REU is estimated directly at the quarterly frequency rather than obtained from quarterly averages of monthly observations. CREU remains the benchmark measure based on 22 target series. In the third column, CREU is estimated from 27 target series, restricting the estimation period to 2007Q4–2025Q4. REU, MU, and FU are quarterly averages of their underlying monthly series in this specification.

The rows labelled "individual" report the coefficient on the respective uncertainty factor when it is the only uncertainty measure included alongside the five common risk factors. The rows labelled "joint" report the corresponding coefficients when REU, CREU, and FU enter simultaneously. The row "excluding GFC" reports the individual CREU specification excluding 2008Q1–2009Q4, as in Table A1. Because the alternative CREU measure is only available from 2007Q4, this exclusion leaves a substantially shorter estimation sample in the third column.

The conditional specifications use 127, 127, and 71 observations, respectively; the unconditional specifications use one to two observations more, depending on whether CREU is included. All regressions include the stock market, bond market, size, value, and momentum factors as controls. Newey–West standard errors with four lags; t-statistics in brackets. Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table A7: Residual Diagnostics for the Main Regressions

	Obs	BG $\chi^2(4)$	p-Value	DW
Panel A: Unconditional models (Table 5)				
(1) factors only	128	1.71	0.789	1.849
(2) + ΔFU(3)	128	1.86	0.761	1.872
(3) + ΔREU(3)	128	1.50	0.826	1.867
(4) + ΔCREU(3)	127	2.43	0.657	1.941
(5) + ΔMU(3)	128	1.47	0.833	1.874
(6) + ΔFU, ΔREU, ΔCREU	127	2.32	0.678	1.940
Panel B: Conditional models (Table 7)				
c = house price growth	127	3.25	0.518	2.023
c = industrial production growth	127	0.97	0.915	1.981
c = consumer sentiment growth	127	1.90	0.755	1.925
c = fed funds rate	127	1.34	0.855	1.959
c = term spread	127	0.69	0.952	1.974
c = VIX	127	2.38	0.666	2.068

Notes: Breusch–Godfrey tests and Durbin–Watson statistics for autocorrelation in the residuals of the regressions reported in Tables 5 and 7, 1994Q1–2025Q4. The Breusch–Godfrey test is the χ^2 version with four lags, chosen to match the lag length used for the Newey–West standard errors elsewhere in the paper; the Durbin–Watson statistic is reported for comparison. The Breusch–Godfrey tests provide no evidence of residual autocorrelation up to order four in any of the twelve specifications, with p-values between 0.52 and 0.95; the Durbin–Watson statistics lie between 1.85 and 2.07. Statistical inference in the paper is nevertheless based on Newey and West (1987) standard errors, which remain valid under both heteroskedasticity and serial correlation.

The Durbin–Watson statistic is not reported for the temporal causality regressions of Tables 3 and 4, since those specifications include lagged dependent variables, under which the test is biased towards two.

Table A8: Correlations Between the Uncertainty Factors

	ΔREU(3)	ΔREU(12)	ΔCREU(3)	ΔCREU(12)	ΔMU(3)	ΔMU(12)	ΔFU(3)	ΔFU(12)
ΔREU(3)	1.000							
ΔREU(12)	0.912^{***}	1.000						
ΔCREU(3)	0.526^{***}	0.568^{***}	1.000					
ΔCREU(12)	0.575^{***}	0.616^{***}	0.861^{***}	1.000				
ΔMU(3)	0.684^{***}	0.640^{***}	0.582^{***}	0.709^{***}	1.000			
ΔMU(12)	0.667^{***}	0.642^{***}	0.567^{***}	0.699^{***}	0.978^{***}	1.000		
ΔFU(3)	0.292^{***}	0.347^{***}	0.263^{***}	0.485^{***}	0.501^{***}	0.532^{***}	1.000	
ΔFU(12)	0.329^{***}	0.388^{***}	0.310^{***}	0.520^{***}	0.531^{***}	0.565^{***}	0.993^{***}	1.000

Notes: Contemporaneous correlations between the uncertainty factors, defined as quarterly log differences of the respective uncertainty indices in Eq. (3), over 1994Q1–2025Q4. The factors are those entering the asset pricing regressions. Correlations in levels, including the six-month horizon and real estate and macroeconomic variables, are reported in Dietl and Lee (2026). Significance: $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table A9: Variable Definitions and Sources

Variable	Description	Source
Panel A: REIT indices		
Nareit AEI	Monthly total return index for the aggregate U.S. REIT market (All Equity REITs).	Nareit (2026)
Property sectors	Monthly total return indices for Office, Industrial, Retail, Residential, Health Care, Lodging/Resorts, Self Storage, and Diversified.	Nareit (2026)
Panel B: Uncertainty measures		
CREU(h)	Commercial real estate uncertainty, constructed from 22 quarterly commercial real estate series following Jurado et al. (2015); estimated directly at the quarterly frequency for $h = \{1, \ldots, 4\}$ quarters.	Dietl and Lee (2026)
REU(h)	Real estate uncertainty, constructed from residential construction activity and supply-side variables; monthly, $h = \{1, 3, 12\}$ months.	Dietl and Lee (2026), following Nguyen Thanh et al. (2020)
MU(h)	Macroeconomic uncertainty from a broad panel of macroeconomic series; monthly, $h = \{1, 3, 12\}$ months.	Ludvigson's data library; Jurado et al. (2015)
FU(h)	Financial uncertainty from financial market variables; monthly, $h = \{1, 3, 12\}$ months.	Ludvigson's data library; Ludvigson et al. (2021)
VIX	CBOE volatility index, daily closing values (VIXCLS); used as a state variable in levels and, in the robustness analysis, in log differences.	FRED
EPU	News-based Economic Policy Uncertainty index, daily (USEPUINDXD); used in log differences.	FRED; Baker et al. (2016)
Panel C: Asset pricing factors		
rf	One-month Treasury bill rate.	Kenneth French's data library
Stocks	Value-weighted excess return on the aggregate U.S. stock market.	Kenneth French's data library
SMB, HML	Size and value factors.	Kenneth French's data library; Fama and French (1993)
MOM	Momentum factor.	Kenneth French's data library; Carhart (1997)
Bonds	Excess return on a ten-year Treasury bond, approximated from the ten-year constant maturity rate (GS10) by a duration-based approximation and net of the one-month Treasury bill rate. Lotz et al. (2023) use the CRSP ten-year constant maturity series, which is not available to us.	Own calculation from FRED
Panel D: State variables		
Δhp	House price growth, quarterly sum of monthly log differences of the seasonally adjusted S&P/Case–Shiller U.S. National Home Price Index (CSUSHPISA), in percent.	FRED
Δip	Industrial production growth, quarterly sum of monthly log differences (INDPRO), in percent.	FRED
$\Delta SENT$	Consumer sentiment growth, quarterly sum of monthly log differences of the University of Michigan index (UMCSENT), in percent.	FRED
ffr	Effective federal funds rate (FEDFUNDS), quarterly average of monthly values, in percent per annum. Lotz et al. (2023) use the value on the last business day of the month.	FRED
$term$	Term spread, ten-year Treasury constant maturity rate (GS10) minus the effective federal funds rate, quarterly average, in percentage points.	FRED
VIX	Quarterly average of daily closing values of the CBOE volatility index (VIXCLS).	FRED

Notes: Variables used in the empirical analysis, 1994Q1–2025Q4. Quarterly REIT excess returns are the sum of monthly logarithmic total returns within each quarter less the corresponding sum of monthly returns on one-month Treasury bills. The uncertainty measures enter the asset pricing regressions as quarterly log differences as defined in Eq. (3), lagged by one quarter. Two series differ from Lotz et al. (2023): the bond market factor, which is approximated rather than taken from CRSP, and the federal funds rate, which is a quarterly average of monthly values rather than of end-of-month values.

References

Baker, Scott R., Nicholas Bloom, and Steven J. Davis (2016). "Measuring Economic Policy Uncertainty." In: *The Quarterly Journal of Economics* 131.4, pp. 1593–1636. DOI: 10.1093/qje/qjw024.

Bloom, Nicholas (2009). "The Impact of Uncertainty Shocks." In: *Econometrica* 77.3, pp. 623–685. DOI: 10.3982/ECTA6248.

Carhart, Mark M. (1997). "On Persistence in Mutual Fund Performance." In: *The Journal of Finance* 52.1, pp. 57–82. DOI: 10.1111/j.1540-6261.1997.tb03808.x.

Chen, Nai-Fu, Richard Roll, and Stephen A. Ross (1986). "Economic Forces and the Stock Market." In: *The Journal of Business* 59.3, pp. 383–403. DOI: 10.1086/296344.

Dietl, Vanessa and Gabriel Lee (2026). "Commercial Real Estate Uncertainty." Working paper, University of Regensburg.

Dorofeenko, Victor, Gabriel S. Lee, and Kevin D. Salyer (2014). "Risk Shocks and Housing Supply: A Quantitative Analysis." In: *Journal of Economic Dynamics and Control* 45, pp. 194–219. DOI: 10.1016/j.jedc.2014.05.013.

Fama, Eugene F. and Kenneth R. French (1993). "Common Risk Factors in the Returns on Stocks and Bonds." In: *Journal of Financial Economics* 33.1, pp. 3–56. DOI: 10.1016/0304-405X(93)90023-5.

Gholipour, Hassan F. et al. (2021). "Responses of REITs Index and Commercial Property Prices to Economic Uncertainties: A VAR Analysis." In: *Research in International Business and Finance* 58, p. 101457. DOI: 10.1016/j.ribaf.2021.101457.

Holland, A. Steven, Steven H. Ott, and Timothy J. Riddiough (2000). "The Role of Uncertainty in Investment: An Examination of Competing Investment Models Using Commercial Real Estate Data." In: *Real Estate Economics* 28.1, pp. 33–64. DOI: 10.1111/1540-6229.00792.

Jurado, Kyle, Sydney C. Ludvigson, and Serena Ng (2015). "Measuring Uncertainty." In: *American Economic Review* 105.3, pp. 1177–1216. DOI: 10.1257/aer.20131193.

Karolyi, G. Andrew and Anthony B. Sanders (1998). "The Variation of Economic Risk Premiums in Real Estate Returns." In: *The Journal of Real Estate Finance and Economics* 17.3, pp. 245–262. DOI: 10.1023/A:1007776907309.

Ling, David C. and Andy Naranjo (1997). "Economic Risk Factors and Commercial Real Estate Returns." In: *The Journal of Real Estate Finance and Economics* 14.3, pp. 283–307. DOI: 10.1023/A:1007754312084.

Lizieri, Colin, Andrew Baum, and Peter Scott (2000). "Ownership, Occupation and Risk: A View of the City of London Office Market." In: *Urban Studies* 37.7, pp. 1109–1129. DOI: 10.1080/00420980050011117.

Lotz, Marton, Daniel Ruf, and Johannes Strobel (2023). "Uncertainty Premia in REIT Returns." In: *Real Estate Economics* 51.2, pp. 372–407. DOI: 10.1111/1540-6229.12423.

Ludvigson, Sydney C., Sai Ma, and Serena Ng (2021). "Uncertainty and Business Cycles: Exogenous Impulse or Endogenous Response?" In: *American Economic Journal: Macroeconomics* 13.4, pp. 369–410. DOI: 10.1257/mac.20190171.

Merton, Robert C. (1973). "An Intertemporal Capital Asset Pricing Model." In: *Econometrica* 41.5, pp. 867–887. DOI: 10.2307/1913811.

Miles, William (2009). "Irreversibility, Uncertainty and Housing Investment." In: *The Journal of Real Estate Finance and Economics* 38.2, pp. 173–182. DOI: 10.1007/s11146-007-9087-x.

Nareit (2026). *REIT Indexes: Real-Time Index Returns*. https://www.reit.com/data-research/reit-indexes/real-time-index-returns. (Visited on 09/26/2026).

Newey, Whitney K. and Kenneth D. West (1987). "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix." In: *Econometrica* 55.3, pp. 703–708. DOI: 10.2307/1913610.

Nguyen Thanh, Binh, Johannes Strobel, and Gabriel Lee (2020). "A New Measure of Real Estate Uncertainty Shocks." In: *Real Estate Economics* 48.3, pp. 744–771. DOI: 10.1111/1540-6229.12270.

Pindyck, Robert S. (1991). "Irreversibility, Uncertainty, and Investment." In: *Journal of Economic Literature* 29.3, pp. 1110–1148.

Titman, Sheridan (1985). "Urban Land Prices under Uncertainty." In: *The American Economic Review* 75.3, pp. 505–514.

Van Nieuwerburgh, Stijn (2019). "Why Are REITs Currently So Expensive?" In: *Real Estate Economics* 47.1, pp. 18–65. DOI: 10.1111/1540-6229.12238.