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The Effects of Conventional and Unconventional Monetary Policy Shocks on US REITs Moments: Evidence from VARs with Functional Shocks

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Abstract

We use a vector autoregressive model with functional shocks, capturing the shift of the entire term structure of interest rates on monetary policy announcement dates, to empirically evaluate the effects of conventional and unconventional monetary policy decisions on the Real Estate Investment Trusts (REITs) markets of the United States (US). Using 5-min interval intraday data, we analyze not only the impact on REITs returns, but also its realized variance (RV), realized jumps (RJ), realized skewness (RSK), and realized kurtosis (RKU) over the daily period of September 2008 to June 2021. While the effects of conventional monetary policy shocks on the moments of REITs returns tend to conform with economic theories, the same is not necessarily the case with unconventional monetary policy shocks. In addition, though monetary policy shocks have the most persistent and strongest effects on RJ, the extreme behaviour of the REITs market is also observed through RSK and RKU. Moreover, when we look into 10 REITs sectors, there is indeed heterogeneity in terms of the strength of the effect, but not so much in terms of the sign of responses of the various moments compared to the overall market. Our results have important implications for REITs market participants, given its exponential growth as an asset class.

Keywords US REITs · Intraday Data · Higher-Moments · Conventional and Unconventional Monetary Policies · VAR with Functional Shocks

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Introduction

Real Estate Investment Trusts (REITs) have grown substantially as an investment instrument in the United States (US). According to the Nareit¹, in the first quarter of 2022, REITs of all types collectively own more than \$3.5 trillion in gross real estate assets across the US, with stock-exchange listed REITs owning approximately \$2.5 trillion in assets, and US listed REITs having an equity market capitalization of more than \$1.35 trillion.² Driven by its accessibility to various investors irrespective of their portfolio size and its utility for asset allocation and risk reduction, REITs provide an unique opportunity for investors to invest in real estate (Akinsomi et al., 2016), with, according to the Nareit, 145 million Americans owning REITs through retirement savings and other investment plans. Furthermore, REITs returns do not suffer from issues of measurement errors and high transaction costs compared to other real estate investments and, hence provide a perfect high-frequency proxy for the overall real estate market. This is due to REITs earning most of their income from investments in real estate, being exchange-traded funds, and also since trading occurs as common stocks (Marfatia et al., 2017). Given these characteristics and the fact that the Global Financial Crisis (GFC) had its roots in the collapse of the US real estate sector, it is of paramount importance from the perspective of academics, investors, and policymakers to understand what factors drive the movements in the US REITs market.

Furthermore, note that, REITs are the primary traded real estate instrument internationally, including the US, and are structured like mutual funds to enhance their tax transparency in comparison to the conventional corporate sector. Dividend payments of the trust are tax exempt subject to two conditions: (i) A minimum of 75% of assets of a particular REITs must be invested in real estate; (ii) A minimum of 90% of taxable income must be passed through to shareholders. Understandably, the constraints placed on REITs (in terms of assets and dividends) tie its performance very closely to that of the underlying property portfolio. Given this, an important issue here is that the private real estate market has a number of fundamental and well-documented linkages with movements in interest rates. For instance, interest rate changes are likely to impact general economic activity, which in turn, will affect occupational demand in the real estate market. This will then cause changes in obtainable rental values and hence, income and REITs dividends. In addition, changes in interest rates will also cause changes in real estate yields, which will be followed by an additional impact on property values.

Naturally, a large literature exists that has analysed the effect of (conventional and unconventional) monetary policy decisions on REITs prices and/or returns (see

¹ Nareit® can be considered as representing worldwide REITs and listed real estate companies, with particular focus on the US.

² <https://www.reit.com/>, assessed on December 4, 2023.

for example, the recent works of Gupta and Marfatia (2018), Gupta et al. (2019), Caraiani et al. (2021), Marfatia et al. (2021), and references cited therein), and hence tends to dominate in terms of the large number of possible factors that can drive the REITs market (Çepni et al., 2021; Ghysels et al., 2013), which is understandable since monetary policy impact possibly all macroeconomic and financial variables (Bañbura et al., 2010; Bernanke & Boivin, 2003; Bernanke et al., 2005). This is not surprising, since traditionally, from a theoretical perspective, asset prices are determined based on the discounted cash flow model (Fisher, 1930; Williams, 1938), whereby asset prices are equal to the present value of expected future net cash flows. In this regard, monetary policy is automatically linked to REITs prices by changing investors' expectations about future cash flows associated with economic activity and by affecting the cost of capital, i.e., the real interest rate, which is used to discount the future cash flows and/or the risk premium associated with holding stocks (Bernanke & Kuttner, 2005; Maio, 2014). However, these two channels are interlinked, given that a more restrictive monetary policy usually implies both higher discount rates and lower future cash flows. Thus, contractionary monetary policy should be related to lower REITs prices, given the higher discount rate for the expected stream of cash flows and/or lower future economic activity. On the other hand, expansionary monetary policy is commonly viewed as good news as these periods are usually associated with low interest rates, increases in economic activity and higher earnings for the REITs firms in the economy, and thus implying higher REITs prices.

Note that, in the wake of the GFC, the Federal Open Market Committee (FOMC) cut its key policy rate, the Federal funds rate (FFR), to near-zero levels (often referred to as the zero lower bound (ZLB) condition) in its meeting held on the 16th December, 2008. The ZLB led to the adoption of unconventional monetary policy tools namely, forward guidance (FG) and large-scale asset purchase programs (LSAP), to further support the economic recovery. FG was an explicit announcement of the likely future path of the FFR, while LSAP involved the announcement of large-scale purchases of long-term US treasuries and mortgage-backed securities to lower long-term interest rates. In this regard, unconventional monetary policies are aimed to impact the REITs (and the general financial) market through the signalling and portfolio rebalancing channels, which in turn are both subsumed in the interest rate channel operating through the discounted cash flow model. The signaling channel operates by influencing investors' expectations about the future path of interest rates, which is what the FG was designed to achieve, with the LSAP also aimed at having significant signaling effects via the reduction of future short-term interest rates (Bauer & Rudebusch, 2014). At the same time, since the portfolio rebalancing channel refers to the purchase of long-term securities by central banks, which would reduce the supply of bonds in the secondary market and lead to an increase in bond prices and a fall in bond yields, investors will adjust their portfolios by buying alternative assets, such as REITs (besides equities), in search of higher returns (Bauer & Neely, 2014; Gagnon et al., 2011). In sum, irrespective of whether we look at conventional or unconventional monetary policy decisions, alternative theories suggest that contractionary monetary policy will reduce REITs prices and/or returns, while expansionary ones will increase REITs prices and/or returns. Nevertheless,

such claims require empirical validation, especially given the mixed observations in the existing findings, particularly involving unconventional monetary policies.

Nakamura and Steinsson (2018a, b) suggest the use of high-frequency data to identify daily monetary policy surprises “in a relatively cleaner manner”, since this would allow monetary policy announcements to capture the effect on agents’ beliefs about economic fundamentals beyond monetary policy via the “information channel”. Given this, we extend the existing literature on the effect of conventional and unconventional monetary policy, primarily at low-frequency (monthly or quarterly), on daily overall and sectoral (all equity, industrial, office, retail, apartments, residential, shopping centers, health care, composite, and regional malls) REITs returns over the period of September 22, 2008 and June 30, 2021. Besides, better identification of monetary policy at high-frequency, an analysis of daily movements of REITs, which is perceived as a leading indicator, would be of tremendous importance from the perspective of nowcasting low-frequency macroeconomic variables (including business cycles) based on mixed data sampling (MIDAS) methods (Baíbura et al., 2011). As should be evident from the sample period, our analysis would need to account for both conventional and unconventional monetary policies, with the latter pursued from September 2008 to June 2016 following the GFC, and also more recently from March 2020 to June 2021 due to the outbreak of the COVID-19 pandemic, and the rest of the in-between period operating under the former (conventional) monetary policy regime.

In light of this, following Inoue and Rossi (2019, 2021), our definition of a monetary policy shock is a shift in the entire term structure of interest rates in a short window of time around the monetary policy announcement dates of the Federal Reserve (Fed). Since the procedure identifies monetary policy shock as exogenous shifts in a function, it is known in the literature as a “functional shock”. In this manner, the monetary policy shocks measured by this approach are broader than that used in the existing literature, which typically uses exogenous changes in the short-term interest rate alone. Moreover, functional monetary policy shocks have the potential to encompass more broadly other changes that monetary policy has on both short- and long-term interest rates, such as announcement effects associated with FG and LSAP (or quantitative easing (QE)). In other words, we are able to capture both conventional and unconventional monetary policy decisions by considering the shift in the entire term structure of interest rates on announcement dates of the Fed. Indeed, there exist alternative approaches (for example, shadow short rates, heteroscedasticity-based identification, event study-based identification, external instruments, sign-restrictions, and structural Dynamic Stochastic General Equilibrium (DSGE) models-based identification) to modeling conventional and unconventional monetary policies simultaneously (see, Rossi (2021) for a detailed review of these methods). While some of these methods can also be utilized in the context of high-frequency data, the fact that the entire term structure contains important information on the duration of the ZLB episode and the expected effects of monetary policy on the overall economy (Gürkaynak & Wright, 2012), makes the functional shock approach preferable. This is because of the fact that monetary policy shocks can now not only be identified at a daily frequency, but also the shift of the term structure would contain high-frequency information of wide array of additional low- and high-frequency

macroeconomic and financial variables that are expected to impact the REITs sector. In other words, functional monetary policy shocks allow us to parsimoniously model a large information set at daily frequency.

While the focus is on REITs returns, since we now have access to (5-min-interval) intraday data available for the REITs market, we are also able to analyze the impact of monetary policy shocks on higher moments namely, realized variance (RV), realized jumps (RJ), realized skewness (RSK), and realized kurtosis (RKU). Note that, returns are computed as the end of the day price difference, close to close. In this context note that, as far as trading levels are concerned, a critical examination of the intraday data in the REITs sector needs to be considered to enhance the robustness and interpretability of the findings derived from high-frequency data. Notably, the REITs sector, despite its substantial growth and importance in the real estate investment sphere, is oftentimes deemed to be a relatively thinly traded sector, especially when juxtaposed against the overall equity market. However, the microstructure of the REITs market, in terms of trading volumes and liquidity, can exhibit notable variations, especially during periods of economic turbulence or significant policy announcements, which is a point that lends some merit to utilizing intraday data in specific contexts. During the Global Financial Crisis (GFC) and the recent COVID-19 pandemic, REITs experienced heightened trading volumes³ and price volatility, which potentially stemmed from their direct linkage to the tangible property market dynamics and macroeconomic conditions. Hence, employing intraday data allows us to discern the immediacy and intensity of market reactions, which can be particularly pertinent when examining the effects of monetary policy shocks that are likely to have swift impacts on investor sentiment and trading behavior in the short term. This is significant, given that REITs, by virtue of being exchange-traded, present an amalgamation of real estate investment and stock market characteristics, thereby assuming a unique position that can be influenced by both tangible property market movements and equity market dynamics. Furthermore, the high moments (realized variance, jumps, skewness, and kurtosis) of REITs may exhibit notable fluctuations in a short time span post any major policy announcement, offering a richer understanding of how such shocks permeate through the real estate sector and subsequently, the broader economy.

While some studies (see for example, Devaney (2001), Cotter and Stevenson (2008), Bredin et al. (2007), Nyakabawo et al. (2018)) have analyzed the impact of interest rate, and conventional and unconventional monetary policy on Generalized Autoregressive Conditional Heteroscedasticity (GARCH)-based conditional models of volatility, RV, computed as the sum of squared intraday returns over a day, provides a more accurate, unconditional and observable metric of volatility (McAlear & Medeiros, 2008). In this regard, it is important to point out that, an unexpected contractionary (expansionary) monetary policy shock, traditionally considered “bad news” (“good news”), negatively (positively) impacts REITs prices and/or returns, which in turn is expected to lead to higher (lower) REITs market volatility, as suggested by the “leverage effect” (Gospodinov & Jamali, 2012, 2018). This is again

³ Figure 15 in Appendix 1 shows the average monthly trading volume of FNAR between 2008 and 2021.

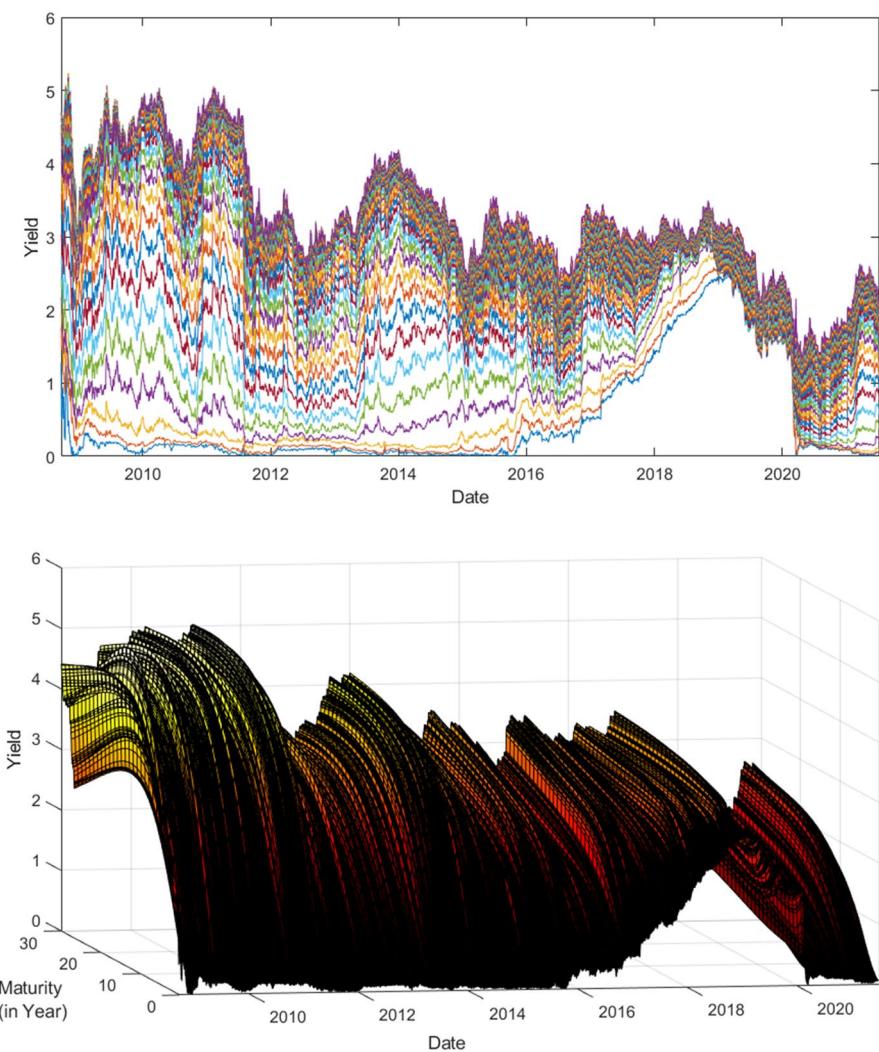


Fig. 1 Yields at 3-month to 30-year maturities. Upper panel: Time series plot. Lower panel: 3-dimensional plot

a theoretical proposition that needs to be tested in the current context, since while Bredin et al. (2007) find evidence of this related to the US conventional monetary policy, Nyakabayo et al. (2018) did not find the effect to be statistically significant. Note that, REITs volatility is an important issue for investors, given that volatility, as a measure of risk, plays a critical role in portfolio diversification, derivatives pricing, hedging and financial risk management, besides RV providing a measure of uncertainty in the real estate market (Bonato et al., 2021a, b, 2022).

Given this, market participants of the REITs sector, just like in the context of the equity market, are expected to care not only about the nature of volatility, but also

about its level, with all traders making the distinction between good and bad volatilities (Giot et al., 2010). Good volatility is directional, persistent and relatively easy to predict, while, bad volatility is jumpy and comparatively difficult to foresee. Therefore, good volatility is generally associated with the continuous and persistent part, while bad volatility captures the discontinuous and jump component of volatility. Hence, an analysis of the drivers of RJ should be of tremendous value to investors in terms of portfolio management, as suggested by Odusami (2021a, b), while highlighting its importance in the price process of REITs. Jump risks are particularly important as they cannot be diversified away, causing investors to demand large risk premia. If jumps are widespread in the dynamics of REITs prices, then their risk premia must account for both the diffusive and jump risk factors. In terms of the dynamics of asset returns, jumps allow for the impact of news carrying significant information, such as that of monetary policy, to quickly dissipate in the return process, but their effect on volatility is more persistent due to their impact on the diffusion process. In fact, Odusami (2021a) indicated that RJ is indeed predictable based on various financial market variables (term spread, default spread, Volatility Index (VIX), equity market returns, commodity returns, and the U.S. dollar exchange rates). We now aim to add to this the role of conventional and unconventional monetary policy shocks, which in turn are expected to incorporate the information contained in the predictors considered by Odusami (2021a). The initial hypothesis is that contractionary monetary policy should positively affect RJ.

Finally, we also get into uncharted territory by analyzing the impact of monetary policy shocks on RSK and RKU, which captures asymmetry and extreme movements (outliers) in REITs returns (Bonato et al., 2022), and are expected to be negatively related to monetary policy shocks. In the aftermath of the GFC, the discussions of these non-normal distributional features of asset returns, and in our case for REITs, which we show to exist, have become pertinent issues. Investors note skewness when judging a return distribution because it better represents the extremes of the data set rather than focusing solely on the average, and can capture possible crash risk especially involving negative RSK values. RSK informs market participants of the direction of outliers, though it does not tell agents how often that occurs, for which we utilize RKU, which is a metric for the tailedness of a distribution. It should be noted that tail risk is the additional risk which fat-tailed asset returns exhibit relative to a normal distribution.

Understandably, going beyond returns, and analyzing the effect of monetary policy shocks on higher moments, such as RV, RJ, RSK and RKU, obtained from high-frequency data, is pivotal to better understanding the impact on the entire distribution of REITs returns, to allow us to draw relevant investment and policy implications. This is more so because, these higher moments can be associated with behavioral aspects of market participants in the REITs market. For instance, RV is a well-accepted metric of uncertainty, whereas jumps can reflect speculative and irrational forces (Baker et al., 2021), to the extent that RJ, RSK and RKU can be even considered as sentiment indicators involving the underlying asset (Frugier, 2014).

To the best of our knowledge, this is the first paper to analyze the impact of conventional and unconventional monetary policy shocks on not only REITs returns, but also its higher moments derived using intraday data, based on a framework referred

to as the Vector Autoregressive (VAR) model with functional shocks. The remainder of the paper is organized as follows: Sect. “[Methodology](#)” discusses the methodology utilized, while Sect. “[Data and higher-moment statistics](#)” outlines the data and the associated computation of the various moments of REITs returns. Section “[Empirical results](#)” presents the results, with Sect. “[Concluding remarks](#)” concluding the paper.

Methodology

In order to comprehensively measure monetary policy shocks, Inoue and Rossi (2019, 2021) propose to identify monetary policy shocks as shifts in the entire term structure of government bond yields in a short window of time around monetary policy announcements. Since shocks are shifts in a function (i.e. the difference between two term structures), Inoue and Rossi (2019, 2021) refer them as functional shocks. Under such set-up, the “whole picture” of an exogenous monetary policy action is entirely included by simultaneously considering the impact on interest rates at all available maturities, whether it is an unexpected change in the short-term or the shift in agent’s expectations on the medium- and long-term. Furthermore, Inoue and Rossi (2019, 2021) develop a framework of VAR with functional shocks to trace the effect of monetary policy shocks in the financial markets. In the following, we briefly summarize their methodology.

Functional shocks identification

Firstly, we have a set of discrete maturities (in years) for which we can observe the data on yields, and let us denote them as $\tau = \tau_1, \tau_2, \dots, \tau_M$, where M is the number of maturities. Then on a specific day t , the yield to maturity of τ is represented by $y_{\tau,t}$. If we view the maturity τ as continuous, then the yield curve can be denoted as a function, $y_t(\tau)$. In order to identify a monetary policy shock, Inoue and Rossi (2019, 2021) assume that the change in the yield curve is predominantly caused by the monetary policy action. Thus, the monetary policy shock is the change of the term structure on the announcement date t :

$$\varepsilon_t^{mp}(\tau) = \Delta y_t(\tau) d_t, \quad (1)$$

where $\Delta y_t(\tau) \equiv y_t(\tau) - y_{t-1}(\tau)$ is the change in the yield curve as a function of maturity τ on day t . Since monetary policies do not occur on each day t , we use a dummy variable d_t to denote a day with a monetary policy announcement (1: with a monetary policy announcement; 0: no announcement). With such a definition, we can see that the monetary policy shock, $\varepsilon_t^{mp}(\tau)$, is no longer a scalar, but a functional data (a curve in this case). The advantage of using the functional data of $\varepsilon_t^{mp}(\tau)$ is that we incorporate all information in the change of the yield curve on the announcement day. This is because τ in practice is ranging between 3-month (1/4 year) and 30-year. Thus, the changes in short-, medium-, and long-term are all included in $\varepsilon_t^{mp}(\tau)$. Considering that a monetary policy shock can have different effects at different maturities, $\varepsilon_t^{mp}(\tau)$ can have a variety of shapes, which we will discuss in detail in Sect. “[Data and higher-moment statistics](#)”.

VARs with functional shocks

Denote m_t as the REITs daily return or its realized higher moments (RV, RJ, RSK and RKU), which are the variables of our interest. Then we construct a reduced-form VAR model with m_t and $\Delta y_t(\tau)$ as follows:

$$X_t = \mu + B_0 + B_1 X_{t-1} + \cdots + B_p X_{t-p} + u_t, \quad (2)$$

where $X_t = [\Delta y_t(1/4), \Delta y_t(1/2), \Delta y_t(1), \Delta y_t(5), \Delta y_t(10), \Delta y_t(20), \Delta y_t(30), m_t]'$, $E(\mu_t \mu_t')$ $\equiv \Sigma$, and we set $p = 1$ in the main analysis and provide robustness checks of $p = 2, 3$ in Sect. "Robustness checks".

By inverting the VAR model, a reduced-form moving average is obtained as:

$$X_t = \tilde{\mu} + \mu_t + \Theta_1 u_{t-1} + \cdots + \Theta_h u_{t-h} + \dots \quad (3)$$

In order to identify the VAR transmission mechanism parameters in the structural VAR, we need an additional assumption that the yield curve responds to m_t only with a lag. Thus, the Cholesky decomposition of $\Sigma = AA'$, and the Cholesky factor is:

$$A = \begin{bmatrix} A_{11} & 0 \\ A_{21} & a_{22} \end{bmatrix}, \quad (4)$$

and Θ_h is

$$\Theta_h = \begin{bmatrix} \Theta_{11,h} & \Theta_{12,h} \\ \Theta_{21,h} & \Theta_{22,h} \end{bmatrix},$$

where A_{11} and $\Theta_{11,h}$ have dimension $M \times M$, $\Theta_{12,h}$ is $1 \times M$, A_{21} and $\Theta_{21,h}$ are $1 \times M$, and lastly a_{22} and $\Theta_{22,h}$ are scalers.

Inoue and Rossi (2019) show that the overall effect as the impulse response to the monetary policy event $\varepsilon_t^{mp} = [\varepsilon_t^{mp}(1/4), \dots, \varepsilon_t^{mp}(30)]$ can be calculated by:

$$(\Theta_{21,h} + \Theta_{22,h} A_{21} A_{11}^{-1}) \varepsilon_t^{mp}, \quad (5)$$

where $h = [0, 1, \dots, H]$.

As for the estimation for Eq. (5), please refer to Inoue and Rossi (2019) for the details on the Bayesian procedure that is adopted.

Contractionary versus expansionary

In Inoue and Rossi (2019), a monetary policy is deemed to be contractionary if $\Delta y_{5,t}^* > 0$ (i.e., the shock of yield at 5-year maturity is positive) during the unconventional period; if $\Delta y_{1/4,t}^* > 0$ (i.e., the shock of yield at 3-month maturity is positive) during the conventional period. Otherwise, it is an expansionary monetary policy. However, such a criterion arbitrarily depends on the choice of a single maturity, which can produce non-robust results. For example, some yield curves can have a

very marginal decrease in the short maturity but a large increase in the longer maturity, which is less convincing to be classified as contractionary. In order to be more systematic, we use a different criterion from Inoue and Rossi (2019) to define a contractionary monetary policy and an expansionary monetary policy during conventional and unconventional periods, as summarized below:

- A contractionary monetary policy is featured by $\int_{1/4}^{30} \varepsilon_t^{mp}(\tau) d\tau > 0$, (i.e. the integral of whole yield curve is positive);
- Otherwise, it is an expansionary monetary policy.

Data and higher-moment statistics

In this section, we elaborate on the empirical dataset for this study, including the term structure data, the REITs data, and the announcement dates of (un)conventional monetary policies. Additionally, we provide a discussion of the higher moments associated with the REITs.

The dataset

For the term structure, the maturities of yields are chosen to be fixed at 3-month, 6-month, and 1–30 years. The term structure data is at daily frequency. The 3- and 6-month daily zero-coupon yields are from the Federal Reserve Board (Fed) H-15 release.⁴ The yields of zero-coupon yields (mnemonics “SVENY”) at 1 to 30 years maturities are from Gurkaynak et al. (2007) that is available in updated form from the Board of Governors of the Federal Reserve System webpage.⁵

We use 5-min-interval intraday data on the FTSE Nareit All REITs Index (FNAR) to conduct our empirical study.⁶ The intraday data cover a 24-h trading day and are ideally suited to construct daily measures of RV, RJ, RSK and RKU, besides returns being computed as the end of the day log-price difference, close to close. Besides the FNAR index, we also investigate the role of monetary policy shocks on the following sectoral REITs: All Equity (FNER), Industrial (FNIND), Office (FNOFF), Retail (FNRET), Apartment (FNAPT), Residential (FNRES), Shopping (FNSHO), Health Care (FNHEA), Composite (FNCO), and Regional Malls (FNMAL). This is because, both theory and empirical evidence suggest that the sectors do not react evenly to changes in interest rates, with the fundamental driver of interest rate sensitivity for REITs being the average lease term of the underlying property type (Almudhaf & Hansz, 2018). Note that apartment, residential, and industrial

⁴ <https://www.federalreserve.gov/releases/h15/>, assessed on December 4, 2023.

⁵ <https://www.federalreserve.gov/data/nominal-yield-curve.htm>, assessed on December 4, 2023.

⁶ The FTSE Nareit All REITs Index is a market capitalization-weighted index that and includes all tax-qualified REITs that are listed on the New York Stock Exchange, the American Stock Exchange or the NASDAQ National Market List. The FTSE Nareit All REITs Index is not free float adjusted, and constituents are not required to meet minimum size and liquidity criteria.

Table 1 Summary statistics of US yields

Maturity (in Year)	Mean	Median	Max	Min	Std. Dev	Skewness	Kurtosis
0.25	0.500	0.120	2.490	0.000	0.737	1.547	3.897
0.5	0.582	0.180	2.580	0.020	0.752	1.455	3.669
1	0.705	0.346	2.759	0.055	0.745	1.366	3.565
2	0.890	0.687	2.961	0.102	0.713	1.184	3.498
3	1.129	1.022	3.026	0.127	0.680	0.771	3.028
4	1.376	1.361	3.061	0.169	0.668	0.311	2.519
5	1.612	1.636	3.091	0.222	0.678	0.006	2.296
10	2.463	2.403	4.835	0.520	0.847	0.125	2.828
20	3.090	2.973	5.056	0.958	0.913	0.132	2.612
30	3.264	3.183	5.036	1.250	0.805	0.084	2.816

generally tend to have relatively low lease terms in comparison to shopping centers, retail, office, regional malls, and health care. The intraday REITs price data, obtained from Bloomberg, is available in a continuous format. The computation of the RV, RJ, RSK and RKU statistics are discussed in the next sub-section in detail.

The period of our dataset is between September 22, 2008 and June 30, 2021,⁷ purely driven by data availability. Since our interest is to analyze the different impact from (un)conventional monetary policies, we divide the entire period into three periods:

- Period 1 (GFC), unconventional monetary policy: September 19, 2008 – June 15, 2016.⁸
- Period 2 (Post-GFC), conventional monetary policy: June 16, 2016 – February 29, 2020.
- Period 3 (COVID-19), unconventional monetary policy: March 1, 2020 – June 30, 2021.

The dates of unconventional monetary policy (UMP) announcements in Period 1 (GFC) are from the Not-for-Publication Appendix 1 of Inoue and Rossi (2021). Note that the UMP dates (22 of them) in Inoue and Rossi (2021) is an extension of the UMP dates (11 in number) in Inoue and Rossi (2019). The 22 UMP dates cover the period of November 25, 2008 (first UMP) to June 15, 2016 (last UMP). For the dates of (un)conventional monetary policy announcements in Period 2 (Post-GFC) and Period 3 (COVID-19), we follow Nakamura and Steinsson (2018a, b) to use the

⁷ The dates of interest rates and REITs are cross-matched so that holidays and weekends are removed.

⁸ The end date of this period follows the Table 1 in the Not-for-Publication Appendix of Inoue and Rossi (2021).

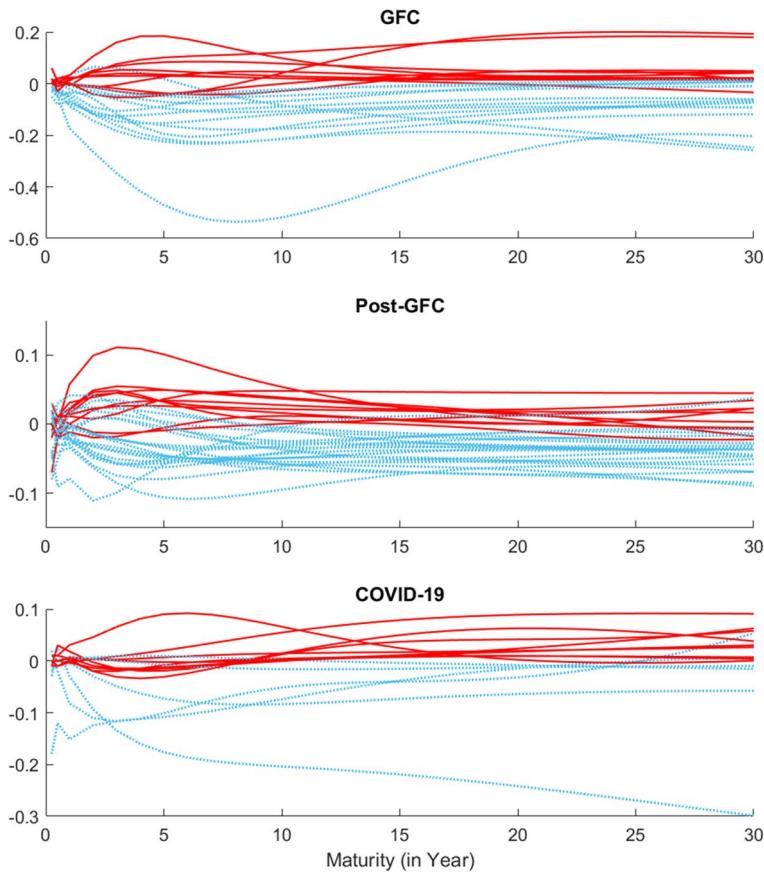


Fig. 2 Shocks in US term structure after monetary policy announcement. Red (blue) solid lines are contractionary (expansionary) monetary policy shocks. Upper panel: shocks in GFC. Middle panel: shocks in Post-GFC. Lower panel: shocks in COVID-19

dates of FOMC meetings, available on the website of the Federal Reserve Board website.⁹

The upper panel of Fig. 1 plots the time series of yields at 3-month to 30-year maturities over our sample period. The 3-month yields are generally at the bottom (blue line), the 30-year yields are at the top (purple line) for most of the time, and the yields at other maturities are between them. To better visualize the term structure, the bottom panel of Fig. 1 shows the 3-dimensional figure of term structure with respect to time (x-axis) and maturity (y-axis). It is prominent that the term structures are noticeably distinguishable in the three periods, with short-maturities yields closely at zero during the two unconventional periods.

⁹ <https://www.federalreserve.gov/monetarypolicy/fomccalendars.htm>, assessed on December 4, 2023.

Figure 2 presents the shocks in term structure following a monetary policy announcement in the three periods. Red solid lines are contractionary monetary policy shocks, while blue dotted lines are expansionary monetary policy shocks. Recall that, a contractionary monetary policy implies that the integral of whole yield curve is positive, i.e., $\int_{1/4}^{30} \varepsilon_t^{mp}(\tau) d\tau > 0$, while, an expansionary monetary policy involves a negative integral, on the monetary policy announcement dates. As can be observed, the shapes of those functional shocks can be considerably different, albeit they have similar changes at a fixed maturity, such as the commonly used 1-year. Therefore, the information contained in the whole curve of functional shocks could be much richer and potentially helpful in investigating the impact of (un)conventional monetary policies. Given the above definition, it might seem that contractionary monetary policy during COVID-19 is contradictory to the whole purpose of reviving the struggling economy, but as shown in Fig. 2, there were indeed such instances, especially at longer maturities. This is because, even though the lower-end of the yield curve stayed quite stable and low, the upper-segment had started to show signs of increase by around August, 2020, with the US real GDP having passed the severe downturn by the 3rd quarter of 2020. So the positive changes in the higher-term maturities on monetary policy announcement dates relative to no-changes at the lower-end tend to represent contractionary monetary policy shocks during the coronavirus pandemic period, which in our case spans till June, 2021. A similar argument can be made about contractionary monetary policy during the GFC as well, though the frequency of expansionary shocks were relatively higher in this context, compared to the COVID-19 sub-sample, as seen from Fig. 2.

Table 1 shows the summary statistics of US yields data. Some stylized facts of term structures are observed here. First, the mean and median of yields increase with the maturity. Second, the range of yields is larger for longer maturities. However, there is an U-shape relationship between standard deviation and maturity in our sample period, with higher standard deviation at shorter and longer maturities. Based on the skewness and kurtosis, we can observe that the distributional property of yields at larger maturities is closer to normal distribution.

Realized moments

REITs returns realized variance is estimated by relying on the classical estimator of RV, i.e., as the sum of squared intraday returns (Andersen & Bollerslev, 1998):

$$RV_t = \sum_{i=1}^M r_{t,i}^2, \quad (6)$$

where $r_{t,i}$ denotes the intraday $M \times 1$ return vector, and $i = 1, \dots, M$ is the number of intraday returns. Next, we consider a jump component (RJ) in the REITs price process. As shown by Andersen et al. (2007), jumps are both highly prevalent and distinctly less persistent than the continuous sample-path-variation process. Moreover, many jumps appear directly associated with specific macroeconomic news

announcements. We use the result, derived by Barndorff-Nielsen and Shephard (2004), that the realized variance converges into permanent and discontinuous (jump) components as:

$$\lim_{M \rightarrow \infty} RV_t = \int_{t-1}^t \sigma^2(s) ds + \sum_{j=1}^{N_t} k_{t,j}^2, \quad (7)$$

where N_t is the number of jumps within day t and $k_{t,j}$ is the jump size. This result implies that RV_t is a consistent estimator of the integrated variance $\int_{t-1}^t \sigma^2(s) ds$ plus the jump contribution. The asymptotic results derived by Barndorff-Nielsen and Shephard (2004, 2006) further show that:

$$\lim_{M \rightarrow \infty} BV_t = \int_{t-1}^t \sigma^2(s) ds, \quad (8)$$

where BV_t is the realized bipolar variation defined as:

$$BV_t = \mu_1^{-2} \left(\frac{M}{M-1} \right) \sum_{i=2}^M |r_{t,i-1}| |r_{i,t}| = \frac{\pi}{2} \sum_{i=2}^M |r_{t,i-1}| |r_{i,t}|, \quad (9)$$

and

$$\mu_a = E(|Z|^a), Z \sim N(0, 1), a > 0. \quad (10)$$

A consistent estimator of the pure jump contribution can then be expressed as:

$$J_t = RV_t - BV_t. \quad (11)$$

The significance of the jump component is tested relying on a formal test estimator proposed by Barndorff-Nielsen and Shephard (2006) given by:

$$JT_t = \frac{RV_t - BV_t}{(\nu_{bb} - \nu_{qq}) \frac{1}{N} TP_t}, \quad (12)$$

where TP_t is the Tri-Power Quarticity:

$$TP_t = M \frac{M}{M-2} \left(\frac{\Gamma(0.5)}{2^{2/3} \Gamma(7/6)} \right) \sum_{i=3}^M |r_{i,t}|^{4/3} |r_{t,i-1}|^{4/3} |r_{i-2,t}|^{4/3}, \quad (13)$$

which converges to the Integrated Quarticity (IQ):

$$IQ_t \rightarrow \int_{t-1}^t \sigma^4(s) ds, \quad (14)$$

even in the presence of jumps. We use the notation $\nu_{bb} = \left(\frac{\pi}{2} \right)^2 + \pi - 3$ and $\nu_{qq} = 2$. Note that for each t , $JT_t \sim N(0, 1)$ as $M \rightarrow \infty$. As can be seen in Eq. (11), the jump contribution to RV_t is either positive or null. Therefore, to avoid obtaining negative

Table 2 Summary statistics of FNAR

	Mean	Median	Max	Min	Std. Dev	Skewness	Kurtosis
Return	0.0105	0.0888	16.2366	-20.5429	1.9970	-0.6761	21.7818
RV	0.0002	0.0001	0.0095	0.0000	0.0006	6.2395	55.5038
RJ	0.0001	0.0000	0.0037	0.0000	0.0003	5.9435	45.8466
RSK	0.0516	0.0338	8.3711	-9.8456	2.0636	0.0735	5.0854
RKU	11.0355	6.8815	114.5339	2.2177	10.8151	2.6014	11.6435

empirical contributions, we redefine, like Zhou and Zhu (2012), the jump measure as:

$$RJ_t = \max(RV_t - BV_t; 0). \quad (15)$$

Finally, we compute RSK and RKU. We consider RSK as a measure of the asymmetry of the daily REITs returns distribution, and RKU as a measure that accounts for extremes. We compute RSK on day t as:

$$RSK_t = \frac{\sqrt{M} \sum_{i=1}^M r_{(i,t)^3}}{RV_t^{3/2}}, \quad (16)$$

and RKU on day t as:

$$RKU_t = \frac{M \sum_{i=1}^M r_{(i,t)^4}}{RV_t^2}. \quad (17)$$

The scaling of RSK and RKU by $(M)^{1/2}$ and M ensures that magnitudes correspond to daily skewness and kurtosis.

Table 2 presents the summary statistics of the returns, RV, RJ, RSK and RKU of the FNAR index, and not surprisingly, there is evidence of negative skewness and excess kurtosis. Figure 3 depicts the returns and the higher moments of the FNAR index, and as can be seen, there is evidence of negative returns during the GFC, the European sovereign debt crisis, and more recently during the ongoing COVID-19 pandemic. These periods are also associated with heightened RV, RJ (indicative of volatility jumps associated with bad volatilities resulting from negative returns), and RKU as well. As far as RSK is concerned, we tend to find both large negative and positive values, with not necessarily visible evidence that the former dominates the latter, but as observed from the overall returns series, FNAR is indeed negatively skewed on average.

Empirical results

Our empirical results are organized with respect to returns and the higher moments separately. We depict the individual responses of FNAR to shocks in the term structure following all (un)conventional monetary policy announcements in the three

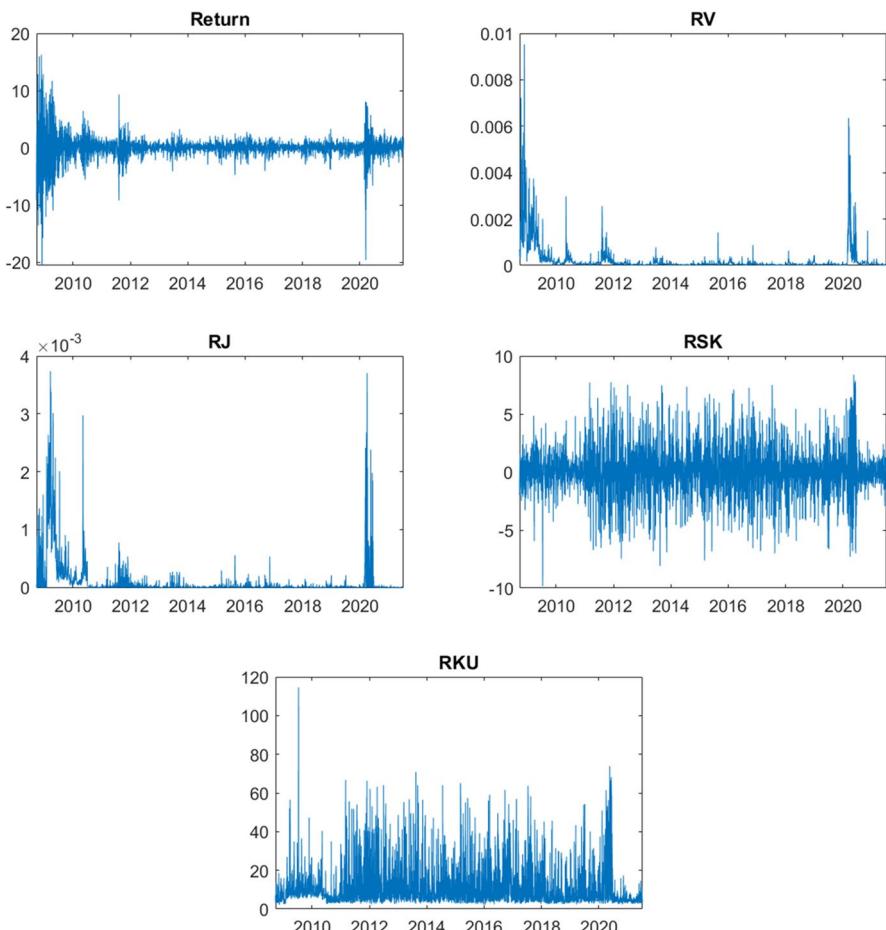


Fig. 3 The return, RV, RJ, RSK, RKU of the FNAR index

periods, with a summary table to present the average responses and their statistical significance. For the sake of conserving space, we provide tables to show the average response of various sectors of the US REITs market to the shocks of contractionary and expansionary monetary policy announcements.

Response of returns

The right panel of Fig. 4 depicts the functional shocks due to contractionary monetary policies in the three periods. First, it can be observed that the functional shocks in the term structure can have extraordinarily different shapes, although they are all classified as contractionary or expansionary. Such observations justify the motivation to consider the shock in the whole term structure, rather than yields at specific maturities. Second, the average functional shocks in GFC and COVID-19 periods

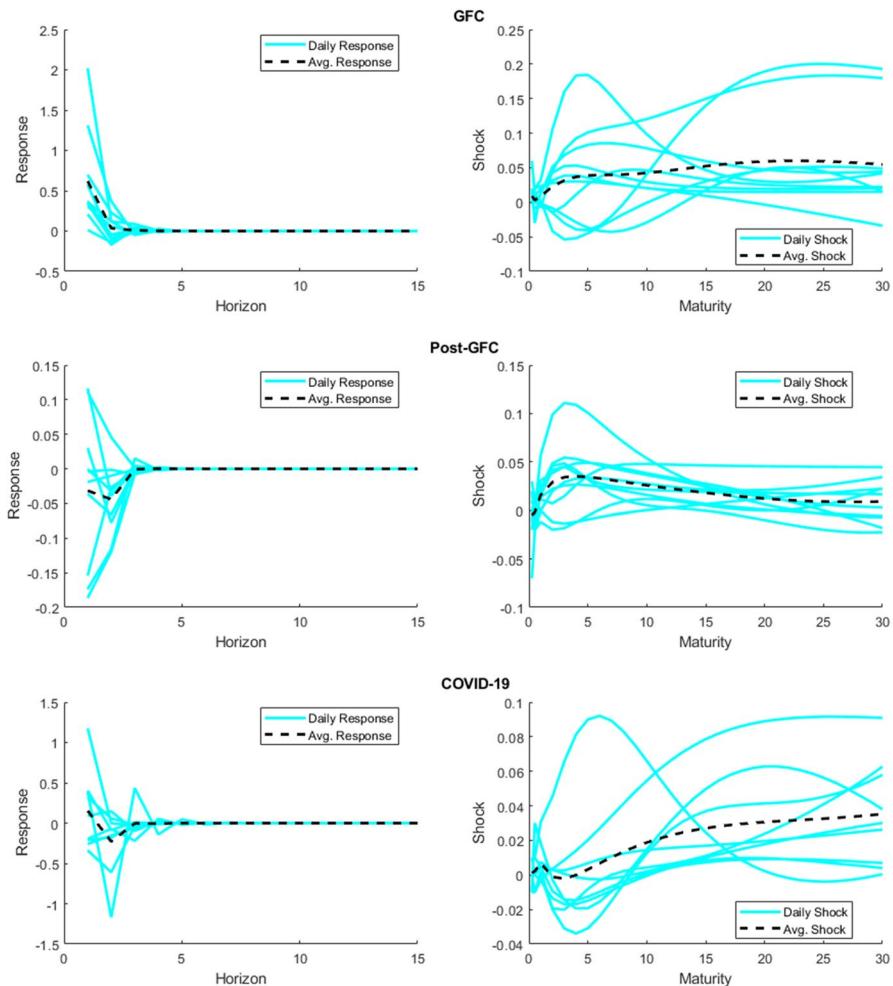


Fig. 4 Response of FNAR returns to contractionary monetary policy shocks. Left: response of returns to shocks. Right: shocks in the yield curves following a monetary policy announcement

have larger increases at longer maturities but marginal changes at shorter maturities. Third, during the post-GFC period, the average shock has a “hump” shape, implying that the conventional monetary policy affects most in the medium term (between 2–5 year maturities).

The responses of FNAR returns are presented in the left panel of Fig. 4, and in general are quite short-lived. On average, a contractionary monetary policy causes: (1) positive FNAR returns for the first two days during the GFC; (2) negative FNAR returns for the first two days during the Post-GFC; (3) a positive FNAR returns on the first day followed by a negative FNAR returns on the second day during COVID-19. The positive response of the FNAR during the GFC is an interesting finding because a contractionary monetary policy is expected to have a negative impact on

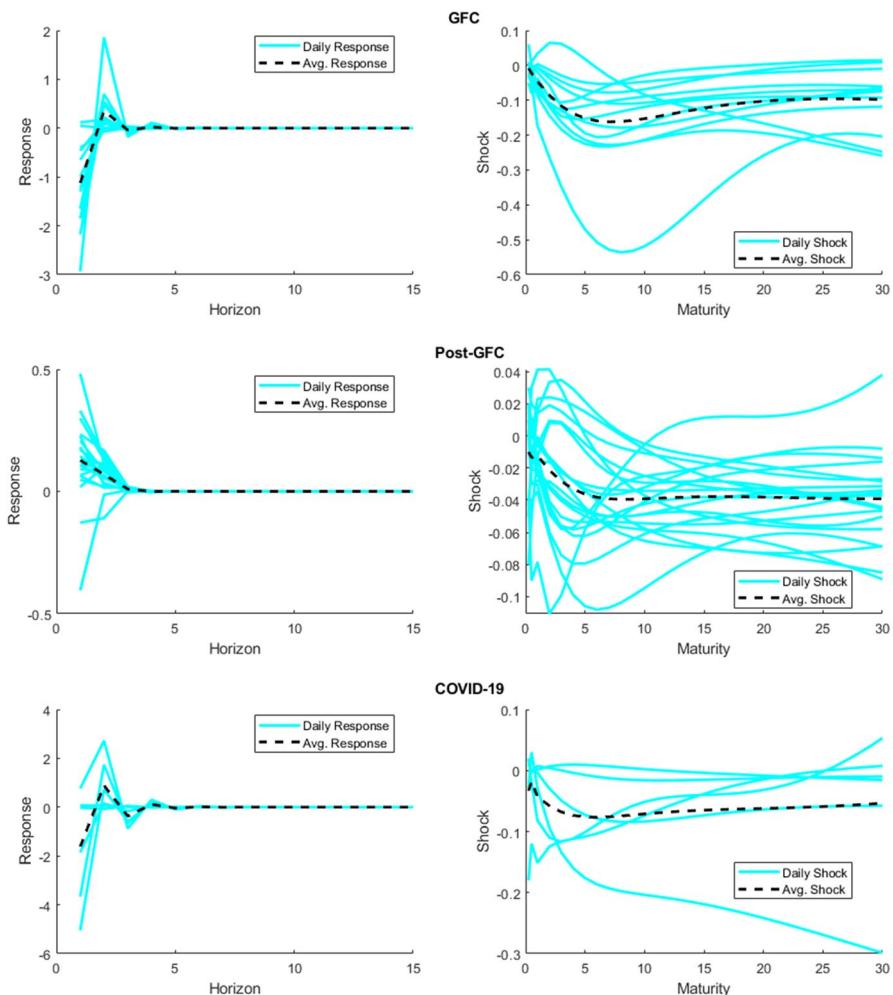


Fig. 5 Response of FNAR returns to expansionary monetary policy shocks. Left: response of returns to shocks. Right: shocks in the yield curves following a monetary policy announcement

FNAR returns, based on the channels discussed in the introduction. However, such expected impact is only observed in the conventional period (Post-GFC) and with a delay in COVID-19 period, involving unconventional monetary policies, but not during the GFC, which was characterized by unconventional policies. A possible explanation is that, contractionary monetary policies during crises could be an indication to the REITs investors that the monetary authorities are expecting the economy to recover soon leading to higher investment in REITs, and the associated hike in demand increasing its prices (Marfatia et al., 2021).

In terms of the expansionary monetary policy, the functional shocks are shown in the right panel of Fig. 5. During GFC and COVID-19, most monetary policy shocks

is zero at the short-end of the yield curve, and gradually deviates from zero at the long-end. This is mainly because of the fact that the short-end of the yield curve hit the ZLB, and unconventional monetary policy mostly operates on medium- and long-term expectations. The left panel of Fig. 5 illustrates the short-lived response of FNAR returns to expansionary monetary policy shocks. We notice an overshooting reaction of FNAR returns during the GFC and the COVID-19 period, i.e., a large negative return on the first day is followed by a recovery. With the GFC originating in the real estate sector, such delayed response due to weak sentiment regarding this market is not surprising even in the wake of monetary policy expansion. Moreover during crises periods, like the GFC and COVID-19, investors are more reliant on investing in safe haven assets and hence, it takes a while for them to possibly undertake portfolio reallocations into the REITs sector following positive monetary policy news. In other words, the delayed positive effects during the GFC and the COVID-19 period resulting from expansionary unconventional monetary policies could be a fall out of initial suggestion to the REITs market that the future economic outlook is subdued, but as these beliefs are updated, the returns tend to overshoot. During the post-GFC period, an expansionary monetary policy produced positive FNAR returns for the first two days, which is in line with our expectation.

Response of higher moments: RV, RJ, RSK and RKU

The left panel of Fig. 6 displays the responses of the FNAR RV to the functional shocks of contractionary monetary policy in the three sub-periods. For the two unconventional monetary policy periods, a contractionary monetary policy shock, on average, leads the RV of the FNAR index to decrease for a few days during the GFC, but a rise is observed for several days during the COVID-19 period. These findings align with the observations made for the FNAR returns reported above, with it rising and declining in the GFC and the pandemic following a contractionary monetary policy shock and signaling “good” and “bad” news, respectively, to decrease and increase RV via the leverage effect. But then again, the intuition-oriented results during the coronavirus pandemic for RV could be associated with better cognizance of the market about unconventional monetary policy decisions, rather than what was known during the GFC, besides low trading in the REITs market due to higher prevailing overall economic uncertainty could have resulted in lower volatility as well. Concentrating on the post-GFC period, the impact of contractionary monetary policy is unclear since half of the reactions are positive and the other half is negative, resulting in an average effect near to zero – a finding in line with Nyakabawo et al. (2018). Note that, the initial impact is negative, and could be a result of lower trading volumes due to “bad” news and associated negative returns culminating into lower volatility via the Mixture of Distribution Hypothesis (MDH, Clark, 1973), or Sequential Information Arrival Hypothesis (SIAH, Copeland, 1976).

The response of the FNAR RV to the functional shocks of expansionary in nature is depicted in the left panel of Fig. 7 for the three periods studied. It is noteworthy that an expansionary monetary policy shock generally leads to a rise in the RV of the FNAR index during the GFC, as a possible fall out of the sharp

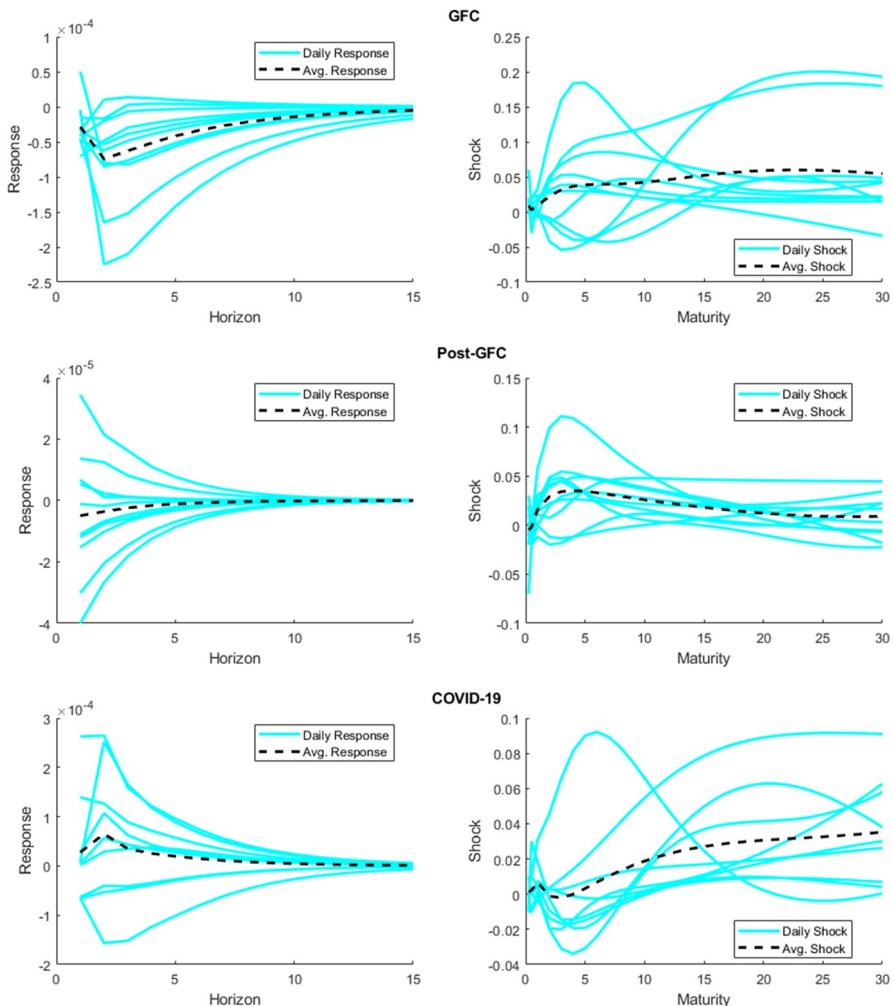


Fig. 6 Response of FNAR RV to contractionary monetary policy shocks. Left: response of RV to shocks. Right: shocks in the yield curves following a monetary policy announcement

reduction in REITs returns conveying “bad” news, or higher trading in the wake of “good” news involving expansionary monetary policy. When we focus on the post-GFC period, similar findings are observed as under the contractionary case, with half of the responses being positive and the other half being negative, producing virtually no impact, as also depicted by Nyakabawo et al. (2018). Additionally, we can observe an increase in the average response of the FNAR RV in the COVID-19 period as a result of an expansionary monetary policy, which could be due to the leverage effect via an initial negative impact on the overall REITs returns, or due to the MDH or SIAH involving higher trading volumes.

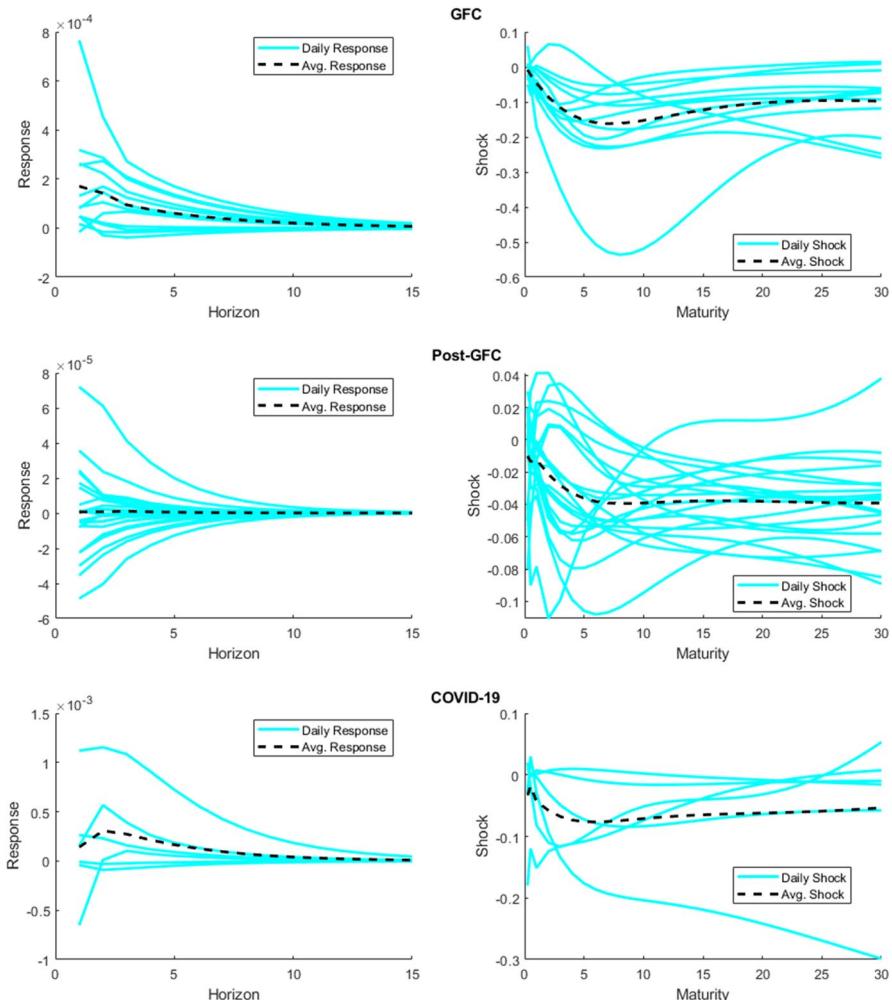


Fig. 7 Response of FNAR RV to expansionary monetary policy shocks. Left: response of RV to shocks. Right: shocks in the yield curves following a monetary policy announcement

From our findings, it is evident that conventional monetary policy also coinciding with relatively calm REITs markets, played a limited role in whatever degree of volatility the sector witnessed due to lesser overall uncertainty and stronger sentiments. In addition, as with returns, the responses of RV of the FNAR to an expansionary monetary policy shock are of a higher magnitude than that of a contractionary one.

Figure 8 (left panel) plots the response of the RJ of the FNAR index to contractionary monetary policy shocks. Our results indicate that, on average, a monetary policy tightening during the GFC period results in a persistent decrease (although at a lower magnitude) of FNAR RJ for more than 15 days. On the contrary, there is only a temporally increase in the FNAR RJ due to a contractionary monetary policy

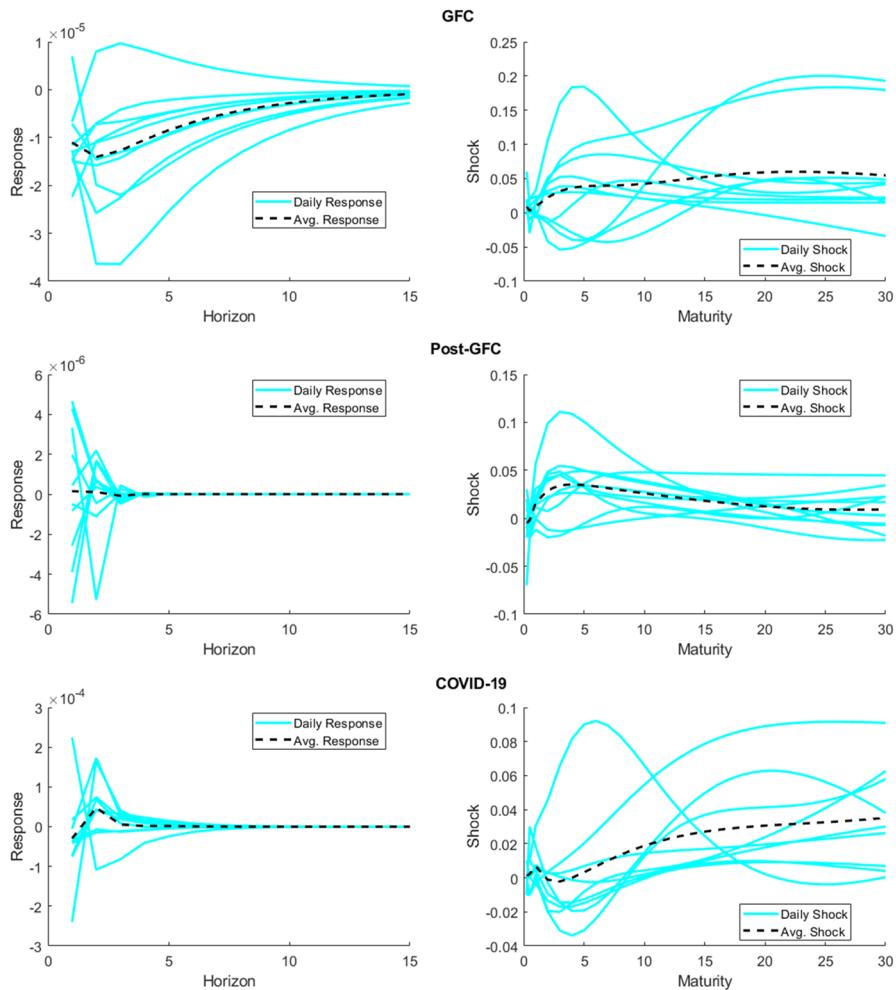


Fig. 8 Response of FNAR RJ to contractionary monetary policy shocks. Left: response of RJ to shocks. Right: shocks in the yield curves following a monetary policy announcement

shock during the COVID-19 period. Interestingly, the effect of contractionary monetary policy shocks on the response of the FNAR RJ is inconclusive during the conventional monetary policy period. The response of the FNAR RJ to expansionary monetary policy shocks is presented in the left panel of Fig. 9. It can be observed that an expansionary monetary policy leads to a persistent increase (at a higher magnitude) to the FNAR RJ, lasting for around 10 days during the GFC period. The FNAR RJ increases for the first two days due to an expansionary monetary policy during post-GFC, but on average, declines. This in turn is not surprising, given that expansionary monetary policy increases returns, and jumps are related more with

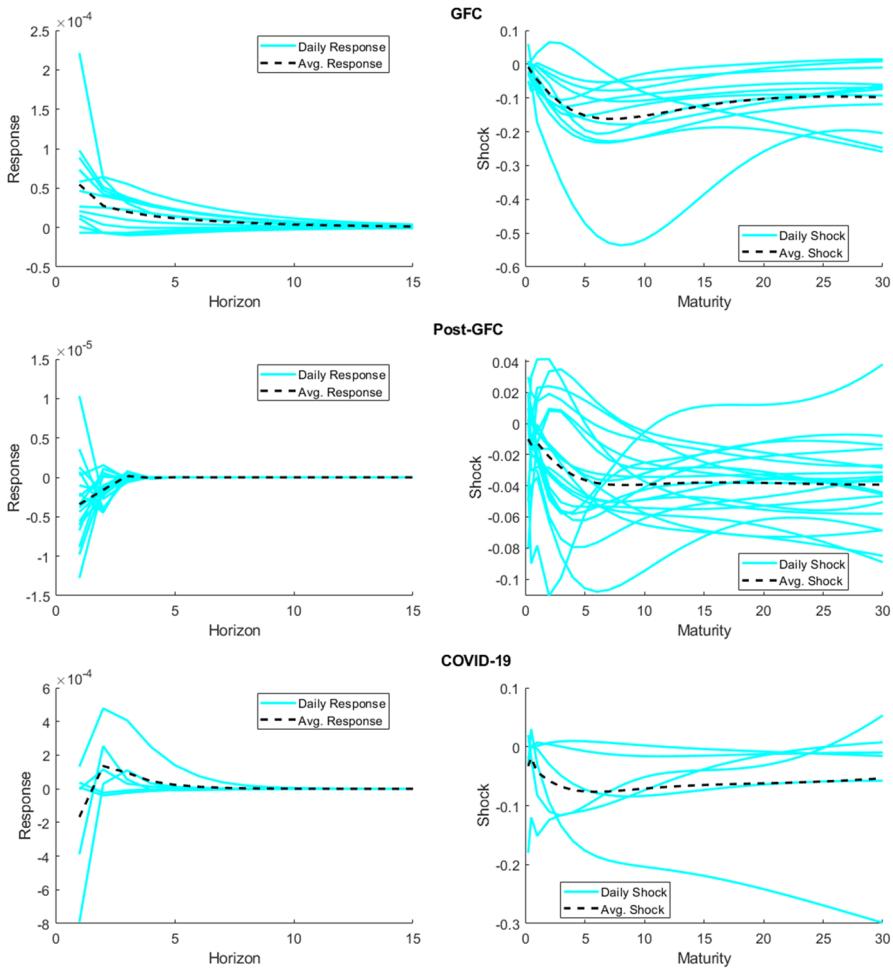


Fig. 9 Response of FNDAR RJ to expansionary monetary policy shocks. Left: response of RJ to shocks. Right: shocks in the yield curves following a monetary policy announcement

bad volatility associated with negative returns. Additionally, we find that an expansionary monetary policy shock during COVID-19 period leads to a modest decrease on the first day, followed by an increase in FNDAR RJ on the second day. Given the importance of RJ in explaining the process of RV as discussed in Odusami (2021a), it is not surprising to see the results mimic those of the RV, particularly during crises, though the impacts are much more persistent. This could be suggesting the role of high-frequency monetary policy shocks in driving sudden market reactions to REITs, is propagated to a large extent by sentiment, beyond discount rates and anticipated profitability effects of monetary policy decisions.

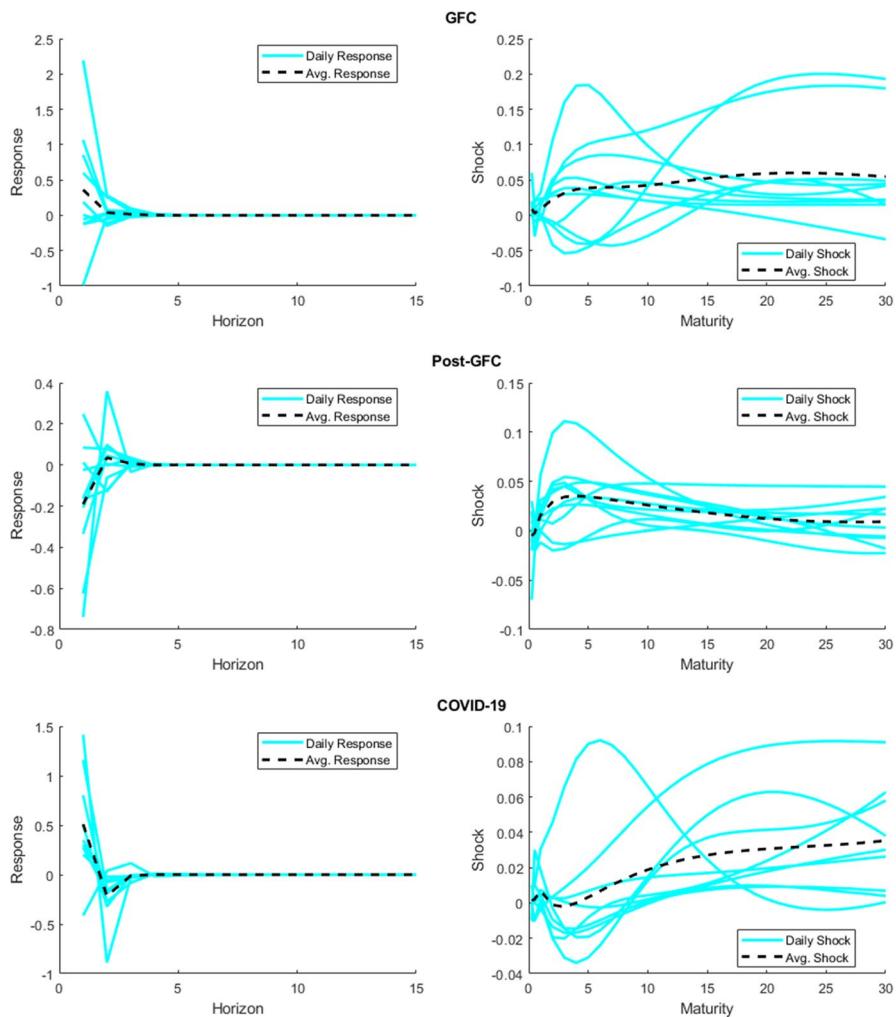


Fig. 10 Response of FNAR RSK to contractionary monetary policy shocks. Left: response of RSK to shocks. Right: shocks in the yield curves following a monetary policy announcement

The left panel of Fig. 10 exhibits the responses of the RSK of the FNAR index to contractionary monetary policy shocks. As the figure indicates, a contractionary monetary policy, on average, induces an increase in the FNAR RSK during the two unconventional periods (GFC and COVID-19) but a decrease in the conventional period (post-GFC). Next, we turn to analyze the response of the FNAR RSK to expansionary monetary policy shocks, as displayed in the left panel of Fig. 11. It is noticeable that the direction of the responses of the FNAR RSK to expansionary monetary policy shocks is precisely in the opposite direction of the response to contractionary monetary policy shocks.

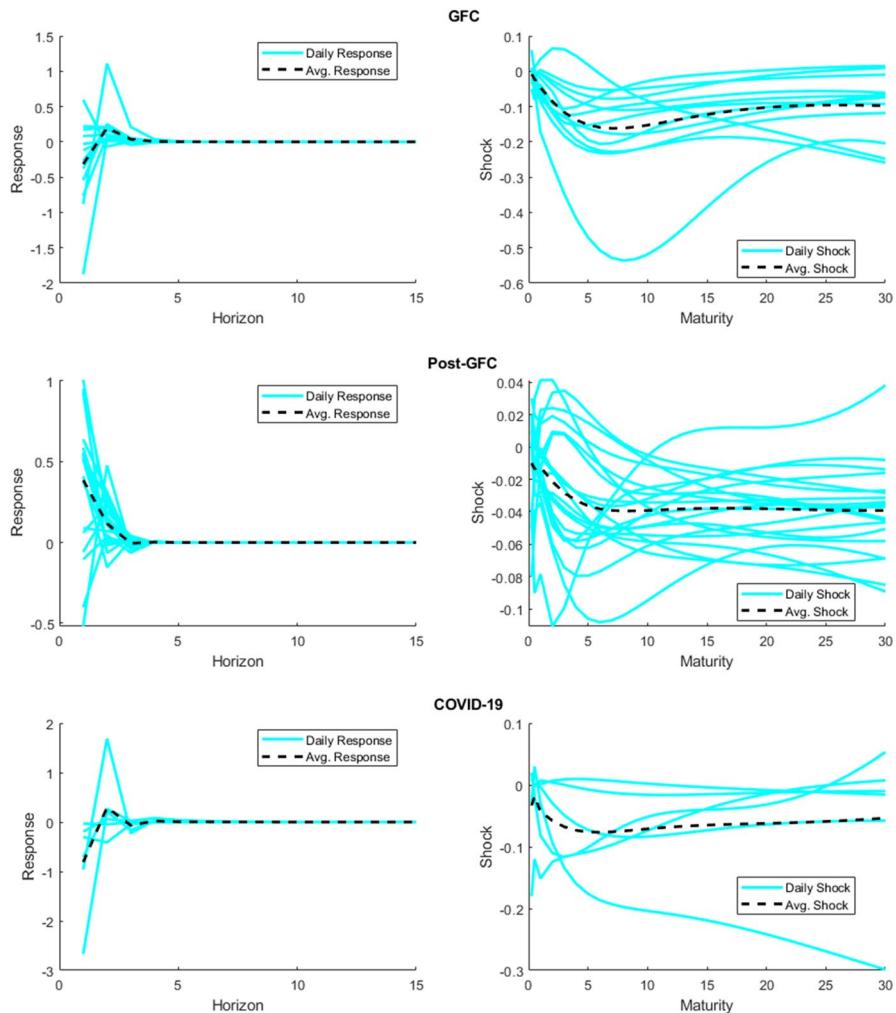


Fig. 11 Response of FNAR RSK to expansionary monetary policy shocks. Left: response of RSK to shocks. Right: shocks in the yield curves following a monetary policy announcement

The left panel of Fig. 12 demonstrates the responses of the RKU of the FNAR index to contractionary monetary policy shocks. During the GFC period, it is difficult to draw a conclusion on the effect of contractionary monetary policy shocks on the FNAR RKU since the average response is close to zero. When it comes to the post-GFC period, the average FNAR RKU has risen for the first two days in response to a contractionary monetary policy shock. Focusing on the COVID-19 period, we detect a delayed response of the FNAR RKU, with the response being near to zero on the first day, but then remarkably increasing on the second and the third days. In terms of expansionary monetary policy shocks, the responses of the

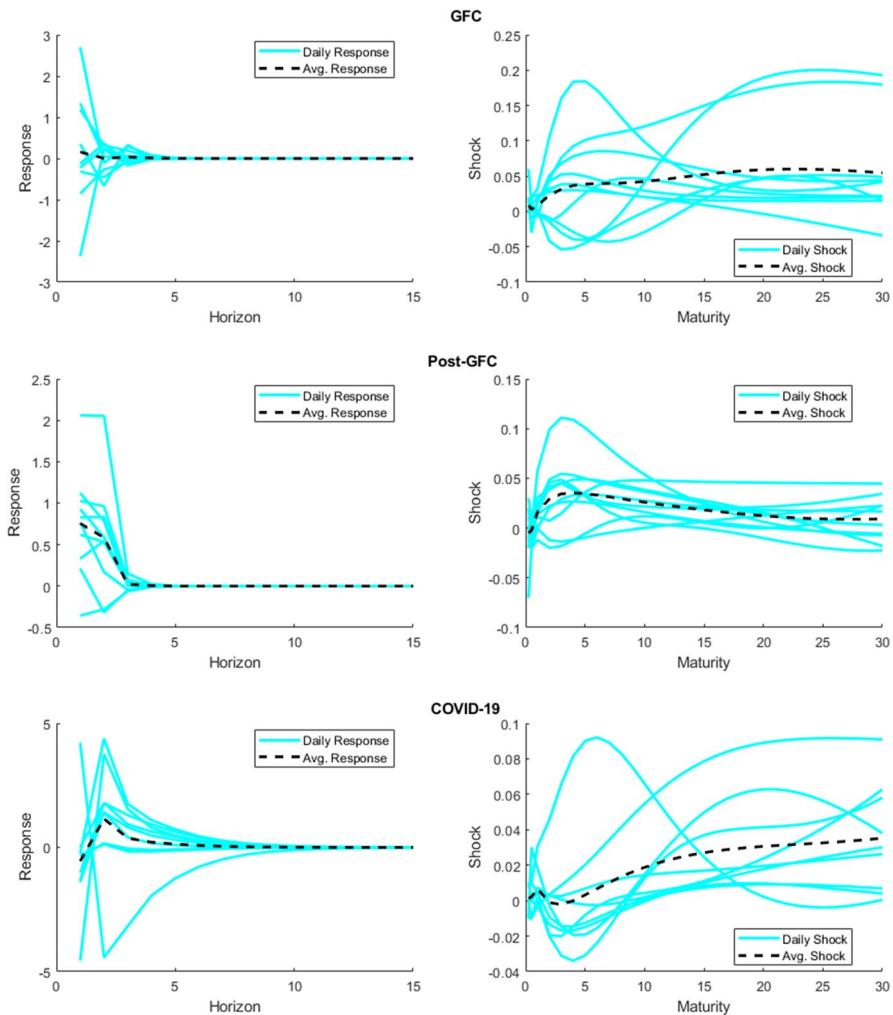


Fig. 12 Response of FNAR RKU to contractionary monetary policy shocks. Left: response of RKU to shocks. Right: shocks in the yield curves following a monetary policy announcement

FNAR RKU are exhibited in the left panel of Fig. 13. We observe, on average, a rise in the FNAR RKU on the first three days during the GFC period. On the contrary, the FNAR RKU falls for the first three days during the post-GFC period. When it comes to the COVID-19 period, an expansionary monetary policy shock leads to an oscillation in the average FNAR RKU, with a decrease on the first day and a similar-sized increase on the second day.

During crises, when returns are already negative, we can conclude that monetary contraction is likely to enhance the degree of asymmetry and extreme

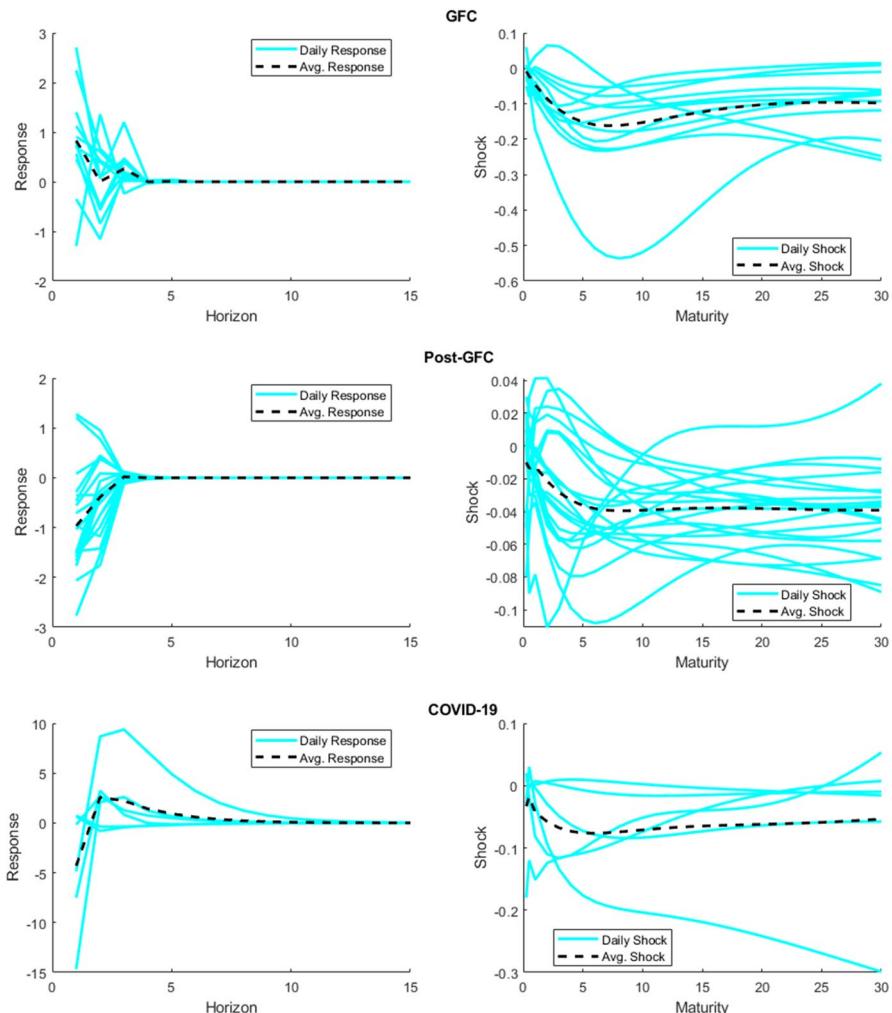


Fig. 13 Response of FNAR RKU to expansionary monetary policy shocks. Left: response of RKU to shocks. Right: shocks in the yield curves following a monetary policy announcement

movements of the overall US REITs market. In other words, tail risks tend to get magnified in such situations, as contractionary monetary policy in particular tends to negatively impact investor sentiment, and hence enhance chances of crash risks in the REITs market.

Meanwhile, it is worthwhile to provide the statistical significance of the various responses. Since we use the Bayesian procedure in Inoue and Rossi (2019) to estimate the model, the typical paradigm to examine the statistical significance in the Bayesian

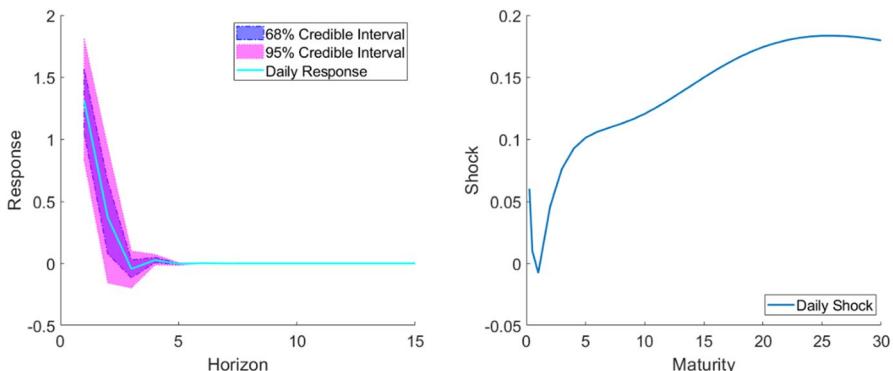


Fig. 14 Example of credible intervals for response to shocks. Left: response of FNAR returns to shocks. Right: shock in the yield curve on January 28, 2009

framework is by using credible intervals.¹⁰ In our setting, we provide credible intervals of responses at two levels, 68% and 95%, based on the posterior distribution of model parameters. The first choice of 68% level follows Inoue and Rossi (2021), while the second choice of 95% is more in line with the traditional convention. To demonstrate the credible interval, we plot an example of credible intervals for the response of FNAR returns to monetary policy shocks on January 28, 2009 in Fig. 14. As can be seen, the response on the first day is outside of both 68% and 95% credible intervals, indicating the statistical significance at the two levels in the Bayesian framework. But the response is only outside of 68% credible interval but not outside of 95% credible interval on the second day, indicating the statistical significance only at 68% level.

To give an overview, Table 3 presents the summary results of the responses of FNAR returns and the higher moments to the contractionary and expansionary shocks of conventional and unconventional functional monetary policy shocks. We present the average response, the number of responses that are outside of the credible intervals, along with the total number of shocks due to contractionary or expansionary monetary policies in the three sub-periods. As can be seen, the response on the first two days generally has higher numbers outside of the credible intervals. Among different moments, the response of RV is most persistent and has highest number outside of the credible intervals. There is no clear pattern between the contractionary and expansionary monetary policies.

Robustness checks

To check whether our results are robust to different settings, we carried out two robustness checks, including 1) using a different criterion of contractionary and

¹⁰ One should not confuse with the confidence interval in the frequentist framework, which has a different conceptual definition and meaning.

Table 3 Summary of FNNAR responses to the shocks of (un)conventional monetary policy

		Contractionary					Expansionary					
		Horizon	1	2	3	4	5	1	2	3	4	5
Panel A: GFC	average	0.620	0.035	0.010	0.002	0.000	-1.124	0.352	-0.039	0.021	-0.003	
	no. outside of 68% CI	9	5	4	6	2	10	7	6	7	5	
	no. outside of 95% CI	8	1	0	0	0	10	4	0	1	0	
	average $\times 10,000$	-0.283	-0.744	-0.627	-0.515	-0.415	1.704	1.422	0.946	0.755	0.602	
	no. outside of 68% CI	7	7	7	7	7	11	9	10	10	10	
	no. outside of 95% CI	5	6	7	7	7	8	7	6	6	6	
	average $\times 10,000$	-0.110	-0.140	-0.127	-0.105	-0.085	0.545	0.275	0.198	0.147	0.117	
	no. outside of 68% CI	4	3	5	6	6	8	6	6	6	6	
	no. outside of 95% CI	2	1	1	1	1	6	2	3	3	3	
	average	0.362	0.039	0.015	0.003	0.000	-0.316	0.198	0.036	0.006	0.001	
Panel B: Post-GFC	no. outside of 68% CI	9	3	7	7	7	9	6	8	6	7	
	no. outside of 95% CI	7	1	1	0	0	5	0	0	0	0	
	average	0.157	0.005	0.033	0.013	0.001	0.831	0.005	0.259	-0.002	0.009	
	no. outside of 68% CI	5	3	4	3	5	6	5	10	2	9	
	no. outside of 95% CI	0	0	0	0	0	1	0	1	0	1	
	Total no. of shocks	10					12					
	average	-0.032	-0.044	-0.001	0.000	0.000	0.127	0.069	0.009	0.000	0.000	
	no. outside of 68% CI	4	4	0	0	0	16	11	4	2	0	
	no. outside of 95% CI	2	1	0	0	0	11	2	0	0	0	
	average $\times 10,000$	-0.050	-0.036	-0.024	-0.016	-0.011	0.006	0.007	0.011	0.007	0.005	
	no. outside of 68% CI	9	7	7	7	7	15	12	13	12	13	

Table 3 (continued)

		Contractionary					Expansionary					
		Horizon	1	2	3	4	5	1	2	3	4	5
RJ	no. outside of 95% CI	8	4	5	5	5	11	7	8	7	7	
	average $\times 10,000$	0.001	0.001	-0.001	0.000	0.000	-0.034	-0.016	0.002	-0.001	0.000	
	no. outside of 68% CI	6	2	1	2	0	13	6	6	6	0	
	no. outside of 95% CI	2	0	0	0	0	11	0	0	0	0	
	average	-0.192	0.036	0.006	-0.001	0.000	0.385	0.116	-0.005	0.003	0.000	
	no. outside of 68% CI	7	3	1	0	0	16	7	2	3	0	
RKU	no. outside of 95% CI	3	0	0	0	0	14	2	0	0	0	
	average	0.754	0.587	0.023	0.005	0.000	-0.969	-0.389	0.019	-0.001	0.000	
	no. outside of 68% CI	7	5	0	0	0	13	5	0	0	0	
	no. outside of 95% CI	1	0	0	0	0	5	0	0	0	0	
	Total no. of shocks	10					20					
	Panel C: COVID-19											
Return	average	0.153	-0.230	-0.003	-0.006	0.001	-1.626	0.887	-0.368	0.115	-0.039	
	no. outside of 68% CI	5	5	3	3	3	3	2	5	3	3	
	no. outside of 95% CI	3	1	2	0	0	3	1	3	1	0	
	average $\times 10,000$	0.276	0.650	0.349	0.254	0.196	1.402	3.068	2.728	2.133	1.651	
	no. outside of 68% CI	4	7	8	8	8	4	5	5	5	5	
	no. outside of 95% CI	4	4	4	4	4	3	4	4	3	3	
RV	average $\times 10,000$	-0.295	0.480	0.053	0.018	0.017	-1.675	1.352	0.951	0.452	0.237	
	no. outside of 68% CI	6	7	7	8	8	3	5	6	5	4	
	no. outside of 95% CI	6	3	2	6	7	3	2	2	2	4	
	average	0.510	-0.215	-0.011	0.001	0.001	-0.811	0.295	-0.067	0.022	0.005	
	no. outside of 68% CI	8	3	0	0	0	4	2	0	0	0	

Table 3 (continued)

	Horizon	Contractionary					Expansionary				
		1	2	3	4	5	1	2	3	4	5
RKU	no. outside of 95% CI	8	2	0	0	0	2	1	0	0	0
	average	-0.554	1.155	0.374	0.210	0.135	-4.301	2.584	2.215	1.422	0.926
	no. outside of 68% CI	4	7	6	6	6	4	3	4	4	4
	no. outside of 95% CI	2	1	1	1	4	2	0	0	0	1
Total no. of shocks		9				6					

expansionary monetary policy; and 2) using different orders of VAR with functional shocks.

We propose to use a criterion to distinguish whether a monetary policy is contractionary or expansionary based on the integral of whole yield curve in Sect. "Contractionary versus expansionary". This is different from the criterion used by Inoue and Rossi (2019). In our first robustness check, we repeat our analysis with the criterion as in Inoue and Rossi (2019): a monetary policy is regarded as contractionary if $\Delta y_{5,t}^* > 0$ (the shock of yield at 5-year maturity is positive) during the unconventional period; if $\Delta y_{1/4,t}^* > 0$ (the shock of yield at 3-month maturity is positive) during the conventional period. The result is presented in Table 5 in Appendix 1. As can be observed, the average responses and the number outside of credible intervals based on the Inoue and Rossi's (2019) criterion are similar to our main analysis, with few exceptions. The differences in those exceptions are either not persistent or marginal in the magnitude.¹¹

In the VAR with functional shocks, we need to choose the order of the model in Eq. (2). In our main analysis, the order is set to be $p = 1$ for the purpose of simplicity. It is possible that the response can be affected by the choice of order. To this end, we repeat our analysis by using $p = 2$ and $p = 3$, and their results are provided in Tables 6 and 7 in Appendix 1, respectively. As can be seen, the results of using $p = 2$ and $p = 3$ are close to our main analysis based on $p = 1$, and their differences are very marginal. Overall, our main conclusion remains the same.

Response in various REIT sectors

Table 4 presents the average response of returns of various REITs sectors to the contractionary and expansionary shocks of conventional and unconventional functional monetary policy shocks. In general, the sign of the responses of the different REITs sectors are similar to that of FNAR during the three sub-periods considered,¹² though the magnitude differs, and highlights different degree of sensitiveness of the sectors to monetary policy shocks, contingent on the length of the lease-term. Note that, strongest (negative) impacts (in particular) following (contractionary) monetary policy shocks are observed for shopping centers, retail, office, regional malls and health care when compared to apartment, residential, and industrial REITs, as the latter group have shorter-term lease agreements which they can reprice quickly by adjusting the rental rates. At the same time, during normal times, especially post the GFC, expansionary monetary policy caused returns in the REITs with shorter lease-terms to be relatively strongly influenced upwards with cyclical and volatile room and occupancy rates. Investors dealing with diversified REITs portfolio should be able to use the sign and degree of responsiveness of the various REITs sub-sectors to monetary policy shocks in reaching optimal decisions considering the

¹¹ Note that we multiple the response of RV and RJ by 10,000.

¹² There are couple of exceptions though, with Industrial (FNIND) showing higher returns during the post-GFC period following a contractionary monetary policy shock, while, Regional Malls (FNMAL) tend to have negative returns during the COVID-19 period due to an expansionary shock, with the latter effect likely due to economic lockdown measures, irrespective of the nature of monetary policies.

Table 4 Average response of returns in various REITs sectors to the shocks of (un)conventional monetary policy

Horizon	Contractionary					Expansionary				
	1	2	3	4	5	1	2	3	4	5
Panel A: GFC										
All Equity REITs (FNER)	0.648	0.041	0.008	0.002	0.000	-1.188	0.352	-0.038	0.022	-0.003
Industrial (FNIND)	0.895	0.198	-0.005	0.008	0.000	-1.664	0.408	-0.025	0.032	-0.004
Office (FNOFF)	0.663	0.104	-0.007	0.006	-0.001	-1.307	0.357	-0.029	0.019	-0.003
Retail (FNRET)	0.655	0.090	0.001	0.005	0.000	-1.251	0.347	-0.015	0.017	-0.002
Apartments (FNAPT)	0.566	0.031	0.011	0.001	0.001	-1.110	0.409	-0.064	0.029	-0.006
Residential (FNRES)	0.564	0.026	0.013	0.001	0.001	-1.096	0.408	-0.060	0.028	-0.006
Shopping Centers (FNSHO)	0.669	0.098	-0.003	0.006	0.000	-1.178	0.270	-0.004	0.015	-0.001
Health Care (FNHEA)	0.476	0.014	0.019	0.000	0.001	-0.823	0.429	-0.065	0.030	-0.006
Composite (FNCO)	0.620	0.038	0.009	0.002	0.000	-1.119	0.347	-0.037	0.021	-0.003
Regional Malls (FNMAL)	0.707	0.108	-0.001	0.006	0.000	-1.490	0.393	-0.012	0.016	-0.001
Panel B: Post-GFC										
All Equity REITs (FNER)	-0.035	-0.044	0.000	0.000	0.000	0.138	0.072	0.010	0.000	0.000
Industrial (FNIND)	0.019	0.022	0.002	0.001	0.000	0.102	0.055	0.013	0.000	0.000
Office (FNOFF)	0.034	-0.005	0.000	0.000	0.000	0.041	0.043	0.006	0.001	0.000
Retail (FNRET)	-0.047	-0.072	-0.002	0.000	0.000	0.138	0.057	0.012	-0.001	0.000
Apartments (FNAPT)	-0.067	-0.028	0.003	0.000	0.000	0.161	0.075	0.006	0.000	0.000
Residential (FNRES)	-0.065	-0.022	0.002	0.000	0.000	0.169	0.077	0.006	0.000	0.000
Shopping Centers (FNSHO)	-0.020	-0.069	-0.002	0.000	0.000	0.122	0.081	0.016	0.000	0.000
Health Care (FNHEA)	-0.178	-0.019	0.001	0.000	0.000	0.337	0.104	0.008	0.001	0.000
Composite (FNCO)	-0.032	-0.044	-0.001	0.000	0.000	0.130	0.070	0.010	0.000	0.000
Regional Malls (FNMAL)	0.040	-0.072	-0.004	0.000	0.000	0.014	0.012	0.010	-0.002	0.000

Table 4 (continued)

Horizon	Contractionary					Expansionary				
	1	2	3	4	5	1	2	3	4	5
Panel C: COVID-19										
All Equity REITs (FNER)	0.150	-0.207	-0.005	-0.005	0.001	-1.661	0.966	-0.388	0.130	-0.043
Industrial (FNIND)	0.132	-0.079	-0.069	0.016	-0.005	-1.418	1.550	-0.444	0.210	-0.042
Office (FNOFF)	0.347	-0.170	-0.043	-0.001	-0.002	-2.011	1.050	-0.285	0.084	-0.012
Retail (FNRET)	0.513	-0.555	-0.022	-0.010	0.000	-2.451	0.207	-0.320	0.007	-0.017
Apartments (FNAPT)	0.382	-0.216	-0.023	-0.001	-0.001	-1.685	0.736	-0.204	0.051	-0.002
Residential (FNRES)	0.291	-0.228	-0.024	-0.002	-0.001	-1.590	0.882	-0.263	0.075	-0.010
Shopping Centers (FNSHO)	0.627	-0.423	-0.071	-0.003	-0.002	-2.373	0.495	-0.275	-0.030	-0.020
Health Care (FNHEA)	0.186	-0.498	-0.008	-0.005	0.008	-1.558	1.324	-0.289	0.210	0.004
Composite (FNCO)	0.152	-0.228	-0.003	-0.006	0.001	-1.633	0.891	-0.369	0.115	-0.039
Regional Malls (FNMAL)	0.823	-0.799	0.014	-0.008	0.001	-3.332	-0.753	-0.514	-0.055	-0.040

lease-terms, with shorter lease terms being more flexible of the REITs would allow them to hedge the risks of economic contraction.

In sum, we do tend to observe asymmetry in the impact of contractionary and expansionary monetary policies in terms of both magnitude and sign of the effect, and the impacts are also contingent on the periods of analyses, i.e., the nature of monetary policy being pursued namely, conventional or unconventional. In general, expansionary policies tend to have a stronger impact.

Finally, Tables 8, 9, 10 and 11 in Appendix 1 present the average response of RV, RJ, RSK, and RKU for the various REIT sectors to the shocks of (un)conventional monetary policy, with the sign of the response being almost identical to the overall market response, though understandably, the magnitude differs, and some exceptions do exist. This information is likely to be of immense value to market participants aiming to diversify their REITs-based portfolios.

Comparison between the response of REIT and stock markets

It is also worthwhile to compare the response between REIT and stock markets, in order to shed light on the uniqueness of the REIT's responsiveness to monetary policy shocks. To this end, we download the 5-min intraday data of S&P 500 index obtained from Bloomberg and compute its realized moments in the same way as Sect. "[Realized moments](#)". Then, we repeat our baseline analysis (i.e., with $p = 1$ based on our definitions of contractionary and expansionary monetary policies) using VARs with functional shocks on the returns, RV, RJ, RSK and RKU of S&P 500, and results are presented in Table 12 in Appendix 1.

By comparing Table 3 and Table 12, the most remarkable difference lies in the response of RJ to the expansionary policy during the unconventional periods. Specifically, the response of RJ in the REIT market has a much larger magnitude than those in the stock market. As noted by Odusami (2021a, b), REITs are highly susceptible to rare disaster events, like the GFC and the COVID-19, which are basically the periods of unconventional monetary policy decisions. The jump risks are likely to average out for the overall stock market, than when a specific sector is considered. Additionally, we can observe a modest distinction between the two markets in the response of RSK and RKU, suggesting similar pattern in terms of crash risk across the REITs and the overall equity markets. Lastly, the response of RV is more persistent in the REITs market during the unconventional periods, which should not come as a surprise given the importance of the jump-component in defining the RV process, with the former being relatively strongly affected for REITs than the S&P500. In fact, Sundaresan (2023), motivated by the literature on inattention, developed a model to show that rare disaster risks mimicking crises episodes trigger persistent spikes in the process of uncertainty, i.e., volatility via jumps.¹³

¹³ In this model, agents choose whether and how to prepare for different possible states of the world by collecting information, but they also optimally ignore sufficiently unlikely events. Hence, the occurrence of such events does not resolve, but increases, uncertainty. With uncertain agents having dispersed beliefs, uncertainty begets uncertainty, and results in endogenous persistence.

Concluding remarks

In line with the current trend of “cleaner” high-frequency identification of monetary policy shocks, and the usage of intraday data of asset prices, we provide, for the first time, a comprehensive analysis of the effects of monetary policy decisions on various moments of the US REITs market. Using 5-min interval intraday data to compute daily statistics namely, returns, realized variance (RV), realized jumps (RJ), realized skewness (RSK) and realized kurtosis (RKU) over the period of September 2008 to June 2021, we analyze the impact of “functional” monetary policy shocks. This, in turn, is captured by the movement of the entire term structure of interest rates on announcement dates, and in the process depict both conventional and unconventional monetary policy shocks, that the Fed undertook during our sample period. Once we obtain the shocks, a VAR model with functional shocks is then used empirically to estimate their effect on the movements of the REITs market.

In general, we tend to find that while the effects of conventional monetary policy shocks on the moments of REITs returns tend to align with existing economic theories, the same cannot be said about unconventional monetary policy shocks, especially from the experience during the GFC, with the REITs market tending to react based on the perception of the information the Fed was trying to convey through its policy decisions. However, investors seemed to have learned to respond more conventionally when looking at the unconventional monetary policy shocks during the recent COVID-19 episode. In addition, though the effects on returns and RV are short-lived, the effect on jumps, capturing sudden movements in the REITs market, is more persistent. Moreover, monetary policy shocks are also shown to affect the extreme behavior of the REITs through the impact on RSK and RKU. Furthermore, we tend to observe asymmetry in the impact of contractionary and expansionary monetary policies in terms of both magnitude and sign of the effect, which, in turn, are also contingent on the periods of analyses, i.e., during GFC, post-GFC, and in the COVID-19 phase. Finally, when we delve into a sectoral analysis, there is indeed heterogeneity in terms of the strength of the effect, but the sign of responses of the various moments aligns with those of the overall market following monetary policy shocks. The fact that monetary policy seems to be affecting the REITs market primarily via RJ, especially during episodes of crises, and also shapes the tail risks of the US REITs market at both the aggregate and sectoral levels, should be valuable information to investors in their design of portfolios involving US REITs, which has grown exponentially as an asset class in the last decade.

Elaborating in this regard, we can point out that the nuanced insights derived from our analysis harbor potential utility for both institutional investors and active traders in the REITs market. Firstly, the asymmetrical and heterogeneous impacts of monetary policy shocks across different REITs sectors and through various moments of their returns, warrant meticulous scrutiny for constructing optimized investment strategies. For instance, our finding that monetary policy shocks impact REITs primarily via RJ, especially during crisis episodes, can serve as a pivotal datum for investors to re-evaluate their risk exposure and hedging strategies. They could, for example, selectively allocate

assets to specific REITs sub-sectors that demonstrate resilience or lower sensitivity to such shocks, thereby curating a portfolio that is potentially more insulated against the vicissitudes of monetary policy fluctuations. The observed persistency in the effect on jumps implies that investors should remain cognizant of lingering impacts and perhaps adapt a more conservative stance in their portfolio management following a policy shock, especially during financially tumultuous periods. This line of reasoning is further confirmed by the fact that driven by the relative dominance of jumps in the REITs market compared to the overall stock market, uncertainty in the former also tends to be more persistent during rare disaster events. Naturally, this suggests that investment in REITs is possibly a better portfolio option, or should carry higher weight, compared to the equity market when the economy is witnessing stability in terms of economic performance. Risk is likely to be better spread across stock market sectors rather than the REITs during crises.

Moreover, the detailed exploration of higher moments such as realized skewness and kurtosis provides a prism through which investors can discern the probability and magnitude of extreme outcomes in the REITs market following monetary policy alterations. Astute investors may exploit this information to tailor their investment strategies, perhaps utilizing derivatives (e.g., options) to hedge against adverse movements in REITs prices or to capitalize on anticipated market shifts. Indeed, discerning the implications of these higher moments is particularly germane for market participants engaging in sophisticated trading strategies that look beyond mere price movements, enveloping nuances of volatility and extreme value theory into their tactical decision-making processes. As for active traders, particularly those employing quantitative or algorithmic trading strategies, understanding the intricate relationship between REITs return moments and monetary policy shocks can be instrumental in fine-tuning their models. For example, they might integrate conditional trading rules or dynamic hedging strategies that are activated in the wake of a significant monetary policy announcement, thereby providing a mechanism to navigate through the ensuing market turbulence.

At the same time, our findings have important monetary policy implications in terms of the so-called “leaning against the wind” concept. The fact that contractionary monetary policy, both conventional and more recently unconventional in nature can negatively impact REITs returns by causing sudden big changes, i.e., jumps, implies that the Fed can in fact control bubbles that might be developing during normal times, especially since monetary policy decisions can impact the uncertainty and extreme behavior of REITs returns as well in terms of RV, RSK and RKU.

As REITs markets of other developed and emerging economies are strongly connected with the US (Ji et al., 2018; Lesame et al., 2021), as is their monetary policy decisions (Antonakakis et al., 2019), it would be interesting to analyse the impact of the Fed’s decision on the moments of other international REITs markets. This, besides the country-specific impact of conventional and unconventional monetary policy decisions on global REITs, would be interesting areas of future research.

Appendix 1

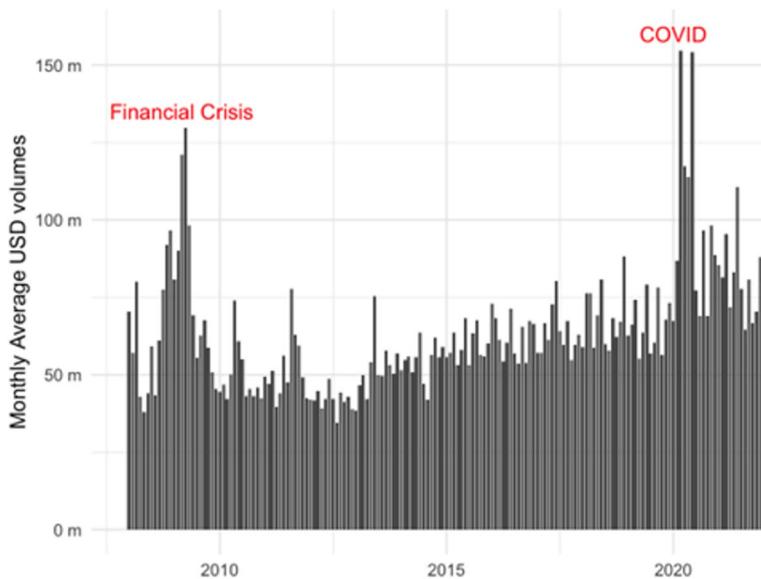


Fig. 15 Monthly average trading volume of FNAR

Table 5 Summary of FNNAR responses to the shocks of (un)conventional monetary policy using Inoue and Rossi's (2019) criterion

		Contractionary					Expansionary					
		Horizon	1	2	3	4	5	1	2	3	4	5
Panel A: GFC	Return	average	0.240	0.009	-0.010	0.000	0.000	-0.657	0.321	-0.021	0.020	-0.002
		no. outside of 68% CI	7	4	2	5	1	12	8	8	8	6
		no. outside of 95% CI	6	1	0	0	0	12	4	0	1	0
		average \times 10,000	-0.382	-0.368	-0.239	-0.187	-0.149	1.477	0.898	0.500	0.386	0.305
		no. outside of 68% CI	5	5	5	5	5	13	11	12	12	12
		no. outside of 95% CI	5	4	4	4	4	8	9	9	9	9
		average \times 10,000	-0.125	-0.105	-0.086	-0.067	-0.053	0.459	0.195	0.128	0.090	0.070
		no. outside of 68% CI	4	3	4	4	4	8	6	7	8	8
		no. outside of 95% CI	2	1	1	1	1	6	2	3	3	3
		average	-0.238	-0.018	-0.009	-0.002	0.000	0.124	0.208	0.047	0.008	0.002
Panel B: Post-GFC	Return	average	0.148	0.054	0.003	0.001	0.000	0.032	0.019	0.008	0.000	0.000
		no. outside of 68% CI	7	6	1	1	0	13	9	3	1	0
		no. outside of 95% CI	5	2	0	0	0	8	1	0	0	0
		average \times 10,000	-0.185	-0.111	-0.076	-0.052	-0.036	0.087	0.052	0.043	0.029	0.020
		no. outside of 68% CI	8	7	7	7	7	16	12	13	12	13
		no. outside of 95% CI	7	6	6	6	6	12	5	7	6	6
		Total no. of shocks	8					14				

Table 5 (continued)

	Horizon	Contractionary					Expansionary				
		1	2	3	4	5	1	2	3	4	5
RJ	average $\times 10,000$	-0.050	0.005	-0.001	0.000	0.000	-0.006	-0.019	0.002	-0.001	0.000
	no. outside of 68% CI	9	1	1	3	0	10	7	6	5	0
	no. outside of 95% CI	5	0	0	0	0	8	0	0	0	0
	average	0.469	0.050	0.003	0.002	0.000	0.033	0.112	-0.004	0.002	0.000
	no. outside of 68% CI	8	3	1	1	0	15	7	2	2	0
	no. outside of 95% CI	8	0	0	0	0	9	2	0	0	0
RSK	average	-0.469	0.125	0.063	0.005	0.001	-0.351	-0.172	-0.005	-0.001	-0.001
	no. outside of 68% CI	6	3	0	0	0	14	7	0	0	0
	no. outside of 95% CI	3	0	0	0	0	3	0	0	0	0
	Total no. of shocks	11					19				
	Panel C: COVID-19										
	Return	0.487	-0.333	0.117	-0.038	0.013	-0.939	0.417	-0.245	0.071	-0.025
RV	no. outside of 68% CI	2	2	2	2	2	6	5	6	4	4
	no. outside of 95% CI	2	1	2	0	0	4	1	3	1	0
	average $\times 10,000$	-0.337	-0.497	-0.452	-0.346	-0.271	1.113	2.386	1.938	1.497	1.160
	no. outside of 68% CI	1	2	3	3	3	7	10	10	10	10
	no. outside of 95% CI	1	0	1	1	1	6	8	7	6	6
	average $\times 10,000$	0.470	-0.246	-0.180	-0.077	-0.043	-1.326	1.220	0.628	0.289	0.158
RJ	no. outside of 68% CI	3	2	4	4	4	6	10	9	9	8
	no. outside of 95% CI	3	0	1	3	4	6	5	3	5	7
	average	0.214	-0.028	0.029	-0.003	-0.001	-0.103	-0.005	-0.056	0.014	0.004
	no. outside of 68% CI	3	0	0	0	0	9	5	0	0	0
	no. outside of 95% CI	3	0	0	0	0	7	3	0	0	0

Table 5 (continued)

	Horizon	Contractionary					Expansionary				
		1	2	3	4	5	1	2	3	4	5
RKU	average	0.888	-0.830	-0.616	-0.357	-0.225	-3.122	2.657	1.738	1.077	0.697
	no. outside of 68% CI	2	3	3	3	3	6	7	7	7	7
	no. outside of 95% CI	0	0	1	1	3	4	1	0	0	2
Total no. of shocks		4				11					

Table 6 Summary of FNAR responses to the shocks of (un)conventional monetary policy using $p = 2$

		Contractionary					Expansionary						
		Horizon		1			2		3			4	
Panel A: GFC													
Return	average	0.625	0.081	-0.258	0.031	-0.018	-1.093	0.443	-0.591	0.096	0.013		
	no. outside of 68% CI	9	6	8	7	4	12.00	7	10	8	3		
	no. outside of 95% CI	8	4	7	4	0	10	5	8	3	0		
RV	average	-0.359	-0.841	-0.571	-0.539	-0.457	1.491	1.328	1.219	0.921	0.837		
	no. outside of 68% CI	8	8	7	7	6	9	10	8	8	8		
	no. outside of 95% CI	7	7	4	5	5	7	7	6	6	6		
RJ	average	-0.096	-0.192	0.070	-0.032	0.000	0.553	0.217	0.189	0.180	0.171		
	no. outside of 68% CI	5	7	2	2	2	11	6	4	6	4		
	no. outside of 95% CI	3	1	1	0	0	6	3	0	1	1		
RSK	average	0.356	0.042	-0.081	0.016	0.002	-0.295	0.223	0.065	0.001	-0.011		
	no. outside of 68% CI	9	3	2	1	0	9	7	1	0	0		
	no. outside of 95% CI	7	0	0	0	0	5	0	0	0	0		
RKU	average	0.075	-0.068	0.015	0.072	0.085	0.857	-0.129	1.078	0.318	0.091		
	no. outside of 68% CI	5	2	3	7	7	8	2	7	7	5		
	no. outside of 95% CI	2	0	0	0	0	1	0	0	0	0		
Total no. of shocks		10					12						
Panel B: Post-GFC													
Return	average	-0.036	-0.034	0.027	-0.009	0.003	0.131	0.074	-0.026	-0.005	-0.004		
	no. outside of 68% CI	4	2	3	3	1	17.00	14	8	7	4		
	no. outside of 95% CI	2	1	0	0	0	12	4	0	0	0		
RV	average	-0.052	-0.043	-0.063	-0.043	-0.040	0.016	0.010	0.035	0.033	0.031		
	no. outside of 68% CI	9	7	9	7	7	15	12	12	13	11		

Table 6 (continued)

		Contractionary					Expansionary					
		Horizon	1	2	3	4	5	1	2	3	4	5
RJ	no. outside of 95% CI	8	4	3	4	4	11	8	7	7	7	
	average	0.001	-0.003	0.001	0.003	0.000	-0.032	-0.015	0.002	0.000	0.000	
	no. outside of 68% CI	6	2	1	3	2	13	8	7	5	3	
	no. outside of 95% CI	2	0	0	0	0	11	0	0	0	0	
	average	-0.191	0.055	0.119	-0.035	-0.009	0.389	0.119	-0.053	0.009	-0.002	
	no. outside of 68% CI	7	3	3	6	0	16	9	10	6	3	
RJKU	no. outside of 95% CI	3	0	0	0	0	14	2	0	1	0	
	average	0.789	0.546	0.063	0.052	-0.007	-0.963	-0.346	0.204	-0.035	0.030	
	no. outside of 68% CI	7	5	0	0	0	13	4	3	0	0	
	no. outside of 95% CI	2	0	0	0	0	5	0	0	0	0	
	Total no. of shocks	10					20					
	Panel C: COVID-19											
RV	Return		0.133	-0.163	-0.460	-0.019	-0.234	-1.550	0.843	-1.134	0.223	
	no. outside of 68% CI	6	3	9	1	9	3.00	3	4	3	2	
	no. outside of 95% CI	3	0	8	0	7	3	1	4	1	1	
	average	0.589	0.512	0.481	0.603	0.294	-1.638	1.966	-0.023	-0.006	-0.649	
	no. outside of 68% CI	8	6	3	4	1	4	5	2	2	1	
	no. outside of 95% CI	5	4	0	2	0	2	4	0	2	0	
RJ	average	-0.191	0.300	-0.665	0.016	-0.234	-2.127	1.647	1.301	-0.408	0.234	
	no. outside of 68% CI	7	8	6	1	7	4	3	2	2	5	
	no. outside of 95% CI	6	3	3	0	3	3	2	1	1	3	
	average	0.518	-0.237	0.133	-0.003	-0.015	-1.110	0.607	-0.692	0.079	-0.047	
	no. outside of 68% CI	8	4	4	1	0	5	4	3	1	0	

Table 6 (continued)

	Horizon	Contractionary					Expansionary				
		1	2	3	4	5	1	2	3	4	5
RKU	no. outside of 95% CI	7	2	0	0	0	2	1	2	0	0
	average	0.486	1.459	-1.106	-0.006	-0.342	-5.096	0.522	4.049	-0.036	1.927
	no. outside of 68% CI	6	7	5	2	5	2	1	2	2	5
	no. outside of 95% CI	0	3	0	0	2	2	0	2	1	3
Total no. of shocks		9				6					

Table 7 Summary of FNAR responses to the shocks of (un)conventional monetary policy using $p = 3$

		Contractionary					Expansionary				
		Horizon	1	2	3	4	5	1	2	3	4
Panel A: GFC	Return	average	0.636	0.090	-0.274	-0.013	0.002	-1.112	0.425	-0.563	0.015
		no. outside of 68% CI	9	6	8	4	3	11.00	6	9	4
		no. outside of 95% CI	8	3	7	0	0	10	5	8	0
	RV	average	-0.394	-0.869	-0.627	-0.586	-0.558	1.327	0.940	0.969	1.536
		no. outside of 68% CI	7	8	7	8	9	9	10	7	11
		no. outside of 95% CI	4	6	5	4	5	6	7	5	9
	RJ	average	-0.093	-0.170	0.064	-0.254	-0.168	0.558	0.246	0.238	0.090
		no. outside of 68% CI	6	6	4	5	5	10	8	5	0.089
		no. outside of 95% CI	2	1	0	2	2	6	2	0	0
	RSK	average	0.360	0.051	-0.083	-0.058	0.015	-0.294	0.252	0.092	0.038
Panel B: Post-GFC	Return	average	0.114	-0.059	0.022	-0.263	0.099	0.848	-0.168	1.008	0.403
		no. outside of 68% CI	5	2	3	4	1	7	2	5	0.032
		no. outside of 95% CI	1	0	0	0	0	1	0	4	0
		Total no. of shocks	10					12			
	RV	average	-0.028	-0.029	0.017	-0.078	-0.006	0.127	0.067	-0.024	0.041
		no. outside of 68% CI	4	1	4	8	1	17.00	13	11	0.007
		no. outside of 95% CI	2	1	0	3	0	13	3	1	2
		average	-0.056	-0.046	-0.070	-0.100	-0.067	0.014	0.008	0.031	0.049
		no. outside of 68% CI	9	7	8	8	9	15	11	13	14
											15

Table 7 (continued)

		Contractionary					Expansionary					
		Horizon	1	2	3	4	5	1	2	3	4	5
RJ	no. outside of 95% CI	8	4	3	6	6	12	7	7	7	8	
	average	0.000	-0.003	-0.002	-0.021	0.003	-0.033	-0.015	0.002	0.006	0.002	
	no. outside of 68% CI	6	2	1	5	3	13	7	8	3	5	
	no. outside of 95% CI	2	0	0	0	0	11	0	0	0	0	
	average	-0.177	0.064	0.124	-0.178	-0.012	0.387	0.111	-0.041	0.127	-0.016	
	no. outside of 68% CI	7	4	4	5	3	16	7	10	12	11	
RKU	no. outside of 95% CI	3	0	0	3	1	14	2	2	3	6	
	average	0.771	0.501	-0.051	-0.074	0.027	-0.954	-0.281	0.223	-0.175	-0.015	
	no. outside of 68% CI	7	4	0	1	0	13	4	2	3	0	
	no. outside of 95% CI	2	0	0	0	0	5	0	0	0	0	
	Total no. of shocks	10					20					
	Panel C: COVID-19											
RV	Return	0.183	-0.341	-0.603	0.127	-0.203	-1.118	1.026	0.254	-0.473	0.587	
	no. outside of 68% CI	5	5	9	6	5	4.00	4	4	5	3	
	no. outside of 95% CI	3	3	9	2	1	2	1	3	3	1	
	average	0.423	0.972	0.884	-0.049	0.213	-2.260	1.011	-2.814	-0.613	-1.077	
	no. outside of 68% CI	8	6	5	8	7	3	5	4	3	3	
	no. outside of 95% CI	5	5	5	3	3	3	4	4	2	2	
RJ	average	-0.196	0.488	-0.595	-0.240	-0.187	-2.013	1.751	0.192	0.912	1.428	
	no. outside of 68% CI	8	8	5	3	4	3	5	2	2	4	
	no. outside of 95% CI	6	4	4	2	2	3	3	0	1	2	
	average	0.517	-0.318	0.057	-0.063	0.083	-1.022	0.436	-0.143	-0.477	-0.046	
	no. outside of 68% CI	8	8	0	4	8	5	4	0	4	3	

Table 7 (continued)

	Horizon	Contractionary					Expansionary				
		1	2	3	4	5	1	2	3	4	5
RKU	no. outside of 95% CI	7	2	0	1	0	2	1	0	1	0
	average	0.353	1.586	-1.375	-0.069	-0.315	-5.315	0.587	4.342	0.786	1.140
	no. outside of 68% CI	3	8	5	1	2	4	1	2	1	3
	no. outside of 95% CI	0	2	0	0	0	2	0	1	0	0
Total no. of shocks		9				6					

Table 8 Average response (multiply by 10,000) of RV in various REITs sectors to the shocks of (un)conventional monetary policy

Horizon	Panel A: GFC	Contractionary					Expansionary				
		1	2	3	4	5	1	2	3	4	5
All Equity REITs (FNER)	-0.266	-0.761	-0.645	-0.532	-0.431	1.819	1.535	1.034	0.829	0.665	
Industrial (FNIND)	-0.623	-1.488	-1.176	-0.925	-0.707	2.310	2.383	1.210	0.961	0.718	
Office (FNOFF)	-0.302	-0.793	-0.662	-0.540	-0.432	2.160	1.823	1.254	0.992	0.786	
Retail (FNRET)	-0.303	-0.781	-0.668	-0.562	-0.462	1.790	1.739	1.170	0.960	0.780	
Apartments (FNAPT)	-0.269	-0.716	-0.599	-0.490	-0.393	1.773	1.613	1.094	0.865	0.685	
Residual (FNRES)	-0.247	-0.718	-0.602	-0.494	-0.396	1.745	1.554	1.044	0.825	0.655	
Shopping Centers (FNSHO)	-0.170	-0.680	-0.587	-0.491	-0.402	1.851	1.605	1.080	0.876	0.708	
Health Care (FNHEA)	-0.149	-0.859	-0.730	-0.605	-0.490	1.681	1.652	1.067	0.850	0.679	
Composite (FNCO)	-0.272	-0.751	-0.633	-0.520	-0.419	1.718	1.446	0.961	0.767	0.612	
Regional Malls (FNMAL)	-0.599	-1.191	-0.986	-0.814	-0.658	2.144	2.241	1.436	1.176	0.940	
Panel B: Post-GFC											
All Equity REITs (FNER)	-0.050	-0.041	-0.026	-0.017	-0.011	0.000	0.003	0.008	0.005	0.003	
Industrial (FNIND)	-0.113	-0.051	-0.027	-0.015	-0.009	0.009	-0.005	0.005	0.001	0.001	
Office (FNOFF)	-0.044	-0.053	-0.030	-0.018	-0.011	0.034	0.026	0.020	0.011	0.007	
Retail (FNRET)	-0.037	-0.006	-0.004	-0.002	-0.001	-0.051	-0.051	-0.019	-0.010	-0.005	
Apartments (FNAPT)	-0.052	-0.019	-0.011	-0.007	-0.004	0.027	-0.006	0.001	0.001	0.001	
Residual (FNRES)	-0.054	-0.027	-0.016	-0.010	-0.006	0.018	-0.009	-0.001	0.000	0.000	
Shopping Centers (FNSHO)	-0.045	-0.013	-0.008	-0.004	-0.002	-0.017	-0.018	-0.005	-0.004	-0.002	
Health Care (FNHEA)	-0.032	-0.011	-0.006	-0.003	-0.002	-0.096	-0.070	-0.034	-0.020	-0.011	
Composite (FNCO)	-0.049	-0.037	-0.025	-0.017	-0.012	0.006	0.008	0.011	0.007	0.005	
Regional Malls (FNMAL)	-0.063	0.002	-0.003	-0.001	0.000	-0.005	-0.056	-0.019	-0.007	-0.002	
Panel C: COVID-19											

Table 8 (continued)

Horizon	Contractionary					Expansionary				
	1	2	3	4	5	1	2	3	4	5
All Equity REITs (FNER)	0.315	0.687	0.354	0.253	0.197	1.421	3.230	2.893	2.252	1.737
Industrial (FNIND)	1.401	1.280	0.870	0.567	0.392	5.295	3.200	2.731	1.979	1.409
Office (FNOFF)	0.510	0.383	0.039	0.039	0.043	2.144	4.502	3.405	2.279	1.509
Retail (FNRET)	-0.072	0.725	0.398	0.275	0.188	1.543	4.739	3.915	2.850	1.965
Apartments (FNAPT)	1.091	1.229	0.655	0.355	0.206	3.810	2.795	2.144	1.365	0.853
Residual (FNRESS)	0.761	0.793	0.459	0.287	0.187	3.299	2.954	2.225	1.527	1.033
Shopping Centers (FNSHO)	0.060	0.101	0.018	0.081	0.067	1.948	5.160	3.439	2.389	1.580
Health Care (FNHEA)	-0.033	0.867	0.514	0.355	0.247	3.098	5.310	4.397	3.279	2.337
Composite (FNCO)	0.283	0.655	0.355	0.258	0.199	1.462	3.095	2.751	2.152	1.666
Regional Malls (FNMAL)	5.428	2.944	1.007	0.426	0.251	12.451	11.299	8.455	4.787	2.661

Table 9 Average response (multiply by 10,000) of RJ in various REITs sectors to the shocks of (un)conventional monetary policy

Horizon	Contractionary					Expansionary				
	1	2	3	4	5	1	2	3	4	5
Panel A: GFC										
All Equity REITs (FNER)	-0.096	-0.154	-0.143	-0.119	-0.097	0.608	0.287	0.206	0.152	0.121
Industrial (FNIND)	-0.213	-0.194	-0.126	-0.088	-0.060	0.615	0.692	0.438	0.298	0.200
Office (FNOFF)	-0.101	-0.203	-0.181	-0.149	-0.120	0.655	0.346	0.257	0.187	0.148
Retail (FNRET)	-0.049	-0.135	-0.132	-0.110	-0.088	0.642	0.262	0.138	0.092	0.069
Apartments (FNAPT)	-0.112	-0.112	-0.116	-0.096	-0.077	0.845	0.360	0.243	0.170	0.131
Residual (FNRES)	-0.093	-0.124	-0.128	-0.106	-0.085	0.860	0.343	0.221	0.153	0.117
Shopping Centers (FNSHO)	0.085	0.047	0.022	0.013	0.010	0.741	0.481	0.332	0.248	0.190
Health Care (FNHEA)	0.055	-0.160	-0.141	-0.113	-0.088	0.644	0.504	0.314	0.224	0.167
Composite (FNCO)	-0.103	-0.142	-0.127	-0.105	-0.084	0.548	0.302	0.221	0.165	0.131
Regional Malls (FNMAL)	-0.161	-0.303	-0.248	-0.185	-0.134	1.097	0.605	0.322	0.217	0.151
Panel B: Post-GFC										
All Equity REITs (FNER)	0.003	0.001	-0.001	0.000	0.000	-0.036	-0.015	0.002	-0.001	0.000
Industrial (FNIND)	-0.007	0.020	-0.001	0.000	0.000	-0.079	-0.032	-0.001	-0.001	0.000
Office (FNOFF)	-0.009	-0.014	0.000	0.000	0.000	0.004	-0.009	0.003	-0.001	0.000
Retail (FNRET)	0.002	0.044	-0.003	0.000	0.000	-0.079	-0.043	0.003	-0.001	0.000
Apartments (FNAPT)	0.007	0.003	0.000	0.000	0.000	-0.025	-0.009	-0.002	0.000	0.000
Residual (FNRES)	0.000	0.007	0.000	0.000	0.000	-0.024	-0.014	-0.001	0.000	0.000
Shopping Centers (FNSHO)	-0.002	0.021	0.001	0.000	0.000	-0.028	-0.016	0.004	0.000	0.000
Health Care (FNHEA)	0.033	0.003	-0.002	0.000	0.000	-0.132	-0.038	-0.003	-0.002	0.000
Composite (FNCO)	0.002	0.001	-0.001	0.000	0.000	-0.034	-0.016	0.002	-0.001	0.000
Regional Malls (FNMAL)	-0.028	0.057	-0.004	0.000	0.000	-0.020	-0.063	0.000	-0.001	0.000

Table 9 (continued)

Horizon	Contractionary					Expansionary				
	1	2	3	4	5	1	2	3	4	5
Panel C: COVID-19										
All Equity REITs (FNER)	-0.313	0.465	0.041	0.012	0.015	-1.604	1.398	0.973	0.451	0.232
Industrial (FNIND)	0.762	1.145	0.179	0.029	0.037	1.888	0.579	1.331	0.475	0.243
Office (FNOFF)	-0.166	0.254	-0.043	-0.019	0.004	-1.352	1.090	0.788	0.333	0.167
Retail (FNRET)	-0.853	0.743	-0.014	0.010	0.020	-3.431	2.954	1.496	0.660	0.336
Apartments (FNAPT)	0.761	1.460	0.247	0.034	0.020	1.870	-0.298	0.728	0.160	0.075
Residual (FNRES)	0.357	0.827	0.123	0.003	0.006	1.099	-0.091	0.424	0.097	0.040
Shopping Centers (FNSHO)	-0.192	0.902	0.185	0.048	0.019	-2.769	0.435	0.289	0.045	0.011
Health Care (FNHEA)	-1.169	0.989	0.179	0.047	0.025	-1.420	1.791	1.077	0.445	0.210
Composite (FNCO)	-0.298	0.484	0.055	0.018	0.017	-1.676	1.364	0.960	0.457	0.239
Regional Malls (FNMAL)	5.358	3.286	0.165	-0.003	0.046	3.001	1.212	3.595	0.990	0.560

Table 10 Average response of RSK in various REITs sectors to the shocks of (un)conventional monetary policy

Horizon	Contractionary					Expansionary				
	1	2	3	4	5	1	2	3	4	5
Panel A: GFC										
All Equity REITs (FNER)	0.358	0.047	0.014	0.003	0.001	-0.340	0.178	0.030	0.007	0.001
Industrial (FNIND)	0.511	-0.004	0.007	0.001	0.000	-0.761	0.115	-0.010	0.008	0.000
Office (FNOFF)	0.446	0.048	0.006	0.001	0.000	-0.666	0.139	0.012	0.003	0.000
Retail (FNRET)	0.436	0.010	0.013	0.001	0.000	-0.556	0.244	0.014	0.005	0.000
Apartments (FNAPT)	0.361	0.063	0.009	0.002	0.000	-0.537	0.165	0.029	0.002	0.001
Residential (FNRES)	0.370	0.063	0.009	0.002	0.000	-0.536	0.170	0.031	0.002	0.001
Shopping Centers (FNSHO)	0.445	0.003	0.007	0.001	0.000	-0.629	0.122	0.002	0.005	0.000
Health Care (FNHEA)	0.250	0.015	0.016	0.002	0.000	-0.239	0.279	0.017	0.007	0.001
Composite (FNCO)	0.347	0.034	0.015	0.003	0.001	-0.302	0.194	0.031	0.007	0.001
Regional Malls (FNMAL)	0.407	0.022	0.012	0.002	0.000	-0.573	0.218	0.024	0.003	0.001
Panel B: Post-GFC										
All Equity REITs (FNER)	-0.197	0.039	0.006	-0.001	0.000	0.411	0.119	-0.007	0.003	0.000
Industrial (FNIND)	-0.091	0.077	0.002	0.000	0.000	0.268	0.091	0.000	0.002	0.000
Office (FNOFF)	0.022	0.082	0.000	0.001	0.000	0.092	0.086	0.001	0.003	0.000
Retail (FNRET)	-0.183	0.029	0.001	0.000	0.000	0.324	0.023	0.007	0.001	0.000
Apartments (FNAPT)	-0.230	0.048	0.005	-0.001	0.000	0.447	0.104	-0.005	0.002	0.000
Residential (FNRES)	-0.228	0.063	0.005	-0.001	0.000	0.452	0.121	-0.010	0.003	0.000
Shopping Centers (FNSHO)	-0.166	0.085	-0.001	0.000	0.000	0.302	0.054	0.005	0.003	0.000
Health Care (FNHEA)	-0.406	0.073	0.001	0.000	0.000	0.727	0.117	-0.003	0.005	-0.001
Composite (FNCO)	-0.196	0.034	0.006	-0.001	0.000	0.393	0.118	-0.005	0.003	0.000
Regional Malls (FNMAL)	-0.022	0.003	0.000	0.000	0.000	0.075	-0.019	0.007	0.000	0.000

Table 10 (continued)

Horizon	Contractionary					Expansionary				
	1	2	3	4	5	1	2	3	4	5
Panel C: COVID-19										
All Equity REITs (FNER)	0.502	-0.214	-0.012	0.001	0.001	-0.308	0.290	-0.066	0.021	0.005
Industrial (FNIND)	0.378	-0.116	-0.041	-0.001	0.000	-0.343	0.540	-0.067	0.028	0.006
Office (FNOFF)	0.496	-0.234	-0.014	0.001	0.001	-1.004	0.330	-0.049	0.034	0.012
Retail (FNRET)	0.631	-0.266	-0.008	-0.001	0.000	-1.049	0.021	-0.128	-0.007	-0.008
Apartments (FNAPT)	0.413	-0.203	-0.020	0.003	0.001	-0.926	0.385	-0.074	0.028	0.009
Residential (FNRES)	0.403	-0.180	-0.012	0.003	0.002	-0.886	0.406	-0.061	0.036	0.010
Shopping Centers (FNSHO)	0.591	-0.259	-0.016	-0.002	0.000	-0.920	0.046	-0.087	0.001	-0.002
Health Care (FNHCA)	0.480	-0.208	-0.016	0.003	0.001	-0.583	0.141	-0.086	0.009	0.002
Composite (FNCO)	0.506	-0.212	-0.011	0.001	0.001	-0.898	0.294	-0.067	0.021	0.005
Regional Malls (FNMAL)	0.538	-0.233	0.007	-0.004	-0.002	-1.360	-0.086	-0.225	-0.043	-0.032

Table 11 Average response of RRU in various REITs sectors to the shocks of (un)conventional monetary policy

Horizon	Panel A: GFC	Contractionary					Expansionary				
		1	2	3	4	5	1	2	3	4	5
Panel A: GFC											
All Equity REITs (FNER)	0.243	0.028	0.027	0.012	0.001	0.579	-0.080	0.256	-0.006	0.009	
Industrial (FNIND)	-0.303	0.282	0.017	0.007	0.001	0.045	-0.353	0.136	0.000	0.005	
Office (FNOFF)	-0.031	0.244	0.019	0.007	0.000	0.525	-0.151	0.145	0.000	0.004	
Retail (FNRET)	0.280	0.434	0.034	0.013	0.002	-0.015	-0.269	0.201	0.010	0.007	
Apartments (FNAPT)	-0.127	0.688	0.029	0.012	0.003	0.723	-0.586	0.157	0.029	0.007	
Residential (FNRES)	-0.105	0.642	0.026	0.012	0.002	0.729	-0.583	0.165	0.026	0.007	
Shopping Centers (FNSHO)	-0.089	0.338	0.035	0.010	0.001	0.910	0.103	0.174	0.009	0.005	
Health Care (FNHEA)	0.286	0.397	0.062	0.015	0.001	0.382	0.488	0.272	0.012	0.008	
Composite (FNCO)	0.249	-0.029	0.024	0.011	0.000	0.723	-0.117	0.249	-0.009	0.009	
Regional Malls (FNMAL)	0.392	0.465	0.044	0.015	0.002	-0.070	-0.076	0.213	0.018	0.008	
Panel B: Post-GFC											
All Equity REITs (FNER)	0.798	0.508	0.018	0.005	0.000	-0.996	-0.431	0.019	-0.006	0.000	
Industrial (FNIND)	0.449	0.248	-0.001	0.003	0.000	-0.709	-0.513	0.022	-0.008	0.001	
Office (FNOFF)	0.371	0.435	0.020	0.003	0.000	-0.231	-0.046	0.052	0.009	0.001	
Retail (FNRET)	0.157	0.984	-0.009	0.005	0.000	-0.761	-0.466	0.045	-0.004	-0.002	
Apartments (FNAPT)	0.775	0.644	0.051	0.009	0.001	-0.738	-0.378	-0.025	0.007	-0.001	
Residential (FNRES)	0.774	0.630	0.037	0.008	0.000	-0.881	-0.445	0.001	0.004	0.000	
Shopping Centers (FNSHO)	0.021	0.884	0.048	0.009	0.001	-0.654	-0.254	0.070	0.005	0.000	
Health Care (FNHEA)	0.411	0.581	-0.016	0.008	-0.001	-1.536	-0.731	0.047	-0.015	0.001	
Composite (FNCO)	0.779	0.582	0.023	0.006	0.000	-1.000	-0.377	0.023	-0.001	0.000	
Regional Malls (FNMAL)	-0.254	0.426	-0.021	0.000	-0.001	-0.238	-0.353	-0.022	-0.007	-0.002	

Table 11 (continued)

Horizon	Contractionary					Expansionary				
	1	2	3	4	5	1	2	3	4	5
Panel C: COVID-19										
All Equity REITs (FNER)	-0.571	1.129	0.363	0.202	0.131	-4.243	2.509	2.213	1.429	0.934
Industrial (FNIND)	-0.398	1.318	0.414	0.172	0.096	-0.018	2.721	2.167	1.179	0.668
Office (FNOFF)	-0.436	0.846	0.245	0.131	0.085	-3.360	1.951	1.738	1.107	0.712
Retail (FNRET)	-0.784	0.923	0.272	0.146	0.091	-3.602	2.552	2.079	1.270	0.777
Apartments (FNAPT)	-0.447	1.693	0.718	0.311	0.152	-1.735	0.707	0.848	0.443	0.245
Residential (FNRES)	-0.477	1.364	0.576	0.269	0.138	-1.894	0.950	0.837	0.442	0.252
Shopping Centers (FNSHO)	-0.516	0.990	0.381	0.213	0.117	-4.239	1.420	0.996	0.616	0.394
Health Care (FNHEA)	-0.932	0.815	0.263	0.126	0.073	-1.302	2.274	1.658	0.934	0.540
Composite (FNCO)	-0.563	1.153	0.372	0.208	0.133	-4.272	2.600	2.224	1.425	0.926
Regional Malls (FNMAL)	-0.166	1.007	0.256	0.073	0.048	0.001	2.139	2.125	1.098	0.584

Table 12 Summary of S&P 500 responses to the shocks of (un)conventional monetary policy

		Contractionary					Expansionary					
		Horizon	1	2	3	4	5	1	2	3	4	5
Panel A: GFC	Return	average	0.546	0.126	-0.007	0.002	0.000	-0.982	0.035	0.000	0.007	-0.001
		no. outside of 68% CI	10	5	5	5	3	11	5	6	9	8
		no. outside of 95% CI	10	4	1	2	0	11	1	0	0	0
		average $\times 10,000$	-0.332	-0.450	-0.326	-0.228	-0.157	0.612	0.309	0.118	0.071	0.046
		no. outside of 68% CI	8	8	8	8	8	8	9	10	10	11
		no. outside of 95% CI	7	7	7	7	7	6	7	6	6	6
		average $\times 10,000$	-0.007	-0.010	-0.005	-0.001	0.000	-0.002	-0.079	-0.007	-0.002	0.000
		no. outside of 68% CI	7	9	8	9	6	7	12	7	12	4
		no. outside of 95% CI	3	5	4	5	0	2	9	3	2	0
		average	0.175	-0.020	0.001	0.000	0.000	-0.221	-0.016	0.004	0.001	0.000
Panel B: Post-GFC	Return	no. outside of 68% CI	9	3	0	0	0	9	2	0	0	0
		no. outside of 95% CI	6	0	0	0	0	6	0	0	0	0
		average	0.241	-0.139	-0.028	-0.004	-0.001	0.082	-0.333	-0.042	-0.016	-0.001
		no. outside of 68% CI	5	3	2	0	0	1	5	1	0	0
		no. outside of 95% CI	0	0	0	0	0	1	0	0	0	0
		Total no. of shocks	10					12				
		average	0.315	-0.049	-0.001	0.000	0.000	-0.284	0.032	0.006	0.000	0.000
		no. outside of 68% CI	10	5	3	1	0	18	3	3	2	0
		no. outside of 95% CI	9	0	0	0	0	18	0	0	0	0
		average $\times 10,000$	-0.090	-0.093	-0.076	-0.063	-0.052	0.097	0.074	0.062	0.050	0.042
		no. outside of 68% CI	9	9	9	9	9	16	16	16	16	16

Table 12 (continued)

		Contractionary					Expansionary					
		Horizon	1	2	3	4	5	1	2	3	4	5
RJ	no. outside of 95% CI	8	5	6	6	6	16	13	13	13	13	
	average $\times 10,000$	0.004	0.001	0.001	0.000	0.000	0.006	0.007	0.000	0.000	0.000	
	no. outside of 68% CI	3	4	2	4	2	12	10	6	9	5	
	no. outside of 95% CI	1	2	0	0	0	4	5	0	2	0	
	average	0.069	-0.089	0.000	0.001	0.000	-0.117	0.073	0.005	-0.001	0.000	
	no. outside of 68% CI	7	7	2	0	0	17	11	2	1	0	
RSK	no. outside of 95% CI	3	2	0	0	0	10	6	0	0	0	
	average	0.202	0.240	0.017	0.002	0.001	0.127	0.036	0.010	0.006	0.000	
	no. outside of 68% CI	8	7	6	2	4	13	8	8	8	2	
	no. outside of 95% CI	2	1	0	0	0	3	0	0	0	0	
	Total no. of shocks	10					20					
	Panel C: COVID-19											
RJ	Return	0.128	-0.030	-0.028	0.008	-0.003	-1.435	0.874	-0.371	0.118	-0.052	
	no. outside of 68% CI	5	4	4	4	4	4	5	5	4	4	
	no. outside of 95% CI	4	0	3	1	0	3	2	3	1	1	
	average $\times 10,000$	0.505	-0.095	0.025	0.022	0.015	2.810	0.927	0.712	0.618	0.506	
	no. outside of 68% CI	8	4	5	5	5	6	5	5	5	5	
	no. outside of 95% CI	6	3	2	2	2	6	2	2	2	2	
RV	average $\times 10,000$	-0.017	-0.011	0.006	0.003	0.001	0.314	0.132	0.039	0.033	0.015	
	no. outside of 68% CI	8	7	7	8	7	5	5	5	5	5	
	no. outside of 95% CI	6	3	4	6	6	4	1	3	3	3	
	average	0.030	-0.009	0.003	0.000	0.000	0.112	0.012	0.027	0.011	0.006	
	no. outside of 68% CI	3	0	0	0	0	3	0	0	0	0	

Table 12 (continued)

	Horizon	Contractionary					Expansionary				
		1	2	3	4	5	1	2	3	4	5
RKU	no. outside of 95% CI	0	0	0	0	0	0	0	0	0	0
	average	0.068	0.163	0.047	0.006	-0.001	0.202	-0.256	-0.068	-0.033	-0.018
	no. outside of 68% CI	2	4	6	0	0	1	1	2	0	0
	no. outside of 95% CI	0	0	0	0	0	0	0	0	0	0
Total no. of shocks		9				6					

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Data Availability The data that support the findings of this study are derived from proprietary sources. Specifically, this research utilized REIT data obtained from the Bloomberg Terminal. Due to the proprietary nature of this data, it is not publicly available. However, the specific Bloomberg tickers used in the analysis are available from the corresponding author upon request.

Declarations

Competing interests The authors have no relevant financial or non-financial interest to disclose.

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References

Akinsomi, O., Aye, G. C., Babalos, V., Economou, F., & Gupta, R. (2016). Real estate returns predictability revisited: Novel evidence from the US REITs market. *Empirical Economics*, 51(3), 1165–1190.

Almudhaf, F., & Hansz, A. J. (2018). Random walks and market efficiency: Evidence from real estate investment trusts (REIT) subsectors. *International Journal of Strategic Property Management*, 22(2), 81–92.

Andersen, T. G., & Bollerslev, T. (1998). Answering the skeptics: Yes, standard volatility models do provide accurate forecasts. *International Economic Review*, 39(4), 885–905.

Andersen, T. G., Bollerslev, T., & Diebold, F. X. (2007). Roughing it up: Including jump components in the measurement, modeling, and forecasting of return volatility. *The Review of Economics and Statistics*, 89(4), 701–720.

Antonakakis, N., Gabauer, D., & Gupta, R. (2019). International monetary policy spillovers: Evidence from a time-varying parameter vector autoregression. *International Review of Financial Analysis*, Elsevier, 65(C), 101382.

Baker, S. R., Bloom, N. A., Davis, S. J., & Sammon, M. C. (2021). *What Triggers Stock Market Jumps?* NBER Working Papers 28687. National Bureau of Economic Research, Inc.

Banbura, M., Giannone, D., & Reichlin, L. (2010). Large Bayesian vector auto regressions. *Journal of Applied Econometrics*, 25(1), 71–92.

Banbura, M., Giannone, D., & Reichlin, L. (2011). Nowcasting. In M. P. Clements & D. F. Hendry (Eds.), *Oxford Handbook on Economic Forecasting* (pp. 63–90). Oxford University Press.

Barndorff-Nielsen, O. E., & Shephard, N. (2004). Power and bipower variation with stochastic volatility and jumps. *Journal of Financial Econometrics*, 2, 1–37.

Barndorff-Nielsen, O. E., & Shephard, N. (2006). Econometrics of testing for jumps in financial economics using bipower variation. *Journal of Financial Econometrics*, 4, 1–30.

Bauer, M. D., & Neely, C. J. (2014). International channels of the Fed's unconventional monetary policy. *Journal of International Money and Finance*, 44, 24–46.

Bauer, M. D., & Rudebusch, G. D. (2014). The Signaling Channel for Federal Reserve Bond Purchases. *International Journal of Central Banking*, 10, 233–289.

Bernanke, B. S., & Boivin, J. (2003). Monetary policy in a data-rich environment. *Journal of Monetary Economics*, 50, 525.

Bernanke, B. S., & Kuttner, K. N. (2005). What explains the stock market's reaction to Federal Reserve policy. *Journal of Finance*, 60, 1221–1257.

Bernanke, B. S., Boivin, J., & Eliasz, P. (2005). Measuring the effects of monetary policy: A factor-augmented vector autoregressive (FAVAR) approach. *Quarterly Journal of Economics*, 120, 387–422.

Bonato, M., Çepni, O., Gupta, R., & Pierdzioch, C. (2021a). Do oil-price shocks predict the realized variance of US REITs? *Energy Economics*, 104, 105689.

Bonato, M., Çepni, O., Gupta, R., & Pierdzioch, C. (2021b). Uncertainty due to infectious diseases and forecastability of the realized variance of United States real estate investment trusts: A note. *International Review of Finance*, 22(3), 540–550.

Bonato, M., Çepni, O., Gupta, R., & Pierdzioch, C. (2022). Forecasting Realized Volatility of International REITs: The Role of Realized Skewness and Realized Kurtosis. *Journal of Forecasting*, 41(2), 303–315.

Bredin, D., O'Reilly, G., & Stevenson, S. (2007). Monetary Shocks and REIT Returns. *The Journal of Real Estate Finance and Economics*, 35(3), 315–331.

Caraiani, P., Călin, A. C., & Gupta, R. (2021). Monetary policy and bubbles in US REITs. *International Review of Finance*, 21(2), 675–687.

Çepni, O., Dul, W., Gupta, R., & Wohar, M. E. (2021). The dynamics of U.S. REITs returns to uncertainty shocks: A proxy SVAR approach. *Research in International Business and Finance*, 58(C), 101433.

Clark, P. (1973). A Subordinated Stochastic Process Model with Finite Variances for Speculative prices. *Econometrica*, 41(1), 135–155.

Copeland, T. E. (1976). A Model for Asset Trading under the Assumption of Sequential Information Arrival. *Journal of Finance*, 31(4), 1149–1168.

Cotter, J., & Stevenson, S. (2008). Modeling long memory in REITs. *Real Estate Economics*, 36(3), 533–554.

Devaney, M. (2001). Time-varying risk premia for real estate investment trusts: A GARCH-M model. *Quarterly Review of Economics and Finance*, 41, 335–346.

Fisher, I. (1930). *The theory of interest*. The Macmillan Company.

Frugier, A. (2014). Higher-order Moments and Investor Sentiment (Alles' Model Revisited). *Quarterly Journal of Finance and Accounting*, 51(3–4), 45–70.

Gagnon, J., Raskin, M., Remache, J., & Sack, B. (2011). The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases. *International Journal of Central Banking*, 7, 3–43.

Ghysels, E., Piazzesi, A., and Valkanov, R., and Torous, W. (2013). Forecasting Real Estate Prices. In: G. Elliott, C. Granger, and A. Timmermann (ed.), *Handbook of Economic Forecasting*, 2(1), 509–580, Elsevier.

Giot, P., Laurent, S., & Petitjean, M. (2010). Trading activity, realized volatility and jumps. *Journal of Empirical Finance*, 17(1), 168–175.

Gospodinov, N., & Jamali, I. (2012). The effects of federal funds rate surprises on S&P 500 volatility and volatility risk premium. *Journal of Empirical Finance*, 19, 497–510.

Gospodinov, N., & Jamali, I. (2018). Monetary policy uncertainty, positions of traders and changes in commodity futures prices? *European Financial Management*, 24(2), 239–260.

Gupta, R., & Marfatia, H. A. (2018). The Impact of Unconventional Monetary Policy Shocks in the U.S. on Emerging Market REITs. *Journal of Real Estate Literature*, 26(1), 175–188.

Gupta, R., Lv, Z., & Wong, W.-K. (2019). Macroeconomic Shocks and Changing Dynamics of the U.S. REITs Sector. *Sustainability*, 11, 2776.

Gürkaynak, R. S., & Wright, J. (2012). Macroeconomics and the Term Structure. *Journal of Economic Literature*, 50(2), 331–367.

Gürkaynak, R. S., Sack, B., & Wright, J. H. (2007). The US Treasury yield curve: 1961 to the present. *Journal of Monetary Economics*, 54(8), 2291–2304.

Inoue, A., & Rossi, B. (2019). The effects of conventional and unconventional monetary policy on exchange rates. *Journal of International Economics*, 118, 419–447.

Inoue, A., & Rossi, B. (2021). A new approach to measuring economic policy shocks, with an application to conventional and unconventional monetary policy. *Quantitative Economics*, 12(4), 1085–1138.

Ji, Q., Marfatia, H. A., & Gupta, R. (2018). Information spillover across international real estate investment trusts: Evidence from an entropy-based network analysis. *The North American Journal of Economics and Finance*, 46(C), 103–113.

Lesame, K., Bouri, E., Gabauer, D., & Gupta, R. (2021). On the Dynamics of International Real-Estate-Investment Trust-Propagation Mechanisms: Evidence from Time-Varying Return and Volatility Connectedness Measures. *Entropy*, 23, 1048.

Maio, P. (2014). Another Look at the Stock Return Response to Monetary Policy Actions. *Review of Finance*, 18, 321–371.

Marfatia, H. A., Gupta, R., & Cakan, E. (2017). The international REIT's time-varying response to the US monetary policy and macroeconomic surprises. *The North American Journal of Economics and Finance*, 42, 640–653.

Marfatia, H. A., Gupta, R., & Lesame, K. (2021). Dynamic Impact of Unconventional Monetary Policy on International REITs. *Journal of Risk and Financial Management*, 14(9), 429.

McAleer, M., & Medeiros, M. C. (2008). Realized volatility: A review. *Econometric Reviews*, 27, 10–45.

Nakamura, E., & Steinsson, J. (2018a). High-frequency identification of monetary non-neutrality: The information effect. *The Quarterly Journal of Economics*, 133(3), 1283–1330.

Nakamura, E., & Steinsson, J. (2018b). Identification in Macroeconomics. *Journal of Economic Perspectives*, 32, 59–86.

Nyakabayo, W., Gupta, R., & Marfatia, H. A. (2018). High Frequency Impact of Monetary Policy and Macroeconomic Surprises on US MSAs, Aggregate US Housing Returns And Asymmetric Volatility. *Advances in Decision Sciences*, 22(1), 204–229.

Odusami, B. O. (2021a). Volatility jumps and their determinants in REIT returns. *Journal of Economics and Business*, 113, 105943.

Odusami, B. O. (2021b). Forecasting the Value-at-Risk of REITs using realized volatility jump models. *The North American Journal of Economics and Finance*, 58, 101426.

Rossi, B. (2021). Identifying and Estimating the Effects of Unconventional Monetary Policy in the Data: How to Do It and What Have We Learned? *The Econometrics Journal*, 24(1), C1–C32.

Sundaresan, S. (2023). Emergency Preparation and Uncertainty Persistence. *Management Science*. <https://doi.org/10.1287/mnsc.2023.4836>

Williams, J. B. (1938). *The theory of investment value*. Harvard University Press.

Zhou, H., & Zhu, J. Q. (2012). An empirical examination of jump risk in asset pricing and volatility forecasting in China's equity and bond markets. *Pacific-Basin Finance Journal*, 20(5), 857–880.

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