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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-minute 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 are 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

JEL Codes: C32, E43, E52, R3

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1. Introduction

Real Estate Investment Trusts (REITs) have grown substantially as an investment instrument in the United States (US). According to the Nareit,[1] 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 a unique opportunity for investors to invest in real estate (Akinsomi et al., 2016). In fact, according to the Nareit, 145 million Americans live in households that benefit from ownership of REITs through stocks, 401(k) plans, pension plans, and other investment funds. 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.

In this regard, a large literature exists that has analysed the effect of (conventional and unconventional) monetary policy decisions on REITs prices and/or returns (see 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 (Ghysels et al., 2013; Çepni et al., 2021), which is understandable since monetary policy impact possibly all macroeconomic and financial variables (Bernanke and Boivin, 2003; Bernanke et al., 2005; Bańbura et al., 2010). 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'

[1] Nareit® is the worldwide representative voice for REITs and publicly traded real estate companies with an interest in U.S. real estate and capital markets.

[2] See: https://www.reit.com/.

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 and 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 and 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 (Gagnon et al., 2011; Bauer and Neely 2014). 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 (Bańbura 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 the 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 and 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-minute-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. While some studies (see for example, Devaney (2001), Cotter and Stevenson (2006), 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 (McAleer and 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 and Jamali, 2012, 2018). This is again 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, Nyakabawo 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).

Given this, REITs market participants, 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, as suggested by Odusami (2021a, b). 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 unchartered territory by analyzing the impact of monetary policy shocks on RSK and RKU, which captures asymmetry and extreme movements in REITs returns (Bonato et al., 2022), and are expected to be positively related to monetary policy shocks.

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 important 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: Section 2 discusses the methodology utilized, while Section 3 outlines the data and the associated computation of the various moments of REITs returns. Section 4 presents the results, with Section 5 concluding the paper.

2. 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.

2.1. 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:

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

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 (such that, 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 scaler, 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 Section 3.

2.2. 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:

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

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 follow Inoue and Rossi (2019) to set $p = 2$.

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

$$X_t = \tilde{\mu} + \mu_t + \Theta_1 u_{t-1} + \cdots + \Theta_h u_{t-h} + \cdots \tag{3}$$

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:

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

and $\Theta_h$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) shows that the overall effect of the monetary policy event

$\varepsilon_t^{mp} = \left[\varepsilon_t^{mp}\left(\frac{1}{4}\right), \dots, \varepsilon_t^{mp}(30)\right]$ can be denoted as:

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

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

As for the estimation for Eq. (6), please refer to Inoue and Rossi (2019) for the details on the Bayesian procedure that is adopted.

2.3. 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.

3. 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 the discussion of the higher moments statistics associated with the REITs.

3.1. 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[3]. 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.[4]

We use 5-minute-interval intraday data on the FTSE Nareit All REITs Index (FNAR) to conduct our empirical study.[5] The intraday data cover a 24-hour 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). 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[6], 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:

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[3] https://www.federalreserve.gov/releases/h15/.

[4] https://www.federalreserve.gov/data/nominal-yield-curve.htm.

[5] The FTSE Nareit All REITs Index is a market capitalization-weighted index that and includes all tax-qualified real estate investment trusts (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.

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

- Period 1 (GFC), unconventional monetary policy: September 19, 2008 – June 15, 2016.[7]
- 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 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 covers 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 (2018) to use the dates of FOMC meetings, available on the website of the Federal Reserve Board website.[8]

The upper panel of Figure 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 Figure 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.

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. 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.

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

[7] The end date of this period follows the Table 1 in the Not-for-Publication Appendix of Inoue and Rossi (2021).
[8] https://www.federalreserve.gov/monetarypolicy/fomccalendars.htm.

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.

3.2. 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 and Bollerslev, 1998):

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

where $r_{t,i}$ denotes the intraday $M \times 1$ return vector, and $i = 1, \ldots, M$ 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:

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

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:

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

where BV_t is the realized bipolar variation defined as:

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

where

$$\mu_a = E(|Z|^a), \qquad Z \sim N(0,1), \qquad a > 0 \ , \tag{10}$$

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

$$J_t = RV_t - BV_t \ . \tag{11}$$

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

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

where TP_t is the Tri-Power Quarticity:

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

which converges to the Integrated Quarticity (IQ):

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

even in the presence of jumps. We use the notation $v_{bb} = \left(\frac{\pi}{2}\right) + \pi - 3$ and $v_{qq} = 2$. Note that for each t, $JT_t \sim N(0,1)$ as $M \rightarrow \infty$. As can be seen in Equation (11), the jump contribution to RV_t is either positive or null. Therefore, to avoid obtaining negative empirical contributions, we redefine, like Zhou and Zhu (2012), the jump measure as:

$$RJ_t = \max(RV_t - BV_t; 0) \ . \tag{15}$$

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:

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

and RKU on day *t* as:

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

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.

4. 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 periods. 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.

4.1. Response of returns

The right panel of Figure 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 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 Figure 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, and 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 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 Figure 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 Figure 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 returns on the first day is followed by a recovery. During the post-GFC period, an expansionary monetary policy produced positive FNAR returns for the first two days, which is in line with expectation. 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.

[INSERT FIGURES 4 AND 5]

Table 3 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,[9] though the magnitude differs, and highlights different degree of sensitiveness of the sectors to monetary policy shocks. Note that, in absolute terms, the strongest impacts are found for Industrial (FNIND), Health Care (FNHEA) and Regional Malls (FNMAL) in the three sub-periods considered. 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.

[INSERT TABLE 3]

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.

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

The left panel of Figure 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. 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

[9] 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.

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 Figure 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 reduction in REITs returns conveying “bad” news. 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.

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. 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.

[INSERT FIGURES 6 AND 7]

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 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 Figure 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 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 FNAR 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, suggesting the role of high-frequency monetary policy shocks in driving sudden market reactions to REITs.

[INSERT FIGURES 8 AND 9]

The left panel of Figure 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 Figure 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.

[INSERT FIGURES 10 AND 11]

The left panel of Figure 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 of 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 FNAR RKU are exhibited in the left panel of Figure 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.

[INSERT FIGURES 12 AND 13]

During crises, when returns are already negative, we can conclude that monetary contraction is likely to enhance the degree of asymmetry and extreme movements of the overall US REITs market. In other words, tail risks tend to get magnified in such situations.

Finally, Tables A1, A2, A3, and A4 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.

5. 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-minute 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 analyse 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 are indeed heterogeneity in terms of the strength of the effect, but the sign of responses of the various moments align 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.

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.

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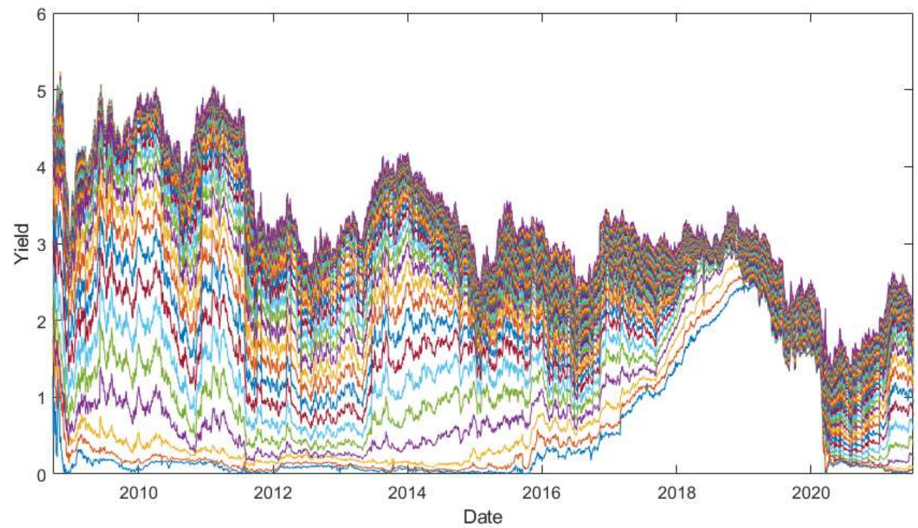

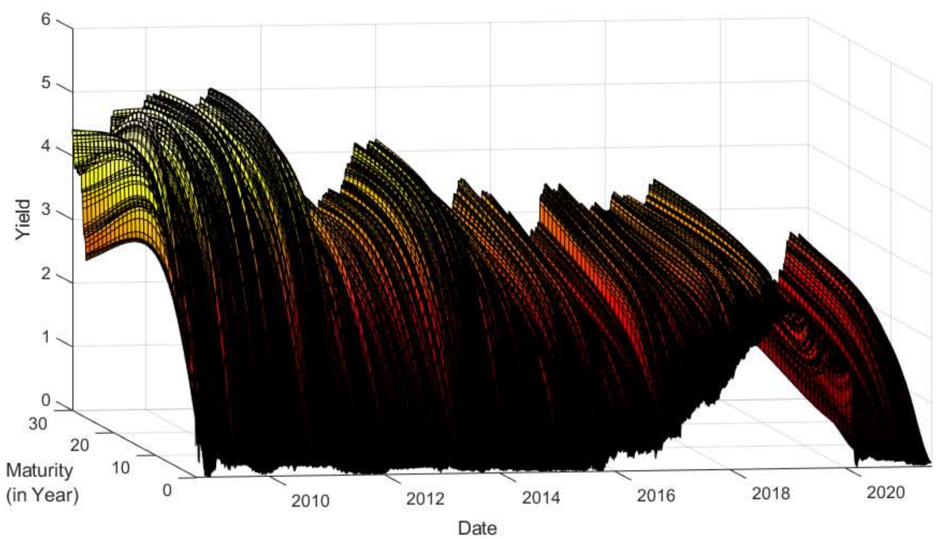

Figure 1. Yields at 3 month to 30 years maturities.

Upper panel: Time series plot. Lower panel: 3-dimensional plot.

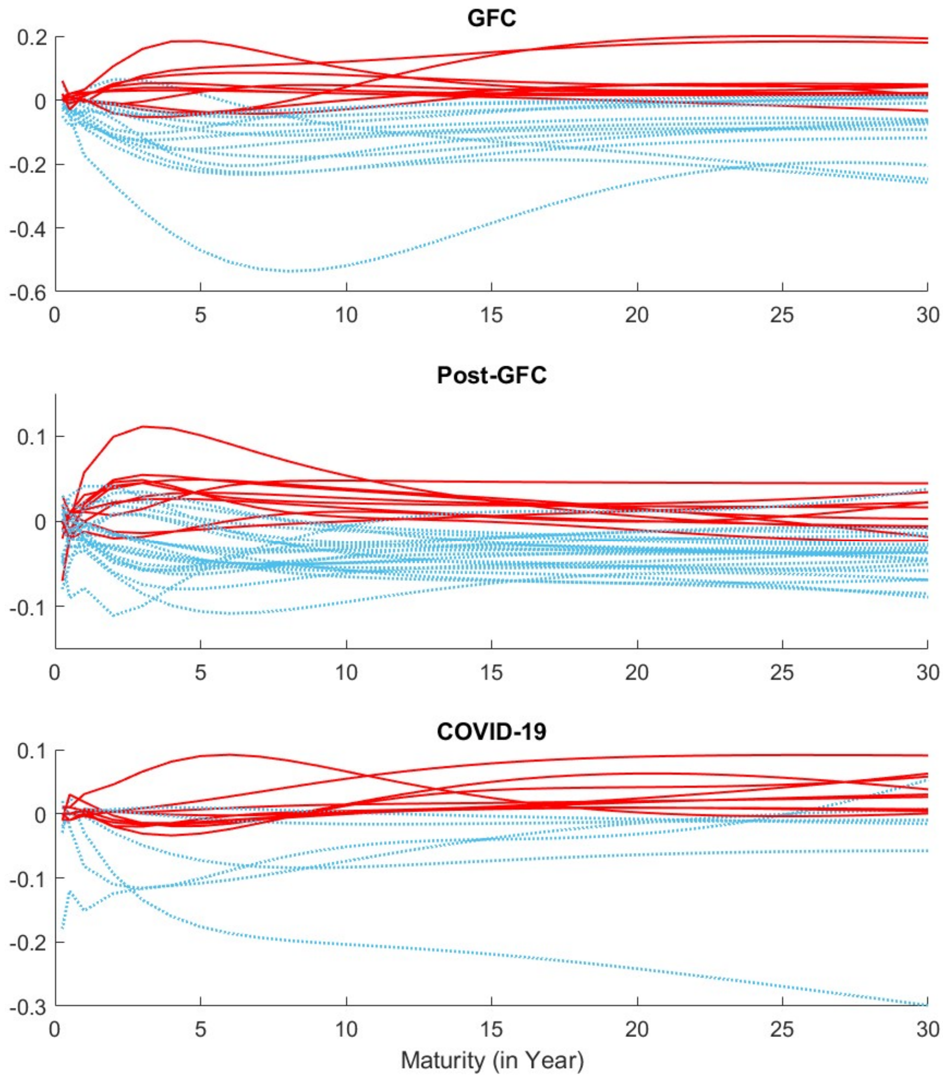

Figure 2. Shocks in US term structure following monetary policy announcement. Red solid lines are contractionary monetary policy shocks, while blue dotted lines are expansionary monetary policy shocks.

Upper panel: shocks in GFC. Middle panel: shocks in Post-GFC. Lower panel: shocks in COVID-19.

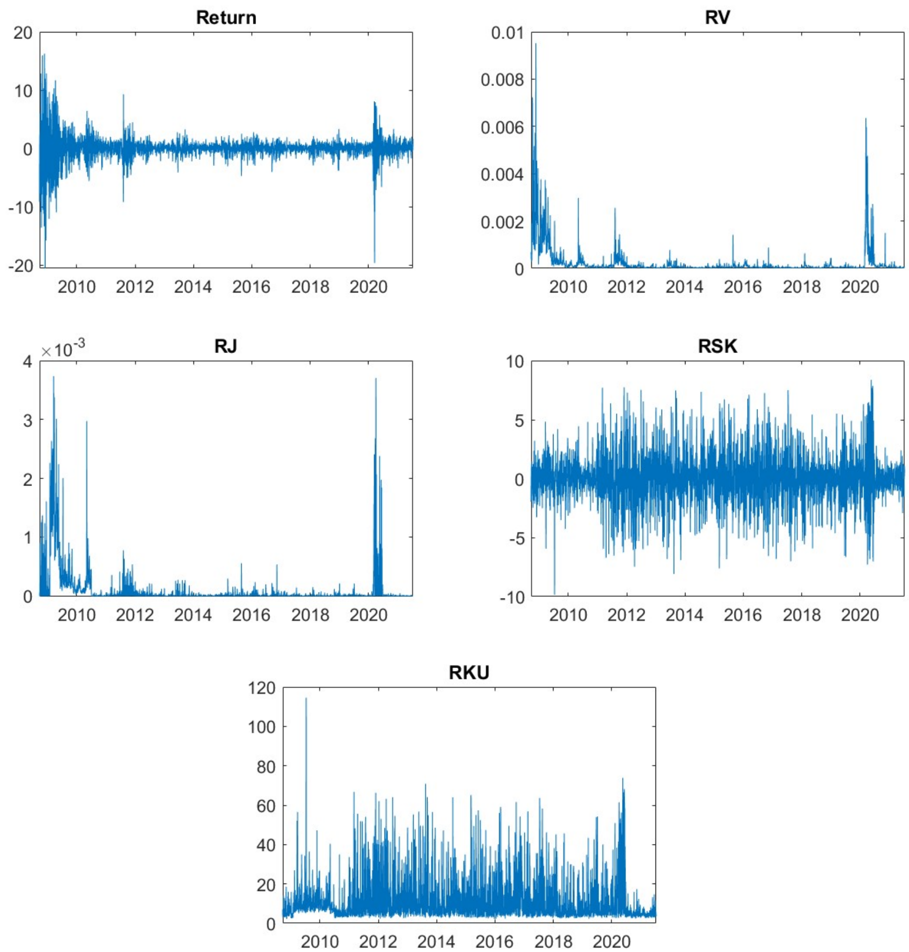

Figure 3. The return, RV, RJ, RSK, RKU of the FNAR index.

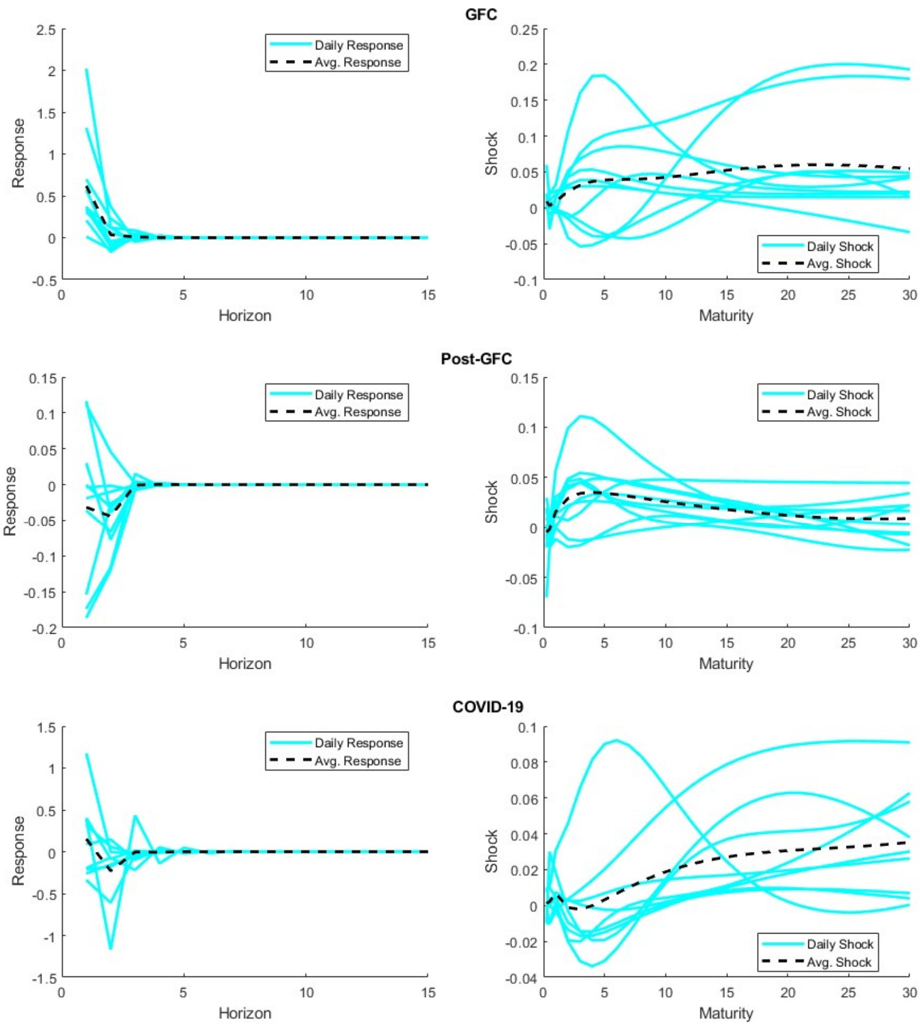

Figure 4. Response of FNAR returns to contractionary monetary policy shocks. Left: response of returns to shocks. Right: shocks in the yield curves following a monetary policy announcement.

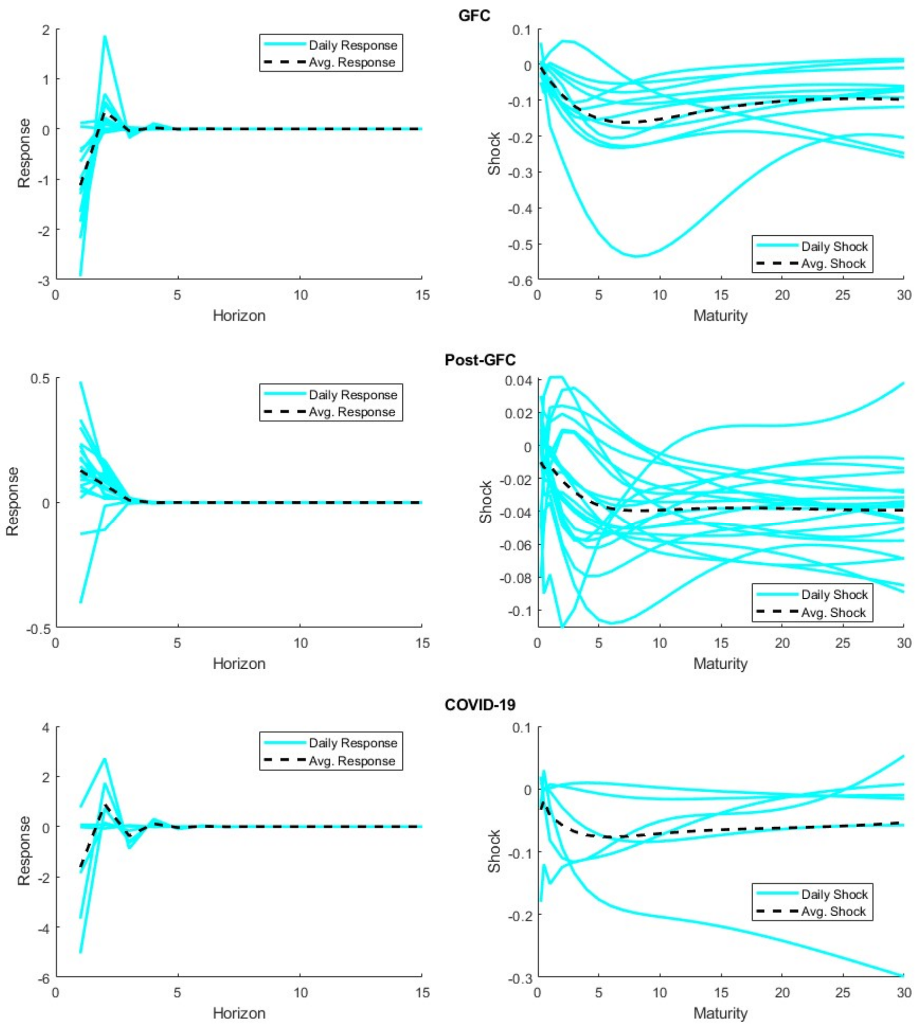

Figure 5. Response of FNAR returns to expansionary monetary policy shocks. Left: response of returns to shocks. Right: shocks in the yield curves following a monetary policy announcement.

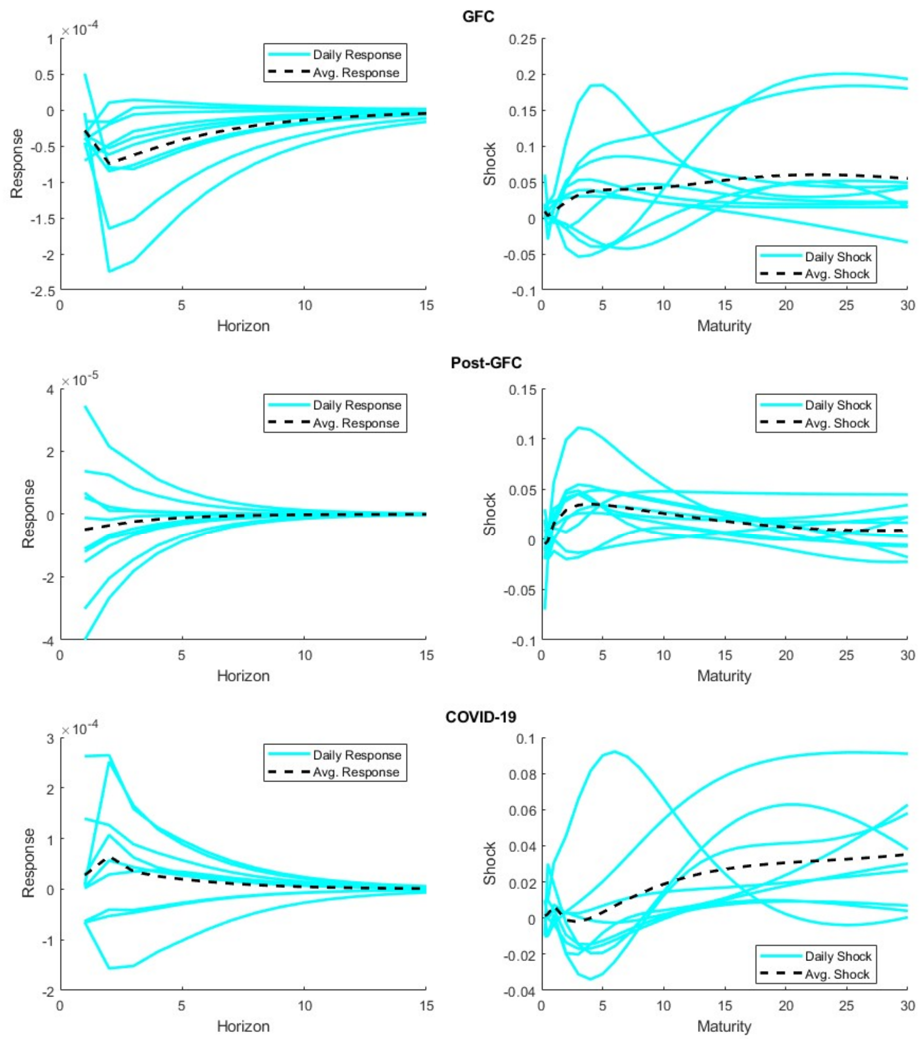

Figure 6. Response of FNAR RV to contractionary monetary policy shocks. Left: response of RV to shocks. Right: shocks in the yield curves following a monetary policy announcement.

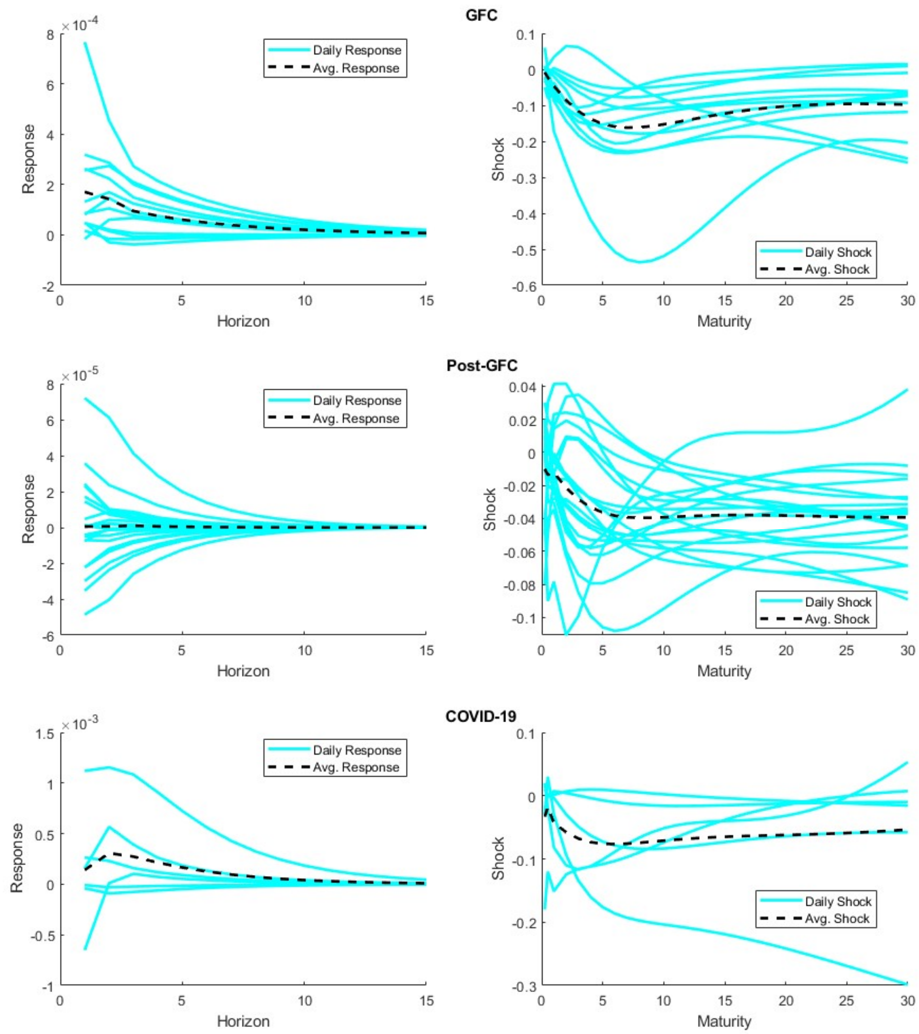

Figure 7. Response of FNAR RV to expansionary monetary policy shocks. Left: response of RV to shocks. Right: shocks in the yield curves following a monetary policy announcement.

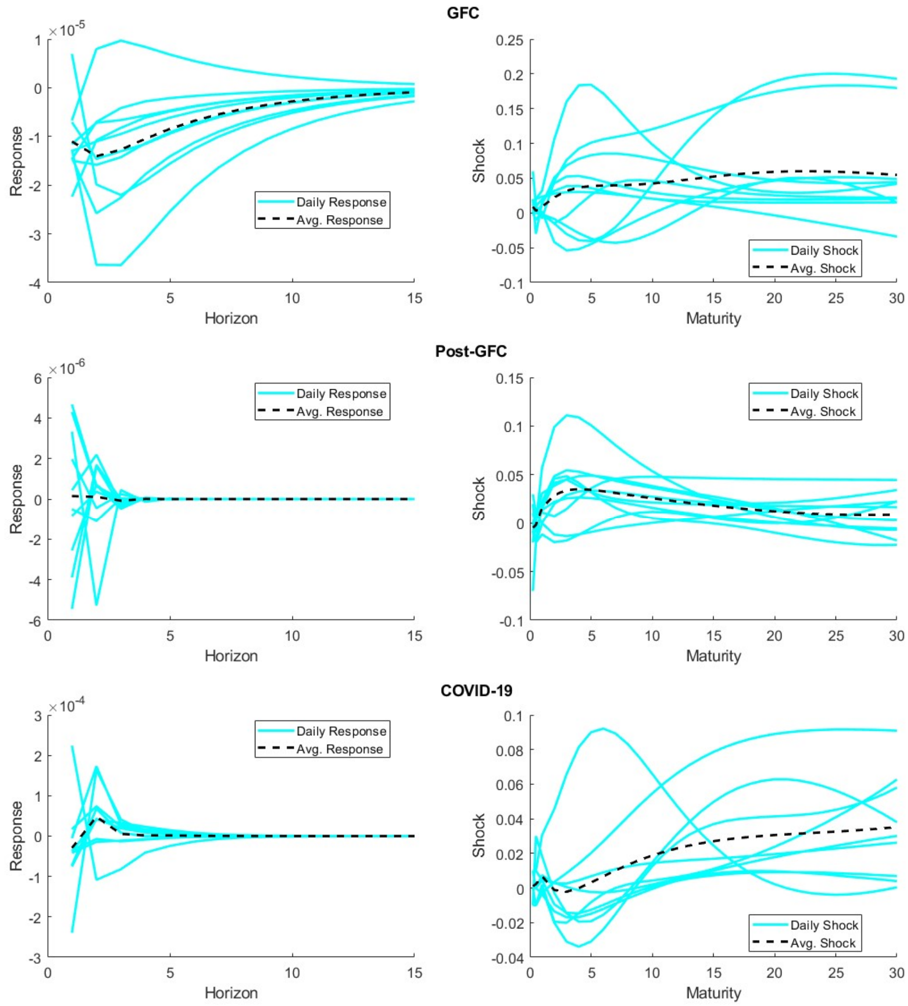

Figure 8. Response of FNAR RJ to contractionary monetary policy shocks. Left: response of RJ to shocks. Right: shocks in the yield curves following a monetary policy announcement.

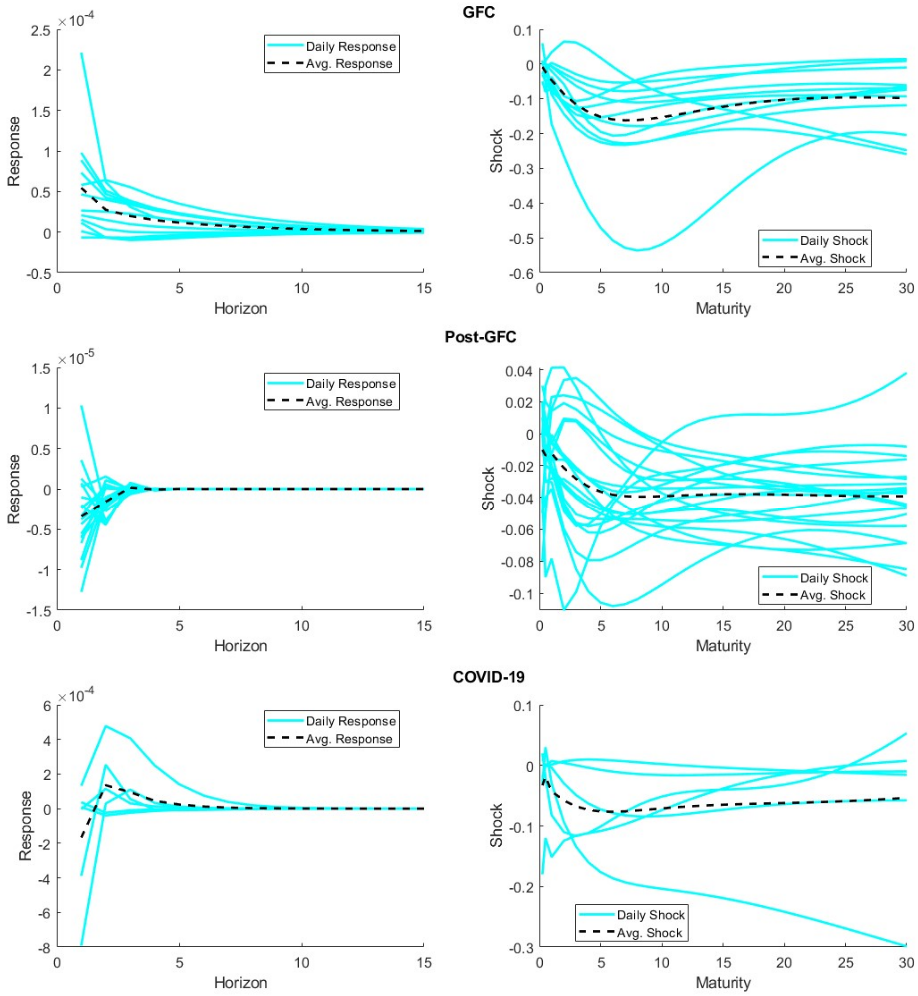

Figure 9. Response of FNAR RJ to expansionary monetary policy shocks. Left: response of RJ to shocks. Right: shocks in the yield curves following a monetary policy announcement.

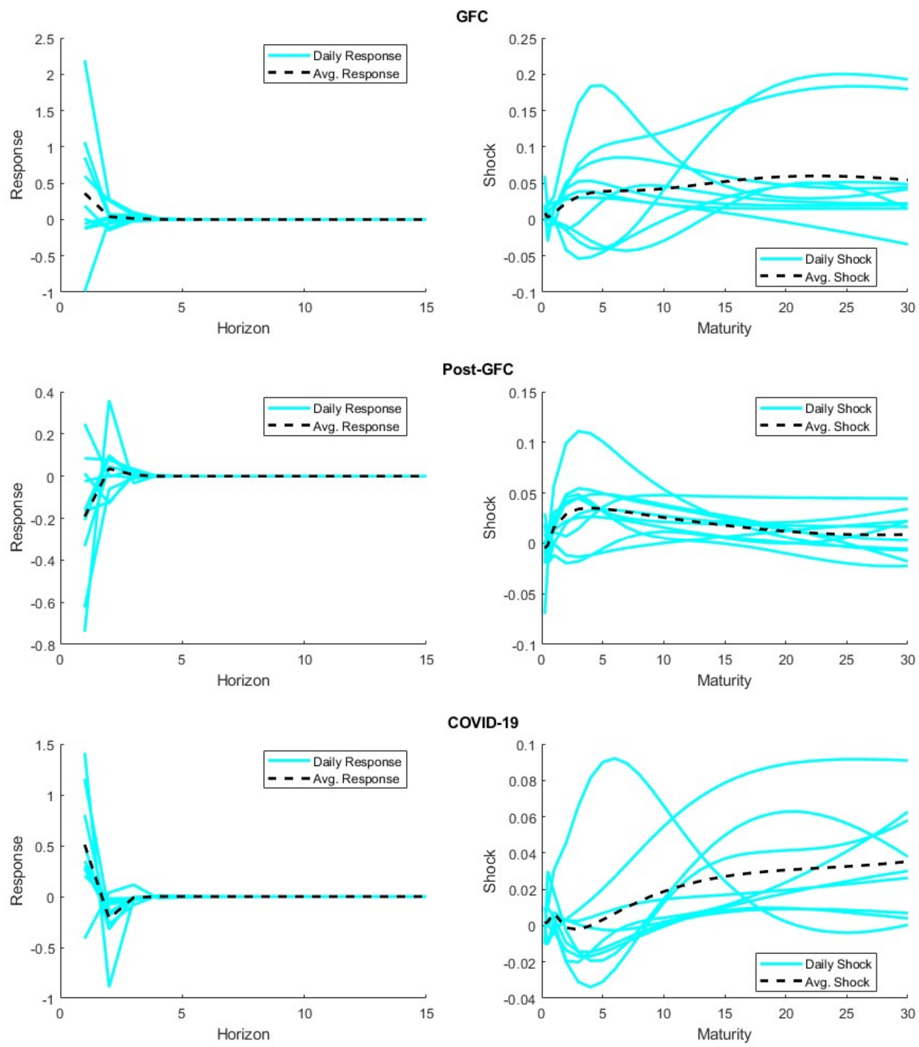

Figure 10. Response of FNAR RSK to contractionary monetary policy shocks. Left: response of RSK to shocks. Right: shocks in the yield curves following a monetary policy announcement.

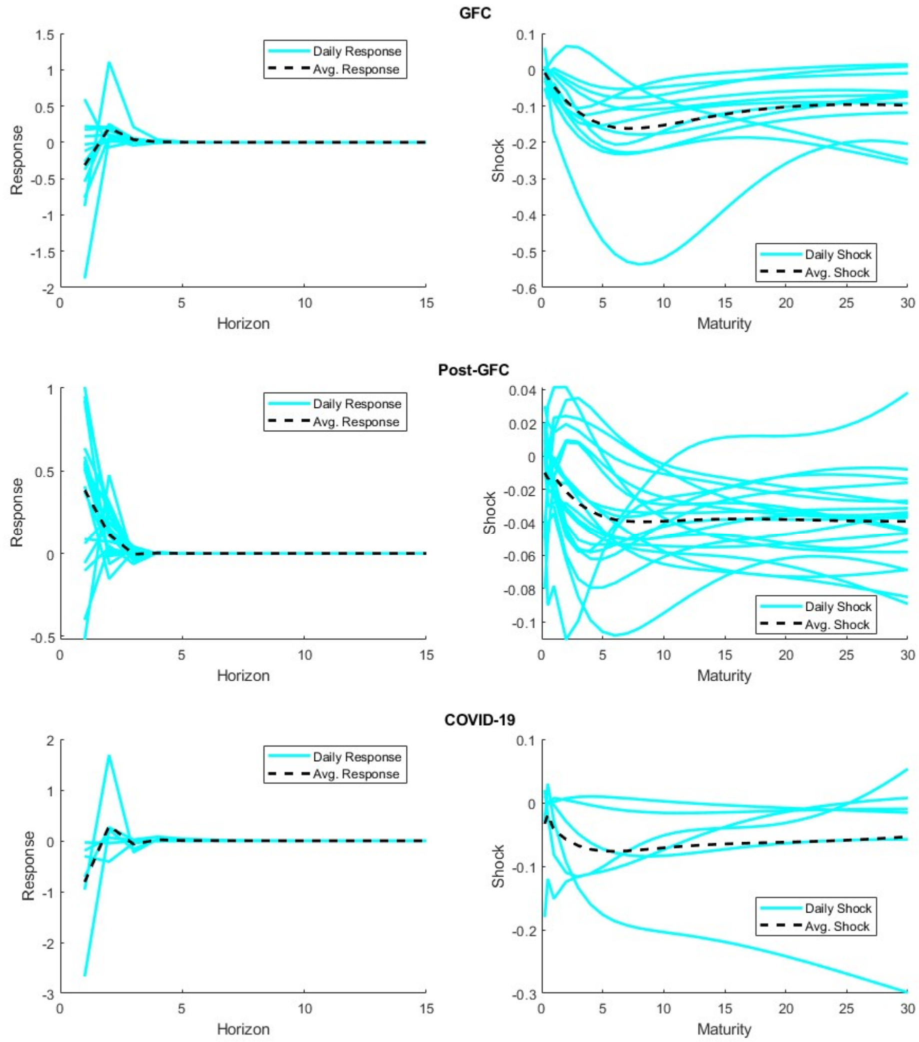

Figure 11. Response of FNAR RSK to expansionary monetary policy shocks. Left: response of RSK to shocks. Right: shocks in the yield curves following a monetary policy announcement.

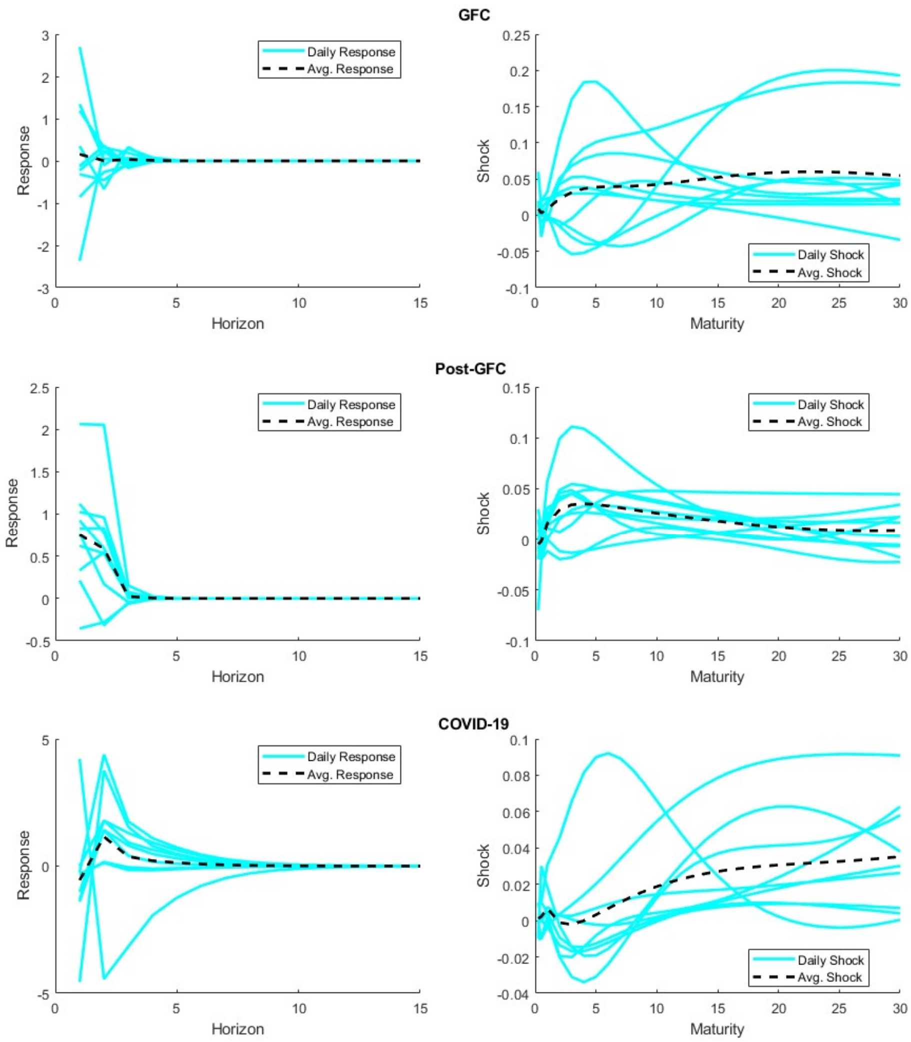

Figure 12. Response of FNAR RKU to contractionary monetary policy shocks. Left: response of RKU to shocks. Right: shocks in the yield curves following a monetary policy announcement.

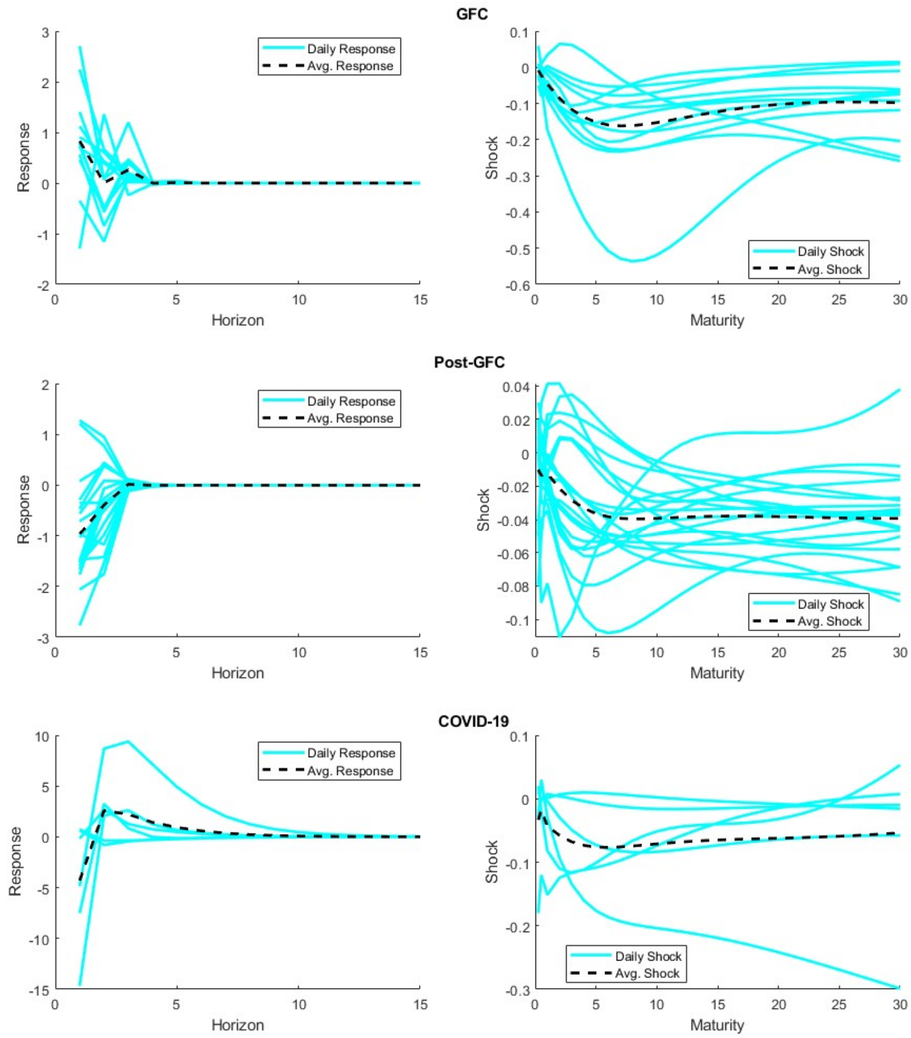

Figure 13. Response of FNAR RKU to expansionary monetary policy shocks. Left: response of RKU to shocks. Right: shocks in the yield curves following a monetary policy announcement.

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

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

Table 3. Average response of returns in various REITs sectors to the shocks of (un)conventional monetary policy

	Contractionary					Expansionary				
Horizon	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
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

APPENDIX:

Table A1. Average response (multiply by 1,000) of RV in various REITs sectors to the shocks of (un)conventional monetary policy

	Contractionary					Expansionary				
Horizon	1	2	3	4	5	1	2	3	4	5
Panel A: GFC										
All Equity REITs (FNER)	-0.027	-0.076	-0.064	-0.053	-0.043	0.182	0.153	0.103	0.083	0.067
Industrial (FNIND)	-0.062	-0.149	-0.118	-0.092	-0.071	0.231	0.238	0.121	0.096	0.072
Office (FNOFF)	-0.030	-0.079	-0.066	-0.054	-0.043	0.216	0.182	0.125	0.099	0.079
Retail (FNRET)	-0.030	-0.078	-0.067	-0.056	-0.046	0.179	0.174	0.117	0.096	0.078
Apartments (FNAPT)	-0.027	-0.072	-0.060	-0.049	-0.039	0.177	0.161	0.109	0.087	0.069
Residential (FNRES)	-0.025	-0.072	-0.060	-0.049	-0.040	0.174	0.155	0.104	0.083	0.065
Shopping Centers (FNSHO)	-0.017	-0.068	-0.059	-0.049	-0.040	0.185	0.160	0.108	0.088	0.071
Health Care (FNHEA)	-0.015	-0.086	-0.073	-0.060	-0.049	0.168	0.165	0.107	0.085	0.068
Composite (FNCO)	-0.027	-0.075	-0.063	-0.052	-0.042	0.172	0.145	0.096	0.077	0.061
Regional Malls (FNMAL)	-0.060	-0.119	-0.099	-0.081	-0.066	0.214	0.224	0.144	0.118	0.094
Panel B: Post-GFC										
All Equity REITs (FNER)	-0.005	-0.004	-0.003	-0.002	-0.001	0.000	0.000	0.001	0.000	0.000
Industrial (FNIND)	-0.011	-0.005	-0.003	-0.002	-0.001	0.001	-0.001	0.000	0.000	0.000
Office (FNOFF)	-0.004	-0.005	-0.003	-0.002	-0.001	0.003	0.003	0.002	0.001	0.001
Retail (FNRET)	-0.004	-0.001	0.000	0.000	0.000	-0.005	-0.005	-0.002	-0.001	0.000
Apartments (FNAPT)	-0.005	-0.002	-0.001	-0.001	0.000	0.003	-0.001	0.000	0.000	0.000
Residential (FNRES)	-0.005	-0.003	-0.002	-0.001	-0.001	0.002	-0.001	0.000	0.000	0.000
Shopping Centers (FNSHO)	-0.004	-0.001	-0.001	0.000	0.000	-0.002	-0.002	0.000	0.000	0.000
Health Care (FNHEA)	-0.003	-0.001	-0.001	0.000	0.000	-0.010	-0.007	-0.003	-0.002	-0.001
Composite (FNCO)	-0.005	-0.004	-0.002	-0.002	-0.001	0.001	0.001	0.001	0.001	0.001
Regional Malls (FNMAL)	-0.006	0.000	0.000	0.000	0.000	-0.001	-0.006	-0.002	-0.001	0.000
Panel C: COVID-19										
All Equity REITs (FNER)	0.031	0.069	0.035	0.025	0.020	0.142	0.323	0.289	0.225	0.174
Industrial (FNIND)	0.140	0.128	0.087	0.057	0.039	0.530	0.320	0.273	0.198	0.141
Office (FNOFF)	0.051	0.038	0.004	0.004	0.004	0.214	0.450	0.340	0.228	0.151
Retail (FNRET)	-0.007	0.072	0.040	0.028	0.019	0.154	0.474	0.391	0.285	0.196
Apartments (FNAPT)	0.109	0.123	0.066	0.036	0.021	0.381	0.279	0.214	0.137	0.085
Residential (FNRES)	0.076	0.079	0.046	0.029	0.019	0.330	0.295	0.222	0.153	0.103
Shopping Centers (FNSHO)	0.006	0.010	0.002	0.008	0.007	0.195	0.516	0.344	0.239	0.158
Health Care (FNHEA)	-0.003	0.087	0.051	0.036	0.025	0.310	0.531	0.440	0.328	0.234
Composite (FNCO)	0.028	0.066	0.035	0.026	0.020	0.146	0.310	0.275	0.215	0.167
Regional Malls (FNMAL)	0.543	0.294	0.101	0.043	0.025	1.245	1.130	0.845	0.479	0.266

Table A2. Average response (multiply by 1,000) of RJ in various REITs sectors to the shocks of (un)conventional monetary policy

	Contractionary					Expansionary				
Horizon	1	2	3	4	5	1	2	3	4	5
Panel A: GFC										
All Equity REITs (FNER)	-0.010	-0.015	-0.014	-0.012	-0.010	0.061	0.029	0.021	0.015	0.012
Industrial (FNIND)	-0.021	-0.019	-0.013	-0.009	-0.006	0.061	0.069	0.044	0.030	0.020
Office (FNOFF)	-0.010	-0.020	-0.018	-0.015	-0.012	0.066	0.035	0.026	0.019	0.015
Retail (FNRET)	-0.005	-0.013	-0.013	-0.011	-0.009	0.064	0.026	0.014	0.009	0.007
Apartments (FNAPT)	-0.011	-0.011	-0.012	-0.010	-0.008	0.084	0.036	0.024	0.017	0.013
Residual (FNRES)	-0.009	-0.012	-0.013	-0.011	-0.008	0.086	0.034	0.022	0.015	0.012
Shopping Centers (FNSHO)	0.008	0.005	0.002	0.001	0.001	0.074	0.048	0.033	0.025	0.019
Health Care (FNHEA)	0.006	-0.016	-0.014	-0.011	-0.009	0.064	0.050	0.031	0.022	0.017
Composite (FNCO)	-0.010	-0.014	-0.013	-0.010	-0.008	0.055	0.030	0.022	0.017	0.013
Regional Malls (FNMAL)	-0.016	-0.030	-0.025	-0.019	-0.013	0.110	0.061	0.032	0.022	0.015
Panel B: Post-GFC										
All Equity REITs (FNER)	0.000	0.000	0.000	0.000	0.000	-0.004	-0.001	0.000	0.000	0.000
Industrial (FNIND)	-0.001	0.002	0.000	0.000	0.000	-0.008	-0.003	0.000	0.000	0.000
Office (FNOFF)	-0.001	-0.001	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000
Retail (FNRET)	0.000	0.004	0.000	0.000	0.000	-0.008	-0.004	0.000	0.000	0.000
Apartments (FNAPT)	0.001	0.000	0.000	0.000	0.000	-0.003	-0.001	0.000	0.000	0.000
Residual (FNRES)	0.000	0.001	0.000	0.000	0.000	-0.002	-0.001	0.000	0.000	0.000
Shopping Centers (FNSHO)	0.000	0.002	0.000	0.000	0.000	-0.003	-0.002	0.000	0.000	0.000
Health Care (FNHEA)	0.003	0.000	0.000	0.000	0.000	-0.013	-0.004	0.000	0.000	0.000
Composite (FNCO)	0.000	0.000	0.000	0.000	0.000	-0.003	-0.002	0.000	0.000	0.000
Regional Malls (FNMAL)	-0.003	0.006	0.000	0.000	0.000	-0.002	-0.006	0.000	0.000	0.000
Panel C: COVID-19										
All Equity REITs (FNER)	-0.031	0.047	0.004	0.001	0.001	-0.160	0.140	0.097	0.045	0.023
Industrial (FNIND)	0.076	0.114	0.018	0.003	0.004	0.189	0.058	0.133	0.047	0.024
Office (FNOFF)	-0.017	0.025	-0.004	-0.002	0.000	-0.135	0.109	0.079	0.033	0.017
Retail (FNRET)	-0.085	0.074	-0.001	0.001	0.002	-0.343	0.295	0.150	0.066	0.034
Apartments (FNAPT)	0.076	0.146	0.025	0.003	0.002	0.187	-0.030	0.073	0.016	0.008
Residual (FNRES)	0.036	0.083	0.012	0.000	0.001	0.110	-0.009	0.042	0.010	0.004
Shopping Centers (FNSHO)	-0.019	0.090	0.019	0.005	0.002	-0.277	0.043	0.029	0.004	0.001
Health Care (FNHEA)	-0.117	0.099	0.018	0.005	0.002	-0.142	0.179	0.108	0.044	0.021
Composite (FNCO)	-0.030	0.048	0.005	0.002	0.002	-0.168	0.136	0.096	0.046	0.024
Regional Malls (FNMAL)	0.536	0.329	0.017	0.000	0.005	0.300	0.121	0.359	0.099	0.056

Table A3. Average response of RSK in various REITs sectors to the shocks of (un)conventional monetary policy

	Contractionary					Expansionary				
Horizon	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
Panel C: COVID-19										
All Equity REITs (FNER)	0.502	-0.214	-0.012	0.001	0.001	-0.808	0.290	-0.066	0.021	0.005
Industrial (FNIND)	0.378	-0.116	-0.041	-0.001	0.000	-0.843	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 (FNHEA)	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	-0.808	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 A4. Average response of RKU in various REITs sectors to the shocks of (un)conventional monetary policy

	Contractionary					Expansionary				
Horizon	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
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	-1.018	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