

Market Reactions to the Federal Reserve's Balance Sheet Normalization Plans

ABSTRACT This paper focuses on interpreting the stock market's reactions to Federal Reserve announcements about its balance sheet normalization plans, applying the methodology developed with Francesco Bianchi and Sai Ma. The results indicate that the stock market declines after announcements, suggesting perceived inflexibility in statements about balance sheet normalization, but many of the large reactions to these announcements can be ascribed to forces that move the stock market but not the broader economy.

In this paper, I focus on interpreting the stock market's reactions to Federal Reserve announcements about its balance sheet normalization plans. To do so, I apply the methodology in recent work with Francesco Bianchi and Sai Ma that integrates a high-frequency monetary event study into a mixed-frequency macro-finance model and structural estimation (Bianchi, Ludvigson, and Ma 2022).¹ We begin with an event study of the major Fed communications pertaining to its balance sheet normalization plans.

1. The underlying code relies on the working paper. The replication materials will be made available when that paper is published.

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I. High-Frequency Event Study

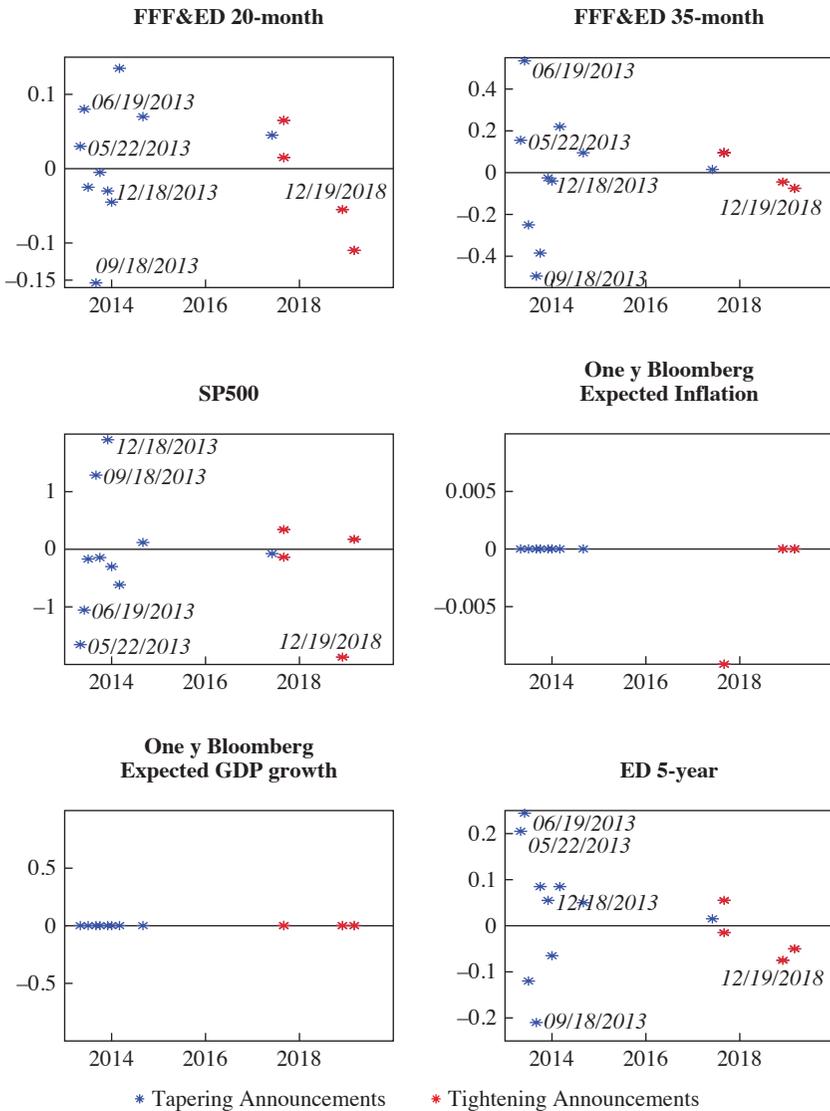
To study the major Fed communications pertaining to its balance sheet normalization plans, I examine communications pertaining to both tapering the pace of its asset purchases, as well as statements pertaining to quantitative tightening (QT), that is, outright reductions in the size of the balance sheet, on grounds that tapering is the first step toward tightening. For brevity, I refer to both types of communication events as QT events.

To identify QT-specific events, we do an exhaustive analysis of published or recorded Fed communications about its balance sheet normalization process dating back to May 2013. The full list of QT events identified is given in the online appendix. We identify fourteen QT-specific events from May 22, 2013, to March 20, 2019, spanning Federal Open Market Committee (FOMC) press releases, Fed chair press conferences, and Fed chair congressional testimonies. We focus on communications that were both specifically about QT and for which QT alone or (in a few cases) QT used in tandem with other types of unconventional monetary policy, such as forward guidance, was the predominant source of news during the short event time window.² My focus here will be on the most relevant communications for the stock market. I study changes in market variables from ten minutes before the beginning of the identified QT communication to the close of market trading on the same business day.

We begin by looking at the reaction of high-frequency variables to Fed QT announcements, including minutely observations on the federal funds futures market and on the S&P 500 stock market index, and daily measures of professional forecasts of inflation and GDP growth from Bloomberg. For each of the fourteen QT events in our sample, figure 1 displays the log change in these variables over the high-frequency event windows described above (with the exception of the Bloomberg forecasts which are day before/day after). The five most quantitatively important events for the stock market are labeled. Besides large jumps in the stock market, we see that some QT events are associated with large jumps in longer-horizon federal funds futures rates. What we do not see—in contrast to the broader FOMC event space studied by Bianchi, Ludvigson, and Ma (2022)—is non-negligible movement in the daily forecasts of inflation and GDP growth in

2. We augment our understanding of the most important pieces of market news surrounding a given communication by conducting a systematic analysis of newspaper reports from Factiva.

Figure 1. High-Frequency Changes in Prices and Expectations



Sources: Tickdata.com; CME Group; and Bloomberg.

Note: For each Fed announcement about balance sheet normalization, the log change in the observed variables in a short time-window around the announcement is shown. In most cases, this corresponds to ten minutes before the announcement to the end of the stock market trading day. For 5/22/2013, 12/18/2013, 9/17/2014, 6/14/2017, 12/19/2018, and 3/20/2019, the twelve-quarter (thirty-six-month) Eurodollar is used in place of missing thirty-five-month federal funds futures data. The labeled dates are the five most quantitatively important Fed announcements based on changes in the S&P 500-lagged GDP ratio, where lagged GDP is the previous month's GDP estimate. The full sample has fourteen balance sheet normalization events spanning May 22, 2013, to March 20, 2019.

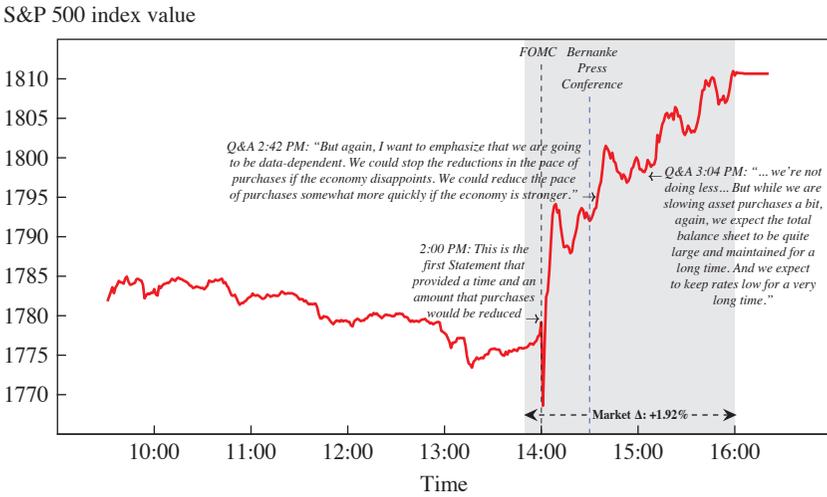
response to the QT events. In particular, the data show that these announcements did nothing to change expectations about the real macroeconomy or inflation, despite large effects on financial market variables.

Figures 2–4 show the intraday movements in the event windows on the three most important QT event dates as measured by the response of the S&P 500 stock market index. These events (from largest to smallest in absolute importance) are: (1) the December 18, 2013, FOMC press release and subsequent Ben Bernanke press conference, which combined to propel the market upward by 1.92 percent from ten minutes before the 2:00 p.m. press release to the end of the trading day (FRB 2013b, 2013c); (2) the December 19, 2018, Jerome Powell press conference in which the market fell 1.9 percent from ten minutes before its beginning at 2:30 p.m. to the end of the trading day (FRB 2018a, 2018b); and (3) the May 22, 2013, Bernanke congressional testimony and subsequent 2:00 p.m. FOMC minutes press release, the combination of which sent the market down 1.7 percent for the day (JEC 2013; FRB 2013a).

In each of the figures 2–4, the shaded area shows the window of time used subsequently to define the QT news event in the structural estimation. In cases where the FOMC press release—in each case at 2:00 p.m.—contained information specifically about balance sheet normalization, the QT event window is measured from ten minutes before the FOMC press release to the close of the stock market. In cases where the post-FOMC press conference contained balance sheet information but the 2:00 p.m. FOMC press did not, the QT event window is measured from ten minutes before the start of the press conference, in each case at 2:30 p.m.

On December 18, 2013, the FOMC made its first statement that provided both when (beginning in January 2014) and by how much the Fed would reduce the pace of asset purchases. An initial drop in the market quickly recovered. News reports indicate that the initial drop was due to the Fed taper statement, but markets recovered when they noticed the taper was tiny—adding to its holdings of mortgage-backed securities (MBS) at a pace of \$35 billion per month rather than \$40 billion, and to its holdings of Treasury securities at a pace of \$40 billion per month rather than \$45 billion. The stock market continued to rise during Bernanke’s press conference when he emphasized that the Fed would be “data-dependent” (2013c, 5) and flexible with reductions in the pace of purchases and could stop the reductions if the economy disappoints. The market rose further when, in response to questions, Bernanke stated that he expected the balance sheet to be maintained “at a large level for a long time” (17). This is the first of several statements in our sample indicating that the market

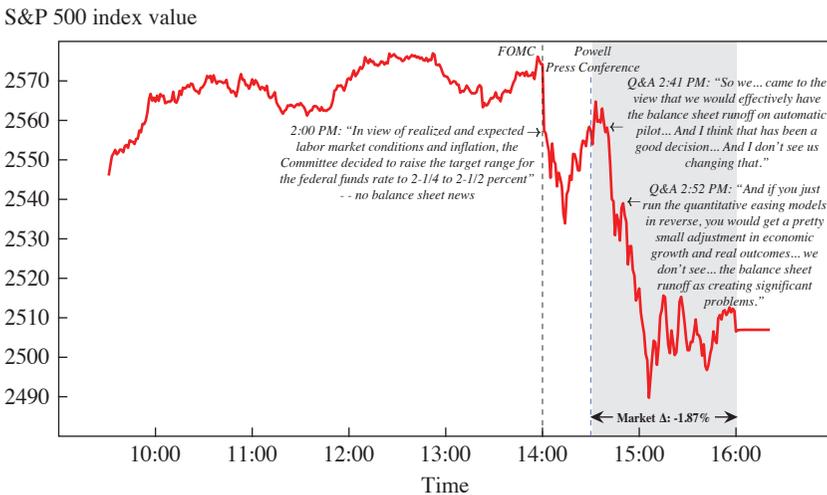
Figure 2. Intraday Movements in the S&P 500: December 18, 2013



Sources: Tickdata.com; FRB (2013b; 2013c, 7 n1, 17).

Note: The gray shaded area represents the event window used for the high-frequency structural event study.

Figure 3. Intraday Movements in the S&P 500: December 19, 2018

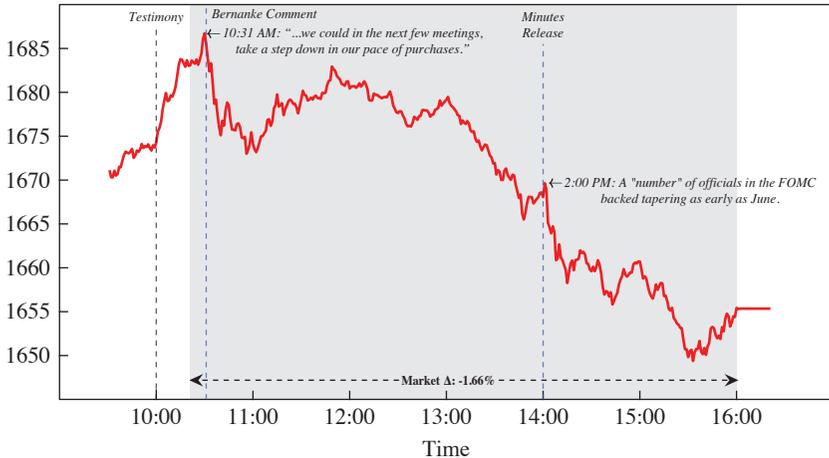


Sources: Tickdata.com; FRB (2018a; 2018b, 6, 11).

Note: The gray shaded area represents the event window used for the high-frequency structural event study.

Figure 4. Intraday Movements in the S&P 500: May 22, 2013

S&P 500 index value



Sources: Tickdata.com; FRB (2013a); FOMC (2013).

Note: The gray shaded area represents the event window used for the high-frequency structural event study.

reacted positively to commentary, suggesting a flexible, “data-dependent” approach to its balance sheet normalization plans, and conversely, as we’ll see next, reacted negatively to commentary suggestive of inflexibility.

The most prominent QT event showcasing the converse case was Powell’s December 19, 2018, press conference at 2:30 p.m., following an FOMC press release at 2:00 p.m. The FOMC press release contained no news about the balance sheet, hence it is excluded from the QT event window. The market’s direction turned downward dramatically during the press conference at a time stamp that immediately followed Powell’s responses in the Q&A in which he stated that the FOMC “came to the view that we would effectively have the balance sheet runoff on *automatic pilot*. . . . And I think that has been a good decision. . . . And I don’t see us changing that” (FRB 2018b, 6; emphasis added). Press reports suggest that the perceived inflexibility of the “automatic pilot” language was the antithesis of the “data-dependent” commentary of the December 18, 2013, event, with opposite consequences for the stock market. The market declined further when Powell suggested that the Fed did not see the shrinking of its balance sheet as a source of economic instability: “And if you just run the quantitative easing models in reverse, you would get a pretty small

adjustment in economic growth and real outcomes. . . . We don't see . . . the balance sheet runoff as creating significant problems" (11).

The May 22, 2013, congressional testimony Bernanke gave resulted in the so-called taper tantrum. In the case of the stock market, the declines began immediately after a 10:31 a.m. Bernanke comment that "we could in the next few meetings, take a step down in our pace of purchases" (JEC 2013, 11). Although the stock market partially recovered later in the day, losses for stocks accelerated once more after the 2 p.m. release of FOMC minutes stating that "a number" of officials in the FOMC supported tapering as early as their next meeting in June (FOMC 2013, 7). News analysis suggests that the stock market focused especially on the information about tapering in the minutes due to Bernanke's comments earlier that morning.

II. Why Did the Market React? Mixed-Frequency Structural Approach

I now use a structural model to make inferences on why the stock market reacted to these QT announcements. I apply the methodology in Bianchi, Ludvigson, and Ma (2022). This section provides a brief description of the model and estimation approach.

Bianchi, Ludvigson, and Ma (2022) integrate a high-frequency monetary event study into a mixed-frequency macro-finance model and structural estimation. We examine Fed communications alongside both high- and lower-frequency data through the lens of a structural equilibrium asset pricing model with New Keynesian-style macroeconomic dynamics. This approach allows us to estimate jumps in investor beliefs about the latent state of the economy, the perceived sources of economic risk, and the future conduct of monetary policy at high frequency surrounding Fed news events. I focus on this aspect of the empirical approach in Bianchi, Ludvigson, and Ma (2022), applied in this instance to Fed announcements about its balance sheet normalization plans.³

The main elements of this model are as follows: (1) It is a two-agent model with New Keynesian macro dynamics with heterogeneous beliefs. Households or workers invest in short-term bonds but have no stock

3. The mixed-frequency structural estimation further permits us to quantify the causal effects of shifts in monetary policy that may occur outside of tight windows surrounding Fed communications. The interested reader can find this analysis in Bianchi, Ludvigson, and Ma (2022).

market wealth; their expectations are formed using backward-looking rules. Investors are forward-looking, and they can react quickly to news. Their expectations are consistent with an understanding of driving forces in the model but they must form beliefs about the future conduct of monetary policy. They earn all income from investments in risk-free nominal bonds and the stock market. (2) The conduct of monetary policy is subject to infrequent nonrecurrent regime shifts, or structural breaks, that take the form of shifts in the parameters of a nominal interest rate rule. Investors understand that breaks occur and form an expectation of what policy rule will come next, once the current regime ends. (3) There are six primitive shocks: a monetary policy shock in the interest rate rule; an aggregate demand shock in the real activity/IS equation; a markup shock in the Phillips curve; a shock to trend growth; an earnings share shock that redistributes the rewards of production between workers and investors without affecting the size of the rewards; and a liquidity premium that represents a preference for risk-free nominal debt over equity. This captures exogenous movements in the equity premium that could be attributable to fluctuations in the liquidity and safety attributes of risk-free nominal debt (Krishnamurthy and Vissing-Jorgensen 2012), changes in risk aversion, flights to quality, and jumps in sentiment. (4) We estimate jumps in investor beliefs around Fed news events about the current economic state (“nowcasts”), about the perceived sources of economic risk, and about future regime change in the monetary policy rule. (5) Numerous forward-looking series at mixed frequency are used to map theoretical implications for beliefs, markets, and the economy into data. (6) The full structural model is solved and estimated using Bayesian methods.

To understand the impetus for modeling two types of agents (households versus investors), note that household survey data indicate that households display substantial inertia in the expectations (Malmendier and Nagel 2016).⁴ On the other hand, it is evident that financial markets react swiftly to central bank communications and actions. This suggests that the expectations of financial market participants are subject to little inertia. The framework reconciles these seemingly contradictory observations by considering two types of agents with different beliefs.

It is worth discussing the channels through which quantitative interventions could influence the model economy. To do so, it is helpful to

4. We follow Malmendier and Nagel (2016) in modeling household inflation expectations as evolving from a constant gain learning algorithm, and we discipline our estimates of the parameters of this process by filtering household expectations data from the University of Michigan Survey of Consumers.

present two equations. Equation (1) is the central bank's interest rate policy rule, which takes the general form:

$$(1) \quad i_t - (r_{ss} + \pi_{\zeta_t}^T) = (1 - \rho_{i,\zeta_t}) [\Psi_{\pi,\zeta_t} (\pi_t - \pi_{\zeta_t}^T) + \Psi_{\Delta y,\zeta_t} (y_t - y_{t-1})] \\ + \rho_{i,\zeta_t} [i_t - (r_{ss} + \pi_{\zeta_t}^T)] + \sigma_i \varepsilon_{i,t}, \varepsilon_i \sim N(0,1),$$

where i_t is the short-term nominal interest rate, r_{ss} is the steady-state real interest rate, π_t is current inflation, y_t is aggregate output, $\varepsilon_{i,t}$ is a monetary policy shock, and $\pi_{\zeta_t}^T$, Ψ_{π,ζ_t} , $\Psi_{\Delta y,\zeta_t}$, ρ_{i,ζ_t} are time-varying parameters of the policy rule where ζ_t denotes a discrete-valued random variable that indexes the estimated policy regimes in our sample. Lags of the variable on the left-hand side appear in the rule to capture the observed smoothness in adjustments to the central bank's target interest rate.

Equation (2) is the log equity premium as perceived by the investor:

$$(2) \quad E_t^b [r_{t+1}^D] - (i_t - E_t^b [\pi_{t+1}])_{\omega, \text{subj. equity premium}} \\ = [-.5V_t^b [r_{t+1}^D] - COV_t^b [m_{t+1}, r_{t+1}^D] - .5V_t^b [\pi_{t+1}] \\ - COV_t^b [m_{t+1}, \pi_{t+1}]]_{\omega, \text{subj. risk premium}} + lp_{t,\omega, \text{liquidity premium}}$$

where $E_t^b [\cdot]$, $V_t^b [\cdot]$, and $COV_t^b [\cdot]$ are the conditional mean, variance, and covariance under the subjective beliefs of the agent. The equity premium has two components. The component labeled “subj. risk premium” is the part attributable to the agent's subjective perception of risk. As explained in Bianchi, Ludvigson, and Ma (2022), this component is driven entirely by realized regime changes in the conduct of monetary policy or investors' subjective beliefs about the probability of a near-term regime change in the policy rule. The liquidity premium is a catchall for all sources of time variation in the equity premium other than those attributable to shifts in subjective beliefs about the monetary policy rule.⁵

With these equations in mind, we can discuss the channels through which quantitative interventions could influence the model economy. First, monetary policy is summarized by the interest rate rule, equation (1), thus the framework doesn't explicitly model quantitative interventions in the form

5. In our structural estimation we use the twenty-year BAA-Treasury spread as a noisy signal of this component.

of explicit Fed purchases of long-term Treasuries, agency debt, or agency MBS. However, quantitative interventions and other forms of unconventional monetary policy, such as forward guidance, show up in the policy rule implicitly through their influence on the time-varying parameter $\pi_{\zeta_t}^T$. Although this parameter plays the role of an inflation target in the interest rate rule, unlike traditional New Keynesian models, $\pi_{\zeta_t}^T$ does not necessarily coincide with the stated long-term inflation objective of the central bank. This happens because the model here differs in two ways from the traditional New Keynesian models: macro (household) expectations are estimated to be strongly backward-looking—implying that long-term inflation expectations of households can persistently deviate by large magnitudes from $\pi_{\zeta_t}^T$ even though they eventually converge toward $\pi_{\zeta_t}^T$ —and because the policy rule parameters are not constant but instead vary over time. In this setting, $\pi_{\zeta_t}^T$ is more appropriately thought of as an implicit time t target rather than an explicit objective. Forward guidance and quantitative easing (QE), two tools that were employed at the zero lower bound, are channels that manifest indirectly in the policy rule as a higher value for the implicit inflation target $\pi_{\zeta_t}^T$, since these policies are designed in part to generate higher expected inflation and lower real rates (thereby stimulating aggregate demand) even as nominal interest rates remain unchanged at the zero lower bound. We could thus refer to this as the inflation expectations channel of unconventional monetary policy transmission. Movements in the real interest rate are the primary channel of monetary transmission to the aggregate macroeconomy in the model of Bianchi, Ludvigson, and Ma (2022) and in New Keynesian models in general. However, in our model such unconventional monetary interventions must be effective at actually changing inflation expectations in order for this channel to be operative. Because we estimate that household inflation expectations respond only very slowly over time to new information about inflation and changes in the implicit target $\pi_{\zeta_t}^T$, we estimate that this inflation expectations channel is quite muted, which we stress is a result rather than an assumption.

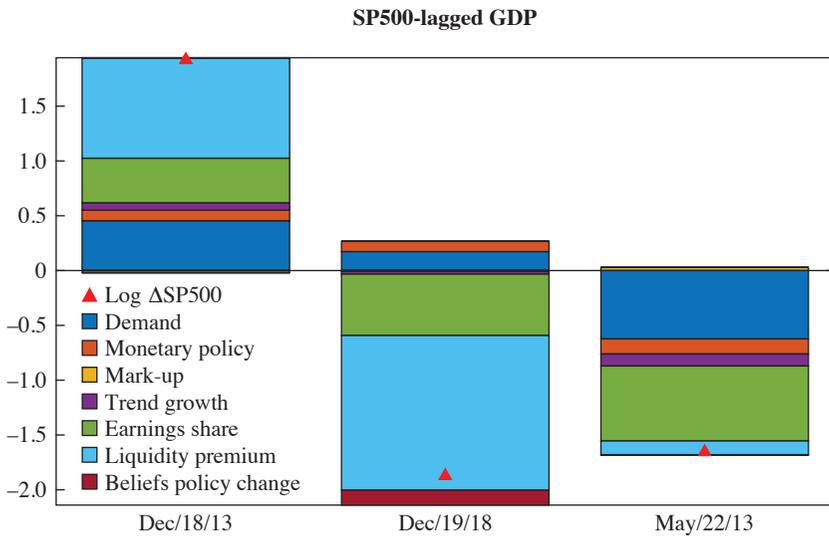
Yet even if quantitative interventions have a limited effect on the macroeconomy through the inflation expectations channel, these interventions—and the Fed’s announcements about them—could still have quantitatively important effects on financial markets through three other distinct channels in the model: (1) by distorting return premia in financial markets; (2) by altering investor beliefs about broader economic activity, such as output growth or inflation (the “Fed information effect”); or (3) by affecting investor nowcasts of the share of output accruing to equity holders

(as opposed to workers). The first channel can be triggered if Fed news about balance sheet normalization either changes the liquidity premium or causes jumps in beliefs about a near-term regime shift in the policy rule. Beliefs about regime change in the policy rule play a crucial role in shaping perceptions of equity market risk. For example, a jump upward in the perceived probability of a near-term shift to a policy rule with greater activism in stabilizing the real economy (manifested as larger values for the activism coefficient $\psi_{\Delta y, \zeta_t}$) lowers expected volatility, driving the subjective risk premium down and the stock price up. Each of these channels can have large effects on the stock market in the model economy, but unless they are accompanied by changes in the real interest rate—through the inflation expectations channel—quantitative interventions will have no effect on the broader macroeconomy in the model.

For the subperiod that is relevant for balance sheet normalization, our estimates imply that markets were expecting the next policy rule to be both more hawkish (lower $\pi_{\zeta_t^p}$) and more active, with higher values for both ψ_{π, ζ_t} and $\psi_{\Delta y, \zeta_t}$. These two forces have offsetting effects on stock market valuations. The expectation of a more hawkish Fed works to lower the stock market's value by raising the perceived probability of persistently higher real rates. By contrast, the expectation of a more active Fed would work to raise the stock market's value by lowering the perceived quantity of risk in the market. Our estimates imply that Fed announcements in this period have a larger effect on the perceived quantity of risk than they do on the path of future short rates, so that Fed communications that trigger a lower perceived probability of transitioning to the next policy rule decrease the stock market's value on net.

III. High-Frequency Structural Analysis: What Did the Market Learn?

What did markets learn from these QT events? I use the methodology of Bianchi, Ludvigson, and Ma (2022), which combines a filtering algorithm with a structural estimation, to decompose movements in forward-looking variables such as the stock market into revisions in beliefs about the primitive shocks affecting the economy and about the possibility of a near-term regime shift in monetary policy. The novelty of this approach allows us to investigate a variety of possible explanations for why markets respond strongly and swiftly to central bank actions and announcements, not merely by delineating which expectations are revised but also

Figure 5. Sources of Movements in the S&P 500: Top Three QT Events

Source: Author's calculations.

Note: The figure reports the decomposition of movements in the S&P 500-lagged GDP ratio attributable to revisions in the perceived shocks hitting the economy and in the belief regimes for the five most quantitatively important Fed announcements (as measured by the absolute magnitude of jumps in the S&P 500-lagged GDP ratio) about balance sheet normalization.

by providing granular detail on why they are revised, with a decomposition of market responses into the primitive economic sources of risk responsible for observed forecast revisions.

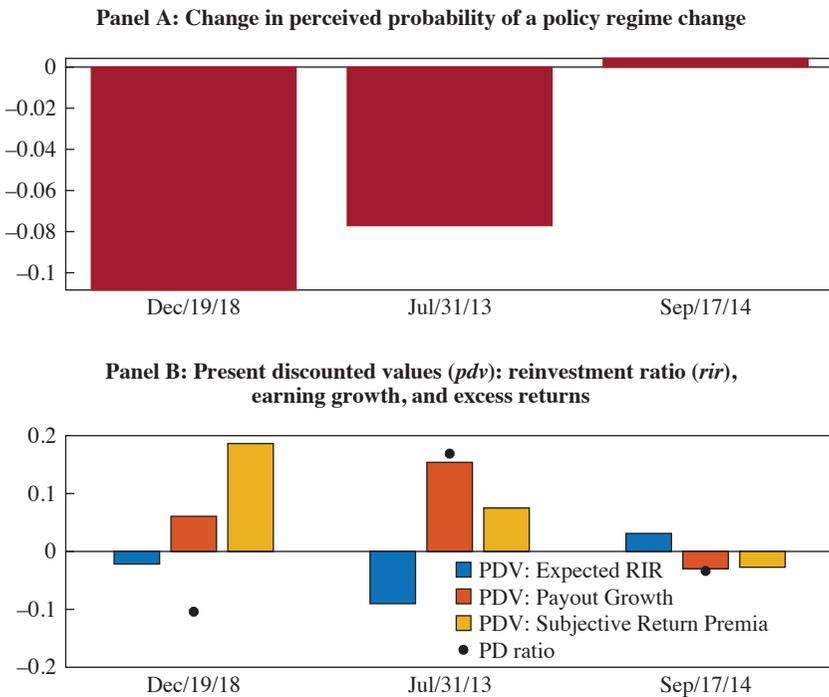
Figure 5 shows the decomposition of jumps in the S&P 500-lagged GDP ratio into components driven by different elements of the perceived vector of Gaussian shocks and by investor beliefs about the probability of a regime shift in the monetary policy rule. These are estimates of how investors' perceived shocks were revised due to the Fed news. For example, if the confluence of data suggests that stock market investors learn from an announcement that there has been a restrictive monetary policy shock, this shows up in our structural estimation as a negative contribution to the stock market. If, at the same time, investors have revised their nowcasts for aggregate demand up—that is, they perceive a higher demand shock than previously as a result of the announcement—this shows up in our structural estimation as making an offsetting positive contribution. Note that jumps in the S&P 500-lagged GDP ratio at QT announcements are entirely attributable to jumps in the stock market, since GDP is lagged one month.

The triangles in the figure mark both the actual change in the S&P 500 during the event window, as well as the model-implied change in the stock market in the window. These two coincide exactly, since our state-space estimation disallows observation errors in the observation equation for the S&P 500–lagged GDP ratio.

Figure 5 shows that the most quantitatively important QT event in our sample—December 18, 2013, when the market rose 1.92 percent in the two hours surrounding the news—was largely driven by a lower nowcast for the liquidity premium component of the subjective equity premium and higher investor nowcasts for the earnings share of output and for aggregate demand, with small supporting contributions from the perception of a more accommodative monetary policy shock and higher trend growth. The second most important QT event for the stock market was on December 19, 2018, when the market fell 1.9 percent in the ninety minutes surrounding Powell’s remarks. In this case, the lion’s share of the decline was attributable to the subjective equity premium rising, mostly due to the liquidity premium rising, but also due to a jump downward in the perceived probability of a near-term regime change in the conduct of monetary policy. In addition, the nowcast for the earnings share fell, contributing to the decline.

If we sort events according to their importance for revisions in investor beliefs about the probability of regime change in the policy rule, we find that the QT event of Powell’s press conference on December 19, 2018, is by far the most important. Figure 6, panel A, shows the change in the perceived probability of a regime change for each of these five events, while panel B shows the decomposition of the jump in the model price–payout ratio, pd_t , into its various contributing forces (subjective return premia, expected real interest rates, and expected payout growth). Panel A shows that the December 19, 2018, QT event is associated with a large downward revision in the perceived probability of a regime change in the policy rule. Panel B shows that this same event is associated with a jump downward in pd_t (the dot), driven almost entirely by a large jump upward in subjective expected return premia. Subjective perceptions of risk rise, in part, because of the sharp decline in the perceived probability of transitioning to the policy rule expected to come next, where the central bank would be more actively engaged in stabilizing the real economy. The decline in the perceived probability of transitioning to this next rule raises expected volatility and the subjective equity premium. This is the structural interpretation of Powell’s “automatic pilot” comment about runoff, seen through the lens of the model.

Figure 6. Jumps in Risk Perceptions, Short Rates, and Earnings Expectations



Source: Author’s calculations.

Note: Panel A shows the pre-announcement and post-announcement changes in the perceived probability that financial markets assign to a switch in the monetary policy rule occurring within one year, for the five most quantitatively important QT announcements based on changes in investor beliefs about the future conduct of monetary policy. Panel B shows a decomposition of the model’s fluctuations in the log price–payout ratio $pd = pdv_t(\Delta d) - pdv_t(r^{ex}) - pdv_t(rir)$ in the same event windows around these announcements that are driven by subjective equity risk premium variation, as measured by $pdv_t(r^{ex})$; subjective expected future real interest rate fluctuations, as measured by $pdv_t(rir)$; and subjective expected earnings growth, as measured by $pdv_t(\Delta d)$. PD ratio is $pdv_t(\Delta d) - pdv_t(r^{ex}) - pdv_t(rir)$.

IV. Taking Stock

What do we take away from these results? Two points stand out. First, whether it’s tapering or tightening, the stock market dislikes perceived inflexibility in statements about balance sheet normalization. Second, financial markets, including the stock market, are clearly attuned to news about the balance sheet. And the stock market is reactive to such news. The subjective equity return premium is a big driver of jumps in the market around QT news events, with the jumps in nowcasts for the earnings share playing an important secondary role. Whether these stock market moves in response

to QT news have any implication for the broader economy is an open question. We find little evidence that high-frequency measures of forecasts of inflation or real GDP growth respond at all to QT news events, despite the large stock market reactions. Extensive literature on asset pricing suggests that much of the variation in stock market return premia has a negligible correlation with broader economic activity. Finally, the movements in the earnings share that we measure—an important source of variation in the stock market—merely redistribute the rewards of production without affecting the size of those rewards. Thus, by construction, perceived changes in this share in response to Fed news have nothing to do with expectations for the broader economy.

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Appendix to Market Reactions to the Fed's Balance Sheet Normalization Plans

SYDNEY C. LUDVIGSON*
NYU, CEPR, and NBER

September 2, 2022

Abstract

TBC

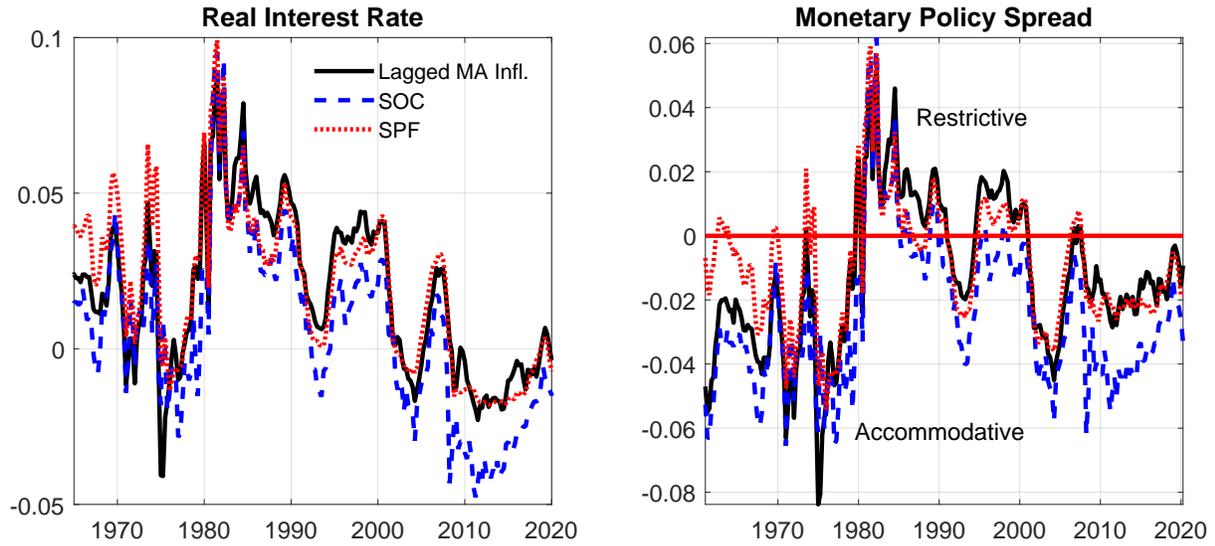
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*Department of Economics, NYU, 19 W.4th St, 6th Floor, New York, NY 10012. (sydney.ludvigson@nyu.edu). This discussion is based on joint work with Francesco Bianchi and Sai Ma. We are grateful to Courtney Wiegand, Nicholas Zarra, and Steven Zheng for excellent research assistance. Ludvigson received financial support from the National Science Foundation under Grant 2116641.

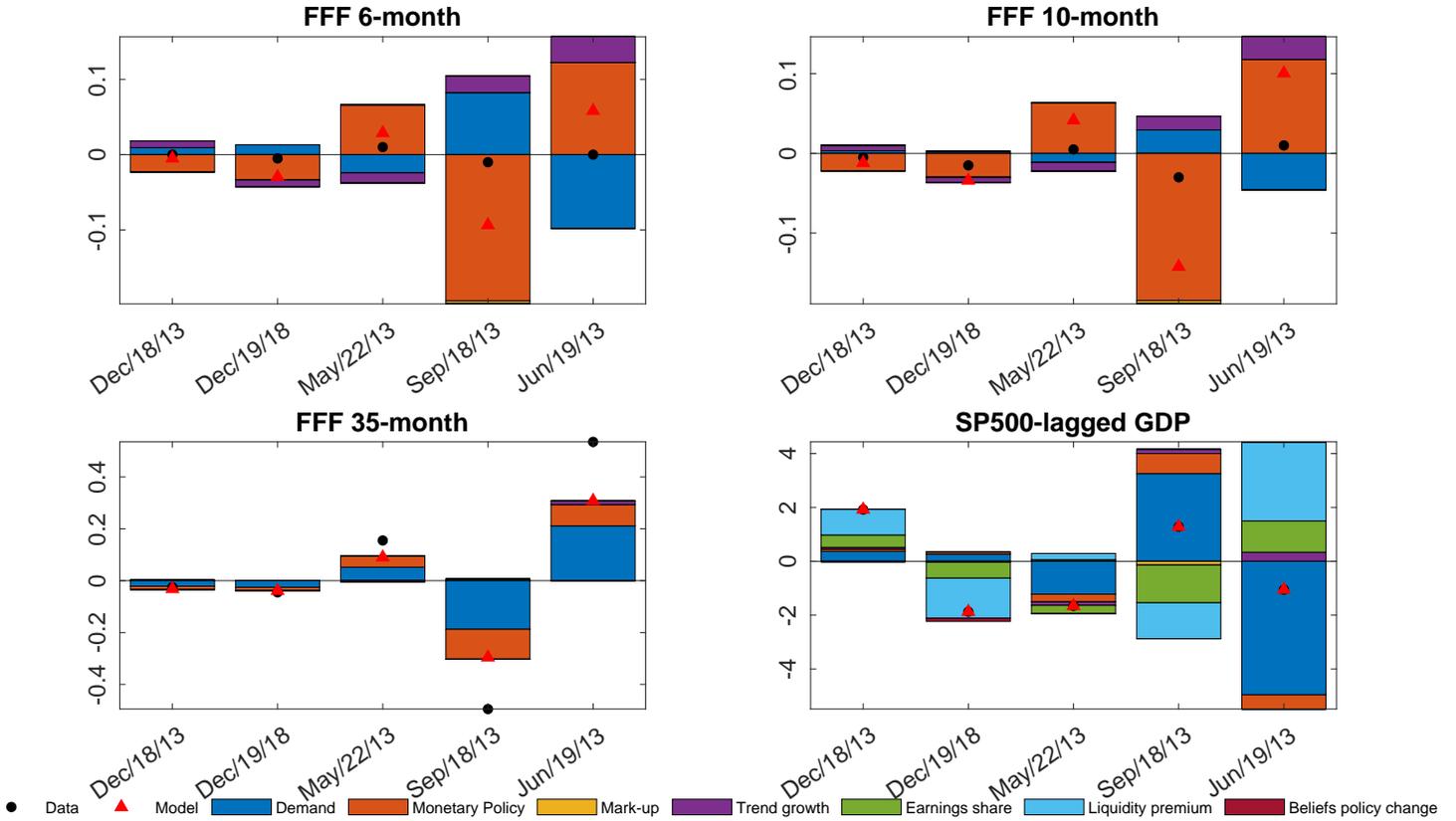
Appendix

Figure A.1: Real Interest Rate



Notes: The real interest rate is measured as the federal funds rate minus a measure of inflation expectation. In the left panel, the black line measures inflation expectation uses a four quarter moving average of inflation. The blue line uses one-year mean forecast of inflation from the Survey of Consumers. The red line uses one-year mean forecast of inflation from the Survey of Professional Forecasters. The right panel plots the monetary policy spread, i.e., the spread between the real interest rate and the ? natural rate of interest. The sample spans 1961:Q1-2020:Q1.

Figure A.2: Top Five Fed QT Events for the SP500



Notes: The figure reports the decomposition of movements in the 6-month FFF rates, the 10-month FFF rates, the 35-month FFF rates, and the stock market attributable to revisions in the perceived shocks hitting the economy and in the belief regimes for the 5 most relevant Fed QT announcements based on changes in the stock market. For panel (d), because we do not have measurement error in the equations for the SP500 to lagged GDP ratio, the black dot (data) and the red triangles (model) lie on top of each other, so the black dot is obscured. The full sample has 14 balance sheet normalization events spanning May 22, 2013 to March 20, 2019.

Fed Announcements on Balance Sheet Normalization

Fed Announcements on Balance Sheet Normalization

Date	Day	Time	HF Window	Event	Information
Tapering Announcements					
5/22/13*	WED	10:31am	10:21am-Mkt cls	Testimony	<ul style="list-style-type: none"> • Taper Tantrum • “If we see continued improvement and we have confidence that that is going to be sustained, then we could in the next few meetings, take a step down in our pace of purchases.” • This statement sent a negative shock to the market, causing bond investors to start selling their bonds and yields on 10-year U.S. Treasuries to rise.
6/19/13*	WED	2:00pm	2:28pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “The Committee is prepared to increase or reduce the pace of its purchases to maintain appropriate policy accommodation as the outlook for the labor market or inflation changes. In determining the size, pace, and composition of its asset purchases, the Committee will continue to take appropriate account of the likely efficacy and costs of such purchases as well as the extent of progress toward its economic objectives.”
6/19/13*	WED	2:30pm	2:28pm-Mkt cls	Press Conference	<p>Opening Remarks:</p> <ul style="list-style-type: none"> • 2:33pm: “While participants continue to think that, in the long run, the Federal Reserve’s portfolio should consist predominantly of Treasury securities, a strong majority now expects that the Committee will not sell agency mortgage backed securities during the process of normalizing monetary policy, although in the longer run, limited sales could be used to reduce or eliminate residual MBS holdings. I emphasize that, given the outlook and the Committee’s policy guidance, these matters are unlikely to be relevant to actual policy for quite a while.” • 2:38pm: “If the incoming data are broadly consistent with this forecast, the Committee currently anticipates that it would be appropriate to moderate the monthly pace of purchases later this year. And if the subsequent data remain broadly aligned with our current expectations for the economy, we would continue to reduce the pace of purchases in measured steps through the first half of next year, ending purchases around midyear.” <p>Q&A:</p> <ul style="list-style-type: none"> • 2:45pm: “I think one thing that’s very important for me to say is that, if you draw the conclusion that I’ve just said, that our policies—that our purchases will end in the middle of next year, you’ve drawn the wrong conclusion because our purchases are tied to what happens in the economy. And if the Federal Reserve makes the same error and we overestimate what’s happening, then our policies will adjust to that. We are not—we have no deterministic or fixed plan. Rather, our policies are going to depend on this scenario coming true. If it doesn’t come true, we’ll adjust our policies to that.”

Note: Events marked with an * represent the 5 most quantitatively important Fed announcements about balance sheet normalization.

Fed Announcements on Balance Sheet Normalization (Cont'd)

Date	Day	Time	HF Window	Event	Information
Tapering Announcements					
7/31/13	WED	2:00pm	1:50pm-2:20pm	FOMC Statement	<ul style="list-style-type: none"> • “The Committee is prepared to increase or reduce the pace of its purchases to maintain appropriate policy accommodation as the outlook for the labor market or inflation changes. In determining the size, pace, and composition of its asset purchases, the Committee will continue to take appropriate account of the likely efficacy and costs of such purchases as well as the extent of progress toward its economic objectives.”
9/18/13*	WED	2:00pm	1:50pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “In judging when to moderate the pace of asset purchases, the Committee will, at its coming meetings, assess whether incoming information continues to support the Committee’s expectation of ongoing improvement in labor market conditions and inflation moving back toward its longer-run objective. Asset purchases are not on a preset course, and the Committee’s decisions about their pace will remain contingent on the Committee’s economic outlook as well as its assessment of the likely efficacy and costs of such purchases.”
9/18/13*	WED	2:30pm	1:50pm-Mkt cls	Press Conference	<p>Q&A:</p> <ul style="list-style-type: none"> • 2:49pm: “So there is no fixed calendar-schedule, I really have to emphasize that. If the data confirm our basic outlook, if we gain more confidence in that outlook and we believe that the three-part test that I mentioned is indeed coming to pass, then we could move later this year, we could begin later this year. But even if we do that, the subsequent steps will be dependent on continued progress in the economy. So we are tied to the data—we don’t have a fixed calendar schedule—but we do have the same basic framework that I described in June.” • 3:03pm: “And our assessment of the data since June is that, taken collectively, that it didn’t quite meet the standard of satisfying our—or of ratifying or confirming our basic outlook for, again, increasing growth, improving labor markets, and inflation moving back towards target. We try our best to communicate to markets—we’ll continue to do that—but we can’t let market expectations dictate our policy actions. Our policy actions have to be determined by our best assessment of what’s needed for the economy.”
10/30/13	WED	2:00pm	1:50pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “In judging when to moderate the pace of asset purchases, the Committee will, at its coming meetings, assess whether incoming information continues to support the Committee’s expectation of ongoing improvement in labor market conditions and inflation moving back toward its longer-run objective. Asset purchases are not on a preset course, and the Committee’s decisions about their pace will remain contingent on the Committee’s economic outlook as well as its assessment of the likely efficacy and costs of such purchases.”

Note: Events marked with an * represent the 5 most quantitatively important Fed announcements about balance sheet normalization.

Fed Announcements on Balance Sheet Normalization (Cont'd)

Date	Day	Time	HF Window	Event	Information
Tapering Announcements					
12/18/13*	WED	2:00pm	1:50pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “Beginning in January, the Committee will add to its holdings of agency mortgage-backed securities at a pace of \$35 billion per month rather than \$40 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of \$40 billion per month rather than \$45 billion per month.” • Note: This is the first Statement that provided a time and an amount that purchases would be reduced.
12/18/13*	WED	2:30pm	1:50pm-Mkt cls	Press Conference	<p>Q&A:</p> <ul style="list-style-type: none"> • 2:42pm: “But again, I want to emphasize that we are going to be data-dependent. We could stop purchases if the economy disappoints. We could pick them up somewhat if the economy is stronger.” • 3:04pm: “Well, again, we’re not doing less. We’ll see how accommodation shapes up. But while we are slowing asset purchases a bit, again, we expect the total balance sheet to be quite large and maintained for-at a large level for a long time. And we expect to keep rates low for a very long time. We’re providing a great deal of accommodation to the economy. I agree with your observation, and the observation of the paper that you cited, that there is a case for being particularly aggressive, and I think we have been aggressive to try to keep the economy growing, and we are seeing progress in the labor market. So I would dispute the idea that we’re not providing a lot of accommodation to the economy.”
1/29/14	WED	2:00pm	1:50pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “In light of the cumulative progress toward maximum employment and the improvement in the outlook for labor market conditions, the Committee decided to make a further measured reduction in the pace of its asset purchases. Beginning in February, the Committee will add to its holdings of agency mortgage-backed securities at a pace of \$30 billion per month rather than \$35 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of \$35 billion per month rather than \$40 billion per month.”
3/19/14	WED	2:00pm	1:50pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “Beginning in April, the Committee will add to its holdings of agency mortgage-backed securities at a pace of \$25 billion per month rather than \$30 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of \$30 billion per month rather than \$35 billion per month.” • There was a sharp drop in the stock market during the press conference, which has been attributed to Yellen clarifying the Statement’s use of the word “considerable” for the next rate hike as probably meaning “something on the order of around six months,” earlier than most anticipated.

Note: Events marked with an * represent the 5 most quantitatively important Fed announcements about balance sheet normalization.

Fed Announcements on Balance Sheet Normalization (Cont'd)

Date	Day	Time	HF Window	Event	Information
Tapering Announcements					
9/17/14	WED	2:00pm	1:50pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “Beginning in October, the Committee will add to its holdings of agency mortgage-backed securities at a pace of \$5 billion per month rather than \$10 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of \$10 billion per month rather than \$15 billion per month.” • Policy Normalization Principles and Plans released with the Statement, providing details on the timing and pace of interest rate increases and balance sheet runoff. <ul style="list-style-type: none"> – “The Committee expects to cease or commence phasing out reinvestments after it begins increasing the target range for the federal funds rate; the timing will depend on how economic and financial conditions and the economic outlook evolve.” – “The Committee currently does not anticipate selling agency mortgage-backed securities as part of the normalization process, although limited sales might be warranted in the longer run to reduce or eliminate residual holdings. The timing and pace of any sales would be communicated to the public in advance.”
9/17/14	WED	2:30pm	1:50pm-Mkt cls	Press Conference	<p>Q&A:</p> <ul style="list-style-type: none"> • 3:08pm: “If we were only to shrink our balance sheet by ceasing reinvestments, it would probably take to get back to levels of reserve balances that we had before the crisis-I’m not sure we will go that low, but we’ve said that we will try to shrink our balance sheet to the lowest levels consistent with the efficient and effective implementation of policy-it could take to the end of the decade to achieve those levels.”
Tightening Announcements					
6/14/17	WED	2:00pm	2:32pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “The Committee currently expects to begin implementing a balance sheet normalization program this year, provided that the economy evolves broadly as anticipated. This program, which would gradually reduce the Federal Reserve’s securities holdings by decreasing reinvestment of principal payments from those securities, is described in the accompanying addendum to the Committee’s Policy Normalization Principles and Plans.” • FFR raised to 1-1/4 percent. • Along with the Statement, the Fed issued an “Addendum to the Policy Normalization Principles and Plans” detailing how its “securities holdings by decreasing its reinvestment of the principal payments it receives from securities held in the System Open Market Account.”

Note: Events marked with an * represent the 5 most quantitatively important Fed announcements about balance sheet normalization.

Fed Announcements on Balance Sheet Normalization (Cont'd)

Date	Day	Time	HF Window	Event	Information
Tightening Announcements					
6/14/17	WED	2:30pm	2:32pm-Mkt cls	Press Conference	<p>Opening Remarks:</p> <ul style="list-style-type: none"> 2:42pm: "What I can tell you is that we anticipate reducing reserve balances and our overall balance sheet to levels appreciably below those seen in recent years but larger than before the financial crisis." <p>Q&A:</p> <ul style="list-style-type: none"> 3:18pm: "But if the economy evolves in line with our expectations, which, you know, we will be watching-always are-we could put this into effect relatively soon."
9/20/17	WED	2:00pm	1:50pm-2:20pm	FOMC Statement	<ul style="list-style-type: none"> "In October, the Committee will initiate the balance sheet normalization program described in the June 2017 Addendum to the Committee's Policy Normalization Principles and Plans." Addendum: "The Committee directs the Desk to continue rolling over at auction the amount of principal payments from the Federal Reserve's holdings of Treasury securities maturing during each calendar month that exceeds \$6 billion, and to continue reinvesting in agency mortgage-backed securities the amount of principal payments from the Federal Reserve's holdings of agency debt and agency mortgage-backed securities received during each calendar month that exceeds \$4 billion. Small deviations from these amounts for operational reasons are acceptable." No change in the FFR.
9/20/17	WED	2:30pm	2:30pm-Mkt cls	Press Conference	<p>Opening Remarks:</p> <ul style="list-style-type: none"> 2:40pm: "As a result, our balance sheet will decline gradually and predictably." 2:41pm: "We therefore do not plan on making adjustments to our balance sheet normalization program." <p>Q&A:</p> <ul style="list-style-type: none"> 2:54pm: "We have said if there were that type of material deterioration in the outlook where we could face a situation where the federal funds rate isn't a sufficient tool for us to adjust monetary policy, we might stop-we might stop roll-offs from our balance sheet and resume reinvestment. But as long as we believe that we can use the federal funds rate as a tool, that is what we intend to do." 2:55pm: "So the only thing I would object to there, is you said that we are "locked in," and I would say that we are not locked in." 2:57pm: "But we're assessing incoming data, and these plans are subject to change. What's not subject to change is our commitment to doing everything in our power to achieve the goals that Congress has assigned to us, which are price stability or 2 percent inflation and maximum employment."

Note: Events marked with an * represent the 5 most quantitatively important Fed announcements about balance sheet normalization.

Fed Announcements on Balance Sheet Normalization (Cont'd)

Date	Day	Time	HF Window	Event	Information
Tightening Announcements					
12/19/18*	WED	2:00pm	2:31pm-Mkt cls	FOMC Statement	<ul style="list-style-type: none"> • “In view of realized and expected labor market conditions and inflation, the Committee decided to raise the target range for the federal funds rate to 2-1/4 to 2-1/2 percent.”
12/19/18*	WED	2:30pm	2:31pm-Mkt cls	Press Conference	<p>Q&A:</p> <ul style="list-style-type: none"> • 2:41pm: “So we thought carefully about this, on how to normalize policy, and came to the view that we would effectively have the balance sheet runoff on automatic pilot and use monetary policy, rate policy, to adjust to incoming data. And I think that has been a good decision. I think that the runoff of the balance sheet has been smooth and has served its purpose. And I don’t see us changing that. And I do think that we will continue to use monetary policy, which is to say rate policy, as the active tool of monetary policy.” • 2:52pm: “And if you just run the quantitative easing models in reverse, you would get a pretty small adjustment in economic growth and real outcomes. So we don’t think, you know, things that are happening at the short run-at the short end-are driven by many other factors other than the balance sheet runoff. For example, just-very large bill supply has pushed up short-term rates, has pushed up repo rates. Tightening of the federal funds rate has raised short-term borrowing costs. So, you know, we’re alert to these issues. We’re watching them carefully. But we don’t see, you know, the balance sheet runoff as creating significant problems.”
3/20/19	WED	2:00pm	1:50pm-Mkt cls	FOMC/Press Release	<ul style="list-style-type: none"> • “In light of its discussions at previous meetings and the progress in normalizing the size of the Federal Reserve’s securities holdings and the level of reserves in the banking system, all participants agreed that it is appropriate at this time for the Committee to provide additional information regarding its plans for the size of its securities holdings and the transition to the longer-run operating regime. At its January meeting, the Committee stated that it intends to continue to implement monetary policy in a regime in which an ample supply of reserves ensures that control over the level of the federal funds rate and other short-term interest rates is exercised primarily through the setting of the Federal Reserve’s administered rates and in which active management of the supply of reserves is not required. The Statement Regarding Monetary Policy Implementation and Balance Sheet Normalization released in January as well as the principles and plans listed below together revise and replace the Committee’s earlier Policy Normalization Principles and Plans.”

Note: Events marked with an * represent the 5 most quantitatively important Fed announcements about balance sheet normalization.

Fed Announcements on Balance Sheet Normalization (Cont'd)

Date	Day	Time	HF Window	Event	Information
Tightening Announcements					
3/20/19	WED	2:30pm	1:50pm-Mkt cls	Press Conference	<p>Opening Remarks:</p> <ul style="list-style-type: none"> • 2:34 pm: “As I noted, my colleagues and I think that this setting is well suited to the current outlook and believe that we should be patient in assessing the need for any change in the stance of policy. “Patient” means that we see no need to rush to judgment. It may be some time before the outlook for jobs and inflation calls clearly for a change in policy.” <p>Q&A:</p> <ul style="list-style-type: none"> • 2:49 pm: “It’s a great time for us to be patient and watch and wait and see how things evolve.”

Note: Events marked with an * represent the 5 most quantitatively important Fed announcements about balance sheet normalization.