Free markets to Fed markets:
How modern monetary policy impacts equity markets ☆

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***Financial Analysts Journal*, forthcoming**

Abstract

The US Federal Reserve doubled its balance sheet during the COVID-19 pandemic in the most aggressive unconventional monetary policy on record. I show that the scale and scope of these actions substantially impacted stock markets, explaining at least one-third of their rebound. The impact occurs predominantly through bond yields (discount rates) and expectations of future macroeconomic conditions (future cash flows). I find while the Fed's balance sheet expansions are more rapid than its contractions, the stock market is more sensitive to contractions. The findings have implications for possible impacts of central banks unwinding the positions accumulated during the pandemic.

JEL classification: E58; E44; E52; G12; G14; C54
Keywords: stock markets, monetary policy, quantitative easing, liquidity, COVID-19

☆ I am grateful for the comments of the editor (William Goetzmann), co-editor (Daniel Giamouridis), two anonymous referees, Thomas Matthys and seminar participants at the COVID-19 Economic Shock Workshop hosted by the University of Technology Sydney. I gratefully acknowledge funding from the Australian Research Council under grant ARC DE150101889.
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1. Introduction

Stock markets became disconnected from the real economy during the COVID-19 pandemic, according to many market commentators. For example, the US S&P 500 index increased 31% from March 23, 2020 in the space of two months taking it back to levels last seen immediately prior to the outbreak of COVID-19 (October 2019 levels), despite a flow of information about deteriorating economic conditions and setbacks in controlling the pandemic.[1] The strong stock market recoveries in the face of deteriorating real economies led many market observers to conclude that "Wall Street [is] disconnected from reality" (Reuters, May 13, 2020) and "the stock market is ignoring the economy" (Wall Street Journal, April 17, 2020).

What are the drivers of this perceived disconnect between stock markets and the economy? This paper examines the role played by strong intervention in markets by central banks through asset purchases and balance sheet expansion. For example, the US Federal Reserve (the "Fed") doubled its assets during the COVID-19 pandemic from $4.17 trillion to $8.33 trillion in August 2021 (37% of GDP), with most of the expansion occurring in the first five months of 2020. The magnitude and speed of this unconventional monetary policy is unprecedented and dwarfs previous quantitative easing (QE) programs.[2] While practitioners have long recognized that the Fed's actions impact the stock market, as per the Wall Street adage "Don't fight the Fed",[3] this paper quantifies the impacts, measures their timing, examines the transmission channels, and characterizes the asymmetry in stock market reactions to expansionary/contractionary actions

[1] Including the IMF declaring the global economy is headed for the worst economic recession since the Great Depression, economic data worse than economist consensus expectations, second and third waves of infections, and setbacks in the development of a vaccine.
[2] "Unconventional monetary policy", which includes quantitative easing (central banks directly purchasing financial securities), has been around since at least the Global Financial Crisis (GFC) of 2008-2009 (e.g., Bernanke, 2020).
[3] This mantra is commonly attributed to Marty Zweig, author of the book "Winning on Wall Street" published in 1970.

during the period 2009–2020. It also estimates the reverse effect, namely how the Fed responds to stock market movements, controlling for changes in macroeconomic indicators.

The first key finding is that there is a strong symbiotic relation between the Fed's balance sheet and stock markets. The Fed tends to respond to stock market declines or the deteriorating economic outlook that is reflected in negative market returns with a lag of 2–5 weeks by expanding its balance sheet through asset purchases. A 10% fall in stock markets is estimated to result in a cumulative balance sheet expansion of around 5.6% over the following 10 to 15 weeks, with most of the effect occurring in the two months following the shock. These estimates from VAR models control for persistence in the Fed's actions and momentum/reversal in markets.

Subsequently, stock markets respond to the Fed's balance sheet expansion with positive returns in the 1–4 weeks following the Fed's actions. A 10% expansion of the Fed's balance sheet is estimated to result in a positive 9.1% impact on cumulative stock market returns over the following five to ten weeks, with most of the effect occurring in the five weeks following the Fed's intervention. These estimates control for momentum and reversals and exclude potential confounding effects by controlling for a range of macroeconomic indicators, stock market return predictors, the Fed funds rate, and other measures of monetary policy shocks.

There is asymmetry in these bi-directional relations. First, the Fed responds more strongly to negative stock market returns (expanding its balance sheet) than it does to positive market returns (contracting its balance sheet). Second, the market is more sensitive to the Fed's balance sheet contractions than it is to balance sheet expansions. The result implies a significant fall in stock markets is likely if the Fed surprises the market with a larger than expected contraction or unwinding of its unconventional monetary policy—the estimated magnitude can be gauged from the impulse response functions in this paper.

Not all stocks are impacted equally. Sectors that tend to be more cyclical such as consumer durables are far more sensitive to the Fed's interventions than less cyclical sectors such as utilities. Small stocks are substantially more sensitive to the Fed's actions than large stocks.

I find that most of the Fed's impact on stock markets can be attributed to two channels. The first is long-term bond yields. When the Fed buys fixed income securities, long term bond yields tend to fall, reducing the discount rate for equities and increasing stock prices. Second, the Fed's balance sheet expansion/contraction impacts expectations of future macroeconomic conditions and thereby expected future corporate earnings.

The Fed's intervention during the COVID-19 pandemic was unprecedented not only in scale, but also in scope, with the Fed directly purchasing corporate bond exchange-traded funds (ETFs) since May 2020. These actions triggered speculation that the Fed could even directly purchase equities if needed. I find that the stock market's reaction to the Fed's asset purchases is slightly stronger during 2020 than in previous rounds of quantitative easing (QE), accounting for differences in scale. Also, the Fed's impacts are stronger around the time that the Fed commenced using a facility that enabled it to directly purchase corporate bond ETFs. These results are consistent with the notion that in addition to scale, the *scope* of the Fed's actions during the COVID-19 pandemic may have contributed to its impact on stock markets.

Finally, to quantify the Fed's impact on markets during the COVID-19 pandemic, I turn to the task of estimating a counterfactual: how much would stock prices have rebounded following their March 2020 decline *without* the Fed's intervention? I model several scenarios corresponding to different assumptions about the unanticipated part of the Fed's actions and the horizon over which the impacts materialize: four weeks, eight weeks, and the long run. The estimates suggest that one-third to one-half of the S&P 500's 31% rebound from March to May 2020 can be attributed to the Fed's aggressive balance sheet expansion during March and April of 2020. In terms of returns, the Fed's balance sheet expansion from around $4 trillion to $7 trillion is estimated to account for a stock market return of 12%−15% in the eight weeks to May 2020, with a further 5% as the full cumulative effect.

What do these results mean for asset managers and investors? First, if we assume that the Fed will not keep expanding its balance sheet indefinitely, periods of substantial expansion, such as during the COVID-19 pandemic, are likely to be followed by a "tapering" of balance sheet expansion and an eventual contraction. The timeseries models in this paper imply that based on past behavior of the Fed and stock markets: (i) a contraction of the Fed's balance sheet from its current level is likely to occur in a more gradual manner than the rate at which the balance sheet was expanded, but (ii) the stock market reaction to any unexpected tapering or contraction of the Fed's balance sheet is likely to be sharper and faster than the positive stock market reaction to balance sheet expansion. This means that while the Fed may take a gradual approach to unwinding its positions, the market is likely to be very sensitive to any negative surprises in the Fed's policy stance.[4] The role of expectations is important because the models suggest the stock market mainly responds to the *unexpected* component of the Fed's actions. Thus, tapering that is in line with expectations may have minimal impact on the stock market, but tapering or contraction that is faster or larger than expected is likely to trigger a stock market reaction. The large size of the Fed's accumulated position and the high market sensitivity to Fed balance sheet contractions implies that the Fed's actions are likely to be a major driver of stock returns and volatility in the near term.

What complicates the issue is that the Fed reacts to macroeconomic data, not just stock prices. For example, currently inflation is among the important factors that is monitored and

[4] This implication of the estimates is consistent with the previously mentioned survey evidence that fund managers view tapering of Fed quantitative easing as one of the biggest tail risks in markets in 2021.

factored into the Fed's policy stance. The results in this paper imply that stock markets react negatively to unexpected contractions of the Fed's QE irrespective of the trigger for the Fed's actions. Therefore, an added risk for stock markets is Fed reactions to macroeconomic surprises, which could subsequently impact stock markets. Thus, macroeconomic risks for stock markets are likely to remain elevated in the near future—not only the direct effects of macroeconomic conditions but also how they impact the Fed's policy stance.

A second set of implications concern economists, analysts, and market observers that use the stock market as an indicator of the expected future health of the economy. The countercyclical use of QE and it substantial impacts implies increased divergence between stock markets and the economy particularly during crises. In the absence of central bank interventions, stock markets are leading indicators of economic growth—when future growth is expected to be high, leading to high expected corporate cash flows, company valuations tend to be high. However, when central banks intervene, this positive correlation between the stock market and the future health of the economy breaks down and could even become negative because of the countercyclicality of the central bank's actions—expansionary monetary stimulus putting upward pressure on stock prices during periods of deteriorating economic outlook. The increased magnitude of central bank intervention amplifies these effects leading to a greater divergence between stock markets and the real economy. This is one of the reasons why during the COVID-19 pandemic the divergence between stock markets and the economy has become particularly apparent.[5]

A final set of implications are for central banks and policymakers. While some central banks such as the Bank of Japan have turned to directly buying equities via exchange traded funds

[5] Other factors contributing to the divergence include the non-representativeness of listed companies relative to the overall economy, such as the substantial weight of large technology companies in the stock market (e.g., Schlingemann and Stulz, 2020).

(ETFs), the Fed and other central banks have not (yet). The results suggest that a central bank need not directly buy equities to have a substantial effect on equity markets. Large scale buying of fixed income securities, as was done by the Fed during the COVID-19 pandemic, can have a substantial positive spillover effect on stock markets.

A few limitations of the analysis are worth noting. First, in estimating how the Fed responds to the stock market, the analysis does not distinguish whether the Fed is reacting to stock prices directly or to expected future economic conditions reflected in stock prices. The models do control for contemporaneous monthly macroeconomic data. Second, while studies of *conventional* monetary policy can use event studies specifically around interest rate announcements, estimating the effects of unconventional monetary policy is more challenging as announcements are rarely precise about the intended magnitude of the QE. I therefore extract expected and unexpected balance sheet changes from a dynamic VAR model and focus on how *unexpected* changes impact stock markets (the equivalent of monetary policy *surprises*).

2. Related literature

This paper is related to a growing literature on the effects of conventional and unconventional monetary policy on financial markets. Bernanke (2020) provides a thorough recent review of this literature, which I only succinctly summarize below. Starting with *conventional* monetary policy, previous studies have examine how interest rate decisions affect stock markets (e.g., Thorbecke, 2007; Bernanke and Kuttner, 2005; Maio, 2014a, 2014b; Cieslak, Morse, and Vissing-Jorgensen, 2019; Brusa, Savor, and Wilson, 2020) and Treasury bonds (e.g., Cochrane and Piazzesi, 2002; Hanson and Stein, 2015; Stein and Sunderam, 2018), showing that interest rate cuts and expansionary monetary policy has a positive effect on stock returns and tends to increase bond yields, and vice versa.

While the evidence is clear that conventional monetary policy affects asset prices, there is less evidence of causality in the opposite direction, that is, central banks responding directly to the stock market. Using textual analysis of FOMC documents, Cieslak and Vissing-Jorgensen (2021) find that policymakers at the Fed do pay attention to the stock market due to the consumption-wealth effect of stock returns, supporting the earlier empirical evidence in Rigobon and Sack (2003). The tendency for policymaker to cut rates in response to falling stock markets has been termed the "Fed put" by traders.[6] This paper's contribution is in showing that the "Fed put" is still a feature of markets in today's zero interest rate environment but takes on a different form: rather than cutting rates, the "new Fed put" involves the Fed expanding its balance sheet in response to stock market declines. Just like the "old Fed put", I show that the "new Fed put" also has a substantial impact on stock returns.

The more recent studies of *unconventional* monetary policy, including QE, have mainly examined the effects on Treasury bond markets (e.g., Gagnon, Raskin, Remache, and Sack, 2011; Krishnamurthy and Vissing-Jorgensen, 2011), corporate bond markets (e.g., Guo, Kontonikas, and Maio, 2020), and bank risk taking (Matthys, Meuleman, and Vennet, 2019). Barbon and Gianinazzi (2019) show that the Bank of Japan's large-scale purchases of ETFs has a positive and persistent impact on Japanese stock prices during the 2014–2016 period. The Fed's recent actions are different in that they do not involve directly purchasing equities yet they still impact stock

[6] For example, Bloomberg describes the Fed put as follows "The notion among traders was that the U.S. central bank's interest rate moves were driven by the stock market. If the S&P 500 was falling, it would feel the need to cut. If the market rose, the Fed would after a suitable interval start raising rates" (John Authers, August 4, 2020, https://www.bloomberg.com/opinion/articles/2020-08-04/fed-props-up-falling-stocks-doesn-t-try-to-prick-bubbles). See Cieslak and Vissing-Jorgensen (2021) for a review of the literature on the Fed put.

markets. The contribution to this literature is in characterizing how unconventional monetary policy—including the Fed's extreme actions during the COVID-19 pandemic—affects stock markets.

3. Data and descriptive statistics

I use weekly data on the value of assets on the US Federal Reserve's (Fed) balance sheet from the Economic Research Division of the Federal Reserve Bank of St. Louis.[7] From the same data source, I obtain quarterly measures of US GDP. I supplement these datasets with S&P 500 index values from Thomson Reuters, stock market return data from the Center for Research in Security Prices (CRSP), Fama-French factors from CRSP, and industry return data from the Kenneth French data library.[8] I obtain macroeconomic variables from Bloomberg and the Fed Funds Rate from Bloomberg.[9] I also add variables that predict stock returns following Goyal and Welch (2008).[10] Finally, I obtain data on the Fed Funds Futures and the Eurodollar futures from Refinitiv Tick History.

The analysis is based on the period January 1, 2009 to October 7, 2020.[11] The start of the sample is soon after the US Fed commenced using asset purchases on a large scale as part of its monetary policy response to the Global Financial Crisis (GFC) of 2008–2009.

< Table 1 here >

[7] Available at https://fred.stlouisfed.org
[8] https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[9] The macroeconomic variables include core Consumer Price Index (CPI), nonfarm payrolls (NFPAY), retail sales (RETL), the Purchasing Managers' Index (PMI), the unemployment rate (UE), and the quarterly GDP growth rate (GDP) and their expected values from Bloomberg surveys of economists.
[10] The predictors include dividend yield, earnings yield, book-to-market ratio, term spread, default yield spread, and net equity expansion. They are from Amit Goyal's webpage https://sites.google.com/view/agoyal145
[11] For the models that include macroeconomic control variables, the sample is slightly shorter, ending on 26 August 2020 due to availability of the macroeconomic data.

Table 1 reports annual trends in the value of assets on the Fed's balance sheet and US stock market, represented by the S&P 500 index. During the ten years since the GFC, the Fed's balance sheet has expanded considerably from $2.23 trillion or 15.3% of GDP in 2009 to $7.07 trillion or 32.8% of GDP as of October 2020.[12] The most rapid expansion during this period is in response to the COVID-19 pandemic in 2020. In the first half of 2020, the Fed's assets almost doubled from $4.17 trillion or 19.2% of GDP to $7.07 trillion. The dollar magnitude and rate of the Fed's balance sheet expansion in 2020 is unprecedented.

During the decade since the GFC the Fed has tended to expand its balance sheet, but 2018 stands out in contrast to this trend. During this year, the Fed contracted its balance sheet by around 9% in log growth terms. Interestingly, this is also the year with the worst full-year stock market performance since the GFC: a decline in the S&P 500 by 7.3% in log returns.[13]

< Figure 1 here >

Figure 1 Panel A visually illustrates the relation between the Fed's balance sheet and the stock market, plotting the two time-series since the GFC. The two time-series share a similar trend for most of the time period, rising and plateauing at approximately the same times. A notable departure occurs in the more recent years, particularly during 2020.

Figure 1 Panel B zooms in on the year 2020 when the stock market and Fed were impacted by the unfolding events of the COVID-19 pandemic. The S&P 500 peaks in late February and then

[12] The Fed has continued to expand its balance sheet following the end of the sample to $8.8 trillion as of August 25, 2021.
[13] Throughout the paper stock returns and balance sheet expansion/contraction are measured in log returns or log growth to avoid the asymmetry in how simple returns/growth handles increases vs decreases.

falls by a dramatic 35% through to about March 23, 2020. Meanwhile the Fed's balance sheet remains largely unchanged during the start of 2020 until the major fall in the stock market at which point it rapidly expands from around $4 trillion in early March to around $7 trillion by May and then stabilizing at that level. The stock market, perhaps partly in response to the Fed's balance sheet expansion, rises or "rebounds" approximately 30% from its low on March 23, 2020 through to late May 2020. These patterns are consistent with the notion that the Fed responds to deteriorating economic and financial market conditions, and that the Fed's balance sheet expansion in turn has a positive impact on stock market returns. The next section tests this conjecture more formally.

4. The relation between the US Fed's balance sheet and stock returns

4.1 Evidence from lead/lag cross-correlations

I begin the analysis of the relation between the US stock market and the Fed's balance sheet by considering the lead/lag cross-correlations between the two. First, I measure the weekly log growth[14] (expansion or contraction) of the Fed's balance sheet:

$$\Delta FedAssets_t = \ln(FedAssets_t) - \ln(FedAssets_{t-1}) \qquad (1)$$

where $FedAssets_t$ is the dollar value of the US Fed's assets in week t. I also measure the weekly log returns of the stock market using the CRSP value-weighted stock returns including dividends,

[14] Using log growth makes the distribution of changes approximately symmetric around zero, which is why this is a common way to specify such time-series models.

$r_{MKT,t}$. In robustness tests I examine various alternative market return measures, including returns on the S&P 500 index, equal weighted returns, and sector returns.[15]

Then I measure the correlation between the expansion/contraction of the Fed's assets in week t and the stock market returns in week $t + h$ with h ranging from –8 weeks to +8 weeks. Correlations at negative values of h capture the Fed's response to lagged stock returns, while correlations at positive values of h capture how future stock returns respond to the Fed's actions.

< Figure 2 here >

Figure 2 Panel A plots these lead/lag cross-correlations. Panels B and C provide t-statistics for these lead/lag effects. The t-statistics use Newey West standard errors from time-series regressions of $r_{MKT,t+h}$ on $\Delta FedAssets_t$ for different lead/lag values, h. The t-statistics in Panel B are from univariate regressions, whereas in Panel C the t-statistics are from regressions in which I control for a range of variables that predict market returns (dividend yield, earnings yield, book-to-market ratio, bond term spread, default yield spread, and net equity expansion).

The first striking feature is the negative correlations at horizons of $h = -5$ to $h = -1$. These correlations are consistent with the Fed reacting to negative stock returns, or to a deteriorating economic outlook reflected in negative market returns, by expanding its balance sheet through asset purchases. The Fed's reaction follows with a delay of about 2–5 weeks following the corresponding stock market returns. The correlation at $h = -3$ is statistically significant at the 5% level in both univariate and multivariate tests (Panels B and C).

[15] The impacts of the Fed's actions are almost twice as strong when measured using equal-weighted returns, consistent with small stocks being more sensitive than large stocks, and the results are virtually unchanged when using market returns in excess of the risk-free rate.

Equally interesting are the positive correlations at horizons $h = +1$ through to $h = +4$. These positive correlations are consistent with the stock market reacting positively to the Fed's balance sheet expansion. The stock market's reaction to the Fed's actions is faster (starting in the week immediately following expansion of the Fed's balance sheet, $t + 1$) than the Fed's response to falling stock markets, but even so, the stock market reaction is not instantaneous as Fed balance sheet expansion in week t continues to positively predict stock market returns out at a horizon up to $h = 4$ weeks following the Fed's asset purchases. The correlations at $h = +3, +4$ are statistically significant at the 5% level in both univariate and multivariate tests (Panels B and C).

The stock market reaction to the Fed's asset purchases, being stronger in the 2–3 weeks following the Fed's balance sheet expansion rather than contemporaneously, is consistent with market participants reacting to the positive signal of seeing actual realized balance sheet expansion, as opposed to an announcement effect that would occur earlier (e.g., at time t or $t - 1$) upon announcement of intended asset purchases. Second, the lead/lag correlations are consistent with a spillover of liquidity from the asset classes directly affected by Fed purchasing through to equity markets. For example, the excess liquidity generated by Fed's transactions in fixed income securities leads to subsequent buying pressure in riskier asset classes including equities. It is also possible that stock market participants react, although in a slightly delayed manner, to the reduction in fixed income yields that is a direct consequence of the Fed's asset purchases and subsequently revalue equities at lower opportunity costs of capital.

I explore some further features of the lead/lag relation between the Fed's balance sheet and the stock market. In the interest of conciseness, I do not tabulate the additional results, but summarize the findings below. First, I consider monthly observations instead of weekly. At monthly horizons, the same lead/lag pattern as in Figure 2 also occurs, but with even stronger correlations of –0.29 being the Fed's balance sheet response to the previous month's stock returns and +0.33 being the stock market's response to the previous month's Fed asset purchases.

I also analyze conditional cross-correlations to explore asymmetry in the Fed's response to negative market returns vs the Fed's response to positive market returns. I find that the Fed's response to negative stock market returns (expanding its balance sheet) is much stronger than its response to positive market returns (contracting its balance sheet). For example, the correlation between changes in the Fed's balance sheet and the three-week prior stock market return is around –0.34 conditional on the market return being negative, whereas the correlation is around –0.02 conditional on that market return being positive. Put simply, the Fed responds aggressively to falling stock prices, but is far less aggressive in tapering back its balance sheet in response to rising stock prices. This finding mirrors the asymmetric response of *conventional* monetary policy to stock returns (e.g., Cieslak and Vissing-Jorgensen, 2021). Later subsample tests also show a second form of asymmetry—the stock market reaction to changes in the Fed balance sheet tends to be stronger in periods of balance sheet contraction than in periods of balance sheet expansion.

4.2 Evidence from a VAR

To further analyze the bi-directional relation between the Fed's asset purchases and stock market returns while controlling for serial correlation, anticipation effects, persistence in the Fed's actions, and the dynamics of the relations, I turn to Vector Auto-Regressions (VAR). VARs have the advantage that by controlling for past Fed balance sheet expansion/contraction, they can isolate the impacts of *unexpected* expansion/contraction (innovations) accounting for the fact that Fed asset purchases today signal that further purchases are likely in the near term. They also control for momentum and reversal in stock returns, thereby mitigating measurement error from the tendency for stock markets to spring back in the weeks or months following a substantial fall (and vice versa). Finally, adding macroeconomic variables, the Fed Funds Rate and other variables to the VAR models controls for a range of potentially confounding effects and sheds light on whether the Fed reacts to the stock market or to economic conditions reflected in stock returns.

Starting with a simple VAR with eight lags of weekly observations to account for the serial correlation cross-correlations between the Fed's balance sheet and market returns:[16]

$$\Delta F_t = a_0 + \sum_{l=1}^{8} a_{1,l} \Delta F_{t-l} + \sum_{l=1}^{8} a_{2,l} \Delta S_{t-l} + \varepsilon_{\Delta F,t} \quad (2)$$

$$\Delta S_t = b_0 + \sum_{l=0}^{8} b_{1,l} \Delta F_{t-l} + \sum_{l=1}^{8} b_{2,l} \Delta S_{t-l} + \varepsilon_{\Delta S,t} \quad (3)$$

where ΔF_t is the log growth in the Fed's assets in week t (abbreviation of $\Delta FedAssets_t$) and $\Delta S_t = r_{MKT,t}$ is the log return of the stock market (CRSP value-weighted index return including dividends) in week t. The lags of ΔF_t in the first VAR equation allow for persistence in balance sheet expansion—the tendency for expansion in a given week to be followed by further expansion in subsequent weeks. The lags of ΔS_t in the first equation allow for a delay in the Fed's response to deteriorating economic of financial market conditions as reflected in stock market returns. The ΔF_t term in the second VAR equation captures the immediate stock market reaction to Fed balance sheet expansion or contraction, while the lags of ΔF_t allow for gradual or delayed reactions to the Fed's actions. Finally, the lags of ΔS_t in the second VAR equation capture serial correlation in stock market returns such as momentum and reversal. Later I add a range of macroeconomic and stock market control variables, but given they do not overly change the model estimates, I use the above more parsimonious model as the baseline model.

[16] The previous section showed that lead/lag correlations are significant for up to eight weeks.

I examine results from both the structural and reduced form versions of the VAR above—for further details of the two versions and how they are estimated see Appendix A. The structural VAR above embeds assumptions about contemporaneous relations between variables in the lag structure, driven by economic reasoning. It assumes that the Fed can respond to stock market movements (or the economic news reflected in stock returns) the following week (or in subsequent weeks) as it takes time for policymakers to formulate and then implement a response. In contrast, the stock market can respond to the Fed's actions contemporaneously and then also in subsequent weeks. These assumptions are consistent with markets being fast in pricing new information, while central banks can respond quickly, but not instantly, to new information. The assumptions are supported by the lead/lag cross-correlations in the previous subsection.[17]

< Table 2 here >

Table 2 reports the coefficient estimates of the reduced form VAR.[18] The constants in both equations are positive, picking up the tendency for both the Fed's balance sheet and stock prices to increase through the decade since the GFC. The lags of ΔF_t in the ΔF_t equation show persistence in the Fed's asset purchase actions: balance sheet expansion (/contraction) by the Fed tends to be followed by further expansion (/contraction) in the following four weeks. The lags of ΔS_t in the ΔF_t equation show that, after controlling for previous Fed actions, there is a tendency for the Fed

[17] These structural assumptions are similar to those made in VAR models applied to financial markets at shorter horizons, such as intraday models in which it assumed that stock returns can respond to contemporaneous order flow, but order flow can only react to stock returns starting from the period following the return (e.g., Hasbrouck, 1991a, 1991b).

[18] For simplicity, Table 2 reports the coefficients from the reduced-form VAR but the structural VAR is used in the subsequent analysis of impulse response functions as detailed in Appendix A.

to respond to stock market declines with balance sheet expansion. This effect is significant at horizons of up to three weeks following market declines.

The lags of ΔF_t in the ΔS_t equation show that, after controlling for serial dependence in market returns, there is a positive stock market reaction to Fed balance sheet expansion, which is strongest and most significant three to four weeks following the Fed's actions. Finally, the lags of ΔS_t in the ΔS_t equation show that stock market returns have negative serial correlation, or a tendency to reverse at monthly and weekly horizons, consistent with previous literature (e.g., Jegadeesh, 1990; Lehmann, 1990). That is, large declines tend to be followed by positive returns in the coming 1–4 weeks and vice versa, with the reversals at four-week horizons being statistically significant.

< Figure 3 here >

To examine the dynamics of how the system (the Fed and the stock market) responds to an unanticipated shock to one or the other, I compute the cumulative impulse response functions for both the structural and reduced form VAR. Figure 3 Panel A plots the cumulative log balance sheet growth that results from a −10% negative shock to stock market log returns. The impulse response shows that negative stock market returns tend to be followed by balance sheet expansion, consistent with the results in the previous subsection. The response takes around 15 weeks to (almost) fully materialize, with the long-run cumulative impact of the −10% stock market shock being a 5.6% expansion of the Fed's balance sheet.

Figure 3 Panel B plots the cumulative log return of the stock market in response to a +10% positive shock to the Fed's balance sheet in log growth terms. The impulse response shows that balance sheet expansion tends to be followed by a run-up in the stock markets, consistent with the results in the previous subsection. The response takes around 5 to 10 weeks for most of the effects to materialize, with the long-run cumulative impact of the +10% balance sheet expansion being a positive log return on the stock market of around 9.1%. Panel C shows the equivalent impulse response function for the reduced form VAR. The overall pattern of how the stock market responds is similar, as are the magnitudes.

I also use the VAR models to estimate the cumulative response of the Fed's balance sheet to an initial unanticipated shock to the Fed's balance sheet and find the response is continued balance sheet expansion (persistence in Fed's actions) through to about 20 weeks, by which time the cumulative expansion is around 2.3 times the initial shock. The impulse response function of stock market returns to a shock in stock market returns shows a tendency for some of the initial shock to reverse, consistent with the previously documented negative serial correlation in stock returns and the one week and one-month reversal effects.

Given that in the full sample period, the Fed has tended to expand its balance sheet, I examine the robustness of the estimated stock market reactions by re-estimating the VAR in three subperiods in which there are overall balance sheet contractions. Figure 1 and Table 1 show that the Fed contracted its balance sheet in each of the years 2015–2018 and most of 2019 (except for an increase in Q4 of 2019). I therefore test three subperiods: (i) the five contraction years 2015–2019, (ii) the two years with sharper contractions, 2018–2019, and (iii) the subperiod of those two years with the largest contraction in the Fed's balance sheet, Q1 2018 – Q3 2019.

In all three subperiods, the model estimates suggest that the stock market tends to fall in response to Fed balance sheet contractions, consistent with the full sample results. The magnitudes of the stock price reactions in all three contraction subsamples are even stronger than in the main sample. For example, while in the full sample the estimated stock return impact of a 10%

contraction in the Fed's balance sheet is a return of –9.1%, in the Q1 2018 – Q3 2019 contraction subperiod and the contraction years 2015–2019, the estimated impacts are –11.3% and –16.7%, respectively. These results are consistent with the notion that the stock market tends to be more sensitive to Fed balance sheet contractions (per percentage point) than expansions. They also suggest that using the full sample results to estimate the possible magnitudes of stock reactions to any future balance sheet contraction events would tend to provide conservative estimates.

4.3 Controlling for potential confounding effects

I investigate whether the estimates reported from the VAR above could be capturing confounding effects from unexpected changes in macroeconomic conditions, stock market variables, or other factors. To do this, I follow the approach of Rigobon and Sack (2003) and augment the VAR model by adding a range of macroeconomic variables that capture changes in economic conditions and surprises in the information set. By controlling for macroeconomic data, the augmented VAR can shed light on whether the Fed reacts to the stock market directly (as suggested by Rigobon and Sack (2003), Cieslak and Vissing-Jorgensen (2021) and the literature on the "Fed put") or whether the association between the Fed's actions and stock returns arises due to the macroeconomic conditions reflected in stock returns. The augmented VAR is:

$$\Delta F_t = a_0 + \sum_{l=1}^{8} a_{1,l}\Delta F_{t-l} + \sum_{l=1}^{8} a_{2,l}\Delta S_{t-l} + \sum_{l=0}^{8} a_{3,l}X_{t-l} + \varepsilon_{\Delta F,t} \qquad (4)$$

$$\Delta S_t = b_0 + \sum_{l=0}^{8} b_{1,l}\Delta F_{t-l} + \sum_{l=1}^{8} b_{2,l}\Delta S_{t-l} + \sum_{l=0}^{8} b_{3,l}X_{t-l} + \varepsilon_{\Delta S,t} \qquad (5)$$

where the additional vector of variables, X_{t-l}, includes contemporaneous and up to eight lagged values of a range of key macroeconomic variables: core Consumer Price Index (CPI), nonfarm payrolls (NFPAY), retail sales (RETL), the Purchasing Managers' Index (PMI), the unemployment rate (UE), and the quarterly GDP growth rate (GDP). Following Rigobon and Sack (2003) I calculate the announcement surprises of the macroeconomic variables by subtracting their expected values from Bloomberg surveys of economists.[19]

The results of the augmented VAR model are reported in Table 3, Panels A1 and A2. For conciseness Table 3 does not report the coefficients on the control variables as there are simply too many (6×9×2=108 coefficients). The results are broadly consistent with the effects discussed above for the baseline model. Namely: (i) the lags of ΔF_t in the ΔF_t equation show persistence in the Fed's asset purchase actions, (ii) the lags of ΔS_t in the ΔF_t equation show a tendency for the Fed to respond to stock market declines with balance sheet expansion, (iii) the lags of ΔF_t in the ΔS_t equation show that there is a positive stock market reaction to Fed balance sheet expansion, which is strongest and most significant three to four weeks following the Fed's actions, and (iv) the lags of ΔS_t in the ΔS_t equation show a tendency for stock return reversals. All the effects above hold after controlling for previous Fed actions, previous stock returns, and a range of macroeconomic measures.

< Table 3 here >

[19] The macroeconomic variables are available monthly, except the quarterly GDP growth rate. While the relatively low frequency of the GDP growth rate makes it less likely to have substantial explanatory power for stock returns or monetary policy, the other macroeconomic indicators such as retail sales and employment measures provide a more frequent indication of evolving economic conditions. The reason for using surprises in the macroeconomic variables is that the surprise component, rather than the expected change or expected level, is more likely to trigger changes in monetary policy. For example, when the macroeconomic variables indicate an economic slowdown is occurring, if the slowdown is in line with expectations, the Fed is less likely to react to it (because the Fed is likely to have factored in the expected slowdown in its existing policy) than if the slowdown comes as a surprise. If the slowdown is stronger than expected, it is likely to trigger more accommodative monetary policy, whereas if the slowdown is not as severe as expected, it is likely to trigger a less accommodative stance.

Figure 4 Panel A shows the cumulative impulse response function for how shocks to the Fed's balance sheet impact stock returns in the VAR that controls for macroeconomic variables. The overall pattern and magnitude of the response is similar to that of the baseline model. The same is true of estimated Fed balance sheet response to stock market shocks, controlling for macroeconomic variables, stock market predictors, and the Fed Funds Rate (not plotted for conciseness).

< Figure 4 here >

I also test how the results change when controlling for a range of variables that predict stock returns. These include the dividend yield, the earnings yield, the book-to-market ratio, and net equity expansion, which become the variables in the vector X_{t-l}. The models do not include predictors that involve bond yields, such as the term spread or default yield spread, as those variables are likely to be impacted by the Fed's asset purchases/sales and therefore act as conduits through which the impacts of QE are transmitted to the stock market—when investigating the transmission channels in the sect section I also include bond yields in the VAR. The results in Table 3 Panels B1 and B2 and Figure 4 Panel B are qualitatively consistent with the baseline model and the previous conclusions. The dynamics of the stock market response to a Fed balance sheet shock are also similar to those of the baseline model.

I test a further potentially confounding factor: the Fed funds rate. In the augmented VAR above, I replace the vector X_{t-l} with the Fed funds rate. The results in Table 3 Panels C1 and C2 show that the four effects described above are robust to controlling for the Fed funds rate. There is still a bidirectional relation between the Fed's balance sheet and equity returns: the Fed responds to stock returns with a lag, and likewise, the stock market responds to the Fed's balance sheet expansion, with a lag. Similarly, Figure 4 Panel C shows that the dynamic response of the stock market controlling for the Fed funds rate is similar to that of the baseline model.

While the Fed funds rate is an obvious instrument of monetary policy, alternative measures of monetary policy shocks have been used in prior studies. I follow Guo, Kontonikas, and Maio (2020) and construct two alternative proxies for monetary policy shocks. The first is the return on the 8-quarter ahead Eurodollar futures contract on FOMC announcement dates.[20] The second is similar, but instead of the Eurodollar futures contract, I take the 3-month Fed funds futures contract and compute its return on FOMC dates. I then include both these monetary policy shock measures in the vector X_{t-l} in the augmented VAR model.

The results in Table 3 Panels D1 and D2 show that the four effects described above are robust to controlling for these alternative monetary policy surprise measures. Similarly, Figure 4 Panel D shows that the dynamic response of the stock market controlling for the Fed funds rate is similar to that of the baseline model.

What happens to the magnitudes of the estimated relation between stock prices and the Fed's balance sheet when the models are augmented with macroeconomic variables, stock market variables, the Fed funds rate, and alternative measures of monetary policy shocks? Because the magnitudes are difficult to read directly from the VAR coefficients given the feedback effects and dynamics, I turn again to the impulse response functions (as illustrated in Figure 4). The baseline model estimated that a +10% positive shock to the Fed's balance sheet results in a cumulative log stock return of around 9.1%. With the full set of macroeconomic control variables, this effect becomes an estimated 6.9% cumulative log return, controlling for the stock market variables the estimated effect becomes 7.8%, controlling for the Fed funds rate the effect is 8.5%, and

[20] The return is set to zero on non-FOMC announcement date. The weekly values are just an average of the daily values each week.

controlling for the alternative monetary policy shock measures the effect is 8.7%. Similarly, most of the magnitudes of the estimated Fed response to a stock market shock remain similar to those of the baseline model. Therefore, after controlling for the potentially confounding effects, the magnitudes of the bi-directional effects between the Fed balance sheet and stock returns remain large.

4.4 The channels by which the Fed's asset purchases impact stock markets

There are several potential mechanisms through which the Fed's unconventional monetary policy impacts stock markets.

First, past studies find that QE by the Fed tends to reduce long-run bond yields. For example, Gagnon et al. (2010) show that the Fed's QE in response to the GFC resulted in economically meaningful and long-lasting reductions in longer-term interest rates. Importantly, the reduction in the rates is likely to reflect a lower term premium rather than lower expectations of future short-term interest rates, according to Gagnon et al. (2010). Lower long-run yields on fixed income securities should lead to an increase in stock prices by reducing equity discount rates. Intuitively, if one asset class has a decrease in its expected return due to the Fed's purchasing driving up prices (e.g., Treasuries and mortgage-backed securities, MBS), other asset classes become relatively more attractive investments, leading to their prices also being bid up, such that their expected returns also decrease commensurate with the fall in long-term yields. I therefore conjecture that the first channel through which QE affects stock returns is through the change in long-run bond yields, which impacts equity discount rates.

A second potential channel is through the impacts on the future health of the economy and therefore corporate earnings. Recall the underlying dual mandate of the Fed to ensure stable prices and maximum sustainable employment. To the extent that QE contributes to achieving these macroeconomic objectives, expansionary QE is likely to have a positive impact on expected future corporate earnings and therefore stock prices. There are several ways that QE can positively impact economic conditions, including wealth effects (inflated asset prices increase household wealth and thus spending), credit channels (lower interest rates incentivize borrowing for consumption and investment), and exchange rates. Thus, I conjecture that the second channel through which QE affects stock prices is by increasing the expectations of strong future economic conditions and thus high corporate earnings.

If we think of stock valuation using a discounted cash flow model, then the first channel is about the discount rate in the denominator, whereas the second channel is more about the cash flows in the numerator. Also, both channels are consistent with the so called “Fed model” which is popular among practitioners (e.g., Maio, 2013; Asness, 2003; Campbell and Vuolteenaho, 2004). The model is based on the premise that stock and long-term bonds are competing assets in investors’ portfolios. Therefore, the “yields” of the two assets should be related and any yield gap between the two is likely to result in asset price changes as investors shift from the less attractive to the more attractive asset, thereby reducing the gap (Maio, 2013). For equities, the equivalent of the bond yield is the earnings yield (future earnings divided by price) or the dividend yield. Therefore, the Fed model predicts that if bond yields have a negative shock (e.g., due to QE), then equity yields should also come down, which, if we hold earnings fixed, means stock prices should increase (consistent with Channel 1 above). Additionally, the model also predicts that holding yields fixed, a positive shock to future expected earnings (e.g., QE improving expected future economic conditions) should drive up stock prices to maintain the same yield (consistent with

Channel 2 above). Thus, both Channels 1 and 2 are consistent with the popular "Fed model" of stock and bond prices.

A third possible mechanism depends on the specific assets purchased by the Fed. For example, if we consider the "preferred habitat" theories (e.g., Modigliani and Sutch, 1966, 1967), when yields or expected returns change on one asset (e.g., a particular maturity on the term structure), expected returns on other assets should adjust to some extent as some investors leave their "preferred habitat" to seek better returns and quasi-arbitrageurs exploit return differentials. However, they are unlikely to change as much in related assets as they are in the asset directly hit by the demand shock because of habitat preferences of investors, imperfect substitutes, and various frictions. For example, fixed income securities and equities are not perfect substitutes from an investor's perspective, nor are Treasuries vs low-grade corporate debt. Therefore, while some return spillovers between asset classes or market segments can be expected (as per Channel 1), the effects of Fed asset purchases are likely to be strongest in assets purchased by the Fed.[21]

What this third mechanism means is that if the market expects the Fed's actions to be limited to particular fixed income markets such as Treasuries and MBS, the impacts on say corporate bonds and equities are likely to be smaller than if the market expects the Fed to directly intervene in corporate bonds and even more so equities. Interesting, the scope of the Fed's interventions during the COVID-19 pandemic were broader than during the GFC. In May 2020, the Fed began directly buying corporate bond ETFs.[22] This action, together with remarks by Fed officials along

[21] Consistent with this notion is the evidence that demand and supply curves within an asset class (e.g., equities or currencies) are not perfectly elastic, and much of the return fluctuations can be explained by inflows and outflows or buying and selling (e.g., Gabaix and Koijen, 2021; Hau, Massa, and Peress, 2010; Kaul, Mehrotra, and Morck, 2000; Shleifer, 1986).

[22] On March 23, 2020, for the first time in its history, the Fed created a facility to purchase corporate bonds directly from secondary markets, known as the Secondary Market Corporate Credit Facility (SMCCF). This facility paved the way for the Fed to start buying corporate bond ETFs, which it commenced from 12 May 2020. See O'Hara and Zhou (2021) for more details.

the lines of the Fed being willing to do "whatever it takes" are likely to have signaled to the market that buying equities (e.g., via an equity ETF) is not out of the question and possibly a step the Fed would be willing to take. To the extent that direct intervention in the stock market is likely to have a larger impact on stock prices than intervention that is limited to fixed income markets as discussed above, the signal sent by the Fed taking the unprecedented step of buying fixed income ETFs may have provided an additional positive shock to equities compared to previous rounds of QE that were more limited in scope.

To provide some empirical evidence on whether these channels are supported by the data, I re-estimate the VAR models adding variables to capture these channels. First, I add long-term bond yields to the right-hand side of the VAR equations (2) and (3) to absorb the effect of the Fed's balance sheet changes on the stock market that occurs via changes in bond yields.[23] If Channel 1 holds, then we should see the remaining ("independent") effect of changes in the Fed's balance sheet (the effect that is not transmitted via bond yields) decrease, with the amount of the decrease being approximately the effect that occurs through bond yields. Indeed, this is what the results[24] show—the "total effect" in the baseline VAR, being an estimated log return of 9.1% per 10% expansion of the Fed's balance sheet, falls to a log return of 6.7% once we absorb the effect that occurs via bond yields.

Similarly, to absorb the effect that occurs because of changing expectations of future economic conditions, I construct a measure of future expected unemployment (average of the monthly expected unemployment rates for the next 12 months based on Bloomberg economist surveys) and subtract from it the past year's actual average realized unemployment rate. I do the

[23] I use the long-term bond yields from Welch and Goyal (2008) obtained from Amit Goyal's webpage https://sites.google.com/view/agoyal145 .

[24] Not tabulated as only a few key numbers are relevant and they are provided in the text.

same for inflation and for the GDP growth rate, given full employment and price stability are the Fed's macroeconomic mandates and GDP as an additional variable captures general economic growth. These variables capture how much future economic conditions are expected to improve or deteriorate relative to past economic conditions. I find that adding these variables the effect of expanding/contracting the Fed's balance sheet falls from the baseline "total" effect of 9.9% log stock market return per 10% change in the balance sheet to a log return of 4.9%. These results suggest that a substantial amount of the total effect plays out through changing expectations of future economic conditions.

When the models include both bond yields and expected future macroeconomic conditions, the remaining effect that is not attributed to Channel 1 or 2 is a log return of 3.5%. Thus, Channels 1 and 2 explain approximately two-thirds of the total effect of the Fed's balance sheet changes on stock returns.

Finally, I investigate whether the Fed's unprecedented step of directly buying corporate bond ETFs during the COVID-19 pandemic and thereby signaling the possibility of directly buying equities if needed led to a stronger impact on stock markets than previous QE. When I estimate the baseline VAR model (2-3) separately in the pre-COVID years (the sample up to January 1, 2020) I get an estimated effect size of an 8.2% log stock return per 10% Fed balance sheet expansion (recall in the full sample the effect is 9.1%), whereas from January 1, 2020, the estimated effect is an 9.8% log stock return per 10% Fed balance sheet expansion. The slightly larger return per percent balance sheet expansion during COVID-19 is consistent with a stronger effect than previous rounds of QE, but there are also other possible reasons for the larger effect.

As a more direct test, I return to the VAR used to test Channels 1 and 2. Rather than adding bond yields and expected future macroeconomic conditions, I add a dummy variable for the week when the Fed announced the facility (SMCCF) that paved the way for its buying of corporate bond ETFs (March 23, 2020). With a contemporaneous term and eight lags of this dummy variable included in the VAR, it effectively spans the weeks from the creation of the facility through to when the facility was actually used to commence buying corporate bond ETFs on May 12, 2020. Thus, these dummy variables should absorb stock returns associated with the speculation that the Fed might directly intervene in equity markets. After absorbing the effects captured by these dummy variables, the remaining effect of Fed balance sheet shocks is substantially lower: log returns of 4.5% per 10% balance sheet expansion. These results are consistent with the notion that the Fed's announcement of the SMCCF and use of the facility to buy ETFs had a substantial effect on the stock market—i.e., not only the scale of the Fed's intervention during the COVID-19 pandemic was relevant, but also the scope. These tests, however, are limited in how precisely they can attribute effects to the SMCCF because many other factors were changing around the same time and the tests cannot rule out the role of other factors.

Finally, I test whether the SMCCF impacted the stock market for reasons unrelated to Channel 1 and 2, or whether the effects play out via the SMCCF's impact on bond yields and expectations of future economic conditions. If the impact of the SMCCF occurs for reasons other than Channel 1 and 2, we would expect that adding the SMCCF dummy variables to the VAR that captures Channels 1 and 2 (the VAR with bond yields and expected future macroeconomic conditions) would further drive down the remaining impact of Fed balance sheet shocks on stock returns. Adding the SMCCF dummy variables to the VAR has virtually no effect on the estimated stock market impacts of Fed balance sheet shocks after accounting for Channels 1 and 2.[25] Thus, the

[25] The estimated impact of Fed balance sheet shocks that is not explained by Channels 1 and 2 is log returns of 3.5% per 10% balance sheet expansion, as noted earlier. Adding the SMCCF dummy variables barely changes this estimate to log returns of 3.6% per 10% balance sheet expansion.

results are consistent with the notion that while the SMCCF was an impactful event, its impact on stock markets occurs via Channels 1 and 2, that is, impacting bond yields and impacting expected future economic conditions.

4.5 Impacts on different sectors

The impacts of the Fed's balance sheet expansion/contraction are likely to vary across industry sectors. For example, some sectors tend to be more cyclical and sensitive to overall economic conditions, such as consumer durables, whereas others are less so, such as utilities. Given the results in the previous subsection suggest that one of the main channels through which the Fed's balance sheet shocks affect stock markets is through expected future economic conditions, we expect that more cyclical sectors will be more heavily impacted by the Fed's actions than less cyclical sectors.

To test this hypothesis, I re-estimate the structural VAR model (2-3) but this time for each industry sector separately, replacing the market return with the sector's value-weighted return. I use the Fama-French ten sectors available from the Kenneth French data library.[26]

Figure 5 plots the results. The general tendency in how QE impacts different sectors is consistent with the hypothesis. The sectors most sensitive to the Fed's actions tend to be the more cyclical sectors: Consumer Durables, Energy, and HiTech. The least sensitive sectors are the less cyclical sectors: Utilities, Wholesale and Retail, Telecommunications, and Non Durables. Health and Manufacturing are towards the middle of the spectrum. These results support the notion that

[26] https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

one of the key mechanisms by which the Fed's asset purchases impact stock returns is by changing expectations of future economic conditions.[27]

< Figure 5 here >

4.6 Constructing a counterfactual of S&P 500 values without the Fed's COVID-19 intervention

The cumulative impulse response functions to an unanticipated shock allow computation of interesting counterfactuals such as how much of the stock market's rebound following its February-March 2020 decline is explained by the Fed's aggressive balance sheet expansion and asset purchases during March and April of 2020? I model the counterfactual of a market without the Fed's interventions under three different scenarios, corresponding to three different assumptions about how much of the Fed's aggressive balance sheet expansion was unanticipated.

The first scenario uses the VAR model for guidance as to what was anticipated based on prior stock market movements and prior dynamics of the Fed's balance sheet. It uses the VAR model residuals of the ΔF_t equation as natural estimates of the unanticipated balance sheet shocks (these are equivalent to errors in forecasting the Fed's actions or surprises by the Fed) accounting for past market returns and past balance sheet dynamics. I take the residuals during March 2020 (ending April 1, 2020) as the shock of interest. As reported in Table 4, this shock is equal to a log expansion of the Fed's assets of 17.3%.

The second scenario takes the full value of the Fed's balance sheet expansion during the two months March-April 2020 and scales that magnitude back by the multiplier of 2.4 to arrive at

[27] To examine the effects on different size companies, I replace the stock market return in the VAR with the Fama and French (1993) small-minus-big (SMB) return factor and find that small stocks are more sensitive to the Fed's actions than big stocks.

the unanticipated shock magnitude of 19.6% in log terms. The multiplier of 2.4 comes from the impulse response function estimates that an unanticipated shock of say +10% to the Fed's balance sheet results in a total cumulative long-run balance sheet expansion of around 24%, so for every 24% of balance sheet expansion, the initial 10% is the surprise component and the subsequent 14% is expected upon observing the initial +10% surprise.

The third scenario just looks at the initial realized balance sheet expansion in the first two weeks following the S&P 500's major fall (the two weeks starting to March 11, 2020) as the unanticipated shock, treating the subsequent expansion that played out over the next six weeks as anticipated on the basis of the initial actions during that two-week period. That shock is equal to a 19.8% in log growth terms.

I then take these three shocks to the Fed's balance sheet, calculate the implied stock market impact based on the cumulative impulse response functions of the baseline VAR model. I contrast those implied stock market impacts with the actual stock market returns during the period following the Fed's intervention. Table 4 reports the results. In Panel A, the stock market response to the Fed's COVID-19 balance sheet expansion is measured in cumulative log return terms. In Panel B, those reactions are expressed as regular percentage returns. In Panel C, they are expressed as a percentage of the actual realized stock market return of +31% from the S&P 500 low on March 23, 2020 through to eight weeks later (May 19, 2020), which is the period over which most of the impact of the Fed's actions in March are expected to materialize. It is also the period of the strong rebound in equity prices.

< Table 4 here >

The results show that the Fed's actions during COVID-19 had a considerable positive impact on the US stock markets and explain around one-third to one-half (41.37% to 47.83%) of the rebound in stock markets in the eight weeks following their low in March. The full impact of the Fed's March 2020 balance sheet expansion, allowing the effects to fully materialize, is estimated to have impacted stock returns by 17% to 20%. The variation in the estimates comes from the different assumptions about what part of the Fed's actions was the unanticipated initial shock (the different Scenarios) and what horizon we consider following the Fed's actions: four weeks, eight weeks, or the full long-run impact.

The point estimate in which I place the highest confidence is Scenario 1 (using the VAR residuals or innovations to infer the unanticipated part of the Fed's actions) and the eight-week horizon as that is period over which the rebound in stock markets is measured as the point of reference. That point estimate suggests that about 41.37% of the strong stock market rebound in the eight weeks following its low on March 23, 2020 can be directly attributed to the Fed's aggressive balance sheet expansion.

Under all scenarios, the general conclusion is the same: the Fed's actions explain a considerable proportion of the stock market rebounds and are responsible for a substantial positive impact on stock valuations. Thus, the Fed's actions play a material role in determining stock market prices and returns.

An important implication of these findings is that the Fed's impact on stock markets drives a disconnect between the stock market and the real economy. Stock markets tend to fall when expectations of the future health of the economy (and therefore corporate earnings) decline. It is precisely at such times that the Fed tends to intervene in markets and, since the GFC, that intervention is often in the form of asset purchases and balance sheet expansion. For example, during the past two decades, the two occasions on which the Fed has been the most active in intervening in asset markets is in response to the GFC and in response to the COVID-19 pandemic. These actions in turn have a substantial positive effect on stock market returns as shown in this paper, which can cause stock markets to rise while the underlying economy is still in the midst of a crisis. This effect is what can cause an apparent disconnect between “Main Street” and “Wall Street”, in other words, between the stock market and the real economy.

5. Conclusion

I find a strong symbiotic relation between the Fed’s balance sheet and stock markets. The Fed responds to falling stock prices by engaging in asset purchases, which in turn tend to push stock prices back up. The reverse effects are also present, although with a degree of asymmetry in the magnitudes. The Fed responds more strongly to negative stock market returns than it does to positive market returns, whereas the stock market is more sensitive to the Fed’s balance sheet contractions than it is to balance sheet expansions. The timing of the market reactions suggest that the stock market largely responds to realized balance sheet changes as opposed to announcement effects that would imply an earlier reaction. Cyclical sectors such as consumer durables and small stocks are far more sensitive to the Fed’s interventions than less cyclical sectors such as utilities and large stocks.

The evidence supports two main channels for how the Fed’s intervention in fixed income markets impacts stock markets. The first is long-term bond yields, which tend to fall when the Fed buys fixed income securities, reducing the discount rate for equities and increasing stock prices. Second, the Fed’s actions impact expected future macroeconomic conditions and thereby expected future corporate earnings.

The Fed's aggressive balance sheet expansion during COVID-19 explains at least one-third of the stock market's rebound following its crash in March 2020. Therefore, central bank intervention in markets explains some of the apparent disconnect between stock markets and the economy due to the countercyclical nature of central bank intervention.

Looking forward, one of the major policy questions facing central banks in the US and other countries is whether/when/how to unwind the positions accumulated during the pandemic. The estimated magnitudes of the impacts and the asymmetry found in the analysis helps understand the likely effects of any surprises in how central banks may choose to unwind their positions.

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Appendix A: Details of VAR models

I examine both the structural and reduced form version of the VAR below:

$$\Delta F_t = a_0 + \sum_{l=1}^{8} a_{1,l}\Delta F_{t-l} + \sum_{l=1}^{8} a_{2,l}\Delta S_{t-l} + \varepsilon_{\Delta F,t} \tag{A.1}$$

$$\Delta S_t = b_0 + \sum_{l=0}^{8} b_{1,l}\Delta F_{t-l} + \sum_{l=1}^{8} b_{2,l}\Delta S_{t-l} + \varepsilon_{\Delta S,t} \tag{A.2}$$

where ΔF_t is the log growth in the Fed's assets in week t and $\Delta S_t = r_{MKT,t}$ is the log return of the stock market in week t. The key difference is in how the contemporaneous effects are handled. In the structural version (above), the term $\sum_{l=0}^{8} b_{1,l}\Delta F_{t-l}$, where the summation begins at zero, embeds the assumption that the stock market can react contemporaneously (within the same week) to changes in the Fed's balance sheet, as discussed in the paper. In contrast, the reduced form of this VAR is as per the equations (A.1 and A.2) above but with the summations all starting from one, i.e., the term above is $\sum_{l=1}^{8} b_{1,l}\Delta F_{t-l}$.

Rather than having to estimate separate structural and reduced form models, I follow the approach commonly used in the empirical finance literature and estimate the reduced form model and use it to compute the impulse response functions corresponding to both the reduced form and structural VARs (e.g., Brogaard, Nguyen, Putnins, and Wu, 2021). Specifically, having estimated the reduced form model, I run the following shocks through the system at $t = 0$ to produce the reduced form VAR impulse response functions:

(i) 10% shock to the Fed's balance sheet: $(\varepsilon_{\Delta F,0} = 0.1,\ \varepsilon_{\Delta S,0} = 0)$

(ii) –10% shock to stock returns: $(\varepsilon_{\Delta F,0} = 0,\ \varepsilon_{\Delta S,0} = -0.1)$

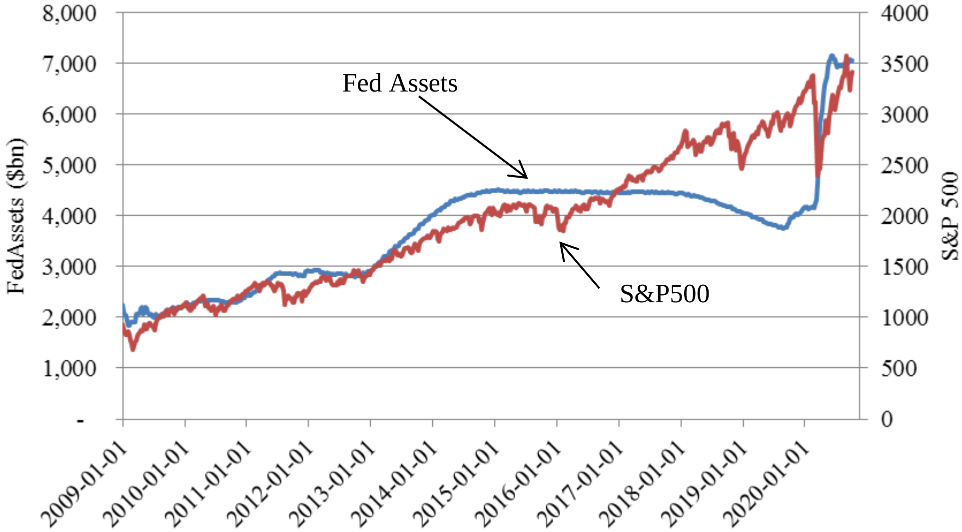
Similarly, the structural VAR impulse response functions can also be recovered from the estimated reduced form model by accounting for the contemporaneous effect when forming the shock vectors. Therefore, to get the structural VAR impulse response functions, I run the following shocks through the system at $t = 0$:

(i) 10% shock to the Fed's balance sheet: $\left(\varepsilon_{\Delta F,0} = 0.1,\ \varepsilon_{\Delta S,0} = \frac{\sigma_{\Delta F,\Delta S}}{\sigma_{\Delta F}^2}\varepsilon_{\Delta F,0}\right)$

(ii) –10% shock to stock returns: $(\varepsilon_{\Delta F,0} = 0,\ \varepsilon_{\Delta S,0} = -0.1)$

where $\sigma_{\Delta F,\Delta S}$ is the contemporaneous covariance of the reduced form VAR residuals and $\sigma_{\Delta F}^2$ is the variance of the reduced form residuals of ΔF_t.

Panel A: Trends since the GFC (2009-2020)



Panel B: Trends during COVID-19

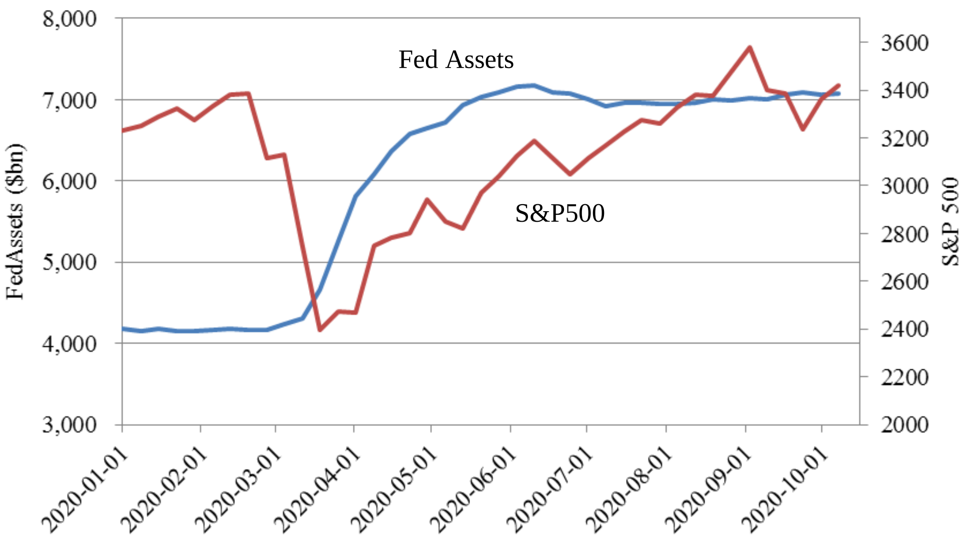


Figure 1. US Fed's balance sheet and the S&P 500 index.

This figure shows trends in the value of the US Fed's balance sheet (assets) measured in billions of dollars and the level of the S&P 500 stock market index measured in index points since the Global Financial Crisis (Panel A) and since the COVID-19 pandemic (Panel B).

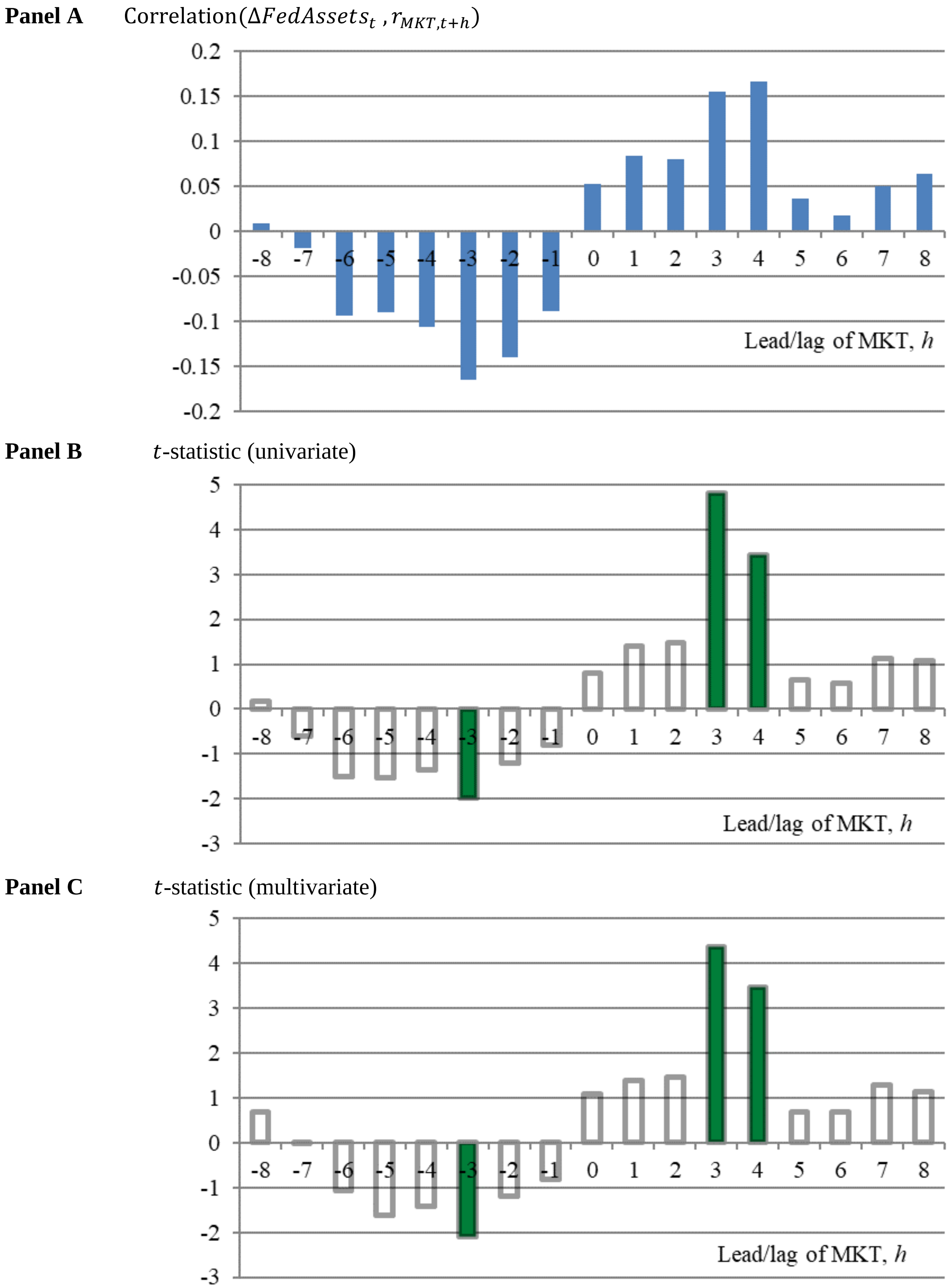
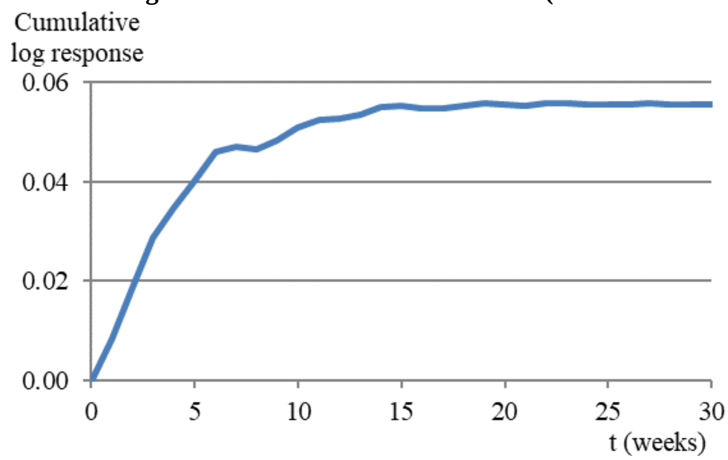
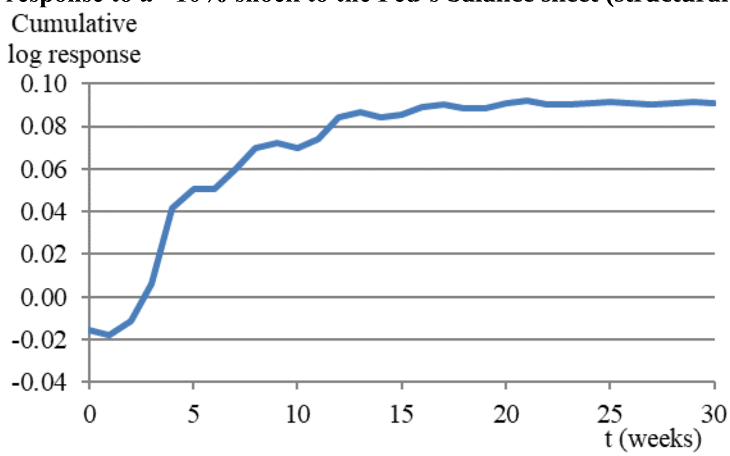


Figure 2. Lead/lag cross-correlations of changes in the Fed's balance sheet and stock market returns.
Panel A shows the correlations between log growth in Fed's balance sheet (assets) in week t, $\Delta FedAssets_t$ and the log returns of the stock market $r_{MKT,t+h}$ in week $t + h$, i.e., lagged or led by h weeks. Panel B reports the t-statistics of the lead/lag relations using Newey West standard errors from time-series regressions of $r_{MKT,t+h}$ as the dependent variable and $\Delta FedAssets_t$ as the explanatory variable. Panel C also reports t-statistics of the lead/lag relations using Newey West standard errors with 13 lags, but it augments the time-series regressing by including a range of control variables known to affect market return premia (dividend yield, earnings yield, book-to-market ratio, term spread, default yield spread, and net equity expansion). Dark solid bars indicate statistically significant t-statistics at the 5% level.

Panel A: Fed response to a –10% log return shock to the stock market (structural model)



Panel B: Stock market response to a +10% shock to the Fed's balance sheet (structural model)



Panel C: Stock market response to a +10% shock to the Fed's balance sheet (reduced form model)

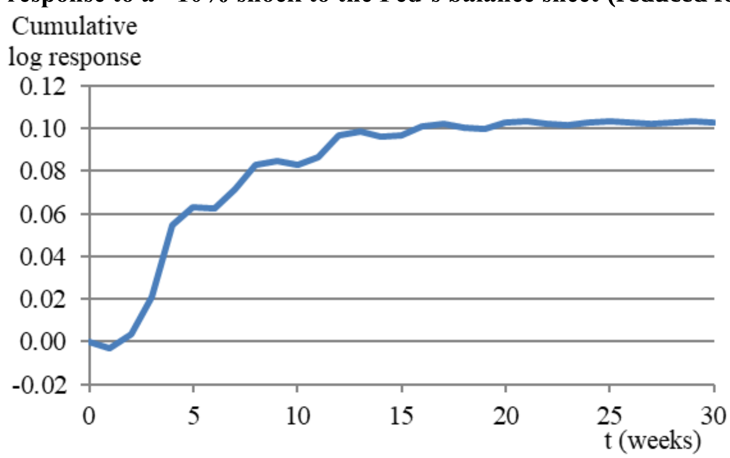
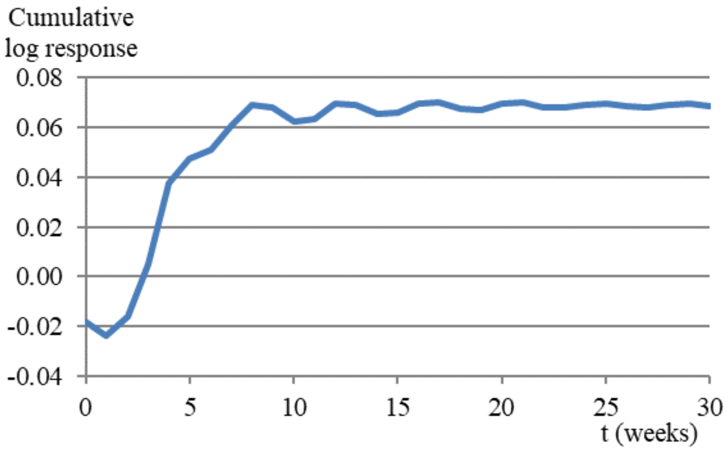
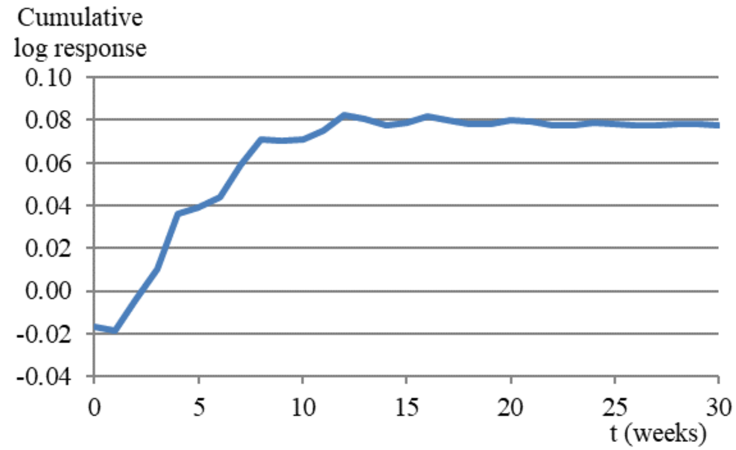


Figure 3. Cumulative impulse response functions of relation between Fed balance sheet and stock returns. Panel A plots the estimated cumulative response of the Fed's balance sheet (assets) measured as a log change to an unanticipated –10% log return shock to the stock market (CRSP value-weighted stock market returns). Panel B plots the estimated cumulative log return response of the stock market to an unanticipated +10% expansion of the Fed's balance sheet (assets) measured as a log change. Panel C shows the same impulse response function as in Panel B except that it is from the reduced form VAR as opposed to the structural VAR used in Panels A and B. The horizontal axis measures the weeks going forward from the shock at $t = 0$.

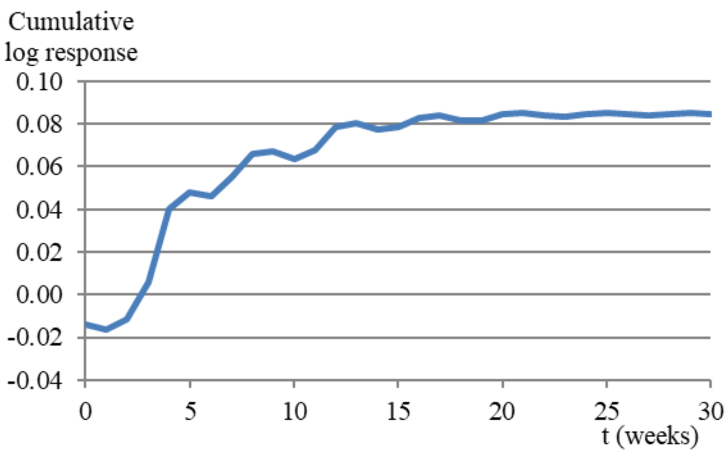
Panel A: Controlling for macroeconomic indicators



Panel B: Controlling for factors that predict stock market returns



Panel C: Controlling for the Fed funds rate



Panel D: Controlling for alternative measures of monetary policy shocks

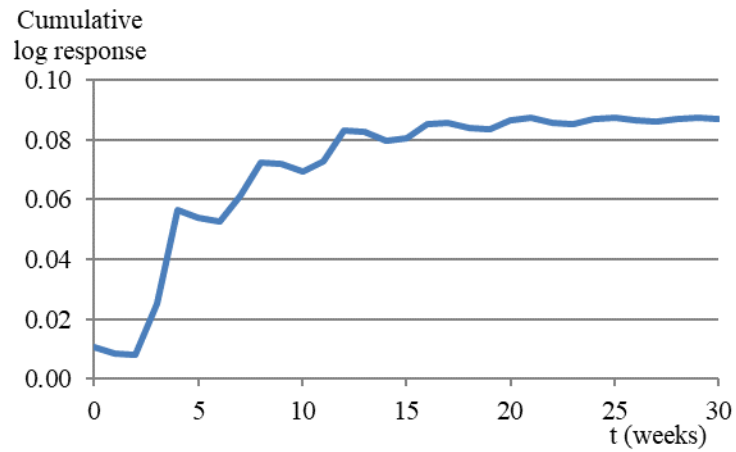


Figure 4. Cumulative impulse response functions (stock market response to a Fed balance sheet shock) with various sets of controls.
This figure shows the estimated cumulative response of log stock market returns (CRSP value-weighted stock market returns) to an unanticipated +10% expansion of the Fed's balance sheet (assets), from the structural VAR model. Each panel includes a different set of control variables in the VAR. Panel A includes a range of macroeconomic control variables (core Consumer Price Index (CPI), nonfarm payrolls (NFPAY), retail sales (RETL), the Purchasing Managers' Index (PMI), the unemployment rate (UE), and the quarterly GDP growth rate (GDP), adjusted for expectations). Panel B includes factors that predict stock market returns (dividend yield, earnings yield, book-to-market ratio, and net equity expansion). Panel C includes the Fed funds rate. Panel D includes alternative measures of monetary policy shocks (Fed Funds Rate Futures and Eurodollar Futures returns on FOMC dates). The horizontal axis measures the weeks going forward from the Fed balance sheet shock at $t = 0$.

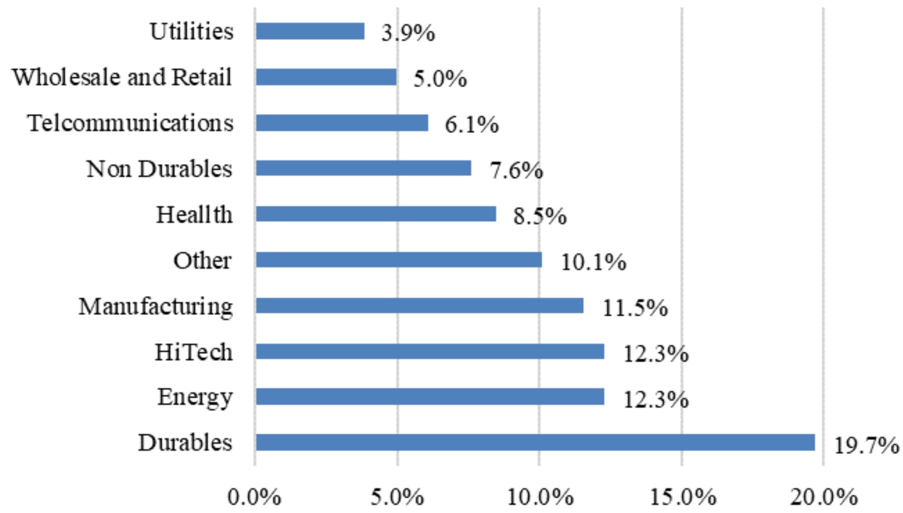


Figure 5. Impact of Fed balance sheet shocks by industry sector.
The plot shows the estimated long run ($t = 60$ weeks) impacts on the log stock returns of different industry sectors from a 10% shock the Fed's balance sheet. The estimates are from the baseline structural VAR model, except rather than using market returns, I estimate a model for each sector using the sector's value-weighted average returns.

Table 1

Value of US Fed balance sheet and the S&P 500 index

This table reports annual values (since the Global Financial Crisis in 2009) of (i) the value of the Fed's balance sheet (assets) in trillions of dollars, (ii) the value of the Fed's balance sheet as a percentage of US GDP, (iii) the annual log growth in the value of the Fed's balance sheet, (iv) the annual log return of the S&P 500 index. All values are based on calendar years and measured until the year end, except for the year 2020, where the values are calculated up to October 7, 2020.

Year	Fed Assets ($tn)	Fed Assets (%GDP)	ΔFed Assets	ΔS&P500
2009	2.23	15.3%	–0.2%	18.0%
2010	2.42	15.9%	8.0%	12.0%
2011	2.93	18.5%	19.0%	0.0%
2012	2.91	17.8%	–0.6%	10.9%
2013	4.03	23.6%	32.7%	27.2%
2014	4.50	25.2%	10.9%	11.1%
2015	4.49	24.4%	–0.2%	–0.7%
2016	4.45	23.4%	–0.8%	9.1%
2017	4.45	22.3%	–0.1%	17.7%
2018	4.08	19.5%	–8.8%	–7.3%
2019	4.17	19.2%	2.2%	26.5%
2020	7.07	32.8%	53.0%	5.9%

Table 2

VAR coefficients in baseline model

This table reports the coefficients (t-statistics in parentheses) of a VAR model with two equations. The first equation models the dynamics of the log growth in the Fed's balance sheet (assets), ΔF_t. The second equation models the dynamics of log stock market returns (CRSP value-weighted stock returns), ΔS_t. The model uses weekly observations from January 2009 to October 2020, and includes eight lags of the endogenous variables, reported in columns $l = 1$ to $l = 8$. N is the number of observations. *** and ** indicate statistical significance at the 1% and 5% levels.

Equation	Variable	Constant	$l = 1$	$l = 2$	$l = 3$	$l = 4$	$l = 5$	$l = 6$	$l = 7$	$l = 8$
Panel A: Fed balance sheet equation										
ΔF_t	ΔF_{t-l}	0.001***	0.298***	0.018	0.059	0.389***	-0.031	-0.074	-0.065	0.078**
		(3.34)	(7.25)	(0.42)	(1.39)	(9.24)	(-0.75)	(-1.80)	(-1.58)	(2.00)
	ΔS_{t-l}		-0.085***	-0.082***	-0.073***	-0.028	-0.007	-0.010	0.023	0.013
			(-5.36)	(-5.07)	(-4.41)	(-1.67)	(-0.43)	(-0.63)	(1.44)	(0.79)
	N	614								
	R^2	41.1%								
Panel B: Stock market return equation										
ΔS_t	ΔF_{t-l}	0.002	-0.030	0.073	0.160	0.296***	0.001	-0.073	0.023	0.010
		(1.68)	(-0.28)	(0.66)	(1.46)	(2.70)	(0.01)	(-0.68)	(0.21)	(0.10)
	ΔS_{t-l}		-0.063	0.013	-0.011	-0.097**	-0.008	0.003	0.035	0.115***
			(-1.54)	(0.32)	(-0.26)	(-2.21)	(-0.19)	(0.07)	(0.84)	(2.77)
	N	614								
	R^2	6.1%								

Table 3

VAR coefficients in augmented model with macroeconomic, stock market, and monetary policy controls

This table reports the coefficients (t-statistics in parentheses) of augmented VAR models that control for macroeconomic indicators, stock market return predictors, the Fed funds rate, and alternative measures of monetary policy shocks. The first equation models the dynamics of the log growth in the Fed's balance sheet (assets), ΔF_t. The second equation models the dynamics of log stock market returns (CRSP value-weighted stock returns), ΔS_t. Each panel includes a different set of control variables in the VAR including contemporaneous value and eight lags. Panels A1-A2 include a range of macroeconomic control variables (core Consumer Price Index (CPI), nonfarm payrolls (NFPAY), retail sales (RETL), the Purchasing Managers' Index (PMI), the unemployment rate (UE), and the quarterly GDP growth rate (GDP), adjusted for expectations). Panels B1-B2 include factors that predict stock market returns (dividend yield, earnings yield, book-to-market ratio, and net equity expansion). Panels C1-C2 include the Fed funds rate. Panels D1-D2 include alternative measures of monetary policy shocks (Fed Funds Rate Futures and Eurodollar Futures returns on FOMC dates). The coefficients of control variables are not shown for conciseness (e.g., in Panels A1-A2 alone there are 6×9×2=108 coefficients for these control variables). The models use weekly observations from January 2009 to October 2020. Columns $l = 1$ to $l = 8$ report the coefficients of the lagged endogenous variables. N is the number of observations. *** and ** indicate statistical significance at the 1% and 5% levels.

Equation	Variable	Constant	$l = 1$	$l = 2$	$l = 3$	$l = 4$	$l = 5$	$l = 6$	$l = 7$	$l = 8$
Panel A1: Fed balance sheet equation with macroeconomic controls										
ΔF_t	ΔF_{t-l}	0.001**	0.290***	0.062	0.051	0.386***	-0.035	-0.142***	-0.091**	0.085
		(2.52)	(6.62)	(1.36)	(1.14)	(8.60)	(-0.78)	(-3.14)	(-1.98)	(1.93)
	ΔS_{t-l}		-0.099***	-0.088***	-0.061***	-0.012	-0.010	-0.016	0.027	0.024
			(-5.84)	(-4.98)	(-3.37)	(-0.67)	(-0.58)	(-0.90)	(1.56)	(1.37)
	N	608								
	R^2	48.3%								
Panel A2: Stock market return equation with macroeconomic controls										
ΔS_t	ΔF_{t-l}	0.001	-0.073	0.103	0.201	0.263**	0.021	-0.084	-0.014	-0.010
		(1.05)	(-0.65)	(0.89)	(1.75)	(2.29)	(0.18)	(-0.72)	(-0.12)	(-0.08)
	ΔS_{t-l}		-0.086**	0.032	0.013	-0.036	-0.010	-0.023	0.021	0.092**
			(-1.98)	(0.71)	(0.29)	(-0.77)	(-0.23)	(-0.51)	(0.47)	(2.05)
	N	608								
	R^2	18.2%								
Panel B1: Fed balance sheet equation with stock market controls										
ΔF_t	ΔF_{t-l}	0.013**	0.308***	-0.024	0.048	0.350***	-0.043	-0.070	-0.054	0.066
		(1.98)	(7.27)	(-0.54)	(1.10)	(8.08)	(-1.00)	(-1.67)	(-1.27)	(1.65)
	ΔS_{t-l}		-0.079***	-0.074***	-0.081***	-0.031	-0.017	-0.019	0.022	0.005
			(-4.84)	(-4.40)	(-4.69)	(-1.76)	(-0.98)	(-1.12)	(1.33)	(0.31)
	N	614								
	R^2	47.9%								
Panel B2: Stock market return equation with stock market controls										
ΔS_t	ΔF_{t-l}	-0.012	-0.042	0.149	0.115	0.219	-0.009	-0.001	0.098	0.073
		(-0.69)	(-0.39)	(1.31)	(1.02)	(1.96)	(-0.08)	(-0.01)	(0.89)	(0.71)
	ΔS_{t-l}		-0.142***	-0.031	-0.012	-0.109**	-0.025	-0.033	0.005	0.115***
			(-3.35)	(-0.71)	(-0.27)	(-2.38)	(-0.55)	(-0.73)	(0.11)	(2.71)
	N	614								
	R^2	18.1%								

Table 3 (continued)

Equation	Variable	Constant	$l=1$	$l=2$	$l=3$	$l=4$	$l=5$	$l=6$	$l=7$	$l=8$
Panel C1: Fed balance sheet equation with Fed funds rate controls										
ΔF_t	ΔF_{t-l}	0.001***	0.290***	0.012	0.068	0.384***	-0.035	-0.072	-0.070	0.079**
		(2.70)	(6.99)	(0.27)	(1.61)	(9.12)	(-0.85)	(-1.75)	(-1.71)	(2.02)
	ΔS_{t-l}		-0.087***	-0.081***	-0.074***	-0.026	0.000	-0.008	0.027	0.009
			(-5.44)	(-4.94)	(-4.42)	(-1.50)	(0.00)	(-0.47)	(1.66)	(0.55)
	N	608								
	R^2	43.4%								
Panel C2: Stock market return equation with Fed funds rate controls										
ΔS_t	ΔF_{t-l}	0.002	-0.032	0.055	0.168	0.283***	-0.004	-0.085	0.020	0.012
		(1.72)	(-0.30)	(0.49)	(1.53)	(2.59)	(-0.04)	(-0.79)	(0.19)	(0.12)
	ΔS_{t-l}		-0.055	0.021	-0.005	-0.086	-0.007	-0.004	0.031	0.123***
			(-1.34)	(0.50)	(-0.11)	(-1.95)	(-0.16)	(-0.09)	(0.73)	(2.95)
	N	608								
	R^2	8.0%								
Panel D1: Fed balance sheet equation with alternative monetary policy shock controls										
ΔF_t	ΔF_{t-l}	0.001**	0.045	-0.050	0.098**	0.460***	0.070	-0.027	-0.117***	0.018
		(2.34)	(1.13)	(-1.29)	(2.57)	(12.13)	(1.95)	(-0.79)	(-3.37)	(0.57)
	ΔS_{t-l}		-0.006	-0.002	-0.025	-0.021	0.001	-0.015	0.012	0.021
			(-0.45)	(-0.17)	(-1.80)	(-1.50)	(0.05)	(-1.11)	(0.91)	(1.57)
	N	608								
	R^2	66.6%								
Panel D2: Stock market return equation with alternative monetary policy shock controls										
ΔS_t	ΔF_{t-l}	0.002**	-0.011	-0.003	0.174	0.334***	0.020	-0.004	-0.005	-0.043
		(2.27)	(-0.09)	(-0.03)	(1.52)	(2.91)	(0.18)	(-0.04)	(-0.05)	(-0.45)
	ΔS_{t-l}		-0.123***	-0.027	-0.042	-0.055	-0.052	0.013	0.012	0.129***
			(-2.92)	(-0.64)	(-0.99)	(-1.30)	(-1.24)	(0.32)	(0.31)	(3.25)
	N	608								
	R^2	28.2%								

Table 4

Estimated counterfactual of markets without Fed's intervention during COVID-19

This table reports estimates of the impact of the March 2020 Fed balance sheet expansion on stock market returns. It models three scenarios corresponding to different assumptions about how much of the balance sheet expansion was unanticipated. Scenario 1 uses the residuals of the Fed balance sheet equation in the VAR model during March 2020 (ending April 1) as the shock. Scenario 2 takes the Fed's balance sheet expansion during the two months March-April 2020 and scales it down by the multiplier of 2.4 to arrive at the unanticipated shock. In Scenario 3 the shock is the two weeks of balance sheet expansion following the stock market's major fall (the two weeks starting to March 11, 2020). Panel A reports the estimated cumulative log returns in response to the Fed's balance sheet expansion, Panel B measures the return response in standard percentage returns, and Panel C measures the response as a percentage of the 31% rebound in the S&P 500 in the eight weeks following its low on March 23, 2020 (through to May 19, 2020). The cumulative responses are measured at horizons of four weeks, eight weeks, and long run (60 weeks) following the balance sheet expansion.

		S&P 500 cumulative response		
	Shock	$t+4$ weeks	$t+8$ weeks	Long run
Panel A: Log returns				
Scenario 1	0.173	0.072	0.121	0.157
Scenario 2	0.196	0.082	0.137	0.178
Scenario 3	0.198	0.083	0.138	0.180
Panel B: Regular percentage returns				
Scenario 1		7.49%	12.82%	17.03%
Scenario 2		8.54%	14.67%	19.52%
Scenario 3		8.63%	14.83%	19.74%
Panel C: Fraction of S&P 500 rebound				
Scenario 1		24.15%	41.37%	54.92%
Scenario 2		27.53%	47.31%	62.98%
Scenario 3		27.83%	47.83%	63.68%