The calming of short-term market fears and its long-term consequences: The central banks' dilemma*

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Abstract

We study the short-term effects and long-term consequences of Fed crisis interventions on market fears — the risk perception of large asset price drops. We extract daily fear term structures from option markets covering event horizons from two weeks up to 10 years ahead and use announcement surprises in a broad set of futures contracts and ETFs, covering equity, fixed income and FX markets, to identify the unexpected component of Fed interventions. Focusing on the 2020 market turmoil, we find that the Fed crisis actions impacted markets fear via a risk premium and an information channel. The risk premium channel is the dominant channel for asset purchases and operates at the short to medium term, while the information channel has the strongest impact on long term fears and is the dominant channel for interest rate policies.

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1 Introduction

The central banks have increasingly come to see the calming of market fear — the likelihood financial market participants attach to large asset price dislocations — as a critical part of their mission. They reason that sustained market stress has real economic costs since it can lead to the failure of systemically important financial institutions, and perceived high risk reduces investment activity in the real economy. This view dates back to the Bank of England's refusal to engage with the Panic of 1866, triggered by a collapse in transportation stocks, and led the government to force the Bank to develop a formal crisis response following Bagehot's classic exposition of the lender of last resort function (Bagehot, 1873).

The implication is that the central banks should be concerned with how their crisis interventions impact on market fear. The central banks have powerful tools — lender and buyer of last resort facilities — that can put a floor under asset prices and prevent market participants from coordinating their expectations on worst-case scenarios. However, the calming of market fear is not costless. The financial markets might perceive the central bank's interventions as signaling an increased willingness to support markets in future stress episodes, thus inducing market participants to take on positions that would have previously been considered too risky. The central bank hence faces a dilemma. Quiet down immediate distress and risk moral hazard, or let a crisis play out with potentially even costlier consequences.

The degree to which central bank interventions aimed at calming the markets create moral hazard is controversial, motivating our work here. A key challenge is measurement, and to that end, we study the impact of Federal Reserve (Fed) crisis interventions on the price of insurance against significant financial losses over event horizons from one week to ten years into the future. Our primary focus is on fears in the SP-500 index, as encoded in option prices, as it provides a natural focal point for market participants in crisis times to coordinate their expectations. While the short-term impact of Fed interventions captures its ability to calm immediate market fears, the priced long-term impact provides information on whether the financial markets see the central bank intervention as a signal of its willingness to backstop future losses. The latter reduces market participants' private cost of risk-taking, creating moral hazard.

Focusing on the extreme market turmoil in the spring of 2020, we find that the Fed achieved its immediate goal, calming fear. However, that came at a cost as the Fed's actions also strongly reduced the likelihood the market attached to large losses over long horizons. Ultimately, the strong flare-up of market fears before the Fed's crisis interventions and the big market surprises around its announcements also raise the question of how well market participants understood the Fed's crisis rulebook and whether the Fed fully appreciates how the market reacts to its decisions.

When investigating how the Fed interventions are perceived by the market, both over a short-term and long-term horizon, we need financial instruments that contain information on the risk of significant losses over different event horizons. Options do precisely that. They encode information about the market's perception of significant price moves over pre-specified time horizons and how much market participants are willing to pay to insure against them. In this paper, we use a uniquely rich data set on the over-the-counter options markets,[1] allowing us to capture tail risk perceptions from one week ahead up to ten years into the future. We extract the risk-neutral distribution of future asset price moves from the option prices by applying standard methods that build on the insights of Breeden and Litzenberger (1978). Our primary focus is on the 10% quantile of the SP-500 risk-neutral log return distribution for a given investment horizon. We refer to this 10% quantile as *market fear* for that horizon.

The focus of our empirical analysis on the impact of the Fed's reactions to the financial turmoil in the spring of 2020 (February to July) is motivated by two considerations. First, to study the impact of Fed crisis interventions, we need heightened market turmoil, as certain central bank tools, especially the broadly targeted lender of last resort interventions, are only deployed in crises. Market reactions to regular Fed actions, such as interest rate decisions taken at pre-announced FOMC meetings, do not allow us to gauge how effective Fed interventions are in calming market fears about worst-case scenarios at the peak of a crisis. Second, a range of Fed crisis tools, such as the Fed's macroprudential levers, were only introduced after the financial crisis in 2008. The 2020 market turmoil is the first episode where this broad range of crisis tools was fully available to the Fed.

To study the impact of Fed interventions on market fears, we concentrate on the surprise component of interventions. Pragmatically, our causal strategy requires unexpected Fed actions; option prices already factor in Fed actions that follow an established and well-understood crisis rule book. But, more importantly, from a conceptual perspective, we expect discretionary crisis actions to be particularly powerful but also costly; very effective in breaking destabilizing dynamics as surprises lead market participants to update their beliefs about the likelihood of extreme market outcomes, but also costly as market participants will update their beliefs about the central bank's reaction function in future crises, giving rise to moral hazard.

Empirically, we face three challenges. First, Fed crisis announcements can refer to a multitude of policy levers impacting financial markets through various transmission channels. This means that announcement surprises are multidimensional, and we need a measurement approach that captures this aspect. Second, crises are fast moving, and market conditions can change within hours. To identify the Fed's impact on fear, it is important to pinpoint the exact moment an announcement

[1] The data is provided by IHS Markit's Totem, the leading consensus pricing service for the over-the-counter (OTC) derivatives market. The option prices are the mid-quote estimates of the leading market makers, mostly large international banks. The data include prices for options with distant times-to-expiration and extreme strike prices corresponding to price drops in the underlying asset of more than 80%. Options with such extreme contract terms are exclusively traded in the OTC market and not available in standard option price datasets derived from exchange-based trading activity.

surprise hits the market. Third, not all announcements create surprises of the same magnitude. This is particularly important if we want to compare the relative effectiveness of different Fed policies. We need a method to compare the size of announcement surprises across policies.

To address these empirical challenges, we propose an identification strategy that adapts techniques developed for identifying monetary policy shocks from high-frequency asset price moves around regular FOMC announcements (see, e.g., Bernanke and Kuttner (2005); Gürkaynak et al. (2005); Swanson (2020)) to the crisis intervention context. First, we use a wide range of futures contracts and ETFs that cover fixed income, foreign exchange, and equity markets to capture the broad transmission channels of Fed crisis policies. We then measure how each announcement changes prices in a narrow event window around Fed crisis announcements, leaving us with a panel of Fed interventions and price moves, i.e., announcement surprises. We then use a principal component analysis (PCA) on the Z-scored panel of announcement shocks to obtain a low dimensional representation of the Fed's announcement surprise that captures a large fraction of the informational content of the individual shock series and use the first three principal components (PCs) as our measure of Fed surprises.

The principal components load naturally on announcement surprises in particular assets. The first PC loads mainly on surprise shifts in the yield curve, and we hence refer to it as the "level" factor. Meanwhile, the second PC loads most strongly on equity market surprises, negatively on expected volatility, and positively on returns. It also loads positively on surprise depreciation of the US dollar against major currencies but does not co-move strongly with surprises in interest rate futures. Consequently, we refer to it as the "risk premium" factor. Finally, the third PC loads strongly on interest-rate futures where the signs are opposite at the short and long maturity end, and we, therefore, refer to it as the "slope" factor.

To measure the impact of Fed announcements on market fear, we regress daily changes in market fear on Fed announcement surprises as captured by our three factors; level, slope, and risk premium. As the timing of Fed interventions can depend on market conditions, we control for market volatility, macroeconomic uncertainty, and pandemic severity measures. Our main object of interest is the regression coefficient for the respective factors. We run these regressions varying the time horizons over which fear is measured. This gives us three impact coefficients, one per factor, for each time horizon of fear, from two weeks to ten years ahead. We refer to the collection of regression coefficients for a given factor across time horizons as the factor's *impact term structure*. The three impact term structures capture Fed announcement surprises' impact on market fears across different transmission channels and time horizons.

Interestingly, we find that announcements leading to an unexpected fall in interest rates coincide with an increase in fear. This suggests the presence of an *information channel* where market participants use announcements to indicate the Fed's private information about the state of the economy. As stated colloquially, the market reaction to such unexpected easing appears to be "things must be very bad for the Fed to do this". Incidentally, worries that unexpected easing via interest rates creates moral hazard by encouraging additional risk taking are inconsistent with our results. Instead, we find that unexpected lowering of rates and flatting of the interest term structure negatively impact risk sentiment, especially for longer maturities.

The impact of the risk premium factor, on the other hand, does raise a concern about the moral hazard caused by discretionary central bank interventions. While its impact is strongest at the short to medium horizons, Fed announcements that lower risk premia reduce market fears over the ongoing crisis horizon as expected, it is of particular importance that this positive effect does not die out with the time horizon. When market participants perceive that the central bank is willing to intervene to mitigate the worst aggregate losses in the current crisis, they also react by reducing the price of insuring large losses beyond the immediate market turmoil and far into the future.

While historically the Fed crisis interventions primarily focused on short-term liquidity provision, what we term conventional crisis policies, since the crisis in 2008 it has developed a variety of non-conventional tools to fight crises, many of which were first wielded in the 2020 turmoil. We propose five categories, designed to capture the primary economic aspects, and we further use Fed press releases to classify them; First is IR, policies related to interest rate decisions, including forward guidance. Second is LEN, or lender of last resort actions that provide liquidity to market participants. The third is asset purchases or AP, focused on bonds, including a new corporate bond facility. Foreign exchange, FX, is the fourth, US dollar liquidity support that foreign central banks intermediate to their own financial institutions. Finally, is macro prudential relaxing, MPR, were the Fed as the regulator of bank holding companies relaxed macro prudential constraints. These categories are not fully mutually exclusive, because LEN incorporates both the lending of last resort to domestic and foreign institutions. We therefore include the FX component both separately and as a part of LEN.

We can identify how each type of policy intervention contributes to the principal components by regressing each of the PCs on dummy variables that encode the policy type. We refer to the regression coefficients for these dummies as *policy attributions*, as they measure how announcement surprises in a given policy are reflected via the three factors and how this differs across policies. The impact of Fed interventions on fear can differ across policy types to the extent policies moves the PCs in different ways, i.e the transmission channels differ across policies. When considering the individual impact of the various policy interventions, the contrast between the conventional interest rate policies and the non-conventional actions is of particular interest. The interest rate interventions affect fear via the information channel, suggesting a trade-off between supporting the market by easing funding costs and spooking the market by sending negative signals about the economic outlook and thus increasing fear. By contrast, we find that the non-conventional policies mostly work via the risk premium channel. Among the non-conventional tools, we find the Fed's asset purchases to have the strongest impact reducing fear via the risk premium channel.

Taken together, these results suggest there is a direct trade-off between calming short run market fear and the distortion of longer-term risk taking incentives for the Fed's non-conventional crisis tools, especially its asset purchases, which potentially can lead to moral hazard.

We make three main contributions. First, we focus on the term structure of the impact to capture both the immediate benefits and long-term consequences of crisis interventions. To do so, we develop the notion of a term structure of market fears and implement it empirically. We profit from access to a unique dataset on OTC options with extreme contract terms that cover sufficiently extreme price drops over time horizons from several weeks up to ten years into the future. An increasing body of evidence finds that the Fed's interventions affected the market perception of risk. Haddad et al. (2022), for example, focusing on the Fed's announcement of US corporate bond and bond ETF purchases during the 2020 crisis, find that this has led to significant revisions in market participants' perception of the Fed's willingness to support corporate bond prices in future market turmoils. Kelly et al. (2016) have documented large premia in option prices due to implicit disaster insurance that the US government provides to the financial sector, echoing results for stock returns in Gandhi and Lustig (2015). More broadly, previous work has shown that monetary policy substantially impacts market risk perceptions extracted from option prices (Bekaert et al., 2013; Hattori et al., 2016; Hu et al., 2019).

Second, we analyze how unexpected central bank interventions — actions that deviate from what markets understood to be the central bank's crisis rulebook — impact risk perceptions. We see these surprises to be of particular importance; after all, surprises are, by definition, new information on which market participants update their beliefs about extreme events. The interventions can be very effective in breaking destabilizing dynamics. But they can also lead market participants to update their beliefs about the central bank's reaction function in a future crisis, creating moral hazard. To construct announcement surprises, we use well-established methods developed to extract monetary policy shocks from futures prices (Bernanke and Kuttner, 2005; Gürkaynak et al., 2005). However, our aim is not to identify the effects of conventional monetary policy. Instead, we study how effective discretionary, unexpected crisis interventions are in calming financial markets. In using future contracts other than the fed funds futures to capture broader transmission channels of Fed policy, we follow Jarociński and Karadi (2020) and Swanson (2020).

Finally, we evaluate the relative efficacy of the Fed's crisis toolkit in calming market fears by studying how the transmission channels from Fed surprises to market fears differ across crisis tools. A range of papers have evaluated the effectiveness of individual Fed crisis facilities both after the 2008 financial crisis (e.g. Acharya et al., 2017; Carlson and Macchiavelli, 2020; Bahaj and Reis, 2020b) and the 2020 market crisis (e.g. Bahaj and Reis, 2020a; O'Hara and Zhou, 2021; Haddad et al., 2021; Boyarchenko et al., 2021; Fleming et al., 2021). More broadly, several recent papers have analyzed the impact of the Covid-19 shock had on US equity markets (e.g. Alfaro et al., 2020; Croce et al., 2020; Ramelli and Wagner, 2020; Baker et al., 2020; Gormsen and Koijen, 2020; Landier and Thesmar, 2020; Cox et al., 2020).

The remainder of the paper is organized as follows. First, section 2 introduces the risk terms structures we construct, the Fed policy announcements, and the identification strategy. Next, we discuss the empirical results in section 3. Finally, in the Appendix, we show robustness checks and information on the Fed policies.

2 Market fear and Fed interventions

Our empirical framework is based on regressions of the following type,

$$\Delta \text{Fear}_{t,\tau} = \alpha_\tau + \gamma_\tau \,\text{Fed crisis action}_t + \xi_\tau \,\text{Controls}_t + \epsilon_{t,\tau}, \tag{1}$$

where we regress contemporaneous daily changes in market fear, $\Delta\text{Fear}_{t,\tau}$, across time horizons τ (measured in months) on Fed crisis actions. Our main object of interest is the coefficient γ_τ measuring how a Fed action impacts on fear over horizon τ. We thus obtain a collection of impact coefficients, which we refer to as the *impact term structure*. To implement this approach, we need empirical measures of market fear and Fed crisis actions.

2.1 Measuring market fear

We obtain our fear measure from the options markets. As an option insures its owner against price moves, the option's price contains information on how likely the market deems the price move to be and how much market participants are willing to pay to insure against it. Given a sufficiently large range of strike prices for a given time to expiration, one can back out the risk-neutral distribution of possible price moves of the asset over the corresponding horizon as first pointed out by Breeden and Litzenberger (1978).

While there are several sources of option data, we rely on data from the IHS Markit's Totem service, the leading consensus pricing service for the OTC derivatives market, an information aggregation service helping market participants to gauge the price of a particular option.[2] We opted for Totem instead of alternative sources because it contains options with long maturities and deep out-of-the-money strike prices on SP-500 which are crucial for capturing tail events but are not available in standard data sets derived from exchange-based trading activity.

Our primary notion of fear over a particular time horizon τ is the negative of the 10% quantile of the risk-neutral excess log-return distribution of the SP-500,

[2] Totem collects end-of-day price estimates for a fixed grid of strike prices and maturities from the major dealers in the OTC market, where all contracts are valued at a single point in time, facilitating the construction of the risk-neutral densities.

$\text{Fear}_{t,\tau}$. Specifically, the excess log-return given by the return from capital gains plus the dividend yield $\delta_{t,\tau}$ minus the risk-free rate for the corresponding horizon $r^f_{t,\tau}$, with current futures price for time-to-maturity τ given by $f_{t,t+\tau}$:

$$r_{t,\tau} := \ln \frac{S_{t+\tau}}{f_{t,t+\tau}} = \ln \frac{S_{t+\tau}}{S_t} + \delta_{t,\tau}\tau - r^f_{t,\tau}\tau.$$

Given the risk-neutral distribution of excess-log-returns, fear for a given horizon τ is then defined as:

$$\text{Fear}_{t,\tau} := -q^*_{t,\tau} \quad \text{where} \quad \mathbb{Q}_t\left(r_{t,\tau} \leq q^*_{t,\tau}\right) = 0.1, \tag{2}$$

where $\mathbb{Q}_t$ is the risk-neutral distribution of excess log-returns obtained from option prices.

We also use our risk neutral distributions to construct alternative measures of fear, especially the CBOE VIX index which we create for all points on our maturity structure, both for robustness and also to study how the distribution of returns changes in response to policy announcements. See Appendix B for the technical details.

Figure 1: SP-500 Fear of loss at the height of the 2020 financial turmoil

The risk-neutral cumulative distribution on 19 and 20 March 2020 with maturity of one year. The red line highlights the daily change in the risk-neutral negative 10% quantile.

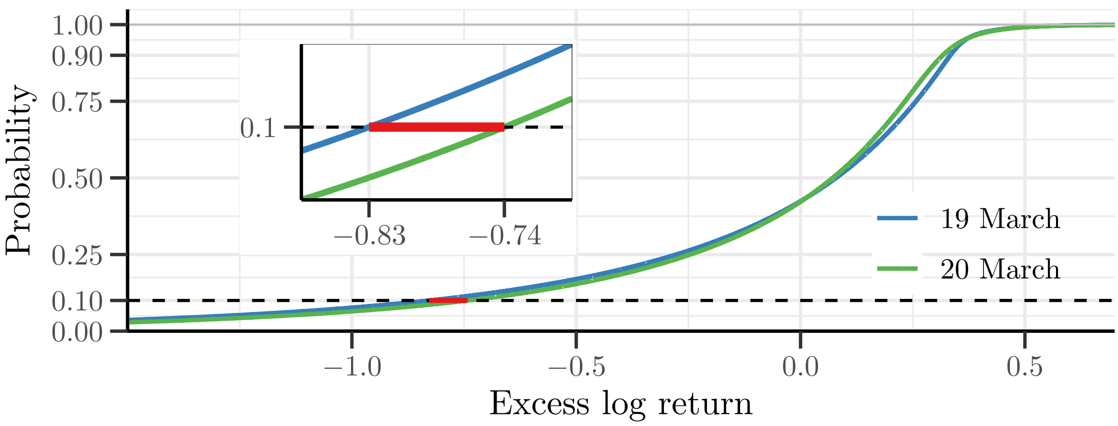


Figure 1 provides an example of the fear of loss in the US SP-500 stock market index over a one year horizon on two consecutive days at the height of the crisis, March 19 and 20, 2020. $\Delta\text{Fear}_{t,\tau}$ in this particular case was:

$$\Delta\,\text{Fear}_{\text{March 20,12}} = \text{Fear}_{\text{March 20,12}} - \text{Fear}_{\text{March 19,12}} = 0.743 - 0.828 = -0.0850$$

moving from a loss of $e^{-0.828} - 1 \approx -56\%$ to a loss of $e^{-0.743} \approx -52\%$, i.e. the market assessed on 19 March that there was a 10% chance of the SP-500 dropping by over 56% over the subsequent year, that number fell to 52% the day after, a reduction in fear of 0.085 log return units.

Figure 2 shows how the ,market turmoil manifested itself in the term structure of fear. First, we see how different the main crisis days, here 18 March, are from calmer days, such as 3 February. On the calm day, fear increases linearly, approximately at the rate of the square root of time. Likewise, fear increases across the maturity structure on the crisis day, but what stands out is the relatively higher increase at shorter immediate maturities, one month to three years, and the substantially higher level at longer maturities.

Figure 2: SP-500 term structure of fear before and during the crisis

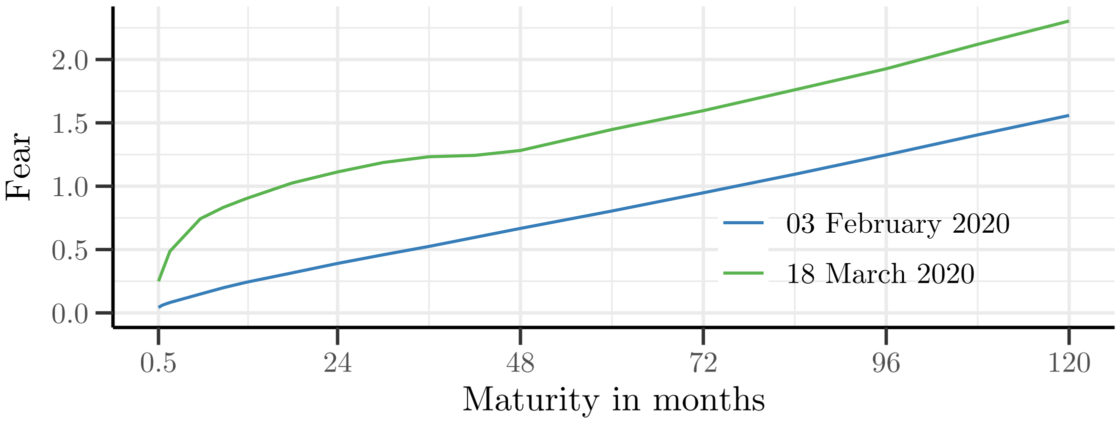


Figure 3 shows fear in the SP-500 from 2005 until the end of 2021, monthly until 2018 and daily thereafter. The Figure covers two crisis episodes, 2008 and 2020, and three maturities, one month, one year, and a decade. The two crises are visibly different from normal times, as fear shoots up sharply and only reverts slowly. There are important differences between the 2008 and 2020 crises. In the 2020 crisis, short term fear is more pronounced, while in 2008, the strongest reactions were in long term fears. Furthermore, while the flareup of fear happens more quickly in 2020, it also reverts faster. These differences reflect the different nature of these two crises: one is a banking crisis and the other a crisis triggered by a significant liquidity demand shock. It might also reflect differences in the financial authorities' crisis interventions. In the following analysis, we do not compare the two episodes, both due to data limitations for the 2008 crisis — daily option price data for long-dated maturities are not available for that time period — and since the main Fed crisis fighting tools only became available after the peak crisis of 2008 had passed.

2.2 Fed announcements

Once it became clear in early spring of 2020 that considerable market turmoil was on the way, most central banks reacted quickly. As an example of the speed of interventions, on the morning of 17 March, the Fed established the Commercial Paper Funding Facility, while in the afternoon of the same day, it announced the

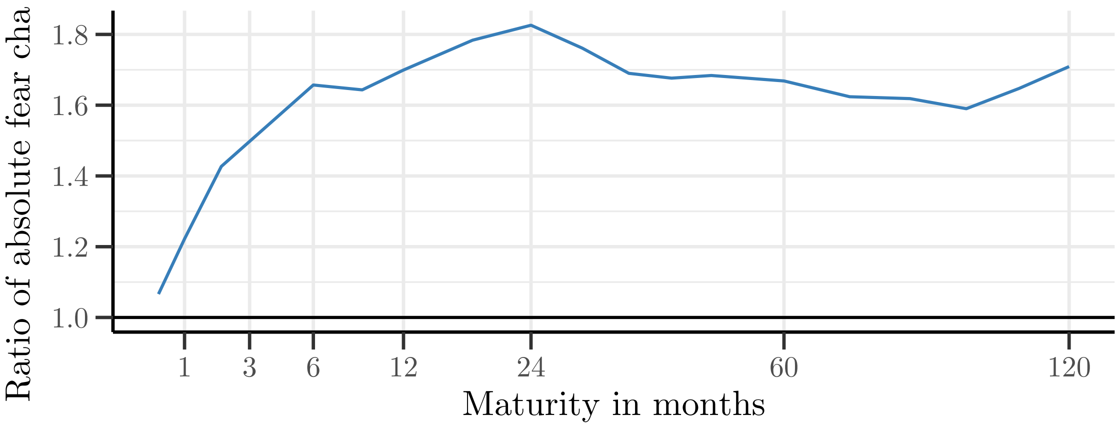
Figure 3: SP-500 term structure of fear, 2005-2021

The time series of SP-500 fears for one month, one year, and ten years from 2005 to 2021. The data frequency is monthly until 2018, then daily.

Primary Dealer Credit Facility. Not only was the Fed quick to react, but the actions also appear to have moved market fears. Figure 4 displays the ratio of change in fear on Fed announcement days against non-announcement days. For short horizon fears, the average movement on announcement days was slightly larger than on non-announcement days. For long horizon, on Fed announcements days fears moved almost twice as much as on days without announcements.

Figure 4: SP-500 fear movement on Fed announcement days

This Figure takes the ratio of average absolute change in daily fear on Fed announcement days versus non-announcement days. The ratio is measured from 2020-02-03 to 2020-07-31. The fear horizon is stated on the x-axis and is displayed on a square root scale.



The Fed intervened using a wide range of instruments. We collect all announcements of the Fed's economic and financial crisis policies from 3 February 2020 to 29 July 2020, including precise time stamps of when an announcement was made, from the press releases section of the Fed's website.[3]

[3]See https://www.federalreserve.gov/newsevents/pressreleases.htm for more information and data.

While the obvious way forward might be to directly use a announcement dummy in regression (1), that is not possible since at the height of the crisis, the Fed made multiple interventions on the same day, while the fear measures are only available at a daily frequency. Furthermore, some announcements were presumably more important than others, and we want to be able to capture this intensive margin of Fed interventions. We, consequently, need an approach that can both pick up an announcement's timing and identify its importance. Lastly, Fed crisis announcements refer to a multitude of policy levers impacting financial markets through various transmission channels. This means that announcement surprises are multidimensional, and we need a measurement approach that captures this aspect.

We propose a strategy for measuring Fed crisis interventions based on techniques for identifying how monetary policy announcements affect asset prices, see e.g. Bernanke and Kuttner (2005); Gürkaynak et al. (2005); Swanson (2020). To start, we collected a number of high frequency futures and ETF prices, chosen to represent a wide spectrum of financial market activities, such as stock market returns and volatility, various aspects of the US money and government bond market and foreign exchange.[4] The aim is to capture the broad transmission channels of Fed policies. For each asset, we measure how its price changes in a narrow window around the announcement (10 minutes before to 20 minutes after).[5] As an illustration, consider Figure 5, where we highlight the reaction of VIX ETF (VIXY) prices to different announcements of the Fed. In each panel, the black dots correspond to the intraday minute-by-minute aggregates of VIXY prices.

We z-score the panel of announcement surprises and do a principal components analysis to reduce data dimensionality while preserving the most salient features. Table 1 shows the factor loadings of the first three principal components (PCs). Together these PCs capture approximately 70% of the variation in the announcement surprises captured by the futures and ETF prices. More details can be found in see Appendix A.

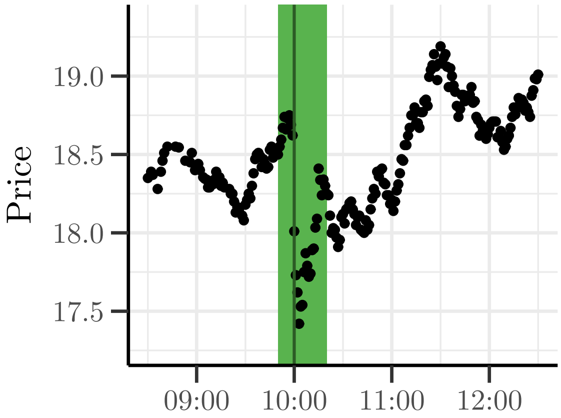
Although the PCA is a statistical technique for dimensionality reduction, the loadings in Table 1 admit intuitive economic interpretations. PC1 picks up surprise level shifts in the interest rate term structure. All interest rate futures, from the short end (Fed funds futures) to the long end (10y T-Note futures) have loading of the same sign and magnitude. The loadings of PC1 on VIXY and E-Mini futures are low, implying that this factor does not strongly impact the equity market. An increase in PC1, i.e. a surprise decrease in interest rates, coincides with a surprise depreciation of the US dollar against the euro, yen and the pound. This is consistent with a standard transmission mechanism from interest rates to exchange rates. In what follows, we refer to PC1 as the "level" factor. PC2 loads strongly

[4] Our sample of financial assets is the VIXY ETF, E-Mini Futures, Fed fund futures 1st, Fed fund futures 3rd, USD/EUR future, USD/Yen future, USD/GBP future, 2-year T-Note futures, 5-year T-Note futures, 10-year T-Note futures, Eurodollar futures 1st, Eurodollar futures 3rd.

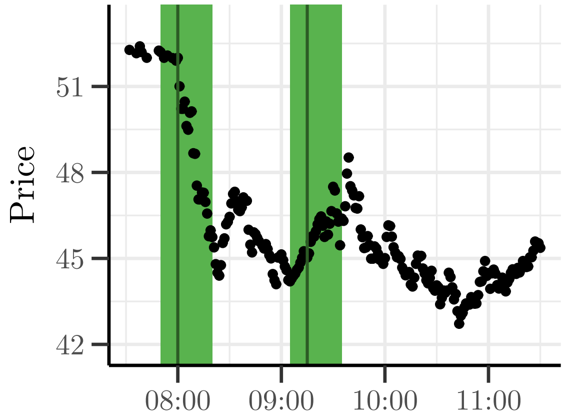
[5] For robustness, we tried other window sizes and our main results are robust to such changes, see Appendix F. One announcement was made on Sunday 15 March at 5 PM, where we used the last price before the announcement and the next after for the price impact.

Figure 5: Change in VIX ETF prices around Fed announcements

These figures illustrate the intraday changes in the VIXY ETF prices around Fed policy announcements, the intraday one-minute aggregates of the VIXY ETF prices (black dots) around the Fed announcements timestamps. The event window starting 10 minutes before and ending 20 minutes after the announcement, is displayed in green. The two events are: (a) an unscheduled FOMC meeting at 10:00 on 3 March (IR) and (b) an unscheduled FOMC meeting at 08:00 (LFI, unlimited purchases, "all it takes" moment), and two press releases regarding CHBP at 08:00 as well as regarding MPR at 09:15 on 23 March. The timestamps of the announcements are retrieved from the website of the Federal Reserve: https://www.federalreserve.gov/newsevents/pressreleases.htm.



(a) 03 March 2020



(b) 23 March 2020

on the equity markets, negatively on the VIXY ETF and positively on the E-mini futures. An increase in PC2 also leads to a depreciation of the US dollar against the three major currencies. PC2 does not load strongly on interest rate futures. Given that increases in PC2 imply a surprise reduction in expected market volatility, positive stock market returns and a depreciation of the US dollar, all effects that are consistent with an easing of risk sentiment, we refer to PC2 as the "risk premium" factor. Lastly, PC3 strongly loads on interest rate futures with opposite signs at the short and long end, where a decrease in PC3 corresponds to a surprise flattening of the interest rate term structure. It also coincides with a surprise depreciation of the US dollar, increase in expected equity market volatility and negative stock market returns. We refer to PC3 as the "slope" factor.

2.3 Identifying the impact of Fed crisis interventions

We face three main challenges in our empirical exercise. First, as we regress daily changes in market fear on policy shocks, we must be mindful that factors other than the policy shock can cause changes in fear, especially during a fast moving crisis. A second identification problem is the potential endogeneity of the timing of Fed crisis actions. The Fed could intervene after extreme days in financial markets, hence days with high market fears. To address both concerns, the regressions control for the contemporaneous severity of the pandemic, news about the US macro economy, and realized stock market variance on the day before the Fed actions. The final challenge is using futures prices to indirectly measure the surprise in Fed crisis actions, implying we measure surprises with noise. A priori, this measurement

Table 1: PCA loadings

	PC1	PC2	PC3
Fed fund futures 1st	0.30	-0.14	0.52
Fed fund futures 3rd	0.29	-0.12	0.57
2-year T-Note futures	0.32	-0.13	-0.16
5-year T-Note futures	0.35	-0.15	0.01
10-year T-Note futures	0.29	0.06	-0.29
Eurodollar futures 1st	0.35	-0.10	-0.13
Eurodollar futures 3rd	0.36	-0.08	0.06
USD/EUR future	0.30	0.31	-0.02
USD/Yen future	0.29	0.22	-0.22
USD/GBP future	0.26	0.32	-0.30
VIXY ETF	0.09	-0.56	-0.31
E-Mini Futures	0.05	0.59	0.18

error would lead us to underestimate the effects working in our favor. To address this concern, we use a wide range of futures contracts spanning fixed income, foreign exchange, and equity markets. This guarantees that we consider a broad concept of market surprise capturing broad transmission channels of the various Fed policies into financial markets. See Appendix **??** for more details.

Our empirical investigation is based on regressing daily changes in fear a, $\Delta \text{Fear}_{t,\tau}$, on Fed announcement surprises and a set of controls. We start by modifying (1) to incorporate three shock variables, Fed announcements, and the three controls,

$$\Delta \text{Fear}_{t+r,\tau} \;=\; \alpha_\tau + \gamma^1_\tau \,\text{PC1}_t + \gamma^2_\tau \,\text{PC2}_t + \gamma^3_\tau \,\text{PC3}_t + \sum_{j=1}^{3} \xi^j_\tau \,\text{Controls}^j_t + \epsilon_{t,\tau}. \quad (3)$$

We control for the severity of the pandemic, macroeconomic uncertainty, and stock market volatility.[6] To control for residual serial correlation and heteroskedasticity, we use the Newey-West (HAC) estimator to calculate all standard errors.

[6]We use the log of the 7-day rolling mean of new Covid-19 cases collected from the Johns Hopkins Coronavirus Resource Center, https://github.com/CSSEGISandData/COVID-19 and proxy for macroeconomic uncertainty using Bloomberg's economic surprise index (ECSU). To control for the endogenous response of the Fed to strong market volatility, we include the first difference of previous day realized variance of the SP-500 obtained from Oxford-Man's realized variance library according to their measure of quadratic price variations over 10-minute intervals, see https://realized.oxford-man.ox.ac.uk/documentation/econometric-methods.

3 Impact of Fed announcements on fear

Our interest is both in the effectiveness of discretionary central bank actions in alleviating short term financial market turmoil and the longer-term consequences of such crisis interventions. To that end, we use regressions of the form (3) that relate daily changes in market fear for a range of time horizons (two weeks to up to 10 years) to Fed announcement surprises and controls. The primary sample is daily data for February to July 2020, when the Fed directly intervened to address significant financial market dislocations and support the wider economy. The conventional Fed response to address such turmoil is to lower its target for the federal funds rate, perhaps coupled with strong forward guidance. And these were indeed the first two crisis actions of the Fed on March 3 and 15. However, as markets became more fearful by the middle of March, the Fed proceeded to deploy a broader set of tools developed in response to the 2008 crisis. These include asset purchases, macroprudential interventions, credit provision to banks and non-banks, and foreign exchange interventions, clearly showing that different aspects of the crisis were targeted. By extracting announcement surprises from a wide array of future contracts, we aim to span the two underlying channels, information, and risk premium, through which the Fed's crisis actions affected market fears.

3.1 The impact term structure of Fed announcements

We start by investigating how strongly Fed announcement surprises impact fear by running regression (3) with our multidimensional measure of announcement surprises, changes in the VIX as well as the level and the slope of the yield curve, varying the maturity of market fears from two weeks to ten years ahead. We refer to the resulting collection of regression coefficients for a given factor as the *impact term structure* of that factor.

For a given maturity and factor, the regression coefficient gives the change in fear at that horizon caused by an announcement surprise in that factor.

Recall that we normalize factors by their standard deviation, e.g. the value 1 for the VIX factor corresponds to a surprise increase in the VIX equal to the standard deviation of the VIX announcement shock distribution during our sample period.[7] For example, $\gamma_{36}^{\mathrm{VIX}}$ then gives the change in the three-year ahead fear caused by a Fed announcement that induces a one standard deviation change in the VIX. As fear is measured as the negative of the 10% log return quantile, this change is thus measured in units of (non-annualized) log returns over the next three years. A positive value implies an increase in fear.[8]

[7] Similarly a value of 1 for "level" corresponds to a one standard deviation surprise increase in the interest rate level and for "slope" a one-standard-deviation surprise steepening of the interest rate term structure.

[8] If log returns were independently and normally distributed, fear would scale with the square root of maturity as it is a quantile of this distribution. Suppose a Fed announcement surprise was to permanently increase the variance of such a log return distribution. The impact coefficients

We present summary results for these regressions in Table 2, while Figure 6 displays the impact term structures for VIX (solid blue), level (solid red), and slope (solid yellow). The sign on γ_τ^{VIX} is as expected. An announcement that shocks the VIX positively increases fear. This effect increases up to one year ahead and then reverts without dying out even at the ten year horizon. For the one year horizon, a Fed announcement that induces a one standard deviation increase in the VIX increases fear by 0.04, i.e. causes the 10% quantile of the log return distribution to drop by 0.04. With maturity, this impact decreases but stabilizes at a value of 0.02, implying a permanent impact of such surprises. The sign $\gamma_\tau^{\text{level}}$ is negative and becomes more negative with maturity. An announcement that positively shocks the level of interest rates, a more restrictive announcement than expected, decreases fear. The direction of this impact suggests an information effect of Fed surprises, i.e. market participants inferring information about the economic outlook from the Fed's announcements. A more traditional transmission channel working via easing of funding costs would be the opposite sign. At the ten year horizon, a one standard deviation surprise level shift up in interest rates reduces market fears by 0.03. The impact of surprise increases in the slope of the yield curve as captured by γ_1^{slope} are quantitatively very similar to the impact of the level factor. The coefficient estimates are negative and significant, implying a steeper slope.

We repeat the above analysis for regular FOMC announcements from mid-2018 to January 2000 and contrast those with the crisis period results in Figure 6.

Comparing the crisis versus non-crisis impact of Fed surprises shows that crisis times are different. The impact coefficients for all three factors are much smaller for regular pre-crisis FOMC announcement surprises and in the opposite direction for level and slope. This is because policy instruments and the targeted outcomes of the central bank's actions differ across economic conditions. In normal times, inflation and output are of primary importance, and the main policy lever is interest rates. In crisis times, financial stability consideration comes into play, and a more comprehensive range of tools is deployed. The variation in the impact of announcement surprises across economic conditions echoes Jarociński and Karadi (2020), who show that announcement surprises contain a significant information effect component during stock market downturns but primarily reflect revisions about the future path of interest rates in normal times.

3.2 Analysis

We find that the impact of the interest level and the slope factor of Fed surprises is increasing in term and strongest at the long end. It is of particular interest to us that announcements leading to an unexpected fall in interest rates or an unexpected flattening of the term structure of yields coincide with an increase in

would increase with the square root of maturity. A temporary impact of Fed announcement surprises will induce a decreasing or hump shaped impact term structure that converges to 0 for sufficiently long maturities. Appendix C provides more details.

Table 2: Intervention impacts on market fears

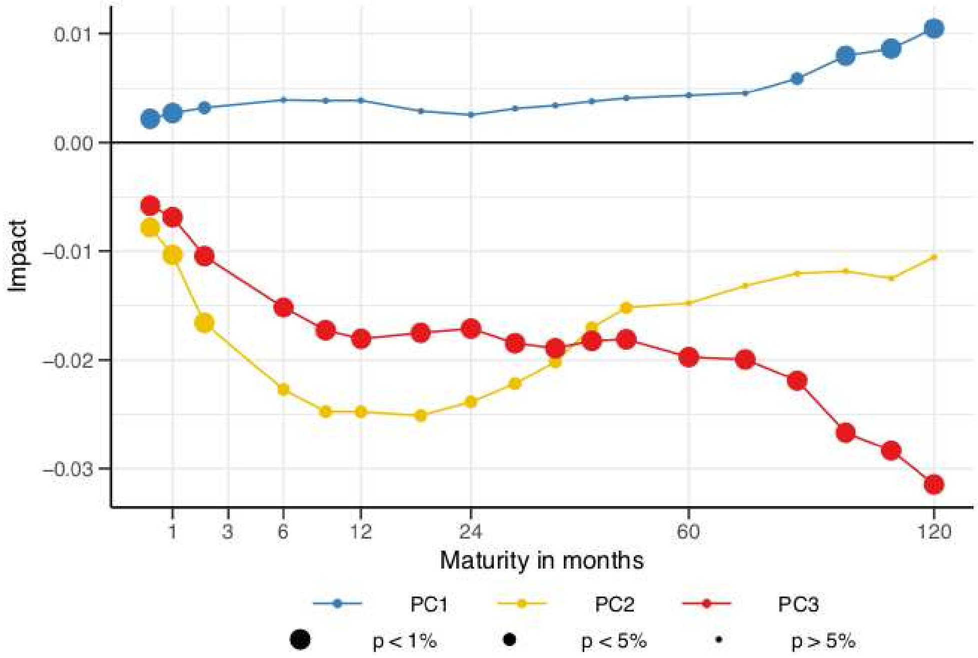
The table reports the coefficient estimates of the announcement effects of Fed crisis actions on market fears over horizon τ. γ_τ^{VIX}, $\gamma_\tau^{\text{level}}$, $\gamma_\tau^{\text{slope}}$ are the policy impact coefficients from running (3) for the three shock variables VIX, PC_1 and PC_2 respectively. Three controls are included in the regressions. $C_{t,covid}$ is the rolling 7-day mean of the confirmed covid cases in the US. $C_{t,\Delta ECSU}$ is the change in the Bloomberg economic surprise index. $C_{RV_{t-1}}$ is the previous day's median realized variance provided by oxford man institute. The dependent variable is $\Delta \text{Fear}_{t,\tau}^{SP}$ for maturities $\tau = 1$, $\tau = 12$, $\tau = 36$, $\tau = 60$, and $\tau = 120$ months. Sample period: daily, 3 February 2020 to 31 July 2020. Heteroskedasticity and autocorrelation robust standard errors based on Newey and West (1987) are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01.

	$\tau = 1$	$\tau = 12$	$\tau = 36$	$\tau = 60$	$\tau = 96$
γ_τ^{PC1}	0.002**	0.003	0.002	0.003	0.007***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)
γ_τ^{PC2}	−0.011***	−0.026**	−0.021**	−0.016*	−0.013*
	(0.003)	(0.011)	(0.009)	(0.009)	(0.008)
γ_τ^{PC3}	−0.006***	−0.016***	−0.017***	−0.017***	−0.024***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
$C_{t,\text{covid}}$	−0.002	0.028	0.042	0.037	0.038
	(0.018)	(0.028)	(0.038)	(0.035)	(0.035)
$C_{t,\text{ECSU}}$	0.005	0.005	0.003	0.002	−0.004
	(0.007)	(0.013)	(0.014)	(0.014)	(0.015)
$C_{t,\Delta\text{RV}}$	23.441***	37.393***	40.237***	39.893***	51.259***
	(3.127)	(4.407)	(7.308)	(6.330)	(8.671)
Constant	−0.001	−0.001	−0.001	−0.0001	0.001
	(0.002)	(0.005)	(0.006)	(0.005)	(0.005)
Observations	119	119	119	119	119
R^2	0.566	0.502	0.461	0.502	0.592
Adjusted R^2	0.542	0.475	0.432	0.475	0.570

fear. The direction of the impact is consistent with an information channel of Fed surprises: market participants infer information about the state of the economy from the Fed's actions. Colloquially expressed by market participants as "Things must be terrible if the Fed does this." The fact that the effect is most potent for long term fears indicates that market participants' information extraction is mainly about the probability of a protracted crisis. When considering the temporal impact of the level and slope shocks, neither point to a trade-off between calming shorter market fear at the expense of distorting long-run risk-taking incentives-moral hazard. For example, suppose the lowering of long-term rates reduced the private cost of insuring against significant financial losses over the longer horizon as market participants now expect similar accommodating Fed intervention in future crises, potentially inducing more risk taking. In that case, the impact should be of the opposite sign. Instead, the results point to a different trade-off between relaxing funding costs and increasing market fears, as the former sends worrying

Figure 6: Impact term structure of the SP-500

This figure contrasts the coefficient estimates for the three types of announcement shocks during crisis and non-crisis times. The y-axis provides the value of point estimates of the coefficients, and the x-axis gives the horizon over which fear is measured on a square root scale. The bullet size •, ●, ⬤ indicate the significance level at 10%, 5% and 1% of the coefficients, respectively. The standard errors are calculated using robust standard errors based on Newey and West (1987).



signals about long-term economic prospects.

Furthermore, the impact of the VIX factor is to reduce fear. An unexpected decrease in the VIX coincides with lower fear when the announcement is made. Not surprisingly, the impact is strongest at the short to medium term horizons, but it does not die out, staying significant even at the ten year horizon. Unlike the interest rate channels, the impact of Fed announcements via the VIX channel raises the concern of moral hazard. The VIX captures risk sentiment, suggesting that this factor captures the risk premium channel of Fed announcement surprises. The Fed likely intended to reduce short term risk premia. However, the cheapening of private disaster risk insurance for longer term horizons points to the potential costs of such relaxation.[9]

[9] This result is further supported by the same analysis done for systemically important banks in the US and non-US G7 countries, presented in the Appendix. We show that the VIX channel is much stronger for US-GSIBs than non-US GSIBs. The former have direct access to Fed support, and, additionally, any systemic crisis would likely involve large drops in the stock prices of US-GSIBs. Therefore, we expect changes in the expectation about future Fed support to be particularly impactful for US GSIBs.

4 Announcement effects by policy type

Prior to the crisis in 2008, the primary Fed reaction to market turmoil were liquidity injections via interest rates reductions. Such conventional interventions proved insufficient in that crisis, and the Fed has since developed a range of more unconventional interventions, some of which were put in use in 2008 and others developed subsequently. These were all implemented in 2020, most for the first time, which allows us to identify how various policy interventions met the objectives of the Fed and how the market perceived them.

To that end, we classify all Fed crisis announcements into five policy categories, designed to capture the main economic channels interventions operate through.[10] First (IR) are policies related conventional interest rate decisions, including forward guidance. Second, (LEN) are all lender-of-last resort type actions aimed at providing liquidity to stressed financial market participants, primarily banks and primary dealers. An example is the Primary Dealer Credit Facility. Third, (AP) are asset purchases, both targeted at market functioning, especially for the US Treasury market, and at lowering longer term borrowing costs, i.e. quantitative easing. One example is the Fed's new facilities for buying corporate bonds, the Primary and Secondary Market Corporate Credit Facilities. Fourth, (FX) are foreign liquidity support interventions that provide dollar liquidity to foreign central banks and international organizations via the Fed's FX swap lines and its FIMA repo facility. Lastly, (MPR) is macroprudential relaxing. The Fed as the regulator of US bank holding companies, loosened macroprudential levers, such as the exclusion of reserves and US Treasuries from banks' supplementary leverage ratio calculations. For the complete list of the announcements and category assignments and more details, see Appendix E. Altogether, there are 40 unique press releases and 52 (N) policy events subdivided into $N_{LEN} = 23$, $N_{\mathrm{IR}} = 5$, $N_{AP} = 10$, $N_{\mathrm{MPR}} = 15$, $N_{\mathrm{FX}} = 5$. FX is counted twice, by itself and as a part of LEN.

To see how announcement surprises in different policy categories are picked up through the three PCs, we regress individual PCs on policy type dummies,

$$\mathrm{PCA}_{i,n} = \beta_{i,\mathrm{IR}}\,\delta_n^{\mathrm{IR}} + \beta_{i,\mathrm{LEN}}\,\delta_n^{\mathrm{LEN}} + \beta_{i,\mathrm{AP}}\,\delta_n^{\mathrm{AP}} + \beta_{i,\mathrm{FX}}\,\delta_n^{\mathrm{FX}} + \beta_{i,\mathrm{MPR}}\,\delta_n^{\mathrm{MPR}} + \varepsilon_{i,n}, \quad (4)$$

where n refers to the n^{th} Fed announcement in our sample and δ_n^p is a dummy variable for policy p, i.e. it is equal to 1 if the n-th announcement involved a policy of type p and 0 otherwise. The regression coefficient $\beta_{i,p}$ corresponds to the conditional mean of PC_i for an announcement that involved policy p but not other policy type. Intuitively, it gives the average size and direction of an announcement surprise in policy p captured by the given PCs.

[10] Our selection is similar to Cox et al. (2020), but we additionally include macroprudential policies and extend the date set until the end of July. We also add the following policies which are not included in Cox et al. (2020): policies announced at 16:30 on 16 March 2020, at 08:30 on 19 March 2020, at 11:00 on 20 March 2020, at 17:30 on 23 April 2020 in our category LFI and the policy announced at 11:00 on 20 March 2020 in our category CHBP. We do not include the policy announced at 17:45 on 23 April 2020 since it is considered a proposal rather than an implementation.

Table 3 shows the regression coefficients for all five policies grouped by PC, along with an F test for whether all the policy coefficients have the same sign. Table XXX in Appendix XXX shows the p-values for whether each coefficient is different from zero.

Table 3: Policy weights attributed to PC

	PC1 — Level	PC2 — Risk premium	PC3 — Slope
IR	4.41	-1.83	1.37
LEN	-0.95	0.11	-0.01
FX	2.17	0.17	-1.20
AP	-0.34	1.52	-0.55
MPR	-0.28	-0.54	-0.20

The contrast between the conventional interest rate policies (IR) and the four non-conventional policies is particularly interesting. Announcement surprises in IR, on average, took the shape of an unexpected increase in the level of interest rate (PC1 ¿ 0), an unexpected increase in equity risk premia (PC2 ¡ 0) and a steepening of the term structure (PC3 ¿ 0). Thus, the Fed's interest rate related actions would have increased fear via the first two channels, while easing fear via the latter. The effect for the first two channels suggests a trade-off between supporting the market by easing funding conditions and increasing fear by spooking the market. Among the non-conventional crisis policies, announcement surprises in FX policies and asset purchases appear to have had the strongest impact on market fears. Unexpected FX actions would have, on average, contributed to an increase in market fear via the level and slope channel. Asset purchases would have calmed market fear by mostly operating via PC2, i.e. the risk-premium channel. To the extent that the risk premium channel creates moral hazard, these results suggest that asset purchases are most costly in terms of longer term consequences that work via updated expectations about future central bank support. Ultimately, there is a trade-off between the short term calming of market fear and the distortion of longer term risk-taking incentives.

5 Conclusion

We study the impact of the Federal Reserve's 2020 crisis policy interventions on market fear. The analysis is based on the term structure of market fear, derived from a unique dataset on daily option prices covering extreme outcomes and horizons up to ten years into the future. We use high frequency price movements in a broad set of financial asset prices around the Fed announcements to identify the importance of individual policy actions, and classify these actions into five policy categories: interest rate policies, emergency lending, foreign exchange policies, asset purchases and macroprudential policies, and study their effects on the risk term structure.

We find that, among the Fed's crisis policies, asset purchases had the strong calming impact on market fear, while interest rate policies, on average, increased fear by sending negative signals about the future economic outlook. The strong effects on long-run risk perceptions of asset purchases point to the moral hazard of crisis interventions via non-conventional policy tools. A key message of this paper is that the central banks should pay attention to the impact of their discretionary crisis actions on insurance premia in long-term financial contracts to gauge distortions in the private sector's incentives to take on risk.

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A Principal components details

	DateTime	Policy	Weight
1	2020-03-03 10:00:00	IR	1.00
2	2020-03-15 17:00:00	LFI,FX,IR,MPR	0.25
3	2020-03-16 16:30:00	IR	1.00
4	2020-03-17 09:15:00	MPR	1.00
5	2020-03-17 10:45:00	CHBP	1.00
6	2020-03-17 18:00:00	LFI	1.00
7	2020-03-18 23:30:00	LFI,CHBP	0.50
8	2020-03-19 08:30:00	LFI	1.00
9	2020-03-19 09:00:00	FX	1.00
10	2020-03-20 10:00:00	FX	1.00
11	2020-03-20 11:00:00	LFI,CHBP	0.50
12	2020-03-23 08:00:00	LFI,CHBP	0.50
13	2020-03-23 09:15:00	MPR	1.00
14	2020-03-27 12:00:00	MPR	1.00
15	2020-03-31 08:30:00	FX	1.00
16	2020-04-01 16:45:00	MPR	1.00
17	2020-04-03 18:30:00	MPR	1.00
18	2020-04-06 09:00:00	MPR	1.00
19	2020-04-06 14:00:00	CHBP	1.00
20	2020-04-07 15:00:00	MPR	1.00
21	2020-04-09 08:30:00	CHBP	1.00
22	2020-04-09 09:30:00	MPR	1.00
23	2020-04-14 18:00:00	MPR	1.00
24	2020-04-23 17:30:00	LFI	1.00
25	2020-04-24 10:00:00	MPR	1.00
26	2020-04-27 16:30:00	CHBP	1.00
27	2020-04-29 14:00:00	LFI,IR	0.50
28	2020-04-30 10:00:00	CHBP	1.00
29	2020-04-30 17:15:00	CHBP	1.00
30	2020-05-05 15:30:00	MPR	1.00
31	2020-05-15 17:45:00	MPR	1.00
32	2020-06-03 13:00:00	CHBP	1.00
33	2020-06-08 15:30:00	CHBP	1.00
34	2020-06-10 14:00:00	LFI,IR	0.50
35	2020-06-15 14:00:00	CHBP	1.00
36	2020-07-15 16:30:00	CHBP	1.00
37	2020-07-17 10:00:00	CHBP	1.00
38	2020-07-23 14:30:00	CHBP	1.00
39	2020-07-28 09:30:00	CHBP,LFI	0.50
40	2020-07-29 14:00:00	LFI,FX,IR	0.33

Table 4: Policy Weight

VIXY	1.00	-0.79	-0.24	-0.18	-0.19	0.01	-0.19	0.37	0.43	0.15	-0.40	-0.30
E-Mini F	-0.79	1.00	0.01	-0.00	0.52	0.40	0.40	-0.06	-0.05	0.16	0.02	-0.04
Fed FF 1st	-0.24	0.01	1.00	0.98	-0.56	-0.48	-0.33	-0.65	-0.83	-0.49	0.75	0.84
Fed FF 3rd	-0.18	-0.00	0.98	1.00	-0.53	-0.46	-0.32	-0.61	-0.79	-0.45	0.70	0.81
USD/EUR F	-0.19	0.52	-0.56	-0.53	1.00	0.77	0.84	0.54	0.64	0.65	-0.69	-0.70
USD/Yen F	0.01	0.40	-0.48	-0.46	0.77	1.00	0.75	0.62	0.65	0.65	-0.73	-0.70
USD/GBP F	-0.19	0.40	-0.33	-0.32	0.84	0.75	1.00	0.52	0.50	0.57	-0.65	-0.60
2-y T-N F	0.37	-0.06	-0.65	-0.61	0.54	0.62	0.52	1.00	0.89	0.68	-0.86	-0.87
5-y T-N F	0.43	-0.05	-0.83	-0.79	0.64	0.65	0.50	0.89	1.00	0.77	-0.94	-0.96
10-y T-N F	0.15	0.16	-0.49	-0.45	0.65	0.65	0.57	0.68	0.77	1.00	-0.73	-0.74
ED F 1st	-0.40	0.02	0.75	0.70	-0.69	-0.73	-0.65	-0.86	-0.94	-0.73	1.00	0.96
ED F 3rd	-0.30	-0.04	0.84	0.81	-0.70	-0.70	-0.60	-0.87	-0.96	-0.74	0.96	1.00

Table 5: input correlation

1	2	3	4	5	6	7	8	9	10	11	12
0.33	0.52	0.64	0.72	0.78	0.85	0.89	0.93	0.96	0.97	0.99	1.00

Table 6: PCA cum relative stdev

	PC1	PC2	PC3
IR	3.93	0.67	2.01
LFI	1.18	1.24	0.32
FX	1.32	1.14	0.39
MPR	1.24	0.99	0.41
CHBP	0.81	1.14	0.33

Table 7: Policy weights attributed to PCsd

	PC1	PC2	PC3
IR	6	6	6
LFI	11	11	11
FX	5	5	5
MPR	13	13	13
CHBP	16	16	16

Table 8: Policy weights attributed to PC length

	PC1	PC2	PC3
IR	1.00	0.00	1.00
LFI	1.00	1.00	0.00
FX	1.00	0.99	0.00
MPR	0.00	0.00	0.00
CHBP	0.00	1.00	1.00

Table 9: Policy weights attributed to PC p-values

B Decomposition

We have shown how our fear of loss measure, (the negative of) a quantile, has been reduced in the Covid crisis by the various policy surprises. We now show that the shift upwards in the quantile has been due to the combined effects of the policies shifting the mean of the distribution of log returns upwards ($E_t^{\mathbb{Q}}[r_{t,\tau}] = -\tau \mathrm{VIX}_{t,\tau}^2/2$), reducing the dispersion of the log-returns ($\mathrm{std}_t^{\mathbb{Q}}(r_{t,\tau})$), and finally changing the quantile of the standardised distribution ($(F_{t,\tau})^{-1}(0.1)$), as seen in (**??**):

$$\mathrm{Fear}_{t,\tau} = -q_{t,\tau}^* = \tau \mathrm{VIX}_{t,\tau}^2/2 + \mathrm{std}_t^{\mathbb{Q}}(r_{t,\tau}) \times \big(-(F_{t,\tau})^{-1}(0.1)\big)$$

The first two effects are significant and reinforce each other, while the effects via the changing shape of the standardised distribution due to policy effects on higher moments is more muted but nevertheless interesting.

Performing the same regression for VIX^2,

$$\Delta \mathrm{VIX}_{t,\tau}^2 = \alpha_\tau + \sum_{c \in \text{categories}} \gamma_\tau^c \,\text{Fed surprise}_t^c + \sum_{j=1}^{3} \xi_\tau^j \,\text{Controls}_t^j + \epsilon_{t,\tau} \;;\; t \in T$$

The regression parameters are displayed in Figure **??** and the regression table **??** is in Appendix E.

The standard deviation of log-returns $\mathrm{std}_t^{\mathbb{Q}}(r_{t,\tau})$ can itself be reconstructed from options prices, and a regression then shows the effect of policy surprises on this dispersion,

$$\Delta \mathrm{std}_t^{\mathbb{Q}}(r_{t,\tau}) = \alpha_\tau + \sum_{c \in \text{categories}} \gamma_\tau^c \,\text{Fed surprise}_t^c + \sum_{j=1}^{3} \xi_\tau^j \,\text{Controls}_t^j + \epsilon_{t,\tau} \;;\; t \in T$$

The regression parameters are displayed in Figure **??** and the regression table **??** is Appendix E. We see that policy surprises have again the usual consistent pattern we have outlined above, this time by reducing the dispersion (around the higher mean).

We can then assert the overall effect of policies on the second component $\mathrm{std}_t^{\mathbb{Q}}(r_{t,\tau}) \times (F_{t,\tau})^{-1}(0.1) = \mathrm{Fear}_{t,\tau} - \tau \mathrm{VIX}_{t,\tau}^2/2$ by running the following regression

$$\Delta\big(\mathrm{Fear}_{t,\tau} - \tau \mathrm{VIX}_{t,\tau}^2/2\big) = \alpha_\tau + \sum_{c \in \text{categories}} \gamma_\tau^c \,\text{Fed surprise}_t^c + \sum_{j=1}^{3} \xi_\tau^j \,\text{Controls}_t^j + \epsilon_{t,\tau} \;;\; t \in T$$

We see from Figure **??** (and Table **??** in Appendix E) that policy surprises have had very similar effects on both components, shifting the distribution upwards while at the same time changing its shape. Policies do not reduce fear by simply calming VIX, a measure of an increased expected log return. This is especially clear when considering that the effect of policy surprises is being reduced as the horizon increases, implying that higher moments are responsible for changes in long-term fear.

We now show in Figure **??** (and in Table **??** in Appendix E) that the effects on the shape stem largely from a reduced dispersion of log returns, with the effects of policy surprises on the standardised quantile $(F_{t,\tau})^{-1}(0.1)$ small. The regression is

$$\Delta \frac{\text{Fear}_{t,\tau} - \tau \text{VIX}^2_{t,\tau}/2}{\text{std}^{\mathbb{Q}}_t(r_{t,\tau})} = \alpha_\tau + \sum_{c \in \text{categories}} \gamma^c_\tau \text{ Fed surprise}^c_t + \sum_{j=1}^{3} \xi^j_\tau \text{ Controls}^j_t + \epsilon_{t,\tau} \ ; \ t \in T$$

C Benchmarks

Consider the N-period log excess return $r_1 + r_2 + \cdots + r_N$. Assume annual returns are independently distributed and that the normalised distribution of r_i and of the sum are the same.

Consider a policy event that can have a one-period effect on the DGM or a permanent one (and anything in between, but let's focus on those two first).

Assume before the policy announcement (that is in bad Covid times), $r_t \sim \Phi(\mu, \sigma)$, and after the policy, $r_t \sim \Phi(\tilde{\mu}, \tilde{\sigma})$, with $\tilde{\mu} > \mu$ and $\tilde{\sigma} < \sigma$, where Φ is the standardised annual distribution, which for simplicity we assume to be unaffected by the policy (as our empirical work shows to be very largely the case).

Consider first the *temporary case,* where the policy bites once only for the first year, and then the DGP is back to the old $r_t \sim \Phi(\mu, \sigma)$.

$$\begin{aligned}
\mathbb{Q}\left(\sum_{i=1}^{N} r_i \leq q^*\right) &= \mathbb{Q}\left(\frac{\sum_{i=1}^{N} r_i - (\tilde{\mu} + (N-1)\mu)}{\sqrt{\tilde{\sigma}^2 + (N-1)\sigma^2}} \leq \frac{q^* - (\tilde{\mu} + (N-1)\mu)}{\sqrt{\tilde{\sigma}^2 + (N-1)\sigma^2}}\right) \\
&= \Phi\left(\frac{q^* - (\tilde{\mu} + (N-1)\mu)}{\sqrt{\tilde{\sigma}^2 + (N-1)\sigma^2}}\right)
\end{aligned}$$

and so

$$\tilde{q}^*_{\text{temp}}(N) = (\tilde{\mu} + (N-1)\mu) + \sqrt{\tilde{\sigma}^2 + (N-1)\sigma^2}\,\Phi^{-1}(\epsilon)$$

which implies

$$\gamma_{\text{temp}}(N) = \tilde{q}^*_{\text{temp}}(N) - q^*_{\text{temp}}(N) = (\tilde{\mu} - \mu) + \left[\sqrt{\tilde{\sigma}^2 + (N-1)\sigma^2} - \sqrt{N\sigma^2}\right] \Phi^{-1}(\epsilon)$$

We use the crisis period to estimate an average σ and σ^2, the $\mathbb{Q}$ standard deviation of annual log returns, which we can read off options prices. One can show that the Jensen effect is small so that the choice of σ is immaterial and will lead to no discernable changes. Last thing we need is $\tilde{\sigma}^2$, which the regression coefficients capture, $\Delta\tilde{\sigma} = \frac{\gamma_{\text{temp}}(1)-(\tilde{\mu}-\mu)}{\Phi^{-1}(\epsilon)}$, where $\gamma_{\text{temp}}(1) = \gamma(1)$ from the fear regression and $(\tilde{\mu}-\mu) = \frac{1}{2}\Delta\text{VIX}^2(1)$ is estimated by the regression coefficient $\gamma^{\text{VIX}}(1)$ from the VIX^2 regression. Hence, we have an estimate for $\Delta\tilde{\sigma}$ and we can deduce $\Delta\tilde{\sigma}^2$:

$$\Delta\tilde{\sigma}^2 = \tilde{\sigma}^2 - \sigma^2 = (\tilde{\sigma}-\sigma)(\tilde{\sigma}+\sigma) = \Delta\tilde{\sigma}(\Delta\tilde{\sigma}+2\sigma)$$

We know $\Delta\tilde{\sigma}^2$ and we know σ^2, so we know $\tilde{\sigma}^2 = \sigma^2 + \Delta\tilde{\sigma}^2$. We can use this to construct the schedule

$$N \mapsto \gamma_{\text{temp}}(N)$$

It will look as one would intuitively expect it to, starting negative and converging to 0 with larger N.

Consider now the *permanent case:* we get

$$\begin{aligned}\Delta\tilde{q}^*_{\text{perm}}(N) &= N(\tilde{\mu}-\mu) + \left[\sqrt{N\tilde{\sigma}^2} - \sqrt{N\sigma^2}\right]\Phi^{-1}(\epsilon) \\ &= N(\tilde{\mu}-\mu) + \sqrt{N}\Delta\tilde{\sigma}\cdot\Phi^{-1}(\epsilon)\end{aligned}$$

so that

$$\gamma_{\text{perm}}(N) = \Delta\tilde{q}^*_{\text{perm}}(N) = N(\tilde{\mu}-\mu) + \sqrt{N}\Delta\tilde{\sigma}\cdot\Phi^{-1}(\epsilon)$$

D Decomposition

Panels (a) and (b) of figures 8 show the regressions result when the change in fear is replaced by $\Delta E_t^{\mathbb{Q}}[r_{t,\tau}]$ and $\Delta\text{std}_t^{\mathbb{Q}}(r_{t,\tau})$. Both panels show a similar pattern for the different shock types. The shift upwards in the quantile is due to the combined effects of the policies shifting the mean of the distribution of log returns upwards and reducing the dispersion of the log-returns. The remaining announcement effect on the RND is due to the shape of the distribution, captured by the standardized quantile.

An alternative approach to isolate the effect on the tail, is to analyze the change in the interquantile ranges, $\Delta q^*_{t,\tau}(0.1) - q^*_{t,\tau}(0.2)$. The interquantile range corrects a possible location shift (adding a constant) in the RN distribution. This comes close to removing the effect of a change in the mean but keeping in the change due to the variance and shape of the risk neutral distribution. The results in Figure 9 are consistent with the quantile decomposition presented above. These results imply that the Fed actions not just simply shift the centre of the distribution, but that higher moments are responsible for changes in long-term fear.

E Additional tables and figures

Figure 7: Impact term structure of the SP-500

Impact of different policy categories on fear for different terms τ (x-axis). The effect of a policy on the change in the excess log return for the tail probability 10%. In red are the empirical effects of the policies, in green the permanent effect and in blue the one-period effect, respectively. The sizes of the dots give the different levels of significance, $\cdot$ p$\geq$0.05; $\bullet$ p<0.05; $\bullet$ p<0.01, calculated using robust standard errors based on Newey and West (1987).

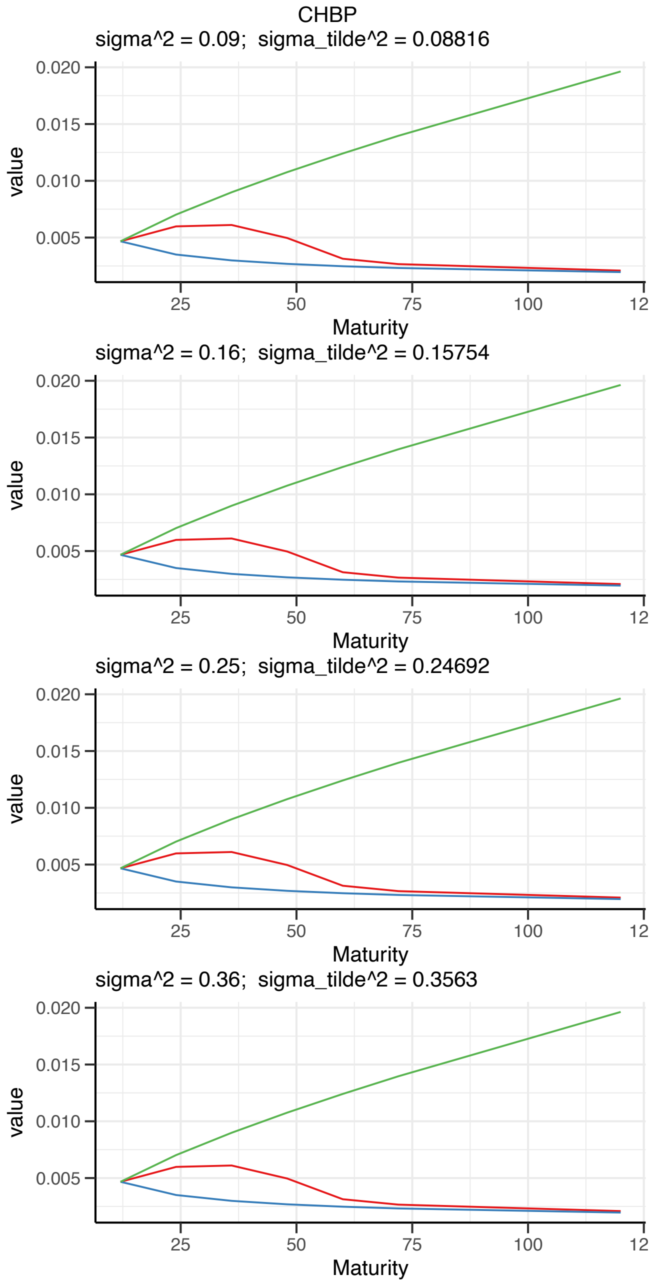
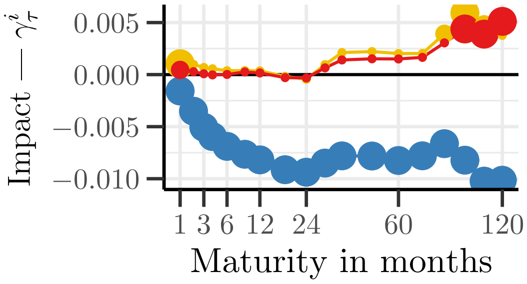
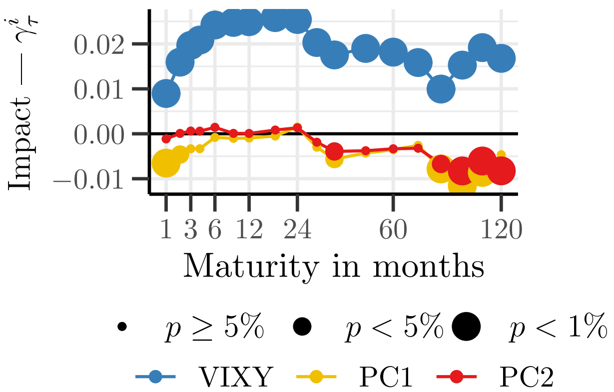


Figure 8: Quantile decomposition

The impact of annoucements on $\Delta\mu_{t,\tau}$ are in panel (a) and $\Delta\sigma_{t,\tau}$ in panel (b) for different terms τ (x-axis). The black bullets and lines are the estimates extracted from the VIXY ETF data. The dark red bullets and lines display the coefficient estimates for PC_1 shocks and the orange bullets and lines for the PC_2 shocks.The bullet size •, ●, ⬤ indicate the significance level at 10%, 5% and 1% of the coefficients, respectively. The standard errors are calculated using robust standard errors based on Newey and West (1987).



(a) $\Delta\mu_{t,\tau}$



(b) $\Delta\sigma_{t,\tau}$

Figure 9: Impact term structure interquantile ranges

This figure contrasts the coefficient estimates for the three types of announcement shocks on the interquantile range during crisis times. The interquantile range is constructed by subtracting the 20% RN quantile from the 10% RN quantile. The y-axis provides the value of point estimates of the coefficients and the x-axis gives the horizon over which interquantile range is measured. It is displayed on a square root scale. The black bullets and lines are the estimates extracted from the VIXY ETF data. The dark red bullets and lines display the coefficient estimates for PC_1 shocks and the orange bullets and lines for the PC_2 shocks. The bullet size •, ●, ⬤ indicate the significance level at 10%, 5% and 1% of the coefficients, respectively. The standard errors are calculated using robust standard errors based on Newey and West (1987).

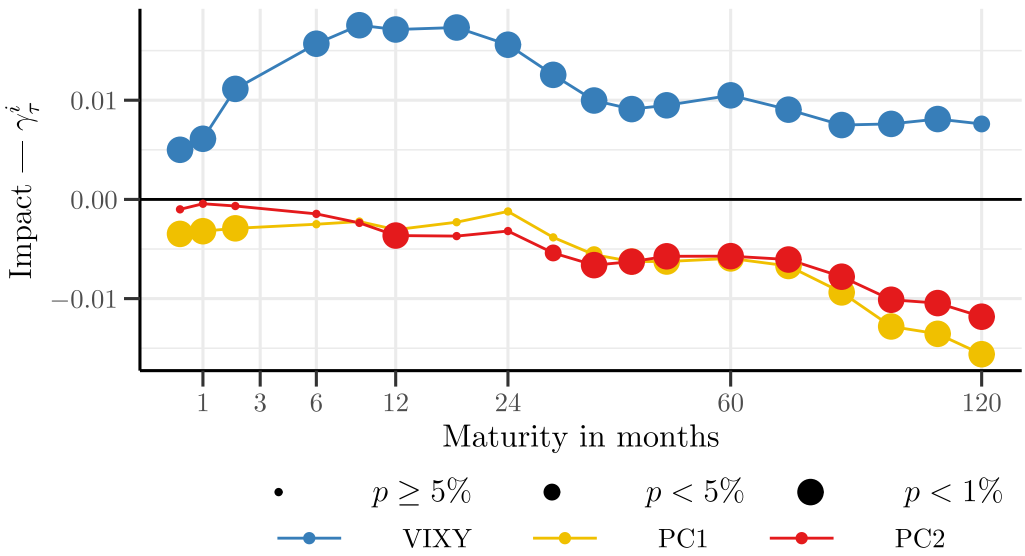


Table 10: Federal Reserve announcements March-July 2020

Date and Time Stamp	Category	Policy Description	VIXY	PC1	PC2
03/03/2020 10:00	IR	FOMC lowered the target range for the federal funds rate by 1/2 percentage point, to 1 to 1-1/4 percent.	-0.25	-9.86	3.51
15/03/2020 17:00	IR	FOMC lowered the target range for the federal funds rate by 1 percentage point, to 0 to 1/4 percent.	1.93	-3.56	-0.82
15/03/2020 17:00	LFI	FOMC will increase its holdings of Treasury securities by at least $500 billion and its holdings of agency mortgage-backed securities by at least $200 billion. The Fed announced measures related to the U.S. dollar liquidity swap line arrangements.	1.93	-3.56	-0.82
15/03/2020 17:00	MPR	The Fed is encouraging banks to use their capital and liquidity buffers as they lend to households and businesses.	1.93	-3.56	-0.82
17/03/2020 09:15	MPR	Banks allowed to continue lending to households and businesses easing the use of firms' capital buffers.	0.99	-0.30	0.05
17/03/2020 10:45	CHBP	The Fed announced that it will establish a Commercial Paper Funding Facility (CPFF) to support the flow of credit to households and businesses.	-1.32	0.75	0.02
17/03/2020 18:00	LFI	The Fed announced that it will establish a Primary Dealer Credit Facility (PDCF) to support the credit of households and businesses. The Boston Fed will make loans available to eligible financial institutions.	0.35	-0.71	-0.11
18/03/2020 23:30	CHBP	The Fed established a Money Market Mutual Fund Liquidity Facility (MMLF) to support the flow of credit to households and businesses by taking steps to enhance the liquidity and functioning of crucial money markets.	0.49	0.12	0.50
18/03/2020 23:30	LFI	The Fed established a Money Market Mutual Fund Liquidity Facility (MMLF) to support the flow of credit to households and businesses by taking steps to enhance the liquidity and functioning of crucial money markets.	0.49	0.12	0.50
19/03/2020 08:30	LFI	Interim final rule to ensure that financial institutions will be able to effectively use a liquidity facility, the MMLF.	-1.20	-0.61	-0.14
19/03/2020 09:00	LFI	The Fed announced temporary U.S. dollar liquidity arrangements (swap lines) with several international central banks.	-0.26	-2.33	-1.75
20/03/2020 10:00	LFI	The BoC, the BoE, the BoJ, the ECB, the Fed, and the SNB announced a coordinated action to enhance the provision of liquidity via the standing U.S. dollar liquidity swap line arrangements.	-3.70	-0.87	-0.19
20/03/2020 11:00	CHBP	The Fed expanded its program of support for the flow of credit to the economy by enhancing the liquidity and functioning of money markets. The Boston Fed will make loans available to eligible financial institutions.	0.69	0.14	0.07
20/03/2020 11:00	LFI	The Fed expanded its program of support for the flow of credit to the economy by enhancing the liquidity and functioning of money markets. The Boston Fed will make loans available to eligible financial institutions.	0.69	0.14	0.07
23/03/2020 08:00	LFI	The Fed will continue to purchase Treasury securities and agency mortgage-backed securities in the amounts needed to support smooth market functioning and effective transmission of monetary policy.	-3.23	-0.76	-0.59
23/03/2020 08:00	CHBP	The FOMC is taking further actions to support the flow of credit to households and businesses by addressing strains in the markets for Treasury securities and agency mortgage-backed securities. The Fed announces the Primary Market Corporate Credit Facility (PMCCF) and Secondary Market Corporate Credit Facility (SMCCF).	-3.23	-0.76	-0.59

Date and Time Stamp	Category	Policy Description	VIXY	PC1	PC2
23/03/2020 09:15	MPR	The Fed announced a change to automatic restrictions associated with a firm's "total loss-absorbing capacity", or TLAC, buffer requirements, to support the U.S. economy and allow banks to continue lending to households and businesses.	2.19	-0.15	-0.04
27/03/2020 12:00	MPR	Announced actions to support the U.S. economy and allow banks to continue lending to households and businesses.	0.21	-0.01	-0.02
31/03/2020 08:30	LFI	The Fed announced a temporary repurchase agreement facility for foreign and international monetary authorities (FIMA Repo Facility) to help support the smooth functioning of financial markets, including the U.S. Treasury market.	-0.23	-0.27	0.07
01/04/2020 16:45	MPR	The Fed announced a temporary change to its supplementary leverage ratio rule to ease strains in the Treasury market and increase banking organizations' ability to provide credit to households and businesses.	-0.31	-0.90	-0.53
03/04/2020 18:30	MPR	Issued a policy statement providing regulatory flexibility to enable mortgage servicers to work with struggling consumers.	0.54	0.55	0.85
06/04/2020 09:00	MPR	Issued two interim final rules to provide temporary relief to community banking organizations which require the agencies to temporarily lower the community bank leverage ratio to 8 percent.	-0.04	0.19	-0.08
06/04/2020 14:00	CHBP	The Fed will ease lending to small businesses via the Small Business Administration's Paycheck Protection Program (PPP).	0.00	0.00	-0.02
07/04/2020 15:00	MPR	Issued a revised interagency statement encouraging financial institutions to work constructively with borrowers affected by COVID-19.	-0.02	0.54	0.70
09/04/2020 08:30	CHBP	The Fed took additional actions to provide up to $2.3 trillion in loans to support the economy.	-1.08	-0.10	0.03
09/04/2020 09:30	MPR	Announced an interim final rule to encourage lending to small businesses through the Small Business Administration's Paycheck Protection Program, or PPP.	-0.11	0.08	0.02
14/04/2020 18:00	MPR	Issued an interim final rule to temporarily defer real estate-related appraisals and evaluations to allow regulated institutions to extend financing to creditworthy households and businesses quickly.	0.27	-0.06	-0.08
23/04/2020 17:30	LFI	The Fed outlined the extensive public information regarding its programs to support the flow of credit to households and businesses.	-0.32	0.29	-0.40
24/04/2020 10:00	MPR	The Fed announced an interim final rule to amend Regulation D (Reserve Requirements of Depository Institutions) to delete the six-per-month limit on convenient transfers from the "savings deposit" definition.	-0.40	-0.57	-0.84
27/04/2020 16:30	CHBP	The Fed announced an expansion offering up to $500 billion in lending to states and municipalities.	0.05	-0.08	0.13
29/04/2020 14:00	IR	The Fed decided to maintain the target range for the federal funds rate at 0 to 1/4 percent.	0.06	-0.05	0.82
29/04/2020 14:00	LFI	To support the flow of credit to households and businesses, and market functioning, the Fed will continue to purchase Treasury securities and agency residential and commercial mortgage-backed securities.	0.06	-0.05	0.82
30/04/2020 10:00	CHBP	The Fed announced an expansion with respect to loan options available to businesses.	-0.28	-0.05	0.12
30/04/2020 17:15	CHBP	The Fed expanded access to its Paycheck Protection Program Liquidity Facility (PPPLF) to additional lenders.	0.24	-0.50	-0.40
05/05/2020 15:30	MPR	The Fed announced an interim final rule that modifies the agencies' Liquidity Coverage Ratio (LCR) rule to support banking organizations' participation in the Fed's Money Market Mutual Fund Liquidity Facility.	0.52	-0.15	-0.05

Date and Time Stamp	Category	Policy Description	VIXY	PC1	PC2
15/05/2020 17:45	MPR	The federal bank regulatory agencies announced temporary changes to their supplementary leverage ratio rule to provide flexibility to depository institutions to expand their balance sheets to provide credit to households and businesses.	-0.25	-0.07	-0.13
03/06/2020 13:00	CHBP	The Fed announced an expansion in the number and type of entities eligible to use its Municipal Liquidity Facility (MLF) directly.	-0.01	0.02	0.02
08/06/2020 15:30	CHBP	The Fed expanded its Main Street Lending Program to allow more small and medium-sized businesses to receive support.	0.21	-0.02	0.00
10/06/2020 14:00	IR	The Fed decided to maintain the target range for the federal funds rate at 0 to 1/4 percent.	-0.38	-0.10	-0.04
10/06/2020 14:00	LFI	The Fed will increase its holdings of Treasury securities and agency residential and commercial mortgage-backed securities to sustain smooth market functioning, thereby fostering effective transmission of monetary policy to broader financial conditions.	-0.38	-0.10	-0.04
15/06/2020 14:00	CHBP	The Fed announced updates to the Secondary Market Corporate Credit Facility (SMCCF), which will begin buying a broad and diversified portfolio of corporate bonds to support market liquidity and the availability of credit for large employers.	-1.48	0.06	0.06
15/07/2020 16:30	CHBP	The Fed announced an extension to bolster the Small Business Administration's (SBA) Paycheck Protection Program (PPP).	-0.07	0.37	0.35
17/07/2020 10:00	CHBP	The Fed modified the Main Street Lending Program to provide greater access to credit.	0.08	0.10	0.04
23/07/2020 14:30	CHBP	The Fed broadened the set of firms eligible to transact with and provide services in three emergency lending facilities.	-0.23	0.06	-0.13
28/07/2020 09:30	LFI	The Fed announced a three-month extension of its lending facilities that will ease planning by potential facility participants and provide certainty that the facilities will continue to be available.	-0.01	-0.03	0.04
28/07/2020 09:30	CHBP	The Fed announced a three-month extension of its lending facilities that will ease planning by potential facility participants and provide certainty that the facilities will continue to be available.	-0.01	-0.03	0.04
29/07/2020 14:00	IR	The Fed decided to maintain the target range for the federal funds rate at 0 to 1/4 percent.	-0.09	-0.05	-0.06
29/07/2020 14:00	LFI	The Fed will increase its holdings of Treasury securities and agency residential and commercial mortgage-backed securities to sustain smooth market functioning, fostering effective transmission of monetary policy to broader financial conditions. The Open Market Desk will continue to offer large-scale overnight and term repurchase agreement operations.	-0.09	-0.05	-0.06

Notes: In this table, the Federal Reserve (Fed) announcements that we collected between March and July 2020 are reported. The announcement dates and time stamps are collected from the press release section of the Federal Reserve website at https://www.federalreserve.gov/newsevents/pressreleases.htm. In the second column, the category of the policy, namely "Credit to households, businesses, and public sector" (CHBP), "Foreign Exchange" (FX), "Interest rate" (IR), "Liquidity for financial intermediation" (LFI), and "Macroprudential regulations" (MPR) is reported. In the third column, we briefly describe the policy. See the Federal Reserve website above for a more extensive description of the policy and more details. The intraday SP-500 changes around the 30-minute policy announcement window are reported in the last column.

F Additional results and robustness checks

We check the robustness of our results by controlling for other variables in addition to the set of controls, $C_{t,o}$, which includes the 7-day rolling mean of new Covid-19 cases and the Bloomberg Economic Surprise Index. We repeated the same robustness checks for the US individual stocks and sector indices. The results still hold robust after the inclusion of other controls and are available upon request from the authors. First, we control for days with scheduled FOMC meetings by including a dummy which takes a value of 1 on days with scheduled FOMC meetings and 0 otherwise. The scheduled meetings during our sample period (from 3 February to 31 July) took place on 29 April, 10 June, and 29 July. and these appear to be robust. Lucca and Moench (2015) document how US equities might anticipate monetary policy decisions at scheduled FOMC meetings, what they call the pre-FOMC announcement drift. We show that high-frequency identification is robust by controlling for the scheduled FOMC announcements. The possible reactions in the risk-neutral distribution are not due to the effect of the pre-announcement drift risk premia being monetized. We instead capture in our results the effect of the set of unprecedented Fed policies that the market, so the fear measures we construct, may not have anticipated yet.

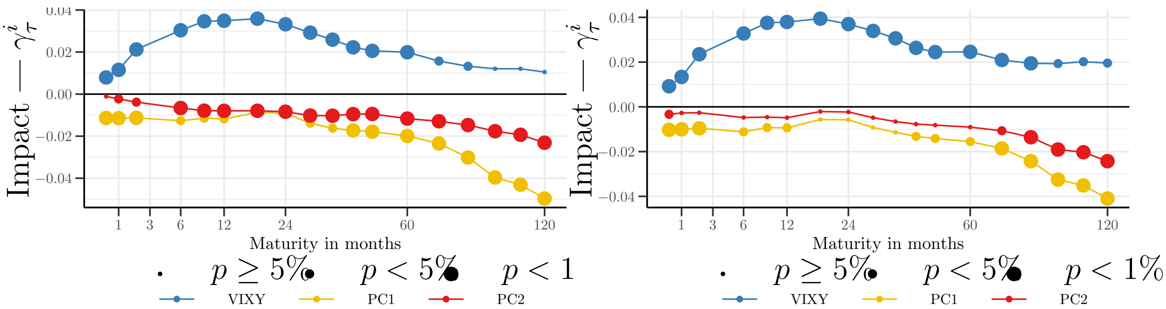
Next, the distribution of market outcomes, especially second moments and quantiles, have strong mean-reverting properties, potentially driving the results. When financial markets' fear is high, the Fed might react by introducing policies to calm the market, which would have reverted to normal levels anyway. To address this, we control for the last changes in fears in our regressions. We include the lagged dependent variables, namely $\Delta F^{a\leftarrow}_{t-1,\tau}(x)$ and $\Delta \text{VIX}^{a}_{t-1,\tau}$. We find that our results are robust to including the dependent variables' lags. This corroborates the main message of this section that policies in categories such as LFI, and MPR effectively reduce fears, even when controlling for mean reversion.

At the onset of the crisis, options trading volume in tech companies has seen a significant increase. The trading volume could be correlated with days of Fed announcements and subsequently bias our results. To control for changes in trading volume, the total option volume on the shares of the big technological companies, Alphabet (GOOGL), Amazon (AMZN), Facebook (FB), Apple (AAPL), and Microsoft (MSFT), which we collected from Bloomberg, is included as a control. The corresponding results are shown in the Web appendix and again are robust.

Besides that, we also repeat the analysis by looking at the effect on excess log returns for different tail probabilities and VIXs of the Russell 2000 Index and SP-500 sectoral indices, namely the energy and financial sectors. Due to data availability, the impact on sectoral indices is only reported up to the one-year maturity. This shows whether the impact on fear is different for small- and mid-cap companies than large ones represented in the SP-500 and gives further insights into potential heterogeneities across industries. We find that this analysis confirms the somewhat larger magnitudes for the financial sector as a whole and that and that again FX, LFI, and MPR have the strongest effects.

Finally, we control for the effect of announcements of five important fiscal policy responses (see also Alfaro et al., 2020). In particular, we add a dummy to $C_{t,o}$ which takes a value of 1 on days when one of the five acts we include either passed the House of Representatives or the Senate or became law. The five acts with the corresponding dates of the stages in the legislative process are listed in Table 11, and the results are reported in the Web Appendix. Once again, our results are robust.

Figure 10: Impact term structure different event window length



(a) 5 min - 10 min

(b) 15 min - 60 min

Table 11: Fiscal policy responses to Covid-19

The policy dates are collected from the online database of US Congress legislative information at https://www.congress.gov/. The dates correspond to the days on which the dummy for important fiscal policy responses takes value 1. Exceptions are that the dummy takes value 1 on 15 instead of 14 March because this is a Sunday. Moreover, the dummy also takes value 1 on the 18 and 27 March on which multiple stages of the legislative process were passed.

Date	Act	Stage in legislative process
04 March	Coronavirus Preparedness and Response Supplemental Appropriations Act	Passed House of Representatives
05 March	Coronavirus Preparedness and Response Supplemental Appropriations Act	Passed Senate
06 March	Coronavirus Preparedness and Response Supplemental Appropriations Act	Became Law
14 March	Families First Coronavirus Response Act	Passed House of Representatives
18 March	Families First Coronavirus Response Act	Passed Senate
18 March	Families First Coronavirus Response Act	Became Law
25 March	Coronavirus Aid, Relief, and Economic Security Act	Passed Senate
27 March	Coronavirus Aid, Relief, and Economic Security Act	Passed House of Representatives
27 March	Coronavirus Aid, Relief, and Economic Security Act	Became Law
21 April	Paycheck Protection Program and Health Care Enhancement Act	Passed Senate
23 April	Paycheck Protection Program and Health Care Enhancement Act	Passed House of Representatives
24 April	Paycheck Protection Program and Health Care Enhancement Act	Became Law
28 May	Paycheck Protection Program Flexibility Act	Passed House of Representatives
03 June	Paycheck Protection Program Flexibility Act	Passed Senate
05 June	Paycheck Protection Program Flexibility Act	Became Law