Monetary Policy and the Stock Market in the COVID Era

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Abstract

This article examines the period following the onset of the COVID-19 pandemic as a case study of how monetary policy affects the stock market. I decompose equity price movements between early 2020 and early 2022 into changes in risk-free rates, expected cash flows, and a residual component containing risk premia. Identifying the effects of monetary policy through sign restrictions on these three components of stock returns, I find that the FOMC's policy actions had significant effects through all three channels throughout the first two years of the pandemic. These effects dissipated and then reversed as the policy tightening of March 2022 approached.

1 Introduction

In the first quarter of 2020, as the scale of the COVID-19 crisis became apparent, equity indices in the United States endured one of their most dramatic deteriorations in history. By August, however, the stock market had bounced back, and the rally continued apace all the way into late 2021. While a number of developments likely contributed to the rebound—including Federal Reserve liquidity support, fiscal stimulus, and the development of vaccines—one factor that has received particular attention is the extraordinarily accommodative monetary policy that the Fed adopted during this period. At the onset of the crisis, the FOMC slashed the federal

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funds target range to near zero, and it subsequently purchased over $4 trillion of Treasury and mortgage-backed securities. These actions lowered interest rates and supported the economic recovery, while also likely having an outsized effect on asset prices, including the prices of equities. Similarly, when policymakers began to signal the removal of accommodation around the end of 2021, equity prices sputtered.

This article provides a case study of the relationship between monetary policy, long-term interest rates, and the stock market by unpacking these developments. In general, monetary policy has three distinct effects on stock prices. First, by stimulating the macroeconomy, accommodative policy raises corporate profits, increasing the expected cash flows of equity claims. Second, by lowering the term structure of interest rates, accommodation reduces the risk-free rate at which dividends are discounted, boosting their present value. Finally, easier monetary policy may lower risk premia by helping to remove tail risk and relieving financial institutions' balance-sheet constraints, through the "risk-taking channel" (e.g., Borio and Zhu, 2012; Morris and Shin, 2016; Bauer et al., 2023). I explore how important each of these mechanisms was in supporting the growth of equities during the period of policy easing following the onset of the pandemic.

The analysis proceeds in two steps. First, using an extension of the Campbell-Shiller (1988) dividend-discount model, where expected profits are estimated by a vector autoregression (VAR), I decompose total stock market changes in each quarter after the peak of the market in early 2020 into changes resulting from expected earnings and discount rates. Consistent with evidence from this type of model from before the COVID period, I find that most stock-market fluctuations were not primarily driven by profit expectations but rather by discounting. My model allows me to go beyond Campbell-Shiller by further separating discount factors into a risk-free component and a residual component that embeds the equity risk premium. I find that, while shifts in risk-free discount rates and expected profits had large effects on the stock market at times, most of the early drop in stock prices and a significant fraction of the subsequent recovery were due to fluctuations in the component containing risk premia.

This decomposition does not tell us how much of the stock-market dynamics over this period resulted from monetary policy, since monetary policy can affect all the components of stock prices. To answer that question, the second-stage of the analysis identifies monetary-policy shocks within the VAR. The identification uses sign restrictions on the three components of stock prices to sweep out potential "information effects,"—that is, changes in the economy or financial markets that might result from the Fed conveying its private information about underlying fundamentals, rather than from changes in policy. I use the results to construct a counterfactual scenario in which the Fed maintained medium-term yields at their pre-COVID level throughout the COVID period. I focus on medium-term yields because short-term rates were constrained by the effective lower bound throughout this period and the Fed operated further out the yield curve using forward guidance and large-scale asset purchases. The exercise shows that, if policy had maintained five-year yields at their pre-COVID level, stock prices would have been 37% lower than observed nine months after the onset of the pandemic, with the effect operating through all three components. These effects gradually reversed as markets priced in the anticipation of policy tightening. By the time policy liftoff occurred in March 2022, longer-term yields exceeded their pre-COVID levels, and the model implies that monetary policy had become a net drag on the stock market, again operating roughly equally through all three components.

These results are of interest for several reasons. First, they show that monetary policy can be an effective tool in stabilizing markets during crises. Although I do not directly examine the macroeconomic effects of COVID-era monetary policy, the stock market is an important channel through which households accumulate purchasing power and businesses finance themselves, and I show that monetary policy supported it significantly. Second, the results highlight that monetary policy does not necessarily exert all of its effects through profits or risk-free rates as one might expect. Policy shocks do not have large effects on expected real profits many years in the future or on long-term yields, but these distant-horizon objects loom large in equity valuations. Rather, the results are qualitatively consistent with previous studies, like Bernanke and Kuttner (2005), Bekaert et al. (2013), Cieslak and Pang (2021), and Bauer et al. (2023), that suggest significant changes in the equity premium in response to FOMC actions and are consistent with an important role for the risk-taking channel.

Several other papers have presented decompositions of the stock-market movements during the COVID crisis using various methodologies, with particular focus on the large gyration in the first half of 2020. Gormsen and Koijen (2020) and Knox and Vissing-Jorgensen (2022) use information from dividend strips, while Landier and Thesmar (2020) rely on analysts' earnings forecasts. Cox et al. (2020) use a method similar to that adopted below but with more structure on the discount rate. Broadly consistent with my findings, all of these papers conclude that the large movements in early 2020 were primarily due to discount rates. However, none of them explicitly examines the role of monetary policy in driving these changes. All of them also stop short of analyzing the significant further developments in the stock market and monetary policy through early 2022. Separately, there is a long tradition examining the extent to which monetary policy effects the stock market, dating at least to Gurkaynak et al. (2005) and

Rigobon and Sack (2005). This paper is in that tradition, but it extends the methodology by examining the effects on the three components of stock prices noted above. It also incorporates recent insights into the potential for Fed information effects (Nakamura and Steinson, 2018; D'Amico and King, 2023) that may bias other estimates.

2 Unconditional Decomposition of Equity Prices

2.1 Conceptual framework

I begin by decomposing changes in equity prices into changes due to three components: (1) risk-free discount rates, (2) expected future earnings, and (3) a residual term reflecting risk premia and other factors. By definition, the risk-free discount factor for a cash flow n periods ahead is given by $\delta_t^{(n)} = \exp\left[-ny_t^{(n)}\right]$, where $y_t^{(n)}$ is the zero-coupon riskless bond yield. Thus, for an equity contract with a claim to an infinite future stream of profits $\{\Pi_t\}$, we can define the risk-free present value of the expected cash flow stream as

$$V_t = \sum_{n=0}^{\infty} \delta_t^{(n)} \mathrm{E}_t[\Pi_{t+n}] \tag{1}$$

Letting s_t denote the log of the market price of the equity claim, we can write

$$s_t = \log V_t - ERP_t \tag{2}$$

where ERP_t is the equity risk premium. This equation *defines* the equity risk premium for the purposes of this paper. It is the difference between the riskless discounted value of future cash flows and their current price.[1]

Substituting (1) into (2) and taking a first-order Taylor series expansion gives the approxi-

[1] If $M_t^{(n)}$ is the stochastic discount factor for cash flows n periods hence, then under no-arbitrage stock prices are given by

$$\begin{aligned} \exp[s_t] = \sum_n \mathrm{E}_t[M_t^{(n)}\Pi_{t+n}] &= \sum_n \mathrm{E}_t[M_t^{(n)}]\mathrm{E}_t[\Pi_{t+n}] + \sum_n \mathrm{cov}_t[M_t^{(n)}, \Pi_{t+n}] \\ &= V_t + \sum_n \mathrm{cov}_t[M_t^{(n)}, \Pi_{t+n}] \end{aligned}$$

since $\mathrm{E}_t[M_t^{(n)}] = \delta_t^{(n)}$. Consequently, we can write $ERP_t = \log\left(1 + \sum_n \mathrm{cov}_t[M_t^{(n)}, \Pi_{t+n}]/V_t\right)$, consistent with the intuition that greater comovement between cash flows and discount factors should require higher expected returns and thus lower asset prices.

mate log change in the stock price over a period:

$$\Delta s_t \approx \frac{1}{V_{t-1}} \sum_{n=0}^{\infty} \Delta\delta_t^{(n)} \mathrm{E}_{t-1}[\Pi_{t+n}] + \frac{1}{V_{t-1}} \sum_{n=0}^{\infty} \delta_{t-1}^{(n)} (\mathrm{E}_t[\Pi_{t+n}] - \mathrm{E}_{t-1}[\Pi_{t+n-1}]) - \Delta ERP_t \quad (3)$$

This shows that stock returns can in principle be decomposed into three parts. The first term is a change in risk-free discounting of a given expected profit stream; the second term is a change in expectations of the profit stream itself, holding the discount rate constant; and the third term is a change in the risk premium. To understand a change in stock prices over a given period, we can try to measure each of these components. The approach is reminiscent of Campbell and Shiller (1988a, 1988b), although in those papers the authors do not separate risk-free rates from risk premia. This is a key distinction for the present paper, because the effects of monetary policy on Treasury yields may be quite different from its effects on the compensation investors demand for risk.

Note that, if investors expected the economy to grow faster than their risk-free discount rate in the long run, they would bid up V_t to an infinite value. For the calculation of the level of V_t to make sense, it must therefore be the case that, in at a long enough horizon, discount rates are always higher than expected profit growth, a restriction I impose in the estimation. The result that far-forward bond yields are greater than long-run rates of economic growth holds in a fairly broad set of asset-pricing models under standard parameterizations, as discussed in the accompanying box. However, even if the condition does not hold in reality, the decomposition in (3) can still be viewed as an approximation that holds when calculated over finite horizons.

[BOX ABOUT HERE]

2.2 Estimation

Because equity prices are claims to nominal cash flows, all variables in the model are in nominal terms and discounted at nominal rates.[2] Risk-free discount factors $\delta_t^{(n)}$ can be computed directly from the nominal Treasury curve. To measure expected nominal profits, I use forecasts from a VAR model. The same VAR will be used to identify and trace out the dynamic effects of monetary policy shocks, discussed in the next section. The "risk premium" ERP_t is treated

[2] Adding inflation to the model could provide some interesting further insights into the sources of cash-flow and discount-rate variation, but it is not necessary for the decomposition presented here.

as a residual—it is the movement in stock prices that cannot be accounted for by changes in risk-free rates or expected profits. The method of using a VAR to estimate expected cash flows follows Campbell and Shiller and other subsequent work. One caveat to such an approach is that, if market participants have in mind a different model for forecasting profits than the VAR, changes in ERP_t may reflect this misspecification in addition to embedding the true equity risk premium.[3]

The VAR contains the 1-, 5-, and 30-year zero-coupon Treasury yields from the Gurkayak-Sack-Wright (2007) dataset, the log first difference of after-tax corporate profits from the NIPA data, and the log first difference of the Wilshire 5000 total-return equity index. To reduce short-term noise in the asset-price series, I measure stock and bond prices using the averages of the daily values over the last month of each quarter. The model is estimated on data from 1990:1 through 2022:2.

In order to discipline the model, I impose two restrictions on the reduced-form specification. First, I assume that stock prices and corporate profits are cointegrated, a standard assumption in the asset-pricing literature. Operationally, this involves including the difference between the log levels of the two series as a variable in the VAR (making it a vector error-correction model). Second, I impose that the long-run growth of profits cannot be greater than the steady-state value of the long-term interest rate. As noted, this condition is necessary for the risk-free discounted component of stock prices to exist. In order to operationalize it, I estimate the VAR by Bayesian methods, sample repeatedly from the posterior distribution of parameters, and use rejection sampling to exclude parameter draws that violate the inequality. Details about how the VAR is estimated are contained in the appendix.

Using the observed yield curve and VAR-based profits forecasts at each point in time, I compute the first two sums in equation (3) through 800 quarters in the future.[4] Based on these calculations, Table 1 shows the decomposition of log changes in the stock market since December 2019, just before the pandemic began to weigh on U.S. markets. I focus on four subsequent points in time: (a) March 2020, in the immediate aftermath of the shock; (b) September 2020, at which point I estimate monetary policy to have had its largest effect on stock prices; (c) December 2021, by which point the economy had largely recovered to pre-pandemic levels but

[3]Another caveat is that, as will all time-series modeling with fixed parameters, changes in the structural environment could shift the reduced form parameters. This could be a particular concern during the period in question, which saw many unprecedented economic developments.

[4]Beyond the 30-year maturity, where data are not available, I assume that yields converge at a constant rate across maturities from 30-year spot rates to their infinite-horizon level, which is taken to be the steady-state value of $y^{(30)}$.

policymakers had not yet begun to actively tighten policy; and (d) March 2022, after the FOMC had stopped expanding its balance sheet and begun to raise short-term rates. For reference, the blue lines in Figures 1 and 2 show the observed paths of Treasury yields and stock prices.

[TABLE 1 ABOUT HERE]

[FIGURE 1 ABOUT HERE]

[FIGURE 2 ABOUT HERE]

Over the first quarter of 2020, the Wilshire Index declined 17% on net, corresponding to a change in log prices of -0.19. (This net decline is somewhat less dramatic than the 30% drop that occurred between mid-February and late March, which the model does not see, given the frequency of the data.) Meanwhile, as can be seen in the top panels of Figure 1, the yield curve fell significantly in response to accommodative monetary policy and expectations for lower nominal growth, with the 5-year yield, for example, dropping by 101 basis points. The effect of the decline in the yield curve, all else equal, was to boost stock prices; the calculation shows that lower yields raised log stock prices by 0.18 log points. However, this improvement was more than offset by an increase in the ERP that dragged log stock prices down by 0.30. Thus, on balance, discount factors had a negative impact on the stock market during this three-month period. Negative expected profit growth also contributed to downward pressure on stock prices in this quarter, though less so.

Between March and September 2020, risk-free yields and risk premia stayed nearly constant, contributing only modestly to the recovery in stock prices. However, expected profits increased 0.19 log points relative from their early-pandemic lows, driving a recovery in the equity market. Over the next 15 months, as the economy continued to recover from the brief but severe recession, the stock market rose an additional 41% (0.34 log points). The model shows that this growth can be attributed to roughly equal improvements in expected profits and risk premia, with the concomitant rise in Treasury yields offsetting some of this effect through discounting. By this point, inflation had accelerated notably, so much of the growth in expected profits likely reflected higher consumer prices, rather than higher real earnings.

Finally, the last row of the table shows where the stock market ended in March 2022. Between December and March, yields continued rising in the wake of persistent inflation and the removal of policy accommodation. Indeed, except at very short maturities, the March 2022 yield curve exceeded its pre-pandemic level. Consequently, risk-free discounting subtracted a further 15% (0.16 log points) from stock prices during these six months. The expected path of nominal profits was about unchanged, with inflationary effects likely balancing a decline in expected real growth. These two factors more than accounted for the 0.07 decline in log stock prices actually observed during this quarter, so that, perhaps surprisingly, the model sees a modest decline in risk premia supporting stock prices during this time.

3 Identifying the Effects of Monetary Policy

I next ask how much of the changes in equity prices documented above can be explained by monetary policy during the COVID period and through which channels. As noted earlier, monetary policy affects all three components of equity returns: corporate profits, risk-free discount rates, and risk premia. To examine how each of these components changed, the strategy will be to consider a counterfactual world in which policy held medium-term interest rates constant throughout the COVID period.

In order to simulate the effects of a counterfactual monetary-policy path, we need to identify monetary-policy shocks in the VAR. There is, of course, a large literature on this topic. One important issue that has gained attention recently is that there may be different *types* of monetary-policy shocks with different effects. For example, Nakamura and Steinsson (2018) and others have argued that monetary policy communications convey different of signals, and, in particular, they may reveal the Fed's private information about the economic outlook to the market. To sweep out these effects, D'Amico and King (2023) impose on expected interest rates, expected GDP, and expected inflation sign restrictions that can only be consistent with exogenous policy shocks, not with information effects. I follow a similar approach. As discussed above, exogenous policy easing shocks should (1) raise expected nominal profits, (2) cause risk-free discounting to decline, and (3) not cause risk premia to increase. I impose these conditions to identify exogenous monetary-policy shocks in the VAR. In contrast, an endogenous policy easing–in response to recessionary or deflationary developments—would typically be associated with a *decrease* in nominal profits or an *increase* in risk premia or both.

A number of recent papers take a related approach by combining interest-rate movements with sign restrictions on the stock market (e.g., Matheson and Stavrev, 2014; D'Amico et al., 2016; and Jarocinksi and Karadi, 2020). Those papers impose restrictions on stock prices, but not on expected economic performance. Yet, it is not clear that that approach is sufficient to remove possible information effects. The Fed revealing its privative information (or being perceived to do so) has an ambiguous effect on stock prices because risk-free discounting and profits move in opposite directions in response to such shocks while the effects on risk premia are unclear. It is thus likely that sign restrictions on stock prices and interest rates alone are not adequate to isolate exogenous policy innovations. In contrast, my restrictions ensure that information effects are excluded because they also involve expectations of future cash flows.

Specifically, after estimating the VAR described in Section 2, I extract the vector of residuals and calculate its covariance matrix $\mathbf{S}$ over the sample. Since $\mathbf{S}$ is positive there are an infinite number of matrices $\mathbf{M}$ that satisfy $\mathbf{M}'\mathbf{M} = \mathbf{S}$. These matrices can be thought of as candidates for the contemporaneous multipliers on structural shocks that have zero mean and unit variance. Without loss of generality, I designate the first row of the $\mathbf{M}$ as corresponding to an exogenous monetary policy shock. I then repeatedly draw random candidate matrices and check whether the elements of the first row satisfy the conditions just mentioned. In particular, I keep drawing until I have 1,000 draws for which the three components of stock returns shown in equation (3) all have the same sign.[5] Finally, I follow Fry and Pagan (2005), Cieslak and Pang (2019), and others by selecting the "median target" draw (i.e, the draw closest to the vector of the medians of the multipliers) for analysis. These multipliers specify the relative effects of monetary-policy shocks on the contemporaneous values of yields, stock prices, and profits. I repeat this procedure for each of 1,000 draws of the reduced-form VAR parameters from the posterior distribution of the estimation. The details of this procedure are described more fully in the Appendix.

Figure 3 shows how the components of stock prices respond to a monetary-policy shock thus identified. The experiment is one in which, starting from the steady state of the VAR, the economy receives a shock sufficient to raise the 5-year yield by 25 basis points on impact. Such a shock causes one-year yields to rise by 31 basis points and 30-year yields to rise by 8 basis points in the period when it occurs. As shown by the blue line, it causes a contemporaneous decline in stock prices of 0.08 log points. Based on the changes in yields and stock prices, as well as on the change in the expected path of profits, I can calculate the three components of equity returns in equation (3) in each period after the shock.

[FIGURE 3 ABOUT HERE]

[5] Following D'Amico and King (2023), I also impose that the expected short-term rate moves in the opposite direction of expected economic activity (profits, in this case) for at least four quarters following a shock. This restriction is largely redundant, given the sign restriction on the risk-free discount term, and the results are robust to its removal.

The initial decline in stock prices is split roughly equally between the three components. Over time, the expected profits component stays nearly constant (since *expected* cash flows at any given horizon follow a martingale). It seems unlikely that monetary policy has sizable permanent effects on real activity, so presumably its permanent effect on nominal profits derives mostly from its disinflationary effects. Meanwhile, the risk-free discounting component and the risk-premium component of stock prices both return gradually to zero over time, as policy rates revert to the steady state. These transitory movements in discounting induce predictability in stock returns. In the long run, the expected change in stock prices is equal to the expected change in profits, a feature that is imposed by the error-correction structure of the model and is consistent with the stationarity of both yields and the ERP.

4 Counterfactual Simulation

I follow Gertler and Karadi (2015) and others by taking a medium-term bond yield—in this case, the 5-year yield—to be the indicator of the monetary-policy stance. The five-year yield has a correlation of 93% or higher with all other yields across the curve. It is affected significantly by changes in the contemporaneous target rate, expectations for the medium-term path of that rate (such as might result from forward guidance), and term premia that can be affected by QE or changes in rate volatility. Consequently, unlike very short-term or very long-term rates, it is likely to capture the effects of the full array of monetary-policy tools.[6]

Based on the results of the structural identification, I calculate the series of quarterly monetary-policy shocks that would have been sufficient to keep the five-year yield at the February 2020 level throughout the COVID period. The red lines in Figures 1 and 2 show the paths of yields and the stock market in the counterfactual scenario where these shocks are applied.[7] By assumption, the counterfactual 5-year yield is flat at a value of 1.33%. Given the multipliers on policy shocks, the counterfactual 1-year yield hovers near its February 2020 value of 1.45% for a few quarters and then declines in order to be consistent with the flat 5-year path. Thus, the scenario imagines a monetary policy that lowered short-term rates somewhat, though not as dramatically as we actually observed, while keeping the middle of the yield curve approximately stable around its initial value. In contrast, the counterfactual path for the 30-year yield is not much different from the actual path, reflecting the fact that the estimated multipliers on

[6]That said, the results below also generally hold if one-year yields are used as the measure of policy.

[7]All estimates reported for the counterfactual simulation are based on the medians of the posterior distributions. To measure statistical uncertainty, I report interquartile ranges of the posteriors (i.e., the middle 50% of the distribution.

monetary shocks are relatively small at the long end. Thus, the model attributes most of the observed movements in long-term yields to non-monetary factors, consistent with the intuition that monetary policy has only transitory effects.

The red line in Figure 2 shows the model-implied counterfactual path taken by the stock market during this period. If policy had held the five-year rate at 1.33%, rather than allowing it to fall as low as 0.30% as it did in reality, the model implies that the stock market would have fallen by 34% on net over Q1 of 2020—more than twice the decline actually observed. Moreover, under this scenario stocks would have only very gradually recovered and not exceeded their December 2019 value until 2022. In contrast, in the first quarter of 2022, the effects of monetary policy tightening, including expectations about increases in short-term rates and balance-sheet runoff that were yet to come, exerted a negative effect on the market. By the end of the sample, the observed value is about 15% *below* the counterfactual value.

Looked at another way, the red line in Figure 4 shows the proportion by which model-implied counterfactual stock prices fell short of the observed values (the percentage difference between the blue and red lines in Figure 2), a measure of the size of support that policy easing during the pandemic was providing to the stock market. The figure shows that, at the peak of this support in late 2020, this difference was about 0.37%; in other words, policy was boosting prices by about $\frac{1}{1-0.37} = 59\%$ from the level they would otherwise have had.

[FIGURE 4 ABOUT HERE]

Using the counterfactual paths of yields, stock prices, and profits, I recompute the decomposition presented earlier. I infer the entire yield curve, which is required for this decomposition, by first projecting the levels of yields, using all data from 1990 - 2022, onto the three yields that are included in the VAR. I then use the resulting factor loadings to compute complete quarter-by-quarter yield curves that are consistent with the counterfactual simulation. (As is well known, three factors are sufficient to explain nearly all of the variation in the yield curve—98% or more across all maturities, in this case—so this procedure involves very little loss of accuracy.) Table 2 presents the results, reported as the difference between the components of stock returns in reality and under the counterfactual scenario. The numbers in the table can be read as reflecting the effects of the policy actions that occurred, relative to what would have happened if medium-term interest rates had been held constant throughout the period.

According to the model, monetary policy affected stock prices roughly equally through all three channels throughout the COVID era. In the three quarters of the pandemic (summing the top two rows of the table), expected profits, risk-free discounting, and risk premia contributed 0.18, 0.13, and 0.16 log points to stock prices, respectively. Between Q3 2020 and Q4 2021, policy rates remained low, but anticipated tightening gradually led to a rise in the five-year yield, pushing stock prices 0.29 log points lower than they otherwise would have been. The largest effect was through risk premia, but profits and discounting also contributed substantially. As policy rates began rising, QE ended, and market participants priced in a faster pace of tightening, these effects continued, again spread across all three components.

While the risk-free discounting effects on stock prices are to be expected of monetary policy, and the effects on nominal profits are intuitive given monetary policy's impact on both real activity and prices, the response of the risk premium component is perhaps surprising. The black line in Figure 4 shows the amount of support that the model indicates monetary policy would have provided to the stock market if it had operated through this component alone. Looked at this way, fluctuations in risk premia accounted for more than one-third of monetary policy's overall effect on the stock market through the end of 2020. Likewise, when policy began to subtract from equity prices in 2022, the risk premium component was the primary culprit. Again, we should note that there is some reason to take this conclusion with a grain of salt, since misspecification in the VAR model as a measure of market expectations would show up in the "risk premium" component. Even so, the results are consistent with recent literature, such as Bauer et al. (2023), that ascribes a significant role to the risk-taking channel.

[TABLE 2 ABOUT HERE]

5 Conclusion

This article has analyzed the behavior of the stock market during the two years following the onset of the COVID-19 pandemic. The stock market is important as a source of wealth for consumers, a source of financing for firms, a source of information for policymakers, and a source of interest for researchers. The analysis shows that the early decline and subsequent rally of equity prices was due in some part to shifting expectations for corporate profits but resulted mainly from the "residual" component, consistent with a large swing in the equity risk premium. Meanwhile, the decline and rebound of the yield curve pushed against this tide, keeping stock prices somewhat higher that they otherwise would have been in early 2020 and somewhat lower in early 2022. Monetary policy helped prevent a much bigger catastrophe in stock prices; the model estimates that without this support equities would have been 37% lower at their trough. Policy worked through all three components of stock prices. Among other implications, the results suggest that monetary policy's effects on risk premia could be considered as a potentially key transmission channel in both empirical analyses and theoretical treatments of monetary policy.

Box: Log-term yields and growth in a simple model

The model presented in this paper assumes that long-run bond yields are always greater than long-run rates of profit growth. While there is no guarantee that this condition must hold in the economy, this box demonstrates the conditions under which it is the case in a commonly used consumption-based asset-pricing model.

Suppose consumers have preferences over real consumption C_t with constant relative risk aversion. Let β be the rate of time preference, γ be the risk-aversion coefficient, and P_t be the price level. The nominal discount function (or bond price) for such an economy, reflecting the present value of a dollar delivered with certainty n periods from now, is given by

$$\begin{aligned} \delta_t^{(n)} &= \beta^n \mathrm{E}_t \left[\left(\frac{C_{t+n}}{C_t} \right)^{-\gamma} \frac{P_t}{P_{t+n}} \right] \\ &= \beta^n \mathrm{E}_t \left[\exp \sum_{m=1}^{n} (-\gamma g_{t+m} - \pi_{t+m}) \right] \end{aligned}$$

where where g_t is the rate of real consumption growth and π_t is the rate of inflation.

The infinite-horizon nominal bond yield in this model is, by definition,

$$y_t^{(\infty)} = \lim_{n \to \infty} -\frac{1}{n} \log \delta_t^{(n)}$$

Supposing permanent innovations in consumption and prices to be log-normal, this becomes

$$y_t^{(\infty)} = \pi^* + \gamma g^* - \log \beta - \frac{1}{2} \left(\gamma^2 \sigma_c^2 + \sigma_p^2 \right)$$

where g^* and π^* are the long-run rates of growth and inflation, respectively; σ_c^2 is the conditional variance of the stochastic trend in $\log C_t$; σ_p^2 is the conditional variance of the stochastic trend in $\log P_t$; and I have assumed for simplicity that any trends in consumption and prices are uncorrelated.

From this expression, it is clear that infinite-horizon nominal bond yields are greater than long-run nominal growth ($y_t^{(\infty)} > \pi^* + g^*$) whenever

$$(\gamma - 1) g^* - \log \beta > \frac{1}{2} (\gamma^2 \sigma_c^2 + \sigma_p^2) \qquad \text{(B.1)}$$

This inequality holds under a wide range of plausible parameter values. Moreover, the requirement that equity prices be finite implies further restrictions on the values of parameters that are admissible. In particular, consider contracts ("Lucas trees") paying dividends D_t equal to nominal consumption. Their price is

$$\begin{aligned} S_t &= \sum_{n=0}^{\infty} \beta^n E_t \left[\left(\frac{C_{t+n}}{C_t} \right)^{-\gamma} D_{t+n} \right] \\ &= D_t \sum_{n=0}^{\infty} \beta^n E_t \left[\exp(1-\gamma)(g_{t+1} + ... + g_{t+n}) \right] \end{aligned}$$

This infinite sum converges if and only if $(\gamma - 1)g^* - \log\beta > 0$. One implication is that if the economy is trend stationary, so that $\sigma_c^2 = \sigma_p^2 = 0$, inequality (B.1) i is always satisfied. More generally, the condition is only violated in cases involving very volatile stochastic trends. For example, under typical annual parameter values of $\beta = 0.96$, $\gamma = 2$, and $g^* = 0.02$, and conservatively high values of $\sigma_c = \sigma_p = 1\%$, the left-hand side of equation (B.1) is equal to 6.08%, while the right-hand side is just 0.03%.[8]

[8]Models with recursive preferences place higher weight on long-run outcomes, boosting the effects of the variance terms in (B.1), and thus are more likely to lead to non-existence of V_t in the presence of stochastic trends.

Appendix: Estimation and identification details

Let $\mathbf{x}_t$ be a vector containing, in order, 1-year, 5-year, and 30-year zero coupon Treasury yields, the log change in nominal corporate profits, the log change in the stock-market index, and the difference between the log levels of profits and stock prices (the "error correction" term). The VAR is specified as

$$\mathbf{x}_{t+1} = \mathbf{a} + \mathbf{A}\mathbf{x}_t + \mathbf{e}_t$$

(Information criteria suggest a lag length of 1 is optimal.) This model is estimated by Bayesian methods, assuming a flat prior for the coefficients and, for simplicity, treating the covariance matrix of $\mathbf{e}_t$ as given.

The unconditional mean of $\mathbf{x}_t$ is given by

$$\bar{\mathbf{x}} = \mathbf{a}(\mathbf{I} - \mathbf{A})^{-1}$$

I sample draws j from the posterior distribution of the VAR parameters, rejecting draws for which $\bar{\mathbf{x}}_{\{3\},j}$ (the mean of the 30-year yield) is less than $\bar{\mathbf{x}}_{\{4\},j}$ (the mean of profit growth). This ensures that the risk-free-discounted value of profits exist. (I also reject any draw for which the VAR violates the conditions for stationarity.) Sampling continues until 1,000 draws are kept.

For each accepted draw of the estimated reduced-form VAR parameters, the structural identification of the monetary-policy shocks proceeds as follows.

1. Draw a sequence of matrices $\mathbf{M}_i$ such that, for each draw i, $\mathbf{M}_i\mathbf{M}_i' = \mathbf{\Sigma}$. Designate the first row of $\mathbf{M}_i$ as $\mathbf{m}_i$. This will be the vector of candidate multipliers on the monetary policy shock. Rotate $\mathbf{M}_i$ such that $\mathbf{m}_{\{2\},i}$, the element corresponding to the contemporaneous effect of this shock on the five-year yield, is positive.

2. For each draw, calculate the VAR-implied response to an impulse of magnitude $\mathbf{m}_i$ over 800 quarters. This is given by $\mathbf{A}_j^h\mathbf{m_i}$, where $h = 0, ..., 800$ is the matrix power.

3. From the impulse-response for profits, calculate the term $T_i^1 = \sum_{n=1}^{\infty} \delta_0^{(n)}(\mathrm{E}_1[\Pi_n] - \mathrm{E}_0[\Pi_{n-1}])$ using steady-state discount factors for $\delta_0^{(n)}$. (The latter are calculated using $\bar{\mathbf{x}}_{\{1\},j}$ through $\bar{\mathbf{x}}_{\{3\},j}$ and applying the estimated yield-curve loadings to derive the entire curve). This term reflects the impact of a shock on the expected-profits component of stock prices.

4. From the impulse-response for yields, calculate the term $T_i^2 = \sum_{n=1}^{\infty} \Delta\delta_1^{(n)}\mathrm{E}_0[\Pi_n]$, where

$E_0[\Pi_n]$ is calculated based on the steady-state growth rate of profits $\bar{\mathbf{x}}_{\{4\},j}$. This term reflects the impact of a shock on the risk-free-discount component of stock prices.

5. Calculate the component of the initial stock-price response not accounted for by either of the other two terms, $T_i^3 = \bar{\mathbf{x}}_{\{5\}} - T_i^1 - T_i^2$.

6. Reject the draw if T_i^1, T_i^2, or T_i^3 is positive or if $(\mathbf{A}_j^4 \mathbf{m_i})_{\{1\}}$ is negative. This term reflects the ERP.

Sampling continues until 1,000 draws $\mathbf{m}_i$ are kept for each draw j. I find the "median target" draw $\mathbf{m^{MT}}_j$ by computing the Euclidean distance from each draw to the vector median of $\mathbf{m}_{i,j}$. I keep this vector as the contemporaneous multipliers associated with the VAR-parameter draw j. The collection of these vectors constitutes the posterior distribution of the multipliers on the monetary-policy shocks.

References

[1] Bauer, M. D.; Bernanke, B. S.; and Milstein, E., 2023. "Risk Appetite and the Risk-Taking Channel of Monetary Policy." *Journal of Economic Perspectives* 37(1): 77-100.

[2] Bekaert, G.; Hoerva, M.; and Lo Duca, M., 2013. "Risk, Uncertainty, and Monetary Policy." *Journal of Monetary Economics* 60(7): 771-88.

[3] Bernanke, B. S., and Kuttner, K., N., 2005. "What Explains the Stock Market's Reaction to Federal Reserve Policy?" *Journal of Finance* 60(3): 1221-57.

[4] Borio, C. and Zhu, H., 2012. "Capital Regulation, Risk-Taking, and Monetary Policy: A Missing Link in the Transmission Mechanism?" *Journal of Financial Stability* 8(4): 236-51.

[5] Campbell, J. Y. and Shiller, R. J., 1988a. 'Stock Prices, Earnings, and Expected Dividends." *Journal of Finance* 43(3): 661-76

[6] Campbell, J. Y. and Shiller, R. J., 1988b. 'The Dividend-Price Ratio and Expectations of Future Dividends and Discount Factors." *Review of Financial Studies* 1 (3): 195-228.

[7] Cieslak, A., and Pang, H., 2019. "Common Shocks in Stocks and Bonds." *Journal of Financial Economics* 142: 880-904.

[8] Cox, J.; Greenwald, D. L.; and Ludvigson, S. C., 2020. "What Explains the COVID-19 Stock Market?" NBER Working Paper 27784 (September).

[9] D'Amico, S., and Farka, M., 2011. "The Fed and the Stock Market: An Identification Based on Intraday Futures Data." *Journal of Business and Economic Statistics* 29(1): 126-37.

[10] D'Amico, S., and King, T. B., 2023. "What Does Anticipated Monetary Policy Do?" *Journal of Monetary Economics.*

[11] D'Amico, S.; King, T. B.; and Wei, M., 2016. "Macroeconomic Sources of Recent Interest Rate Fluctuations." FRB Chicago *Chicago FedLetter* 363.

[12] Fry, R.; and Pagan, A., 2005. "Sign Restrictions in Structural Vector Autoregressions: A Critical Review." *Journal of Economic Literature* 49(4): 938-960.

[13] Gertler, M. and Karadi, P., 2015. “Monetary Surprises, Credit Costs, and Economic Activity.” *American Economic Journal: Macroeconomics* 7(1): 44-76.

[14] Gormsen, N. J., and Koijen, R. S. J., 2020. “Coronovirus: Impact on Stock Prices and Growth Expectations.” *Review of Asset Pricing Studies* 10(4): 574-97.

[15] Gurkaynak, R.; Sack, B.; and Swanson, E. T., 2007. “Do Actions Speak Louder than Words?”

[16] Gurkaynak, R.; Sack, B.; and Wright, J. H., 2007. ”The U.S. Treasury Yield Curve: 1961 to the Present.” *Journal of Monetary Economics* 54(8): 2291-2304.

[17] Jarocinski, M. and Karadi, P., 2020. ”Deconstructing Monetary Policy Surprises—the Role of Information Shocks” *American Economic Journal: Macroeconomics* 12(2): 1-43.

[18] Knox, B., and Vissing-Jorgensen, A., 2022. “A Stock Return Decomposition Using Observables.” FEDS Working paper (March).

[19] Landier, A., and Thesmer, D., 2020. “Earnings Expectations during the COVID-19 Crisis.” *Review of Asset Pricing Studies* 10(4): 598-617.

[20] Matheson, T., and Stavrev, E., 2014. “News and Monetary Shocks at a High Frequency: A Simple Approach.” *Economics Letters* 125(2): 282-6.

[21] Morris, S., and Shin, H. S., 2016. “Risk Premium Shifts in Monetary Policy: A Coordination Approach.” In *Monetary Policy through Asset Markets: Lessons from Unconventional Measures and Implications for an Integrated World*, E. Albagli, D. Saravia, and M.Woodford, eds. Santiago: Central Bank of Chile.

[22] Nakamura, E. and Steinsson, J., 2018. ”High-Frequency Identification of Monetary Non-Neutrality: The Information Effect.” *Quarterly Journal of Economics* 133(3): 1283-1330.

[23] Rigobon, R.; and Sack., B, 2004. “The Impact of Monetary Policy on Asset Prices.” *Journal of Monetary Economics* 51(8): 1553-1575.

Table 1 – Decomposition of Stock Returns during the COVID period

Time Period		**Log change in stock price**	**Decomposition of stock return**		
			expected nominal profits	risk-free discounting	residual / risk premium
Initial shock and policy response	Dec. 2019 - March 2020	-0.19	-0.08 [-0.16, 0.02]	+0.18 [0.17, 0.19]	-0.30 [-0.39, -0.21]
Rebound	March - Sep. 2020	+0.25	+0.19 [0.13, 0.24]	+0.03 [0.03, 0.03]	+0.03 [-0.03, 0.09]
Continuing recovery	Sep. 2020 – Dec. 2021	+0.34	+0.25 [0.19, 0.31]	-0.12 [-0.12, -0.11]	+0.20 [0.14, 0.26]
Beginning of policy tightening	Dec. 2021 - March 2022	-0.07	-0.01 [-0.06, 0.04]	-0.16 [-0.16, -0.14]	+0.10 [0.04, 0.15]

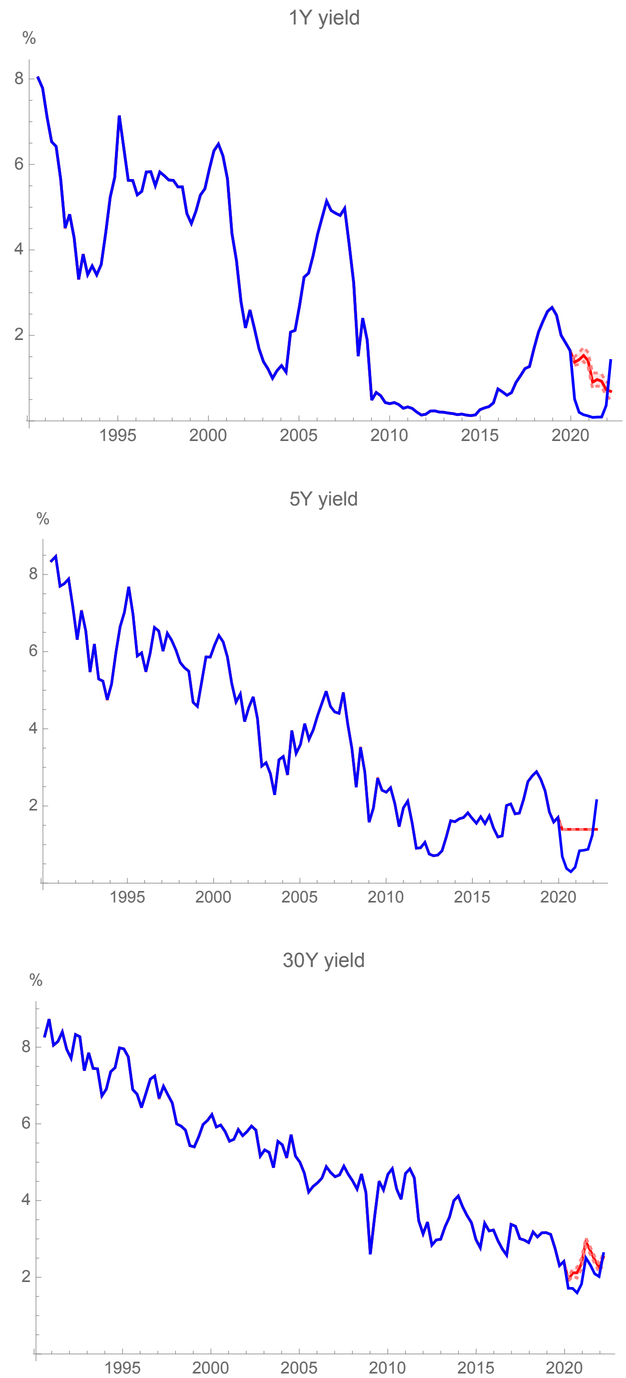
Notes: The table shows the model-estimated components of changes in log stock prices over various intervals. The top number in each row is the posterior median; posterior interquartile ranges are shown in brackets. Units are log prices. Rows do not sum exactly because of nonlinearities and approximation errors, but these are always less than 0.01 in magnitude.

Table 2 – Estimated Effects of Monetary Policy

Time Period		Effect of monetary policy on log stock price	Decomposition of policy effects on stock return		
			expected nominal profits	risk-free discounting	residual / risk premium
Initial shock and policy response	Dec. 2019 - March 2020	+0.22 [0.19, 0.27]	+0.09 [0.07, 0.12]	+0.06 [0.05, 0.08]	+0.08 [0.06, 0.09]
Rebound	March - Sep. 2020	+0.24 [0.19, 0.31]	+0.09 [0.06, 0.12]	+0.07 [0.05, 0.10]	+0.08 [0.03, 0.14]
Continuing recovery	Sep. 2020 – Dec. 2021	-0.29 [-0.40, -0.17]	-0.08 [-0.13, -0.05]	-0.08 [-0.12, -0.05]	-0.11 [-0.21, -0.05]
Beginning of policy tightening	Dec. 2021 - March 2022	-0.32 [-0.37, -0.27]	-0.11 [-0.15, -0.09]	-0.09 [-0.11, -0.07]	-0.11 [-0.14, -0.08]

Notes: The table shows the model-estimated components of changes in log stock prices over various intervals. The top number in each row is the posterior median; posterior interquartile ranges are shown in brackets. Units are log prices. Rows do not sum exactly because of nonlinearities and approximation errors, but these are always less than 0.01 in magnitude.

Figure 1. Observed and Counterfactual Paths of Bond Yields



Blue lines – observed data
Red lines – counterfactual simulation (median and interquartile range)

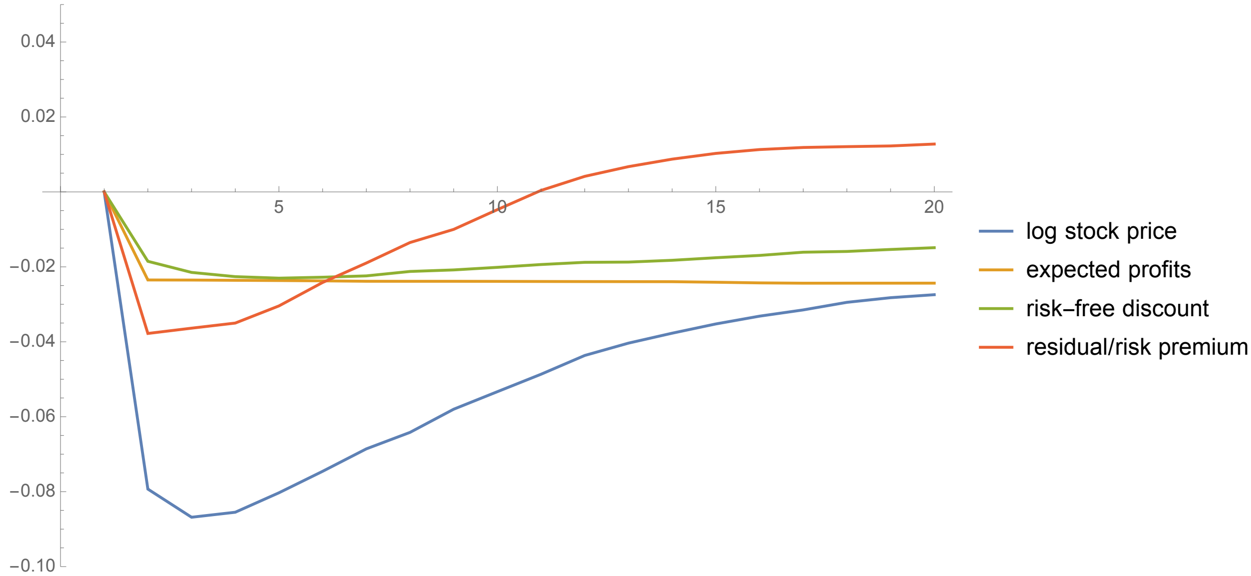
Notes: The figure shows zero-coupon Treasury yields over time, together with the counterfactual paths simulated by the model to hold five-year yields constant over the COVID period.

Figure 2. Observed and Counterfactual Paths of Stock Prices

Blue lines – observed data
Red lines – counterfactual simulation (median and interquartile range)

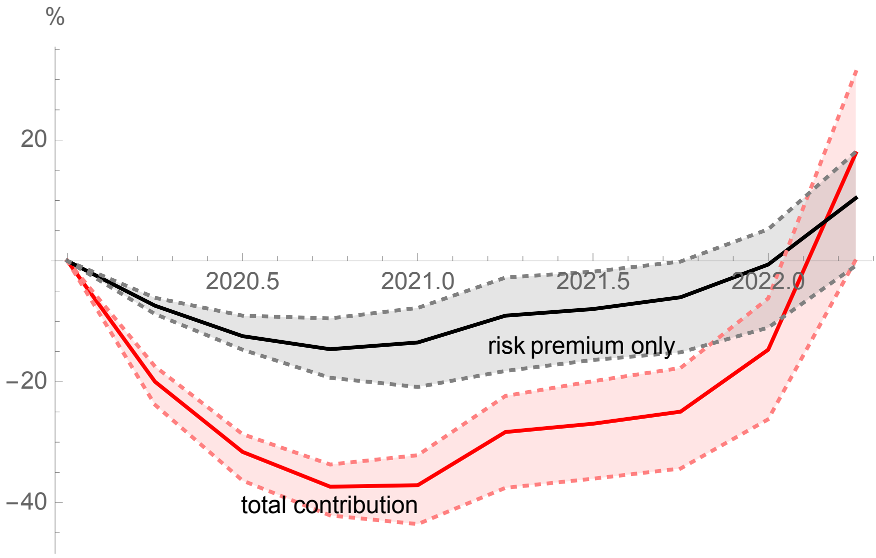
Notes: The figure shows the Wilshire 5000 stock-price index over time, together with the counterfactual path simulated by the model to hold five-year yields constant over the COVID period.

Figure 3. Response of Stock-Price Components to Monetary-Policy Shock



Notes: The figure shows impulse-response functions, for log stock prices and their components, to a 25bp monetary-policy shock, identified as described in the text, starting from the steady-state of the VAR.

Figure 4. Effect of Monetary Policy on Stock Prices



Notes: The red line in the figure shows the esimated contribution (posterior median) of monetary policy to stock prices over the COVID period, calculated as the percentage difference between the observed stock-price index and the counterfactual index if policy had held the five-year yield constant. The black line shows the portion of this effect accounted for by the residual component of stock prices, which contains the equity risk premium. Shaded regions show interquartile ranges.