Central Banks, Stock Markets, and the Real Economy*

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Abstract

This article summarizes empirical research on the interaction between monetary policy and asset markets, and reviews our previous theoretical work that captures these interactions. We present a concise model in which monetary policy impacts the aggregate asset price, which in turn influences economic activity with lags. In this context: (i) the central bank (the Fed, for short) stabilizes the aggregate asset price in response to financial shocks, using large-scale asset purchases if needed ("the Fed put"); (ii) when the Fed is constrained, negative financial shocks cause demand recessions, (iii) the Fed's response to aggregate demand shocks increases asset price volatility, but this volatility plays a useful macroeconomic stabilization role; (iv) the Fed's beliefs about the future aggregate demand and supply drive the aggregate asset price; (v) macroeconomic news influences the Fed's beliefs and asset prices; (vi) more precise news reduces output volatility but heightens asset market volatility; (vii) disagreements between the market and the Fed microfound monetary policy shocks, and generate a policy risk premium.

JEL Codes: G12, E43, E44, E52, E32

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Link: `https://www.dropbox.com/scl/fi/h1z978nrh1k2ah0k1zhaa/ARFE-public.pdf?rlkey=pvxsjlj7at4py07saf6367sm4&dl=0`

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1. Introduction

The aim of monetary policy is to ensure equilibrium in the *goods* market: to align aggregate spending with potential output. In contrast, its tools operate exclusively by influencing *financial* markets, which then affect the goods market with "long and variable lags." Furthermore, even though monetary policy is commonly articulated in terms of actions regarding an overnight policy rate, modern central banks exert a much broader influence on financial markets. In practice, monetary policy seeks to influence *financial conditions*—a summary measure of aggregate asset prices—which subsequently affects the real economy, subject to various frictions and delays.

Several decades ago, monetary policy shifted from targeting monetary aggregates to directly targeting overnight interest rates. The primary rationale behind this shift was the recognition that the relationship between monetary aggregates and aggregate demand was less stable than that between interest rates and aggregate demand. Similarly, whether explicitly or subtly, monetary policy has been progressively transitioning from a narrow emphasis on overnight rates to a significantly wider focus on financial conditions. This transition reflects the significant increase in the role of financial markets in driving aggregate demand decisions over the past fifty years. Prominently, wealth effects have become a more pivotal concern in economies like the U.S., where there's been a significant rise in the ratio of household wealth to disposable income over the last five decades (from 4.5 in the 1970s to about 7.5 in recent years—source: the Federal Reserve Board, retrieved from FRED). Similarly, an increasing share of corporate funding is taking place in markets rather than through traditional bank lending. In the U.S., the inflation-adjusted value of outstanding non-financial corporate bonds today is five times larger than in the 1980s; over the same period the share of bank loans in total credit has declined from 26% to less than 10% (see Contessi et al. (2013)). The U.S. stands at the forefront of financial deepening among global economies, but broader financial conditions are becoming increasingly integral in driving aggregate demand and shaping monetary policy all around the world.

The shift from narrow to (implicit) comprehensive targeting of financial conditions has important implications for asset markets. Monetary policy can no longer be viewed as an independent input influencing asset prices. Instead, *markets are increasingly becoming enmeshed in a symbiotic and reflexive relationship with central banks:* financial markets react to (actual or anticipated) central bank actions, and central banks react to and attempt to influence financial markets. This review article summarizes the empirical literature on the relationship between monetary policy and asset markets, and provides a simple model based on our previous work to capture the main implications of this relationship.

The empirical review section supports the key ingredients of our model. The section documents five main points: (i) monetary policy has a significant impact on stock prices; (ii) monetary policy reacts to large movements in stock prices; (iii) monetary policy reacts to stock prices not only to ensure financial stability but also, and perhaps primarily, to manage aggregate demand; (iv) the wealth effects of stock prices are large and operate with long lags; and (v) stock prices have the largest contribution to fluctuations in financial conditions in the U.S. and in most major economies. While we focus on the evidence on stock prices, many of the findings we report have direct counterparts on other assets such as bonds and real estate. Our discussion of the leading financial conditions indices (FCIs) at the end of the section covers some of these parallels.

The model is a stylized "risk-centric" New Keynesian (NK) model; meaning it's a NK model where asset markets and risk are explicitly incorporated. We use this model to summarize our research on optimal monetary policy and its implications for asset pricing. In our model, when monetary policy is unconstrained, the *aggregate* asset price is determined by imbalances between aggregate supply and demand (macroeconomic needs), rather than by conventional financial forces. Instead, financial forces influence *relative* asset prices. For instance, if the equity market becomes more optimistic about the future state of the economy, but there is not (yet) an increase in current supply, then the Fed raises rates and keeps the *aggregate* asset price unchanged. It does so to prevent an excessive increase in aggregate demand. Nonetheless, in this scenario equity prices rise while bond prices decline, as these are substitutes for a given aggregate asset price. Conversely, if the equity market becomes pessimistic or the risk premium increases, the Fed again stabilizes the aggregate asset price, which limits the decline of equity prices and increases the price of bonds. This provides an explanation for the "Fed put" and LSAPs (Large-Scale Asset Purchases), even in the absence of concerns about financial instability. In contrast to the Fed's asset market stabilization role with respect to financial shocks, we show that the optimal policy response to aggregate demand shocks *increases asset price volatility.* However, this financial market volatility plays a useful macroeconomic stabilization role. In other words, the Fed also "uses" asset prices to achieve its conventional macroeconomic stabilization goals.

Our model also illustrates that, if monetary policy is constrained by an interest rate lower bound (and cannot use LSAPs), then negative asset price shocks can induce a demand recession, even without any of the standard financial frictions. With heterogeneity in risk tolerance, negative shocks can also trigger a downward spiral in asset prices, as emphasized by a large macro-finance literature. Our model highlights the aggregate demand reduction that these types of negative spirals would cause, and the key role of central banks in preventing them.

A central element of our model is "transmission lags": financial conditions respond immediately to policy actions, even in anticipation to them, while the effects of financial conditions on real activity have significant delays. This means that the Fed effectively makes policy decisions for the future. Therefore, the Fed's *beliefs* about future macroeconomic needs—future aggregate supply and demand—drive asset prices. This implies that macroeconomic news about the future aggregate supply and demand influence the Fed's beliefs and affect asset prices. In this context, an improvement in the precision of news reduces output volatility, by enabling the Fed to mitigate demand-driven business cycles, but it also raises asset price volatility, since the Fed "uses" asset prices to control aggregate demand. This result helps understand why the Fed was a key driver of asset price volatility in the Covid-19 cycle, and suggests that this type of Fed-induced asset price volatility might become an increasingly prominent feature of business cycles.

We also allow the market to hold a different belief than the Fed, as we routinely see in practice. With belief disagreements, the market constantly tries to infer the Fed's beliefs and its policy reaction. In practice, the market often learns the Fed's beliefs through policy speeches or announcements. This perspective provides a microfoundation for the often ad-hoc monetary policy shocks studied in empirical research. In our model, a hawkish interest rate shock arises when the Fed is revealed to be more demand-optimistic than the market anticipated before the policy announcement. We also find that when the market disagrees with the Fed, it perceives policy "mistakes." These perceived "mistakes" affect the design of optimal monetary policy and give rise to an endogenous *policy risk premium*. With recurring disagreements, the market thinks the Fed will make future "mistakes" that will induce excess asset price volatility. This raises the risk premium, especially at times with large disagreements between the Fed and the market.

The rest of the paper is organized as follows. Section 2 contains our review of the empirical evidence. Section 3 describes the basic model and its immediate implications. Section 4 adds transmission lags and discusses the impact of the Fed's and market's beliefs about the future state of the economy on asset prices. Section 5 provides final remarks.

2. Monetary policy, stock prices, and financial conditions

In this section, we review the empirical literature that establishes the symbiotic relationship between monetary policy and asset prices. We focus on the evidence on stock prices, but the core findings and insights are applicable to various other assets such as bonds and real estate. In the last subsection, we discuss FCIs that aggregate the effects of several asset classes.

2.1. Monetary policy affects stock prices

There is ample evidence that monetary policy affects asset prices and, in particular, stock prices. One of the earliest explorations is Rozeff (1974), which presents evidence that a surprise decrease in the current and future rate of money growth have a negative impact on current stock returns. Fast-forward a few decades, Rigobon and Sack (2004) use high-frequency data together with an heteroskedasticity-based identification strategy to find that an unanticipated 25 basis point increase in the short-term interest rate generates a 1.7% decline in the S&P 500 index on impact. Bernanke and Kuttner (2005) use an event-study approach that confirms Rigobon and Sack (2004) findings: an unanticipated 25 basis point increase in the short-term interest rate results in a 1.2% decline in the CRSP value-weighted index.

Bauer and Swanson (2022) synthesize and extend the literature using high-frequency data to identify the effects of monetary policy on financial markets and the real economy. They conclude that a 100 basis point monetary policy surprise leads to a 5.4% drop in the S&P 500. They also show that this result is robust to using a measure of the policy surprise that is orthogonal to macroeconomic and financial data observed before the announcement (thus addressing critiques on the suitability of previous measures of monetary policy surprise on the grounds of their predictability).

While in the model section we are largely agnostic about the transmission channel from monetary policy to stock prices, there is clear evidence that the risk-premium channel is important in practice. One of the early papers documenting this channel is Bernanke and Kuttner (2005), who find that the bulk of the effect of monetary policy comes from changes in the equity premium (as opposed to changes in expected real risk-free rates or expected cash flows). Using the Campbell-Shiller decomposition and estimating a VAR on data between 1973 and 2002, they document that the variance in expected future excess returns accounts for 76% of the variance of the current equity returns. Likewise, using a decomposition of the VIX and multiple identification strategies in a SVAR, Bekaert et al. (2013) show that monetary policy affects both the expected stock market volatility and the market's willingness to bear risk. They find that a one standard deviation negative shock to the real rate lowers risk aversion by about 0.032 after 9 months and remains significant for around 3 years. More recently, Bauer et al. (2023) develop an index of risk appetite and find that monetary policy shocks have strong and persistent effects on the economy's risk appetite, which in turn drives a substantial component of the transmission of monetary policy to financial markets and the real economy.[1] Moving from monetary policy shocks to policy rules, Bianchi et al. (2022) document that periods with hawkish monetary policy rules coincide with persistently low asset valuations and high equity return premia.

There is also evidence that U.S. monetary policy affects asset prices around the world. Miranda-Agrippino and Rey (2020) document that a single global factor explains a large fraction of the cross-sectional variation in risky asset prices, which they interpret as aggregate risk aversion. Furthermore, they find that U.S. monetary policy strongly commoves with this factor. Quantitatively, a 100 basis point increase in U.S. 1-year interest rate decreases risk-appetite (as measured by the global factor) by 40% on impact and keeps it below its average level for a year, which translates into an 8% average decline in local stock markets.

2.2. Central banks pay attention to stock prices

There is ample evidence that central banks monitor financial markets closely and react to large movements in asset prices. The evidence also shows that this reaction function is not only a financial stabilization tool but also, and perhaps primarily, an aggregate demand management tool.

Rigobon and Sack (2003) use U.S. daily data from 1985 to 1999 to show that a 5% rise in the S&P 500 index increases the likelihood of a 25 basis tightening by about a half. Similarly, Bjornland and Leitemo (2009) use a SVAR framework to show that a one percent increase in aggregate real stock prices (as measured by the CPI-deflated S&P 500 index), results in a federal funds rate increase of around 4 basis points on impact, and a peak effect of 7 basis points after 9 months. Extending to other assets and countries,

[1] While not about stock prices, Gertler and Karadi (2015) augments a VAR framework with high-frequency identified monetary policy shocks and find that they have an important impact on the real cost of long-term credit through changes in the term premium and the credit spread. Along similar lines, Hanson and Stein (2015) shows that monetary policy shocks have important effects on long-term real rates and provide evidence of this being driven by movements of the term premium.

Bjornland and Jacobsen (2010) find that in both the UK and Sweden, a 1% increase in house prices results in a 15-20 basis points increase in their respective policy rates. Relatedly, Pflueger et al. (2020) show that changes in the price of volatile stocks predict future changes in interest rates and economic activity.

Recent research uses textual analysis to shed further light on the central banks' reaction to the stock market. Shapiro and Wilson (2022) estimate the sentiment expressed by Fed's policymakers in their internal meetings between 2000 and 2011. They find that the impact of changes in the stock market on this sentiment variable is similar in magnitude to the one for contemporaneous inflation, and much larger than those for unemployment and output growth. Cieslak and Vissing-Jorgensen (2020) find evidence supporting the "Fed put" (that is, a tendency of negative stock market returns to be followed by monetary policy accommodation by the Federal Reserve). They first estimate that a 10% stock market decline predicts a reduction in the federal funds rate target of 32 basis points at the next meeting and 127 basis points after one year. They then use textual analysis of the FOMC minutes and transcripts to assess whether this result is just coincidental (i.e., a result of the stock market being correlated with other variables that drive the Fed's decision-making) or a consequence of the Fed actually reacting to the stock market. They find that the evidence strongly supports the latter interpretation: a 10% more negative past inter-meeting return is associated with 6.4 more negative stock market mentions in the FOMC minutes (a fairly large effect, as the mean number of mentions is 1.8). Moreover, a one standard deviation increase in the number of negative mentions —2.6 more— results in a 32 basis points cumulative reduction in the FFR target.

Cieslak and Vissing-Jorgensen (2020) go further and document that the importance of the stock market for the Fed's decision-making follows from its perceived role as an important *driver* of economic fluctuations (instead of being just a predictor without causal significance), which mostly works through wealth effects. Out of all the mentions of the stock market, 38% align with the driver view while only 8% with the predictor view. Furthermore, the driver view accounts for 80% of the mentions by FOMC participants. Finally, within the mentions aligned with the driver view, they find that most of them explicitly refer to consumption as the mechanism through which the stock market impacts the real economy (257 out of 373) and, out of those, most attribute the consumption response to wealth effects (213 out of 257).

2.3. Stock prices affect economic activity

A large empirical literature documents that asset prices *do* affect aggregate demand and output—consistent with the central banks' attention to asset prices. We briefly discuss the evidence on stock prices but we note that a growing literature shows similar aggregate demand effects for other asset prices such as credit spreads (Gilchrist and Zakrajšek (2012)) and house prices (Mian et al. (2013); Mian and Sufi (2014)).

Stock prices can affect aggregate demand through a consumption wealth effect as well as several other channels (such as Q-theory or cost-of-capital effects on investment). The wealth effect has been empirically studied for several decades (see Poterba (2000) for an early survey). The earlier literature mostly relied on time series data, which makes it difficult to isolate a stock market wealth effect from common drivers of stocks and consumption. The recent literature makes progress by using richer data and exploiting *the cross-sectional* variation in wealth. Using the heterogeneity in stock wealth across the U.S. regions, Chodorow-Reich et al. (2021) show that stock market changes affect consumption and labor market outcomes. Their results imply that the U.S. households have a wealth-weighted average marginal propensity to consume (MPC) out of stock wealth of around 3.2 cents per year. They also find substantial transmission lags: the peak impact of a stock price shock on economic activity obtains 4 to 8 quarters after the shock. Likewise, Di Maggio et al. (2020) show substantial wealth effects by exploiting the *individual-level* variation in portfolio holdings and wealth. They find that the top 30% of the income distribution, who own most of the stocks, have an MPC of around 3 cents per year (and the bottom half of households have a much larger MPC of around 23 cents).[2]

2.4. Financial conditions indices

Given the findings described above, it is not surprising that FCIs have become standard jargon in monetary policy speeches and analysis. By now, there are several proposals to capture financial conditions and trace their impact on real activity. Goldman Sachs' FCI is one of the earliest and best known indices. It is a weighted average of short-term interest rates, long-term interest rates, the trade-weighted dollar, an index of credit spreads, and the ratio of equity prices to the 10-year average of earnings per share (see Hatzius and Stehn (2018) for more details). The assigned weights are derived from estimates of the impact of shocks to each financial variable on real GDP growth over the subsequent year

[2] There is a parallel literature that investigates the effects of the stock market on investment through Tobin's Q-theory or other channels. That literature also finds effects but the results are less conclusive (see Caballero (1999) for an early survey and Gutiérrez and Philippon (2017) for a more recent discussion).

according to a stylized macroeconomic model. Hatzius et al. (2017) show that a 100 basis point tightening in the GS-FCI reduces GDP by about 20 basis points on impact, and the effect builds up to 90 basis points after one year.

Another FCI that has attracted attention recently is the new FCI-G index (the Financial Conditions Impulse on Growth) by a research team at the Federal Reserve Board (Ajello et al. (2023)). The explicitly stated purpose of this index is to gauge broad financial conditions and assess how these conditions are related to future economic growth. The FCI-G weights seven financial variables: the federal funds rate, the 10-year Treasury yield, the 30-year fixed mortgage rate, the triple-B corporate bond yield, the Dow Jones total stock market index, the Zillow house price index, and the nominal broad dollar index. Resembling the GS-FCI, the weights are based on the impulse response coefficients that quantify the cumulative impact of unanticipated permanent changes in each variable on real GDP growth over the subsequent year. Importantly, these impulse responses are computed using the FRB/US model and other large-scale DSGE models developed by the Federal Reserve, aligning the index with the Fed's decision-making process.

The FCI-G explicitly allows for GDP to be affected by several lags of financial variables. A FCI-G value of 0% means that the cumulative effect on growth of current and past changes in all included financial variables sums up to zero; a value of 1% means that financial conditions constitute a headwind to real economic activity equivalent to a 100 basis point drag on GDP growth over the following year. There are two versions of the index that differ only in the lookback window (i.e., the length of the period over which past changes in financial variables are included in the calculation of the index)—one or three years. While the two versions are usually close to each other, at times they differ significantly, highlighting the importance of "long and variable lags."[3] As expected, the FCI-G increases (i.e., financial conditions tighten) during tightening policy cycles, indicating that monetary policy is a key driver of financial conditions.

FCIs can be decomposed into the contribution of each financial variable. Thus, it is possible to assess the main drivers behind movements in financial conditions. By construction, this is equivalent to determining which financial variables have a larger impact on the real economy in a given period. These decompositions reveal that stock price changes are an important driver of economic activity because stocks are more volatile than most other asset prices. For example, Hatzius et al. (2017) show that equity is the main con-

[3] Recently, the degree of tightening estimated using a three-year lookback window is noticeably smaller than using a one-year lookback window. This is explained by the highly accommodative conditions that were in place in the aftermath of the COVID-19 pandemic through mid-2021, and that have partly offset the restraining effects on GDP since late 2021.

tributor to the GS-FCI for the U.S. between 2000 and 2017. Equity accounts for about 40% of the fluctuations in GS-FCI, while trade weighted dollar and long rates account for slightly more than 20% each, and corporate spreads for about 16% (the residual is accounted for by short rates). While typically less important in other major economies, equity fluctuations still play a very significant role in most of them. Hatzius et al. (2017) show that the equity market's contribution to the GS-FCI is about 30% in the Euro area, Japan, UK, Sweden, Norway and Switzerland, and a bit lower in Canada, Australia and New Zealand. In all these non-U.S. economies, the loss of equity weight is gained by their respective trade-weighted currency index rather than by credit or interest rate variables.[4]

The FCI-G also attests to the importance of equity prices and extends it to house prices. Ajello et al. (2023) conclude that a 1% increase in equity prices (as measured by the Dow Jones total stock market index) is associated with 2 basis points of extra GDP growth over the subsequent year, and 4 basis points over the following two years (see their Table 1). For housing, the magnitudes are similar: a 1% increase in house prices (as measured by the Zillow house price index) is associated with 3 basis points of extra GDP growth over the following year and 5 basis points over the following two years. Ajello et al. (2023) also conduct an event study over the COVID-19 cycle. They show that rising equity and house prices were by far the largest contributors to the easing of financial conditions during the recovery from the COVID-19 shock. Symmetrically, the sharp decline in equity prices during 2022 was a key contributing factor to the abrupt tightening of the FCI-G by the end of 2022 (the other important factors were the rise in mortgage rates and the dollar appreciation).[5]

3. Baseline model

In this section, we focus on a largely standard New-Keynesian model with an asset pricing block and illustrate its implications for asset prices. The model is a simplified version of Caballero and Simsek (2023). For details, we refer the reader to the original paper.[6]

[4]Given the lack of real time housing indices in many non-US economies, the GS-FCI excludes housing in order to make it comparable across countries (see Hatzius et al. (2017)).

[5]Beyond the U.S., Adrian et al. (2018) study the role of financial conditions in a multi-country setting (9 advanced economies, and 10 emerging market economies). They find robust evidence that loose financial conditions forecast a high output gap and low output gap volatility.

[6]The standard New-Keynesian model is often log-linearized and does not explicitly discuss asset prices. See Woodford (2005); Galí (2015) for textbook treatments. A strand of the New-Keynesian literature incorporates banks and financial frictions (see, e.g., Bernanke et al. (1999); Curdia and Woodford (2010); Gertler and Karadi (2011); Adrian and Duarte (2018)). However, asset prices can affect economic activity even without the standard financial frictions. Our model is designed to capture these broader linkages,

3.1. Environment

There are two types of agents: "asset-holding households" (the households) and "hand-to-mouth agents." Hand-to-mouth agents provide all of the labor in the economy and spend all of their income. They do not play an important role beyond decoupling the labor supply from households' consumption. Our focus is on households, who make a consumption-savings decision that determines aggregate demand and a portfolio choice decision that determines asset prices.

The economy is set in discrete time $t \in \{0, 1, ..\}$. Our focus is on periods 0 and 1, which we view as the short run. The short run has four features. First, there are nominal rigidities, which ensures output is driven by aggregate demand and is not *necessarily* determined by productivity. Second, aggregate demand is influenced by asset prices (financial conditions). Third, there is aggregate risk about future output, which leads to a risk premium in asset prices. Fourth, monetary policy influences asset prices by steering asset prices subject to policy constraints. We next introduce these ingredients. In the next section, we introduce transmission lags.

Nominal rigidities and demand-driven output. The supply side features a competitive final goods sector and monopolistically competitive intermediate goods firms. Aggregate output is:

$$Y_t = \left(\int_0^1 Y_t(\nu)^{\frac{\varepsilon-1}{\varepsilon}} d\nu \right)^{\frac{\varepsilon}{\varepsilon-1}}, \text{ where } Y_t(\nu) = A_t L_t(\nu)^{1-\alpha}.$$

The intermediate good firms have fully sticky nominal prices. This is only for simplicity: in Caballero and Simsek (2023), we show that our main results remain unchanged when the prices are partially flexible (and we derive additional results for inflation). Since these firms operate with a markup, they find it optimal to meet the demand for their good. Therefore, aggregate output and employment are determined by aggregate demand. When firms face higher demand, they increase their labor input to increase production (and vice versa for lower demand).

Aggregate demand for goods. Aggregate demand depends on the spending of households and hand-to-mouth agents, $Y_t = C_t^H + C_t^{HM}$. Hand-to-mouth agents hold no assets and have preferences $\log C_t^{HM} - \chi \frac{L_t^{1+\varphi}}{1+\varphi}$. They provide all of the labor supply and spend all their labor income when they receive it. We assume their labor income is equal to the

while also accommodating the standard frictions.

labor's share of production, $C_t^{HM} = (1-\alpha) Y_t$.[7] Combining these equations, aggregate demand is driven by households' consumption

$$Y_t = \frac{C_t^H}{\alpha}. \tag{1}$$

Hand-to-mouth agents create a Keynesian multiplier effect, but output is ultimately determined by (asset-holding) *households'* spending, C_t^H.

Aggregate supply of goods and risk. Consider the same setup except the intermediate good firms have fully flexible prices. In this benchmark, the equilibrium labor supply is constant and solves $\chi (L^*)^{1+\varphi} = \frac{\varepsilon-1}{\varepsilon}$. Output is given by $Y_t^* = A_t (L^*)^{1-\alpha}$. We refer to Y_t^* as *potential* output. We assume log potential output, $y_t^* = \log Y_t^*$, evolves according to

$$\begin{aligned} y_{t+1}^* &= y_t^* + g + z_{t+1} \\ \text{where } z_1, z_2 &\sim N\left(0, \sigma^2\right) \text{ and } z_t = 0\ \forall t \geq 3. \end{aligned} \tag{2}$$

Here, g denotes the expected log productivity growth and z_{t+1} denotes a permanent supply shock realized at the beginning of period $t+1$. We focus on $t \in \{0,1\}$, where *the next period's* supply shock is uncertain and has volatility σ. In future periods $t \geq 2$, there are no subsequent supply shocks. In particular, future potential output follows a deterministic path given the realization of z_2 and y_2^*. We also assume that in these future periods the policy sets output equal to its potential,

$$y_t = y_t^* = y_2^* + g(t-2) \text{ for } t \geq 2,$$

Here, $y_t = \log Y_t$ denotes log output. For periods $t \in \{0,1\}$ output is not necessarily equal to potential output. We let $\tilde{y}_t = y_t - y_t^*$ denote the output gap.

Financial assets. There are two assets. A risk-free asset in zero net supply and a market portfolio. The market portfolio is a claim on firms' profits αY_t (the firms' share of output). We let P_t denote the ex-dividend price of the market portfolio (which we also refer to as "the aggregate asset price"). The gross return of the market portfolio is

$$R_{t+1} = \frac{\alpha Y_{t+1} + P_{t+1}}{P_t}. \tag{3}$$

[7] To simplify the exposition, we assume the government taxes part of the firms' profits (lump-sum) and redistributes to workers (lump-sum), so that labor's share is as in the fully competitive case.

As we describe subsequently, the risk-free asset gross return R_t^f is set by the Fed. We let $r_t^f = \log R_t^f$ denote the log risk-free interest rate.

Households' consumption-savings and portfolio decisions. Households own the market portfolio and do not provide any labor. They have log utility with a discount factor β. They choose how much to consume, C_t^H, and what fraction of their assets to allocate to the market portfolio, ω_t^H. Their optimality conditions are:

$$\begin{aligned} C_t^H &= (1-\beta)\left(\alpha Y_t + P_t\right) \\ E_t\left[M_{t+1}\left(R_{t+1} - R_t^f\right)\right] &= 0, \quad \text{where } M_{t+1} = \frac{1}{R_t^f + \omega_t^H\left(R_{t+1} - R_t^f\right)}. \end{aligned} \tag{4}$$

The first condition says that households spend a constant fraction of their lifetime income. The second condition says that households invest into the market portfolio until the marginal-utility adjusted expected excess return is equal to zero, where the marginal utility (or the stochastic discount factor) is driven by the return on wealth.

The asset market clearing condition sets $\omega_t^H = 1$. In equilibrium, households reinvest their wealth in the market portfolio. Combining this with (5), we obtain, $E_t\left[\frac{R_t^f}{R_{t+1}}\right] = 1$. Assuming the return on the market portfolio R_{t+1} is (approximately) log-normally distributed, we further obtain the condition we use in the rest of the paper:[8]

$$\sigma_t\left[r_{t+1}\right] = \frac{E_t\left[r_{t+1}\right] + \frac{\sigma_t^2\left[r_{t+1}\right]}{2} - r_t^f}{\sigma_t\left[r_{t+1}\right]}. \tag{5}$$

Here, $r_{t+1} = \log R_{t+1}$ is the log return on the market portfolio, and $E_t\left[r_{t+1}\right]$ and $\sigma_t\left[r_{t+1}\right]$ denote its mean and standard deviation. This is a standard mean-variance portfolio optimality condition that says the risk of the households' optimal portfolio (the left side) is proportional to the Sharpe ratio on the market portfolio (the right side).

Campbell-Shiller approximation to the equilibrium return. To facilitate closed-form solutions, we approximate the equilibrium log return on the market portfolio (see Campbell (2017)). Absent shocks, the dividend-price ratio is constant and given by $\frac{\alpha Y_t}{P_t} =$

[8] This approximation holds exactly in the baseline model (see (9)).

$\frac{1-\beta}{\beta}$. We log-linearize (3) around this ratio to obtain

$$\begin{aligned} r_{t+1} &= \rho - (1-\beta) m + (1-\beta) y_{t+1} + \beta p_{t+1} - p_t, \\ \text{where } \rho &= -\log \beta \text{ and } m = \log \left(\frac{1-\beta}{\alpha \beta} \right). \end{aligned} \tag{6}$$

Here, the derived parameters ρ and m capture the discount rate and the MPC times the multiplier, respectively.

The central bank (the Fed) and monetary policy. The Fed sets the risk-free interest rate to close the output gaps. Since prices are fixed, inflation is zero and the Fed effectively sets the real interest rate. For now, we assume the Fed is unconstrained and sets $r_t^f = r_t^{f*}$ where r_t^{f*} ("rstar") is the real interest rate that replicates $y_t = y_t^*$.

3.2. Equilibrium conditions

We next solve for the equilibrium in the baseline model. Our simplifying assumptions ensure that the economy settles in a balanced growth path in future periods,

$$y_t = y_t^* \text{ and } P_t = \alpha \frac{\beta}{1-\beta} Y_t^* \Longrightarrow p_t = y_t^* - m \text{ for } t \geq 2. \tag{7}$$

In this section, we focus on the equilibrium for period $t = 1$ (we consider $t = 0$ in the next section). We next derive the two equations that characterize the equilibrium.

Output-asset price relation. Combining Eqs. (1) and (4) implies

$$Y_t = \frac{1}{\alpha} \frac{1-\beta}{\beta} P_t \Longrightarrow y_t = m + p_t. \tag{8}$$

We refer to this equation as *the output-asset price relation.* It says that higher asset prices increase aggregate wealth and consumption, which leads to greater output.

Eq. (8) also implies that the aggregate asset price p_t is the model counterpart to the financial condition indices that we discuss in 2.4 (with an appropriate normalization). Thus, we view this equation as capturing a broad set of mechanisms (beyond wealth effects) by which asset prices affect economic activity. For example, in models with investment, stock prices matter via Q-theory (e.g., Brunnermeier and Sannikov (2014); Caballero and Simsek (2020); Jeenas and Lagos (2022)) or by influencing the net worth of credit constrained firms or financial institutions (e.g., Bernanke et al. (1999); Kiyotaki and Moore (1997); Gertler and Kiyotaki (2010)).

Risk balance condition. First consider Eq. (6) for period $t = 1$. We use Eq. (7) to substitute for y_2 and p_2 to obtain

$$r_2 = \rho + g - m + y_1^* + z_2 - p_1. \tag{9}$$

Combining this with (2), we obtain $\sigma_1 [r_2] = \sigma$ and $E_1 [r_2] = \rho + g - m + y_1^* - p_1$. Substituting this into (5), we further obtain

$$\sigma = \frac{\rho + g + \frac{\sigma^2}{2} + (y_1^* - m) - p_1 - r_1^f}{\sigma}. \tag{10}$$

We refer to this as *the risk-balance condition.* In equilibrium, the supply of risk is equal to the demand for risk. The demand for risk is given by the Sharpe ratio: in particular, it is increasing in the expected growth of cash-flows (g), and decreasing in the price p_1, the risk-free rate r_1^f, and the amount of risk (σ).

3.3. Role of macroeconomic needs vs finance

We next show that, in equilibrium, the *aggregate* asset price is driven by macroeconomic needs. Recall that the policy targets $y_t = y_t^*$. Combining this with (8), we solve

$$p_1 = p_1^* \equiv y_1^* - m. \tag{11}$$

To ensure that output is equal to potential, the policy needs to target a particular asset price that depends on the MPC and multiplier (both embodied in m), and potential output. We refer to this asset price as "pstar." Note that "pstar" depends *only* on macroeconomic variables and shocks rather than on classical financial forces such as risk premia or beliefs.

How does the Fed achieve "pstar"? This depends on the financial market side of the model. Using Eqs. (10) and (11), we solve for the risk-free interest rate ("rstar")

$$r_1^f = r_1^{f*} \equiv \rho + g - \phi, \qquad \text{where } \phi \equiv \frac{\sigma^2}{2}.$$

Note that standard financial forces such as risk premia (ϕ) or growth expectations (g) are absorbed into the risk-free interest rate.

In addition to determining the risk-free rate, the standard financial forces drive *relative* asset prices. To illustrate this, consider a simple extension in which (in period 1 only) there are two claims on production firms: the equity claim ("aggregate stocks") and a risk-free debt claim with face value D that matures in the next period ("aggregate bonds"). The market portfolio is the sum of aggregate stocks and aggregate bonds, $P_1 = P_1^s + P_1^b$. In this model, macroeconomic needs still drive P_1 but standard financial forces influence P_1^s and P_1^b. In particular, assuming the debt claim is safe, we have

$$\begin{aligned} P_1^b &= \frac{D}{R_1^f} \\ P_1^s &= P_1 - P_1^b, \end{aligned}$$

where P_1 is still given by (11). For small shocks to growth expectations ($g = \overline{g} + \tilde{g}$) and risk premia ($\phi = \frac{\sigma^2}{2} = \overline{\phi} + \widetilde{\phi}$), we further characterize the log-linearized prices as:

$$\begin{aligned} \tilde{p}_1^b &= -\left(\tilde{g} - \widetilde{\phi}\right) \\ \tilde{p}_1^s \frac{\overline{P}_1^s}{\overline{P}_1} &= \tilde{g} - \widetilde{\phi} - \tilde{p}_1^b \frac{\overline{P}_1^b}{\overline{P}_1}. \end{aligned}$$

Here, $\overline{P}_1^b, \overline{P}_1^s$ and $\overline{P}_1 = \overline{P}_1^b + \overline{P}_1^s$ denote the asset prices in a benchmark with no shocks to expected growth or risk premium, $g = \overline{g}$ and $\phi = \overline{\phi}$. These expressions show that the price of the individual components P_1^b and P_1^s are still influenced by traditional forces, while the sum $P_1 = P_1^b + P_1^s$ is driven by macroeconomic needs. For instance, an increase in growth expectations $\tilde{g} > 0$ increases the price of stocks $\tilde{p}_1^s$ and reduces the price of bonds $\tilde{p}_1^b$ because stocks are more exposed to cash flows. Likewise, a decrease in the risk premium ($\widetilde{\phi} < 0$) raises the price of stocks relative to bonds.

3.4. The Fed put

An immediate implication of this analysis is the Fed put: the Fed's tendency to stabilize asset prices. In response to financial shocks ($\tilde{g}$ or $\widetilde{\phi}$), the Fed adjusts the interest rate and stabilizes the *aggregate* asset price. This is consistent with the empirical finding in Cieslak and Vissing-Jorgensen (2020).

In theory, the Fed put is symmetric: it stabilizes positive financial shocks ($\tilde{g} > 0$ or $\phi < 0$) as much as the negative shocks. Empirically, however, the Fed appears to be more concerned with negative than positive shocks (hence the name "the Fed put"), although this empirical pattern is probably due to the prevalence of risk-off shocks during the last two decades. More recently, with the surge on inflationary pressure the Fed has also found itself fighting a bullish market (e.g., Chair Powell's hawkish speech at the 2022 Jackson Hole's Conference, which helped overturn the summer equity rally).

3.5. Policy constraints and the real effects of financial shocks

So far, we have assumed that the Fed is unconstrained. In practice, conventional monetary policy can be constrained. Suppose, for example, that the policy rule is subject to a lower bound constraint:

$$r_1^f = \max\left(0, r_1^{f*}\right).$$

Suppose also the parameters are such that $r_1^{f*} < 0$ (specifically, $\rho + g < \phi$). In this case, solving Eqs. (8) and (10), we obtain the equilibrium

$$\begin{aligned}
r_1^f &= 0 \\
p_1 &= p_1^* + \rho + g - \phi < p_1^* \\
y_1 &= m + p_1 = y_1^* + \rho + g - \phi < y_1^*.
\end{aligned}$$

Since the policy is constrained, the Fed cannot replicate the potential outcomes: the asset price is below "pstar" and, correspondingly, output is below its potential.

Importantly, financial shocks now have *real* effects even though the model does not feature any financial frictions. For instance, an increase in risk premium (ϕ) reduces the aggregate asset price p_1, which in turn reduces aggregate demand and output through wealth effects. In previous work, we developed several implications of this mechanism. Among other things, we showed that the collapse of speculative asset price bubbles can cause aggregate demand recessions, and that ex-ante macroprudential policies (such as leverage limits) can be effective in mitigating this damage (Caballero and Simsek (2020); Simsek (2021)).

In Caballero and Simsek (2021a), we further show that when the economy features heterogeneous risk tolerance, surprise negative supply shocks (such as Covid-19) can induce a large asset price decline that can reduce aggregate demand and amplify the recession. With heterogeneous risk tolerance, more risk tolerant agents such as banks or institutional investors are levered and disproportionately exposed to surprise asset price changes. This makes the risk premium endogenous to asset prices and amplifies the damage from a surprise adverse shock such as Covid-19. A lower asset price reduces the risk tolerant agents' wealth share, which then increases the risk premium and further reduces asset prices, and so on. These results are reminiscent of a large macro-finance literature that shows how levered financial intermediaries' losses can induce downward asset price spirals (e.g., Shleifer and Vishny (1997); Kiyotaki and Moore (1997); Geanakoplos (2010); He and Krishnamurthy (2013); Brunnermeier and Sannikov (2014)). Our model highlights the aggregate demand reduction that these types of negative spirals would cause, and the key role of central banks in preventing them.

3.6. Large-scale asset purchases

The real effects of financial shocks motivate unconventional policies designed to support asset prices and financial markets. In Caballero and Simsek (2021a), we also analyzed the effects of LSAPs. Suppose the government buys risky assets in exchange for risk-free debt. In future states, this policy creates gains or losses for the government, which are absorbed by an unborn future generation of agents. In period 1, this policy reduces the supply of risky assets that need to be absorbed by the private sector. Consequently, the risk balance condition (10) becomes

$$(1-\lambda)\,\sigma = \frac{\rho + g + \frac{\sigma^2}{2} + (y_1^* - m) - p_1 - r_1^f}{\sigma}$$

where $\lambda > 0$ denotes the fraction of aggregate risk absorbed by the government. Solving this equation with r_1^f and using (8), we obtain

$$\begin{aligned} p_1 &= p_1^* + \rho + g + \frac{\sigma^2}{2} - (1-\lambda)\,\sigma^2 \\ y_1 &= m + p_1 = y_1^* + \rho + g + \frac{\sigma^2}{2} - (1-\lambda)\,\sigma^2. \end{aligned}$$

Note that LSAPs increase *both* the asset price and output. By absorbing some of the risk, the government reduces the risk premium. This raises asset prices, aggregate demand and output. In Caballero and Simsek (2021a), we show that the policy is especially powerful when the economy features heterogeneous risk tolerance, because it reverses the negative asset price spirals that we discussed earlier.[9]

Remark 1 (Monetary policy and financial stability)**.** *While we emphasize the role of monetary policy in shielding the economy from financial shocks, an intriguing possibility is that monetary policy might also* increase *financial fragility by fueling asset price and*

[9] Beyond our paper, a large literature empirically investigates the impact of LSAPs and finds they affect asset prices in the intended direction. Importantly, this effect is not restricted to the purchased assets nor their close substitutes (e.g. safe assets). See Bernanke (2020) for a recent review and Haddad et al. (2021); Swanson (2021) for subsequent research that consider the effects on stock prices in particular.

credit booms that subsequently collapse (see, e.g., Jiménez et al. (2023); Grimm et al. (2023), for recent empirical evidence). In Caballero and Simsek (2021b), we present an extension of our framework in which prudential monetary policy (PMP)—setting interest rates higher than the level necessary for macroeconomic balance—can improve financial stability. In that setting, PMP reduces asset prices during the boom, which can—under certain conditions—soften the asset price crash when the economy transitions into a recession. More broadly, a large literature investigates the mechanisms by which monetary policy interacts with financial stability and discusses the benefits and costs of using monetary policy for prudential purposes (e.g., Woodford (2012); Borio (2014); Svensson (2017); Gourio et al. (2018); Farhi and Werning (2020); Fontanier (2022); Kashyap and Stein (2023); Acharya et al. (2023); Goldberg and López-Salido (2023)).

3.7. Demand shocks and Fed-induced asset price volatility

So far, we demonstrated that the Fed insulates the aggregate asset price from financial shocks. In practice, however, the Fed does not always stabilize asset prices. We next show that the Fed's optimal response to *aggregate demand shocks* increases asset price volatility, but this volatility plays a useful macroeconomic stabilization role.

Consider the same setup with the difference that the discount factor (only) in period $t = 1$, denoted by β_1, is stochastic. Given β_1, the optimal consumption is given by [cf. (4)]

$$C_1^H = \frac{1-\beta}{1-\beta+\beta_1}\left(\alpha Y_1 + P_1\right). \tag{12}$$

The optimal portfolio choice is still given by (5). Consequently, the equilibrium remains unchanged except for the output asset price relation (8) in period 1, which is now given by

$$Y_1 = \frac{1-\beta}{\alpha\beta_1} P_1 \Longrightarrow y_1 = \delta_1 + m + p_1.$$

We define $\delta_1 \equiv \log\beta - \log\beta_1$ as the deviation of the discount rate relative to its steady-state level, and refer to it as a *demand shock*. When $\delta_1 > 0$, households spend more than usual (and vice versa when $\delta_1 < 0$).

Suppose the policy is unconstrained. The equilibrium is now given by

$$\begin{aligned} p_1 &= p_1^* \equiv y_1^* - m - \delta_1 \\ r_1^f &= r_1^{f*} \equiv \rho + g - \phi + \delta_1 \end{aligned} \tag{13}$$

where $\phi = \frac{\sigma^2}{2}$. In response to a positive demand shock, the Fed *lowers* the aggregate asset price to prevent the output boom that the demand shock would otherwise induce (and vice versa for a negative demand shock). In our model, the Fed reduces asset prices by raising the interest rate (in practice the Fed might use other available tools).

In this case, the Fed might seem to create "excess" asset price volatility—in contrast to the Fed put—but notice that this volatility plays a useful role and helps stabilize the real economy. In fact, the Fed put and the Fed-induced asset price volatility follow from the same principle that under optimal policy the *aggregate* asset price is driven by macroeconomic needs rather than by financial market forces.

3.8. Monetary policy effects on risk premia

As we discussed in Section 2.1, a growing empirical literature finds that monetary policy affect risky asset prices, such as stocks, not only by changing the risk-free interest rate—as in our model—but also by changing the risk premium. A recent theoretical literature has developed New-Keynesian models to explain this empirical regularity. For instance, Kekre and Lenel (2022) show that a surprise interest rate cut raises asset prices and redistributes wealth to agents with high marginal propensity to take risk (e.g., more risk tolerant or more optimistic agents), which then reduces the effective risk premium (see also Kekre et al. (2023)). Pflueger and Rinaldi (2022) show that, with consumption habits, an interest rate cut that increases consumption can also reduce the risk premium (by raising consumption above the habit).[10]

These features can be added to our model without losing the essential feature that the *aggregate* asset price is determined by macroeconomic needs and policy constraints. To illustrate this, consider the model in the previous section with demand shocks with the only difference that the households' perceived return volatility is a function of the interest rate:

$$\frac{\sigma_t^2\left[r_{t+1}\right]}{2} = \frac{\sigma^2}{2} + \zeta\left(r_t^f - \overline{r}^f\right) \text{ where } \overline{r}^f = \rho + g - \frac{\sigma^2}{2}.$$

Here, $\overline{r}^f$ is the interest rate absent shocks and the parameter $\zeta \geq 0$ captures the observed sensitivity of the risk-premium to interest rates. In particular, Eq. (5) now implies $E_t\left[r_{t+1}\right] - r_t^f = \frac{\sigma^2}{2} + \zeta\left(r_t^f - \overline{r}^f\right)$. This expression captures in reduced form the broader mechanisms emphasized in the recent theoretical literature. Following the same steps as

[10] A separate literature investigates the effects of monetary policy on asset prices via liquidity premia in models with search frictions (see, e.g., Lagos and Zhang (2019); Altermatt et al. (2021)).

before, the equilibrium is now given by

$$\begin{aligned} p_1 &= p_1^* \equiv y_1^* - m - \delta_1 \\ r_1^f &= r_1^{f*} \equiv \overline{r}^f + \frac{1}{1+\zeta}\delta_1. \end{aligned}$$

Demand shocks have *the same* effects on the aggregate asset price p_1 as before, but they have a smaller effect on the risk-free interest rate r_1^f (cf. (13)). The Fed targets the same asset price by adjusting the interest rate relatively less, because the risk premium adjustment "does part of the work." Therefore, the mechanisms emphasized in the recent literature change the channels by which the Fed affects the aggregate asset price, but *not the asset price the Fed ultimately targets.*

4. Model with transmission lags

In practice, monetary policy is complicated by long transmission lags, which are absent from the standard NK model. In Caballero and Simsek (2022, 2023), we analyzed the implications of transmission lags for optimal monetary policy and asset prices. We showed that with policy lags, asset prices are determined by macroeconomic needs *under the Fed's beliefs*. This perspective naturally implies that macroeconomic news about the future state of the economy affects asset prices. When the market and the Fed have different beliefs, this perspective also provides a theory of monetary policy shocks and policy risk premium. We next modify the baseline model to illustrate these results and discuss their connections to the empirical literatures on the asset price impact of macroeconomic news and policy announcements.

To analyze lags, we assume households' consumption decisions are subject to additional frictions, whereas the portfolio optimality is still given by (5).[11] Specifically, we replace the optimal consumption rule (4) with

$$C_t^H = \frac{1-\beta}{1-\beta+\beta_t}\left(\alpha Y_t + P_{t-1}\exp\left(g\right)\right).$$

Here, $\beta_t = \beta$ except possibly in period 1: we continue to allow for demand shocks in period

[11] We "microfound" this separation in Caballero and Simsek (2023), where we assume that households delegate their portfolio choice to portfolio managers (the market). These portfolio managers are infinitesimal and do not consume. Instead, they make a portfolio allocation on behalf of households to maximize expected log household wealth. We formulate the portfolio problem in terms of wealth, rather than consumption, because we allow consumption to deviate from the optimal rule. It is easy to check that the optimal portfolio choice still implies (5).

1. The main difference is that consumption depends on the *last-period's* asset price, P_{t-1}. This is a short-cut modeling device to capture the fact that asset prices typically affect the economic activity with long lags (see Sections 2.3 and 2.4).[12] The exponential term $\exp(g)$ is unimportant and ensures that the equation holds in a balanced growth path. After solving, we obtain

$$Y_t = \frac{1-\beta}{\alpha\beta_t} P_{t-1} \exp(g) \Longrightarrow y_t = \delta_t + m + p_{t-1} + g, \tag{14}$$

where $\delta_t = 0$ except possibly in period 1. This expression illustrates that, with transmission lags, the Fed might be unable to set output equal to its potential. For instance, in the first period, a positive demand shock $\delta_1 > 0$ can raise y_1 above y_1^* and induce a positive output gap. Likewise, an unanticipated negative supply shock $z_1 < 0$ can lower y_1^* below y_1 and also induce a positive output gap.

In this case, we assume the Fed sets policy to minimize the expected output gaps *under its belief*, $E_t^F \left[\sum_{h=0}^{\infty} \beta^h \tilde{y}_{t+h}^2\right]$. Then, the optimal policy implies

$$E_t^F [\tilde{y}_{t+1}] = 0 \Longrightarrow E_t^F [y_{t+1}] = E_t^F \left[y_{t+1}^*\right]. \tag{15}$$

The Fed sets output equal to potential output *in expectation*. Shocks relative to the Fed's expectations can induce positive or negative output gaps.

Suppose that all agents including the Fed know and agree that potential output for periods $t \geq 2$ follows the processes in (2). Recall also that in these future periods there are no demand shocks. Then, the future equilibrium is given by (cf. (7))

$$y_t = E_{t-1}[y_t^*] = y_{t-1}^* + g \quad \text{ and } \quad p_{t-1} = y_{t-1}^* - m \text{ for } t \geq 2. \tag{16}$$

Output is equal to the *ex-ante* expected potential output, $y_t = y_{t-1}^* + g$. The Fed adjusts the ex-ante asset price p_{t-1} to ensure this outcome (see (14)).

4.1. Fed's beliefs and asset prices

We focus on the output in the first period, y_1, and on the asset price in the previous period that brings about this outcome, p_0. To characterize this equilibrium, suppose in

[12] Theoretically, this type of delayed response of consumption to asset prices can emerge from a variety of frictions that range from adjustment costs to habit formation. See Bertola and Caballero (1990) for an early general review on adjustment costs and Alvarez et al. (2012) for a more recent article focused on consumption. See Campbell and Cochrane (1999) for a seminal paper that builds a model with consumption habits and Carrasco et al. (2004) for empirical evidence on habits.

period 0 the Fed believes the subsequent demand and supply shocks are uncorrelated with each other and are distributed according to:

$$\delta_1 \sim_F N\left(E_0^F\left[\delta_1\right], \overline{\sigma}_\delta^2\right) \quad z_1 \sim_F N\left(E_0^F\left[z_1\right], \overline{\sigma}_z^2\right). \tag{17}$$

$E_0^F\left[\delta_1\right], E_0^F\left[z_1\right]$ denote the Fed's *ex-ante* expectation and $\overline{\sigma}_\delta^2, \overline{\sigma}_\delta^2$ denotes its perceived variance of demand and supply shocks, respectively. For now, we also assume the Fed and the market have the same beliefs (we introduce disagreements in Section 4.4).

We can then combine Eqs. $(15), (14)$, and (2) to obtain the key equation of this section

$$p_0 = y_0^* - m + E_0^F\left[z_1\right] - E_0^F\left[\delta_1\right]. \tag{18}$$

Aggregate asset prices are determined by *future* expected macroeconomic needs *under the Fed's beliefs*. In particular, the aggregate price to potential output ratio $p_0 - y_0^*$ ("pystar") is increasing in the Fed's belief about future supply shocks ($E_0^F\left[z_1\right]$) and decreasing in the Fed's belief about future demand shocks ($E_0^F\left[\delta_1\right]$). The Fed targets higher asset prices when it expects aggregate supply to increase; it does so to increase aggregate demand to match the higher level of future aggregate supply. Conversely, the Fed targets lower asset prices when it expects aggregate demand to increase; it does so to prevent the inflationary boom that the higher level of future aggregate demand would otherwise cause.

Substituting (18) back into (14), yields

$$\begin{aligned} y_1 &= \overbrace{y_0^* + g + E_0^F\left[z_1\right]}^{E_0^F\left[y_1^*\right]} + \left(\delta_1 - E_0^F\left[\delta_1\right]\right) \\ \tilde{y}_1 &= \left(\delta_1 - E_0^F\left[\delta_1\right]\right) - \left(z_1 - E_0^F\left[z_1\right]\right) \end{aligned} \tag{19}$$

The Fed ensures that output y_1 is equal to its potential in expectation. However, realized output depends on demand shocks relative to the Fed's expectation. Likewise, the Fed ensures that output gap $\tilde{y}_1$ is equal to zero under its expectation, but the realized output gaps depend on demand and supply shocks relative to the Fed's expectation.

How does the Fed implement the asset price in (18)? To address this, we need to consider the financial market equilibrium in period 0. Recall that we assume the market has the same beliefs as the Fed, given by (17). Then, Eqs. $(6), (16)$ and (19) imply

$$\begin{aligned} E_0^M\left[r_1\right] &= \rho + g + E_0^F\left[\delta_1\right] \\ var_0^M\left[r_1\right] &= (1-\beta)^2\,\overline{\sigma}_\delta^2 + \beta^2\overline{\sigma}_z^2. \end{aligned} \tag{20}$$

Combining this with (5), we obtain

$$r_0^f = \rho + g + E_0^F[\delta_1] - \phi_0, \quad \text{where } \phi_0 \equiv \frac{(1-\beta)^2 \overline{\sigma}_\delta^2 + \beta^2 \overline{\sigma}_z^2}{2}. \tag{21}$$

The Fed implements p_0 by adjusting the interest rate appropriately. If the Fed anticipates high demand ($E_0^F[\delta_1] > 0$) it raises the interest rate and reduces the aggregate asset price p_0. In contrast, if the Fed anticipates high supply ($E_0^F[z_1] > 0$), the asset price rises without an interest rate reaction: this is because the market has the same belief as the Fed and its anticipation of high supply increases asset prices. The perceived variance of both demand shocks and supply shocks contribute to the risk premium, since these shocks affect the future cash-flows and future asset prices, respectively.

4.2. Macroeconomic news and asset prices

Eqs. (18) and (21) imply that macroeconomic news, as interpreted by the Fed, affects asset prices. To see this, suppose in period 0 agents' prior belief for next period's shocks are given by $\delta_1 \sim N(0, \sigma_\delta^2)$ and $z_1 \sim N(0, \sigma_z^2)$. In addition, agents receive signals about future demand and supply shocks:

$$\begin{aligned} n_{\delta 0} &= \delta_1 + e_{\delta 0}, \quad \text{where } e_{\delta 0} \sim N\left(0, \tilde{\sigma}_\delta^2\right) \\ n_{z0} &= z_1 + e_{z0}, \quad \text{where } e_{z0} \sim N\left(0, \tilde{\sigma}_z^2\right). \end{aligned}$$

For simplicity, the signal noises $e_{\delta 0}$ and e_{z0} are uncorrelated with each other. Then, after observing these signals, the Fed and the market have common posterior beliefs as in (17), with the means given by

$$\begin{aligned} E_0^F[\delta_1] &= \gamma_\delta n_{\delta 0}, \quad \text{where } \gamma_\delta = \frac{1/\tilde{\sigma}_\delta^2}{1/\sigma_\delta^2 + 1/\tilde{\sigma}_\delta^2}, \\ E_0^F[z_1] &= \gamma_z n_{z0}, \quad \text{where } \gamma_z = \frac{1/\tilde{\sigma}_z^2}{1/\sigma_z^2 + 1/\tilde{\sigma}_z^2}, \end{aligned} \tag{22}$$

and the perceived variances given by

$$\overline{\sigma}_\delta^2 = \frac{1}{1/\sigma_\delta^2 + 1/\tilde{\sigma}_\delta^2} \quad \text{and} \quad \overline{\sigma}_z^2 = \frac{1}{1/\sigma_z^2 + 1/\tilde{\sigma}_z^2}.$$

The posterior means are dampened versions of the corresponding signals, and the posterior variances are smaller than the prior variances.

Substituting (22) into (18) and (21), we obtain

$$\begin{aligned} p_0 &= y_0^* - m + \gamma_z n_{z0} - \gamma_\delta n_{\delta 0} && (23)\\ r_0^f &= \rho + g + \gamma_\delta n_{\delta 0} - \phi_0, && (24) \end{aligned}$$

where ϕ_0 is still given by (21).

A positive surprise in a macroeconomic announcement (news), such as nonfarm payrolls, typically implies that both supply and demand are stronger than expected. In this context, Eq. (23) says this *good news* can either increase (be *good news* for) or decrease (be *bad news* for) the aggregate asset price, depending on whether the supply or demand component dominates. In contrast, Eq. (24) says that positive news increases the interest rate as long as there is a positive demand component.[13] These results are consistent with a large empirical literature which finds that good macroeconomic news typically reduces bond prices (e.g., Fleming and Remolona (1997); Balduzzi et al. (2001)) but it can either raise or reduce stock prices depending on whether the expected cash-flow or the discount rate effect dominates (e.g., McQueen and Roley (1993)).

Relatedly, there is substantial evidence of a cyclical pattern in the price impact of news (see, e.g., McQueen and Roley (1993); Boyd et al. (2005); Andersen et al. (2007); Elenev et al. (2023)). In particular, during recessions *good news* is typically *good news* for stock prices, regardless of whether they are due to supply or demand surprises. Our model can accommodate these findings if we introduce a lower-bound constraint on the interest rate (or any other friction in the Fed's capacity to fully offset negative shocks). To illustrate this, suppose the interest rate rule is given by $r_0^f = \max\left(0, r_0^{f*}\right)$ as in Section 3.5. Suppose also that the parameters are such that the constraint binds and $r_0^f = 0$. Then, the equilibrium is characterized by the following system:

$$\begin{aligned} r_0^f &= 0\\ p_0 &= \beta E_0^F[y_1] + (1-\beta) E_0^F[y_1^*] - \phi_0\\ y_1 &= m + p_0 + g + \delta_1. \end{aligned}$$

The aggregate asset price depends on future output through cash-flows. In turn, future output depends on the past asset price through lagged effects. Solving the system, we obtain

$$p_0 = \overline{p}_0 + \gamma_z n_{z0} + \frac{\beta}{1-\beta}\gamma_\delta n_{\delta 0}, \tag{25}$$

[13]This result relies on our assumption that supply shocks are persistent. If the supply shocks are temporary and mean-revert, then a positive temporary supply shock can reduce the interest rate.

where $\overline{p}_0$ is the asset price that obtains when $n_{z0} = n_{\delta 0} = 0$.

In this case, demand news and supply news *both* increase the aggregate asset price. Intuitively, positive demand news raises expected output and cash-flows, which increases the aggregate asset price. The interest rate is constrained and does not undo the price impact of demand news. In fact, this price impact is amplified via a virtuous cycle by which high current asset prices increase expected future cash-flows, which further increases current asset prices, which further increase future cash-flows, and so on.[14]

4.3. Macroeconomic news and asset price volatility

In recent decades, macroeconomic news has become more precise due to better measurement (e.g., micro data) or better estimation techniques (e.g., machine learning). Our analysis implies that this type of improvement in news can have very different effects on output and asset price volatility. To see this, consider the case where the lower bound constraint does not bind and observe that output and asset prices are given by (see (19) and (23))

$$\begin{aligned} y_1 &= y_0^* + g + \gamma_z n_{z0} + \delta_1 - \gamma_\delta n_{\delta 0} \\ p_0 &= y_0^* - m + \gamma_z n_{z0} - \gamma_\delta n_{\delta 0}. \end{aligned} \tag{26}$$

Suppose $\tilde{\sigma}_\delta^2$ decreases so that the demand signal becomes more informative. This reduces the posterior demand variance $\overline{\sigma}_\delta^2$ but it also raises the weight on demand news γ_δ (see (22)). Thus, as we show in Caballero and Simsek (2023), more precise demand news makes output less volatile but asset prices *more volatile.* When the Fed can forecast the future better, it mitigates demand-driven business cycles and facilitates a "Great Moderation" in the real economy. However, since the Fed controls demand by *changing* asset prices, this moderation comes at the expense of greater Fed-induced volatility in markets.

Remark 2 (Macroeconomic news announcement premium)**.** *In our model, the volatility induced by macroeconomic news also increases the risk premium—and more so as the news becomes more precise. For instance, in the unmodeled period* -1*, the risk premium would be increasing in the variance of demand news that arrives in period* 0*,* $var_{-1}[\gamma_\delta n_{\delta 0}] = \sigma_\delta^2 - \overline{\sigma}_\delta^2$ *(see Caballero and Simsek (2023)). This* macroeconomic news premium *is broadly consistent with an empirical literature that finds stock returns and risk premia are high on*

[14] In Caballero and Simsek (forthcoming), we demonstrate a version of this result in a dynamic setting in which asset prices depend on the current output gap, in view of inertia, and macroeconomic news shifts the current output gap.

days with macroeconomic news announcements (see, e.g., Savor and Wilson (2013, 2014); Faust and Wright (2018)). On the other hand, since we work with a standard model with time-separable expected utility, our model cannot explain why this macro news premium is realized at the time of the announcement (in our model, the risk premium is realized somewhere between the end of period -1 *and the end of period* 0*). We could capture the announcement premium in a version of our model with non-expected utility preferences; for instance, a preference for early resolution of uncertainty or ambiguity aversion (see Ai and Bansal (2018)).*

4.4. Fed-market disagreements and policy "mistakes"

So far, we have assumed the Fed and the market have the same beliefs about future shocks. We next introduce disagreements and derive their implications for asset prices. Consider the same setup with two differences. First, for simplicity only, there is no news about future supply ($\tilde{\sigma}_z^2 = \infty$). Second, the Fed and the market can have different interpretations about future demand. Specifically, after observing the public signal, each agent $j \in \{F, M\}$ forms an idiosyncratic interpretation, μ_t^j. Given this interpretation, the agent believes the public signal is drawn from

$$n_{\delta 0} =^j \delta_1 - \mu_0^j + e_{\delta 0}, \quad \text{where } e_{\delta 0} \sim N\left(0, \tilde{\sigma}_\delta^2\right).$$

The noise term $e_{\delta 0}$ is i.i.d. across periods and independent from other random variables. The notation $=^j$ captures that the equality holds under agent j's belief. Given their interpretations, agents form posterior mean-beliefs:

$$E_0^F[\delta_1] = \gamma_\delta\left(n_{\delta 0} + \mu_0^F\right) \quad \text{and} \quad E_0^M[\delta_1] = \gamma_\delta\left(n_{\delta 0} + \mu_0^M\right), \tag{27}$$

where γ_δ is the same as before. Each agent thinks its interpretation is correct. Hence, when agents interpret the signal differently, they develop belief disagreements about the future aggregate demand shock. We assume agents observe the others' interpretations (and beliefs).

We also assume that agents' interpretations follow a joint Normal distribution (and both agents know this distribution):

$$\mu_0^F, \mu_0^M \sim N\left(0, \sigma_\mu^2\right) \quad \text{and} \quad corr\left(\mu_0^F, \mu_0^N\right) = \rho_0. \tag{28}$$

The correlation coefficient $\rho_0 \leq 1$ controls the extent of disagreement. When $\rho_0 = 1$, there are no disagreements. Otherwise, there are disagreements. Note that this specification also implies the regression

$$\mu_0^F = \rho_0 \mu_0^M + \varepsilon_0^F. \tag{29}$$

Here, $\rho_0 \mu_0^M$ denotes the component of μ_0^F that can be predicted by μ_0^M, and ε_0^F denotes the residual component.

In this case, the aggregate asset price is determined *entirely* by *the Fed's interpretation and belief*

$$p_0 = y_0^* - m - \gamma_\delta \left(n_{\delta t} + \mu_0^F \right). \tag{30}$$

That is, under the optimal policy *there is no role for the market's belief in determining the aggregate asset price.* Eq. (30) ensures that output and the output gap still satisfy (19) under the Fed's belief. In contrast, taking the expectation of (19) *under the market's belief,* we obtain

$$\begin{aligned} E_0^M [y_1] &= y_0^* + g + \gamma_\delta \left(\mu_0^M - \mu_0^F \right) \\ E_0^M [\tilde{y}_1] &= \gamma_\delta \left(\mu_0^M - \mu_0^F \right). \end{aligned} \tag{31}$$

Since the market disagrees with the Fed, it perceives policy "mistakes." When the market expects higher demand than the Fed, it expects a positive output gap (and vice versa if the market is more pessimistic than the Fed).

In Caballero and Simsek (2022), we show that the market's perceived "mistakes" affect the policy interest rate the Fed needs to set to implement the asset price in (30). To see this result, observe that Eqs. (6), (16), (31) and (5) now imply

$$\begin{aligned} r_0^f &= E_0^M [r_1] - \phi_0 \\ \text{where } E_0^M [r_1] &= \rho + g + \gamma_\delta n_{\delta 0} + \gamma_\delta \left((1-\beta) \mu_0^M + \beta \mu_0^F \right). \end{aligned} \tag{32}$$

The policy rate depends on both the market's and the Fed's interpretation of news. When the market expects higher demand than the Fed $\mu_0^M > \mu_0^F$, it expects high cash-flows and has high asset valuations. The Fed then needs to raise the interest rate more than a benchmark in which the market shared the same belief as the Fed.[15]

[15] In Caballero and Simsek (2023), we show that the interest rate the Fed needs to set also depends on the extent of inertia.

4.5. Monetary policy shocks driven by Fed belief surprises

As we discuss in Section 2.1, a large literature in finance and macroeconomics analyzes the response of asset prices to monetary policy shocks. This literature typically takes monetary policy shocks as random deviations from a rule. This assumption raises several concerns with interpretation and identification, since in practice the Fed does not randomly set interest rates. In Caballero and Simsek (2022), we provide a theory of *endogenous* monetary policy shocks driven by Fed's belief surprises.

To illustrate these results, suppose we divide period 0 into two phases. In the first phase, agents observe the signal $n_{\delta 0}$ and their *own* interpretations μ_0^M, μ_0^F. Suppose also that the Fed observes the market's interpretation μ_0^M (in practice, the Fed might infer the market's interpretation from the yield curve or other asset prices). However, the market does not know the Fed's interpretation. In the second phase, the market observes the Fed's interpretation. Let $\tilde{E}_0^M[\cdot]$ denote the market's expectation in the first phase and $E_0^M[\cdot]$ denote its expectation in the second phase. We also use $\Delta x = x - \tilde{E}_0^M[x]$ to denote the surprise realization of a variable x in the second phase relative to the market's expectation.

In the first phase, Eq. (29) implies that the market expects the Fed's interpretation to be $\tilde{E}_0^M\left[\mu_0^F\right] = \rho_0 \mu_0^M$. Therefore, using (30) and (32), the market also expects

$$\begin{aligned}
\tilde{E}_0^M[p_0] &= y_0^* - m - \gamma_\delta\left(n_{\delta t} + \rho_0 \mu_0^M\right) \\
\tilde{E}_0^M\left[r_0^f\right] &= \rho + g + \gamma_\delta n_{\delta_t} + \gamma_\delta\left((1-\beta)\,\mu_0^M + \beta \rho_0 \mu_0^M\right) - \phi_0.
\end{aligned}$$

In the second phase, the market learns the Fed's interpretation and therefore p_0, r_0^f are given by (30) and (32). Combining these observations and using (32), we obtain

$$\Delta p_0 = -\gamma_\delta \varepsilon_0^F \quad \text{and} \quad \Delta r_0^f = \beta \gamma_\delta \varepsilon_0^F.$$

If the Fed is revealed to be more demand-optimistic than the market expected, then the interest rate increases and the aggregate asset price declines (and vice versa if the Fed is revealed to be more demand pessimistic). This provides a theory of *endogenous* monetary policy shocks driven by Fed belief surprises.

4.6. Policy risk premium driven by disagreements

In Caballero and Simsek (2023), we further show that the Fed-market disagreements affect the risk premium. To illustrate these results, we extend the model to introduce the possibility of disagreements in period 1. Specifically, suppose we shift all periods forward by one so that period 1 has the same structure as in the earlier analysis. We also allow agents' interpretations in period 1 to be driven by the following analogue of (28)

$$\mu_1^F, \mu_1^M \sim N\left(0, \sigma_\mu^2\right) \quad \text{and} \quad corr\left(\mu_1^F, \mu_1^N\right) = \rho_1. \tag{33}$$

The future interpretations μ_1^F, μ_1^M are uncorrelated with past interpretations. As before, $\rho_1 \leq 1$ captures (inversely) the scope for disagreements.

With these assumptions, the asset price and output in period 1 is given by the following analogues of (30) and (19)

$$\begin{aligned} p_1 &= y_1^* - m - \gamma_\delta\left(n_{\delta 1} + \mu_1^F\right) \\ y_1 &= y_0^* + g + \left(\delta_1 - \gamma_\delta\left(n_{\delta 0} + \mu_0^F\right)\right). \end{aligned}$$

Now consider the market's expectation of p_1 and y_1 from the perspective of period 0. For y_1, the same analysis as before implies

$$\begin{aligned} E_0^M\left[y_1\right] &= y_0^* + g + \gamma_\delta\left(\mu_0^M - \mu_0^F\right) \\ var_0^M\left[y_1\right] &= \overline{\sigma}_\delta^2. \end{aligned}$$

For p_1, we instead have

$$\begin{aligned} E_0^M\left[p_1\right] &= y_0^* + g - m \\ var_0^M\left[p_1\right] &= \sigma_z^2 + \sigma_\delta^2 - \overline{\sigma}_\delta^2 + \gamma_\delta^2 D_1 \sigma_\mu^2 \quad \text{where } D_1 \equiv 2\left(1 - \rho_1\right). \end{aligned}$$

The term $\sigma_\delta^2 - \overline{\sigma}_\delta^2$ captures the asset price volatility the market expects due to future demand news (that arrive in period 1) in a common belief benchmark. Importantly, the term $\gamma_\delta^2 D_1 \sigma_\mu^2$ captures the additional asset price volatility the market expects due to disagreements about the future demand news. This term depends on the parameter D_1, which captures the scope for future disagreements. The market recognizes that the future asset price will depend on the Fed's beliefs and it thinks that Fed's beliefs will be "noisy" due to disagreements. Therefore, the market expects higher asset price volatility.

In equilibrium, this perceived volatility is priced and affects the risk premium. In particular, combining the expressions for the variance with (6) and (5), we obtain

$$\begin{aligned} \phi_0 &= \frac{var_0^M [r_1]}{2} \quad \text{where} \\ var_0^M [r_1] &= (1-\beta)^2 \overline{\sigma}_\delta^2 + \beta^2 \left(\overline{\sigma}_z^2 + \sigma_\delta^2 - \overline{\sigma}_\delta^2 \right) + \beta^2 \gamma_\delta^2 D_1 \sigma_\mu^2. \end{aligned} \tag{34}$$

The rest of the equilibrium is the same as before. In particular, Eq. (32) still holds after replacing ϕ_0 with (34).

Eq. (34) shows that disagreements between the market and the Fed increases the risk premium. We refer to the component of risk premium $\beta^2 D_1 \sigma_\mu^2$ as a *policy risk premium.* We expect this component to be especially large when macroeconomic uncertainty is elevated and the Fed and the market disagree with each other.

Remark 3 (Monetary policy announcement premium)**.** *Our policy risk premium is consistent with an empirical literature which finds that large stock returns and risk premia realized on or around FOMC announcement days (e.g., Savor and Wilson (2013); Lucca and Moench (2015)). In fact, as we illustrate in Section 4.5, the uncertainty about the extent of Fed-market disagreements—which drives the policy risk premium in our model—is likely to be resolved through policy announcements or speeches. Therefore, a version of our model with an appropriate non-expected utility preference could explain the policy* announcement *premium—similarly to our proposed explanation for the macroeconomic news announcement premium (see Remark 2).*

5. Final Remarks

We began this article by examining the empirical evidence that supports a "risk-centric" view of monetary policy and its effects on asset prices. While our main focus was on stock prices, many of our findings also apply to other assets like real estate and fixed income. Our observations can be summarized into five main points: (i) Monetary policy significantly influences stock prices; (ii) large fluctuations in stock prices prompt reactions from monetary policy; (iii) the primary purpose of this reaction is to manage aggregate demand, (iv) stock price wealth effects are substantial and manifest over extended periods (long lags); (v) stock prices largely drive the fluctuations in financial conditions indices in the U.S. and, to a lesser extent, in other major economies.

Subsequently, we revisited our previous research on the asset pricing implications of this perspective. We introduced a simplified New Keynesian model that incorporates asset markets, risk, and transmission delays. The model has two key insights. First, when monetary policy is unrestricted, the aggregate asset price is determined by *macroeconomic needs*—imbalances between aggregate demand and supply—rather than by conventional financial forces. Instead, these conventional forces determine relative asset prices and the interest rate policy the Fed needs to set to meet its objectives. Second, transmission lags imply that the aggregate asset price is driven by *the Fed's beliefs* about *future* macroeconomic needs. These two insights translate into several results, including: (i) the Fed stabilizes the aggregate asset price in response to financial shocks, using large-scale asset purchases if needed ("the Fed put"); (ii) when the Fed is constrained, negative financial shocks induce demand recessions, even in absence of standard financial frictions, and can trigger downward asset price spirals; (iii) the Fed's response to aggregate demand shocks increases asset price volatility, but this volatility plays a useful macroeconomic stabilization role; (iv) the Fed's beliefs about future aggregate demand and supply drive asset prices; (v) macroeconomic news about aggregate demand and supply influences the Fed's beliefs and therefore asset prices, with good news (higher demand and supply) typically reducing bond prices but having a more nuanced effect on the aggregate asset price; (vi) more precise news can reduce output volatility while heightening asset market volatility; (vii) disagreements between the market and the Fed provide a microfoundation for monetary policy shocks and create an endogenous policy risk premium.

In terms of extensions, in Caballero and Simsek (2023, forthcoming), we explore two additional dimensions: internal demand inertia and inflation. First, not only do households respond to asset prices with a lag, but they also tend to echo their previous spending habits. By accounting for this internal demand inertia, current output persists into subsequent periods, even in the absence of lasting shocks. In response, the Fed aims for a "pystar" that counteracts the lingering impacts of the present output. If output is below its potential, the Fed proactively overshoots asset prices. While this strategic overshooting may give the impression of a misalignment between the real economy and financial markets, it effectively hastens the recovery. In this context, disagreements give rise to a "behind-the-curve" phenomenon, wherein the market anticipates a policy reversal by the Fed. Second, in this paper we assumed that goods prices are fully sticky. In Caballero and Simsek (2023), we endogenize inflation using a standard New Keynesian Phillips Curve and find a negative correlation between inflation and the aggregate asset price, regardless of whether demand or supply shocks drive inflation.[16]

Finally, we note that our article highlights the value of making FCIs the main interme-

[16] This is consistent with recent evidence in Fang et al. (2022). See Cieslak and Pflueger (2023) for a review of the empirical literature on inflation and asset prices.

diate target of monetary policy. While in the current article this is mostly an alternative formalization of an interest rate policy rule, our early exploration of this theme suggests that making the intermediate target explicit has value in terms of reducing volatility in financial markets and the economy.

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