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Monetary Policy and Asset Price Overshooting: A Rationale for the Wall/Main Street Disconnect

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ABSTRACT

We analyze *optimal* monetary policy and its implications for asset prices when aggregate demand has inertia. If there is a negative output gap, the central bank optimally overshoots aggregate asset prices (above their steady-state levels consistent with current potential output). Overshooting leads to a temporary disconnect between the performance of financial markets and the real economy, but accelerates the recovery. When there is a lower bound constraint on the discount rate, good macroeconomic news is better news for asset prices when the output gap is more negative. Finally, we document that during the COVID-19 recovery, the policy-induced overshooting was large.

THE INITIAL RECOVERY FROM THE COVID-19 recession featured a large disconnect between the performance of the real economy and financial markets. The left panel of Figure 1 shows that, by the end of 2020, U.S. output was still significantly below its long-run potential, whereas stock prices (as well as house and bond prices) vastly exceeded their prepandemic levels.[1] The robust recovery of asset markets was primarily due to the aggressive monetary (and fiscal) policy response to the COVID-19 shock. During the early stages of the recession, monetary policy stabilized asset prices by containing and then reversing the large spike in the risk premium (see, for example, Caballero and Simsek (2021a)). Subsequently, monetary policy supported asset prices by keeping short and long interest rates low. By the end of 2020, the excess

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[1] The early disconnect between the quick recovery of financial markets and the sluggish response of the real economy was the source of much debate, as highlighted by the cover page of *The Economist*, May 9, 2020 ("A dangerous gap: The markets v the real economy").

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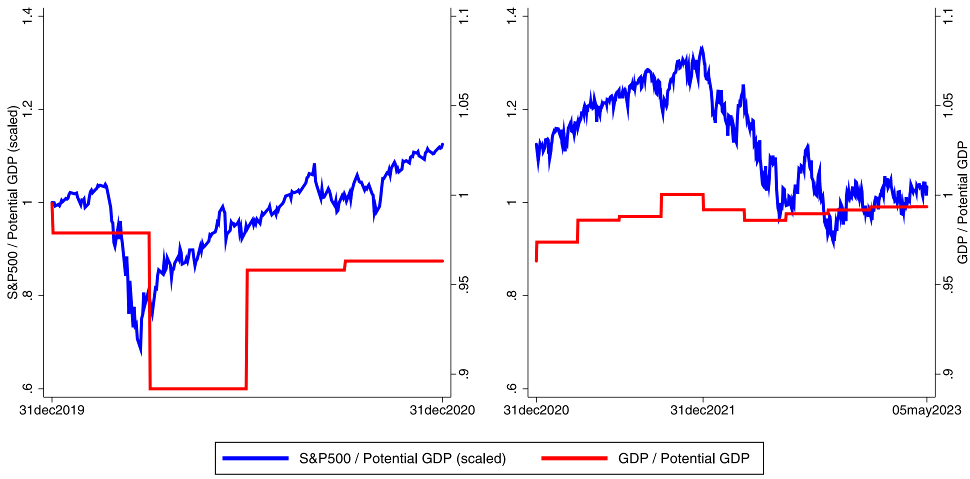

Figure 1. The Wall/Main Street disconnect and the subsequent reconnect. The blue line in this figure shows the series for the S&P 500 index over potential GDP, scaled to equal one on December 31, 2019. The red line shows the series for the GDP over potential GDP. Potential GDP is the estimate by the Congressional Budget Office (CBO). For data sources, see the Internet Appendix.

valuation in asset prices (relative to pre-COVID) was mostly attributable to the sharp decline in safe real rates, rather than to a decline in the risk premium (see Section III and Knox and Vissing-Jorgensen (2022)). A debate then emerged regarding whether monetary policy support was excessive and creating frothy financial market conditions.

Fast-forward to 2022 and the disconnect between the real economy and the markets disappeared.[2] The economy recovered faster than most people expected, and the rapid recovery created inflationary pressures. The Fed responded to the rise in inflation by announcing the gradual withdrawal of monetary policy support. This announcement led to a sharp decline in asset prices and induced a reconnect between the markets and the economy. The decline in stock prices in 2022 can be explained largely by the increase in real interest rates (see Section III).

In this paper, we present a model in which this type of initial disconnect and subsequent reconnect between the markets and the economy, driven by policy-induced fluctuations in real rates, is not an anomaly but rather a desirable feature. Our model is similar to the textbook New Keynesian model, with the key difference being that aggregate demand has inertia and responds to asset prices gradually (see, for example, Chodorow-Reich, Nenov, and Simsek (2021) for empirical evidence supporting this property). Our main result shows that, when output is below its potential, monetary policy optimally induces asset price overshooting: Aggregate asset prices are initially

[2] The Internet Appendix is available in the online version of the article on *The Journal of Finance* website.

high (above their steady-state levels consistent with current potential output) even though output is low. A central bank that dislikes output gaps reduces real rates and boosts asset prices to close the output gap as fast as possible. This boost creates a large, temporary disconnect between the performance of financial markets and the real economy, but it also accelerates the recovery. As output recovers, the central bank gradually raises real rates and reverses the asset price overshooting, which reconnects markets and the economy.

The specific reason for the overshooting result in our model is that individual agents adjust their consumption infrequently. Output is determined by aggregate demand, and aggregate demand depends on asset prices through a wealth effect on consumption. With continuous and full microeconomic adjustments, the central bank "sets" asset prices at the right level, to make aggregate demand equal to potential output at all times. In contrast, with infrequent microeconomic adjustments, a central bank facing a negative output gap due to a depressed aggregate demand needs to overshoot asset prices so that those agents that do adjust (partially) compensate for the depressed consumption of those that do not. At a more general level, the key factor that drives overshooting is the inertial response of aggregate demand to asset prices. Aggregate demand inertia also emerges from frictions outside of our model, such as habit formation (see the literature review for further discussion).[3]

Our second set of results follows from adding a lower bound constraint on the discount rate. This constraint makes the overshooting a concave and nonmonotonic function of the output gap. For a deeply negative initial output gap, the asset price boost is low since the constraint is severely binding. As the output gap improves (becomes less negative) up to a threshold, the asset price boost grows since the constraint is effectively relaxed. As the output gap improves beyond the threshold, the asset price boost shrinks toward zero. In this range, the central bank is nearly unconstrained and it optimally "tapers" the overshooting in response to an improvement in the output gap. This interaction between constraints and optimal overshooting also provides an explanation for the fact that the impact of macroeconomic news on stock prices depends on the stage of the business cycle (e.g., McQueen and Roley (1993), Boyd, Hu, and Jagannathan (2005), Andersen et al. (2007), Elenev et al. (2023)). In our model, as in the data, good macroeconomic news is better news for asset prices when the output gap is more negative and the economy is farther from full recovery.

Our last set of results documents the size and impact of the policy-induced overshooting during the recovery from the COVID-19 recession. To facilitate this exercise, we decompose the aggregate asset price in our setting into a "market bond portfolio" driven by forward interest rate changes and a "residual" driven by expected cash flows and other factors. The market bond portfolio captures the policy support to asset prices through risk-free rates. The

[3] Aggregate demand inertia also provides a natural explanation for the "long and variable" monetary policy transmission lags observed in practice (see Woodford (2005), Chapter 5, for a formalization). In a recent speech, Federal Reserve Chairman Powell emphasized the importance of these transmission lags: "Finally, we continue to believe that monetary policy must be forward looking, taking into account… the lags in monetary policy's effect on the economy" (Powell (2020)).

price of this portfolio increased substantially during the COVID-19 recovery—sufficient to explain the high levels of stock and house prices in 2021. A back-of-the-envelope calculation suggests that this asset price overshooting in 2021 increased output in 2022 by about 2.2%.

Literature review. In our model, monetary policy operates through financial markets as in Caballero and Simsek (2020, 2021a, 2021b). The central bank affects asset prices, which in turn affect aggregate demand. The distinctive feature of this paper is the delayed response of aggregate demand to asset prices. Also, in the context of the COVID-19 recession, Caballero and Simsek (2021a) provide an explanation for the large initial decline in asset prices and highlight the key role of large-scale asset purchases (LSAPs) in reversing that decline, while this paper provides a rationale for the subsequent Wall/Main Street disconnect (see Figure 1).

Our paper is part of a large New Keynesian literature (see Woodford (2005) and Galí (2015) for textbook treatments). Our key ingredient—aggregate demand inertia—is routinely assumed in quantitative New Keynesian models because it helps match the observed gradual response of spending to a variety of shocks (see Brayton, Laubach, and Reifschneider (2014)). However, the policy implications of aggregate demand inertia are less well understood. Fuhrer (2000) and Amato and Laubach (2004) study the optimal monetary policy implications of habit formation, a specific source of aggregate demand inertia.[4] We also study optimal monetary policy with aggregate demand inertia, but we focus on the implications for asset prices and obtain an overshooting result. In follow-on work (Caballero and Simsek (2023)), we investigate the effects of aggregate demand inertia in an environment with a temporary supply shock. There, we focus on the implications for overheating and inflation, rather than on asset prices and overshooting.

We capture aggregate demand inertia by assuming infrequent adjustment of individual consumption. An extensive literature on durables' consumption (and investment) uses fixed adjustment costs to document this type of infrequent adjustment and its implications for aggregate durables' consumption and investment (see Bertola and Caballero (1990) for an early survey). A related literature emphasizes infrequent reoptimization for broader consumption categories, due to behavioral or informational frictions, and uses this feature to explain the inertial behavior of aggregate consumption (e.g., Caballero (1995), Reis (2006)) as well as asset pricing puzzles (e.g., Lynch (1996), Marshall and Parekh (1999), Gabaix and Laibson (2001)). We take infrequent adjustment of individual consumption as given (driven by a Poisson process for simplicity) and study its implications for optimal monetary policy.

Our asset price decomposition in the context of the COVID-19 recovery is related to recent work by Van Binsbergen (2020) and Knox and Vissing-Jorgensen (2022). Our market bond portfolio is the same as the duration-

[4] A strand of the literature uses models of aggregate demand inertia to compare the performance of different monetary policy rules (see, for example, Svensson (2003) and Svensson and Woodford (2007)).

matched fixed-income portfolio analyzed by Van Binsbergen (2020). We focus on the price change of this portfolio, which is central for our analysis, whereas Van Binsbergen (2020) focuses on the total return. Likewise, Knox and Vissing-Jorgensen (2022) focus on the total return of the stock market and provide a more general asset-price decomposition that incorporates the risk premium and cash flow news, in addition to the safe-rate news that we analyze. For the COVID-19 episode, Knox and Vissing-Jorgensen (2022) find that the initial decline in stock prices is driven by an increase in the risk premium, but the subsequent recovery and boom are heavily influenced by declining interest rates, consistent with our findings. More broadly, a growing empirical literature analyzes stock price changes after the COVID-19 shock and finds that monetary policy plays a large role (see, for example, Gormsen and Koijen (2020)).[5] Also, as we discuss in Section II.B, our results with constrained monetary policy shed some light on the empirical literature documenting that the impact of macroeconomic news on asset prices depends on the stage of the business cycle.

In terms of the model's ingredients, this paper is related to and supported by an extensive empirical literature documenting that: (i) monetary policy affects asset prices (e.g., Jensen, Mercer, and Johnson (1996), Thorbecke (1997), Jensen and Mercer (2002), Rigobon and Sack (2004), Ehrmann and Fratzscher (2004), Bernanke and Kuttner (2005), Bauer and Swanson (2020))—these papers find that, on average, an unanticipated 100 basis points (bp) increase in the policy rate or the one-year treasury yield is associated with a 5% to 7% decrease in stock market returns; (ii) asset prices affect aggregate demand and output (e.g., Davis and Palumbo (2001), Dynan and Maki (2001), Gilchrist and Zakrajšek (2012), Mian, Rao, and Sufi (2013), Kyungmin, Laubach, and Wei (2020), Di Maggio, Kermani, and Majlesi (2020), Chodorow-Reich, Nenov, and Simsek (2021), Guren et al. (2021))—these papers find wealth and balance sheet effects in the range of 3 to 10 cents on the dollar depending on the sample and the specific asset price;[6] and (iii) the effect of asset prices on aggregate demand and output is gradual (e.g., Davis and Palumbo (2001), Dynan and Maki (2001), Lettau and Ludvigson (2004), Carroll, Otsuka, and Slacalek (2011), Case and Shiller (2013), Chodorow-Reich, Nenov, and Simsek (2021))—these papers find that consumption typically takes about two years to fully adjust to stock price changes.

The rest of the paper is organized as follows. Section I introduces our baseline model, establishes our main overshooting result, and discusses several

[5] Several studies find that unconventional monetary policies (which we discuss in Section III) also had a large positive impact on asset prices (e.g., Fed (2020), Cavallino and De Fiore (2020), Arslan, Drehmann, and Hofmann (2020), Haddad, Moreira, and Muir (2021)). Other studies analyze the broader set of factors that drive asset prices during the Covid-19 episode (e.g., Ramelli and Wagner (2020), Landier and Thesmar (2020), Baker et al. (2020), Davis, Liu, and Sheng (2021), Davis, Hansen, and Seminario-Amez (2021)).

[6] In addition, Cieslak and Vissing-Jorgensen (2020) show that the Fed pays attention to the stock market, mainly because policymakers believe that the stock market affects the economy through a wealth effect.

extensions. Section II analyzes asset price overshooting with a discount-rate lower bound. Section III quantifies the asset price overshooting driven by risk-free rates during the recovery from the COVID-19 recession. Section IV provides final remarks. The Internet Appendix contains omitted microfoundations, proofs, extensions, and details on the empirical analysis.

I. Aggregate Demand Inertia and Overshooting

In this section, we describe our model, define the equilibrium, and establish our main results. We focus on a recovery scenario following a recessionary shock to the economy, when aggregate demand is below potential output. We show that when aggregate demand has inertia and responds to asset prices gradually, optimal monetary policy overshoots asset prices, which creates a disconnect between the performance of asset prices and the real economy. We keep the baseline model simple and discuss various extensions at the end of the section.

A. Environment and Equilibrium

Our model is a variant of the textbook New Keynesian model presented in Galí (2015). The key difference is aggregate demand inertia, which is central for our asset price overshooting and disconnect results.

Agents. There are two types of agents, denoted by superscripts $i = s$ ("stockholders") and $i = h$ ("hand-to-mouth households"). This separation is useful because it allows us to decouple stockholders' consumption problem from the labor supply decision. Our focus is on stockholders, whose spending has inertia and responds to asset prices sluggishly. Stockholders own all financial assets (claims on firms' profits) but do not supply any labor. Hand-to-mouth households supply labor (endogenously) and spend all of their income in each period.

Supply side and nominal rigidities. Time $t \geq 0$ is continuous and there is no uncertainty. A competitive final goods producer combines the intermediate goods according to the constant elasticity of substitution (CES) technology $Y(t) = \left(\int_0^1 Y(t, \nu)^{\frac{\varepsilon-1}{\varepsilon}} d\nu\right)^{\varepsilon/(\varepsilon-1)}$ for some $\varepsilon > 1$. A continuum of monopolistically competitive firms, denoted by $\nu \in [0, 1]$, produce the intermediate goods. These firms have fully sticky nominal prices (we endogenize inflation in the Internet Appendix). Since these firms operate with a markup, they find it optimal to meet the demand for their good (for relatively small demand shocks, which we assume). Output is therefore determined by aggregate demand, which depends on the consumption of stockholders, $C^s(t)$, and hand-to-mouth households, $C^h(t)$:

$$Y(t) = C^s(t) + C^h(t). \tag{1}$$

Labor, L, is the only factor of production. The intermediate good firms produce according to the Cobb-Douglas technology

$$Y(t, \nu) = AL(t, \nu)^{1-\alpha},$$

where $1-\alpha$ denotes the share of labor. Labor is supplied by hand-to-mouth households. They have per-period utility function

$$\log C^h(t) - \chi \frac{L(t)^{1+\varphi}}{1+\varphi},$$

which leads to a standard labor supply curve (see Section I of the Internet Appendix).

With these production technologies, if the model was fully competitive, the labor's share of output would be constant and given by $(1-\alpha)Y(t)$. However, since the intermediate-good firms have monopoly power and make pure profits, the labor's share is smaller than $(1-\alpha)Y(t)$. To simplify the exposition, we assume that the government taxes part of firms' profits (lump-sum) and redistributes to workers (lump-sum) so that the labor's share is as in the fully competitive case. This implies that the spending of hand-to-mouth households (who supply all labor) is[7]

$$C^h(t) = (1-\alpha)Y(t). \tag{2}$$

Combining equations (1) and (2) yields

$$Y(t) = \frac{C^s(t)}{\alpha}. \tag{3}$$

Hand-to-mouth households create a Keynesian multiplier effect, but output is ultimately determined by stockholders' spending, $C^s(t)$.

In Section I of the Internet Appendix, we characterize the equilibrium in a flexible-price benchmark economy without nominal rigidities (the same setup except the intermediate good firms have fully flexible prices). In this benchmark, labor supply is the solution to $\chi (L^*)^{1+\varphi} = \frac{\varepsilon-1}{\varepsilon}$ and output is given by $Y^* = A(L^*)^{1-\alpha}$. We refer to Y^* as the potential output. In our model with sticky prices, output is determined by equation (3) and can deviate from potential output. We define the output gap as the log-deviation of output from its potential, $y(t) = \log\left(\frac{Y(t)}{Y^*}\right)$.

Financial markets. There are two assets. First, there is a market portfolio that is a claim on firms' profits, $\alpha Y(t)$ (the firms' share of output). We let $P(t)$ and $R(t)$ denote the real price and the real discount rate of the market portfolio. Second, there is a risk-free asset in zero net supply with real interest rate $R^f(t)$. The central bank controls $R^f(t)$ by setting the nominal interest rate. Since there is no inflation in the baseline model, the nominal and real interest rates are the same. Since there is no risk, the interest and discount rates

[7] Formally, letting $T(t)$ denote the appropriate transfer, hand-to-mouth agents' income is $W(t)L(t) + T(t) = (1-\alpha)Q(t)Y(t)$, where $W(t)$ is the nominal wage, $Q(t) = \left(\int Q(t,\nu)^{1-\varepsilon} d\nu\right)^{1/(1-\varepsilon)}$ is the nominal price of the final good, and $Q(t,\nu)$ denotes the nominal price of good ν. See Section I of the Internet Appendix for details.

are also the same, $R^f(t) = R(t)$. Going forward, we drop $R^f(t)$ from the notation and assume that the central bank directly controls the discount rate. We discuss how a risk premium would affect our analysis in Section I.C.5.

By definition of the return, the discount rate on the market portfolio satisfies

$$R(t) = \frac{\alpha Y(t) + \dot{P}(t)}{P(t)}. \tag{4}$$

Log-linearizing this equation around the steady state with potential levels (characterized below), we also obtain

$$r(t) = \frac{\rho}{1+\rho}(y(t) - p(t)) + \frac{1}{1+\rho}\dot{p}(t). \tag{5}$$

Here, $x(t) = \log\left(\frac{X(t)}{X^*}\right)$ is the log-deviation of the corresponding variable from its potential level, with the exception of $r(t) \equiv \log\frac{1+R(t)}{1+R^*}$, which denotes the log-deviation of the gross discount rate from its potential.

Equation (5) is the continuous-time version of the standard Campbell-Shiller return approximation. Integrating this equation forward (and using $\lim_{t\to\infty} p(t) = 0$, which will hold in equilibrium), we also obtain the present discounted value formula:

$$p(t) = p^{MB}(t) + p^C(t) \tag{6}$$

$$\text{where} \quad p^{MB}(t) = -\int_t^\infty e^{-\rho(s-t)}(1+\rho)r(s)ds$$

$$p^C(t) = \int_t^\infty e^{-\rho(s-t)}\rho y(s)ds.$$

In log-deviations, the price is determined by (expected) future interest rates and (expected) future cash flows. For future reference, we decompose the price into components that are purely explained by rates and cash flows, denoted by $p^{MB}(t)$ and $p^C(t)$. We refer to the former component as the market bond portfolio—it corresponds to the price of a bond portfolio that has the same duration as the market portfolio (see Section III for further discussion).

Benchmark without inertia. There is a continuum of identical stockholders who own the market portfolio and make consumption-savings and portfolio choices. These stockholders have time-separable log utility, with discount rate ρ. If there were no other frictions, stockholders would spend a constant fraction of their wealth,

$$C^s(t) = \rho P(t). \tag{7}$$

Using equation (3), if the central bank adjusts the asset return to target an output level equal to its potential, the economy immediately reaches a steady state:

$$Y(t) = Y^*, \quad C^s(t) = C^{s,*} = \alpha Y^*, \tag{8}$$

$$R(t) = R^* = \rho \quad \text{and} \quad P^* = \frac{\alpha Y^*}{\rho}.$$

In our setting, monetary policy can be interpreted as working through a wealth effect: By setting aggregate asset prices (wealth) at the appropriate level (P^*), monetary policy ensures that stockholders' spending is aligned with aggregate supply (see Remark 1 for an alternative interpretation). We next introduce aggregate demand inertia.

Aggregate demand inertia. We depart from the benchmark environment by assuming that stockholders adjust their spending (and portfolio allocations) infrequently. At every instant, a random fraction of stockholders adjusts, with constant hazard θ. Their allocations remain unchanged until the next time they have a chance to adjust. Let $C^{s,adj}(t)$ denote the adjusting stockholders' total spending. Since the adjusting stockholders are randomly selected, stockholders' total spending follows

$$\dot{C}^s(t) = \theta\Big(C^{s,adj}(t) - C^s(t)\Big).$$

Total spending increases if and only if the adjusting stockholders' spending exceeds the current level of spending, $C^s(t)$. Using equation (3), and log-linearizing around the potential steady state, we further obtain

$$\dot{y}(t) = \theta\Big(c^{s,adj}(t) - y(t)\Big). \tag{9}$$

Equation (9) captures our key friction: Aggregate demand (and the output gap) has inertia and responds to the spending decisions of adjusting stockholders sluggishly. The hazard parameter θ captures the degree of aggregate demand inertia.[8]

Wealth effect with aggregate demand inertia. We next specify adjusting stockholders' consumption. We start by considering the case in which the adjusting stockholders are sophisticated and anticipate that they will be able to readjust their consumption in the future. This case uncovers the drivers of optimal consumption with inertia and motivates our main specification, where we assume that consumption follows a simple rule that is (qualitatively) consistent with the optimal rule.

The following result characterizes the optimal consumption at time $t = 0$. The problem is recursive, and the same rule also applies at future times (see the proof in the Internet Appendix).

LEMMA 1: *Consider the optimization problem of a (sophisticated) stockholder with wealth $A(0)$ that can adjust at time $t = 0$ and accounts for the fact that*

[8] For symmetry, we assume that stockholders are also sluggish with respect to their portfolio choices, although this does not play any role in our analysis. Specifically, equation (4) also holds with sluggish stockholders. Given these returns, those stockholders who adjust are indifferent to changing their portfolios. We assume that all stockholders invest all of their wealth in the market portfolio, which ensures market clearing.

she will adjust in the future according to a Poisson event with hazard rate θ. The optimal consumption satisfies

$$C^{s,adj}(0) = \rho A(0) X(0), \tag{10}$$

where $X(0)$ is the unique solution to the equation

$$\frac{1}{X(0)} = \int_0^\infty \theta(\theta+\rho) e^{-(\theta+\rho)T} \frac{\int_0^T \exp\left(-\int_0^t R(s)ds\right)dt}{1-\rho X(0)\int_0^T \exp\left(-\int_0^t R(s)ds\right)dt} dT. \tag{11}$$

For the steady state with $R^*(t) = \rho$ for each t, we have $X^*(0) = 1$. Starting from this steady state, a small increase in future interest rates (over any time interval with positive Lebesgue measure) increases $X(0)$.

To understand this result, consider the optimal consumption in the benchmark case without inertia given by (7). In this case, consumption is determined by a pure wealth effect, because log preferences imply that income and substitution effects exactly cancel each other. With inertia, there is still a wealth effect on consumption, captured by the term $A(0)$ in (10). However, there is an additional adjustment for anticipated future interest rates, captured by the term $X(0)$. Equation (11) characterizes this adjustment and implies that it is increasing in future interest rates. The fact that the stockholder cannot reoptimize in the future (in some states) weakens the substitution effect. Therefore, despite log preferences, the substitution and income effects do not net out. Instead, the income effect dominates and implies that, controlling for wealth, spending is increasing in future interest rates. A higher discount rate makes it cheaper to finance a steady consumption stream ($C^{s,adj}$), which induces the stockholder to spend more. In the limit with very rapid adjustment, $\theta \to \infty$, we recover the benchmark consumption rule, $X(0) \to 1$.

In general, optimal consumption is complicated and depends on the whole path of future interest rates. In equilibrium, we will see that the economy converges to the steady state at a constant rate. Our next result shows that optimal consumption has a simple formulation along these types of constant-rate convergence paths.

LEMMA 2: *Consider a representative adjusting stockholder with wealth $A(0) = P(0)$. Suppose $r(t) = r(0)\exp(-\gamma t)$, where $\gamma > 0$. Then the optimal log-linearized consumption satisfies*

$$c^{s,adj}(0) = p(0) + \frac{(1+\rho)r(0)}{\theta+\gamma}. \tag{12}$$

Suppose, in addition, $p(t) = p(0)\exp(-\gamma t)$. Then the interest rate gap satisfies $(1+\rho)r(0) = \rho y(0) - (\rho+\gamma)p(0)$, and log-linearized consumption can be written as a function of the current asset price and current output:

$$c^{s,adj}(0) = \frac{\theta-\rho}{\theta+\gamma} p(0) + \frac{\rho}{\theta+\gamma} y(0). \tag{13}$$

Equation (12) calculates (10) and (11) along a path in which interest rates converge to the steady state at the constant rate γ. The interest rate adjustment term, $\frac{(1+\rho)r(0)}{\theta+\gamma}$, is declining in the convergence rate γ as well as in the adjustment rate θ. Equation (13) substitutes the interest rate using (5) to write consumption as a function of asset prices and output. As long as $\theta > \rho$ (adjustment is not too sluggish), the coefficient in front of the asset price is positive but less than one, $\frac{\theta-\rho}{\theta+\gamma} \in (0, 1)$.

Importantly, equation (13) implies that, as in the benchmark model without inertia, monetary policy can still be interpreted to work through a wealth effect. In fact, recall that current output $y(0)$ is predetermined due to inertia. The central bank can therefore affect adjusting stockholders' spending only by changing $p(0)$. For instance, if the central bank wants to increase spending, it can cut $r(0)$ and increase $p(0)$. As long as $\theta > \rho$, stockholders still respond to this type of interest rate—driven increase in $p(0)$, although less so than in the benchmark model (because low interest rates also create a negative income effect that partially offsets the wealth effect).

In the rest of the paper, we assume that the adjusting stockholders choose their consumption according to an ad hoc rule that is (qualitatively) consistent with the optimal rule. Specifically, we assume that the (representative) adjusting stockholder follows[9]

$$c^{s,adj}(t) = mp(t) + ny(t), \tag{14}$$

where we treat $m \in (0, 1)$, $n \in [0, 1)$ as exogenous parameters. Equation (13) shows that this rule is optimal for appropriately chosen m, n that are endogenous to the equilibrium path. To avoid fixed-point arguments that are orthogonal to our main contributions, we do not focus on the fully rational case and instead treat m, n as exogenous parameters. The Internet Appendix shows that our main result also holds with endogenous m, n.

Output gap dynamics. Combining equations (9) and (14), the output gap follows

$$\dot{y}(t) = \theta(mp(t) + ny(t) - y(t)). \tag{15}$$

The initial output gap, $y(0)$, is exogenous (determined by an unmodeled history). The output gap responds to the asset price gap, $p(t)$, due to the consumption wealth effect. However, the response is gradual due to aggregate demand inertia.

Monetary policy. The central bank implements a path of output, asset price, and discount rate gaps, $[y(t), p(t), r(t)]_{t\in(0,\infty)}$, that satisfy equations (5) and

[9] Individual stockholders follow a similar rule scaled by their wealth. Formally, let $a^i(t)$ denote a stockholder's wealth and $\alpha^i(t) = \frac{a^i(t)}{P(t)}$ denote her wealth share. A stockholder with wealth share $\alpha^i(t)$ follows the rule $C^{i,adj}(t) = C^{s,*}\alpha^i(t)\exp(mp(t) + ny(t))$. Aggregating across all adjusting stockholders, we obtain (14) since wealth shares satisfy $\sum_i \alpha^i(t) = 1$. With this rule, there might be paths along which some stockholders' wealth becomes zero, for example, if the stockholder does not adjust for a long time. If this happens, the budget constraint binds and consumption falls to zero. We ignore these paths since we focus on relatively small shocks and log-linearized dynamics.

(15) given $y(0)$. We can think of the central bank as targeting a path of output and asset price gaps, $[y(t), p(t)]_{t\in(0,\infty)}$, that satisfy equation (15) given $y(0)$. Then equation (5) describes the equilibrium rate path, $[r(t)]_{t\in(0,\infty)}$, that the central bank needs to set to achieve its target.

We assume that the central bank's objective function is

$$V(0, y(t)) = \int_0^\infty e^{-\rho t}\left(-\frac{1}{2}y(t)^2 - \frac{\psi}{2}p(t)^2\right)dt. \tag{16}$$

As usual, the central bank dislikes output gaps, $y(t)$. We assume a quadratic cost function, which leads to closed-form solutions. In addition, the central bank also dislikes asset price gaps, $p(t)$. In the limit $\psi \to 0$, we have the conventional setup in which the central bank does not (directly) pay attention to asset prices. Our main results hold in this conventional limit, but optimal policy overshoots asset prices by an extreme amount. In practice, large asset price overshooting could lead to a number of concerns that range from financial stability (e.g., the reversal of high asset prices can increase the risk of a financial collapse, as we have seen in the late stages of the COVID-19 recovery) to wealth redistribution (e.g., high asset prices can increase inequality). We capture these types of concerns with the parameter $\psi > 0$, which we refer to as aversion to overshooting. The central bank's discount rate is the same as that of stockholders, ρ.

Finally, we assume that the central bank sets the current policy without commitment, that is, it sets the current asset price gap $p(t)$, taking the path of future gaps as given. In this case, the central bank's policy problem can be formulated recursively as[10]

$$\begin{aligned} \rho V(y) &= \max_p -\frac{y^2}{2} - \psi\frac{p^2}{2} + V'(y)\dot{y}, \\ \dot{y} &= \theta(mp - (1-n)y), \\ V(y) &\leq 0 \text{ and } V(0) = 0. \end{aligned} \tag{17}$$

The constraints in the last line follow from the objective function in (16) and ensure that we pick the correct solution to the recursive problem. We define the equilibrium as follows.

DEFINITION 1: A (log-linearized) equilibrium with optimal monetary policy, $[y(t), p(t), r(t)]_{t=0}^\infty$, is such that the path of output and asset price gaps, $[y(t), p(t)]$, solve the recursive problem (17) and the discount rate satisfies equation (5).

[10] The lack of commitment does not restrict monetary policy in our baseline model. The principle of optimality implies that maximizing (16) subject to (15) is equivalent to solving problem (17). Lack of commitment is restrictive when we introduce inflation (see Section B of the Internet Appendix) or when we endogenize the consumption function in (14) (see Section A of the Internet Appendix).

REMARK 1 (Does wealth cause or correlate with consumption?): We emphasize the wealth effect on consumption, which creates the impression that wealth causes consumption. While this is the natural interpretation in our setup, our results are consistent with an alternative interpretation in which stockholders react to interest rates and their future capital incomes (through variants of the Euler equation). Under this alternative interpretation, the central bank's interest rate changes affect both asset prices and consumption, which induces a correlation between wealth and consumption. Regardless of the interpretation, equations (13) and (14) are useful analytical tools to understand the path of asset prices implied by optimal monetary policy when there is aggregate demand inertia.

B. Asset Price Overshooting in a Recovery

We next solve for the equilibrium and establish our overshooting result. To capture the recovery from a recessionary shock, we focus on the case with a negative initial output gap, $y(0) < 0$, where aggregate demand has yet to catch up with potential output. Our main result shows that the optimal policy features asset-price overshooting: The central bank optimally chooses a positive asset price gap, that is, even though output is below its potential level, the asset price is high and above its potential level. We also show that the central bank overshoots the asset price by more when aggregate demand is more inertial and responds to asset prices more gradually.

Consider the planner's problem (17). In the Internet Appendix, we conjecture and verify that the solution is a quadratic function,

$$V(y) = -\frac{1}{2v}y^2, \tag{18}$$

$$0 = v^2 - (\rho + 2\theta(1-n))v - \frac{\theta^2 m^2}{\psi}. \tag{19}$$

Here, v ("value") denotes an endogenous coefficient. Since $V(y) < 0$, we also have $v > 0$: The solution corresponds to the positive root of (19).

Combining the value function in (18) with the optimality condition, we solve for the optimal asset price as

$$p = \frac{\theta m}{\psi} V'(y) \Longrightarrow p(t) = -\frac{\theta m}{\psi v} y(t). \tag{20}$$

This expression illustrates the overshooting of asset prices. Starting with a negative output gap, the optimal asset price is above its potential level.

Next consider the change in output gaps along the optimal path. Combining equations (20) and (15), we obtain

$$\dot{y}(t) = -\gamma y(t), \quad \text{where } \gamma \equiv \theta\left(\frac{\theta m^2}{\psi v} + 1 - n\right) > 0. \tag{21}$$

The composite parameter γ captures the convergence rate. Starting with a negative output gap, and an associated positive asset price gap (in view of overshooting), both gaps converge monotonically to zero at rate γ.

Consider the discount rate gap. Combining equations (5), (20), and (21), we obtain

$$\begin{aligned} r(t) &= \frac{\rho}{1+\rho}(y(t) - p(t)) + \frac{1}{1+\rho}\dot{p}(t) \\ &= \frac{\rho}{1+\rho}\left(1 + \frac{\theta m}{\psi v}\right)y(t) + \frac{1}{1+\rho}\frac{\theta m}{\psi v}\gamma y(t) \\ &= \mathcal{R} y(t), \\ \text{where } \mathcal{R} &\equiv \frac{\rho}{1+\rho} + \frac{\theta m}{\psi v}\left(\frac{\gamma+\rho}{1+\rho}\right). \end{aligned} \tag{22}$$

Hence, the discount rate gap is (positively) proportional to the output gap. Starting with a negative output gap, the discount rate gap starts below zero and gradually increases, that is, $r(0) < 0$ and $\dot{r}(t) > 0$.

Finally, consider the decomposition of the price into the cash flow and market bond components. Combining equations (6), (20), and (21), we obtain

$$p^C(t) = \frac{\rho}{\rho+\gamma}y(t) \quad \text{and} \quad p^{MB}(t) = -\left(\frac{\rho}{\rho+\gamma} + \frac{\theta m}{\psi v}\right)y(t). \tag{23}$$

Starting with a negative output gap, the cash flow component of the price is below its potential, but the market bond component is above its potential. The latter effect dominates so that the price is also above its potential (compare (20)). The central bank cuts the interest rate sufficiently to overturn the decline in asset prices that a negative output gap would otherwise induce via anticipated cash flows. The following result summarizes this discussion.

PROPOSITION 1: *The value function is given by (18), where $v > 0$ is the positive solution to (19). The equilibrium path of the output, asset price (and its components), and discount rate gaps, $\left[y(t), p(t), r(t), p^C(t), p^{MB}(t)\right]_{t=0}^{\infty}$, is characterized by equations (20) to (23). Starting with a negative output gap, $y(0) < 0$, the equilibrium features asset price overshooting the asset price is above its potential, $p(0) > 0$, and the discount rate is below its potential, $r(0) < 0$. Over time, all gaps converge to zero at the exponential rate $\gamma = v - (\rho + \theta(1-n)) > 0$.*

Figure 2 illustrates the equilibrium dynamics for a particular parameterization starting with a negative output gap. The equilibrium (solid lines) features overshooting: The central bank sets a positive asset price gap and gradually closes the output gap. The central bank achieves this outcome by starting with a low discount rate, and then gradually increasing the discount rate and reducing the asset price gap. The figure also illustrates the case without overshooting ($\psi = \infty$), where the central bank sets the asset price equal to its potential. In this case, output gaps are closed more slowly and the economy operates below its potential for a longer time.

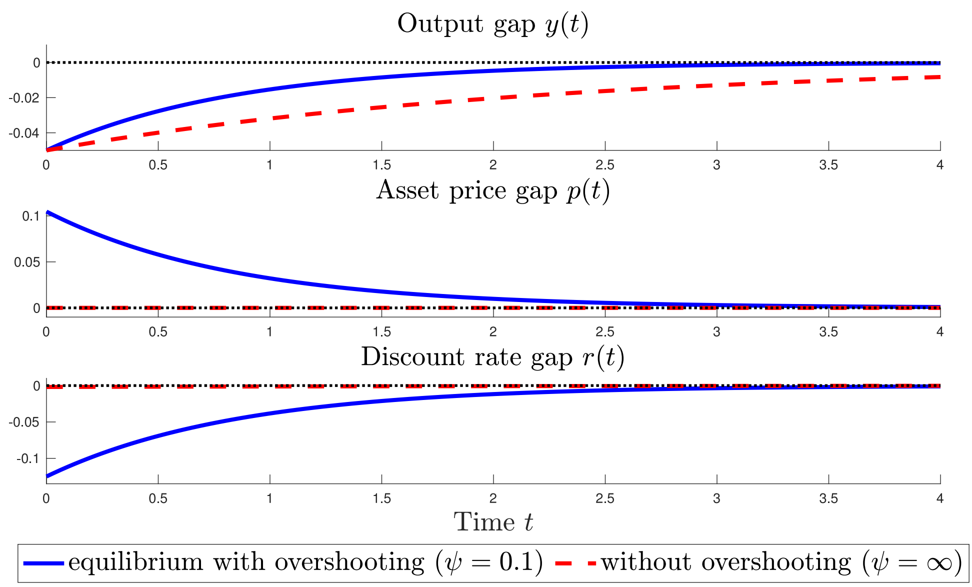

Figure 2. Asset price overshooting. This figure shows simulations of the equilibrium with low aversion to overshooting $\psi = 0.1$ (solid lines) and high aversion $\psi = \infty$ (dashed lines). We set the adjustment rate θ equal to 0.5, the discount rate ρ equal to 0.04, and the parameters of the adjusting stockholder m, n equal to 0.7 and 0.1, respectively.

Why does the central bank overshoot asset prices? Since only a fraction of stockholders adjust at any moment, the central bank sends a stronger "spend" signal to the adjusting stockholders to (partially) compensate for the depressed consumption of those that do not. This policy requires overshooting asset prices, which is costly, but it also accelerates the demand recovery and shrinks the negative output gaps. The following corollary reinforces this intuition by establishing the comparative statics of overshooting with respect to the adjustment hazard rate θ. We measure asset price overshooting using the cumulative sum of expected asset price gaps, $\int_0^\infty p(t)\,dt$—the area under the asset price panel of Figure 2.

COROLLARY 1: *The equilibrium features greater cumulative asset price overshooting per unit of negative output gap (greater $\frac{\int_0^\infty p(t)dt}{-y(0)}$) when a smaller fraction of stockholders adjust at any moment (smaller θ). In the limit with very frequent adjustment, the cumulative asset price overshooting is zero,* $\lim_{\theta\to\infty} \frac{\int_0^\infty p(t)dt}{-y(0)} = 0$.

Figure 3 illustrates the comparative statics with respect to θ. When aggregate demand has smaller inertia (higher θ), the central bank overshoots asset prices for a brief period (vanishingly small as $\theta \to \infty$). This small amount of overshooting ensures that demand recovers quickly and asset prices stay at

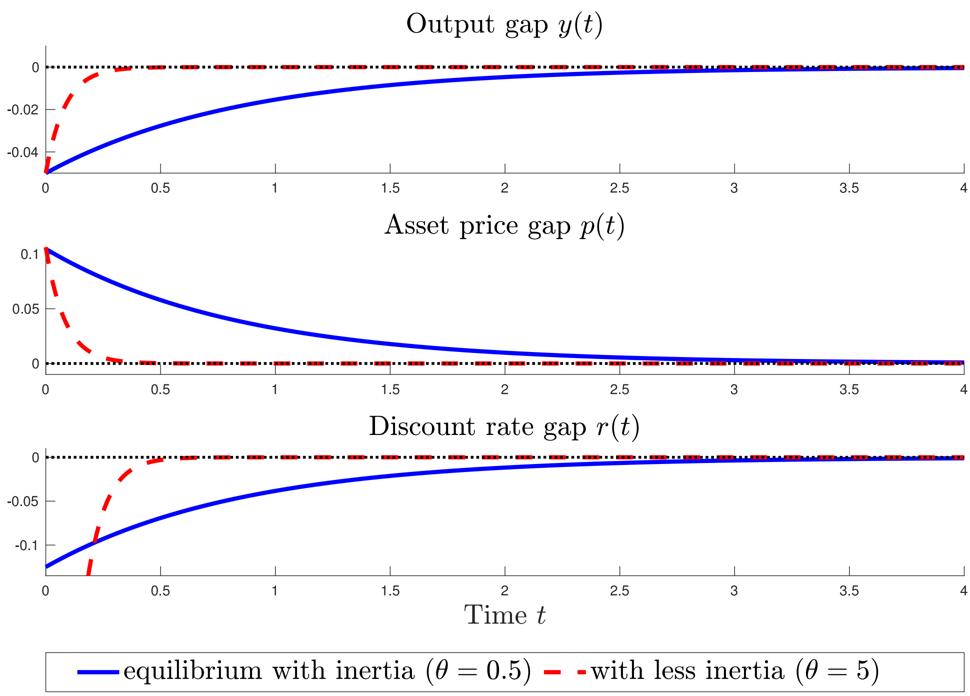

Figure 3. The role of inertia in driving asset price overshooting. This figure shows simulations of the equilibrium with high inertia and low adjustment rate $\theta = 0.5$ (solid lines) and low inertia and with high adjustment rate $\theta = 5$ (dashed lines). The dotted lines correspond to the potential levels for the corresponding variables. We use the same parameters as in the overshooting case of Figure 2.

their potential level except for the brief initial period. [11] In contrast, when aggregate demand has greater inertia (lower θ), and therefore responds to asset prices more sluggishly, the central bank overshoots asset prices by a longer period. This result further highlights that the asset price overshooting is driven by our key friction—aggregate demand inertia.

C. Overshooting in Richer Environments

Our main overshooting result extends to richer environments.

C.1. Overshooting with Growth

In our model, the asset price level declines over time (after an initial jump). This feature is not essential to the argument. The same result would continue to apply for the asset price gap in a variant with productivity growth. In this

[11] Figure 3 also illustrates that, without any aggregate demand inertia, an optimizing central bank would close the output gap at all times. In practice, however, often there are sizable output gaps, which provides indirect evidence of either inertia or monetary policy constraints.

case, the potential asset price would also be increasing over time (at the growth rate), so overshooting would not necessarily imply a declining asset price level. Rather, it would only imply frontloading of some of the future gains on the market portfolio.

C.2. Overshooting with Sophisticated Stockholders

For simplicity, we assume that adjusting stockholders exogenously follow the rule in (14). In Section A of the Internet Appendix, we establish an analog of Proposition 1 for fully sophisticated stockholders who choose their consumption optimally (see Proposition IA.1). Recall from Lemma 2 that these consumers also follow the rule in (14) but with endogenous coefficients $m(\gamma) = \frac{\theta-\rho}{\theta+\gamma}$ and $n(\gamma) = \frac{\rho}{\theta+\gamma}$ that depend on the convergence rate γ. Absent commitment (which is the case we focus on), the planner takes these coefficients as given. Our earlier analysis therefore applies. Also recall that the convergence rate γ depends on the coefficients of the consumption rule, m, n. Hence, with fully rational stockholders, the equilibrium corresponds to a fixed point that we characterize in the Internet Appendix.

C.3. Overshooting with Inflation

For simplicity, we assume fully sticky prices. In Section B of the Internet Appendix, we extend our analysis to allow for partially flexible prices. In this case, inflation is endogenous and determined by a New-Keynesian Phillips curve (see equation ((IA.45)). Proposition IA.2 shows that inflation reinforces our main result. Starting with a negative output gap, the central bank still overshoots real asset prices. Moreover, when nominal prices are more flexible, the central bank overshoots real asset prices by more. When nominal prices are flexible, negative output gaps create disinflationary pressures, that is, they reduce inflation below its target. These negative inflation gaps are costly and create an additional reason for the central bank to fight negative output gaps. The central bank overshoots real asset prices by even more than in our baseline setting to close the output gaps more quickly.

C.4. Preemptive Overshooting and Overheating

In the main text, we focus on a recovery scenario in which the output gap is negative and the central bank's main concern is to close it as quickly as possible. In Section D of the Internet Appendix, we extend our analysis to a situation in which the main concern is not the current output gap but rather the anticipation that the output gap will become negative in the near future. This situation may arise, for example, when the economy is experiencing a sharp but temporary decline in potential output, as in the COVID-19 recession. In the low-supply phase, potential output experiences a deep contraction but is expected to recover according to a Poisson event, in which case the economy transitions to a high-supply phase with a negative output gap (as in the main text). Proposition IA.4 shows that the recession features preemptive overshooting: the central bank boosts asset prices even if output is at its (depressed) potential level.

By preemptively overshooting asset prices, the central bank temporarily overheats the economy: It induces positive output gaps until the potential output recovers. The central bank anticipates that the high-supply phase will start with a large negative output gap due to aggregate demand inertia. The central bank therefore acts preemptively to boost asset prices and aggregate demand during the low-supply phase, to ensure that aggregate demand is not too depressed during the early stages of transition to high supply. This boost temporarily induces positive asset price and output gaps, which are costly, but it also shrinks the expected negative output gaps after the potential output recovers. In Caballero and Simsek (2023), we investigate this trade-off further by focusing on the implications for overheating and inflation—rather than on overshooting and asset prices.

C.5. Overshooting with a Time-Varying Risk Premium

An important omission from our analysis is the lack of a risk premium. In practice, aggregate wealth is associated with a time-varying risk premium (see, for example, Cochrane (2011)). We could incorporate a risk premium without changing our main conclusions. Suppose the discount rate on the market portfolio is given by $r(t) = r^f(t) + \xi(t)$, where $r^f(t)$ is the risk-free rate and $\xi(t)$ is the risk premium. As long as the elasticity of intertemporal substitution is equal to one, our analysis would still apply, but the central bank would target the discount rate on the market portfolio, $r(t)$, as opposed to the risk-free rate, $r^f(t)$. For instance, equation (20) would apply: the optimal policy would still overshoot asset prices. equation (22) would also apply, and imply that the central bank should set the risk-free rate according to $r^f(t) = -\xi(t) + \mathcal{R}y(t)$. If the risk premium is countercyclical (as suggested by empirical evidence), $\xi(t) = \xi_0 - \xi_1 y(t)$, then the risk-free rate becomes more procyclical than in our model,

$$r^f(t) = -\xi_0 + (\xi_1 + \mathcal{R})y(t). \tag{24}$$

In a demand recession, the optimal policy cuts the risk-free rate aggressively to first "undo" the increase in the risk premium and then to overshoot asset prices as in our model.

The presence of a risk premium not only leaves our main result unchanged, but it also expands the policies the central bank can use to affect the discount rate on the market portfolio, $r(t)$. Even if conventional monetary policy is constrained due to, for example, an effective lower bound on the interest rate, the central bank can reduce the risk premium, $\xi(t)$, via unconventional policies. In Caballero and Simsek (2021a), we formalize this argument in a model without transmission lags. In that model, LSAPs can reduce the risk premium by transferring risk to the government's balance sheet. These policies are especially powerful after a large surprise shock, such as COVID-19, that damages risk-tolerant agents' balance sheets and increases the risk premium. We discuss the role of different types of monetary policies in the COVID-19 recession in Section III.

C.6. Comparison with Taylor Rules

A strand of the New Keynesian literature focuses on interest rate rules for monetary policy that are easy to implement and that approximate the fully optimal policy. For instance, Taylor rules prescribe the interest rate response to output (and inflation) gaps, for example, $r(t) = \tau_y y(t)$. A natural question is whether these types of rules would also induce asset price overshooting in our setup. In our baseline model, the central bank follows a particular Taylor rule, $r(t) = \mathcal{R} y(t)$. Equation (22) further implies that $\mathcal{R}$ is decreasing in ψ and satisfies $\lim_{\psi \to \infty} \mathcal{R} \Im \frac{\rho}{1+\rho}$. This in turn implies that in our setup a Taylor rule is equivalent to an optimal overshooting policy (for some ψ) as long as the rule is sufficiently sensitive to the output gap, $\tau_y > \frac{\rho}{1+\rho}$ (see Section C of the Internet Appendix for a formalization). When the policy follows a Taylor rule, the output gap has counteracting effects on the price of the market portfolio. On the one hand, a low output gap decreases cash flows, which reduces the asset price. On the other hand, a low output gap decreases the real discount rate, which increases the asset price. The second effect dominates and the asset price overshoots as long as the discount rate is sufficiently sensitive to the output gap.

This "equivalence" result has one important caveat: The standard Taylor rules apply to the risk-free rate, whereas the overshooting policy targets the discount rate on the market portfolio. As we discuss in the previous subsection, the discount rate might also include a time-varying risk premium. Consequently, our model suggests that the Taylor rule should be modified to include a direct response to the aggregate risk premium (see (24)). If the policy does not respond to the risk premium, then it might fail to overshoot asset prices in recessions in which the risk premium increases substantially (such as financial crises). Viewed from this lens, our model suggests that overshooting was particularly salient in the COVID-19 recession because this recession was not driven by a financial shock, and the initial damage to financial markets was contained by aggressive unconventional monetary policy (as well as fiscal policy).

II. Constrained Overshooting and the News Effect on Asset Prices

So far we have assumed that the central bank can achieve any desired level of overshooting by appropriately adjusting the discount rate. In this section, we analyze the optimal policy when there is a limit on the extent to which the policy can reduce the discount rate.[12] We find that with a lower bound

[12] We focus on a lower bound constraint on the discount rate but interpret it more broadly as a limit on both conventional monetary policy and LSAPs.

constraint, overshooting is a concave and nonmonotonic function of the output gap: The asset price boost is low for a deeply negative initial output gap, grows as the output gap improves over a range, and shrinks toward zero as the output gap improves further. This pattern also implies that good macroeconomic news is better news for asset prices when the output gap is more negative and the economy is farther from full recovery.

A. Overshooting with an Interest Rate Constraint

Consider the baseline model in Section I, with the only difference that the central bank sets the discount rate subject to a lower bound constraint,

$$r(t) \geq \bar{r} \quad \text{for each } t. \tag{25}$$

The parameter $\bar{r} < 0$ captures the severity of the constraint. Combining equations (5) and (17), the central bank's recursive problem becomes

$$\begin{aligned} \rho V(y) &= \max_p -\frac{y^2}{2} - \psi\frac{p^2}{2} + V'(y)\dot{y}, \\ \dot{y} &= \theta(mp - (1-n)y), \\ r(t) &= \frac{\rho}{1+\rho}(y(t) - p(t)) + \frac{1}{1+\rho}\dot{p}(t) \geq \bar{r}. \end{aligned} \tag{26}$$

As before, we assume that the central bank sets the current policy without commitment. The planner takes future output and asset price gaps (as well as the price drift $\dot{p}(t)$) as given and sets the instantaneous asset price, $p(t)$, subject to the lower bound constraint.[13]

Consider the solution corresponding to a negative initial output gap, $y(0) < 0$. Recall that when there is no lower bound constraint, the discount rate is increasing over time (see Figure 2). With a lower bound constraint, there exists a cutoff output gap, $\bar{y} \leq 0$, such that the discount rate constraint binds for $y(t) < \bar{y}$ but not for $y(t) \in (\bar{y}, 0)$. When the constraint does not bind, the solution is exactly as in Section I.B. In particular, the optimal asset price gap is given by (20) and the corresponding discount rate is given by (22). Setting $r(t) = \bar{r}$, we solve for the cutoff output and asset price gaps as follows:

$$\bar{y} = \frac{\bar{r}}{\frac{\rho}{1+\rho} + \frac{\theta m}{\psi v}\frac{\gamma+\rho}{1+\rho}} < 0 \quad \text{and} \quad \bar{p} = -\frac{\frac{\theta m}{\psi v}\bar{r}}{\frac{\rho}{1+\rho} + \frac{\theta m}{\psi v}\frac{\gamma+\rho}{1+\rho}} > 0. \tag{27}$$

When the discount rate constraint binds, the solution satisfies the differential equation system

$$\dot{y}(t) = \theta(mp(t) - (1-n)y(t)), \tag{28}$$

[13] Unlike in Section I, the no-commitment constraint binds in this section. The planner might want to promise low interest rates in the future so as to relax the current lower bound constraint. We abstract from these types of forward guidance policies as they are not our focus and their benefits are well understood (see, for example, Eggertsson and Woodford (2003)).

$$\bar{r} = \frac{\rho}{1+\rho}(y(t) - p(t)) + \frac{1}{1+\rho}\dot{p}(t).$$

Starting with the point $(\bar{y}, \bar{p})$, we can uniquely solve this system backward over time. The resulting path describes the optimal asset price gap p corresponding to each output gap $y \leq \bar{y}$. Over time, the gaps travel along the solution path until they reach the point $(\bar{y}, \bar{p})$. Subsequently, the gaps follow the unconstrained solution.

Our next result characterizes the solution for the constrained range. The proof (in the Internet Appendix) relies on the phase diagram corresponding to the differential equation system in (28). We assume that the parameters satisfy a technical condition that ensures the system has two real eigenvalues and a unique steady state.

PROPOSITION 2: *Consider the model with a lower bound on the discount rate $\bar{r} < 0$ for parameters that satisfy $(\theta(1-n) - \rho)^2 > 4\theta\rho(m - (1-n)) \neq 0$. Let $\bar{y} < 0, \bar{p} > 0$ denote the output and asset price gap cutoffs given by (27).*

When $y(0) \geq \bar{y}$, the constraint does not bind and the solution is the same as in Proposition 1. The asset price gap is a function of the output gap, $p = \mathbf{p}(y) = -\frac{\theta m}{\psi v} y$.

When $y(0) < \bar{y}$, the constraint binds and the path $(y(t), p(t))$ solves the system in (28), reaching $(\bar{y}, \bar{p})$ in finite time. The output gap improves over time ($\dot{y}(t) > 0$). There exists another cutoff $\underline{y} < \bar{y}$ such that the asset price gap is increasing over time ($\dot{p}(t) > 0$) iff $y < \underline{y}$. The asset price gap is a strictly concave function of the output gap, $\mathbf{p}(y)$, and it attains its maximum at the lower cutoff, $\underline{y}$.

The asset price gap is a concave and nonmonotonic function of the output gap, $\mathbf{p}(y)$—increasing below a cutoff level ($\underline{y}$) and decreasing above the cutoff level. Figure 4 illustrates this asset price function for a numerical example. The left panel compares the asset price function with the baseline model without a lower bound. The right panel decomposes the asset price function into cash flow and market bond components, denoted by $\mathbf{p}^C(y)$ and $\mathbf{p}^{MB}(y)$ (see Section II of the Internet Appendix for a derivation of these functions). As in the baseline model, as the output gap improves (toward zero), the cash flow component rises and the interest rate component declines (see, for example, (23)). Unlike in the baseline model, however, the balance of these two forces is such that the asset price initially rises and subsequently declines with the recovery of the output gap.

Figure 5 illustrates the dynamics of equilibrium for the same example. In this example, the discount rate stays at the lower bound until time $T \in [6, 7]$, at which point the gaps satisfy $y(T) = \bar{y}$ and $p(T) = \bar{p}$. After time T, the discount rate "lifts off" above the lower bound. Before time T, the output gap improves over time (although more slowly than in the unconstrained case), and the asset price gap follows a nonmonotonic path—increasing until the output gap hits $y(t) = \underline{y}$ and decreasing thereafter.

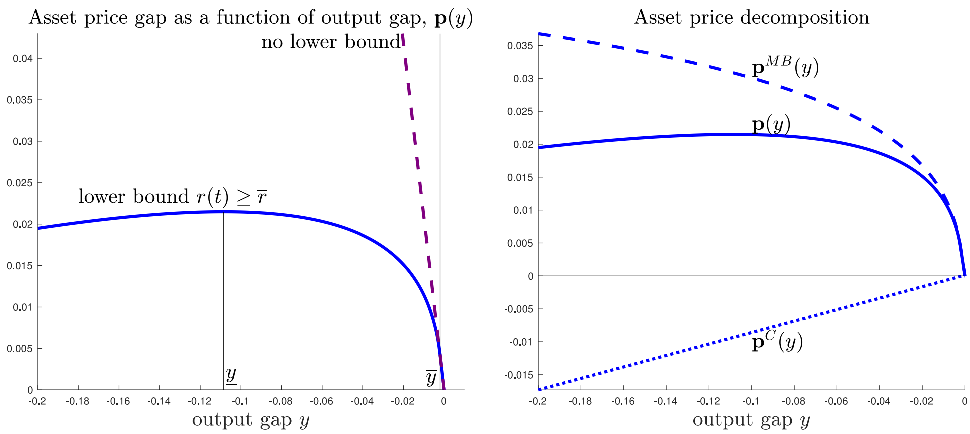

Figure 4. Overshooting with an interest rate lower bound. The left panel of this figure plots the asset price function with an interest rate lower bound (solid curve) and without a lower bound (dashed line). The right panel decomposes the asset price (solid curve) into components explained by future interest rates (dashed curve) and future cash flows (dotted line). We set the bound $\bar{r}$ equal to -0.5% and use the same parameters as in the overshooting case of Figure 2.

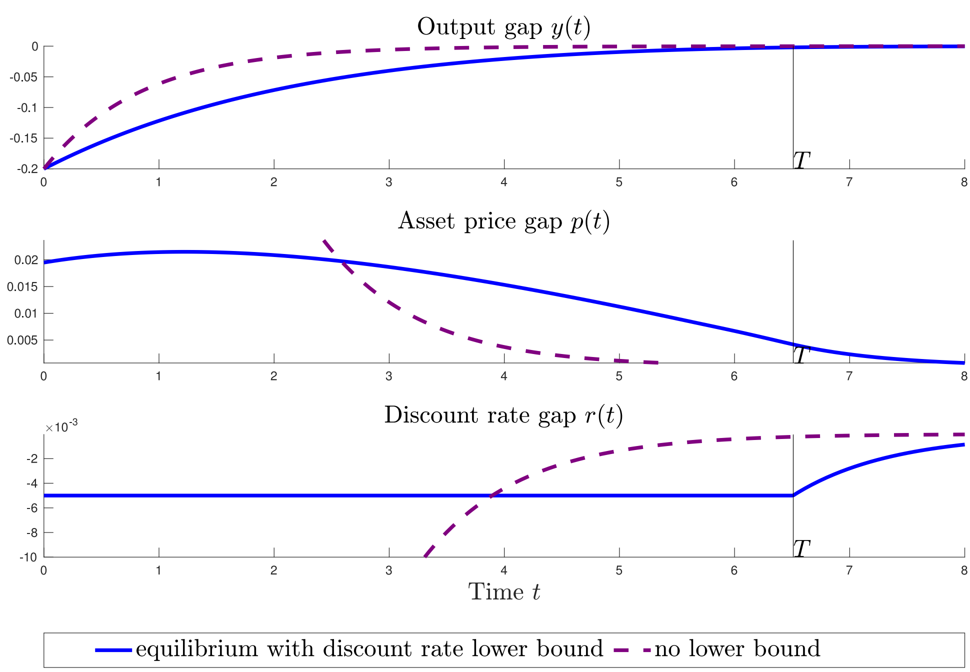

Figure 5. Equilibrium dynamics with an interest rate lower bound. This figure shows simulations of the equilibrium over time with an interest rate lower bound (solid lines) and no lower bound (dotted lines). We set the bound $\bar{r}$ equal to -0.5%, and we use the same parameters as in the overshooting case of Figure 2.

Why is the asset price gap a concave and nonmonotonic function of the output gap? For intuition, consider an initial output gap slightly below $\bar{y}$, which corresponds to an initial time t slightly before the lift-off time T. In this range, the central bank is nearly unconstrained and effectively "sets" asset prices by adjusting the discount rates beyond T. As the output gap improves, the central bank optimally "tapers" the overshooting, as in the baseline model. While an improved output gap increases expected cash flows, it increases expected discount rates by even more, so it results in a decline in asset prices.

Now consider a lower initial output gap, for example, closer to $\underline{y}$, which corresponds to an initial time t farther from the lift-off time T. In this range, the central bank is more constrained—it would like a greater overshooting but cannot achieve it. An improved output gap still increases expected cash flows, but it induces a smaller increase in expected discount rates than before. The cash flow and discount rate effects roughly cancel each other, and the extent of overshooting is relatively insensitive to the output gap.

Finally, consider a much lower initial output gap, for example, to the left of $\underline{y}$, which corresponds to an initial time t very far from the lift-off time T. In this range, the planner is severely constrained. An improved output gap induces an even smaller increase in expected discount rates than before. The cash flow effects dominate the discount rate effects, and the extent of overshooting rises as the output gap improves (see the right panel of Figure 4).

B. Macroeconomic News and Asset Prices

We next show that, in our model, good macroeconomic news is better news for asset prices when the output gap is more negative and the economy is farther from full recovery. This pattern is consistent with existing empirical evidence. For instance, Elenev et al. (2023) show that stock prices react to macroeconomic news announcements more strongly when the output gap is sufficiently negative, and the relationship becomes weaker (and can have a negative sign) when the output gap is closer to zero. In earlier work, Boyd, Hu, and Jagannathan (2005) observe a similar pattern and attribute the cyclicality of the response to changes in the relative strength of the interest rate and the cash flow effects of news (see also McQueen and Roley (1993), Andersen et al. (2007)). Our model in this section provides an explanation for these findings.

Formally, let N denote a zero-mean random variable that captures macroeconomic news. For instance, N might correspond to the surprise component of a scheduled macroeconomic announcement such as nonfarm payroll. Suppose initial and potential outputs are increasing functions of N:

$$Y(0) = \tilde{Y}(0)\exp(aN) \quad \text{and} \quad Y^* = \tilde{Y}^*\exp\big(bN\big). \tag{29}$$

Here, $a, b > 0$ capture the impact of the news on output and potential output, respectively. A positive piece of news (e.g., nonfarm payrolls above expectations) implies stronger economic activity, which reflects both higher aggregate demand and aggregate supply. The news also affects the output gap, which is given by

$$y(0) = \tilde{y}(0) + (a - b)N. \tag{30}$$

Here, $\tilde{y}(0) = \log\left(\tilde{Y}(0)/\tilde{Y}^*\right)$ is the expected output gap. We assume $a - b > 0$ so that good news improves the output gap. This assumption is natural since good macroeconomic news typically increases bond yields and forward interest rates (see Andersen et al. (2007)). In our model, an improved output gap implies higher future interest rates (see Figure 5).

The news is realized at the beginning of the model. Once the news is realized, there is no further uncertainty and the setup is the same as in Section II. Our next result shows that the asset price impact of news depends on the level of the output gap.

PROPOSITION 3: *Consider the setup in Proposition 2 with one-time macroeconomic news that affects both aggregate demand and aggregate supply according to (29). Suppose $a > b$, so that good news improves the output gap. Then:*

(i) The impact of the news on asset prices is given by

$$\left.\frac{d \log P(0)}{dN}\right|_{N=0} = (a - b)\left.\frac{d\mathbf{p}(y)}{dy}\right|_{y=\tilde{y}(0)} + b, \tag{31}$$

where $\mathbf{p}(y)$ is the function characterized in Proposition 2.

(ii) Good news has greater impact on asset prices when the expected output gap is more negative:

$$\frac{d}{d\tilde{y}(0)} \left.\frac{d \log P(0)}{dN}\right|_{N=0} \leq 0. \tag{32}$$

The first part of the result characterizes the asset price impact of macroeconomic news. Good news affects the price of the market portfolio through two channels: by increasing potential output, captured by b, and by improving the output gap, captured by $(a - b)\left.\frac{d\mathbf{p}(y)}{dy}\right|_{y=\tilde{y}(0)}$. Since $\mathbf{p}(y)$ is a concave function, as the output gap improves, this second term becomes smaller and eventually flips sign and becomes negative. The second part of the result uses this observation to show that the asset price impact of good news becomes smaller as the output gap improves. In fact, if the parameters satisfy $b < \frac{\theta m}{\psi v}(a - b)$ (the effect via the potential output is smaller than the effect via the output gap when the central bank is unconstrained), then we have the stronger result that $\frac{d \log P(0)}{dN}$ flips sign (from positive to negative) as the output gap improves toward zero.

While good news always raises the price of the market portfolio through its impact on aggregate supply, it induces competing effects through its impact on aggregate demand and the output gap. An improved output gap raises the expected cash flows, but it also raises the expected discount rates (see the right panel of Figure 4). Therefore, an improved output gap is good news for asset prices when the discount rate is mostly constrained (the economy is far from the discount rate lift-off) and the central bank does not overturn the price impact of higher cash flows. Conversely, an improved output gap is bad news for asset prices when the discount rate is mostly unconstrained (the economy is close to the lift-off), and the central bank optimally overturns the price impact of higher cash flows by accelerating interest rate hikes. Combining the supply and demand effects, good macroeconomic news is "better news" for the market when the output gap is more negative.

III. Real Interest Rates and Overshooting during the COVID-19 Recovery

In this section, we document the magnitude of the asset market overshooting generated by the decline in real interest rates during the COVID-19 episode. We show that it was large—sufficient to explain the high levels of stock and house prices in 2021. A back-of-the-envelope calculation suggests that this overshooting had a sizable impact on output in the COVID-19 recovery. Our analysis also suggests that the Fed's LSAPs for safe assets played an important role in driving the asset price overshooting in this episode.

To quantify the overshooting induced by the decline in risk-free rates, we rely on the asset price decomposition in (6).[14] Recall that $p^{MB}(t)$ and $p^{C}(t)$ capture the price deviations driven by expected interest rates and expected cash flows, respectively. We focus on quantifying $p^{MB}(t)$, for two reasons. First, as we describe next, $p^{MB}(t)$ can be directly measured from available data on treasury yields. Second, in our model, monetary policy affects asset prices primarily through $p^{MB}(t)$: By changing the forward rates, the central bank has a direct effect on the valuation of cash flows. This change in asset prices also affects expected cash flows, creating indirect knock-on effects captured by $p^{C}(t)$. In general, monetary policy can affect asset prices through other channels, for example, by changing the risk premium. We interpret our measured $p^{MB}(t)$ as capturing the asset price impact of monetary policy via risk-free rates, and the residual term $p^{C}(t)$ as capturing other channels of monetary policy as well as other drivers of asset prices such as a time-varying risk premium.

A. Measuring the Price of the Market Bond Portfolio

To facilitate the measurement of $p^{MB}(t)$, consider a fixed-income portfolio that matches the duration of the market portfolio strip-by-strip. Formally, consider a portfolio of zero-coupon bonds with face values that match the steady-state payoffs of the dividend strips of the market portfolio (αY^*). We refer to

[14] This decomposition does not require monetary policy to be optimal. As Section II illustrates, the magnitude and dynamics of the optimal overshooting policy depends on the precise constraints faced by the central bank. In practice, these constraints are richer than in our stylized model (e.g., a rise in expected inflation can reduce the real interest rate and alleviate the lower bound constraint). In addition, the central bank might deviate from the optimal overshooting policy for reasons outside our model. Therefore, we attempt to quantify the asset price overshooting by imposing a minimal theoretical structure.

this portfolio as the market bond portfolio and denote its price by $P^{MB}(t)$. By no-arbitrage, this price satisfies

$$P^{MB}(t) = \int_0^\infty P^{MB}(t,\mu)d\mu, \quad \text{where } P^{MB}(t,\mu) \equiv \alpha Y^* e^{-\int_t^{t+\mu} R(s)ds}, \tag{33}$$

where $P^{MB}(t,\mu)$ is the time-t price of the μ-maturity strip of the market bond portfolio. It is easy to check that $p^{MB}(t) \simeq \log \frac{P^{MB}(t)}{P^{MB,*}}$: The price that appears in the decomposition in (5) and (6) is the log-linearized price of the market bond portfolio. Our next result describes the price change $\dot{p}^{MB}(t)$ in terms of changes in the zero-coupon yields or forward interest rates. Let $y(t,\mu) = \frac{\int_t^{t+\mu} R(s)ds}{\mu}$ denote the continuously compounded zero-coupon yield with maturity μ, and $f(t,\mu) = R(t+\mu)$ denote the μ-period-ahead instantaneous forward rate.

PROPOSITION 4: *Let $\left[y(t), p(t), p^{MB}(t), p^{C}(t), r(t)\right]_{t=0}^{\infty}$ denote a feasible path that satisfies (6). The following identities hold up to a first-order approximation:*

Yield-based measurement:

$$\dot{p}^{MB}(t) = -\int_0^\infty w_\mu \mu \frac{\partial y(t,\mu)}{\partial t} d\mu, \quad \textit{where } w_\mu = \frac{P^{MB*}(\mu)}{P^{MB*}} = e^{-\rho\mu}\rho. \tag{34}$$

Forward-rate-based measurement:

$$\dot{p}^{MB}(t) = -\int_0^\infty W_\mu \frac{\partial f(t,\mu)}{\partial t} d\mu, \quad \textit{where } W_\mu = \int_\mu^\infty w_{\tilde{\mu}} d\tilde{\mu} = e^{-\rho\mu}. \tag{35}$$

Equation (34) shows that the price change of the market bond portfolio depends inversely on the yield changes of the individual strips multiplied by the weighted duration, $w_\mu \mu$. The weights are proportional to the (steady-state) value of the corresponding strip, $w_\mu = \frac{P^{MB*}(\mu)}{P^{MB*}}$. Equation (35) expresses the price change in terms of forward rates. The price depends inversely on a cumulative-weighted-average of forward rates at all horizons μ. The cumulative weights capture the weights of bond strips with maturity beyond μ, that is, $W_\mu = \int_\mu^\infty w_{\tilde{\mu}} d\tilde{\mu}$. Intuitively, each forward rate affects the valuation of strips with maturities that exceed its horizon.

Since we do not observe yields or forward rates for distant horizons, we fix some $\overline{\mu}$ and bunch the values of all bond strips with maturities beyond $\overline{\mu}$ at the strip with maturity $\overline{\mu}$. This bunching procedure yields the following approximation to equations (34) and (35):

$$\dot{p}^{MB}(t) \simeq -\int_0^{\overline{\mu}} w_\mu \mu \frac{\partial y(t,\mu)}{\partial t} d\mu - W_{\overline{\mu}} \overline{\mu} \frac{\partial y(t,\overline{\mu})}{\partial t} \tag{36}$$

$$\simeq -\int_0^{\overline{\mu}} W_\mu \frac{\partial f(t,\mu)}{\partial t} d\mu, \tag{37}$$

where recall that $w_\mu = e^{-\rho\mu}\rho$ and $W_\mu = e^{-\rho\mu}$. Our bunching procedure and the resulting approximation are similar to the bond portfolio return analyzed by Van Binsbergen (2020).

B. Overshooting in the COVID-19 Recovery via Risk-Free Rates

We next use equation (36) and (37) to measure the policy support in the COVID-19 recovery through risk-free rates. We adopt a yearly calibration for the bond maturity (μ). We focus on real (inflation-adjusted) prices and obtain daily one-year-ahead TIPS forward rates up to a 30-year horizon ($\overline{\mu} = 30$) from the term structure data provided by the Federal Reserve, based on the approach by Gürkaynak, Sack, and Wright (2007). We use the forward-rate–based measure in equation (37) (see Section A of the Internet Appendix for details). Finally, we set ρ to target the annual dividend yield of the S&P 500 index with an adjustment for share buybacks. In recent years, the dividend yield of the S&P 500 has been slightly lower than 2% and share buybacks have been slightly higher than 2%. Incorporating both sources of payout, we set $\rho = 0.04$. This choice implies that the aggregate stock market has an average duration of roughly 25 years, which is somewhat lower than the values typically assumed in the recent literature (see, for example, Van Binsbergen (2020), Knox and Vissing-Jorgensen (2022)).[15] Figure IA.5 in the Internet Appendix shows that our results are robust to setting the payout yield to a lower ($\rho = 0.03$) or a higher value ($\rho = 0.06$).

The blue line in Figure 6 illustrates the evolution of $p^{MB}(t)$ from the end of 2019 until May 2023. The market bond portfolio increased early in the COVID-19 recession and remained high until the end of 2021—the average value of $p^{MB}(t)$ between July 1, 2020, and the end of 2021 is about 16 log points. However, the market bond portfolio declined substantially once the output recovered close to its pre-COVID level and the economy showed clear signs of overheating. By early 2023, $p^{MB}(t)$ was below its level at the end of 2019.

The figure also plots the S&P 500 index and the house price index, as well as household net worth (from the Federal Reserve), which aggregates various sources of wealth. We view these assets as proxies for $p(t)$ in our model and normalize them by potential GDP (from the CBO) to adjust for inflation and growth. The figure illustrates that stock and house prices boomed in the COVID-19 recovery along with the market bond portfolio. Accordingly, household net worth increased by an unprecedented amount: from about \$116.8 trillion in 2019Q4 to about \$150.4 trillion in 2021Q4 (about 14 log points increase after normalizing by potential GDP). The figure also suggests that the high level of stock and house prices throughout 2021 can be mostly attributed

[15] Our calibrated duration is relatively low because we make the conservative assumption that share buybacks are mostly financed by cutting dividends. Knox and Vissing-Jorgensen (2022) illustrate that share buybacks that are financed by debt issuance do not increase the dividend yield (they simply swap equity for debt). Asness, Hazelkorn, and Richardson (2018) show that in recent years (net) debt issuance has been roughly equal to the (net) equity buybacks.

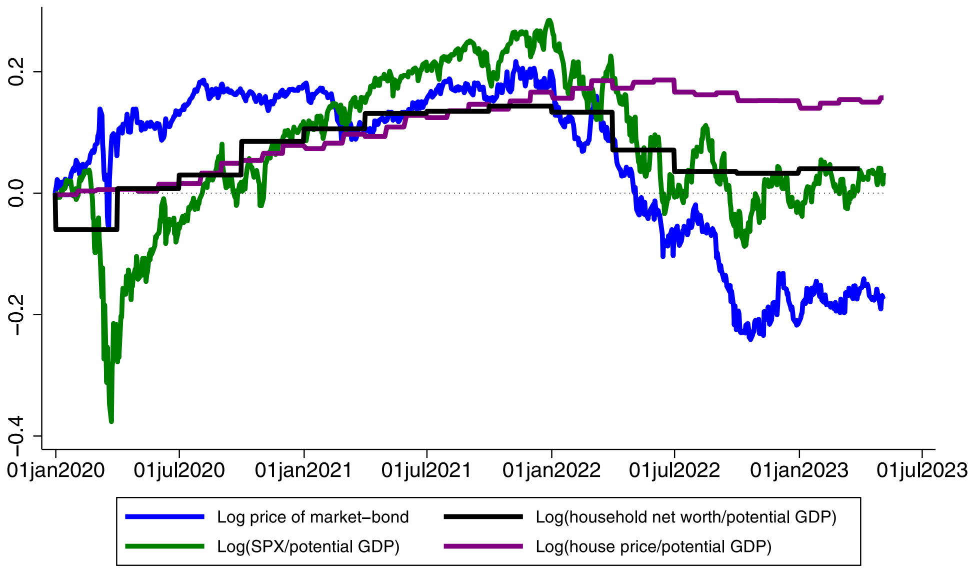

Figure 6. Asset price overshooting during the COVID-19 recovery. This figure shows the evolution of the log price of the market bond portfolio, $p^{MB}(t)$, along with the log S&P 500 index, log house price index, and log household net worth normalized by potential output according to the CBO. All series are normalized to zero on December 31, 2019.

largely to the market bond portfolio. Likewise, the decline in the stock prices in 2022 can be attributed to the decline in the market bond portfolio. These observations suggest that, as in our model, monetary policy has been a key driver of aggregate asset prices in the recovery from the COVID-19 recession.[16]

C. Effect of Overshooting on the Recovery

We next present a back-of-the-envelope calculation to assess the likely impact of the observed asset price overshooting on output's recovery. Consider the discretized version of equation (15) that describes output dynamics,

$$y(t+\Delta t) \simeq y(t) + \theta[mp(t) - (1-n)y(t)]\Delta t.$$

Setting $\Delta t = 1$ (interpreted as one year) and substituting $x(t) \simeq \frac{X(t)-X^*}{X^*}$, we can write this as

$$\frac{Y(t+1)}{Y^*} \simeq \frac{Y(t)}{Y^*} + \theta m \frac{P(t)-P^*}{P^*} - \theta(1-n)\frac{Y(t)-Y^*}{Y^*}.$$

[16] In the stock market, the residual component dragged prices down earlier in the recession, arguably due to a spike in the risk premium, but this residual effect disappeared (and might have flipped sign) by early 2021. Knox and Vissing-Jorgensen (2022) provide a more detailed decomposition of the stock market returns and argue that the risk premium increased substantially earlier in the recession but had declined to close to its preshock level by the end of 2020.

The equation above describes output in year $t+1$ in terms of output in year t and asset prices in year t. Note that if there were no asset price overshooting in year t, then output would be given by a similar expression with $P(t) = P^*$. Thus, the impact of asset price overshooting (relative to a no-overshooting benchmark) is

$$\frac{\Delta Y(t+1)}{Y^*} = \theta m \frac{P(t) - P^*}{P^*} = \frac{1}{\alpha}\theta M \frac{P(t) - P^*}{Y^*}, \text{ where } M = m\rho. \tag{38}$$

The second equality substitutes $\frac{Y^*}{P^*} = \frac{\rho}{\alpha}$ from (8). The parameter $M = m\rho = m\frac{C^{s*}}{P^*}$ is the marginal propensity to consume (MPC) out of stock wealth for the stockholders (see equation (14). The impact of asset price overshooting depends on the MPC, M, the fraction of the stockholders who adjust their spending, θ, and the Keynesian multiplier, $\frac{1}{\alpha}$ (see (3)).

For a back-of-the-envelope calculation, we set M to target the (yearly) MPC out of wealth based on recent empirical estimates. Chodorow-Reich, Nenov, and Simsek (2021) estimate an MPC out of stock wealth equal to 3 cents, and Mian, Rao, and Sufi (2013) estimate an MPC out of housing wealth equal to 5 to 7 cents. We set $M = 0.04$. Chodorow-Reich, Nenov, and Simsek (2021) also find that the response of spending to stock wealth is sluggish and stabilizes in about two years after the wealth shock. Based on this result, we set $\theta = 0.5$: Half of stockholders adjust their spending in a given year. Finally, we set the Keynesian multiplier to a relatively conservative level, $\frac{1}{\alpha} = 1.5$.[17] Substituting these expressions, we obtain

$$\frac{\Delta Y(t+1)}{Y^*(t)} = \underbrace{1.5 \times 0.5 \times 0.04}_{0.03} \frac{P(t) - P^*(t)}{Y^*(t)}. \tag{39}$$

Each dollar of overshooting in a given year increases aggregate spending in the next year by about 3 cents. We index potential output and potential asset price by year, $Y^*(t), P^*(t)$, since these terms grow over time due to inflation and technological progress.

Consider the year $t = 2021$, in which asset price overshooting was substantial and mostly driven by the market bond portfolio (see Figure 6). Let $P(2021)$ denote average household net worth in 2021. Let $P^*(2021) = P(2019Q4)\frac{Y^*(2021)}{Y^*(2019Q4)}$ denote projected potential household net worth in 2021, based on the pre-COVID household net worth and the growth of potential output (we take pre-COVID household net worth to be equal to potential). Substi-

[17] The analysis in Chodorow-Reich (2019) suggests that the aggregate zero lower bound multiplier is at least 1.7 (it could be considerably greater than this level since the empirical estimates often identify a cross-sectional multiplier, and the aggregate zero lower bound multiplier exceeds the cross-sectional multiplier in standard models). Note also that our calibration of the multiplier implies a share of capital that is larger than the empirical estimates, $\alpha = 0.66$. This discrepancy is due to the stark assumptions of our model (e.g., stockholders earn no labor income).

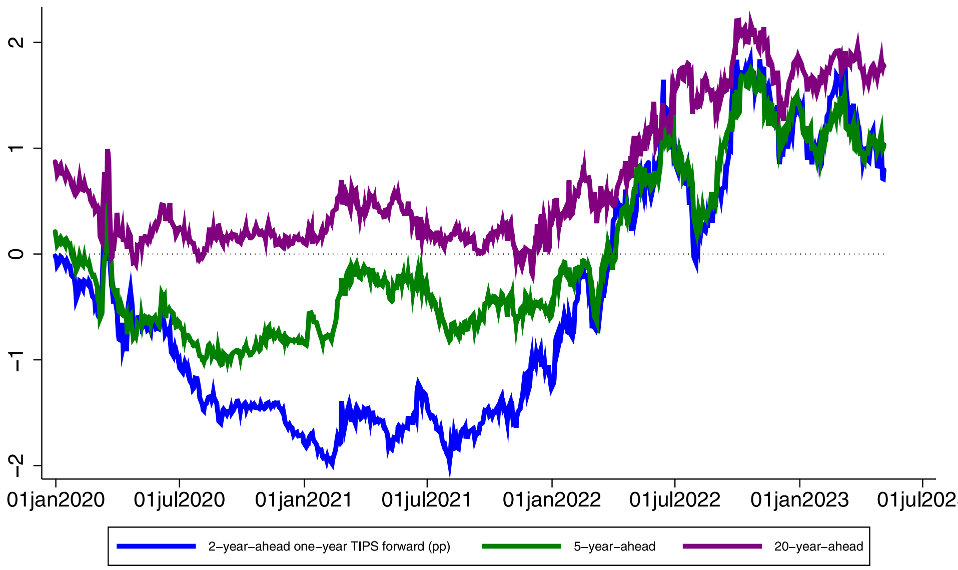

Figure 7. Drivers of the market bond portfolio in the COVID-19 recovery. This figure shows one-year TIPS forward rates at select horizons.

tuting the data counterparts, we calculate

$$\frac{P(2021) - P^{*}(2021)}{Y^{*}(2021)} = \frac{\$143.9T - \$116.8T \times \frac{\$23.6T}{\$21.8T}}{\$23.6T} \simeq 0.74.$$

In 2021, household net worth exceeded its pre-COVID level by about \$27.1 trillion. After adjusting for the projected increase due to inflation and technological progress, this amounts to an asset price overshooting of about 74% of potential output. Together with (39), we find that the asset price overshooting in 2021 increased output in 2022 by about 2.2% (0.03× 0.74).

D. The Role of Long-Term Rates and LSAPs

We end this section with a discussion of the role of long-term real rates in explaining the asset price overshooting in the COVID-19 recovery. Recall that $p^{MB}(t)$ reflects a weighted-average of TIPS forward rates at various maturities (see (37)). Figure 7 plots select TIPS forward rates to illustrate the drivers of $p^{MB}(t)$ in this episode. Early in the recession, the shorter term forward rates were compressed due to the lower bound on the nominal rates and expected disinflation. Nonetheless, $p^{MB}(t)$ increased because the longer term forward rates also declined (except for March 2020). During the recovery, the policy support for $p^{MB}(t)$ gradually shifted from longer term to shorter term rates, which declined substantially due to an increase in expected inflation. In 2022, when the economy showed clear signs of overheating, $p^{MB}(t)$ declined because the short-term as well as long-term rates recovered and eventually exceeded their pre-COVID levels.

In our model, the optimal policy induces and then tapers overshooting by adjusting the short-term discount rates by a large amount and then quickly undoing this aggressive cut. This aspect of our model does not fully match the data: Figure 7 suggests that in the COVID-19 recovery, monetary policy partly operated through distant-horizon forward rates. We think these long-term rate changes were likely driven by the large LSAP programs for safe assets that the Fed implemented in this episode.[18] The Fed purchased or financed trillions of dollars of treasuries and agency mortgage-backed securities between March and June 2020, and it bought about $120 billion a month from mid-2020 until the end of 2021. The Fed started tapering its asset purchases in November 2021 and stopped expanding its balance sheet in March 2022.[19]

Our model is stylized and does not have the appropriate frictions that make LSAPs operational, such as risk absorption by the government (e.g., Caballero and Simsek (2021a)) or segmented markets (e.g., Vayanos and Vila (2021), Ray (2019), Sims, Wu, and Zhang (2023)). Nonetheless, from the perspective of our model, we view LSAPs as a close substitute for conventional monetary policy, conditional on LSAPs inducing the same impact on aggregate wealth, $p(t)$. In particular, the price of the market bond portfolio also captures the wealth effect driven by long-term safe asset purchases typical of quantitative easing policies. These purchases can substitute for short-term rate cuts by reducing the long-term rates, for example, by absorbing the duration risk and reducing the term premium.[20]

IV. Final Remarks

Summary. We proposed a model to illustrate that when aggregate demand is below its potential and responds to asset prices with a lag, optimal monetary policy naturally generates large temporary gaps between the performance of financial markets and the real economy. The central bank boosts asset prices to close the output gap as fast as possible. We also show that when the central bank faces a lower bound on the discount rate it can set, the overshooting becomes a concave and nonmonotonic function of the output gap. Due to competing cash flow and interest rate effects, the asset price boost is low for a

[18] See Hanson and Stein (2015) for the puzzling finding that conventional monetary policy shocks also seem to affect real long-term interest rates. See also Bianchi, Lettau, and Ludvigson (2022) for an explanation of these long-lasting effects of monetary policy over real rates and asset prices based on a regime-switching model with sticky inflation expectations. Note, however, that the space for conventional monetary policy during the Covid-19 recovery was very limited, which suggests that LSAPs also played a central role in driving $p^{MB}(t)$ in this episode.

[19] For the Fed's response, see https://www.brookings.edu/research/fed-response-to-covid19/.

[20] An extensive empirical literature documents that the LSAPs in recent years have been good substitutes for conventional monetary policy (see, for example, d'Amico et al. (2012), Swanson and Williams (2014), Swanson (2018), Sims and Wu (2020), Sims and Wu (2021)).

deeply negative initial output gap, grows as the output gap improves over a range, and shrinks toward zero as the output gap improves further. This result also implies that good macroeconomic news is better news for asset prices when the output gap is more negative, which is consistent with the empirical literature on the news effect on asset prices (see, for example, Elenev et al. (2023)).

While we do not explicitly model fiscal policy, our analysis of the price impact of news suggests that fiscal policy is likely to complement monetary policy when the output gap is significantly negative, and to substitute for it when the output gap is closer to zero. When output is significantly below its potential, fiscal policy increases asset prices—an outcome that the central bank desires but cannot achieve due to the discount rate constraint. When the output is close to its potential, fiscal policy induces the central bank to accelerate interest-rate hikes sufficiently to decrease asset prices.

We estimate a large policy-induced overshooting in the COVID-19 recovery driven by risk-free rates. To facilitate this exercise, we decomposed the aggregate asset price in our setting into a market bond portfolio driven by expected interest rate changes and a residual driven by expected cash flows and other factors. The market bond portfolio increased substantially in the COVID-19 recovery—a rise sufficient to explain the high levels of stock and house prices in 2021. A back-of-the-envelope calculation suggests that this asset price overshooting in 2021 increased output in 2022 by about 2.2%.

Observations. While we demonstrate that the broad features of asset markets during the COVID-19 episode are consistent with optimal monetary policy, we do not wish to imply that there were no anomalies or pockets of irrational exuberance in some markets. Having said this, the logic of the model suggests that experiencing an episode of irrational exuberance during the recovery from a deep recession has a positive dimension, since it reduces the burden on the central bank to engineer an overshooting.

Finally, we note that adding heterogeneity in productivity (a central feature of the COVID-19 episode not present in our model) does not change our main results, but it introduces large dispersion in asset prices across firms. In particular, firms whose relative productivity is positively affected by the recession shock see their shares' value rise by even more since they benefit from the central bank's attempt to boost asset prices without suffering from a decline in productivity. In the COVID-19 episode, this provides a rationale for the extraordinary performance of indices such as the NASDAQ 100, whose main components consist of "COVID-sheltered" firms.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix.
Replication Code.