Back to the 1980s or Not? The Drivers of Real and Inflation Risks in Treasury Bonds *

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Abstract

This paper explains changes in nominal and real bond risks in a New Keynesian model of monetary policy, where habit formation preferences generate endogenously time-varying risk premia. In the 1979.Q4-2001.Q1 calibration, a strong monetary policy response to volatile supply shocks leads to "stagflations", the inflation-output correlation is negative, and the nominal bond-stock correlation is positive. In the 2001.Q2-2019.Q4 calibration, demand shocks are dominant, leading to a positive inflation-output correlation, and a negative nominal bond-stock correlation. Combining 1980s-style supply shocks with a 2000s-style monetary policy rule does not turn model nominal bond betas positive, consistent with post-pandemic evidence.

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1 Introduction

Did the severe stagflation of the 1980s occur because the economy was subject to supply shocks or because the Volcker Fed raised interest rates and engineered a recession? This question is newly relevant as post-pandemic supply shocks leave economists and policy makers wondering whether there will be a repeat. Nominal Treasury bond risks price inflation and are informative about its fundamental economic drivers, such as supply shocks, demand shocks, and monetary policy. I model this link formally within a New Keynesian asset pricing model, which I fit to the data separately for the 1980s and the 2000s. I argue that the evidence on changing bond risks over the decades supports an economic interpretation whereby stagflations arise as a "perfect storm" of supply shocks and a reactive monetary policy rule, but not from either supply shocks or monetary policy in isolation.

Figure 1 shows that just as the macroeconomy changed from the 1980s to the 2000s, the risks of nominal and inflation-indexed Treasury bonds, as measured by their stock market betas, also changed.[1] During the 1980s nominal bond betas were positive – nominal bonds were risky – whereas during the 2000s nominal bond betas were negative – nominal bonds were safe. The beta of inflation-indexed bonds also changed but was substantially smaller during the 1980s, indicating that inflation expectations were important for nominal bond betas. As nominal bond prices fall with expected inflation and stocks rise with output, it is intuitive that the stagflations and negative inflation-output correlation of the 1980s led to a positive nominal bond-stock correlation.[2] Maybe surprisingly then, the post-pandemic picture looks different from the 1980s, with little stagflation risk priced into nominal bond betas, which were mostly negative and always below real bond betas.

To understand how supply shocks, demand shocks, and monetary policy drive changes in bond risks, I build a New Keynesian asset pricing model with plausibly time-varying

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[1] Panel A shows the regression coefficient of quarterly bond excess returns onto quarterly stock returns over five-year rolling windows. Panel B shows the regression coefficient of daily bond returns onto daily stock returns post-2018 using six-month rolling windows. I compute bond returns from zero-coupon nominal and inflation-indexed yields, so the bond duration is held constant at ten years. I use UK inflation-linked bond yields prior to 1999 and yields on US Treasury Inflation Protected Securities (TIPS) after 1999, when TIPS data becomes available. Campbell, Shiller and Viceira (2009) find similar changes in US and UK nominal and inflation-indexed bond-stock betas.

[2] Campbell, Pflueger and Viceira (2020) argue that nominal bond-stock betas price stagflation risks, but in contrast to this paper do not speak to supply shocks, demand shocks, monetary policy or the post-pandemic evidence. While this paper focuses on the macroeconomic information priced into bond risks, bond risks also matter directly. A positive comovement between nominal Treasuries with the stock market makes them risky assets to hold for a traditional long-term investor (Campbell and Viceira (2002), Piazzesi and Schneider (2006)), affects the price and quantity of debt optimally issued by sovereign governments (Barro (2003), Lustig, Sleet and Yeltekin (2008), Du, Pflueger and Schreger (2020), De Lannoy, Bhandari, Evans, Golosov and Sargent (2022)), and changes the state-contingency of corporate debt (Fisher (1933), Kang and Pflueger (2015), Bocola and Lorenzoni (2022)).

and countercyclical risk premia. I calibrate it separately for the 1980s and for the 2000s, and then conduct counterfactual analyses asking which fundamental drivers can account for the puzzling post-pandemic bond risks. The model combines a standard small-scale New Keynesian model with Campbell, Pflueger and Viceira (2020)'s habit formation preferences, which are exactly consistent with a standard log-linear macro Euler equation and generate lower risk bearing capacity after a series of bad shocks. The macroeconomic side of the model boils down to a standard three-equation New Keynesian model with an Euler equation, Phillips curve, and monetary policy rule (Clarida, Gali and Gertler (2000)). Risk premia are driven by a separate state variable, the surplus consumption ratio, which is highly non-linear but driven by the same fundamental economic shocks as the economy. The model matches equity market moments, such as the equity Sharpe ratio, the persistent price-dividend ratio, and stock excess return predictability from the price-dividend ratio, so bond risks in the model are based on a plausible description of countercyclical risk premia in the economy overall.

The demand shock in the model is a preference shock for bonds, such as a change in the convenience benefit of Treasuries (Krishnamurthy and Vissing-Jorgensen (2012), Du, Tepper and Verdelhan (2018b), Jiang, Krishnamurthy and Lustig (2021)), credit spreads (Gilchrist and Zakrajšek (2012)), or a preference for safety not immediately driven by aggregate risk aversion (Pflueger, Siriwardane and Sunderam (2020)). Alternatively, the demand shock can be interpreted as a shock to growth expectations, in line with a growing literature that points to these types of shocks as an important driver of business cycles (e.g. Beaudry and Portier (2006), Chahrour and Jurado (2018)). Inflation in the model satisfies a log-linearized Phillips curve with partially adaptive inflation expectations and sticky wages in the manner of Rotemberg (1982), so a supply shock corresponds to a wage markup shock. The choice to model sticky wages rather than sticky prices leads to procyclical firm profits and means that a levered claim to consumption (Abel (1990)) coincides with a claim to firm profits, but otherwise does not affect the model's macroeconomic or asset price dynamics.

This paper performs two main exercises. First, I calibrate the model to macroeconomic dynamics of long macroeconomic periods, and show that it provides a reasonable explanation of the macroeconomic and bond risk changes from the 1980s vs. the 2000s. I choose a break date of 2001.Q2 as in Campbell, Pflueger and Viceira (2020) when the correlation between inflation and the output gap turned from negative (i.e. stagflations) to positive. I allow the volatilities of shocks, the monetary policy rule parameters, and the adaptiveness of wage-setters' inflation expectations to vary across calibrations, while preference parameters and the slope of the Phillips curve are held constant at the value estimated by Hazell, Herreno, Nakamura and Steinsson (2022). The volatilities of shocks and monetary policy parameters are calibrated for each subperiod to match the inflation-output gap, fed funds rate-output gap, and inflation-fed funds rate relationships at several leads and lags, as well as the volatilities of consumption growth, long-term inflation expectations, and the fed funds rate. Holding the volatilities of shocks and the monetary policy rule fixed, the adaptiveness of wage-setters' inflation expectations is then chosen to match the well-known predictability of bond excess returns of Campbell and Shiller (1991).

For the 1980s, the calibration procedure leads to volatile supply shocks but almost no demand shocks, and a monetary policy rule with a high inflation weight, a low output weight, and little inertia. Partially adaptive inflation expectations generate predictability in in bond excess returns (Campbell and Shiller (1991)), predictable inflation forecast errors (Coibion and Gorodnichenko (2015)), and reconcile volatile nominal bond yields with much less volatile long-term survey inflation expectations. For the 2000s, the calibration procedure leads to volatile demand shocks, almost no supply shocks, and a more inertial monetary policy rule that puts less weight on inflation and more weight on output. The change to a more inertial rule with relatively greater weight on output is intuitively in line with central bankers' increased focus on output fluctuations and smaller policy steps that tend to be followed by changes in the same direction during recent decades.[3] I set inflation expectations to be perfectly forward-looking for the 2000s calibration, in line with a lack of predictability of bond excess returns and inflation forecast errors in the 2000s data.

Even though nominal and real bond betas are not explicitly targeted in the calibration, the model matches them well for both subperiods. It generates a highly positive nominal bond-stock beta and a smaller positive real bond-stock beta for the 1980s. The channel is simple: A positive supply shock drives up inflation expectations, leading to lower nominal bond prices. Because monetary policy raises the nominal policy rate swiftly and strongly, real rates also rise, and prices of real bonds fall. The higher real interest rate leads consumers to postpone consumption, and consumption falls toward habit, increasing risk aversion and lowering stock valuations. The 2000s calibration generates negative stock market betas for both nominal and real bonds, also in line with the data. The key channel depends on demand shocks, which tend to raise interest rates and inflation just as the output gap and stock prices rise.

Endogenously time-varying risk premia amplify the switch in bond betas from the 1980s to the 2000s, and depend on the macroeconomic equilibrium. When investors understand that nominal bonds are risky, as in the 1980s calibration, this leads to positively correlated time-varying risk premia in nominal bonds and stocks. Time-varying risk premia in this

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[3] An increase in the monetary policy output gap weight and increased inertia post-2000 are also supported by the survey evidence from Bauer, Pflueger and Sunderam (2022).

calibration are quantitatively large and even flip the sign of the nominal bond response to demand shocks. Understanding that nominal bonds are risky in this equilibrium, a positive demand shock endogenously makes investors more willing to bear risks, raising the valuations of both stocks and nominal bonds. Bond risks in the model therefore reflect investors' views about the equilibrium rather than past realized shocks, and are inherently forward-looking.

The 1980s calibration of the model explains bond excess return predictability from the yield spread, consistent with the long-standing evidence of Campbell and Shiller (1991). In the model, a strong backward-looking component in the Phillips curve generates a persistent inflation process, so the expectations hypothesis component roughly cancels from the spread between long- and short-term nominal interest rates following a supply shock. The term spread therefore loads onto time-varying risk premia and predicts future bond excess returns. For the 2000s, the model generates no return predictability in nominal bond excess returns, consistent with the data for this subperiod. Bond risks in this model therefore discipline a further component of the standard New Keynesian model, and contribute to the literature on forward- vs. backward-looking Phillips curves (Fuhrer (1997)).

Which combination of changes would flip the nominal bond-stock beta to positive and make nominal bonds risky as in the stagflationary 1980s? This question is of relevance not only for policy makers trying to understand what drives the economy, but also for the Treasury borrowing from markets, and long-term investors seeking to diversify their portfolios. In my second exercise, I compute model counterfactuals to answer this question.

Maybe surprisingly, model nominal bond betas remain negative in a counterfactual that starts from the 2000s calibration but changes the volatilities of shocks towards the supply shock dominated 1980s calibration. The intuition is that the more inertial and output-focused monetary policy rule of the 2000s allows the real rate to fall in response to an inflationary supply shock, leading to a very shallow recession, and no stagflation risk in nominal bond betas. Real bonds in this counterfactual mostly load on monetary policy shocks, which tend to increase output and stock prices just as the real rate declines, hence inducing a positive correlation between real bond prices and stock prices. However, when both the monetary policy rule and the volatilities of shocks are set to their 1980s values, nominal bond betas turn positive as in the 1980s calibration. These counterfactuals line up well with Figure 1, Panel B which shows that post-pandemic nominal bond betas remained mostly negative and real bond betas turned positive. The visible increase in empirical nominal bond betas during the second half of 2022 also fits this narrative, as this was the time when monetary policy started to act more aggressively. Asset pricing moments from Treasury markets therefore support the view that supply shocks matter for the real economy because monetary policy responds to them (Bernanke, Gertler and Watson (1997)).

This paper contributes to the broad literatures understanding the sources of stagflations, the link between monetary policy and asset prices, and the drivers of changes in bond-stock comovements. The long literature seeking to explain the extraordinary inflation dynamics in the 1980s can broadly be divided into a strand emphasizing changes in shocks (Stock and Watson (2002), Sims and Zha (2006), Justiniano and Primiceri (2008)) and a strand emphasizing changes in monetary policy (Clarida, Gali and Gertler (2000), Lubik and Schorfheide (2004), Bernanke, Gertler and Watson (1997)). One narrative that has emerged from this literature is that supply shocks were initially not recognized by monetary policy, forcing the Fed to raise interest rates drastically under Volcker, which resulted in severe stagflation (Primiceri (2006)). More recently, several authors have argued that the reemergence of inflation can at least be partly attributed to supply-type shocks (e.g. Rubbo (2022), Harding, Lindé and Trabandt (2022), Di Giovanni et al. (2022)). I contribute to this literature by bringing new asset pricing moments to speak to the question of shocks vs. policy. I show that changing bond risks support a narrative whereby the *interaction* of supply shocks and monetary policy was essential to generate the risky nominal Treasury bond markets of the stagflationary 1980s, and a return to such an equilibrium would be needed to turn nominal bonds risky.

While the textbook New Keynesian model features constant risk aversion and hence little variation in risk premia, my model accounts for the high volatility of risk premia via habit formation preferences. The traditional view that monetary policy has short- to medium-term effects makes it appealing to use a model of financial market discounts that also respond to shorter-term fluctuations. The highly nonlinear habits of Campbell, Pflueger and Viceira (2020) have this feature, and are specifically designed to reconcile highly volatile and nonlinear risk premia in stocks with a much less volatile risk-free rate that is well-described by a linear policy rule, an important requirement for modeling monetary policy.[4] Pflueger and Rinaldi (2022) show that these preferences reconcile the strong and persistent stock response to high-frequency monetary policy surprises around FOMC announcements with the empirical output response to identified monetary policy shocks, thereby providing a proof-of-concept of monetary policy risk premia. While my model builds on habit formation preferences, the findings should be regarded more broadly as the result of countercyclical risk premia, whether they are generated from the price of risk as here, the quantity of risk as in Jurado, Ludvigson and Ng (2015), or heterogeneous agents with different risk aversion (Chan

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[4] Some research, including Uhlig (2007), Dew-Becker (2014), and Rudebusch and Swanson (2008) has embedded simplified finance habit preferences into New Keynesian models, though this integration has been challenging. Verdelhan (2010) and Wachter (2006) show that similar finance habit preferences combined with more reduced-form models of the macroeconomy can explain risk premia in foreign exchange and bond markets, respectively.

and Kogan (2002), Kekre and Lenel (2022), Caballero and Simsek (2022)). The advantage of the habits model is that it is relatively simple and its quantitative implications for stock risk premia are well-understood. These properties help me unify a wider range of macro and asset pricing features, including time-varying stock risk premia and the changing risks of bonds. The focus on preferences is also useful because I do not have to make additional assumptions on the variation in the quantity of risk, and the macroeconomic side of the model can be summarized by a standard log-linear New Keynesian model. This paper therefore contributes a new tool to jointly understand asset prices, monetary policy, and fundamental economic shocks.

Finally, this paper also contributes to the growing literature on changing bond risks. It complements the perspectives of Bianchi, Lettau and Ludvigson (2022b), Bianchi, Ludvigson and Ma (2022c), Gourio and Ngo (2020), and Li, Zha, Zhang and Zhou (2022), who model bond risk premia or bond risks within New Keynesian models, but focus on the role of monetary policy with constant shock volatilities and constant risk aversion. This paper differs through its focus on the interaction between changing shocks and changing monetary policy, and by generating endogenously time-varying risk premia through habit formation preferences. Several papers have also documented the changing risks in bonds and studied their drivers in more reduced-form models (e.g. Baele, Bekaert and Inghelbrecht (2010), Viceira (2012), David and Veronesi (2013), Campbell, Sunderam and Viceira (2017), Campbell, Pflueger and Viceira (2020), Song (2017)). He, Nagel and Song (2022) document a brief episode of positive bond-stock comovements in March 2020. Consistent with this paper, they conclude that this was not a break from previous patterns but instead reflected short-term constraints on intermediaries. This paper also complements the more reduced-form approach of Chernov, Lochstoer and Song (2021), who use rolling correlations rather than betas to argue that the time-varying bond-stock comovements are similar for inflation-indexed and nominal bonds. However, if the same structural shock drives both real bond yields and inflation expectations, as in most New Keynesian models, correlations may not reveal the separate roles of inflation vs. real rate risks. My focus on betas reveals distinct differences between nominal and real bond risks pre-2000, which I attribute to demand and supply shocks, and their interactions with monetary policy.

The rest of the paper proceeds as follows. Section 2 describes the model. Section 3 describes the targeted empirical moments and the calibration procedure. Section 4 evaluates the model fit for macroeconomic and asset pricing moments for the 1980s and 2000s subperiods. Section 5 presents the counterfactual exercises. Finally, Section 6 concludes.

2 Model

The model combines a small-scale log-linearized New Keynesian model on the macroeconomic side with a model of habit-formation preferences for asset prices, thereby leading to volatile and countercyclical risk premia. I use lower-case letters to denote logs, π_t to denote log price inflation, and π_t^w to denote log wage inflation. I refer to price inflation and inflation interchangeably.

2.1 Preferences

As in Campbell and Cochrane (1999), a representative agent derives utility from real consumption C_t relative to a slowly moving habit level H_t:

$$U_t = \frac{(C_t - H_t)^{1-\gamma} - 1}{1-\gamma}. \tag{1}$$

Habits are external, meaning that they are shaped by aggregate consumption and households do not internalize how habits might respond to their personal consumption choices. The parameter γ is a curvature parameter. Relative risk aversion equals $-U_{CC}C/U_C = \gamma/S_t$, where surplus consumption is the share of consumption available to generate utility:

$$S_t = \frac{C_t - H_t}{C_t}. \tag{2}$$

Risk aversion therefore declines when consumption has fallen close to habit. As equation (2) makes clear, a model for market habit implies a model for surplus consumption and vice versa. As in Campbell, Pflueger and Viceira (2020), I model market consumption habit implicitly by assuming that log surplus consumption, s_t, satisfies:

$$\begin{aligned} s_{t+1} &= (1-\theta_0)\bar{s} + \theta_0 s_t + \theta_1 x_t + \theta_2 x_{t-1} + \lambda(s_t)\varepsilon_{c,t+1}, && (3) \\ \varepsilon_{c,t+1} &= c_{t+1} - \mathrm{E}_t c_{t+1}. && (4) \end{aligned}$$

Here, x_t equals stochastically detrended consumption (up to a constant):

$$x_t = c_t - (1-\phi)\sum_{j=0}^{\infty}\phi^j c_{t-1-j}, \tag{5}$$

where ϕ is a smoothing parameter. For the microfoundations in Section 2.4, x_t equals the log output gap, or the difference between between log output and log potential output under flexible prices and wages, and I refer to it as the output gap for short.

The sensitivity function $\lambda(s_t)$ takes the form as in Campbell and Cochrane (1999)

$$\lambda(s_t) = \begin{cases} \frac{1}{\bar{S}}\sqrt{1-2(s_t-\bar{s})}-1 & s_t \leq s_{max} \\ 0 & s_t > s_{max} \end{cases}, \tag{6}$$

$$\bar{S} = \sigma_c\sqrt{\frac{\gamma}{1-\theta_0}}, \tag{7}$$

$$\bar{s} = \log(\bar{S}), \tag{8}$$

$$s_{max} = \bar{s} + 0.5(1-\bar{S}^2). \tag{9}$$

This function is decreasing in log surplus consumption, so marginal utility becomes more sensitive to consumption surprises when surplus consumption is already low, as would be the case after a sequence of bad shocks. Here, σ_c denotes the standard deviation of the consumption surprise $\varepsilon_{c,t+1}$ and $\bar{s}$ is the steady-state value for log surplus consumption. Both consumption and the output gap are equilibrium objects that depend on fundamental shocks, and in equilibrium they are conditionally homoskedastic and lognormal. As shown in Campbell, Pflueger and Viceira (2020), the specification for log surplus consumption (3) implies that log market habit follows approximately a weighted average of lagged consumption and lagged consumption expectations.

2.2 Asset Pricing Equations and Preference Shock

Investors price bonds and stocks with the stochastic discount factor arising from consumption utility (1), and an i.i.d. homoskedastic preference shock ξ_t for bonds. The stochastic discount factor (SDF) for consumption claims M_{t+1} in this economy equals:

$$M_{t+1} = \beta\frac{\frac{\partial U_{t+1}}{\partial C}}{\frac{\partial U_t}{\partial C}} = \beta\exp\left(-\gamma(\Delta s_{t+1}+\Delta c_{t+1})\right). \tag{10}$$

The Euler equation for the one-period risk-free rate includes the preference shock for bonds ξ_t:

$$1 = E_t\left[M_{t+1}exp\left(r_t-\xi_t\right)\right], \tag{11}$$

and one-period real and nominal interest rates are linked via the Fisher equation

$$i_t = E_t\pi_{t+1}+r_t. \tag{12}$$

Equation (12) is an approximation, effectively assuming that the inflation risk premium in one-period nominal bonds is zero. Longer-term bond prices do not use this approximation and are given by the recursions:

$$P^{\$}_{1,t} = exp(-i_t),\ P_{1,t} = exp(-r_t), \tag{13}$$

$$P^{\$}_{n,t} = exp(-\xi_t)E_t\left[M_{t+1}exp(-\pi_{t+1})P^{\$}_{n-1,t+1}\right],\ P_{n,t} = exp(-\xi_t)E_t\left[M_{t+1}P_{n-1,t+1}\right], \tag{14}$$

where all expectations are rational. The assumption that all bonds are priced with the preference shock ξ_t ensures that in the absence of uncertainty the expectations hypothesis holds for nominal and real bonds.

I model stocks as a levered claim on consumption or equivalently firm profits, while preserving the cointegration of consumption and dividends. The asset pricing recursion for a claim paying consumption at time $t+n$ and zero otherwise takes the following form

$$\frac{P^c_{n,t}}{C_t} = E_t\left[M_{t+1}\frac{C_{t+1}}{C_t}\frac{P^c_{n-1,t+1}}{C_{t+1}}\right]. \tag{15}$$

The price-consumption ratio for a claim to all future consumption then equals

$$\frac{P^c_t}{C_t} = \sum_{n=1}^{\infty}\frac{P_{n,t}}{C_t}. \tag{16}$$

At time t the aggregate levered firm buys P^c_t and sells equity worth δP^c_t, with the remainder of the firm's position financed by one-period risk-free debt worth $(1-\delta)P^c_t$, so the price of the levered equity claim equals $P^\delta_t = \delta P^c_t$.

The preference shock ξ_t allows for several intuitive interpretations, corresponding to prominent sources of demand shocks proposed in the literature. Most simply, an increase in ξ_t represents an increased desire to borrow and a decreased desire to hold bonds at a given policy rate controlled by the Fed. It therefore acts like a decline in Treasury bond convenience (Du, Im and Schreger (2018a), Jiang, Krishnamurthy and Lustig (2021)) or a decline in credit spreads (Gilchrist and Zakrajšek (2012))). Alternatively, ξ_t can be interpreted as a shock to expected (but not necessarily realized) potential output growth, decreasing the valuations of bonds relative to stocks at any given level of current consumption. Such an interpretation is similar to expectations-based demand shocks proposed by Beaudry and Portier (2006), Angeletos and La'O (2013), Angeletos, Collard and Dellas (2018), De La'O and Myers (2021), Bordalo, Gennaioli, LaPorta and Shleifer (2022).[5] My results do not

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[5] Details of the interpretation as an expected growth shock are provided in Appendix C. I model the demand shock as arising from a preference shock for bonds rather than from a shock to the discount factor

depend on the specific interpretation of ξ_t within these broad categories. The next Section shows that a positive preference shock ξ_t gives rise to a positive demand shock in the macroeconomic Euler equation, increasing consumption and output at a given policy rate.

2.3 Macroeconomic Euler Equation from Preferences

The macroeconomic Euler equation is simply the asset pricing equation for a one-period risk-free bond (11). Substituting for the SDF and surplus consumption dynamics gives (up to a constant):

$$\begin{aligned} r_t &= \gamma \mathrm{E}_t \Delta c_{t+1} + \gamma \mathrm{E}_t \Delta s_{t+1} - \frac{\gamma^2}{2}\left(1+\lambda(s_t)\right)^2 \sigma_c^2 + \xi_t, && (17) \\ &= \gamma \mathrm{E}_t \Delta c_{t+1} + \gamma\theta_1 x_t + \gamma\theta_2 x_{t-1} + \underbrace{\gamma(\theta_0 - 1)s_t - \frac{\gamma^2}{2}\left(1+\lambda(s_t)\right)^2 \sigma_c^2}_{=0} + \xi_t. && (18) \end{aligned}$$

The sensitivity function (6) through (9) has the advantageous property that the two bracketed terms drop out and the real risk-free rate therefore has the familiar log-linear form, and much lower volatility than the stock market. Substituting (5) then gives the exactly loglinear macroeconomic **Euler equation**:

$$x_t = f^x E_t x_{t+1} + \rho^x x_{t-1} - \psi r_t + v_{x,t}. \tag{19}$$

Imposing the restriction that the forward- and backward-looking terms in the Euler equation add up to one, the Euler equation parameters are given by

$$\rho^x = \frac{\theta_2}{\phi - \theta_1}, f^x = \frac{1}{\phi - \theta_1}, \psi = \frac{1}{\gamma(\phi-\theta_1)}, \theta_2 = \phi - 1 - \theta_1. \tag{20}$$

Non-zero values for the habit parameters, θ_1 and θ_2, are therefore needed to generate the standard New Keynesian block with forward- and backward-looking coefficients. The demand shock in the Euler equation equals

$$v_{x,t} = \psi \xi_t. \tag{21}$$

The demand shock $v_{x,t}$ is conditionally homoskedastic, serially uncorrelated and uncorrelated with supply and monetary policy shocks because ξ_t is. The standard deviation of $v_{x,t}$ is

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β shared by bonds and stocks (Albuquerque, Eichenbaum, Luo and Rebelo (2016)), because a shock to the discount factor β would generate strongly positive bond-stock correlations, in stark contrast to the post-2000 data.

denoted by σ_x. A preference shift towards bonds (a decrease in ξ_t) leads to a reduction in consumption and a more negative output gap as if the real risk-free rate was above the policy rate set by the central bank, which could be due to an increase in bond convenience, an increase in credit spreads, or a decline in expected potential output growth.

2.4 Supply Side

I keep the supply side as simple as possible to generate a standard log-linearized Phillips curve describing inflation dynamics, and the link between consumption and the output gap. Because the supply side is largely standard I only provide an overview and relegate details to the Appendix. There is no real investment and the aggregate resource constraint simply states that aggregate consumption equals aggregate output:

$$C_t = Y_t. \tag{22}$$

Following Lucas (1988) I assume that productivity depends on past economic activity. Potential output is defined as the level of real output that would obtain with flexible prices and wages taking current productivity as given. The log output gap is the difference between log real output and log potential output and in equilibrium satisfies (5).

I consider the simplified case where wage unions charge sticky wages but firms' product prices are flexible. Specifically, I assume that wage-setters face a quadratic cost as in Rotemberg (1982) if they raise wages faster than past inflation. The indexing to past inflation is analogous to the indexing assumption in Smets and Wouters (2007) and Christiano, Eichenbaum and Evans (2005). I assume that households experience disutility of working outside the home due to the opportunity cost of home production as in Greenwood, Hercowitz and Huffman (1988), with external home production habit defined so that home production drops out of the intertemporal consumption decision and the asset pricing stochastic discount factor. Log-linearizing the intratemporal first-order condition of wage-setting unions gives the **Phillips curve**:

$$\pi_t^w \quad = \quad f^\pi E_t \pi_{t+1}^w + \rho^\pi \pi_{t-1}^w + \kappa x_t + v_{\pi,t}, \tag{23}$$

for constants ρ^π, f^π, and κ. The parameter κ is a wage-flexibility parameter. The supply or Phillips curve shock $v_{\pi,t}$ is assumed to be conditionally homoskedastic with standard deviation $\sigma_{\pi,t}$, serially uncorrelated, and uncorrelated with other shocks. This supply shock can arise from a variety of sources, such as variation in optimal wage markups charged by unions or shocks to the marginal utility of leisure.[6]

I allow wage setters to have partially adaptive subjective inflation expectations of the form

$$\tilde{E}_t \pi^w_{t+1} \quad = \quad (1-\zeta) E_t \pi^w_{t+1} + \zeta \pi^w_{t-1}, \tag{24}$$

where E_t denotes the rational expectation conditional on state variables at the end of period t. Hence, while financial assets are priced with rational inflation expectations, wage setters' expectations are more sluggish, capturing the idea that markets are more sophisticated and attentive to macroeconomic dynamics than individual wage-setters. A similar assumption has been used by Bianchi, Lettau and Ludvigson (2022b). The case $\zeta = 0$ corresponds to rational forward-looking inflation expectations, while $\zeta > 0$ reflects partially adaptive inflation expectations. A long-standing Phillips curve literature has found that adaptive inflation expectations and a strongly backward-looking Phillips curve are helpful for capturing the empirical persistence of inflation (Fuhrer and Moore (1995), Fuhrer (1997)).[7] If $\rho^{\pi,0}$ is the backward-looking component obtained under rational inflation expectations ($\zeta = 0$), the backward- and forward-looking Phillips curve parameters equal:

$$\rho^\pi = \rho^{\pi,0} + \zeta - \rho^{\pi,0}\zeta, \;\; f^\pi = 1 - \rho^\pi. \tag{25}$$

Ten-year survey inflation expectations are modeled similarly to wage-setters' expectations as a weighted average of a moving average of inflation over the past ten years and the rational forecast, with the weight on past inflation given by ζ.

In equilibrium price inflation equals wage inflation minus productivity growth, which in equilibrium depends on the output gap:

$$\pi_t \quad = \quad \pi^w_t - (1-\phi) x_t. \tag{26}$$

In the calibrated model, ϕ is close to one, and price and wage inflation are very similar. The reason to assume sticky wages rather than sticky prices is simply that with these assumptions a consumption claim (Abel (1990)) is identical to a claim to firm profits.[8]

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[6] While I do not model fiscal sources of inflation, under certain conditions a shock to expectations about fiscal policy can act similarly to a shift to the Phillips curve (Bianchi, Faccini and Melosi (2022a)). Up to the distinction between wage and price inflation, supply shocks would also be isomorphic to shifts to potential output that are unrecognized by the central bank and consumers, in which case $x_t + \frac{1}{\kappa} v_{\pi,t}$ would be the actual the output gap and x_t the output gap perceived by consumers and the central bank.

[7] Consistent with this older literature that emphasized aggregate inflation dynamics, a quickly growing literature has documented deviations from rationality (Coibion and Gorodnichenko (2015), Bianchi, Lettau and Ludvigson (2022b)) and excess dependence on lagged inflation (Malmendier and Nagel (2016)).

[8] It is also in line with Christiano, Eichenbaum and Evans (1999) who find that sticky wages are more

2.5 Monetary Policy

Let i_t denote the log nominal risk-free rate available from time t to $t+1$. Monetary policy is described by the following rule (ignoring constants):

$$
\begin{aligned}
i_t &= \rho^i i_{t-1} + \left(1-\rho^i\right)\left(\gamma^x x_t + \gamma^\pi \pi_t\right) + v_{i,t}, &(27)\\
v_t &\sim N\left(0, \sigma_i^2\right). &(28)
\end{aligned}
$$

Here, $\gamma^x x_t + \gamma^\pi \pi_t$ denotes the central bank's interest rate target, to which it adjusts slowly.[9] The parameters γ^x and γ^π represent monetary policy's long-term output gap and inflation weights. The inertia parameter ρ^i governs how quickly monetary policy adjusts towards this long-term target. The monetary policy shock, $v_{i,t}$, is assumed to be mean zero, serially uncorrelated, and conditionally homoskedastic. A positive monetary policy shock represents a surprise tightening of the short-term nominal interest rate above and beyond the rule, which then mean-reverts slowly at rate ρ^i.

2.6 Model Solution

The solution proceeds in two steps. First, I solve for log-linear macroeconomic dynamics. Second, I use numerical methods to solve for highly non-linear asset prices. This is aided by the particular tractability of the surplus consumption dynamics, which imply that the surplus consumption ratio is a state variable for asset prices but not for macroeconomic dynamics. I solve for the dynamics of the log-linear state vector

$$
Y_t = [x_t, \pi_t^w, i_t]'. \tag{29}
$$

The dynamics of these equilibrium objects are driven by the vector of exogenous shocks

$$
v_t = [v_{x,t}, v_{\pi,t}, v_{i,t}], \tag{30}
$$

---

important for aggregate inflation dynamics than sticky prices. See also Favilukis and Lin (2016) who find that wage-setting frictions are important ensure that a claim to firm profits behaves similarly to a claim to consumption in an asset pricing sense. Appendix D shows that model's central results are robust to setting wage- and price inflation equal.

[9] I do not model the zero lower bound here, because I am interested in longer-term regimes, and a substantial portion of the zero lower bound period appears to have been governed by expectations of a swift return to normal (Swanson and Williams (2014)). The zero-lower-bound may however be important for more cyclical changes in bond-stock betas, as emphasized by Gourio and Ngo (2020), and I leave this to future research.

according to the consumption Euler equation (19), the Phillips curve (23), the monetary policy rule (27), and the wage-price inflation link (26). I solve for a minimum state variable equilibrium of the form

$$Y_t \;=\; BY_{t-1} + \Sigma v_t, \tag{31}$$

where B and Σ are $[3 \times 3]$ and $[3 \times 3]$ matrices, and v_t is the vector of structural shocks. I solve for the matrix B using Uhlig (1999)'s formulation of the Blanchard and Kahn (1980) method. In both calibrations, there exists a unique equilibrium of the form (31) with non-explosive eigenvalues. I acknowledge that, as in most New Keynesian models, there may be further equilibria with additional state variables or sunspots (Cochrane (2011)), but resolving these issues is beyond the scope of this paper. Note that equation (31) implies that macroeconomic dynamics are conditionally lognormal. The output gap-consumption link (5) therefore implies that equilibrium consumption surprises $\varepsilon_{c,t+1}$ are conditionally lognormal, as previously conjectured.

The key properties of endogenously time-varying risk premia can be illustrated with a simple analytic expression. Consider a one-period claim with log real payoff αc_t. For illustrative purposes, consider α to be an exogenous constant, though in the full model it will depend on the macroeconomic equilibrium. Denoting the log return on the one-period claim by $r^{c,\alpha}_{1,t+1}$, the risk premium – adjusted for a standard Jensen's inequality term – equals the conditional covariance between the negative log SDF and the log real asset payoff:

$$E_t\left[r^{c,\alpha}_{1,t+1} - r_t\right] + \frac{1}{2}Var\left(r^{c,\alpha}_{1,t+1}\right) = \mathrm{Cov}_t\left(-m_{t+1}, x_{t+1}\right) = \alpha\gamma\left(1 + \lambda\left(s_t\right)\right)\sigma_c^2. \tag{32}$$

This expression shows that assets with risky real cash flows ($\alpha > 0$) require positive risk premia. Since $\lambda(s_t)$ is downward-sloping, it also illustrates that risk premia on risky assets increase further after a series of bad consumption surprises. Conversely, assets with safe real cash flows ($\alpha < 0$) require negative risk premia that decrease after a series of bad consumption surprises. Because real cash flows on nominal bonds are inversely related to inflation, nominal bonds resemble a risky asset ($\alpha > 0$) if inflation is countercyclical (i.e. stagflations) but a safe asset ($\alpha < 0$) if inflation falls in bad times. How nominal bond risk premia respond to bad consumption surprises is therefore endogenous to the macroeconomic equilibrium.

Because full asset prices are not one-period claims, I use numerical value function iteration to solve the recursions (13) through (16) while accounting for the new demand shock and the link between wage and price inflation (26). Asset prices have five state variables: the three state variables included in Y_t, the lagged output gap x_{t-1}, and the surplus consumption ratio

s_t. I need x_{t-1} as an additional state variable because the expected surplus consumption ratio depends on it through the dynamics (3).

3 Empirical Analysis and Calibration Strategy

Table 1 lists the parameters for the calibrations and how they vary across subperiods.

3.1 Calibration Strategy

Because I am interested in economic changes over time, I calibrate the model separately for two subperiods, where I choose the 2001.Q2 break date from Campbell, Pflueger and Viceira (2020). This break date was chosen by testing for a break date in the inflation-output gap relationship and did not use asset prices. I start the sample in 1979.Q4, when Paul Volcker was appointed as Fed chairman. I end the sample in 2019.Q4 prior to the pandemic, leaving the analysis of how shocks changed during the pandemic period for a separate discussion at the end of the paper. However, because the pandemic period represents a small portion of the sample, little would change if I folded it into the post-2001.Q2 sample period. I do not account for the possibility that agents might have anticipated a change in regime.[10]

The calibration proceeds in three steps. First, I set some parameters to values following the literature. Those parameter values are held constant across both subperiods and are listed in the top panel of Table 1. The expected consumption growth rate, utility curvature, the risk-free rate, and the persistence of the surplus consumption ratio (θ_0) are from Campbell and Cochrane (1999), who found that a utility curvature of $\gamma = 2$ gives an empirically reasonable equity Sharpe ratio and set θ_0 to match the quarterly persistence of the equity price-dividend ratio in the data. The output gap-consumption link parameter $\phi = 0.99$ is chosen similarly to Campbell, Pflueger and Viceira (2020) to maximize the empirical correlation between stochastically detrended real GDP and the output gap from the Bureau of Economic Analysis. I choose a slightly higher value because the correlation between the output gap and stochastically detrended real GDP is basically flat over a range of values ($correlation = 76\%$ at $\phi = 0.93$ vs. $correlation = 73\%$ at $\phi = 0.99$), and a larger value for ϕ minimizes the gap between price and wage inflation and therefore simplifies the model. I calibrate $\theta_1 - \phi$ and hence the Euler equation exactly as in Pflueger and Rinaldi (2022), where the habit parameters θ_1 and θ_2 were chosen to replicate the hump-shaped response of output to an identified monetary policy shock in the data. The second habit parameter,

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[10] Cogley and Sargent (2008) have shown that an approximation with constant transition probabilities often provides a good approximation of fully Bayesian decision rules.

θ_2 is implied and set to ensure that the backward- and forward-looking components in the Euler equation sum up to one. Because the model impulse responses to a monetary policy shock are invariant to the shock volatilities, and vary little with the monetary policy rule and Phillips curve parameters, I effectively match habit preferences to the output response to an identified monetary policy shock in the data. I set the slope of the Phillips curve to $\kappa = 0.0062$ based on Hazell, Herreno, Nakamura and Steinsson (2022), who also find little variation in this parameter over time.

In a second step, let $\hat{\Psi}$ denote the vector of twelve (13 for the second subperiod) empirical target moments, and $\Psi(\sigma_x, \sigma_\pi, \sigma_i, \gamma^x, \gamma^\pi, \rho^i; \zeta)$ the vector of model moments computed analogously on model-simulated data. I choose subperiod-specific monetary policy parameters γ^x, γ^π, and ρ^i and shock volatilities σ_x, σ_π, and σ_i while holding the inflation expectations parameter constant at $\zeta = 0$ to minimize the objective function:

$$\left\| \frac{\hat{\Psi} - \Psi(\sigma_x, \sigma_\pi, \sigma_i, \gamma^x, \gamma^\pi, \rho^i; \zeta = 0)}{SE(\hat{\Psi})} \right\|^2. \tag{33}$$

The vector of target moments $\hat{\Psi}$ includes the standard deviations of annual real consumption growth, the annual change in the fed funds rate, and the annual change in survey ten-year inflation expectations, as well as the output gap-inflation, output gap-fed funds rate, inflation-fed funds rate lead-lag relationships at three different horizons.[11] The targeted lead-lag moments take the form of a regression coefficient $a_{1,h}$ at horizons one, three, and seven quarters:

$$z_{t+h} = a_{0,h} + a_{1,h} y_t + a_{2,h} y_{t-1} + \varepsilon_{t+h}. \tag{34}$$

I consider the variable combinations $(z_t, y_t) = (x_t, \pi_t)$, $(z_t, y_t) = (x_t, i_t)$, and $(z_t, y_t) = (\pi_t, i_t)$. For the second calibration period when wage inflation data is easily available, I also estimate the specification $(z_t, y_t) = (x_t, \pi_t^w)$ and include the difference $a_{1,h}^{x,\pi} - a_{1,h}^{x,\pi^w}$ in the vector of target moments $\hat{\Psi}$. The regressions (34) are run analogously on actual and model-simulated data and control for lagged value of the right-hand-side variable in the manner of Jordà (2005). While these regressions do not estimate identified shocks, including lags tends to result in a right-hand-side that is highly correlated with structural shocks in model-simulated data. The vector of empirical standard standard errors $SE(\hat{\Psi})$ is computed via the delta method for the standard deviations of macroeconomic annual changes and with Newey-West

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[11] Empirical ten-year CPI inflation expectations are from the Survey of Professional Forecasters after 1990 and from Blue Chip before that. Long-term inflation forecasts are available from the Philadelphia Fed research website.

standard errors with h lags for lead-lag coefficients a_h.

Note that because I match many more empirical moments than I have parameters, this is a demanding calibration objective.[12] In particular, the macroeconomic side of my model does not feature additional leads and lags, and it is too simple to make precise predictions about some of the dynamics of inflation, output gap, and interest rate dynamics. The targeting of inflation, output gap, and interest rate comovements at several lead-lag horizons should therefore be expected to be matched on average, but possibly not at every lead-lag horizon. The delta-method standard errors based on minimizing the objective function (33) are generally tight, especially for the supply shock standard deviation in the 1980s, the demand shock standard deviation in the 2000s, and the monetary policy inertia parameter.

In a third step, I choose the adaptive inflation expectations parameter ζ to match the empirical evidence on bond excess return predictability for each subperiod, while holding all other parameters constant at their values chosen in the second step. This separate step puts special weight on this asset pricing moment and links it clearly to the adaptive inflation expectations parameter ζ. Because the asset pricing solution is slower than the macroeconomic solution, having a separate step also substantially speeds up procedure. This leads me to set $\zeta = 0.6$ for the 1980s calibration, and $\zeta = 0$ for the 2000s calibration. I acknowledge that this parameter is hard to identify for the 2000s period of extremely stable inflation, so I show results across different values of ζ. Finally, the leverage parameter matters only for the volatility of equity returns, but leaves the Sharpe ratio and return predictability regressions unchanged. I set it to roughly match the volatility of equity returns. The model does not require high leverage, with $\delta = 0.5$ for the 1980s calibration corresponding to a debt-to-assets ratio of 50%, and $\delta = 0.66$ for the 2000s calibration corresponding to a debt-to-assets ratio of 33%.

3.2 Target Empirical and Model Moments

What changed in the data from the first subperiod with positive nominal bond-stock betas to the second subperiod with negative nominal bond-stock betas? This Section shows the targeted empirical moments across the two subperiods, and discusses which parameters in

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[12] Because I match three cross-relationships (output-inflation, output-fed funds, inflation-fed funds) at three different horizons (one, three and seven quarters) and three volatilities, this step of the calibration procedure effectively chooses six parameters to fit $3 \times 3 + 3 = 12$ (13 for the second subperiod) moments. I include only one moment for wage inflation to avoid over-weighting inflation moments by including many nearly identical moments. The grid search procedure is relatively simple and draws 50 random values for (γ^x, γ^π, ρ^i, σ_x, σ_π, σ_i) and picks the combination with the lowest objective function. I repeat this algorithm until convergence, meaning that the grid search result no longer changes starting from the calibrated values for each subperiod calibration. The only parameter value that reaches the externally set upper bound is $\gamma^x = 1$ for the 2000s calibration. I regard this as a plausible upper bound based on economic priors.

Table 1 are crucial for matching the empirical changes. Overall, the economically and statistically significant changes in the output, inflation, and interest rate lead-lag relationships, combined with the intuition that stocks comove positively with output, nominal bond prices comove negatively with inflation expectations and real rates, and real bond prices move negatively with real rates, strongly suggest that these macroeconomic changes were responsible for the changing risks of nominal and real Treasury bonds.[13]

Figure 2, Panel A visualizes the changing inflation dynamics from stagflationary recessions in the 1980s to low inflation recessions in the 2000s, and show that these changing inflation dynamics are replicated by the model. The model matches the negative inflation-output gap relationship in the earlier period and the positive inflation-output gap relationship in the more recent period. While the model inflation-output gap relationship for the 2000s calibration is not quite as positive in the data, the basic upward-shift from the first to the second period is well replicated in the model.[14] A long literature has studied the lead-lag relationship between the output gap and inflation and argued that it is indicative of the volatility of supply shocks (e.g. Fuhrer (1997), Galı and Gertler (1999)), and σ_π is indeed the parameter most closely linked to these moments in my model. Table 1 reveals that the model achieves this fit by setting a high volatility of supply shocks for the 1980s calibration, and almost zero supply shock volatility for the 2000s calibration. Intuitively, when supply shocks in the Phillips curve (23) are dominant, one would expect that an increase in inflation should be associated with a decline in the output gap, as in the left plot of Panel A. By contrast, the right plot in Panel A shows that in the 2000s and increase in inflation tended to be followed by an increase in the output gap, as should be the case if demand and monetary policy shocks move inflation and the output gap along a stable Phillips curve.

While the empirical inflation-output gap relationship in Panel A helps the model to pin down the volatility of supply shocks vs. non-supply shocks, it is less informative about the distinction between monetary policy vs. demand shocks, both of which would tend to move inflation and the output gap along a stable Phillips curve. Panel B therefore turns to the relationship between the output gap and the fed funds rate. The model matches the shift from a negative fed funds rate-output gap relationship to a positive relationship with a high volatility of monetary policy shocks in the 1980s, and a high volatility of demand shocks in

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[13] I reach a different conclusion than Duffee (2022) because I rely on realized output, inflation, and interest rates rather than innovations to surveys, which may be subject to underreaction to news (Coibion and Gorodnichenko (2015)). Similar to Duffee (2022), I attribute an economically significant role to time-varying risk premia, which in my model result from macroeconomic dynamics as discussed in Section 4.2.

[14] The output gap increase in the 2000s calibration is also not as persistent as in the data, potentially because demand shocks in the model are iid whereas in reality they are likely serially correlated. Including persistent demand shocks would likely amplify the role of demand shocks, while leaving the main model properties unchanged.

the 2000s calibration. Intuitively, a high volatility of monetary policy shocks for the 1980s calibration means that typically interest rate increases are followed by declines in economic activity. Conversely, volatile demand shocks and a higher output gap weight in the monetary policy rule γ^x allow the model to match the positive relationship in the right plot of Panel B.[15] Whether one interprets the demand shock as a credit spread or as an expected growth shock, it is empirically plausible that its volatility increased from the first subperiod to the second subperiod.[16]

Finally, Panel C shows the lead-lag relationship between inflation and the fed funds rate for the 1980s and 2000s, both in the data and in the model. The empirical fed funds rate showed a somewhat more than one-for-one increase with inflation in both subperiods, though the fed funds rate increases more and peaks earlier in the first subperiod. While the corresponding model moments are functions of all parameters, they are closely linked to the monetary policy rule parameters. In particular, while the calibrated inflation weights γ^π in Table 1 are greater than one for both subperiods, the 1980s calibration features a higher inflation weight γ^π and a lower inertia parameter ρ^i, while the 2000s calibration features a lower inflation weight γ^π and a higher inertia parameter ρ^i.[17]

Macroeconomic volatilities of annual changes in real consumption and the fed funds rate, shown in the bottom panel of Table 2, are matched well by the model. In particular, the decline in the volatility of long-term inflation expectations from the 1980s to the 2000s in the data is well-matched. The model somewhat undershoots the volatility of changes in the fed funds rate in both periods, potentially due monetary policy timing decisions about the very short-term policy rate that the model does not aim to capture.

Taken together, the empirical cross-relationships between inflation, the output gap, and

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[15] Again, the model matches the sign of the relationship between the fed funds rate and the output gap in the 2000s, but not the persistence. This could likely be remedied by introducing serially correlated demand shocks without changing the main insights of the model.

[16] The standard deviation of the Gilchrist and Zakrajšek (2012) credit spread, which is known to predict recessions empirically, doubled between the first and the second subperiods in the data (0.54% vs. 1.06%). The standard deviation of expectations of one-year earnings growth similarly increased from 0.14 in the first subperiod to 0.37 in the second subperiod. Quarter-end credit spread data from https://www.federalreserve.gov/econres/notes/feds-notes/updating-the-recession-risk-and-the-excess-bond-premium-20161006.html. Quarterly data on one-year earnings growth expectations from De La'O and Myers (2021) ends in 2015.Q3 and was obtained from https://www.ricardodelao.com/data (accessed 12/12/2022).

[17] While a volatile persistent component in inflation during this period is in line with a long-standing econometrics literature (Stock and Watson (2007)) and helps match the predictability of bond excess returns, it means that there is a gap between the empirical and model impulse responses at longer horizons in the left panel of Panel D in Figure 2. I am not concerned about this discrepancy because the empirical measure of inflation combines persistent fluctuations with short-term fluctuations, which the model is not intended to capture, and because unit roots are hard to estimate and detect in finite samples. Appendix Figure A1 shows the model impulse responses with $\zeta = 0$ for comparison.

the fed funds rate changed meaningfully between the 1980s vs. 2000s, and inform intuitive changes in the corresponding model calibrations. Intuitively, the model explains the changing macroeconomic cross-relationships in the data with a change from a supply-shock driven economy to a demand-shock driven one, and a change from a quick-acting and inflation-focused monetary policy rule to more output-focused and gradual monetary policy.

4 Asset Prices in the Model and in the Data

Table 2 reports key asset pricing and macroeconomic moments for both subperiod calibrations side-by-side with the corresponding data moments. Having already discussed the targeted macroeconomic moments in the bottom panel, I now turn to the asset pricing moments shown in the top panels. The model generates a quantitatively plausible match for time-varying risk premia in stocks, matching a high equity Sharpe ratio, equity volatility, stock excess return predictability, and the persistence of price-dividend ratios just like Campbell and Cochrane (1999) and Campbell, Pflueger and Viceira (2020). The model's success for equity moments shows that adding demand shocks does not hurt the its performance along these dimensions, and that implications for bond risks are based on a plausible description of countercyclical risk premia.

The middle panel in Table 2 shows that the model replicates the motivating evidence in Figure 1, even though bond-stock betas were not explicitly targeted in the calibration. The model-implied nominal bond beta switches from strongly positive in the 1980s calibration to negative in the 2000s calibration, similarly to the data. The model-implied real bond-stock beta is small and positive in the 1980s calibration and negative and slightly smaller than the nominal bond beta in the 2000s calibration, matching both the sign-change and the ordering relative to nominal bond-stock betas in the data. The volatility of nominal bond excess returns is also matched for both subperiods. Model-implied nominal Treasury bond excess returns are volatile in the 1980s calibration and much less volatile in the 2000s calibration.[18] The yield spread in the model differs somewhat from the data, turning negative for the 2000s calibration. Most consumption-based models generate an upward-sloping term structure, or positive yield spread, when bond-stock betas are positive and vice versa (e.g. Piazzesi and Schneider (2006)). Because the steady-state slope of the yield curve is hard to determine in finite samples – where investors might have expected rising nominal rates and then been repeatedly surprised – and second moments are better measured, I am less concerned about

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[18] The model-implied standard deviation of changes in ten-year nominal bond yields is about twice the standard deviation of changes in ten-year subjective inflation expectations for both calibrations, thereby confirming in a structural macroeconomic model that habit formation asset pricing preferences can generate low inflation variance ratios as in the data (Duffee (2018)).

the model-implied yield spread than bond-stock betas.[19]

The model also generates empirically-plausible excess return predictability for nominal bonds in the manner of Campbell and Shiller (1991). The 1980s calibration generates a positive regression coefficient of ten-year nominal bond excess returns with respect to the lagged slope of the yield curve, as in the data and as targeted in the calibration. On the other hand, the 2000s calibration does not generate any such bond excess return predictability, which is also in line with a much weaker and statistically insignificant relationship in the data. In unreported results I find that the model does not generate any return predictability in real bond excess returns. This is broadly in line with the empirical findings of Pflueger and Viceira (2016), who find stronger evidence for predictability in nominal than real bond excess returns after adjusting for time-varying liquidity. Overall, the calibration exercise shows that combining a small-scale New Keynesian model of monetary policy and time-varying risk bearing capacity from habit formation preferences can explain changing bond-stock betas, the predictability of bond excess returns, and highly volatile risk premia in stocks across different macroeconomic equilibria. I next turn to the economic mechanisms driving bond-stock betas and bond excess return predictability in the model.

4.1 Model Macroeconomic Impulse Responses

To understand the model mechanism, I start with impulse responses for the macroeconomic state vector. In summary, these macroeconomic impulse responses suggest that supply shocks combined with a reactive monetary policy rule to these shocks are the economic source of high inflation recessions, or stagflations.

Figure 3 shows responses for the output gap, nominal policy rate, and wage inflation to one-standard-deviation demand, supply, and monetary policy shocks. The magnitude of the shocks differs across the two calibrations, as listed in Table 1, so comparing the magnitudes across columns visualizes how much each shock contributes to the overall volatility in the output gap, inflation, and the fed funds rate is driven by each shock. Because of the structure of the model, the macroeconomic impulse responses preserve the intuition of a standard log-linearized three-equation New Keynesian model for given parameter values. However, asset prices enter to the extent that they pin down the backward-looking coefficient in the Phillips curve.

The first column in Figure 3 shows that demand shocks move the output gap, the policy

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[19] Cieslak and Pflueger (2022) show that after subtracting survey inflation expectations, zero-coupon inflation swaps indeed priced a negative inflation risk premium for most of the 2000s, consistent with the yield spread in the data reflecting a substantial expectations hypothesis component that the steady-state in the model does not capture. An expectation of regime switches may also reconcile negative bond-stock betas with an upward-sloping term structure (Song (2017)).

rate, and inflation in the same direction, as if the economy moves along a stable Phillips curve. For the 1980s calibration – shown in black solid – the standard deviation of demand shocks is essentially zero and hence there are no meaningful impulse responses. But in the 2000s calibration – shown in red dashed – a demand shock leads to an immediate increase in the output gap and an increase in the policy rate, while having a small but positive effect on inflation.

The second column in Figure 3 shows that for the 1980s calibration a positive supply shock leads to an immediate and persistent jump in inflation, a rapid increase in the policy rate, and a large and persistent decline in the output gap – a stagflation. For the 2000s calibration, a monetary policy rule that prescribes very little immediate tightening in response to such a shock means that the real rate falls initially after the shock, and the output gap barely declines or even briefly increases. Because a one-standard-deviation supply shock in the 2000s calibration is smaller, the inflation response also appears smaller. For a given size shock, however, the different monetary policy rule in the 2000s calibration leads to a larger inflation response while mitigating the impact on the output gap.

Finally, the third column in Figure 3 shows intuitive responses to monetary policy shocks. A positive monetary policy shock tends to lower the output gap in a hump-shaped fashion and leads to a small and delayed fall in inflation, in line with the empirical evidence from identified monetary policy shocks (Ramey (2016)). While inflation and the output gap comove similarly after monetary policy and demand shocks, a monetary policy shock has a more pronounced effect on the policy rate, as conjectured in the calibration description in Section 3.1.

Taken together, the model's inflation-output gap comovement in response to supply shocks varies with the monetary policy rule across the two calibrations. Further, the model generates positive inflation-output gap comovements in response to demand and monetary policy shocks. The next Section analyzes how these insights translate to the risks of bonds.

4.2 The Role of Endogenously Time-Varying Risk Premia

Impulse responses for bonds and stocks show that time-varying risk premia play a crucial role in linking the risks of nominal bonds to the macroeconomic equilibrium. Figure 4 shows impulse responses of stock and nominal bond yields to one-standard-deviation demand, supply, and monetary policy shocks. The top row shows responses for the dividend yield of levered stocks, the middle row shows responses for risk-neutral ten-year nominal bond yields, which also equal the expected average policy rate over the lifetime of the bond, and the bottom row shows responses for overall ten-year nominal bond yields, which include time-varying risk premia in addition to the risk-neutral response. Because dividend yields are inversely related to stock prices and bond yields are inversely related to bond prices, a shock that moves stock dividend yields and bond yields in the same direction tends to induce a positive nominal bond-stock beta and vice versa. To save space, I only show the overall stock dividend yield response. The stock dividend yield response is always dominated by the countercyclical risk premium component, and therefore stock prices rise and stock dividend yields fall whenever a shock raises the output gap in Figure 3.

The lower two rows reveal intriguing differences between the risk-neutral and overall bond yield responses due to time-varying risk premia. For both calibrations, risk-neutral bond yields tend to increase following positive demand, supply, and monetary policy shock, mirroring the sign and magnitudes of the policy rate responses in the middle panel of Figure 3. As expected from the macroeconomic impulse responses, demand shocks dominate for the 2000s calibration and induce a negative risk-neutral nominal bond-stock beta. Supply shocks dominate for the 1980s calibration and tend to induce a positive risk-neutral nominal bond-stock beta.

Potentially surprisingly, the bottom-left panel in Figure 4 shows that the overall nominal bond yield declines in response to a positive demand shock for the 1980s calibration, having the opposite sign and being significantly larger than the risk-neutral response in the panel immediately above. That is, nominal bonds in this calibration move in the same direction as stocks not only after a supply shock but also after a demand shock, even though a demand shock tends to move expected real cash flows on stocks and nominal bonds in opposite directions. Further, the rightmost column shows that for the 1980s calibration a monetary policy shock also induces a positive comovement between overall nominal bond yields and stock dividend yields, even though the effect on risk-neutral nominal bond yields is negligible. The answer to this maybe surprising result is of course time-varying risk premia, whose cyclicality depends endogenously on the macroeconomic equilibrium.

The logic goes as follows. Dominant supply shocks and a reactive monetary policy rule in the 1980s calibration mean that nominal Treasury bonds have risky cash flows, since inflation expectations tend to rise in high marginal utility states of the world. Because risk aversion in the model varies with the surplus consumption ratio s_t, any shock that drives down the output gap and consumption relative to habit leads investors to require a higher risk premium on all risky assets, including stocks and nominal bonds. Even though demand and monetary policy shocks have only small risk-neutral implications for nominal bonds in this macroeconomic equilibrium, they move the surplus consumption ratio and a positive bond-stock correlation ensues. The role of time-varying risk premia reverses for the 2000s calibration, where bond risk premia are smaller and negatively correlated with stock risk premia. Importantly, this reversal of the role of time-varying risk premia is an endogenous outcome of the different macroeconomic equilibria.

Overall, time-varying risk premia are therefore important for the risks of bonds, and their role changes endogenously with the macroeconomic equilibrium. If investors understand that they are in an equilibrium where nominal bonds are risky even a demand shock induces a positive nominal bond-stock beta.[20] Nominal and real bond-stock betas in the model are therefore forward-looking and reflect investors' understanding of equilibrium shock volatilities and monetary policy.

4.3 What Drives Bond Excess Return Predictability?

The model generates strong predictability in nominal bond excess returns for the 1980s calibration but not for the 2000s calibration, similarly to the data (Table 2). The channel driving this difference is illustrated in Figure 5, which shows comparative statics for the Campbell-Shiller bond excess return predictability coefficient on the y-axis against the adaptiveness of wage-setters inflation expectations, ζ, on the x-axis. A Campbell-Shiller coefficient of zero indicates no bond excess return predictability while a positive coefficient indicates that bond excess returns are predictable and the expectations hypothesis fails. An inflation expectations parameter $\zeta = 0$ indicates perfectly rational inflation expectations while $\zeta = 1$ means that wage-setters inflation expectations are equal to past inflation. The values of ζ chosen for the 1980s and 2000s calibrations are shown with vertical red lines. In short, this figure shows that strongly adaptive inflation expectations are needed to generate bond excess return predictability for the 1980s calibration as in the data.[21]

Figure 6 drills down further into the drivers of Campbell-Shiller bond excess return predictability. It decomposes model impulse responses for the nominal bond yield spread into its risk neutral and risk premium components. The top panels focus on the 1980s calibration and the bottom panels focus on the 2000s calibration. The columns correspond to one-standard-deviation demand, supply, and monetary policy shocks. The overall nominal bond yield spread is the right-hand-side of the Campbell-Shiller regressions, and its risk premium component equals the future expected excess return on the nominal bond over its lifetime. When the overall yield spread is dominated by the risk premium component, the yield spread

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[20] This insight can potentially rationalize the empirical observation that even though supply shocks were subsiding during the 1990s nominal Treasury bond-stock betas remained elevated, potentially because investors were concerned that supply shocks remained an important source of volatility in equilibrium.

[21] I set the parameter ζ to 0.6 in the 1980s calibration because the Campbell-Shiller coefficient appears to have converged and does not increase further as I increase ζ further. Because bond excess return predictability does not change with ζ in the 2000s calibration I set it to $\zeta = 0$ to be conservative. Appendix Table A1 shows that moments other than the Campbell-Shiller coefficient in Table 2 change little with ζ.

therefore predicts future bond excess returns and the Campbell-Shiller coefficient should be positive.

The top row of Figure 6 shows that for the 1980s calibration supply shocks induce a positive correlation between yield spreads and bond risk premia, and are primarily responsible for Campbell-Shiller bond excess return predictability. Intuitively, partially adaptive inflation expectations are necessary because they lead to a strongly backward-looking Phillips curve and a persistent inflation response to this shock. With adaptive inflation expectations, a positive supply shock then has a relatively small effect on the risk-neutral yield spread, and the overall yield spread response is dominated by time-varying risk premia. For the 2000s calibration, the overall yield spread response is clearly dominated by the risk neutral component and demand shocks, generating a close to zero Campbell-Shiller coefficient even when inflation expectations are adaptive (ζ is high).

A quick validation using inflation forecast errors supports partially adaptive inflation expectations in the 1980s and rational inflation expectations in the 2000s, which was calibrated to bond excess return predictability moments. Table 3 runs the well-known test for the rationality of inflation expectations of Coibion and Gorodnichenko (2015):

$$\pi_{t+3} - \tilde{E}_t\pi_{t+3} = a_0 + a_1\left(\tilde{E}_t\pi_{t+3} - \tilde{E}_{t-1}\pi_{t+3}\right) + \varepsilon_{t+3}. \tag{35}$$

Here, a tilde denotes potentially subjective inflation expectations. If expectations are full information rational the forecast error on the left-hand side of (35) should be unpredictable, and the coefficient a_1 should equal zero. The empirical specification follows Coibion and Gorodnichenko (2015), using the Survey of Professional Forecasters four-quarter and three-quarter GDP deflator inflation forecasts to compute forecast revisions. The first column in Table 3 uses a long sample 1968.Q4-2001.Q1 and confirms their well-known empirical result. An upward revision in inflation forecasts tends to predict positive forecast errors. The second and third columns run the same empirical regressions for the 1979.Q4-2001.Q1 and 2001.Q2-2019.Q4 subperiods. I find that for both subperiods the evidence becomes insignificant. While this is potentially due to the smaller sample size and weaker statistical power, the change in a_1 from 1968.Q4-2001.Q1 to 2001.Q2-2019.Q4 is statistically significant. The last two columns of the table show that the model matches this broad pattern in the predictability of inflation forecast errors documented in the data.[22]

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[22] The literature has not reached an agreement on whether inflation expectations have become more or less rational over time. On the one hand, Bianchi, Ludvigson and Ma (2022c) find less inflation forecast error predictability post-1995, and Davis (2012) shows that inflation expectations have become less responsive to oil prices shocks in recent decades. However, Coibion and Gorodnichenko (2015) and Maćkowiak and Wiederholt (2015) provide evidence and a model of decreasing attention to inflation as economic volatility declined during the 1990s.

The link between bond excess return predictability and the persistence of the inflation process in my model is reminiscent of an older empirical literature that has documented that the expectations hypothesis is a better description of the term structure of interest rates in time periods and countries where interest rates are less persistent (Mankiw, Miron and Weil (1987), Hardouvelis (1994)), and Cieslak and Povala (2015)'s evidence that removing trend inflation uncovers time-varying risk premia in the yield curve. Adaptive wage-setter inflation expectations in my model enter through the Phillips curve. When viewed through the lens of my model, the well-known evidence of predictability in nominal bond excess returns therefore supports a long-standing literature in empirical macroeconomics that has found a strongly backward-looking Phillips curve.

5 Counterfactual Analysis and Interpreting the Post-Pandemic Regime

What would it take for bonds to become similarly risky as in the stagflationary 1980s? In this Section, I show how nominal and real bond betas change in the model as I vary the economy's exposure to different types of shocks, the monetary policy rule, and the rationality of inflation expectations. Throughout this counterfactual analysis, the beta of nominal bonds is of particular interest as an indicator of the risks of high inflation recessions (i.e. stagflations).

5.1 Changing the Monetary Policy Rule, Shock Volatilities, and Inflation Expectations

Figure 7 shows that nominal bonds can remain safe, i.e. nominal bond betas remain negative, even in the presence of shock volatilities similar to the 1980s, provided that the monetary policy framework is more output-focused, less inflation focused and more inertial than during the 1980s. Panel A starts from the 1980s calibration and shows model-implied linearized nominal and real bond betas as individual parameter groups are changed to their 2000s calibration values.[23] Panel B conducts the converse exercise, starting from the 2000s calibration and changing individual parameter groups to their 1980s values, effectively asking which parameter group has the potential to turn nominal bonds risky again.

As can be seen in Panel A, starting from the 1980s calibration changing either the volatility of shocks or the monetary policy rule flips nominal bonds from risky (i.e. a positive nom-

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[23] The linearized beta of the change from parameter vector $param_1$ to $param_2$ is computed as $\beta_{param_1} + 2 \times \beta_{\frac{param_1 + param_2}{2}}$ to focus on the linear effects of changing a set of parameters.

inal bond beta) to safe (i.e. a negative nominal bond beta). Said differently, the model does not imply positive nominal bond-stock betas unless it has both: 1980s-style shock volatilities and a 1980s-style monetary policy rule. While changing either the shock volatilities or the monetary policy rule in Panel A implies negative nominal bond-stock betas, the implications for real bond-stock betas are different. Intuitively, real bond betas in the "MP" counterfactual in Panel A turn positive because there are no demand shocks and supply shocks have only small effects on real rates and stock returns. The real bond-stock beta in this counterfactual is therefore mostly driven by monetary policy shocks, which depress stock prices just as the real rate rises and real bond prices fall.

The next two columns in Panel A decompose the monetary policy rule, showing that monetary policy inertia (ρ^i) and the long-term inflation and output weights (γ^x, γ^π) both matter. As shown in Table 1, the 2000s calibration features a monetary policy rule with a lower inflation weight, higher output weight, and higher inertia. Lowering the monetary policy weight on inflation and increasing the weight on output means that the nominal policy rate rises less following an inflationary supply shock, leading to a decline in the real rate and boosting the output gap through the Euler equation. With a strongly inertial monetary policy rule, a sudden increase in inflation similarly leads to a decline in the real rate and a higher output gap. Moving either the monetary policy inflation and output weights or monetary policy inertia to their 2000s calibration values therefore has the ability to change nominal bond betas from positive to negative.

The last column in Panel A of Figure 7 shows that the inflation expectations formation process matters less for bond risks. Changing the inflation expectations parameter ζ to zero so that inflation expectations are perfectly rational, as in the 2000s calibration, implies only a small decline in the model's nominal bond beta. Appendix Figure A2 shows that with rational inflation expectations, a supply shock leads to a less persistent inflation response but a larger output gap response, leaving the covariance between nominal Treasury bonds and stocks roughly unchanged.

Panel B of Figure 7 shows the key result, namely that starting from the 2000s calibration none of the changes to individual parameter groups have the power to flip the sign of nominal bond betas. Most tellingly, the "Shock Volatilities" column implies that even if the shock volatilities were to switch back to the 1980s calibration, an inertial and more output-focused monetary policy rule as in the 2000s calibration would keep nominal bonds safe, i.e. the nominal Treasury bond-stock beta would remain negative. Real bond-stock betas turn positive for this counterfactual, which combines volatile supply shocks with a weak initial monetary policy response similarly to the "MP" column in Panel A. Of course, changing all parameters back to their 1980s values simply returns the model to the 1980s calibration with its strongly positive nominal bond betas. The counterfactuals in Panel B therefore show that the monetary policy rule can protect nominal bonds from turning risky even in the face of 1980s-style shocks. [24]

The counterfactual of a 2000s-style monetary policy rule with volatile supply shocks as in the 1980s ("Shock Volatilities" in Panel B) lines up well with the recent post-pandemic experience of positive real bond betas and negative nominal bond betas, as shown in Figure 1. The model can therefore qualitatively account for the recent empirical evidence, if the post-pandemic economy experienced elevated supply shock volatility but, unlike in the 1980s, the conduct of monetary policy protected nominal Treasury bonds from turning positive. Overall, these counterfactuals indicate that positive nominal bond-stock betas and stagflations are not the result of fundamental economic shocks or monetary policy in isolation, but instead require the interaction of both to create a "perfect storm".

5.2 Decomposing the Supply Shock - Monetary Policy Interaction

So far, I have changed parameter groups between their 1980s and 2000s calibrations. However, history is unlikely to repeat itself. Figure 8 zeroes in on the interaction between volatile supply shocks and the different parameters in the monetary policy rule, effectively asking which types of monetary policy rules would turn nominal Treasury bonds risky when there are also volatile supply shocks. This figure plots model-implied nominal bond-stock betas on the y-axis against the volatility of supply shocks on the x-axis for different monetary policy rules. Panel A varies the long-term output gap weight γ^x, Panel B varies the long-term inflation weight γ^π, and Panel C varies monetary policy inertia ρ^i. All comparative statics start from the 2000s calibration, and increase the volatility of supply shocks along the x-axis. The volatilities of demand and monetary policy shocks are held constant at their 2000s values, to isolate the interaction of supply shocks with the monetary policy rule on nominal bond risks. The baseline monetary policy rule from the 2000s calibration is indicated with a red asterisk line in all three panels.

Figure 8, Panel A shows that a monetary policy rule with a lower output gap weight tends to raise nominal bond in the face of volatile supply shocks. Panel B shows that raising the long-term inflation weight in the monetary policy rule (γ^π) leads to very similar counterfactuals as lowering the long-term output gap weight (γ^x). This is intuitive, because the relative concern about inflation vs. the output gap in the monetary policy rule determines the long-term monetary policy response to supply shocks. Finally, Panel C shows that the monetary policy inertia parameter also has pronounced effects on how an increase in the

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[24] The adaptiveness of inflation expectations appears less crucial, as the last bar in Panel A shows.

volatility of supply shocks affects nominal bond-stock betas. When the volatility of supply shocks is low, a high inertia parameter increases the impact of monetary policy shocks on bond yields, thereby increasing nominal bond-stock betas. However, when supply shocks are volatile, a higher monetary policy inertia ρ^i turns nominal bond-stock betas negative, as the nominal policy rate responds more slowly to inflationary supply shocks. Overall, plausible monetary policy rules can generate nominal bond betas that are flat or downward-sloping in the volatility of supply shocks. Positive nominal Treasury bond betas – as observed during the stagflationary 1980s – arise in the model through the interaction of volatile supply shocks and a monetary policy rule that puts little weight on output, high weight on inflation, and has little inertia.

6 Conclusion

This paper decomposes the changing risks of nominal and real bonds into changes in the nature of economic shocks vs. changes in the conduct of monetary policy. My model integrates a standard small-scale macroeconomic model of demand shocks, supply shocks, and monetary policy, with volatile risk premia in stocks and bonds that are linked to the business cycle. Bond and stock prices feature time-varying risk premia from consumption habits in the manner of Campbell, Pflueger and Viceira (2020). Based on this model, I show that only the interaction between volatile supply shocks and monetary policy has the potential to turn nominal bonds risky as in the stagflationary 1980s.

I fit this model to macroeconomic and bond excess return predictability data separately for the 1980s and the 2000s, and show that it yields an intuitive account of the changes observed in bond risks between these decades. For the 1980s, the model attributes the large and positive comovement between nominal bond returns and stocks and the smaller but also positive real bond-stock comovement to dominant supply shocks, combined with a strong and immediate monetary policy response to inflation. The intuitive model account is that during this period, an adverse supply shock drives up inflation, reducing the value of nominal bonds. Monetary policy raises interest rates in response to this increase in inflation, thereby generating a recession and driving down stock prices, and a positive nominal bond-stock correlation.

Time-varying risk premia amplify the overall positive nominal bond-stock comovement, and even flip the sign of the nominal bond response to demand shocks in the 1980s calibration. Intuitively, a positive demand shock raises consumption relative to habit and makes households more willing to bear risk, raising the prices of both stocks and (in this equilibrium) risky bonds relative to their expected discounted real cash flows. The change in nominal bond risk premia dominates, so nominal bond prices rise after a positive demand shock despite their decline in expected discounted real cash flows. Endogenously time-varying risk premia in the model therefore turn nominal bond-stock betas into a forward-looking measure that depends more on the macroeconomic equilibrium than past realized shocks.

For the 2000s, the model account is that volatile demand shocks, combined with a less inflation-centric and more inertial monetary policy rule, led to negative betas for both nominal and real bonds. In the 2000s calibration, a positive demand shock drives up consumption and stock prices, but also drives up real and nominal interest rates, leading to declines in nominal and real bond prices. The role of time-varying nominal risk premia reverses in this macroeconomic equilibrium, with investors being willing to hold (in this equilibrium) safe nominal bonds at lower risk premia and higher prices when risk aversion is high.

The model also matches the predictability of bond excess returns across the same broad time periods and provides a novel economic mechanism. I document that while bond excess return predictability from the lagged yield spread was stronger during the 1980s, it was statistically insignificant during the 2000s. The model matches these empirical findings with partially backward-looking inflation expectations during the 1980s, leading to a strongly backward-looking Phillips curve and a highly persistent inflation process. As a result, the variation in the yield spread between long- and short-term bond yields is almost unaffected by the expectations hypothesis component, and instead dominated by time-varying risk premia.

My model provides a framework to interpret evolving nominal and real bond-stock betas in the data, as illustrated by the ongoing debate whether the recent rise in inflation is likely to pre-shadow another 1980s stagflation. Model counterfactual analyses suggest that monetary policy is crucial for nominal bond-stock betas when supply shocks are dominant. A counterfactual combining 1980s-style shock volatilities with a 2000s-style monetary policy rule implies negative nominal bond-stock betas and a decoupling of nominal and real bond risks, similar to empirical bond-stock betas in the post-pandemic period.

References

Abel, Andrew B (1990) “Asset prices under habit formation and catching up with the Joneses,” *American Economic Review*, 80, 38–42.

Albuquerque, Rui, Martin Eichenbaum, Victor Xi Luo, and Sergio Rebelo (2016) “Valuation risk and asset pricing,” *Journal of Finance*, 71 (6), 2861–2904.

Angeletos, George-Marios, Fabrice Collard, and Harris Dellas (2018) “Quantifying confidence,” *Econometrica*, 86 (5), 1689–1726.

Angeletos, George-Marios and Jennifer La’O (2013) “Sentiments,” *Econometrica*, 81 (2), 739–779.

Baele, Lieven, Geert Bekaert, and Koen Inghelbrecht (2010) “The determinants of stock and bond return comovements,” *Review of Financial Studies*, 23 (6), 2374–2428.

Barro, Robert (2003) “Optimal Management of Indexed and Nominal Debt,” *Annals of Economics and Finance*, 4, 1–15.

Bauer, Michael D, Carolin Pflueger, and Adi Sunderam (2022) “Perceptions about monetary policy,” National Bureau of Economic Research, working paper wp 30480.

Beaudry, Paul and Franck Portier (2006) “Stock prices, news, and economic fluctuations,” *American Economic Review*, 96 (4), 1293–1307.

Bernanke, Ben S, Mark Gertler, and Mark Watson (1997) “Systematic monetary policy and the effects of oil price shocks,” *Brookings Papers on Economic Activity*, 1997 (1), 91–157.

Bianchi, Francesco, Renato Faccini, and Leonardo Melosi (2022a) “A fiscal theory of trend inflation,” National Bureau of Economic Research Working Paper, wp30727.

Bianchi, Francesco, Martin Lettau, and Sydney C Ludvigson (2022b) “Monetary policy and asset valuation,” *Journal of Finance*, 77 (2), 967–1017.

Bianchi, Francesco, Sydney C Ludvigson, and Sai Ma (2022c) “Belief distortions and macroeconomic fluctuations,” *American Economic Review*, 112 (7), 2269–2315.

Blanchard, Olivier Jean and Charles M Kahn (1980) “The solution of linear difference models under rational expectations,” *Econometrica*, 1305–1311.

Bocola, Luigi and Guido Lorenzoni (2022) “Risk sharing externalities,” Journal of Political Economy, forthcoming.

Bordalo, Pedro, Nicola Gennaioli, Rafael LaPorta, and Andrei Shleifer (2022) “Belief overreaction and stock market puzzles,” Working paper, Oxford, Bocconi, Brown University, and Harvard University.

Caballero, Ricardo J and Alp Simsek (2022) “A monetary policy asset pricing model.”

Campbell, John Y and John H Cochrane (1999) “By force of habit: A consumption-based explanation of aggregate stock market behavior,” *Journal of Political Economy*, 107, 205–251.

Campbell, John Y, Carolin Pflueger, and Luis M Viceira (2020) “Macroeconomic drivers of bond and equity risks,” *Journal of Political Economy*, 128 (8), 3148–3185.

Campbell, John Y and Robert J Shiller (1991) “Yield spreads and interest rate movements: A bird’s eye view,” *Review of Economic Studies*, 58 (3), 495–514.

Campbell, John Y, Robert J Shiller, and Luis M Viceira (2009) “Understanding Inflation-Indexed Bond Markets.,” *Brookings Papers on Economic Activity*, 79–138.

Campbell, John Y, Adi Sunderam, and Luis M Viceira (2017) “Inflation Bets or Deflation Hedges? The Changing Risks of Nominal Bonds,” *Critical Finance Review*, 6 (2), 263–301.

Campbell, John Y and Luis M Viceira (2002) *Strategic Asset Allocation: Portfolio Choice for Long-Term Investors*: Oxford University Press.

Chahrour, Ryan and Kyle Jurado (2018) "News or noise? The missing link," *American Economic Review*, 108 (7), 1702–36.

Chan, Yeung Lewis and Leonid Kogan (2002) "Catching Up with the Joneses: Heterogeneous Preferences and the Dynamics of Asset Prices," *Journal of Political Economy*, 110 (6), 1255–1285.

Chernov, Mikhail, Lars A Lochstoer, and Dongho Song (2021) "The real explanation of nominal bond-stock puzzles," National Bureau of Economic Research Working Paper, wp 29085.

Christiano, Lawrence H, Martin Eichenbaum, and Charles L Evans (2005) "Nominal rigidities and the dynamic effects of a shock to monetary policy," *Journal of Political Economy*, 113 (1), 1–45.

Christiano, Lawrence J, Martin Eichenbaum, and Charles L Evans (1999) "Monetary policy shocks: What have we learned and to what end?" *Handbook of Macroeconomics*, 1, 65–148.

Cieslak, Anna and Carolin E Pflueger (2022) "Inflation and Asset Returns," *Working Paper, Duke University and University of Chicago.*

Cieslak, Anna and Pavol Povala (2015) "Expected returns in Treasury bonds," *Review of Financial Studies*, 28 (10), 2859–2901.

Clarida, Richard, Jordi Gali, and Mark Gertler (2000) "Monetary policy rules and macroeconomic stability: Evidence and some theory," *Quarterly Journal of Economics*, 115 (1), 147–180.

Cochrane, John H (2011) "Determinacy and identification with Taylor rules," *Journal of Political Economy*, 119 (3), 565–615.

Cogley, Timothy and Thomas J Sargent (2008) "Anticipated utility and rational expectations as approximations of Bayesian decision making," *International Economic Review*, 49 (1), 185–221.

Coibion, Olivier and Yuriy Gorodnichenko (2015) "Information rigidity and the expectations formation process: A simple framework and new facts," *American Economic Review*, 105 (8), 2644–2678.

David, Alexander and Pietro Veronesi (2013) "What ties return volatilities to fundamentals and price valuations?" *Journal of Political Economy*, 121, 682–746.

Davis, J Scott (2012) "Inflation expectations have become more anchored over time," *Economic Letter*, 7, 1–4.

De Lannoy, Leo R Aparisi, Anmol Bhandari, David Evans, Mikhail Golosov, and Thomas J Sargent (2022) "Managing Public Portfolios," National Bureau of Economic Research Working Paper, wp 30501.

De La'O, Ricardo and Sean Myers (2021) "Subjective cash flow and discount rate expectations," *Journal of Finance*, 76 (3), 1339–1387.

Dew-Becker, Ian (2014) "Bond Pricing with a Time-Varying Price of Risk in an Estimated Medium-Scale Bayesian DSGE Model," *Journal of Money, Credit and Banking*, 46 (5), 837–888.

Di Giovanni, Julian, Sebnem Kalemli-Özcan, Alvaro Silva, and Muhammed A Yildirim (2022) "Global supply chain pressures, international trade, and inflation," National Bureau of Economic Research Working Paper, wp30240.

Du, Wenxin, Joanne Im, and Jesse Schreger (2018a) "The US Treasury premium," *Journal of International Economics*, 112, 167–181.

Du, Wenxin, Carolin E Pflueger, and Jesse Schreger (2020) "Sovereign debt portfolios, bond risks, and the credibility of monetary policy," *Journal of Finance*, 75 (6), 3097–3138.

Du, Wenxin, Alexander Tepper, and Adrien Verdelhan (2018b) "Deviations from covered interest rate parity," *Journal of Finance*, 73 (3), 915–957.

Duffee, Greg (2022) "Macroeconomic news and stock-bond comovement," Working paper, Johns Hopkins University.

Duffee, Gregory R (2018) "Expected inflation and other determinants of Treasury yields," *Journal of Finance*, 73 (5), 2139–2180.

Favilukis, Jack and Xiaoji Lin (2016) "Wage rigidity: A quantitative solution to several asset pricing puzzles," *Review of Financial Studies*, 29 (1), 148–192.

Fisher, Irving (1933) "The Debt-Deflation Theory of Great Depressions," *Econometrica: Journal of the Econometric Society*, 337–357.

Fuhrer, Jeff and George Moore (1995) "Inflation persistence," *Quarterly Journal of Economics*, 110 (1), 127–159.

Fuhrer, Jeffrey C (1997) "The (un) importance of forward-looking behavior in price specifications," *Journal of Money, Credit, and Banking*, 29, 338–350.

Galı, Jordi and Mark Gertler (1999) "Inflation dynamics: A structural econometric analysis," *Journal of Monetary Economics*, 44 (2), 195–222.

Gilchrist, Simon and Egon Zakrajšek (2012) "Credit spreads and business cycle fluctuations," *American Economic Review*, 102 (4), 1692–1720.

Gourio, François and Phuong Ngo (2020) "Risk premia at the ZLB: A macroeconomic interpretation," Working Paper, Federal Reserve Bank of Chicago.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W Huffman (1988) "Investment, capacity utilization, and the real business cycle," *American Economic Review*, 402–417.

Harding, Martín, Jesper Lindé, and Mathias Trabandt (2022) "Resolving the missing deflation puzzle."

Hardouvelis, Gikas A (1994) "The term structure spread and future changes in long and short rates in the G7 countries: Is there a puzzle?" *Journal of Monetary Economics*, 33 (2), 255–283.

Hazell, Jonathon, Juan Herreno, Emi Nakamura, and Jón Steinsson (2022) "The slope of the Phillips curve: Evidence from US states," *Quarterly Journal of Economics*, 137, 1299–1344.

He, Zhiguo, Stefan Nagel, and Zhaogang Song (2022) "Treasury inconvenience yields during the COVID-19 crisis," *Journal of Financial Economics*, 143 (1), 57–79.

Jiang, Zhengyang, Arvind Krishnamurthy, and Hanno Lustig (2021) "Foreign safe asset demand and the dollar exchange rate," *Journal of Finance*, 76 (3), 1049–1089.

Jordà, Òscar (2005) "Estimation and inference of impulse responses by local projections," *American Economic Review*, 95 (1), 161–182.

Jurado, Kyle, Sydney C Ludvigson, and Serena Ng (2015) "Measuring uncertainty," *American Economic Review*, 105 (3), 1177–1216.

Justiniano, Alejandro and Giorgio E Primiceri (2008) "The time-varying volatility of macroeconomic fluctuations," *American Economic Review*, 98 (3), 604–641.

Kang, Johnny and Carolin E Pflueger (2015) “Inflation Risk in Corporate Bonds,” *Journal of Finance*, 70 (1), 115–162.

Kekre, Rohan and Moritz Lenel (2022) “Monetary policy, redistribution, and risk premia,” *Econometrica*, 90 (5), 2249–2282.

Krishnamurthy, Arvind and Annette Vissing-Jorgensen (2012) “The aggregate demand for Treasury debt,” *Journal of Political Economy*, 120 (2), 233–267.

Li, Erica XN, Tao Zha, Ji Zhang, and Hao Zhou (2022) “Does fiscal policy matter for stock-bond return correlation?” *Journal of Monetary Economics*, 128, 20–34.

Lubik, Thomas A and Frank Schorfheide (2004) “Testing for indeterminacy: An application to US monetary policy,” *American Economic Review*, 94 (1), 190–217.

Lucas, Robert E. Jr. (1988) “On the Mechanics of Economic Development,” *Journal of Monetary Economics*, 22, 3–42.

Lustig, Hanno, Christopher Sleet, and Şevin Yeltekin (2008) “Fiscal hedging with nominal assets,” *Journal of Monetary Economics*, 55 (4), 710–727.

Maćkowiak, Bartosz and Mirko Wiederholt (2015) “Business cycle dynamics under rational inattention,” *Review of Economic Studies*, 82 (4), 1502–1532.

Malmendier, Ulrike and Stefan Nagel (2016) “Learning from inflation experiences,” *Quarterly Journal of Economics*, 131 (1), 53–87.

Mankiw, N Gregory, Jeffrey A Miron, and David N Weil (1987) “The adjustment of expectations to a change in regime: A study of the founding of the Federal Reserve,” *American Economic Review*, 77, 358–374.

Pflueger, Carolin E and Luis M Viceira (2016) “Return predictability in the Treasury market: Real rates, inflation, and liquidity,” in Veronesi, Pietro ed. *Handbook in Fixed-Income Securities*: Wiley, New Jersey.

Pflueger, Carolin and Gianluca Rinaldi (2022) “Why does the Fed move markets so much? A model of monetary policy and time-varying risk aversion,” *Journal of Financial Economics*, 146, 71–68.

Pflueger, Carolin, Emil Siriwardane, and Adi Sunderam (2020) “Financial market risk perceptions and the macroeconomy,” *Quarterly Journal of Economics*, 135 (3), 1443–1491.

Piazzesi, Monika and Martin Schneider (2006) “Equilibrium yield curves,” *NBER Macroeconomics Annual*, 21, 389–472.

Primiceri, Giorgio E (2006) “Why inflation rose and fell: Policy-makers’ beliefs and US postwar stabilization policy,” *Quarterly Journal of Economics*, 121 (3), 867–901.

Ramey, Valerie A (2016) “Macroeconomic shocks and their propagation,” *Handbook of Macroeconomics*, 2, 71–162.

Rotemberg, Julio J (1982) “Monopolistic price adjustment and aggregate output,” *Review of Economic Studies*, 49 (4), 517–531.

Rubbo, Elisa (2022) “Networks, Phillips curves, and monetary policy,” Working Paper, University of Chicago.

Rudebusch, Glenn D and Eric T Swanson (2008) “Examining the bond premium puzzle with a DSGE model,” *Journal of Monetary Economics*, 55, S111–S126.

Sims, Christopher A and Tao Zha (2006) “Were there regime switches in US monetary policy?” *American Economic Review*, 96 (1), 54–81.

Smets, Frank and Rafael Wouters (2007) “Shocks and frictions in US business cycles: A Bayesian DSGE approach,” *American Economic Review*, 97, 586–606.

Song, Dongho (2017) “Bond market exposures to macroeconomic and monetary policy risks,” *Review of Financial Studies*, 30 (8), 2761–2817.

Stock, James H and Mark W Watson (2002) “Has the business cycle changed and why?” *NBER Macroeconomics Annual*, 17, 159–218.

——— (2007) “Why has US inflation become harder to forecast?” *Journal of Money, Credit and Banking*, 39, 3–33.

Swanson, Eric T and John C Williams (2014) “Measuring the effect of the zero lower bound on medium-and longer-term interest rates,” *American Economic Review*, 104 (10), 3154–85.

Uhlig, Harald (1999) “A toolkit for analysing nonlinear dynamic stochastic models easily,” in Marimon, Ramon and Andrew Scott eds. *Computational Methods for the Study of Dynamic Economics*, 30–61: Oxford University Press.

——— (2007) “Explaining asset prices with external habits and wage rigidities in a DSGE model,” *American Economic Review*, 97 (2), 239–243.

Verdelhan, Adrien (2010) “A habit-based explanation of the exchange rate risk premium,” *The Journal of Finance*, 65 (1), 123–146.

Viceira, Luis M (2012) “Bond risk, bond return volatility, and the term structure of interest rates,” *International Journal of Forecasting*, 28 (1), 97–117.

Wachter, Jessica A (2006) “A consumption-based model of the term structure of interest rates,” *Journal of Financial Economics*, 79 (2), 365–399.

Table 1: Calibration Parameters

		1979.Q4-2001.Q1	2001.Q2-2022.Q2
Consumption growth	g	1.89	
Utility curvature	γ	2	
Risk-free rate	$\bar{r}$	0.94	
Persistence surplus cons.	θ_0	0.87	
Backward-looking habit	θ_1	-0.84	
PC slope	κ	0.0062	
Consumption-output gap	ϕ	0.99	
MP inflation coefficient	γ^{π}	1.35	1.10
		(0.22)	(0.05)
MP output coefficient	γ^{x}	0.50	1.00
		(0.32)	(0.19)
MP persistence	ρ^{i}	0.54	0.80
		(0.13)	(0.03)
Vol. demand shock	σ_x	0.01	0.59
		(0.31)	(0.02)
Vol. PC shock	σ_π	0.58	0.07
		(0.05)	(0.01)
Vol. MP shock	σ_i	0.55	0.07
		(0.05)	(0.01)
Adaptive Inflation Expectations	ζ	0.6	0.0
Leverage parameter	δ	0.50	0.66

Consumption growth and the real risk-free rate are in annualized percent. The standard deviation σ_x is in percent, and the standard deviations σ_π and σ_i are in annualized percent. The Phillips curve slope κ and the monetary policy parameters γ^{π}, γ^{x} and ρ^{i} are in units corresponding to the output gap in percent, and inflation and interest rates in annualized percent. Standard errors for parameters shown in parentheses are computed after the second calibration/estimation step, minimization of the objective function (33). Standard errors are computed using the delta method using the same diagonal variance-covariance matrix used to compute the objective function (33).

Table 2: Model and Data Moments

	1979.Q4-2001.Q1		2001.Q2-2019.Q4	
Stocks	Model	Data	Model	Data
Equity Premium	7.33	7.96	9.15	7.64
Equity Vol	14.95	16.42	19.29	16.80
Equity SR	0.49	0.48	0.47	0.45
AR(1) pd	0.96	1.00	0.93	0.84
1 YR Excess Returns on pd	-0.38	-0.01	-0.38	-0.50
1 YR Excess Returns on pd (R^2)	0.06	0.00	0.14	0.28
Bonds				
Yield Spread	2.28	1.53	-0.58	2.06
Return Vol.	15.82	14.81	2.12	9.28
Nominal Bond-Stock Beta	0.86	0.24	-0.09	-0.31
Real Bond-Stock Beta	0.05	0.08	-0.08	-0.06
1 YR Excess Return on slope*	1.26	2.55	-0.31	0.86
1 YR Excess Return on slope (R^2)	0.01	0.07	0.01	0.02
Macroeconomic Volatilities				
Std. Annual Cons. Growth*	0.76	1.15	1.59	1.15
Std Annual Change Fed Funds Rate*	1.64	2.26	0.65	1.40
Std. Annual Change 10-Year Subj. Infl. Forecast*	0.62	0.47	0.12	0.12

Ten-year CPI inflation expectations are from the Survey of Professional Forecasters after 1990 and from Blue Chip before that. Long-term inflation forecast available from the Philadelphia Fed research website. Model ten-year inflation expectations are computed assuming that inflation expectations are adaptive, i.e. $\tilde{E}_t \pi_{t \to t+40} = \zeta \pi_{t-41 \to t-1} + (1-\zeta) E_t \pi_{t \to t+40}$, where E_t denotes rational expectations. Moments that were explicitly targeted in the calibration procedure are noted with an asterisk.

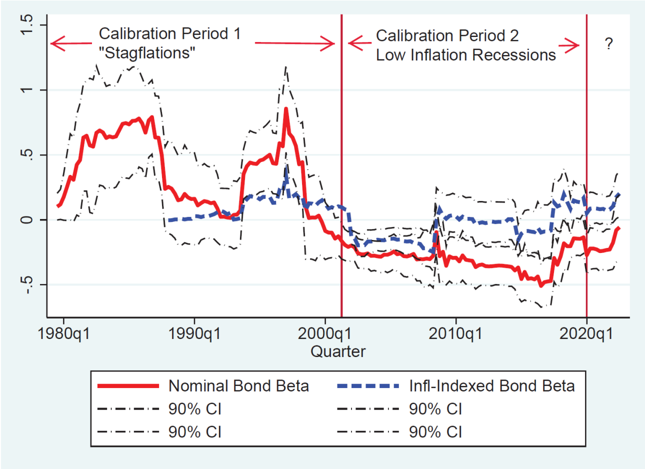
Table 3: Inflation Forecast Error Regressions by Subperiod

	Data			Model	
$\tilde{E}_t\pi_{t+3} - \tilde{E}_{t-1}\pi_{t+3}$	0.926***	0.433	-0.310	1.43	-0.01
	(0.34)	(0.32)	(0.43)		
Const.	-0.114	-0.795***	-0.046		
	(0.28)	(0.20)	(0.18)		
N	126	87	71		
R-sq	0.09	0.03	0.00		
Sample	1968.Q4-2001.Q1	1979.Q4-2001.Q1	2001.Q2-2019.Q4	1979.Q4-2001.Q1	2001.Q2-2019.Q4

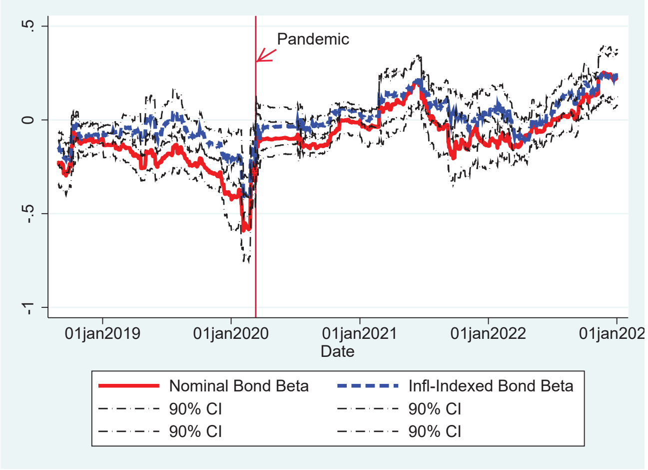
This table estimates Coibion and Gorodnichenko (2015) regressions of the form $\pi_{t+3} - \tilde{E}_t\pi_{t+3} = a_0 + a_1\left(\tilde{E}_t\pi_{t+3} - \tilde{E}_{t-1}\pi_{t+3}\right) + \varepsilon_{t+3}$ using quarterly GDP deflator inflation forecasts from the Survey of Professional Forecasters. Newey-West standard errors with 4 lags in parentheses. Model subjective n-quarter inflation expectations are computed assuming that inflation expectations are a weighted average of rational expectations and past average inflation $\tilde{E}_t\pi_{t+n} = \zeta\pi_{t-n-1\to t-1} + (1-\zeta)E_t\pi_{t+n}$

Figure 1: Rolling Treasury Bond-Stock Betas

Panel A: 1979.Q4-2022.Q3



Panel B: January 2018 - December 2022

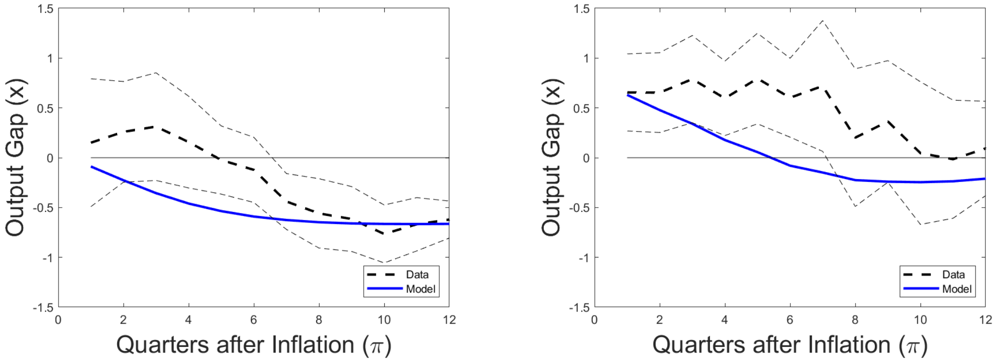


Note: Panel A shows betas from regressing quarterly ten-year Treasury bond excess returns onto quarterly US equity excess returns over five-year rolling windows for the period 1979.Q4-2022.Q3. Quarterly excess returns are in excess of three-month T-bills. Prior to 1999, I replace US Treasury Inflation Protected (TIPS) returns with UK ten-year linker returns. Bond excess returns are computed from changes in yields. I use zero-coupon yield curves from Gurkaynak, Sack and Wright (2006, 2008) and the Bank of England. Vertical lines indicate the start of the second sample period 2001.Q2 and the start of the pandemic 2020.Q1. Panel B shows betas from regressing daily ten-year Treasury bond log returns onto quarterly US equity log returns over 120-trading day backward-looking rolling windows for the sample 01/01/2018 through 30/12/2022. A vertical line indicates the date when the World Health Organization declared Covid-19 a pandemic (March 11, 2020). 90% confidence intervals based on heteroskedasticity robust standard errors are shown in dashed.

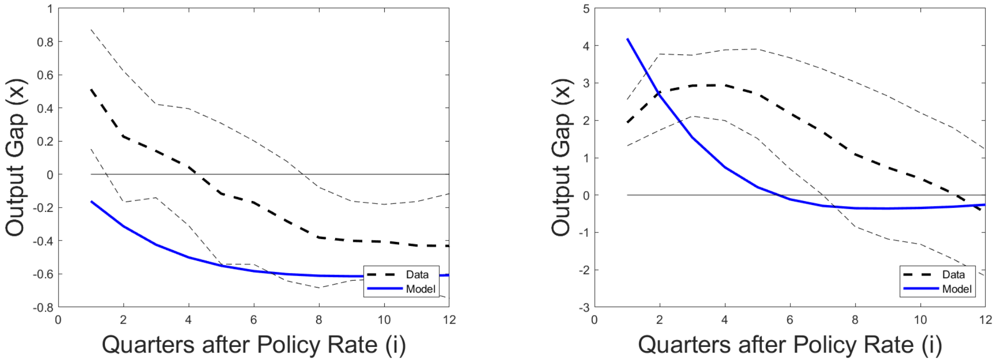
Figure 2: Empirical Output Gap, Inflation, and Policy Rate Dynamics Pre- vs. Post-2001

Panel A: Output Gap onto Lagged Price Inflation

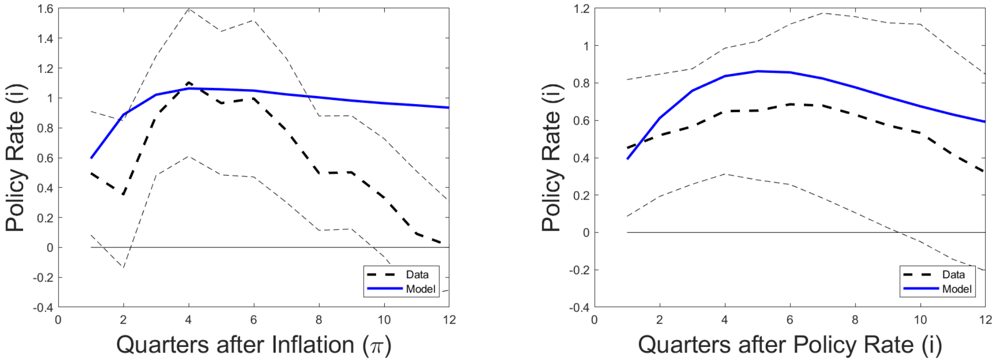
1979.Q4-2001.Q1 2001.Q2-2019.Q4



Panel B: Output Gap onto Lagged Policy Rate

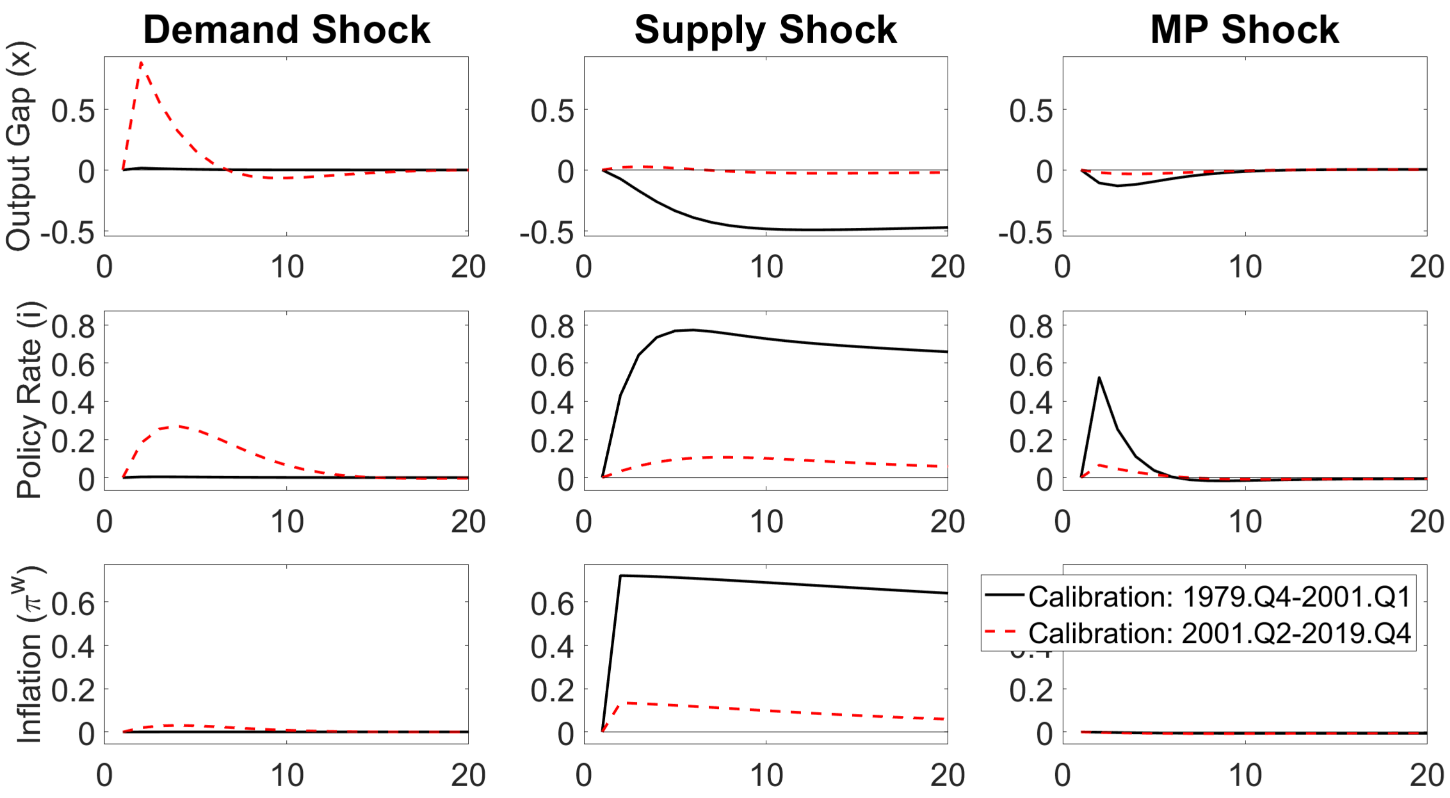


Panel C: Policy Rate onto Lagged Price Inflation



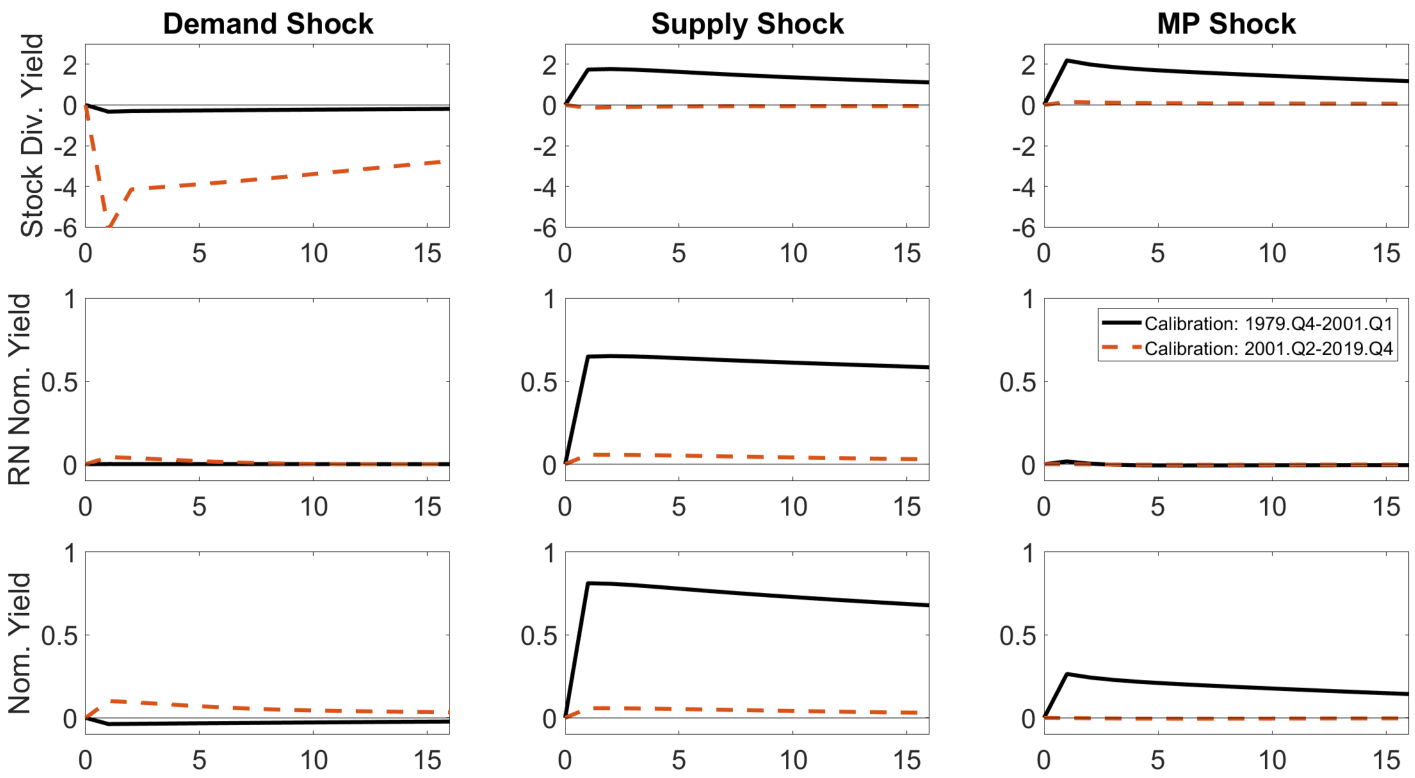
This figure shows quarterly regressions of the form $z_{t+h} = a_{0,h} + a_{1,h} y_t + a_{2,h} y_{t-1} + \varepsilon_{t+h}$ and plots the regression coefficient $a_{1,h}$ on the y-axis against horizon h on the x-axis in the model vs. the data. Panel A uses the output gap on the left-hand side and GDP deflator inflation on the right-hand side, i.e. $z_t = x_t$ and $y_t = \pi_t$. Panel B uses the output gap on the left-hand side and the fed funds rate on the right-hand side, i.e. $z_t = x_t$ and $y_t = i_t$. Panel C uses the fed funds rate on the left-hand side and inflation on the right-hand side, i.e. $z_t = i_t$ and $y_t = \pi_t$. Black dashed lines show the regression coefficients in the data. Thin dashed lines show 95% confidence intervals for the data coefficients based on Newey-West standard errors with h lags. Blue solid lines show the corresponding model regression coefficients averaged across 100 independent simulations of length 1000.

Figure 3: Model Macroeconomic Impulse Responses



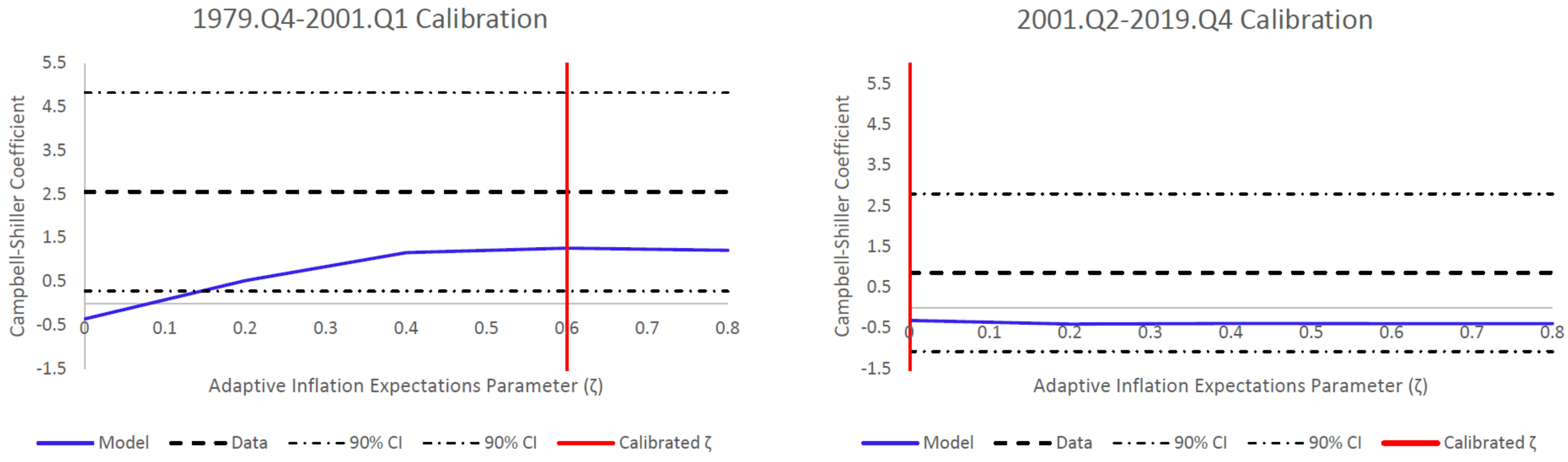
This figure shows model impulse responses for the output gap (top row), nominal policy rate (middle row) and inflation (bottom row). The impulse in the left column is a one-standard-deviation demand shock, in the middle column is a one-standard-deviation Phillips curve or supply shock, and in the right column is a one-standard-deviation monetary policy shock. Impulse responses for the 1979.Q4-2001.Q1 calibration are shown in black, while the impulse responses for the 2001.Q2-2019.Q4 calibration are shown in red dashed.

Figure 4: Model Asset Price Impulse Responses



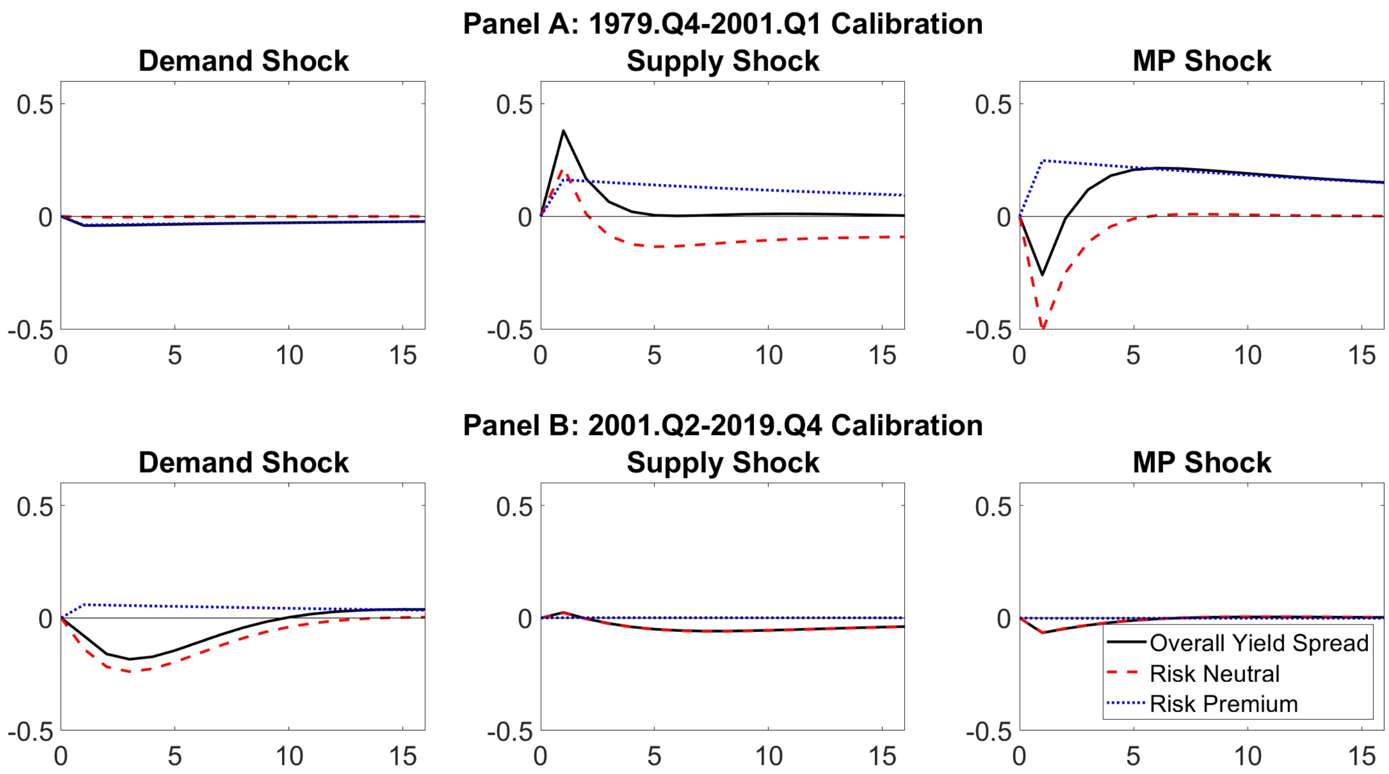
This figure shows model impulse responses for the stock dividend yield, and bond yields for zero-coupon nominal Treasury bonds in response to structural shocks. Stock prices move inversely with the stock dividend yield and bond prices move inversely with the ten-year nominal bond yield. The middle row shows responses for the risk-neutral (or expectations hypothesis) component of ten-year nominal bond yields. The bottom row shows responses for the overall ten-year nominal bond yield. The 1979.Q4-2001.Q1 calibration is shown with black solid lines and the 2001.Q2-2019.Q4 calibration is shown with red dashed lines. The impulse in the left column is a one-standard-deviation demand shock, in the middle column is a one-standard-deviation Phillips curve or supply shock, and in the right column is a one-standard-deviation monetary policy shock.

Figure 5: Model Bond Return Predictability by Backward-Looking Phillips Curve



This figure shows the model Campbell-Shiller bond return predictability regression coefficient as in Table 2 against the parameter determining the adaptiveness of inflation expectations, ζ. The parameter ζ is directly related to the backward-lookingness of the Phillips curve via $\rho^{\pi} = \rho^{\pi,0} + \zeta - \rho^{\pi,0}\zeta$ with the backward- and forward-looking components adding up to one, as in equation (25). All other parameters are held constant at their values listed in Table 1. The corresponding data moment is shown in black dashed. Data 90% confidence intervals for the data moment are based on Newey-West standard errors with 4 lags are shown in black dash-dot. The left Panel shows data and model moments for the 1979.Q4-2001.Q calibration. The right Panel shows model and data moments for the 2001.Q2-2019.Q4 calibration.

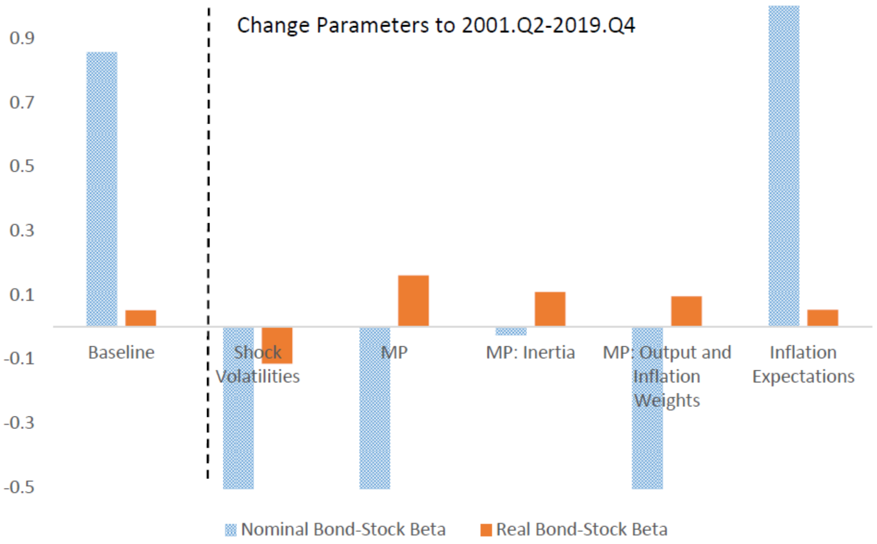
Figure 6: Decomposition of Model Term Spread Impulse Responses



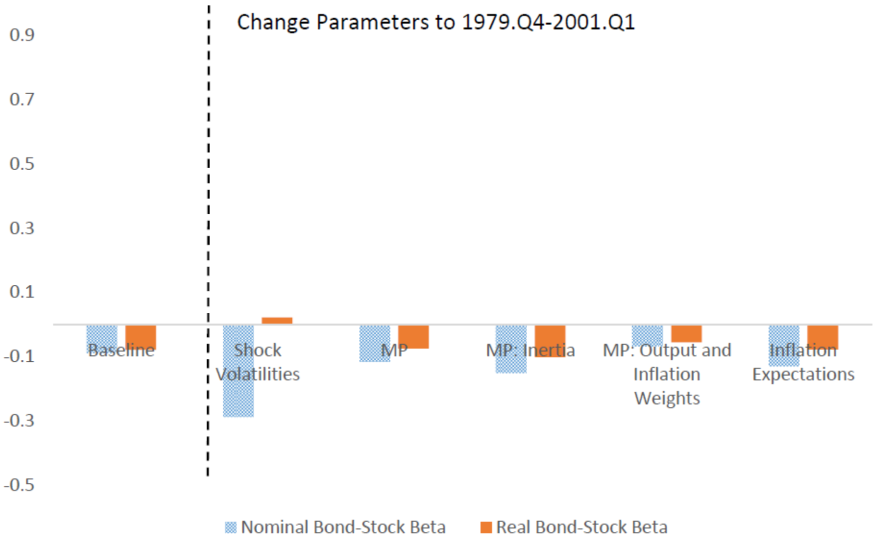
This figure shows model impulse responses for the yield spread, i.e. the right-hand-side of the Campbell-Shiller regressions in Table 2. The yield spread is defined as the ten-year nominal zero-coupon Treasury bond yield minus the nominal risk-free rate. It is decomposed into risk-neutral (expectations hypothesis) and risk premium components, analogously to Figure 4. The top row shows impulse responses for the 1979.Q4-2001.Q1 calibration and the bottom row shows impulse responses for the 2001.Q2-2019.Q4 calibration. The impulse in the left column is a one-standard-deviation demand shock, in the middle column is a one-standard-deviation Phillips curve or supply shock, and in the right column is a one-standard-deviation monetary policy shock.

Figure 7: Counterfactuals for Nominal and Real Bond-Stock Betas

Panel A: Starting from 1979.Q4-2001.Q1 Calibration



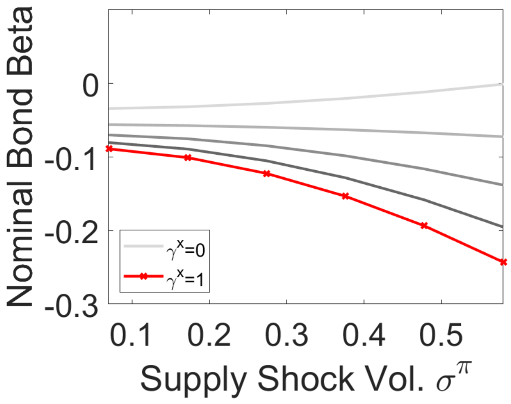
Panel B: Starting from 2001.Q2-2019.Q4 Calibration



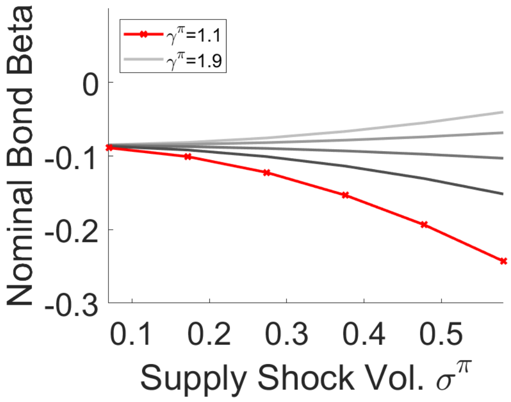
This figure shows model-implied nominal and real bond betas while changing parameter groups one-at-a-time. Panel A sets all parameter values to the 1979.Q4-2001.Q1 calibration unless stated otherwise. It then reports the linearized change beta from setting the following parameters to the average of the 2001.Q2-2019.Q4 values: "MP: Inertia" (ρ^i, γ^x and γ^π), "MP: Inertia" (ρ^i), "MP: Output and Inflation Weights" (γ^x and γ^π), "Shock volatilities" (σ_x, σ_π, and σ_i), "Inflation Expectations" (ζ). Panel B does the reverse exercise, holding all parameter values constant at their 2001.Q2-2019.Q4. The linearized beta of the change from parameter vector $param_1$ to $param_2$ is computed as $\beta_{param_1} + 2 \times \beta_{\frac{param_1+param_2}{2}}$.

Figure 8: Interaction of Supply Shocks with Monetary Policy Rule Parameters

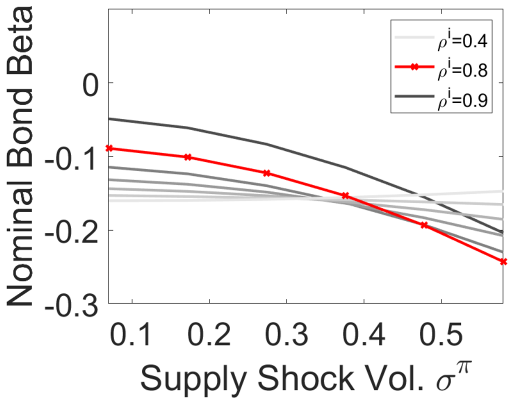
Panel A: Different Monetary Policy Output Gap Weight (γ^x)



Panel B: Varying the Monetary Policy Inflation Weight (γ^π)



Panel C: Varying the Monetary Policy Inertia (ρ^i)



This figure shows shows model-implied ten-year nominal bond-stock betas against the standard deviation of supply shocks for different monetary policy rules. Unless otherwise labeled all parameter values are set to the 2001.Q2-2019.Q4 calibration. Panel A shows different values of γ^x, Panel B shows different values of γ^π, and Panel C shows different values of ρ^i. The 2001.Q2-2019.Q4 calibration monetary policy parameter values are highlighted with red asterisks.