Internet Appendix
Downward Nominal Rigidities and Bond Premia*

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*The views expressed here are those of the authors and do not necessarily represent those of the Federal Reserve Bank of Chicago or the Federal Reserve System.

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Contents

1 Quantitative model: additional results

In this section we present some additional results from the quantitative model. First, we study the model state-dependence, i.e. how its implications vary as a function of inflation, when inflation is driven by realizations of z as opposed to different levels of R^*. Second, we present results for the symmetric model, which demonstrates that our results are driven by the asymmetry. Third, we illustrate the implications of the model for asymmetry. Fourth, we illustrate the implications of a different monetary policy rule. And finally, we present comparative statics across risk aversion and the persistence of the technology shock.

1.1 State-dependence

1.1.1 Impulse response function

Figure 1 presents generalized impulse responses (GIRFs) to a one-standard deviation shock to productivity, conditional on inflation being initially low (2%, red line) vs. high (4%, black dashed line).[1] Here, the conditioning is effectively a conditioning on past productivity shocks. The patterns are quantitatively similar to that of figure (6) in the main text: when inflation is high, output and inflation are more responsive to a productivity shock.

1.1.2 Macro-finance moments as a function of inflation

Figures 2 and 3 depict the macro-finance moments as a function of inflation (when inflation is driven by z), and compares them to the ones of the main text (where differences of inflation come from R^*, and correspond to different "equilibria" as opposed to "histories"). The statistics are calculated in the same way as the data: we simulate the model and construct rolling windows (of length 72 periods), over each of which we calculate the macro-finance moments and the mean of inflation. (We then average across many simulations.) The main message from the two figures is that the two approaches generate very similar implications. The one moment where a difference emerges is the volatility of inflation and interest rates. This is because these variables are highly persistent, and hence, for these, the short sample of the rolling windows lead to an estimate of standard

[1] The GIRF of a variable x for a shock e at horizon k defined as $GIRF(x,s,k,e) = E_t(x(t+k)|s(t) = s+e) - E_t(x(t+k)|s(t) = s)$ where s is the state. It reflects that in a nonlinear model, the response in general depends on the size (and sign) of the shock e as well as the initial condition s - unlike in a linear model. Moreover, the change in conditional expectation is not the same as the realization of a single path.

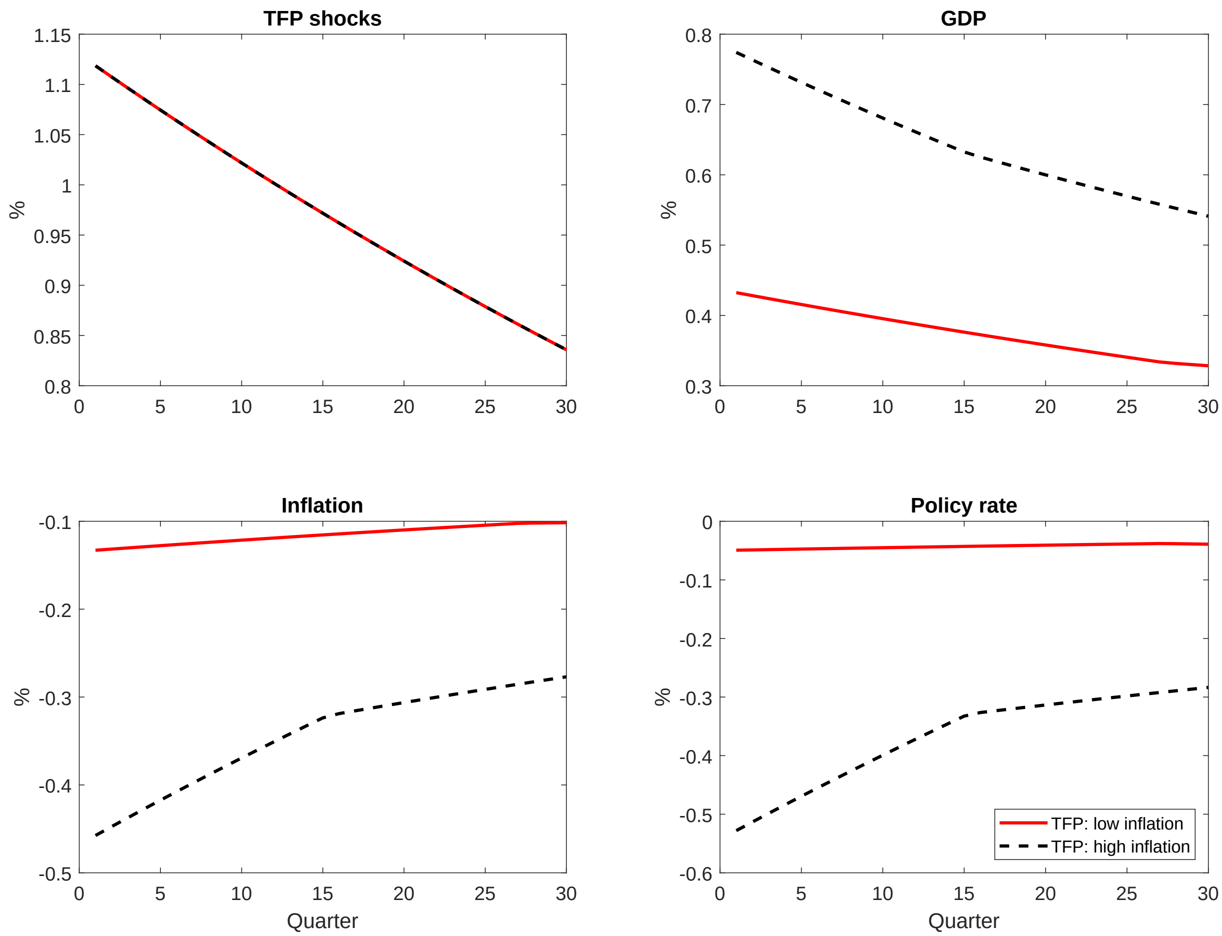

Figure 1: **Generalized impulse response functions in the baseline model.**

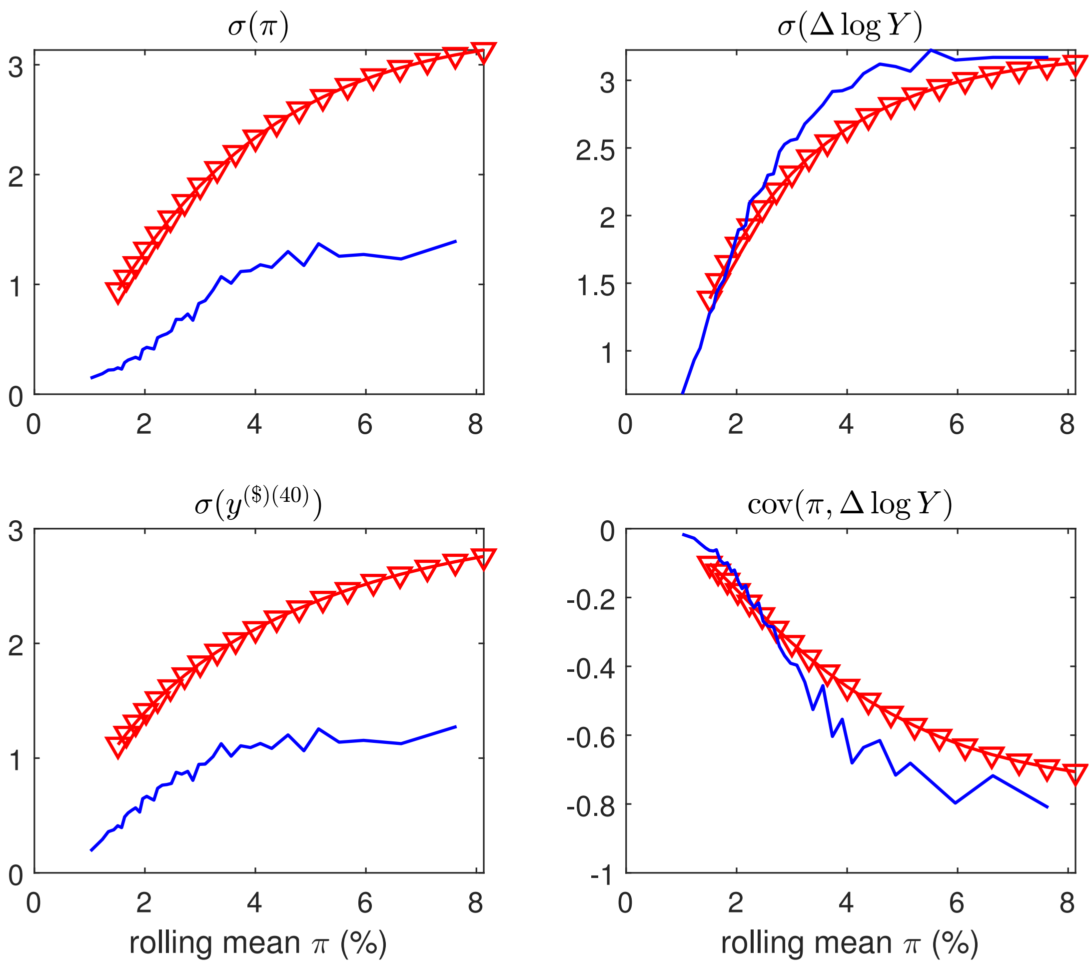

Figure 2: **Macro-finance moments in the benchmark model when inflation is driven by changes in inflation target (as in the main text) or by productivity shocks, 1/2.** Red triangles correspond to the main text calculation (inflation-target driven inflation), blue line to the history-driven inflation.

deviation that is much smaller than the population (or ergodic) standard deviation.[2] Figure 4 depicts the term premium as a function of inflation for the two approaches. Here too they are similar. (The figure also includes results from sections 2 and 3 to be discussed below.)

1.2 Asymmetry in price setting is the key parameter

This section presents further evidence that the asymmetry in price setting is the driving force of our result. We show this by solving the model for $\psi = 0$, keeping all other parameters unchanged. As shown in tables 3 and 5 in the main text, the symmetric model

[2]Hence, if we were to adopt this approach as target, we might have to recalibrate the volatility of shocks.

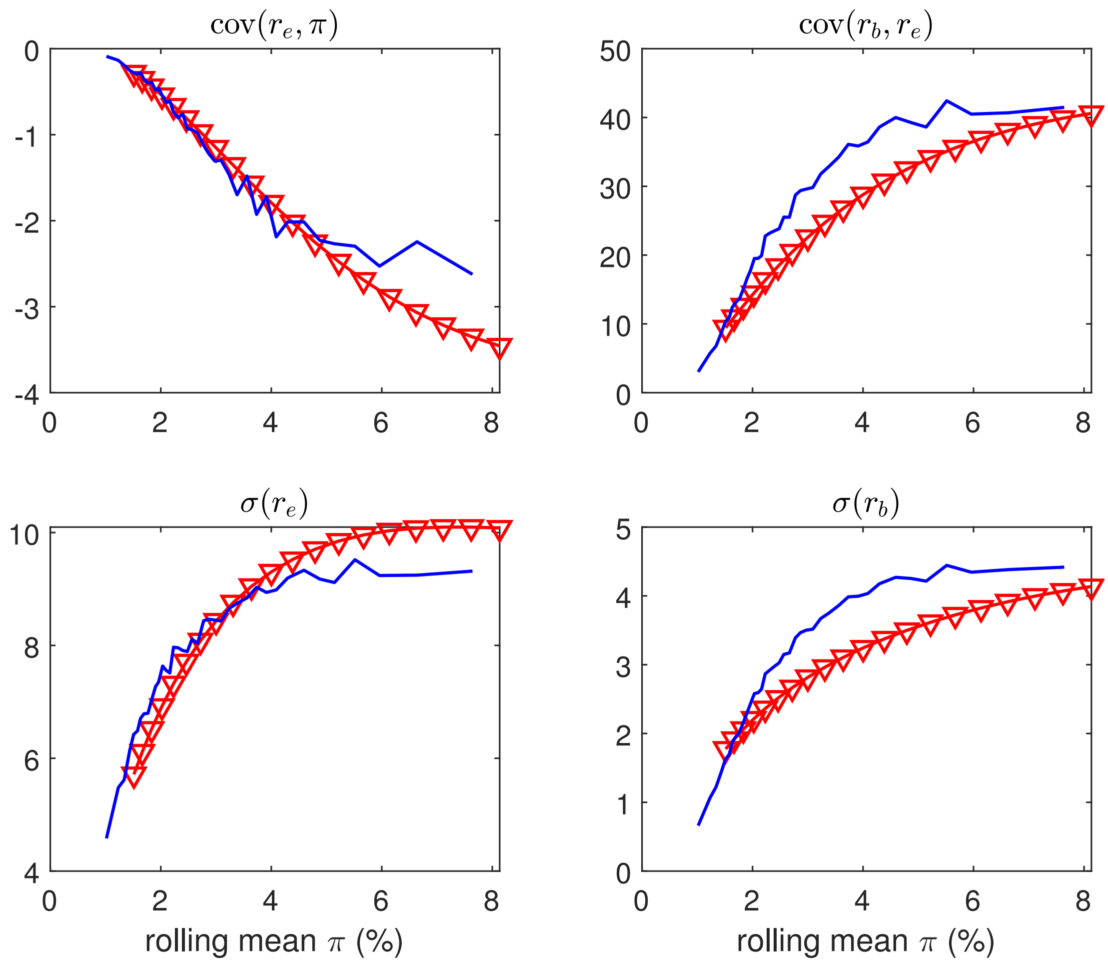

Figure 3: **Macro-finance moments in the benchmark model when inflation is driven by changes in inflation target (as in the main text) or by productivity shocks, 2/2.** Red triangles correspond to the main text calculation (inflation-target driven inflation), blue line to the history-driven inflation.

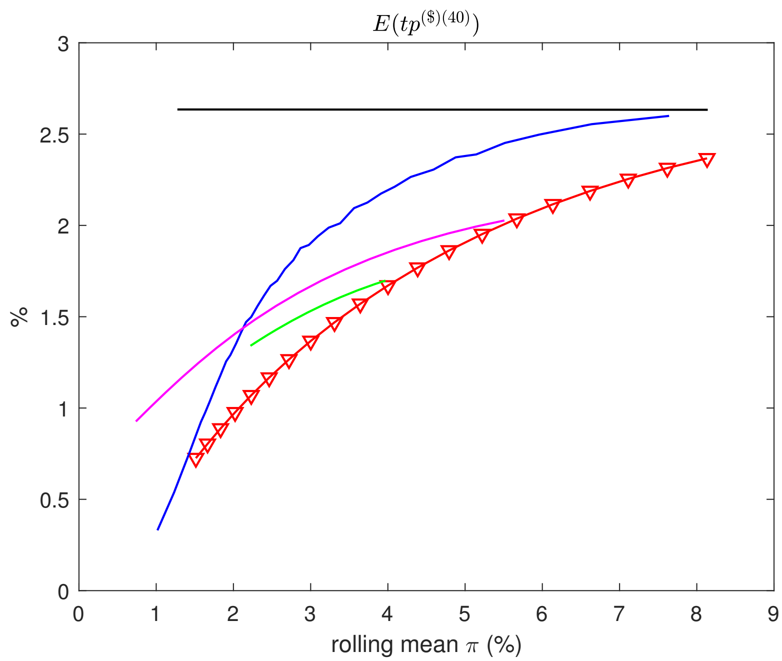

Figure 4: **Mean term premium as a function of average inflation.** The red triangles are the baseline model (main text) with inflation driven by R^*. The blue line is the baseline model where inflation is driven by z. The black line is the symmetric model. The purple line is the model with demand shocks. The green line is the model with wage and price asymmetries.

has high, but nearly constant bond premia, and hence does not generate the predictability evidence (Fama-Bliss regressions). To demonstrate where this comes from, figure 5 presents the impulse response function: the response of the economy to a productivity shock is nearly constant - that is, unlike the benchmark model, there is no state dependence. Finally, figures 6 and 7 reproduce our key experiment of changing the average level of inflation through the inflation target, and show that the symmetric model generates almost no change in macro-finance moments as the average level of inflation changes. Figure 4 shows this is true for the term premium as well. Overall, while this symmetric model has attractive implications along many dimensions (e.g., a high average risk premium), it fails to reproduce the secular and cyclical changes in bond premia that are the focus of this paper, because the market price of risk is nearly constant (and the bond risk is nearly constant).

1.3 Asymmetry in the model

A direct way to illustrate the asymmetry implicit in the model, on the other hand, is to look at the histograms of model variables (figure 8), which show a large positive skewness for inflation and interest rates, and a large negative for output. In contrast, the histograms of the symmetric model are approximately normally distributed.

As explained in the text, for small shocks the model is symmetric. Figure 9 compares the impulse response function to large positive and negative shocks, namely three-standard deviation shocks. For such large shocks, the model does exhibit some asymmetry. The asymmetry, in fact, results from the nonlinearity - the effect of a 3-sd positive shock is less than the sum of 3 one-sd shocks, as the elasticity of the economy to shocks falls as z rises. Yet, even with such large (and unlikely) shocks, the amount of asymmetry is not tremendous. Hence, we do not think that looking at asymmetric responses is the right approach to test this model.

1.4 Monetary Policy

Figure 10 illustrates the effect of changing the monetary policy rule on the distribution of output, inflation, and interest rates. The most striking feature is that the distribution of inflation loses most of its skewness, as does that of the interest rate to a lesser extent. Conversely, output loses some of its negative skewness. Not visible in this figure is the slight difference in the average level of output that is created by this policy change.

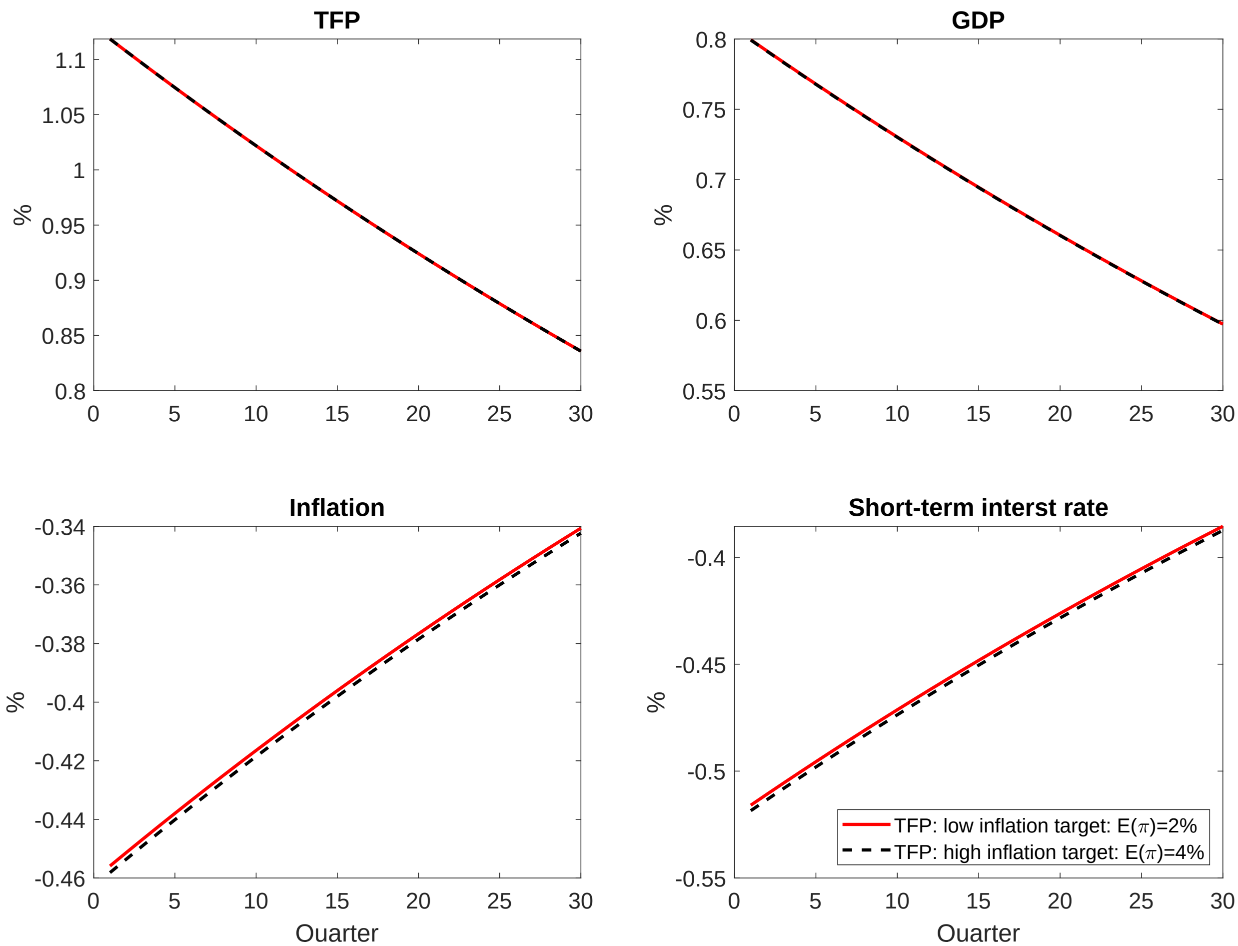

Figure 5: **Impulse response function to a productivity shock. Model with symmetric price adjustment costs.**

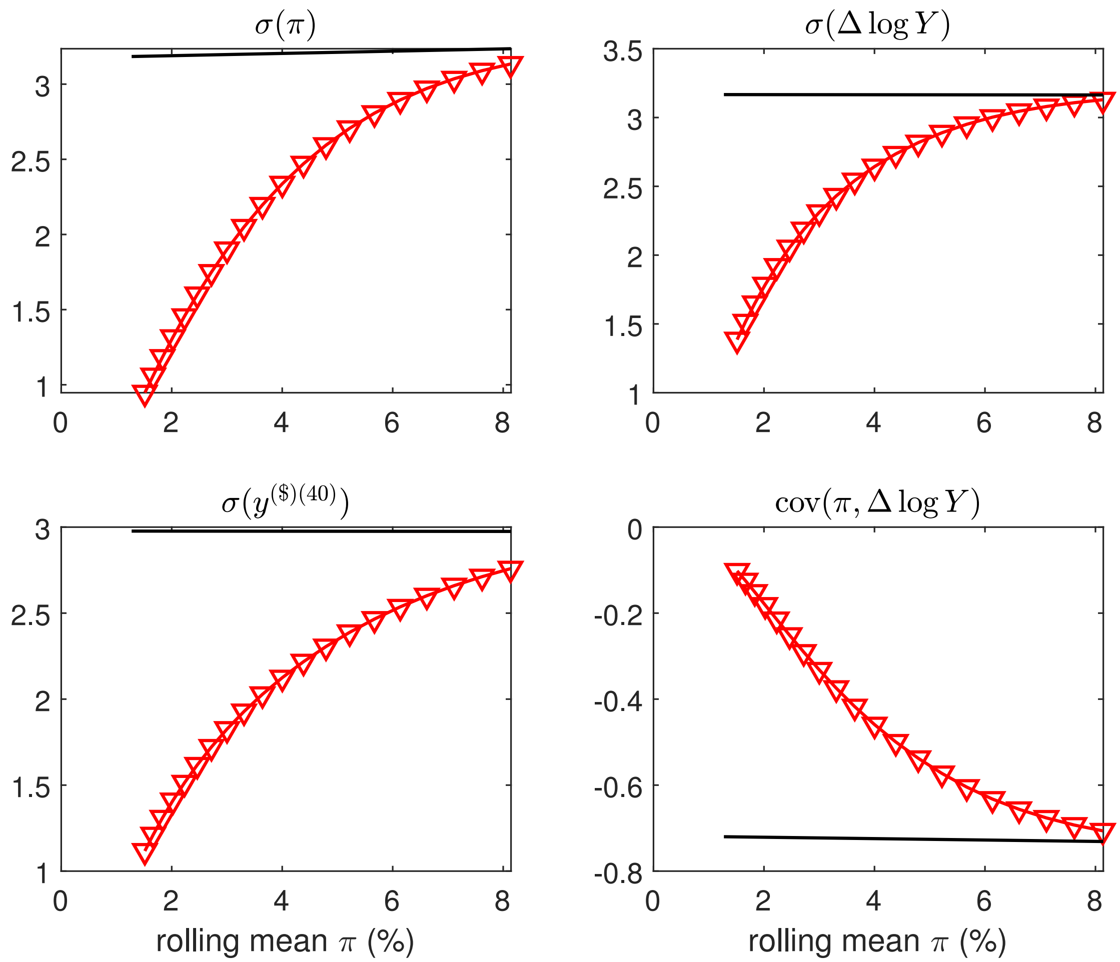

Figure 6: **Macro-finance moments in the symmetric model (black) and in the benchmark model (red triangles), 1/2.**

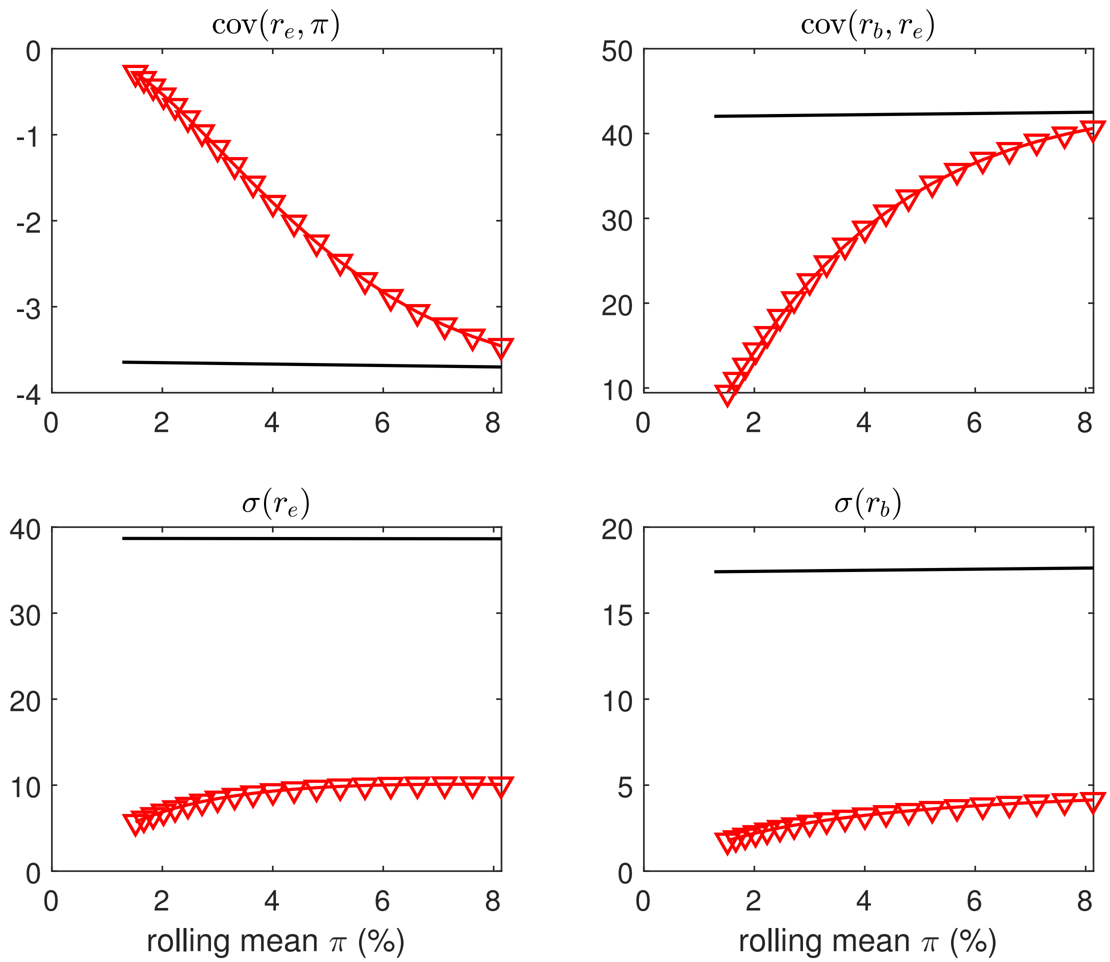

Figure 7: **Macro-finance moments in the symmetric model (black) and in the benchmark model (red triangles), 2/2.**

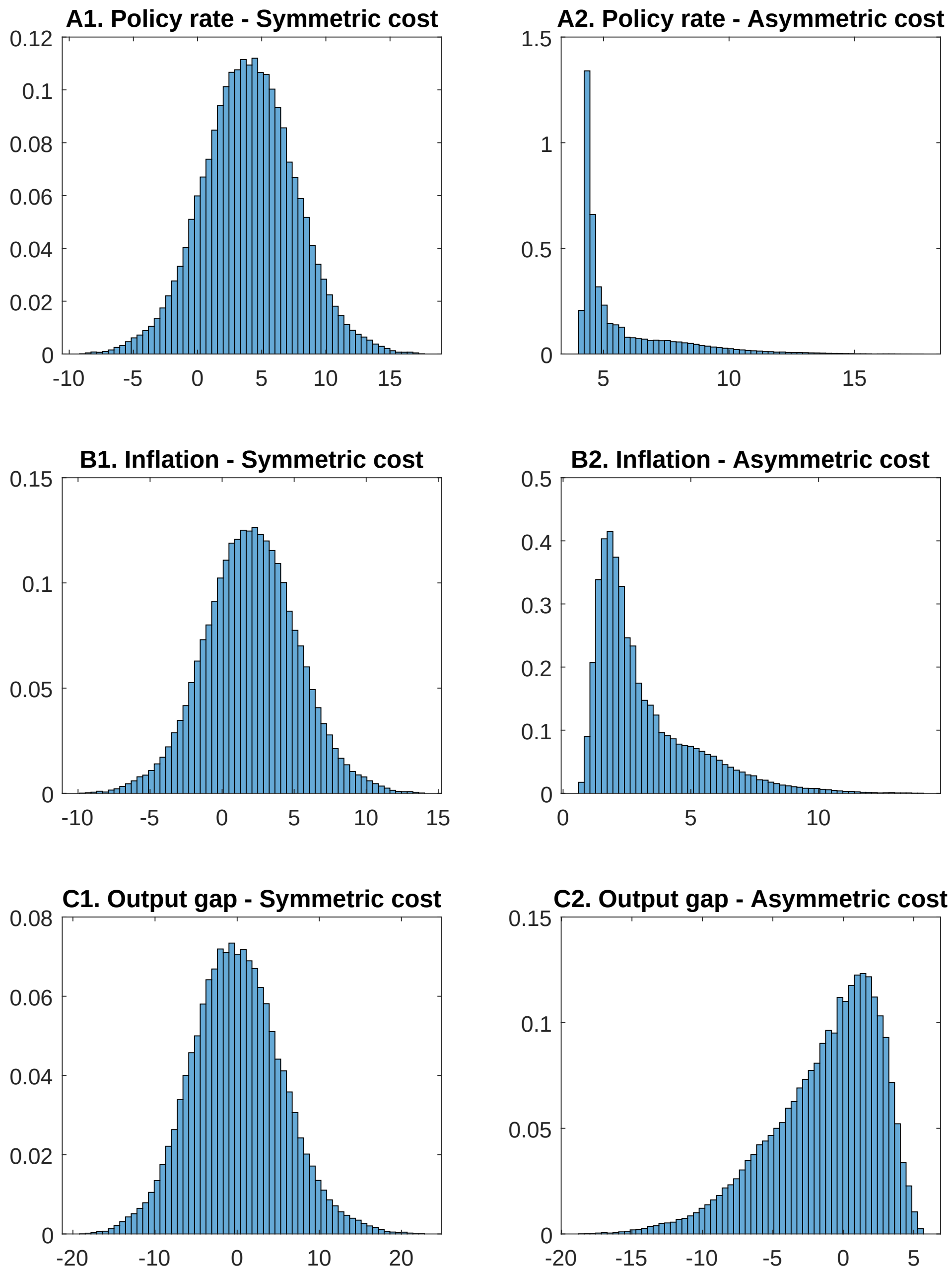

Figure 8: Histogram of macroeconomic variables in the symmetric model (left panel) and in the baseline model (right panel).

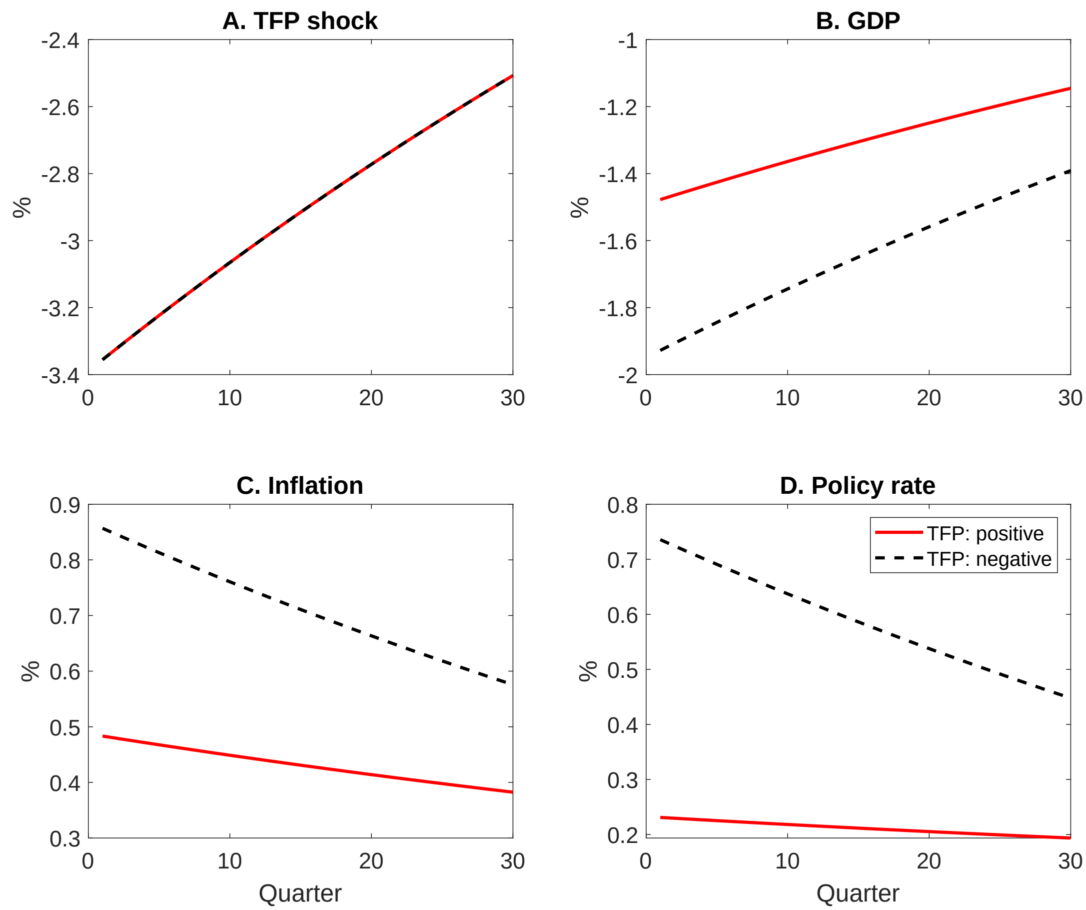

Figure 9: **Impulse response functions to positive and negative shocks with asymmetric price adjustment costs.** Impulse response to a three-standard deviation of productivity innovations shock when the shock is positive (red solid line) vs. negative (black dashed line). The responses to positive shocks are displayed with the reverse sign. The economy is initially at the deterministic steady state.

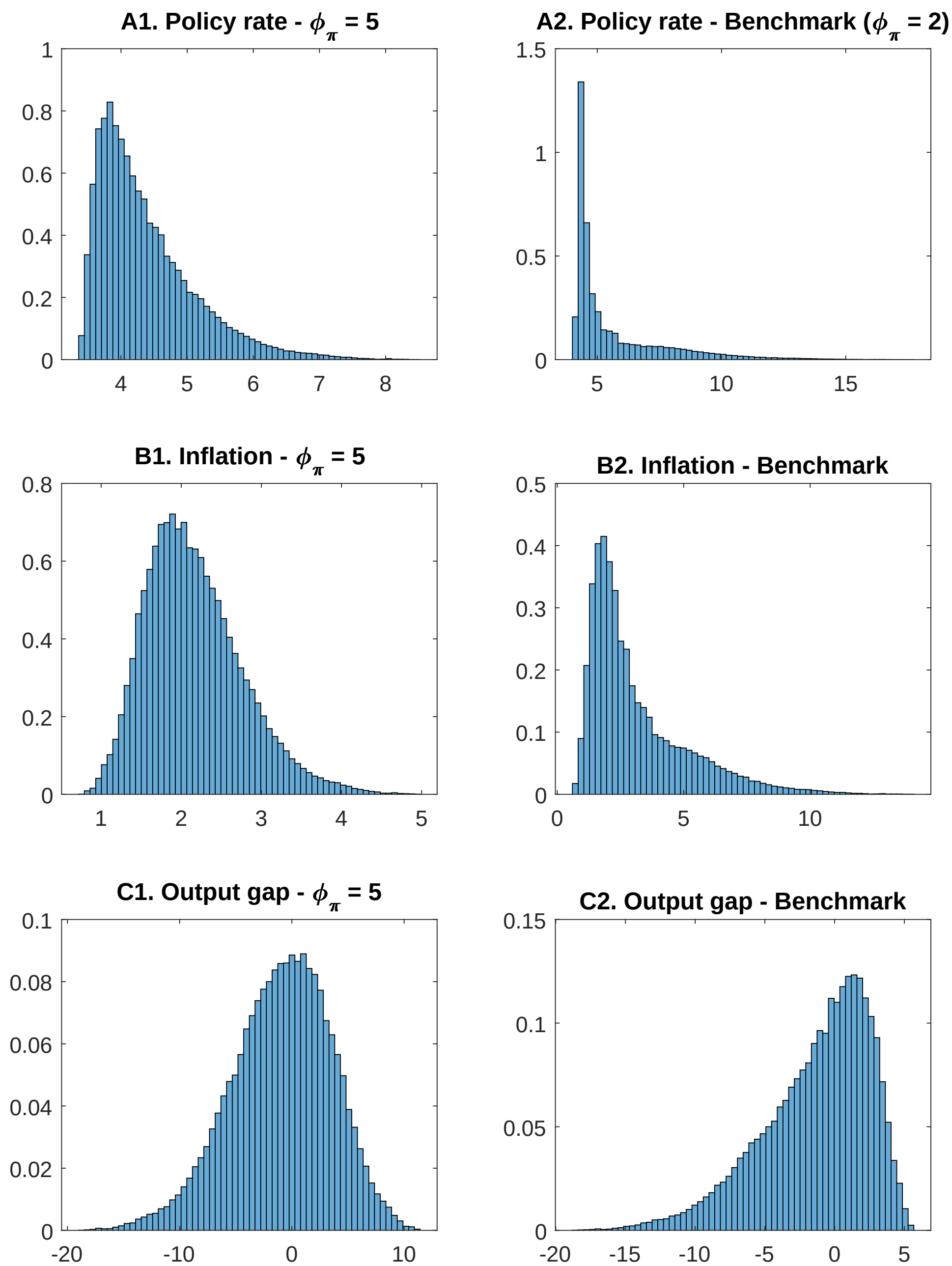

Figure 10: Histogram of macroeconomic variables in the model with $\phi_\pi = 5$ (left panel) and in the baseline model (right panel).

	Data		Model		$\alpha = 0$		$\rho_z = .92$	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
$\Delta \log Y$	–	3.03	0.00	2.37	0.00	2.74	0.00	3.23
π	3.14	1.97	3.14	1.97	3.81	2.72	3.31	1.98
$y^{\$(1)}$	5.63	3.20	5.63	1.97	7.38	3.18	6.54	3.11
$y^{\$(40)}$	7.36	2.97	7.36	2.12	7.34	2.41	7.37	0.93
$y^{(1)}$	–	–	2.37	0.34	3.51	0.52	3.11	1.31
$y^{(40)}$	–	–	2.42	0.19	3.54	0.34	3.48	0.37
Stock return	8.12	16.32	8.98	16.08	3.87	38.78	3.96	20.67
$tp^{(40)}$	–	–	0.02	0.21	0.01	0.01	0.39	0.08
$tp^{\$(40)}$	–	–	1.67	0.68	0.06	0.03	0.97	0.17
Skewness(π)	1.55	–	1.55	–	0.84	–	1.77	–
Prob($\pi < 1\%$)	1.71	–	1.78	–	11.0	–	0.00	–

Table 1: Comparative statics. As in table (3), columns 2-3 report the mean and standard deviation from U.S. data over the sample 1979q4-2008q4, and columns 4-5 report the mean and standard deviation for the benchmark model. Columns 6-7 and 8-9 report the same statistics respectively if $\alpha = 0$ and if $\rho_z = 0.92$, respectively (while keeping all other parameters at the benchmark values).

1.5 Comparative statics: risk aversion and of shock persistence

Table 1 shows the model moments when we set risk aversion to be low ($\alpha = 0$), or when we set a lower persistence of the technology impulse z ($\rho_z = .92$), together with the data and benchmark model. Unsurprisingly, the low risk aversion model has a flat yield curve, with very low and nearly constant risk premia, and the average stock return is close to the average (log) yield on a risk-free bond. More interestingly, low risk aversion also increases the mean and volatility of inflation. This is because with an unchanged monetary policy rule, keeping the same R^* (Taylor rule intercept) when the "neutral risk-free rate" has gone up leads to more inflation. The lesson here is that monetary policy needs to offset variation in the risk-free rate that is due to risk aversion.

The second comparative static we want to highlight is the lower persistence of technology shock. In this case, the real term premium increases significantly, since there is now more predictable variation of growth. On the other hand, the total term premium falls, as these shocks are less "scary" for investors. This suggests to us that a model with more shocks may be do better at matching the data - some low persistence shocks help in some dimensions, while higher persistence helps in others.

2 Model extension: demand shocks

In this section, we extend the model to allow for “demand shocks” (on top of the productivity shocks, or “supply shocks”, which we keep throughout). There are several motivations for considering this extension. First, demand shocks are typically found to be important in accounting for macroeconomic fluctuations. Second, demand shocks generate a positive comovement between output and inflation, and hence can potentially contribute to term premia, in particular in explaining a potential sign switch where bonds become “hedges” and term premia negative (as they might have become in the 2000s).

This section is a simple exercise to assess how demand shocks could affect our results. The answer is nuanced. The main results appear robust - see for instance, figure 4 which shows that as average inflation rises, the model with demand shocks also generates a substantial increase in the term premium. As we explain below, this comes because while the demand shock generates a positive covariance of inflation and output, the magnitude of this covariance does not depend greatly on the level of inflation. As a result, the overall covariance of inflation and output (reflecting both demand and supply shocks) is still decreasing in the level of inflation, as we showed in the main text, since the effects of supply shocks remain the same as in the baseline model. That said, some other results change, at least in our current simple calibration. For instance, the volatility of output may fall, rather than rise, with average inflation.

Since our main point does not require demand shocks, we chose to abstract from demand shocks in the main text. (In particular, while a model with demand shocks does better at matching some statistics such as the stock-bond covariance, it also raises some novel issues - for instance, matching the average slope of the yield curve is more difficult - the yield curve remained on average steep throughout the 2000s, even as the stock-bond covariance became negative.) We also want to note that there is room for improvement in this section, so these results could possibly change if we refine the model or the calibration.

2.1 Model

To incorporate demand shocks, we add a disturbance directly in the Euler equation. This can be motivated (as in Fisher (2014)) as a time-varying convenience yield for bonds. Under this interpretation, the only modification to the model is to the Euler equation, which becomes:

$$E_t\left[\xi_t^{-1}R_tM_{t+1}^{\$}\right]=1, \tag{1}$$

where ξ_t is the liquidity process, reflecting "convenience" demand for bonds. We assume that this process follows a log-normal AR(1):

$$\log\xi_t=\rho_\xi\log\xi_{t-1}+\varepsilon_{\xi,t}, \tag{2}$$

with $\varepsilon_{\xi,t}$ i.i.d $N(0,\sigma_\xi^2)$.

2.2 Parameters

To set the parameters, we follow a calibration approach similar to that of the benchmark model in the main text. We set a number of parameters a priori as before, and set the persistence of demand shocks to 0.9, a common value in the literature. We then calibrate the same parameters we did in the main text (i.e., α,β,σ_z,ψ,$\overline{\Pi}$,$R^{\$}$) as well as the new parameter σ_ξ to match the same statistics we did in the main text (i.e., the mean and volatility of inflation, the mean of short-term and long-term interest rates, the skewness of inflation, the probability that inflation is less then 1%) as well as an additional moment, the correlation of output growth with the change of inflation. We choose this moment because it captures the reduced-form Phillips correlation that is informative about the relative importance of supply vs. demand shocks: inflation increases (resp. decreases) with output if there are demand (resp. supply) shock. We match these moments nearly perfectly, as shown in table 3. (The probability of inflation less than 1% is somewhat too high at 5% vs. 1.7% target.) The parameters used are shown in table 2. Matching the data now requires much higher risk aversion, because demand shocks generate a negative slope.

2.3 Basic moments

Table 3 presents the basic moments. We see that the model generates still significant, but smaller, volatility of the term premium, and of long-term interest rates. The model still undershoots on GDP volatility.

2.4 Impulse responses

The impulse responses of selected macroeconomic variables to both productivity and demand shocks are presented in figure 11. As in the text, we vary the inflation target so the average inflation is high (4%) or low (2%). The patterns for the productivity shock are

Parameter	Description	Value
	A. Taken from the literature	
σ	Preferences: inverse IES	2
υ	Preferences: labor supply	1.5
χ	Preferences: labor supply	40.66
ε	Preferences: substitution across goods	7.66
ϕ_π	Monetary policy rule: weight on inflation	2
ϕ_y	Monetary policy rule: weight on output	0.125
ρ_ξ	Shock: persistence of demand shock	0.9
ρ_z	Shock: persistence of TFP	0.99
ϕ	Adj. cost of prices: size parameter	78
	B. Calibrated to match key moments	
R^*	Monetary policy rule: intercept	1.0093
σ_z	Shock: std. dev. of TFP innovation	0.643
σ_ξ	Shock: std. dev. of demand innovation	0.294
ψ	Adj. cost of prices: asymmetry parameter	396
$\overline{\Pi}$	Adj. cost of prices: location parameter	1.012
β	Preferences: subjective discount factor	0.9906
α	Preferences: Epstein-Zin curvature (note: CRRA=169)	-241

Table 2: Model parameters in the model with demand shocks. The time period is one quarter.

	Data	Model
$E(\pi)$	3.14	3.14
$\sigma(\pi)$	1.97	1.97
$Skewness(\pi)$	1.55	1.55
$Prob(\pi < 1\%)$	1.71	5.03
$E(y^{\$(1)})$	5.63	5.63
$E(y^{\$(40)})$	7.36	7.36
$\rho(\Delta\pi, \Delta \log C)$	0.1	0.11

Table 3: The table shows the data moments used for the calibration of the model with demand shocks, and the corresponding model moments. Data moments are calculated over the sample 1979q4-2008q4.

	Data		Model	
	Mean	Sd	Mean	Sd
$\Delta\log(Y)$	–	3.03	0.00	2.37
π	3.14	1.97	3.14	1.97
$y^{\$(1)}$	5.63	3.20	5.63	1.97
$y^{\$(40)}$	7.36	2.97	7.36	2.12
$y^{(1)}$	–	–	2.37	0.34
$y^{(40)}$	–	–	2.42	0.19
$tp^{(40)}$	–	–	0.02	0.21
$tp^{\$(40)}$	–	–	1.67	0.68

Table 4: **Data and model moments in the model with demand shocks.** Columns 2 and 3 report the mean and standard deviation from U.S. data over the sample 1979q4-2008q4. Columns 4 and 5 report the mean and standard deviation for the model with demand shocks. All statistics are reported in annualized terms.

similar to that in the main text. A demand shock generates lower inflation, lower GDP, and lower interest rates. When inflation is high, prices are less sticky, and consequently demand shocks have less impact on GDP and more on inflation, which is intuitive. Interestingly, the overall covariance of output and inflation remains basically unchanged. Hence, the overall effect of demand shocks on our key result is limited - the results subsist as long as there are productivity shocks.

2.5 Macro-finance moments as a function of average inflation

Finally, in figures 12 and 13 we conduct the main experiment of the paper: showing how macro-finance moments change with average inflation. For clarity, we compare in these figures the benchmark model (with productivity shocks only) to the model with demand shocks (which, to be clear, includes both productivity and demand shocks). As noted above, the results are mixed. The models does still very well on the volatility of inflation, and is qualitatively right on many of the other moments. Some moments are quantitatively off. The most glaring discrepancy is that the volatility of output now falls, rather than rise, with inflation. This is because while the effect of productivity shocks increase with inflation, the effects of demand shocks decrease with inflation.

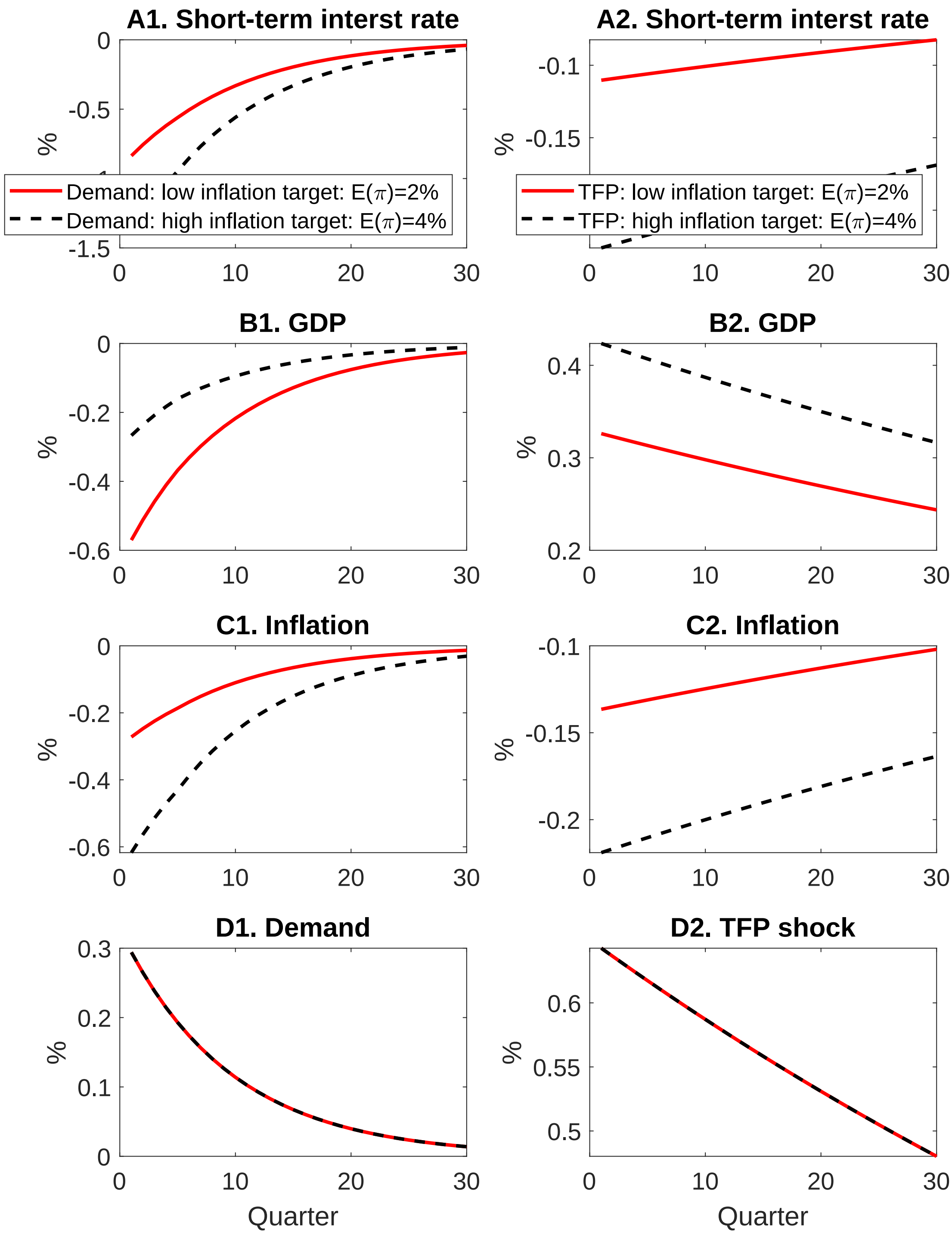

Figure 11: **Impulse response functions with asymmetric price adjustment costs in the model with demand shocks, when the inflation target is low (2%) and high (4%).**

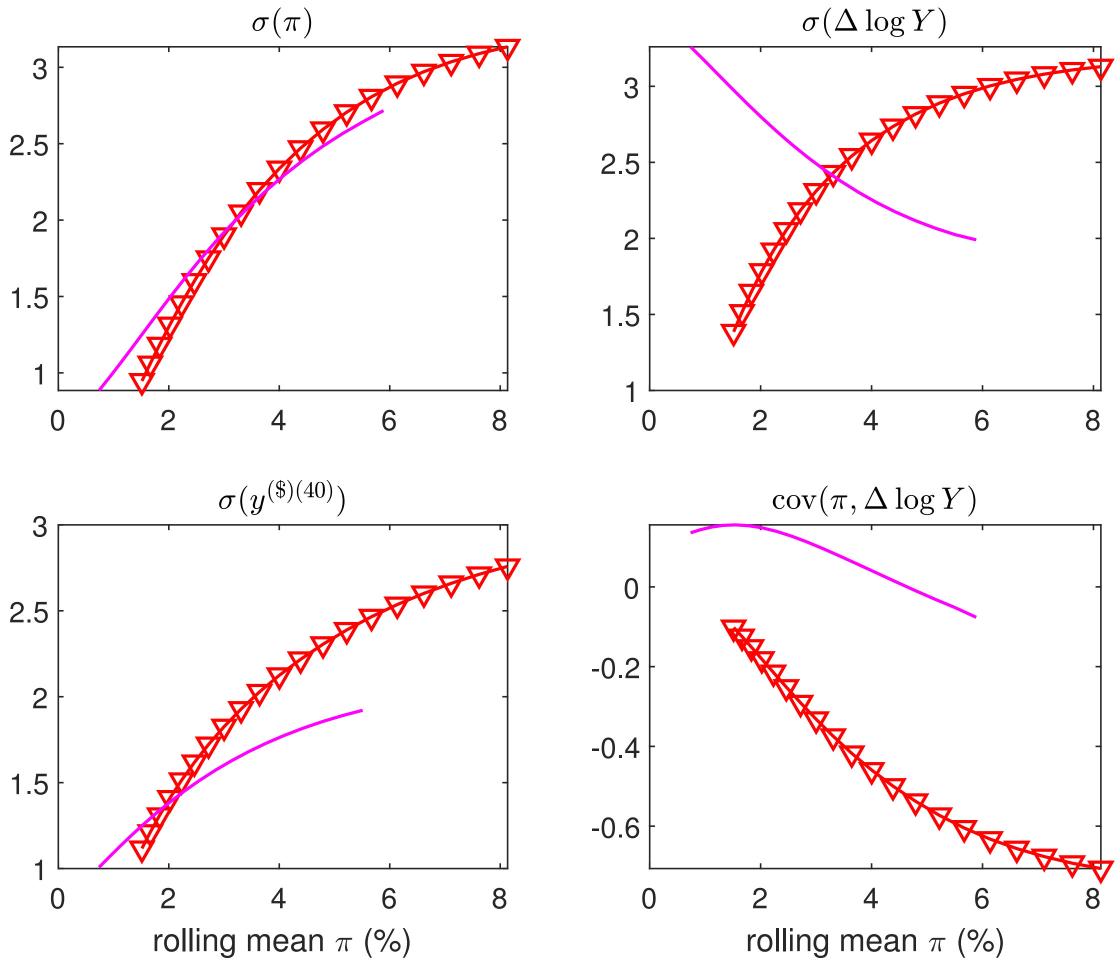

Figure 12: **Macro-finance moments in model with demand shocks (purple line) and in the benchmark model (red triangles), 1/2.**

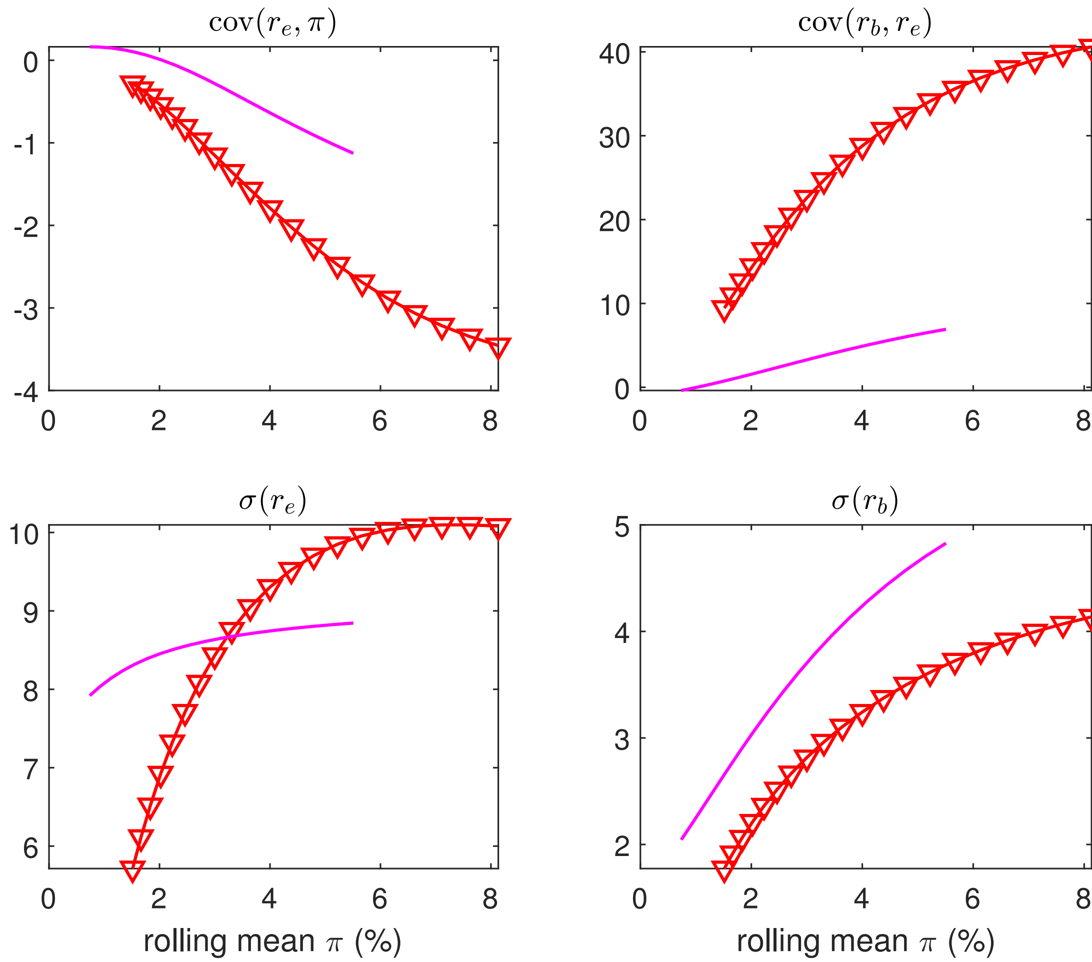

Figure 13: **Macro-finance moments in model with demand shocks (purple line) and in the benchmark model (red triangles), 2/2.**

3 Model extension: asymmetric wage rigidities

In this section, we present an extension of our model that incorporates both downward nominal price and wage rigidities. In the paper, we focus on the case of price asymmetries, but in reality, both wages and prices are asymmetric. (Indeed, at the micro level, the evidence for asymmetries is stronger for wages than prices.) As the figures below illustrate, introducing wage stickiness and wage asymmetries in the model allows to generate many of the similar facts, while reducing the degree of asymmetry assumed for prices. (In that sense, this shows that the asymmetry we assume for prices in the baseline model may reflect asymmetry in wages.) (Here too, the results, while accurate and very supportive, could be further improved.)

3.1 Model

We introduce wage stickiness as in Kim and Ruge-Murcia (2011), who build on Kim and Ruge-Murcia (2009) and Erceg et al. (2000). Some sections that are essentially identical to the baseline model are denoted with an asterisk in the subsection title. We kept them here to make this section independent of the main text.

Composite labor

Firms use composite labor to produce intermediate differentiated goods. Composite labor is created by aggregating a variety of differentiated labor indexed by $h \in [0, 1]$ using a CES technology

$$N_t = \left(\int_0^1 N_t^{h\,\frac{\epsilon_w - 1}{\epsilon_w}} dh \right)^{\frac{\epsilon_w}{\epsilon_w - 1}}, \tag{3}$$

where ε_w determines the elasticity of substitution among differentiated types of labor. The profit maximization problem is given by

$$\max \; W_t N_t - \int_0^1 W_t^h N_t^h dh,$$

where W_t^h and N_t^h are the wage and quantity of differentiated labor of type h.

Profit maximization and the zero-profit condition give the demand for labor of type h

$$N_t^h = \left(\frac{W_t^h}{W_t} \right)^{-\epsilon_w} N_t, \tag{4}$$

and the aggregate wage level

$$W_t = \left(\int_0^1 \left(W_t^h\right)^{1-\epsilon_w} dh\right)^{\frac{1}{1-\epsilon_w}}. \tag{5}$$

Final consumption goods*

To produce consumption goods, households buy and aggregate a variety of differentiated intermediate goods indexed by $i \in [0,1]$ using a CES technology

$$Y_t = \left(\int_0^1 Y_t\left(i\right)^{\frac{\epsilon-1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}},$$

where ε determines the elasticity of substitution among intermediate goods. The profit maximization problem is given by

$$\max \; P_t Y_t - \int_0^1 P_t\left(i\right) Y_t\left(i\right) di,$$

where $P_t\left(i\right)$ and $Y_t\left(i\right)$ are the price and quantity of intermediate good i.

Profit maximization and the zero-profit condition give the demand for differentiated intermediate good i

$$Y_t\left(i\right) = \left(\frac{P_t\left(i\right)}{P_t}\right)^{-\epsilon} Y_t, \tag{6}$$

and the aggregate price level

$$P_t = \left(\int_0^1 P_t\left(i\right)^{1-\epsilon} di\right)^{\frac{1}{1-\epsilon}}. \tag{7}$$

Household h's problem

There is a unit mass of households. Each household indexed by $h \in [0,1]$ provides type-h labor and is competitively monopolistic in the labor market. It is costly to adjust wages. Without loss of generality, we assume that households pay wage adjustment costs which have a general form

$$\Phi_t^h = \Phi\left(\frac{W_t^h}{W_{t-1}^h}\right) W_t^h N_t^h,$$

where $\Phi'\left(\cdot\right) > 0$ and $\Phi''\left(\cdot\right) > 0$.

In this paper, we follow Kim and Ruge-Murcia (2009) and use the linex function to model wage adjustment costs. Specifically,

$$\Phi_t^h = \Phi\left(\frac{W_t^h}{W_{t-1}^h}\right) = \phi\left(\frac{\exp\left(-\psi\left(\frac{W_t^h}{W_{t-1}^h} - \overline{\Pi}\right)\right) + \psi\left(\frac{W_t^h}{W_{t-1}^h} - \overline{\Pi}\right) - 1}{\psi^2}\right), \tag{8}$$

where ϕ_w is the level parameter and ψ_w is the asymmetry parameter. If $\psi_w > 0$, the wage adjustment cost is asymmetric. In particular, the cost to lower a wage is higher than to increase it by the same amount. When ψ_w approaches 0, this function becomes a symmetric quadratic function

$$\Phi(x) = \frac{\phi_w}{2}\left(x - \overline{\Pi}\right)^2.$$

Household h choose $\left\{C_t^h, N_t^h, W_t^h, B_t^h\right\}_{t=1}^{\infty}$ to maximize the inter-temporal utility

$$V_t^h = (1-\beta)\, u(C_t^h, N_t^h) + \beta E_t\left((V_{t+1}^h)^{1-\alpha}\right)^{\frac{1}{1-\alpha}}$$

with the flow utility

$$u\left(C_t, N_t\right) = \frac{C_t^{1-\gamma}}{1-\gamma} - \frac{\chi N_t^{1+\eta}}{1+\eta},$$

subject to the labor demand (4) and the budget constraint as described below.

If the parameters we use lead to a negative flow utility $u(C_t, N_t)$, we define utility as:

$$V_t^h = (1-\beta)\, u(C_t^h, N_t^h) - \beta E_t\left(\left(-V_{t+1}^h\right)^{1-\alpha}\right)^{\frac{1}{1-\alpha}}.$$

The budget constraint is:

$$P_t C_t^h + R_t^{-1} B_t^h = W_t^h N_t^h\left(1 - \Phi_t^h\right) + B_{t-1}^h + D_t^h + T_t^h. \tag{9}$$

$$\text{Given } W_0 \text{ and } B_0. \tag{10}$$

A symmetric solution to this optimization problem, i.e. $W_t^h = W_t$ and $N_t^h = N_t$, implies a New Keynesian Phillips curve for wages and the Euler equation (see derivation in section 3.6):

$$
\begin{aligned}
0 &= (1-\varepsilon_w)\left(1-\Phi\left(\Pi_t^w\right)\right)N_t - \Phi'\left(\Pi_t^w\right)\Pi^w N_t + \varepsilon_w \chi \frac{N_t^{\eta+1}}{w_t C_t^{-\gamma}} \\
&+E_t\left[M_{t,t+1}\frac{\Phi'\left(\Pi_{t+1}^w\right)\left(\Pi^w\right)^2}{\Pi_{t+1}}N_{t+1}\right],
\end{aligned} \tag{11}
$$

$$
E_t\left[M_{t,t+1}\left(\frac{R_t}{\Pi_{t+1}}\right)\right]=1, \tag{12}
$$

where $w_t = W_t/P_t$ is the real wage; $\Pi_t = P_t/P_{t-1}$ is gross inflation; $\Pi_t^w = W_t/W_{t-1}$ is gross wage inflation. Wage inflation and and the stochastic discount factor are given by

$$
\Pi_t^w = \frac{w_t}{w_{t-1}}\Pi_t, \tag{13}
$$

$$
M_{t,t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\left(\frac{V_{t+1}}{\left[E_t\left(V_{t+1}^{1-\alpha}\right)\right]^{\frac{1}{1-\alpha}}}\right)^{-\alpha}, \tag{14}
$$

Note that when $\phi = 0$ and $\varepsilon_w \to \infty$, equation (11) becomes a standard marginal rate of substitution between labor and consumption

$$
\frac{\chi N_t^{\eta}}{C_t^{-\gamma}} = w_t.
$$

Intermediate goods producer $i's$ problem*

There is a unit mass of intermediate goods producers that are monopolistic competitors. Suppose that each intermediate good $i \in [0,1]$ is produced by one producer using the technology

$$
Y_t^i = Z_t N_t^i, \tag{15}
$$

where $\alpha \geq 0$; N_t^i is composite labor input used by firm i; and

$$
\begin{aligned}
\ln\left(Z_t\right) &= \rho_Z \ln\left(Z_{t-1}\right) + \varepsilon_{Z,t}, \\
\varepsilon_{Z,t} &\sim i.i.d\ N\left(0,\sigma_Z^2\right).
\end{aligned} \tag{16}
$$

Following Rotemberg (1982), we assume that each intermediate goods firm i faces costs of adjusting prices in terms of final goods. The adjustment cost function is in a general form

$$\Gamma_t = \Gamma\left(\frac{P_t^i}{P_{t-1}^i}\right)Y_t,$$

where $\Gamma'(\cdot) > 0$ and $\Gamma''(\cdot) > 0$.

We also use the linex function to model price adjustment costs. Specifically,

$$\Gamma(x) = \phi_p\left(\frac{\exp\left(-\psi_p\left(x-\overline{\Pi}\right)\right)+\psi_p\left(x-\overline{\Pi}\right)-1}{\psi_p^2}\right), \tag{17}$$

where ϕ_p, ψ_p are parameters that determines the level and the asymmetry of price adjustment costs. If $\psi_p > 0$, the price adjustment cost is asymmetric. Particularly, the cost to lower a price is higher than to increase it by the same amount. The linex function nests the symmetric quadratic cost when ψ_p approaches 0, i.e. it becomes a quadratic function

$$\Gamma(x) = \frac{\phi_p}{2}\left(x-\overline{\Pi}\right)^2,$$

which is popularly used in the ZLB literature.

The problem of firm i is given by

$$\max_{\{Y_{t+j}^i, N_{t+j}, P_{t+j}^i\}_{j=0}^{\infty}} E_t\sum_{j=0}^{\infty}\left\{M_{t,t+j}\left[\left(\frac{P_{t+j}^i}{P_{t+j}}Y_{t+j}^i - w_t N_t^i\right) - \Gamma\left(\frac{P_{t+j}^i}{P_{t+j-1}^i}\right)Y_{t+j}\right]\right\} \tag{18}$$

subject to its demand (6) and production function (15). In a symmetric equilibrium where all firms choose the same price and produce the same quantity (i.e., $P_t^i = P_t$ and $Y_t^i = Y_t$). The optimal pricing rule then implies the New Keynesian Phillips curve,

$$\left(1-\varepsilon+\varepsilon\frac{w_t}{Z_t}-\Pi_t\Gamma'\left(\Pi_t\right)\right)Y_t + E_t\left(M_{t,t+1}\Pi_{t+1}\Gamma'\left(\Pi_{t+1}\right)Y_{t+1}\right) = 0. \tag{19}$$

Monetary policy*

The central bank conducts monetary policy by setting the interest rate using a simple Taylor rule:

$$R_t = R^*\left(\frac{GDP_t}{GDP^*}\right)^{\phi_y}\left(\frac{\Pi_t}{\Pi^*}\right)^{\phi_\pi} \tag{20}$$

where $GDP_t \equiv C_t$ denotes the gross domestic product (GDP); GDP^* and Π^* denote the target GDP and inflation, respectively; R^* denotes the intercept of the Taylor rule.

Equilibrium systems

With the Rotemberg price setting, the aggregate output satisfies

$$Y_t = Z_t N_t, \tag{21}$$

As in the benchmark model, we assume that price and wage adjustment costs are rebated to households. Hence, the aggregate resource constraint is given by

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

The equilibrium system for the model consists of a system of six nonlinear difference equations (11), (12), (13), (19), (20), (21), (22) for six variables w_t, C_t, R_t, Π_t, Π_t^w, N_t, and Y_t.

3.2 Calibration

We have three new parameters compared to the baseline model, that govern the size, location and asymmetry of wage adjustment costs. For parsimony, we assume that the location is the same as for price, and we set the size of the adjustment cost to a value consistent with the literature (i.e., wages are stickier than prices). This leaves us with one additional parameter ψ_w, and we use as additional moment to calibrate it the skewness of wage growth, which is also significant in our sample.[3]

Table 5 presents the parameters, and the data targets and model moments used for calibration are in table 6. We can see from this table that the model matches the data fairly well.

3.3 Moments

Table 7 reports the basic moments. As in the baseline model, there is a large term premium, but the volatility is now lower.

3.4 Impulse responses

The impulse responses of selected macroeconomic variables to supply shocks in the model with both price and wage asymmetry are presented in figure 14, where we vary the infla-

[3]Because this model is significantly more difficult to solve numerically, some of the results here are based on parameter values that differ slightly from the baseline (because we have not yet updated this part), but the differences should not be material.

Parameter	Description	Value
	A. Taken from the literature	
σ	Preferences: inverse IES	2
υ	Preferences: labor supply	1.5
χ	Preferences: labor supply	40.66
ε	Preferences: substitution across goods	7.66
ϕ_π	Monetary policy rule: weight on inflation	1.75
ϕ_y	Monetary policy rule: weight on output	0.065
ρ_z	Shock: persistence of TFP	0.97
ϕ_p	Adj. cost of prices: size parameter	70
ϕ_w	Adj. cost of wages: size parameter	200
	B. Calibrated to match key moments	
R^*	Monetary policy rule: intercept	1.019
σ_z	Shock: std. dev. of TFP innovation	0.643
ψ_p	Adj. cost of prices: asymmetry parameter	280
ψ_p	Adj. cost of wages: asymmetry parameter	350
$\overline{\Pi}$	Adj. cost of prices: location parameter	1.0099
β	Preferences: subjective discount factor	0.991
α	Preferences: Epstein-Zin curvature (note: CRRA=87)	-120

Table 5: Model parameters in the model with both wage and price asymmetries. The time period is one quarter.

	Data	Model
$\sigma(\Delta \log Y)$	3.03	3.03
$E(\pi)$	3.14	2.97
$\sigma(\pi)$	1.97	1.72
$Skewness(\pi_p)$	1.55	1.56
$Skewness(\pi_w)$	1.91	1.92
$Prob(\pi < 1\%)$	1.74	6.67
$E(y^{\$(1)})$	5.63	5.68
$E(y^{\$(40)})$	7.36	7.25

Table 6: Data and model-based moments in the model with both price and wage asymmetry. Data over the sample 1979q4-2008q4.

	Data		Full sample	
	Mean	Sd	Mean	Sd
$\Delta \log(Y)$	–	3.03	0.00	3.15
π	3.14	1.97	2.97	1.73
$y^{\$(1)}$	5.63	3.20	5.68	2.46
$y^{\$(40)}$	7.36	2.97	7.25	1.05
$y^{(1)}$	–	–	2.56	1.11
$y^{(40)}$	–	–	3.16	0.29
$tp^{(40)}$	–	–	0.59	0.11
$tp^{\$(40)}$	–	–	1.52	0.23

Table 7: Data and model moments in the model with both price and wage asymmetry. Columns 2 and 3 give the mean and standard deviation from U.S. Data over the sample 1979q4-2019q4. Columns 4 and 5 give the mean and standard deviation using simulated data from the model.

tion target so the average inflation is high (4%) or low (2%). As in the benchmark model, the conditional covariance driven by supply shocks is dampened (or less negative) when inflation is low, leading to smaller bond premium. However, the magnitude of the change appears to be less than in the baseline model, which explains why there is less volatility of the term premium.

3.5 Macro-finance moments with both wage and price asymmetries

Finally, figures 15 and 16 show our key experiment. Here too, varying inflation leads macro-finance moments to vary in a substantial way.[4] Overall, the model with price and wage asymmetries seems to do quite well, surpassing in many dimensions the baseline model, despite much lower asymmetries.

3.6 Deriving the wage Phillips Curve

$$V^h\left(B_{t-1}^h, W_{t-1}^h, Z_t\right) = \underbrace{\text{Max}}_{\{C_t^h, N_t^h, W_t^h, B_t^h\}} \left\{ \begin{array}{c} (1-\beta)\left(\frac{\left(C_t^h\right)^{1-\gamma}}{1-\gamma} - \chi \frac{\left(N_t^h\right)^{1+\eta}}{1+\eta}\right) \\ +\beta\left(E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)^{1-\alpha}\right]\right)^{\frac{1}{1-\alpha}} \end{array} \right\} \tag{23}$$

[4]Due to numerical difficulties, we have not yet been able to vary the level of inflation as much as in the other calculations.

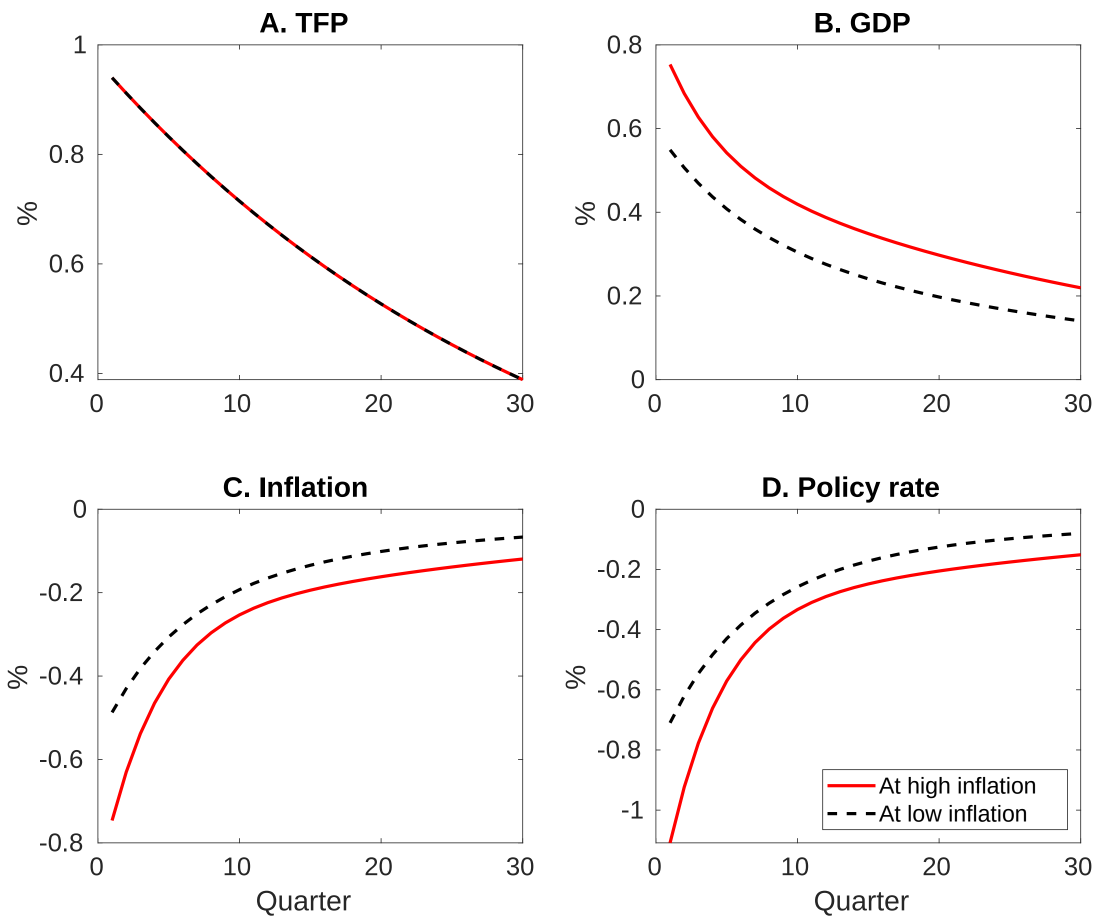

Figure 14: Impulse response functions in the model with both price and wage asymmetry at low and high inflation target.

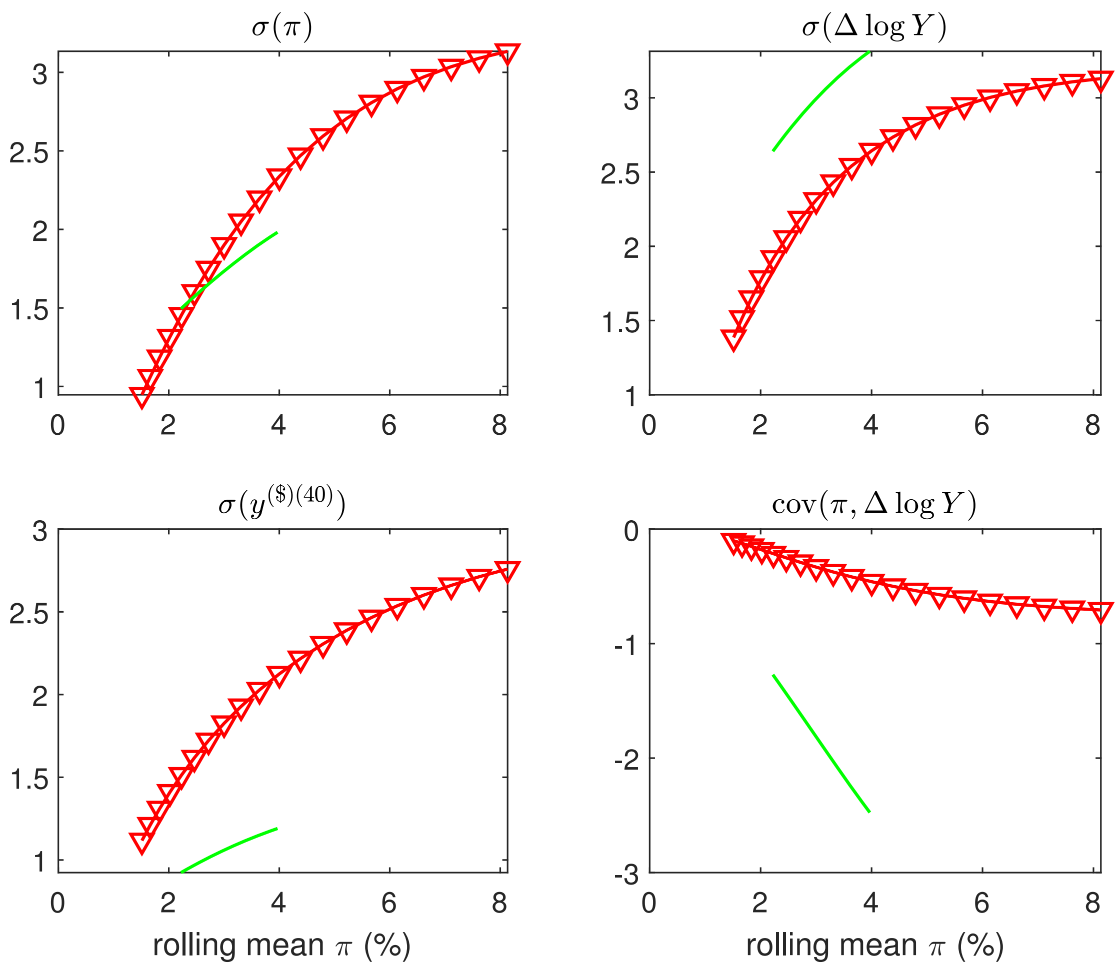

Figure 15: **Macro-finance moments in model with wage asymmetric rigidity (green line) and in the benchmark model (red triangles), 1/2.**

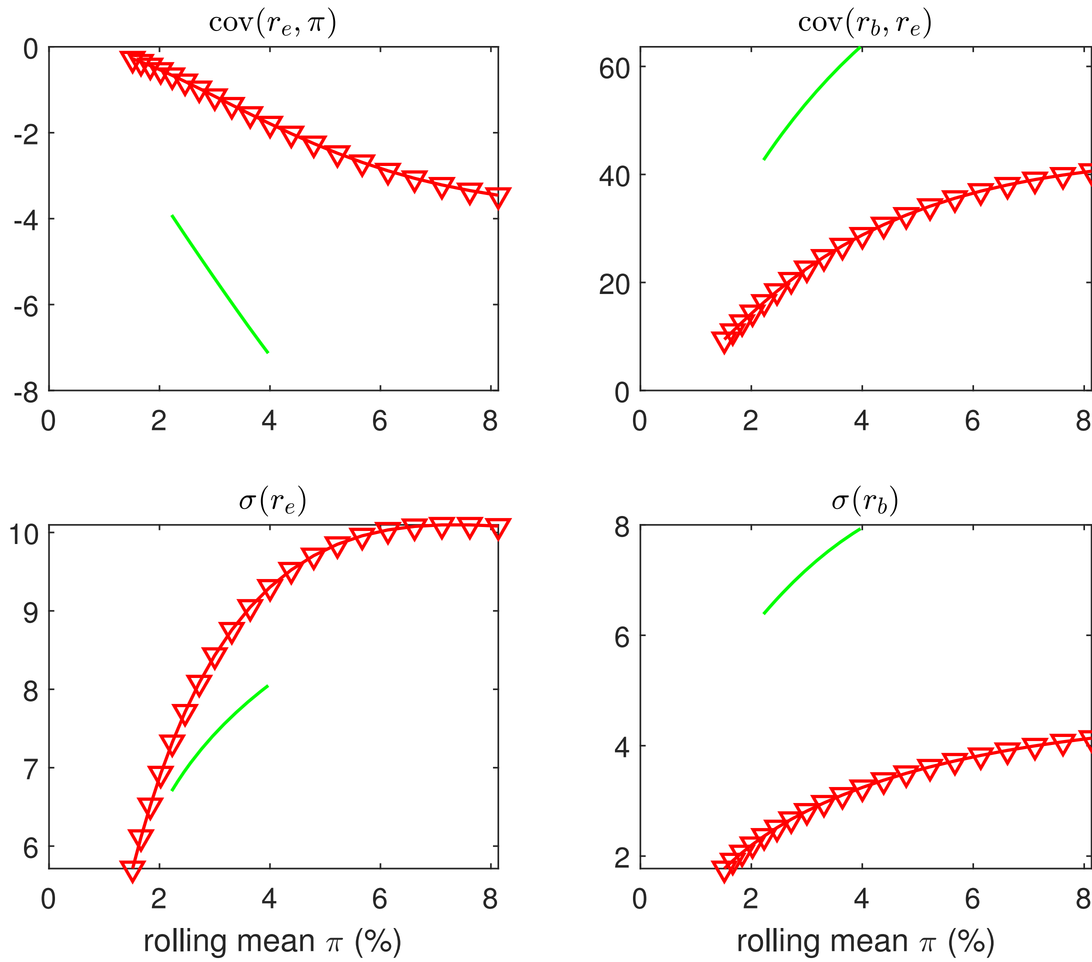

Figure 16: **Macro-finance moments in model with wage asymmetric rigidity (green line) and in the benchmark model (red triangles), 2/2.**

subject to

$$P_t C_t^h + R_t^{-1} B_t^h = (1+\tau_w) W_t^h N_t^h \left(1-\Phi_t^h\right) + B_{t-1}^h + D_t^h + T_t^h + AC_t^h \tag{24}$$

$$N_t^h = \left(\frac{W_t^h}{W_t}\right)^{-\epsilon_w} N_t \tag{25}$$

where

$$\Phi_t^h = \Phi\left(\frac{W_t^h}{W_{t-1}^h}\right) = \phi_w \left(\frac{\exp\left(-\psi_w\left(\frac{W_t^h}{W_{t-1}^h} - \overline{\Pi}\right)\right) + \psi_w\left(\frac{W_t^h}{W_{t-1}^h} - \overline{\Pi}\right) - 1}{\psi_w^2}\right). \tag{26}$$

Let λ_t^{h1} and λ_t^{h2} be the Lagrangian multipliers for the budget constraint and the labor demand at time t, respectively. The first-order conditions include

$$(C_t) : (1-\beta)\left(C_t^h\right)^{-\gamma} - P_t \lambda_t^{h1} = 0, \tag{27}$$

$$(N_t) : -(1-\beta)\chi\left(N_t^h\right)^{\eta} + (1+\tau_w) W_t^h \left(1-\Phi_t^h\right)\lambda_t^{h1} - \lambda_t^{h2} = 0, \tag{28}$$

$$\begin{aligned} (W_t) \quad : \quad 0 = \beta &\left(\frac{E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)\right]}{\left(E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)^{1-\alpha}\right]\right)^{\frac{1}{1-\alpha}}}\right)^{-\alpha} V_w^h\left(B_t^h, W_t^h, Z_{t+1}\right) \\ &\left((1+\tau_w) N_t^h\left(1-\Phi_t^h\right) - (1+\tau_w) W_t^h N_t^h \left(\Phi_t^h\right)' \frac{1}{W_{t-1}^h}\right)\lambda_t^{h1} - \varepsilon_w \frac{N_t^h}{W_t^h}\lambda_t^{h2}. \end{aligned} \tag{29}$$

$$(B_t) : \beta\left(\frac{E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)\right]}{\left(E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)^{1-\alpha}\right]\right)^{\frac{1}{1-\alpha}}}\right)^{-\alpha} V_B^h\left(B_t^h, W_t^h, Z_{t+1}\right) - R_t^{-1}\lambda_t^{h1} = 0. \tag{30}$$

The envelope theorem implies:

$$\frac{\partial V^h\left(B^h_{t-1}, W^h_{t-1}, Z_t\right)}{\partial W^h_{t-1}} \equiv V^h_w\left(B^h_{t-1}, W^h_{t-1}, Z_t\right) \tag{31}$$

$$= \left(\left(1+\tau_w\right) W^h_t N^h_t \left(\Phi^h_t\right)' \frac{W^h_t}{\left(W^h_{t-1}\right)^2}\right) \lambda^{h1}_t \tag{32}$$

$$\frac{\partial V^h\left(B^h_t, W^h_{t-1}, Z_t\right)}{\partial B^h_{t-1}} \equiv V^h_B\left(B^h_{t-1}, W^h_{t-1}, Z_t\right) = \lambda^{h1}_t \tag{33}$$

From equations (27) and (28)

$$\lambda^{h1}_t = \frac{\left(1-\beta\right)\left(C^h_t\right)^{-\gamma}}{P_t}; \lambda^{h1}_{t+1} = \frac{\left(1-\beta\right)\left(C^h_{t+1}\right)^{-\gamma}}{P_{t+1}};$$

$$\lambda^{h2}_t = -\left(1-\beta\right)\chi\left(N^h_t\right)^{\eta} + \left(1+\tau_w\right) W^h_t \left(1-\Phi^h_t\right) \frac{\left(1-\beta\right)\left(C^h_t\right)^{-\gamma}}{P_t}$$

Equation (29) can be simplified to

$$\begin{aligned} 0 = & \left(\left(1+\tau_w\right) N^h_t \left(1-\Phi^h_t\right) - \left(1+\tau_w\right) W^h_t N^h_t \left(\Phi^h_t\right)' \frac{1}{W^h_{t-1}}\right) \frac{\left(1-\beta\right)\left(C^h_t\right)^{-\gamma}}{P_t} \\ & -\varepsilon_w \frac{N^h_t}{W^h_t}\left(-\left(1-\beta\right)\chi\left(N^h_t\right)^{\eta} + \left(1+\tau_w\right) W^h_t\left(1-\Phi^h_t\right)\frac{\left(1-\beta\right)\left(C^h_t\right)^{-\gamma}}{P_t}\right) \\ & +\beta\left(\frac{E_t\left[\left(V^h\left(B^h_t, W^h_t, Z_{t+1}\right)\right)\right]}{\left(E_t\left[\left(V^h\left(B^h_t, W^h_t, Z_{t+1}\right)\right)^{1-\alpha}\right]\right)^{\frac{1}{1-\alpha}}}\right)^{-\alpha} \times \\ & \left(\left(1+\tau_w\right) N^h_{t+1}\left(\Phi^h_{t+1}\right)'\left(\frac{W^h_{t+1}}{W^h_t}\right)^2\right)\frac{\left(1-\beta\right)\left(C^h_{t+1}\right)^{-\gamma}}{P_{t+1}}, \end{aligned}$$

$$
\begin{aligned}
0 &= \left(\left(1+\tau_w\right) N_t^h \left(1-\Phi_t^h\right) - \left(1+\tau_w\right) N_t^h \left(\Phi_t^h\right)' \frac{W_t^h}{W_{t-1}^h}\right) \\
&\quad + \varepsilon_w \chi \frac{\left(N_t^h\right)^{\eta+1}}{W_t^h} \frac{P_t}{\left(C_t^h\right)^{-\gamma}} - \varepsilon_w \left(1+\tau_w\right) N_t^h \left(1-\Phi_t^h\right) \\
&\quad + \beta \left(\frac{E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)\right]}{\left(E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)^{1-\alpha}\right]\right)^{\frac{1}{1-\alpha}}} \right)^{-\alpha} \times \\
&\quad \left(\left(1+\tau_w\right) N_{t+1}^h \left(\Phi_{t+1}^h\right)' \left(\frac{W_{t+1}^h}{W_t^h}\right)^2\right) \frac{\left(C_{t+1}^h\right)^{-\gamma}}{\left(C_t^h\right)^{-\gamma}} \frac{P_t}{P_{t+1}},
\end{aligned}
$$

$$
\begin{aligned}
0 &= \left(1+\tau_w\right)\left(1-\varepsilon_w\right) N_t^h \left(1-\Phi_t^h\right) - \left(1+\tau_w\right) N_t^h \left(\Phi_t^h\right)' \frac{W_t^h}{W_{t-1}^h} + \varepsilon_w \chi \frac{\left(N_t^h\right)^{\eta+1}}{w_t^h \left(C_t^h\right)^{-\gamma}} \quad (34) \\
&\quad + \beta \frac{\left(C_{t+1}^h\right)^{-\gamma}}{\left(C_t^h\right)^{-\gamma}} \left(\frac{E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)\right]}{\left(E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)^{1-\alpha}\right]\right)^{\frac{1}{1-\alpha}}} \right)^{-\alpha} \times \\
&\quad \left(\left(1+\tau_w\right) N_{t+1}^h \left(\Phi_{t+1}^h\right)' \left(\frac{W_{t+1}^h}{W_t^h}\right)^2\right) \frac{P_t}{P_{t+1}}, \qquad (35)
\end{aligned}
$$

Equation (30) becomes

$$
0 = \beta \left(\frac{E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)\right]}{\left(E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)^{1-\alpha}\right]\right)^{\frac{1}{1-\alpha}}} \right)^{-\alpha} \lambda_{t+1}^{h1} - R_t^{-1} \lambda_t^{h1} \qquad (36)
$$

$$
\begin{aligned}
0 &= \beta \left(\frac{E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)\right]}{\left(E_t\left[\left(V^h\left(B_t^h, W_t^h, Z_{t+1}\right)\right)^{1-\alpha}\right]\right)^{\frac{1}{1-\alpha}}} \right)^{-\alpha} \frac{\left(1-\beta\right)\left(C_{t+1}^h\right)^{-\gamma}}{P_{t+1}} \\
&\quad - \left(1+i_t\right)^{-1} \frac{\left(1-\beta\right)\left(C_t^h\right)^{-\gamma}}{P_t} \qquad (37)
\end{aligned}
$$

In a symmetric equilibrium the optimal wage setting becomes the wage Phillips curve:

$$\begin{aligned} 0 &= (1-\varepsilon_w)(1-\Phi_t) N_t - \Phi_t' \Pi_t^w N_t + \varepsilon_w \frac{\chi}{1+\tau_w} \frac{N_t^{\eta+1}}{w_t C_t^{-\gamma}} \\ &\quad + E_t \left[M_{t,t+1} \left((1+\tau_w) \frac{(\Phi_{t+1})' \left(\Pi_{t+1}^w\right)^2}{\Pi_t} N_{t+1} \right) \right], \end{aligned} \tag{38}$$

and the optimality condition for bonds satisfies:

$$E_t \left[M_{t,t+1} \left(\frac{R_t}{\Pi_{t+1}} \right) \right] = 1, \tag{39}$$

where $w_t = W_t / P_t$ is the real wage, $\Pi_t^w = W_t / W_{t-1}$ is the gross wage inflation, $\Pi_t = P_t / P_{t-1}$ is the gross (price)inflation rate, and the stochastic discount factor is given by

$$M_{t,t+1} = \beta \left(\frac{(V(W_t, Z_{t+1}))}{\left(E_t \left[(V(W_t, Z_{t+1}))^{1-\alpha} \right] \right)^{\frac{1}{1-\alpha}}} \right)^{-\alpha} \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma}. \tag{40}$$

4 Additional Empirical Results

Tables 8, 9, and 10 present some robustness analysis for the results of section 6 of the paper. Each table corresponds to a different horizon h equal to 4, 8 or 12 quarters. Specifically, we estimate equation (28) from the main text, but with the following modifications: first, removing the quadratic time trend; second, changing the measure of inflation Z_t for the interaction variable. (We always use the same price measure as outcome variable.) In our baseline specification, we used the 2-year PCE inflation. Instead, we show what happens if we use either the 1-year or 3-year PCE inflation, or the 2-year core PCE inflation.

Regarding the quadratic time trend, as we explained in the main text, its main effect is to reduce the magnitude of standard errors by removing some low-frequency variation in the GDP and inflation series. Looking across the two outcomes (GDP and price level) and three tables (different horizons h), its effect on the point estimates is usually limited. Regarding the alternative inflation measures, they matter relatively little for the key coefficient of interest γ_h (with perhaps one or two exceptions out of 18 cases (across the three tables) where the coefficient becomes smaller). Overall, the results are stable with respect to these changes. As in the main text, the results are only statistically significant at h equal to 4 or 8 quarters, but the signs and magnitudes remain economically meaningful in almost all cases even for h=12 quarters.

	Baseline	No time trend	2y Core	3y	1y
		Real GDP			
$\beta_{z,h}$	0.25**	0.30*	0.40***	0.29**	0.26**
s.e.	(0.12)	(0.16)	(0.12)	(0.12)	(0.12)
t-stat	2.13	1.92	3.26	2.37	2.28
γ_h	0.13***	0.14***	0.10**	0.13**	0.08***
s.e.	(0.03)	(0.04)	(0.04)	(0.05)	(0.03)
t-stat	4.75	3.79	2.26	2.41	2.95
Obs.	256	256	232	252	260
		Core PCE price index			
$\beta_{z,h}$	-0.06	-0.04	-0.11	-0.09	-0.01
s.e.	(0.06)	(0.06)	(0.09)	(0.07)	(0.05)
t-stat	-0.92	-0.65	-1.27	-1.30	-0.22
γ_h	-0.09***	-0.06*	-0.09**	-0.08**	-0.07***
s.e.	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
t-stat	-3.40	-1.78	-2.55	-2.47	-3.29
Obs.	236	236	232	236	236

Table 8: The table reports the estimates of $\beta_{z,h}$ and γ_h from equation (28) in the main text, for horizon $h = 4$ quarters, for $y = \log$ GDP (top panel) or the log core PCE index (bottom panel), for different specifications: the baseline, reported in the main text (column 1); the same, but omitting the quadratic time trend (column 2); and using either the 2-year core inflation, the 3-year inflation, or the 1-year inflation as measure of initial inflation π_t, rather than the 2-year inflation as in the baseline (columns 3-5). The sample is 1953q1:2019q4. Standard errors are Newey-West with 8 lags.

	Baseline	No time trend	2y Core	3y	1y
	Real GDP				
$\beta_{z,h}$	0.47***	0.56**	0.46***	0.50***	0.49***
s.e.	(0.16)	(0.25)	(0.14)	(0.14)	(0.17)
t-stat	3.03	2.28	3.27	3.55	2.93
γ_h	0.08	0.10	0.11	0.07	0.01
s.e.	(0.06)	(0.07)	(0.07)	(0.08)	(0.06)
t-stat	1.36	1.45	1.49	0.96	0.17
Obs.	252	252	228	248	256
	Core PCE price index				
$\beta_{z,h}$	-0.01	0.04	-0.08	-0.05	0.05
s.e.	(0.09)	(0.10)	(0.12)	(0.10)	(0.09)
t-stat	-0.09	0.39	-0.67	-0.47	0.52
γ_h	-0.12**	-0.05	-0.13**	-0.10*	-0.09**
s.e.	(0.05)	(0.06)	(0.07)	(0.06)	(0.04)
t-stat	-2.58	-0.80	-2.02	-1.80	-2.02
Obs.	232	232	228	232	232

Table 9: The table reports the estimates of $\beta_{z,h}$ and γ_h from equation (28) in the main text, for horizon $h = 8$ quarters, for $y = \log$ GDP (top panel) or the log core PCE index (bottom panel), for different specifications: the baseline, reported in the main text (column 1); the same, but omitting the quadratic time trend (column 2); and using either the 2-year core inflation, the 3-year inflation, or the 1-year inflation as measure of initial inflation π_t, rather than the 2-year inflation as in the baseline (columns 3-5). The sample is 1953q1:2019q4. Standard errors are Newey-West with 8 lags.

	Baseline	No time trend	2y Core	3y	1y
		Real GDP			
$\beta_{z,h}$	0.17	0.29	0.30	0.18	0.17
s.e.	(0.17)	(0.29)	(0.19)	(0.17)	(0.18)
t-stat	0.98	1.01	1.59	1.08	0.96
γ_h	0.11	0.14	0.08	0.11	0.04
s.e.	(0.08)	(0.09)	(0.10)	(0.09)	(0.07)
t-stat	1.44	1.52	0.80	1.19	0.49
Obs.	248	248	224	244	252
		Core PCE price index			
$\beta_{z,h}$	0.11	0.20	0.04	0.08	0.14
s.e.	(0.16)	(0.15)	(0.17)	(0.15)	(0.16)
t-stat	0.67	1.32	0.24	0.53	0.88
γ_h	-0.10	0.01	-0.10	-0.06	-0.08
s.e.	(0.07)	(0.10)	(0.09)	(0.08)	(0.06)
t-stat	-1.55	0.06	-1.15	-0.83	-1.38
Obs.	228	228	224	228	228

Table 10: The table reports the estimates of $\beta_{z,h}$ and γ_h from equation (28) in the main text, for horizon $h = 12$ quarters, for $y = \log$ GDP (top panel) or the log core PCE index (bottom panel), for different specifications: the baseline, reported in the main text (column 1); the same, but omitting the quadratic time trend (column 2); and using either the 2-year core inflation, the 3-year inflation, or the 1-year inflation as measure of initial inflation π_t, rather than the 2-year inflation as in the baseline (columns 3-5). The sample is 1953q1:2019q4. Standard errors are Newey-West with 8 lags.

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