Hitting the Elusive Inflation Target

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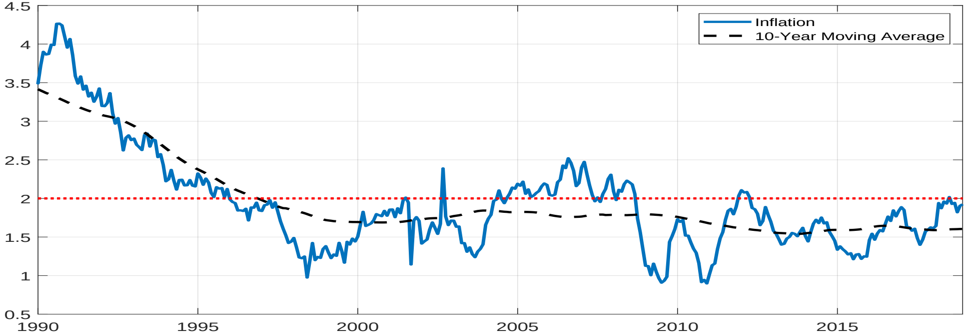
July 9, 2020

NBER Summer Institute 2020 Monetary Economics Workshop

Motivation

Average core inflation is drifting down from the implicit 2% Fed's target



Year-to-year PCE core inflation and its ten-year moving average.
Unit: Annualized percentage rates.

Why the Deflationary Bias is a Concern

The deflationary bias poses serious challenges to the central bank

- It may impair the Fed's ability of committing to future actions
- The U.S. deflationary bias has been growing over time
- **We show that a growing bias is the harbinger of deflationary spirals**
  - A pathological situation in which inflation keeps falling indefinitely

Deflationary Bias in NK Models

The interaction of two factors causes the deflationary bias in NK models

1. Low long-term real interest rate r^*
2. **The symmetry of the central bank's strategy**

We formalize this argument using an **off-the-shelf non-linear New Keynesian model**

The Fed's Symmetric Monetary Policy Framework

An example of symmetric monetary strategy is provided by **the Statement on Longer-Run Goals and Monetary Policy Strategy**:

"The Committee would be concerned if inflation were running persistently above or below this objective. **Communicating this symmetric inflation goal** clearly to the public helps keep longer-term inflation expectations firmly anchored [...]"

$\Longrightarrow$ **symmetric target** calls for a **symmetric strategy**

A Symmetric Target Calls for an Asymmetric Strategy

- In a low-interest-rate environment it is advantageous to be **more concerned about inflation running below target than above target**
- The central bank adjusts the policy rate **less aggressively when inflation is above target than when it is below**
- This asymmetric strategy **removes the deflationary bias because it raises the probability of inflation on the upside** offsetting the downside risk due to the ZLB

$\Longrightarrow$ **symmetric target** calls for an **asymmetric strategy**

Target Ranges for Inflation

- Last September, **the FOMC** debated if **its long-run framework can be improved by adopting the asymmetric strategy**
- We show that the introduction of such a range can close the deflationary bias **provided that the range itself is asymmetric** around the inflation objective
- For instance, if the central bank does not respond when inflation is within the range, specifying a range between **1.5 percent and 2.85 percent** closes the bias

Related Literature

- **Deflationary bias**: Adam and Billi (2007) and Nakov (2008). **We emphasize the importance of the symmetry of the policy rule and show that the deflationary bias is the harbinger of deflationary spirals.**
- **Measurement of the deflationary bias**: Amano et al. (2018) and Hills et al. (2016).
- **Resolution with dynamic rules**: Kiley and Roberts (2017), Mertens and Williams (2019), Bernanke et al. (2019) advocate dynamic monetary policy rules. The asymmetric strategy we analyzed **does not rely on history dependence**.

The Model

Off-the-shelf New Keynesian model (Clarida, Gali, and Gertler 2000; Woodford 2003)

- Zero lower bound constraint (ZLB) on the nominal interest rates
- Price rigidities a la Rotemberg
- Shocks to households' preference to consumption
- **A symmetric Taylor rule**

$$R_t = \max\left[1, \left(\frac{\Pi_t}{\Pi}\right)^{\theta_\Pi}\left(\frac{Y_t}{Y}\right)^{\theta_Y} R\right]$$

The model is solved with **global methods** in its non-linear specification

The Model: Calibration

Parameters		Value
r^*	Steady state real interest rate	1.00
$100\sigma_{\zeta^d}$	Std. dev. preference shock	1.17
ϕ_Π	MP inflation response	2.00
ϕ_Y	MP output response	0.25
100Π	Annualized inflation target	2.00
ρ_{ζ^d}	Persistence preference shock	0.60
α	Curvature of production function	1.00
σ	Relative risk aversion	1.00
η	Inverse Frisch elasticity	1.00
ϵ	Price elasticity of demand	7.67
χ	Disutility labor	0.87
φ	Rotemberg pricing	79.41

Benchmark calibration: Parameter Values

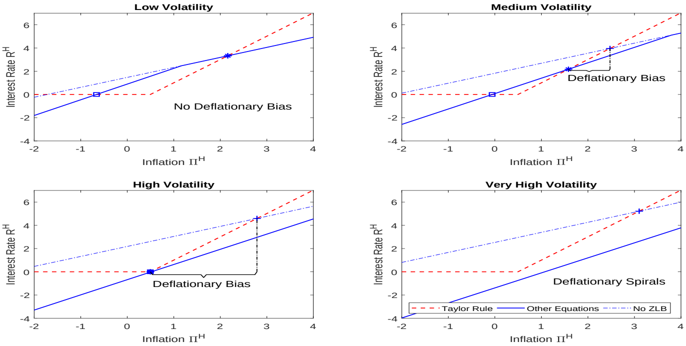
Deflationary Bias is the Harbinger of Deflationary Spirals

- To gain intuition about the causes of the **deflationary bias and its relation with the deflationary spirals**, we make the following simplifying assumptions:

- The shock can only take two values low (bad state) and high (good state)

- Equilibria can be characterized by solving a set of nonlinear equations conditioned on the high or low value of the shock

Deflationary Spirals: A Graphical Characterization



Equilibrium interest rate and inflation when the preference shock is high (good state) for various volatilities of shocks. The red dashed line in this figure represents the Taylor rule in the good state, subject to the ZLB constraint. The blue line in the same figure conflates the restrictions imposed on the inflation rate and the nominal interest rate in the good state by all the remaining equations –including the equations conditional on the bad state. The intersections between the red dashed line and the blue solid line are the (stable) Rational Expectations equilibria in the good state. The blue dashed-dotted line captures the counterfactual case in which we do not impose the ZLB constraint on the nominal interest rate in the bad state and hence the slope of the blue line does not change.

The Deflationary Bias

Nonlinear models admit two notions of steady-state equilibrium:

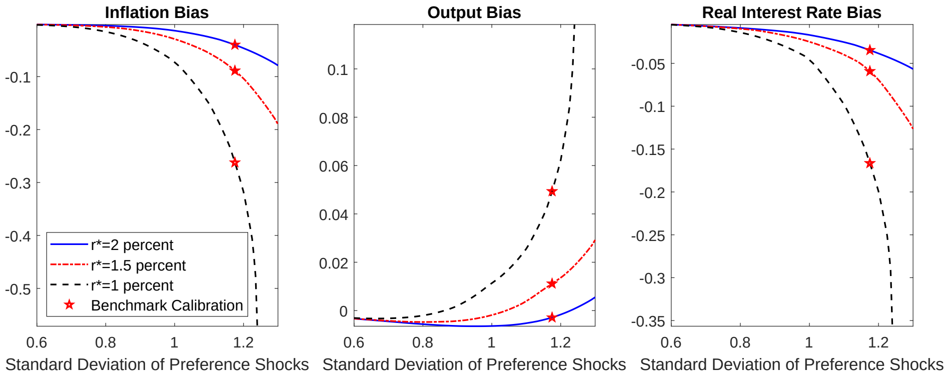
1. **The deterministic steady state**: agents fail to appreciate risk
2. **The stochastic steady state**: agents appreciate risk and adjust their behavior

Inflation at **the deterministic steady state** is the central bank's inflation target (2%)

If no shock occurs, the economy converges to the **the stochastic steady state**

Deflationary bias = Inflation at the stochastic steady state – the inflation target

Volatility, r^*, and Macroeconomic Biases



Macroeconomic distortions due the zero lower bound as the volatility of the preference shocks varies. Left graph: The inflationary bias due to model's non-linearities. The red star denotes the calibrated value of the standard deviation of this shock. The difference between the blue solid line and the black dot-dashed line captures the deflationary effects of a risk of a recession that pushes the nominal interest rate to its lower bound. Center graph: the same as the left graph but the bias is computed with respect to output (level). Right graph: the same as the left graph but the bias is computed with respect to the real interest rate. The gray area marks the region of the values for the standard deviation of the preference which trigger deflationary spirals.

The Asymmetric Policy Rule

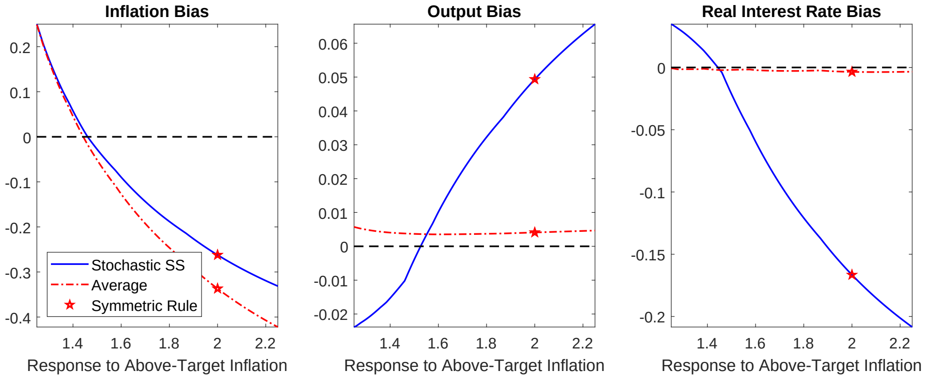
We analyze an **asymmetric policy strategy** that implies
a smaller response to inflation when inflation is above target:

$$R_t = \max\left(1, \left[\mathbf{1}_{\Pi_t<\Pi}\left(\frac{\Pi_t}{\Pi}\right)^{\underline{\theta_\Pi}} + \mathbf{1}_{\Pi_t>\Pi}\left(\frac{\Pi_t}{\Pi}\right)^{\overline{\theta_\Pi}}\right]\left(\frac{Y_t}{Y}\right)^{\theta_Y} R\right)$$

where $\underline{\theta_\Pi} > \overline{\theta_\Pi}$ and:

- $\underline{\theta_\Pi}$ denotes the response of inflation when inflation is below target
- $\overline{\theta_\Pi}$ stands for the response to inflation when inflation is above target
- $\mathbf{1}_{\Pi_t<\Pi}$ is an indicator function equal to one when inflation is below target ($\Pi_t < \Pi$)

The Asymmetric Strategy and the Average Bias

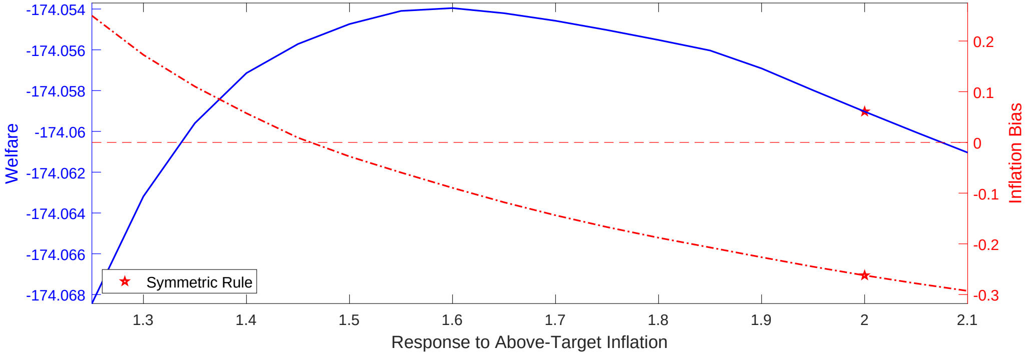


Macroeconomic biases due to the ZLB constraint as the central bank varies its response to positive deviations of inflation from target. The inflation bias (left plot), the output bias (center plot), and the real interest rate bias (the right plot) are computed by taking the difference between these variables at the stochastic steady state and their value at the deterministic steady state (blue solid line). These biases are also computed as the difference between the unconditional mean of these three variables and their value at the deterministic steady state (red dashed-dotted line). The response when inflation is below target is always equal to 2 as in the benchmark calibration. The red star marks the symmetric case in which the central bank responds with equal strength to inflation or deflation.

The Asymmetric Strategy is Not a Makeup Strategy

- The asymmetric strategy is different from the so-called makeup strategies (e.g., price-level targeting and average-inflation targeting)
- **The asymmetric strategy is not history dependent** and does not requires the central bank to engineer an overshooting in inflation after a ZLB episode
- The asymmetric strategy requires the central bank to respond asymmetrically to inflation **with no account for the past dynamics of inflation**

Removing the Bias Entirely is Not Optimal



Welfare and inflation bias as the response to positive deviations of inflation from target varies in magnitude. Welfare is evalutated at the stochastic steady state and reported on the left axis. The inflation bias is defined as the difference between the annualized percentage rate of inflation at the stochastic steady state and the annualized percentage rate of inflation at the deterministic steady state and is reported on the right axis.

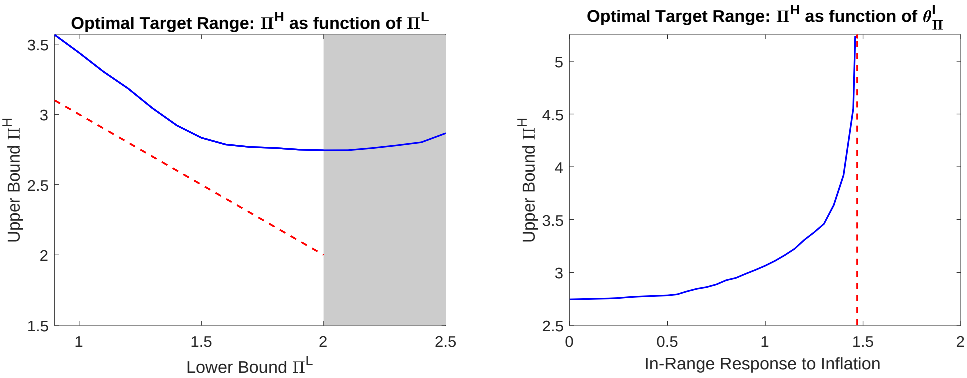
The Asymmetric Target Range

A way to implement the **asymmetric rule** is through an **asymmetric target range**

$$R_t = \max\left(1, \left[\mathbf{1}_{\Pi_t \notin [\Pi_L, \Pi_H]} \left(\frac{\Pi_t}{\Pi}\right)^{\theta_\Pi^O} + \mathbf{1}_{\Pi_t \in [\Pi_L, \Pi_H]} \left(\frac{\Pi_t}{\Pi}\right)^{\theta_\Pi^I}\right] \left(\frac{Y_t}{Y}\right)^{\theta_Y} R\right)$$

when inflation is inside the target range $[\Pi_L, \Pi_H]$, the central bank adjusts the interest rate less aggressively than what it does when inflation is outside the target range: $\theta_\Pi^I < \theta_\Pi^O$

The Asymmetric Target Range (Cont'd)



The target range required to close the deflationary bias. The left plot: the blue line shows the lower and upper bounds of the range that closes the deflationary bias when the central bank's in-range response to inflation is zero. The dashed red line marks the bounds implied by the symmetric target range. The right plot: the blue line shows the upper bound of the range as the central bank's in-range response to inflation varies on the horizontal axis. The lower bound of the range is fixed to 2 percent. The vertical red-dashed line is an asymptote that arises when the in-range response to inflation equals the above-target response to inflation in the asymmetric rule that removes the deflationary bias.

Opportunistic Reflation

- If the central banker is myopic, it could be hard to convince agents that an asymmetric strategy is adopted when inflation is below target
- In this context, the central bank can conduct an **opportunistic reflation** to demonstrate the adoption of the asymmetric strategy
  - The central bank **announces** the adoption of the asymmetric strategy **in the aftermath of a shock that pushes inflation above target**
- **In our calibrated model opportunistic reflation improves welfare.**

Concluding Remarks

- The **deflationary bias** is a predictable consequence of **a low nominal interest rates environment** in which the central bank follows a **symmetric strategy**
- **The deflationary bias has been growing in the U.S.**
- A growing bias is **the harbinger of deflationary spirals**
- Adopting an **asymmetric strategy** corrects the bias
- This strategy does not entail any **history dependence**
- Introducing an **asymmetric target range** is an effective way to remove the bias

Appendix

The Model: Households

The representative household chooses consumption C_t, labor H_t, and government bonds B_t so as to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \zeta_t^d \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{H_t^{1+\eta}}{1+\eta} \right]$$

subject to the flow budget constraint

$$P_t C_t + B_t = P_t W_t H_t + R_{t-1} B_{t-1} + T_t + P_t Div_t$$

where P_t is the price level, W_t is the real wage, R_t is the gross interest rate, T_t are lump-sum taxes, Div_t are real profits from the intermediate good firms, and B_t denotes the one-period government bonds in zero net supply.

The **preference shock** ζ_t^d follows an AR(1) process in logs $\ln(\zeta_t^d) = \rho_\zeta \ln(\zeta_{t-1}^d) + \sigma^{\zeta^d} \epsilon_t^{\zeta^d}$.

The Model: Households

Solving the representative household's problem yields the Euler equation

$$1 = \beta R_t E_t \frac{\zeta_{t+1}^d}{\zeta_t^d} \left(\frac{C_t}{C_{t+1}} \right)^{\sigma} \frac{1}{\Pi_{t+1}},$$

where $\Pi_t = P_t / P_{t-1}$ is gross inflation, and the labor supply

$$W_t = \chi N_t^{\eta} c_t^{\sigma},$$

The Model: Final Good Producers

Final goods producers transform intermediate goods into the homogeneous good, which is obtained by aggregating intermediate goods using the following technology:

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

where $Y_t(j)$ is the consumption of the good of the variety produced by firm j.
The price index for the aggregate homogeneous good is:

$$P_t = \left[\int_0^1 P_t(j)^{1-\epsilon} df \right]^{\frac{1}{1-\epsilon}},$$

and the demand for the differentiated good $j \in (0,1)$ is

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon} Y_t.$$

The Model: Intermediate Good Producers

The firm j produces output with labor as the only input

$$Y_t(j) = A\, H_t(j)^{\alpha}$$

where A denotes the total factor productivity, which follows an exogenous process. The firm j sets the price $P_t\left(j\right)$ of its differentiated goods j so as to maximize its profits:

$$Div_t(j) = P_t(j)\left(\frac{P_t(j)}{P_t}\right)^{-\epsilon}\frac{Y_t}{P_t} - \alpha\, mc_t\left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} Y_t - \frac{\varphi}{2}\left(\frac{P_t(j)}{\Pi P_{t-1}(j)} - 1\right) Y_t,$$

subject to the downward sloping demand curve for intermediate goods. The parameter $\varphi > 0$ measures the cost of price adjustment in units of the final good.

The Model: Policymakers

The monetary authority faces a zero lower bound constraint:

$$R_t = \max\left[1, R\left(\frac{\Pi_t}{\Pi}\right)^{\theta_\Pi}\left(\frac{Y_t}{Y}\right)^{\theta_Y}\right].$$

where Π and Y denote the inflation target and the natural output level, which is the level output that would arise if prices were flexible.

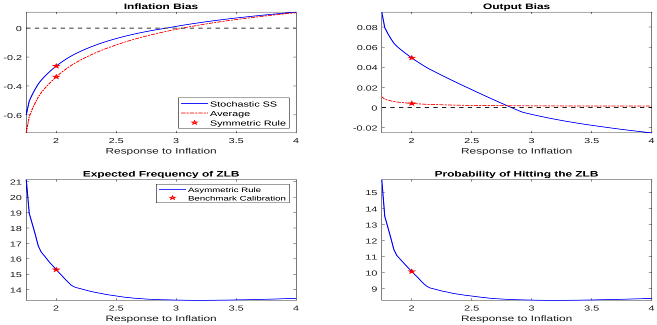
The fiscal authority sets taxes to balance the budget in every period

$$T_t = B_t - R_{t-1}B_{t-1}.$$

The resource constraint is

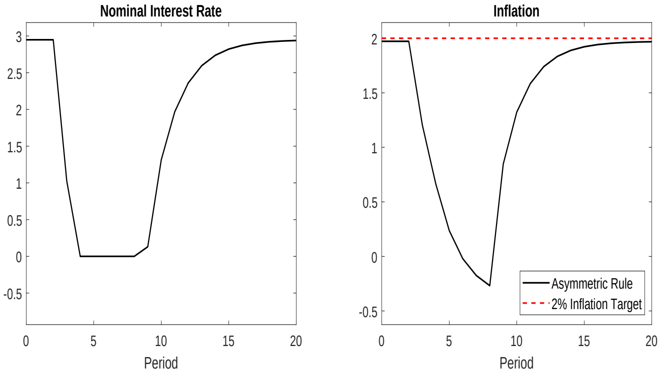
$$C_t = Y_t\left[1 - \frac{\varphi}{2}\left(\frac{\Pi_t}{\Pi} - 1\right)^2\right]$$

Macroeconomic biases under Strategic Interest Rate Cuts



Macroeconomic biases due to risk of hitting ZLB under the asymmetric rule. The biases are computed relatively to the stochastic steady state (blue solid line) or the average inflation (red dashed-dotted line) and are shown in the upper panels. The output gap is expressed in percentage points and inflation gap is expressed in percentage points of annualized rates. The lower panels show the risk of hitting the ZLB in the next period (left) and the expected frequency of the ZLB (right) as the response to inflation below target varies. The frequency is in percentage points and it is computed as the ratio between the number of periods spent at the zero lower bound and the total sample size (300,000). The probability of hitting the zero lower bound in the next period is conditional on being at the stochastic steady state in the current period and is expressed in percentage points.

The Asymmetric Strategy is Not a Makeup Strategy



Simulations of inflation and nominal interest rate during an artificial recession. The economy is at its stochastic steady state in period 0, 1, and 2. From period 3 through period 8, the economy is hit by a one-standard-deviation negative preference shock in every period. Starting from period 9 no more shocks occur and the economy evolves back to its stochastic steady-state equilibrium.