Hitting the Elusive Inflation Target

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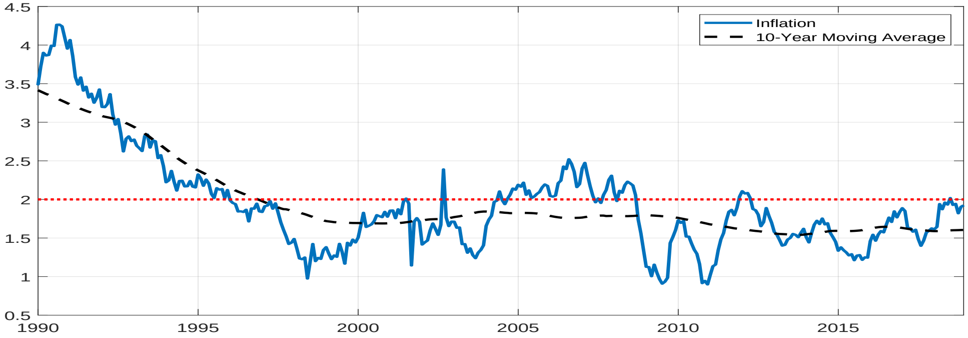
Motivation

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 *former* 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**

Revised Monetary Policy Strategy

- Revision of Statement on Longer-Run Goals and Monetary Policy Strategy **in the direction advocated by our paper**

- Commenting on the revised statement on August 31, 2020, Vice Chairman Clarida seems to echo **insights of our paper**

  *"[...] the aim to achieve **symmetric outcomes for inflation** (as would be the case under flexible inflation targeting in the absence of the ELB constraint) **requires an asymmetric monetary policy** reaction function in a low r* world with binding ELB constraints in economic downturns. "*

Related Literature

- Deflationary bias
  - Adam and Billi (2007), Nakov (2008)

  ⇒ We emphasize the importance of the **symmetry of monetary policy rule**

- Measurement of the deflationary bias
  - Hills, Nakata and Schmidt (2019), Amano and Gnocchi (2020)

  ⇒ We show **that the deflationary bias is the harbinger of deflationary spirals**

- Resolution with dynamic rules
  - Kiley and Roberts (2017), Mertens and Williams (2019), Bernanke et al. (2019)

  ⇒ The asymmetric strategy we propose **does not rely on history dependence** and can be implemented as an **asymmetric target range**

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
ϵ	Price elasticity of demand	7.67
η	Inverse Frisch elasticity	1.00
χ	Disutility labor	0.87
φ	Rotemberg pricing	79.41

Table: Benchmark calibration: Parameter Values

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%)

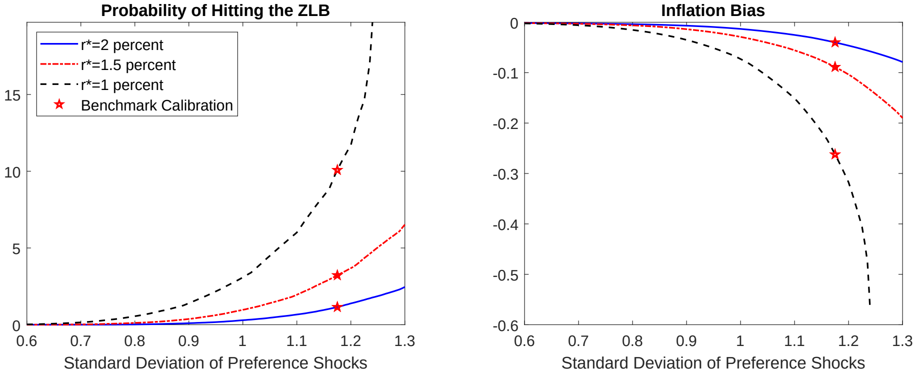
If shocks are expected but do not occur, the economy converges to the **the stochastic steady state**

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

Why Does the Deflationary Bias Arise?

- **The current low interest rate environment makes ZLB episodes more likely**
- The ZLB constraint hinders the Fed's ability to stabilize inflation in recession
- Rational and forward-looking agents factor this in when forming inflation expectations
- These expectations lower inflation **even when the economy is away from the ZLB**
- **Heightened macro uncertainty** also exacerbates the deflationary bias

Volatility, r^*, and Inflation Bias



- Heightened risk of the ZLB increases the deflationary bias
  - Risk of ZLB increases with lower $r^\star$ and the volatility of shocks

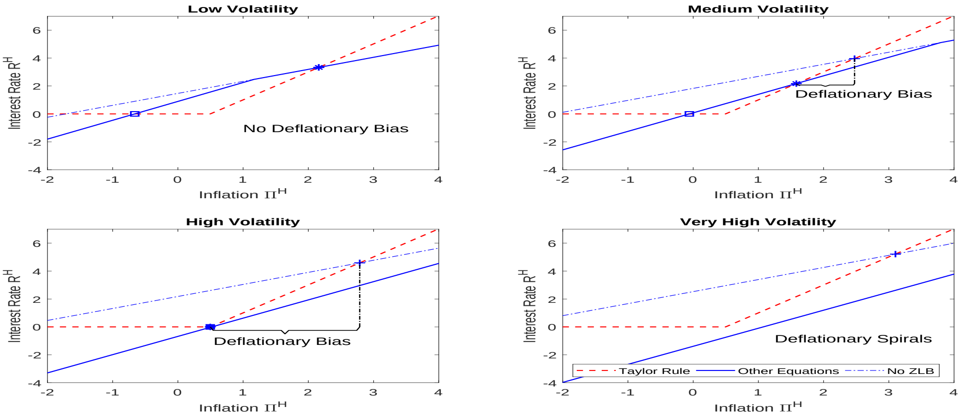
Deflationary Spirals

- 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)**
- Equilibrium outcomes can be conditioned on the high or low value of the shock
- Equations are connected as agents are rational and forward looking

Deflationary Bias is the Harbinger of Deflationary Spirals

- The deflationary bias arises when the risk of hitting the zero lower bound is nonzero
- To respond to the bias, the central bank keeps the interest rate low in the good state
- **Suppose r^* falls more**, then the impact of the zero lower bound increases
- The deflationary bias becomes so large that **the ZLB becomes binding even in the good state**
- **Any further increase in the probability of hitting the ZLB leads the *real* interest rate to rise in the good state**, depressing aggregate demand and exacerbating the deflationary bias
- **This vicious circle of low inflation, rising real interest rates, and even lower inflation sets the stage for deflationary spirals**

Deflationary Spirals: A Graphical Characterization



The Asymmetric Policy Rule

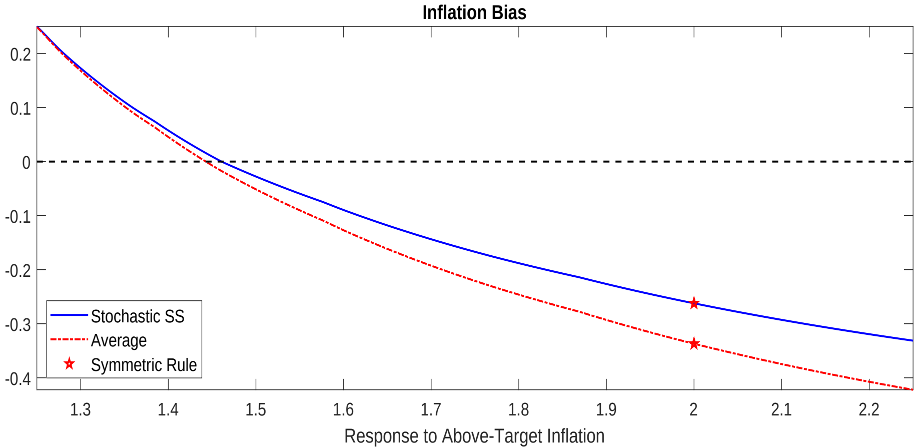
We analyze an **asymmetric policy strategy** that implies **a smaller response to inflation when inflation is above target**:

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

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



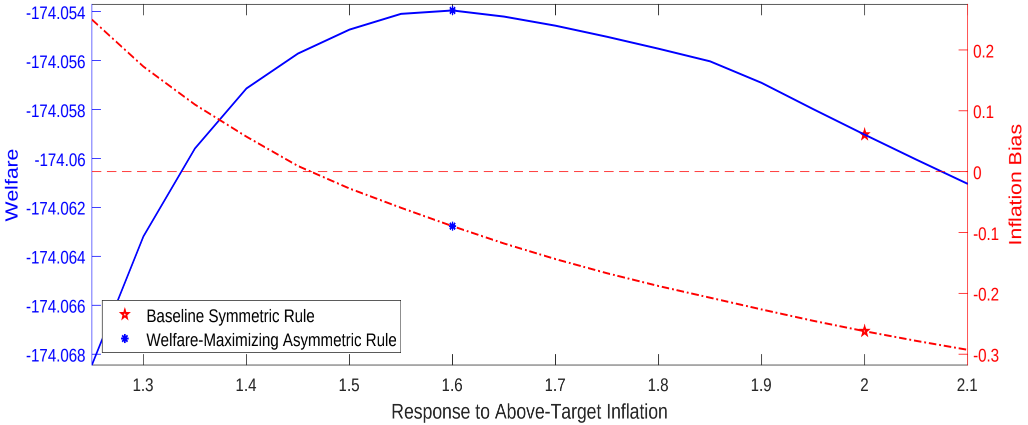
The Asymmetric Strategy is Not a Makeup Strategy

- 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 require 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** Simulation

Removing the Bias Entirely is Not Optimal



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

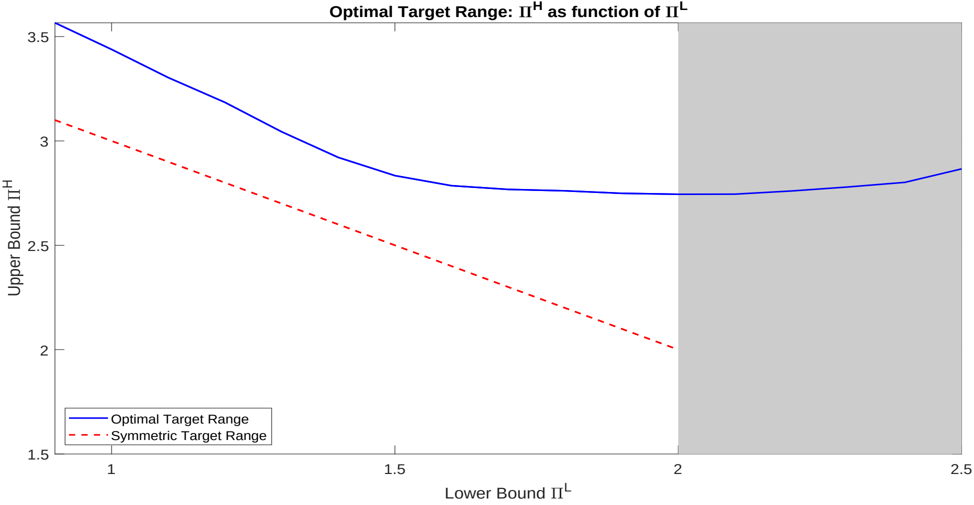
The Asymmetric Target Range

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)



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**

Appendix

Fed's Monetary Policy Framework

- New Statement on Longer-Run Goals and Monetary Policy Strategy

  "*[...] the Committee seeks to achieve inflation that* **averages 2 percent over time** *, and therefore judges that, following periods when inflation has been running persistently below 2 percent, appropriate monetary policy will likely* **aim to achieve inflation moderately above 2 percent for some time**. "

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 $P_t(j)$ 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.

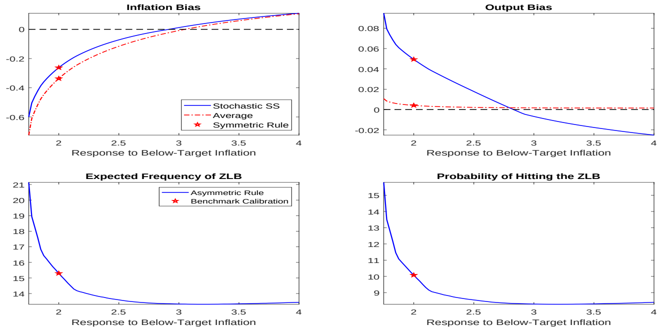
The fiscal authority sets taxes to balance the budget in every period

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

The resource constraint is

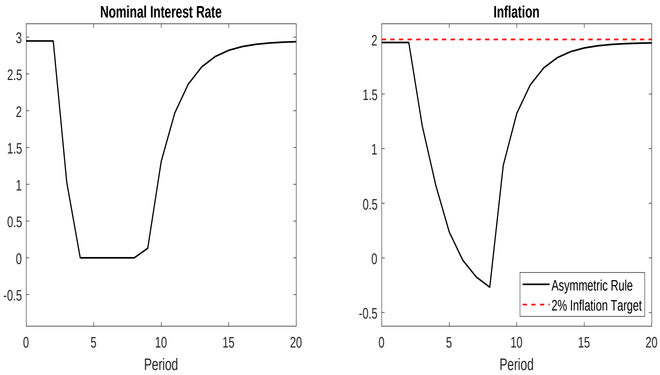
$$C_t = Y_t\left[1 - \frac{\varphi}{2}\left(\frac{\Pi_t}{\Pi} - 1\right)^2\right]$$

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.

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