Should the ECB Adjust its Strategy in the Face of a Lower $r^*$?\(^1\)

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\(^1\)The views expressed here do not necessarily represent those of the Banque de France, the Eurosystem, the Federal Reserve Bank of Boston or the Federal Reserve System.
Motivation

- Decline in $r^*$, possibly permanent
- Implications for monetary policy $\Rightarrow$ higher ELB incidence, given an unchanged strategy
- **Question**: Should the monetary policy strategy be adjusted in the face of a lower $r^*$?
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  - Should the inflation target be raised, given an unchanged policy rule?
  - Should the policy rule be modified, given an unchanged inflation target?
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**Question**: Should the monetary policy strategy be adjusted in the face of a lower $r^*$?

- Should the inflation target be raised, given an unchanged policy rule?
- Should the policy rule be modified, given an unchanged inflation target?

This paper: *quantitative* analysis based on an estimated NK model of the euro area economy

Follow up on the U.S.-based analysis in Andrade et al. (2020)
Preview of Main Findings

- Given the estimated rule, the current inflation target ($\pi^* \lesssim 2\%$) is suboptimal if $r^* < 2\%$
- Keeping that rule unchanged, a 1% decrease in $r^*$ calls for a 0.9% increase in $\pi^*$ ($1.7\% \Rightarrow 2.6\%$)
- Alternatives to raising the inflation target:
  - aggressive countercyclical fiscal policy
  - modifying the rule to incorporate a sufficiently strong "make-up" component
Related literature


- Quantitative analyses of $\pi^*$ with a ZLB/ELB constraint: Coibion et al. (2012), Dordal-i-Carreras et al. (2016), Kiley and Roberts (2017), Blanco (2016),...

- Our contribution: explicit analysis of the relation between $r^*$ and $\pi^*$

- Main caveat: "within the model" analysis
The Model

- Medium-scale NK model
- Non-zero trend inflation
- Staggered price and wage setting à la Calvo
- Imperfect indexation of prices to lagged price inflation; and of wages to lagged price inflation and productivity.
- Shocks: risk premium, marginal utility of consumption, technology, monetary policy, price and wage markups
- Trend growth $\Rightarrow r^* = \rho + \mu_z$
- Baseline monetary policy rule

$$i_t = \max\{i^n_t, e\}$$

$$i^n_t = (1 - \rho_i)i + \rho_i i^n_{t-1} + (1 - \rho_i) [a_\pi (\pi_t - \pi) + a_x x_t] + \zeta_{r,t}$$

with $i = r^* + \pi$ and where $\pi$ defines the inflation target $(\neq \mathbb{E}\{\pi_t\})$
Solution Method

1. Detrending of non-stationary quantities by technology parameter
2. Log-linearization around deterministic steady state.
3. Solution under the ZLB as in Bodenstein et al. (2009) and Guerrieri and Iacoviello (2015)
Calibration and Estimation

- Calibrated parameters: $1/\phi = 0.7$; $\theta_p = 6$; $\theta_w = 3$; $e = -0.5/4$
- Remaining parameters estimated using Bayesian approach on the model without ZLB and sample period 1985Q1-2014Q4
- Gaussian priors for $(\rho, \mu_z, \pi)$ with means consistent with inflation, GDP growth and real rate averages.
- Vector of observables:
  \[ x_t = [\Delta \log GDP_t, \Delta \log GDP \text{ Deflator}_t, \Delta \log Wage_t, \text{Short term rate}_t] \]
- Some model properties
\( \pi^* = 2\% \) (annualized)
r^* = 1% (annualized)
The Optimal Inflation Target

- Second order approximation to household expected utility: $\mathcal{W}(\pi; \theta)$
- The optimal inflation target

$$\pi^*(\theta) = \arg \max_{\pi} \mathcal{W}(\pi; \theta)$$

with solution obtained via numerical simulations allowing for occasionally binding ZLB, and with $\theta$ taken to be the mean of the posterior distribution of parameter estimates
The Optimal Inflation Target

- Second order approximation to household expected utility: $\mathcal{N}(\pi; \theta)$
- The optimal inflation target

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with solution obtained via numerical simulations allowing for occasionally binding ZLB, and with $\theta$ taken to be the mean of the posterior distribution of parameter estimates.

- The baseline $(r^*, \pi^*)$ relation:
  
  (a) varying $\mu_z$
  (b) varying $\rho$

while keeping other parameters at their posterior mean
The graph shows the relationship between the "Annualized steady-state real interest rate" and the "Optimal inflation target (annualized)". Two curves are plotted:

1. The blue curve represents $r^*(\mu_z)$.
2. The red curve represents $r^*(\rho)$.

The local slope of the red curve is indicated as -0.9, with points at 1.7% and 2.6% on the y-axis.
Alternative Strategies

- Emergency Fiscal Package (4% of output, $\rho_g = 0.85$, triggered when cumulative output gap is $-6\%$)
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- Alternative Effective Lower Bound: $e \in \{0, -0.5, 0.8\}$ (annualized)
Alternative Effective Lower Bounds

Optimal inflation target (annualized)

Annualized steady-state real interest rate

$r^*(\mu_z)$, ELB = -50 bps
$r^*(\mu_z)$, ELB = 0 bps
$r^*(\mu_z)$, ELB = -80 bps
Alternative Strategies

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- Alternative inertia coefficients: $\rho_i \in \{0.8, 0.87, 0.95\}$
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- Price level targeting:

\[ i_t^n - i = \rho_i(i_{t-1}^n - i) + (1 - \rho_i) [a_p(p_t - p_t^*) + a_x x_t] + \zeta_{r,t} \]

where $p_t^* = p_0 + \pi \cdot t$ and $a_p \in \{0.1, 0.5\}$
Price Level Targeting

Optimal inflation target (annualized) vs. Annualized steady-state real interest rate for different values of $a_p$.

- Blue line: $a_p = 0.1$
- Red line: $a_p = 1.0$
Alternative Strategies

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  \]
  where $p_t^* = p_0 + \pi \cdot t$ and $a_p \in \{0.1, 0.5\}$
- Average inflation targeting:
  \[
  i_t^n - i = \rho_i (i_{t-1}^n - i) + (1 - \rho_i) [a_p (\pi_t^a - \pi) + a_x x_t] + \zeta_{r,t}
  \]
  where $\pi_t^a = (1/H) \sum_{h=0}^{H-1} \pi_{t-h}$ and $H \in \{1, 16, 32\}$
Average Inflation Targeting

- $r^*(μ)$, Baseline
- $r^*(μ)$, AIT, 4-year window
- $r^*(μ)$, AIT, 8-year window

**Graph Details:**
- Y-axis: Optimal inflation target (annualized)
- X-axis: Annualized steady-state real interest rate

The graph compares the optimal inflation targets under different scenarios.
Summary and Conclusions

- Quantitative assessment of the optimal inflation target in the euro area, as a function of $r^*$ and under an ELB constraint.
- Under the baseline estimated policy rule, a (local) decline in $r^*$ calls for a close to one-for-one (0.9) increase in the inflation target $\Rightarrow$ marginal costs of inflation are low compared to the stabilization benefits of a higher nominal rate.
- If $r^*$ has declined significantly and the rule is unchanged, the current "below but close to 2%" target is suboptimal.
- Alternatives to a higher inflation target:
  - more aggressive countercyclical fiscal policies
  - more aggressive "lower for longer" forward guidance
  - average inflation targeting
The Model

- Representative household with preferences:
  \[ \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left\{ e^{\zeta_{g,t+s}} \log(C_{t+s} - \eta C_{t+s-1}) - \frac{\chi}{1 + \nu} \int_{0}^{1} N_{t+s}(h)^{1+v} \, dh \right\} \]
  and budget constraint
  \[ P_t C_t + e^{\zeta_{q,t}} Q_t B_t \leq \int_{0}^{1} W_t(h) N_t(h) \, dh + B_{t-1} - T_t + D_t \]
- Final goods: perfect competition with technology
  \[ Y_t = \left( \int_{0}^{1} Y_t(f)^{(\theta_p - 1)/\theta_p} \, df \right)^{\theta_p/(\theta_p - 1)} \]
- Intermediate goods: monopolistic competition with technology
  \[ Y_t(f) = Z_t L_t(f)^{1/\phi} \]
  where \( Z_t = Z_{t-1} e^{\mu_z + \zeta_{z,t}} \)
The Model

- Price setting à la Calvo, with stochastic subsidies $\zeta_{u,t}$, and partial indexation
  \[
  P_t(f) = \Pi_{t-1}^{\gamma_p} P_{t-1}(f)
  \]

- Wage setting à la Calvo, with partial indexation
  \[
  W_t(h) = e^{\gamma_{z} \mu_{z}} \Pi_{t-1}^{\gamma_{w}} W_{t-1}(h)
  \]

- Interest rate rule:
  \[
  i_t = \max\{i^n_t, 0\}
  \]
  where
  \[
  i^n_t - i = \rho_i (i^n_{t-1} - i) + (1 - \rho_i) \left[ a_{\pi} (\pi_t - \pi) + a_{y} (y_t - y^n_{t}) \right] + \zeta_{r,t}
  \]
  with $i = \rho + \mu_z + \pi$ and where $\pi$ defines the inflation target.
An Incorrect Argument

"The effects of a decline in $r^*$, independently of its source, can be exactly offset by a commensurate increase in the inflation target $\pi$"
An Incorrect Argument

"The effects of a decline in $r^*$, independently of its source, can be exactly offset by a commensurate increase in the inflation target $\pi$"

The argument ignores:

(i) An increase in inflation has (permanent) welfare costs of its own.
(ii) Changes in $\rho$ and $\mu_Z$ have different effects on wage inflation (given $\pi$)
(iii) Changes in $(\rho, \mu_Z)$ affect the equilibrium dynamics independently of $\pi$

These are the effects that we seek to evaluate.
Table 1: Estimation Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior Shape</th>
<th>Prior Mean</th>
<th>Prior std</th>
<th>Post. Mean</th>
<th>Post. std</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$</td>
<td>Normal</td>
<td>0.20</td>
<td>0.05</td>
<td>0.20</td>
<td>0.05</td>
<td>0.12</td>
<td>0.27</td>
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<td>$\mu_z$</td>
<td>Normal</td>
<td>0.50</td>
<td>0.05</td>
<td>0.45</td>
<td>0.04</td>
<td>0.38</td>
<td>0.52</td>
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<tr>
<td>$\pi$</td>
<td>Normal</td>
<td>0.80</td>
<td>0.05</td>
<td>0.79</td>
<td>0.05</td>
<td>0.71</td>
<td>0.86</td>
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<tr>
<td>$\alpha_p$</td>
<td>Beta</td>
<td>0.66</td>
<td>0.05</td>
<td>0.63</td>
<td>0.04</td>
<td>0.56</td>
<td>0.69</td>
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<tr>
<td>$\alpha_w$</td>
<td>Beta</td>
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<td>0.05</td>
<td>0.60</td>
<td>0.04</td>
<td>0.54</td>
<td>0.66</td>
</tr>
<tr>
<td>$\gamma_p$</td>
<td>Beta</td>
<td>0.50</td>
<td>0.15</td>
<td>0.10</td>
<td>0.04</td>
<td>0.03</td>
<td>0.16</td>
</tr>
<tr>
<td>$\gamma_w$</td>
<td>Beta</td>
<td>0.50</td>
<td>0.15</td>
<td>0.29</td>
<td>0.10</td>
<td>0.12</td>
<td>0.45</td>
</tr>
<tr>
<td>$\gamma_z$</td>
<td>Beta</td>
<td>0.50</td>
<td>0.15</td>
<td>0.50</td>
<td>0.15</td>
<td>0.26</td>
<td>0.75</td>
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<tr>
<td>$\eta$</td>
<td>Beta</td>
<td>0.70</td>
<td>0.15</td>
<td>0.72</td>
<td>0.03</td>
<td>0.67</td>
<td>0.78</td>
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<tr>
<td>$\nu$</td>
<td>Gamma</td>
<td>1.00</td>
<td>0.20</td>
<td>0.95</td>
<td>0.18</td>
<td>0.64</td>
<td>1.24</td>
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<tr>
<td>$a_{\pi}$</td>
<td>Gamma</td>
<td>2.00</td>
<td>0.15</td>
<td>2.10</td>
<td>0.13</td>
<td>1.87</td>
<td>2.31</td>
</tr>
<tr>
<td>$a_y$</td>
<td>Gamma</td>
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<td>0.05</td>
<td>0.50</td>
<td>0.05</td>
<td>0.41</td>
<td>0.58</td>
</tr>
<tr>
<td>$\rho_i$</td>
<td>Beta</td>
<td>0.85</td>
<td>0.10</td>
<td>0.86</td>
<td>0.02</td>
<td>0.84</td>
<td>0.89</td>
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<tr>
<td>$\sigma_z$</td>
<td>Inverse Gamma</td>
<td>0.25</td>
<td>1.00</td>
<td>0.87</td>
<td>0.14</td>
<td>0.63</td>
<td>1.10</td>
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<tr>
<td>$\sigma_m$</td>
<td>Inverse Gamma</td>
<td>0.25</td>
<td>1.00</td>
<td>0.11</td>
<td>0.01</td>
<td>0.10</td>
<td>0.12</td>
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<td>$\sigma_q$</td>
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<td>0.22</td>
<td>0.06</td>
<td>0.14</td>
<td>0.30</td>
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<tr>
<td>$\sigma_c$</td>
<td>Inverse Gamma</td>
<td>0.25</td>
<td>1.00</td>
<td>0.24</td>
<td>0.04</td>
<td>0.18</td>
<td>0.31</td>
</tr>
<tr>
<td>$\sigma_u$</td>
<td>Inverse Gamma</td>
<td>0.25</td>
<td>1.00</td>
<td>0.20</td>
<td>0.11</td>
<td>0.06</td>
<td>0.35</td>
</tr>
<tr>
<td>$\rho_m$</td>
<td>Beta</td>
<td>0.25</td>
<td>0.10</td>
<td>0.37</td>
<td>0.06</td>
<td>0.26</td>
<td>0.47</td>
</tr>
<tr>
<td>$\rho_z$</td>
<td>Beta</td>
<td>0.25</td>
<td>0.10</td>
<td>0.24</td>
<td>0.10</td>
<td>0.09</td>
<td>0.39</td>
</tr>
<tr>
<td>$\rho_c$</td>
<td>Beta</td>
<td>0.85</td>
<td>0.10</td>
<td>0.99</td>
<td>0.00</td>
<td>0.99</td>
<td>1.00</td>
</tr>
<tr>
<td>$\rho_q$</td>
<td>Beta</td>
<td>0.85</td>
<td>0.10</td>
<td>0.95</td>
<td>0.02</td>
<td>0.91</td>
<td>0.98</td>
</tr>
<tr>
<td>$\rho_u$</td>
<td>Beta</td>
<td>0.80</td>
<td>0.10</td>
<td>0.80</td>
<td>0.10</td>
<td>0.66</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Note: 'std' stands for Standard Deviation, 'Post.' stands for Posterior, and 'Low' and 'High' denote the bounds of the 90% probability interval for the posterior distribution. Values for parameters $\rho$, $\mu_z$, $\pi$ are expressed in percent, in quarterly (not annualized) terms.
Table 2: Properties of the Model

<table>
<thead>
<tr>
<th>Policy Parameters</th>
<th>Moments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$E(\pi^a)$</td>
</tr>
<tr>
<td>$e$</td>
<td>$r^*$</td>
</tr>
<tr>
<td>-0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>-0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>-0.50</td>
<td>2.00</td>
</tr>
<tr>
<td>-0.50</td>
<td>2.00</td>
</tr>
<tr>
<td>-0.50</td>
<td>3.00</td>
</tr>
<tr>
<td>-0.50</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Note: Results from simulations of the model under various values of $r^*$ and $\bar{\pi}$, an ELB at $e = -0.5$, and the remaining model parameters at their estimated posterior mean. $\pi^a$ denotes the year-on-year inflation rate, $x$ is the output gap, $E(\cdot)$ stands for mean, $std(\cdot)$ stands for Standard Deviation, P(ELB) denotes the unconditional probability of hitting the ELB.