Monetary policy options in a ‘low for long’ era

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Motivation

Estimates of equilibrium real interest rates ($R^*$) from Del Negro et al. (2019)

Other things equal, persistently low $R^*$ (‘low for long’) implies:

- More frequent encounters with the zero lower bound (ZLB)
- More difficult for monetary policy to return inflation to target
What we do

Model

- Simple New Keynesian model with portfolio frictions that give QE traction
- ‘Over-discounting’ (Gabaix, 2016; McKay et al., 2016) to mitigate forward guidance puzzle
- Estimated on UK and US data

Optimal policy

- Allow for QE to be used alongside policy rate
- Commitment and time-consistent policies
- Incorporate bounds on policy instruments

Macro-model simulation approach

- Simulate model of economy subject to a instrument bounds
- Examine distributions of outcome for key macro variables
- Study effects of assumptions for $R^*$, policy behaviour
- Piecewise-linear solution approach

Key results

- Pre-crisis monetary policy potentially inadequate in ‘low for long’ era
- Structural differences $\Rightarrow$ different effects of low $R^*$ for UK & US
- QE or forward guidance improves outcomes (with different effects on macro distributions)
The log-linearised model

\begin{align*}
\text{(1)} \quad \pi_t &= \beta_t E_t \pi_{t+1} + \eta \pi_{t-1} + \kappa x_t - \frac{\kappa \mu}{1 + \psi \sigma (1-\mu)} x_{t-1} + u_t \\
\text{(2)} \quad x_t &= \frac{1}{1 + \mu + \epsilon_\beta} E_t x_{t+1} + \frac{\mu}{1 + \mu + \epsilon_\beta} x_{t-1} - \frac{\sigma (1-\mu)}{1 + \mu + \epsilon_\beta} (r_t^e - E_t \pi_{t+1} - \hat{r}_t^*) \\
\text{(3)} \quad r_t^e &= \frac{1}{1 + \delta} r_t^s + \frac{\delta}{1 + \delta} E_t r_{t+1}^L \\
\text{(4)} \quad E_t r_{t+1}^L &= r_t^s - \nu q_t - \xi (\Delta q_t - \bar{\beta} E_t \Delta q_{t+1})
\end{align*}

Key model features

- **Rule of thumb firms** reduce forward-lookingness & increase inflation inertia
- **Endogenous discount factor** generates 'over-discounting' in IS equation
- **Portfolio frictions** imply that:
  - Effective interest rate depends on returns on short-term and long-term bonds
  - One period return on long-term bond depends on QE ($q$)

Model driven by cost-push shock ($u_t$) and shocks to equilibrium rate ($\hat{r}_t^* \equiv r_t^* - R^*$):

\begin{align*}
\hat{r}_t^* &= \rho_a \hat{r}_{t-1} + \sigma_a \epsilon_t^a, \\
\epsilon_t &= \rho_u \epsilon_{t-1} + \sigma_u (\epsilon_t^u - \rho \epsilon_{t-1}^u)
\end{align*}
Monetary policy

The baseline: ‘pre-crisis consensus’

Policy minimizes loss function

\[ \mathcal{L}_t = \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left\{ (4\pi_{\tau})^2 + \lambda_x x_{\tau}^2 + \lambda_{\Delta r} (4\Delta r^s_{\tau})^2 \right\} \]

subject to: \( r^s_t \geq zlb \)

Assumptions

- Inflation target fixed at 2% per annum; examine performance of strategies as \( R^* \) varies
- Lower bound on policy rate is zero: in log deviations, \( zlb = - (\pi^* + R^*) \)
- Loss function parameters reflect ‘balanced’ specification (Yellen, 2012; Carney, 2017)
Macroeconomic consequences of ‘low for long’
United States: distributions under ‘pre-crisis consensus’

- When \( R^* = 3 \), distributions broadly symmetric
Macroeconomic consequences of ‘low for long’
United States: distributions under ‘pre-crisis consensus’

- But skews emerge as $R^*$ falls
Macroeconomic consequences of ‘low for long’

Lower R* generates larger average shortfalls in output and inflation
Encounters with the zero bound become more frequent
Even so, ZLB incidence is relatively low
  ▶ Optimal policy (with interest rate smoothing objective)
  ▶ Sensitivity analysis

UK model exhibits higher variability and less sluggish dynamics
  ▶ Parameter comparison
Policy responses to ‘low for long’

Alternative strategies

Generalized loss function

\[
\mathcal{L}_t = \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t}\left\{ \left(4\pi_{\tau}\right)^2 + \lambda_x x_{\tau}^2 + \lambda_{\Delta q} (\Delta q_{\tau})^2 + \lambda_q q_{\tau}^2 + \lambda_{\Delta r} (4\Delta r_{\tau}^s)^2 \right\}
\]

subject to instrument constraints: \( r_t^s \geq zlb; 0 \leq q_t \leq \bar{q} \)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Instruments</th>
<th>Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Pre-crisis consensus’</td>
<td>Short rate ((r^s))</td>
<td>No</td>
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<tr>
<td>‘Post-crisis revealed preference’</td>
<td>Short rate ((r^s)) &amp; QE ((q))</td>
<td>No</td>
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<tr>
<td>‘Woodfordian forward guidance’</td>
<td>Short rate ((r^s))</td>
<td>Yes</td>
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</tbody>
</table>

- Additional assumptions (based on Harrison, 2017)
  - Upper bound on QE is \( \bar{q} = 0.5 \)
  - QE loss function parameters proportional to welfare costs of portfolio frictions
Policy responses to ‘low for long’ ($R^* = 0$)
<table>
<thead>
<tr>
<th></th>
<th>Output gap</th>
<th>Inflation</th>
<th>Policy rate</th>
<th>ZLB</th>
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<td>Mean StD</td>
<td>Mean StD</td>
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<td>2.69 3.21</td>
<td>0.33 11 34 - -</td>
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</table>

‘Frq’ = frequency ; ‘Dur’ = median duration (quarters) ; ‘90pct’ = 90th percentile of duration (quarters) ; ‘UB’ = frequency of \( q = \bar{q} \)

**UK results**
- QE mainly used when short-rate constrained by ZLB: mainly affects the left tail
- Guidance skews distributions to the right

**US results qualitatively similar:** less pronounced given lower costs of ZLB
Effects of ‘low for long’ and policy implications differ for UK & US
- Low $R^*$ seems less damaging (under baseline policy) in US
- QE and guidance have more effect in UK

These results likely reflect structural differences
- US has stickier & more inertial price-setting, higher habit formation
- UK has more persistent and volatile cost-push shocks

Next steps
- Explore fully stochastic solution
- Implications for financial stability & macro-prudential policy
References I


Estimates and forecasts of real equilibrium interest rate
  - King and Low (2014), Rachel and Smith (2017), Holston et al. (2017),
    Del Negro et al. (2019)

Macroeconomic models to study effects of impairment

Discussion of remedies
Variations on a theme

CMS = Coenen, Montes-Galdón & Smets (2019); BKR = Bernanke, Kiley & Roberts (2018); MW = Mertens & Williams (2019)
Household utility

- Household \( h \in (0, 1) \) maximises

\[
\mathbb{E}_t \sum_{\tau=t}^{\infty} D_{t,\tau} \left\{ \left( 1 - \frac{1}{\sigma} \right)^{-1} \left[ (C_{h,\tau} - \mu C_{\tau-1})^{1-1/\sigma} - 1 \right] - \frac{\omega_L L_{h,\tau}^{1+\psi}}{1 + \psi} \right\}
\]

- The discount factor is

\[
D_{t,\tau+1} = \bar{\beta} \left( \frac{C_{\tau}}{C} \right)^{\frac{\epsilon_\beta}{\sigma}} A_\tau D_{t,\tau}
\]

where \( a_t \equiv \ln A_t - \ln A \) evolves according to

\[
a_t = \rho_a a_{t-1} + \sigma_a \epsilon_t^a
\]
- Long-term bond issued at time $t$ with nominal value $V_t$ pays nominal coupons $1, \chi, \chi^2, \ldots$
- The value of a bond issued at date $t - j$ is $\chi^j V_t$
- The real value of long bond holdings is $B_{h,t} = \frac{V_t B^L_{h,t}}{P_t}$
- The one-period nominal return on the long-bond holding is $R^L_t \equiv \frac{1 + \chi V_t}{V_{t-1}}$
Household budget constraint is

\[ C_{h,t} + B_{h,t} + B_{h,t}^L = \frac{R_{t-1}^s}{\Pi_t} B_{h,t-1} + \frac{R_t^L}{\Pi_t} B_{h,t-1}^L + W_t L_{h,t} + \Phi_t - \Psi_{h,t} \]

The portfolio adjustment costs are given by

\[ \Psi_{h,t} = \tilde{\nu} \left[ \delta \frac{B_{h,t}}{B_{h,t}^L} - 1 \right]^2 + \tilde{\xi} \left[ \frac{B_{h,t}}{B_{h,t-1}} \frac{B_{h,t-1}^L}{B_{h,t}^L} - 1 \right]^2 \]

Results in pricing equation for the one-period return

\[ \mathbb{E}_t r_{t+1}^L = r_t^s - \nu (b_t - b_t^L) - \xi (\Delta b_t - \Delta b_t^L) + \bar{\beta} \xi \delta \mathbb{E}_t (\Delta b_{t+1} - \Delta b_{t+1}^L) \]
Government's debt issuance policy is given by:

\[ B_t^g = \bar{B} > 0, \quad B_t^{L,g} = \delta \bar{B} \]

Net purchases of long-term bonds by the central bank are

\[ N_t = Q_t - \frac{Q_{t-1}}{R_t^L} \]

The QE policy instrument is the fraction long-term debt purchased

\[ q_t = \frac{Q_t}{B_t^{L,g}} \]
Four step procedure

1. Calibrated parameters
   ▶ Typical ‘steady state’ parameters
   ▶ ‘Over-discounting’ parameters: set with reference to Gabaix (2016)

2. Bayesian estimation of key structural parameters
   ▶ UK and US data for output gap, inflation and policy rate
   ▶ Samples from 1954Q2 (US) and 1955Q2 (UK) to 2007Q4
   ▶ Monetary policy follows Taylor rule (Smets and Wouters, 2007)
   ▶ Priors from Smets and Wouters (2007)

3. Minimum distance estimation of ‘QE’ parameters
   ▶ Match long-term interest rate response to QE shock
   ▶ Use SVAR estimates from Weale and Wieladek (2016)

4. Loss function parameters
   ▶ Use ‘balanced’ specification (??)
   ▶ QE weights based on welfare-based loss function from Harrison (2017)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>United Kingdom</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Calibrated parameters</strong></td>
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<tr>
<td>Steady-state discount factor</td>
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<td>Long bond coupon decay</td>
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<td><strong>2. Estimated parameters</strong></td>
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<td>Habit formation</td>
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<td>Interest elasticity of demand</td>
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<td>Inverse Frisch elasticity</td>
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<td>Persistence of demand process</td>
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<td>Persistence of cost push shock</td>
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<tr>
<td>Standard deviation of demand shock</td>
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<td><strong>3. QE parameters</strong></td>
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<td>Portfolio share adjustment cost</td>
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<td>Portfolio change adjustment cost</td>
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<td><strong>4. Policy preferences</strong></td>
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<td>Weight on output gap</td>
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</tr>
<tr>
<td>Weight on QE stock</td>
<td>$\lambda_q$</td>
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</tr>
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</table>
Brendon et al. (2010) solution method
- Designed to handle multiple state variables
- Time-consistent Markov-perfect Stackelberg-Nash equilibrium
- Perfect foresight

Algorithm iterates over binding constraints indicators
- Solve for terminal steady state with non-binding constraints
- Guess constraints path in a transition from current to terminal state
- Solve backwards to obtain time-varying policy rules
- Check constraints and non-negativity of Lagrange multipliers

Simulation
- Draw shocks paths with $N + k$ periods
- Calculate transitions to the terminal state for each period
- Save current values for each period and burn the first $k$
Stochastic simulations under commitment

  - Capable of handling multiple state variables
  - Time-inconsistent policy plan
  - Perfect foresight

- Algorithm
  - Solve for unconstrained optimal policy under commitment
  - Introduce anticipated ‘shadow price shocks’ to satisfy constraints

- Simulation
  - Draw shocks paths with $N + k$ periods
  - Project with optimisation in first period
Sensitivity/robustness analysis

Interest rate smoothing in loss function, $\lambda_{\Delta r}$ (UK, $R^* = 0$)

- Other studies have found higher ZLB incidence, though typically assume simple rules
  - Kiley and Roberts (2017) 38% (33%) using FRB/US (DSGE) for $R^* = 1$

- Interest rate smoothing in loss function
  - Reduces ZLB incidence
  - Mimics ability to commit (Woodford, 2003)
  - Can help stabilize economy near ZLB (Nakata and Schmidt, 2019)
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- Habits, price stickiness and indexation higher in US
- Cost-push shocks more variable and persistent in UK