Monetary policy options in a ‘low for long’ era

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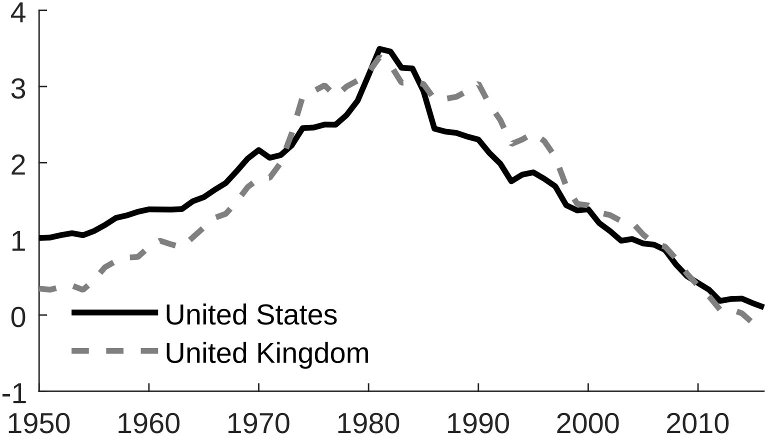
Motivation

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 Details

- 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 Details

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 Literature

- 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 Details

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

(1) $\pi_t = \beta_f \mathbb{E}_t \pi_{t+1} + \eta \pi_{t-1} + \kappa x_t - \frac{\kappa\mu}{1+\psi\sigma(1-\mu)} x_{t-1} + u_t$

(2) $x_t = \frac{1}{1+\mu+\varepsilon_\beta} \mathbb{E}_t x_{t+1} + \frac{\mu}{1+\mu+\varepsilon_\beta} x_{t-1} - \frac{\sigma(1-\mu)}{1+\mu+\varepsilon_\beta} \left(r_t^e - \mathbb{E}_t \pi_{t+1} - \hat{r}_t^* \right)$

(3) $r_t^e \equiv \frac{1}{1+\delta} r_t^s + \frac{\delta}{1+\delta} \mathbb{E}_t r_{t+1}^L$

(4) $\mathbb{E}_t r_{t+1}^L = r_t^s - \nu q_t - \xi \left(\Delta q_t - \bar{\beta} \mathbb{E}_t \Delta q_{t+1} \right)$

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 ($\hat{r}_t^* \equiv r_t^* - R^*$):

$$\hat{r}_t^* = \rho_a \hat{r}_{t-1}^* + \sigma_a \varepsilon_t^a, \qquad u_t = \rho_u u_{t-1} + \sigma_u \left(\varepsilon_t^u - \rho_{\varepsilon^u} \varepsilon_{t-1}^u \right)$$

Monetary policy

The baseline: 'pre-crisis consensus'

Policy minimizes loss function

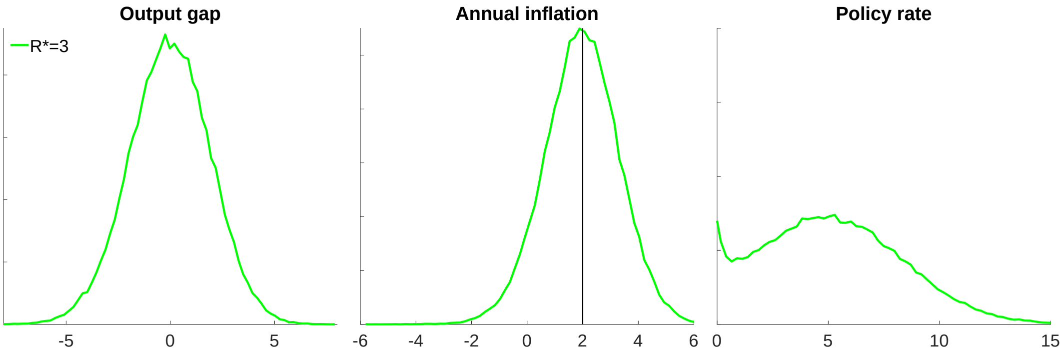
$$\mathscr{L}_t = \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left\{ (4\pi_\tau)^2 + \lambda_x x_\tau^2 + \lambda_{\Delta r} (4\Delta r_\tau^s)^2 \right\}$$

subject to: $r_t^s \geq zlb$

- 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’

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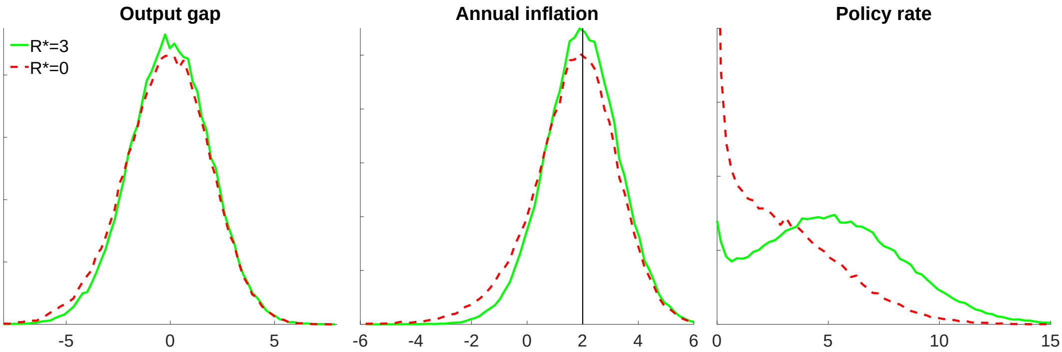
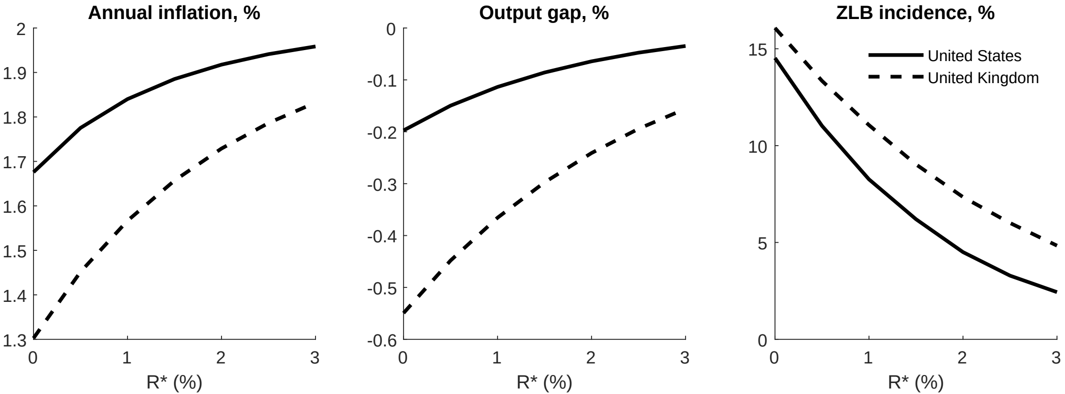


- But skews emerge as R* falls

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

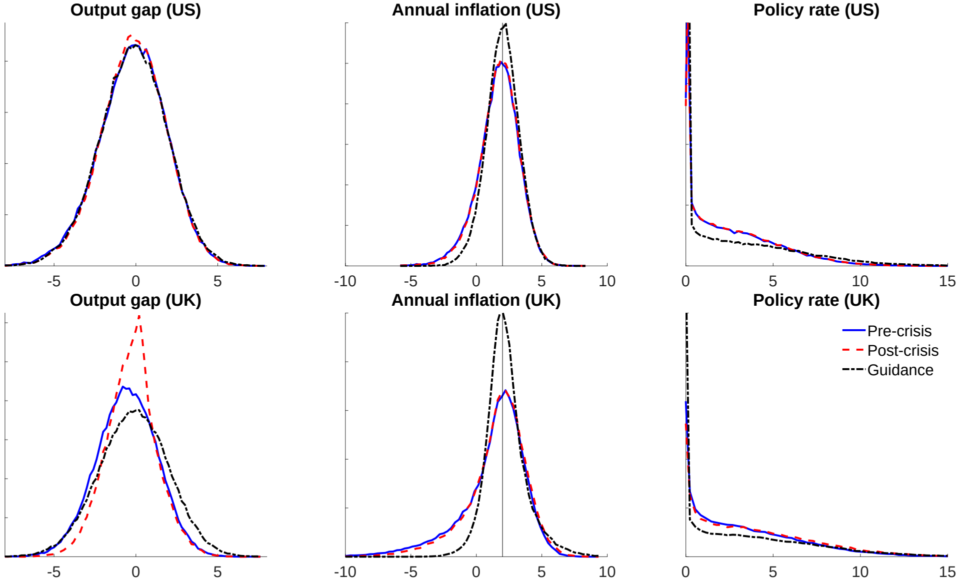
$$\mathscr{L}_t = \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left\{ (4\pi_\tau)^2 + \lambda_x x_\tau^2 + \lambda_{\Delta q} (\Delta q_\tau)^2 + \lambda_q q_\tau^2 + \lambda_{\Delta r} (4\Delta r_\tau^s)^2 \right\}$$

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

Strategy	Instruments	Commitment
'Pre-crisis consensus'	Short rate (r^s)	No
'Post-crisis revealed preference'	Short rate (r^s) & QE (q)	No
'Woodfordian forward guidance'	Short rate (r^s)	Yes

- 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' $(R^* = 0)$



Policy responses to ‘low for long’ ($R^* = 0$)

	Output gap		Inflation		Policy rate		ZLB			QE	
	Mean	StD	Mean	StD	Mean	StD	Frq	Dur	90pct	Frq	UB
UK											
Pre crisis	-0.55	1.83	1.30	2.85	3.12	3.13	0.16	4	13	–	–
Post crisis	-0.29	1.55	1.61	2.55	3.63	3.43	0.13	4	13	0.72	0.03
Guidance	-0.13	2.13	2.26	1.82	2.82	3.51	0.37	10	36	–	–
US											
Pre crisis	-0.20	2.07	1.68	1.82	2.58	2.52	0.15	5	17	–	–
Post crisis	-0.16	2.01	1.72	1.79	2.63	2.53	0.14	5	16	0.66	0.00
Guidance	-0.15	2.06	2.00	1.56	2.69	3.21	0.33	11	34	–	–

‘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

Preliminary conclusions & next steps

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

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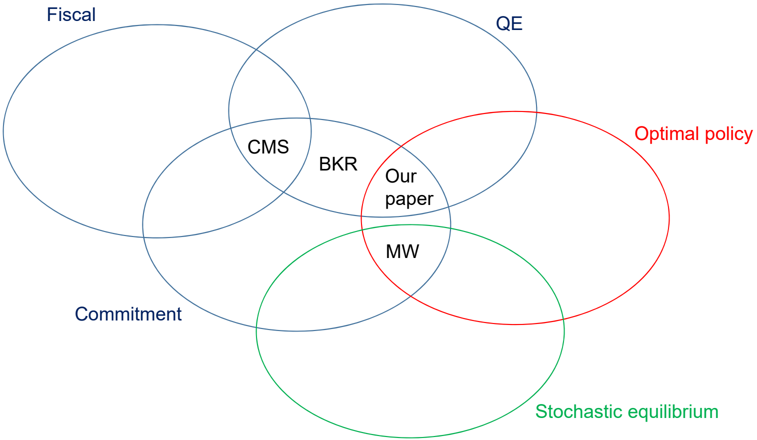
Selected literature Back

- 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
  - Hills et al. (2016), Kiley and Roberts (2017), Seneca (2016), Nakata and Schmidt (2019)
- Discussion of remedies
  - Bernanke (2017), Blanchard and Summers (2017), Williams (2017)
  - Hebden and López-Salido (2018), Kiley (2017), Chung et al. (2019)

Variations on a theme Back



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

Household utility Back

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

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

- The discount factor is

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

where $a_t \equiv \ln A_t - \ln A$ evolves according to

$$a_t = \rho_a a_{t-1} + \sigma_a \varepsilon_t^a$$

Long-term bonds Back

- 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

$$B_{h,t} = V_t \mathscr{B}^L_{h,t} / P_t$$

- The one-period nominal return on the long-bond holding is

$$R^L_t \equiv \frac{1+\chi V_t}{V_{t-1}}$$

Budget constraint Back

- Household budget constraint is

$$C_{h,t} + B_{h,t} + B^L_{h,t} = \frac{R^s_{t-1}}{\Pi_t} B_{h,t-1} + \frac{R^L_t}{\Pi_t} B^L_{h,t-1} + W_t L_{h,t} + \Phi_t - \Psi_{h,t}$$

- The portfolio adjustment costs are given by

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

- Results in pricing equation for the one-period return

$$\mathbb{E}_t r^L_{t+1} = r^s_t - \nu \left(b_t - b^L_t \right) - \xi \left(\Delta b_t - \Delta b^L_t \right) + \bar{\beta} \xi \delta \mathbb{E}_t \left(\Delta b_{t+1} - \Delta b^L_{t+1} \right)$$

Government and central bank Back

- 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

$$q_t = \frac{Q_t}{B_t^{L,g}}$$

Parameter values Back

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)

Parameter values Back

Parameter		United Kingdom	United States
1. Calibrated parameters			
Steady-state discount factor	$\bar{\beta}$	0.9925	0.9925
Overdiscounting	ε_β	0.175	0.175
Fraction of RoT price setters	ω	0.2	0.2
Relative long term debt	δ	1	0.3
Long bond coupon decay	χ	0.98	0.98
2. Estimated parameters			
Habit formation	μ	0.52	0.73
Interest elasticity of demand	σ	0.69	0.71
Inverse Frisch elasticity	ψ	0.83	0.81
Calvo price rigidity parameter	θ	0.80	0.90
Price indexation parameter	ι	0.32	0.93
Persistence of demand process	ρ_a	0.66	0.76
Persistence of cost push shock	ρ_u	0.86	0.16
MA coefficient of cost push shock	ρ_{ε^u}	0.48	0.40
Standard deviation of demand shock	σ_a	1.84	2.69
Standard deviation of cost push shock	σ_u	0.12	0.22
3. QE parameters			
Portfolio share adjustment cost	ν	3.28	1.60
Portfolio change adjustment cost	ξ	14.98	12.90
4. Policy preferences			
Weight on output gap	λ_x	0.25	0.25
Weight on interest rate changes	$\lambda_{\Delta r}$	1.00	1.00
Weight on QE change	$\lambda_{\Delta q}$	7.49	4.58
Weight on QE stock	λ_q	1.64	0.57

Stochastic simulations under discretion Back

- 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

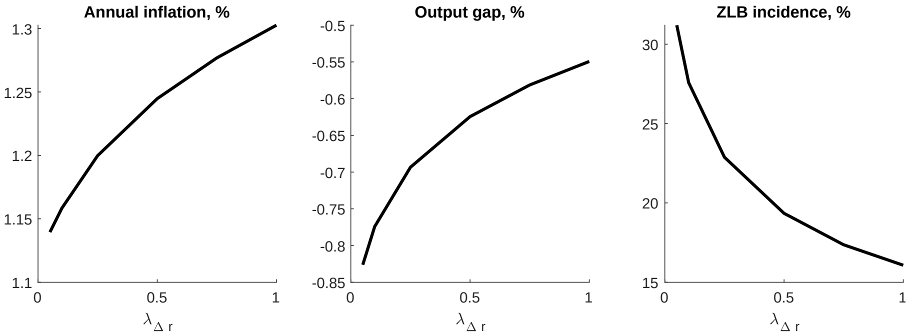
Stochastic simulations under commitment Back

- Dennis (2007) combined with Holden and Paetz (2012)
  - 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 Back

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)



Differences between UK and US results Back

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- Habits, price stickiness and indexation higher in US
- Cost-push shocks more variable and persistent in UK