Threshold-based forward guidance: hedging the zero bound

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Motivation & research question

- Forward guidance more actively used since policy rates became constrained by zero lower bound (ZLB)
- Guidance evolved from calendar based to threshold based:
  - "The Committee anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time" (Fed, 2008)
  - "... the repo rate is expected to remain at a low level until the beginning of 2011" (Riksbank, 2009)
  - "the MPC intends not to raise Bank Rate ... at least until ... the unemployment rate has fallen to a threshold of 7% ..." (BoE, 2013)
- Narrative evidence suggests that actual implementations of threshold-based guidance were not intended to provide stimulus

Q: Can threshold-based forward guidance (TBFG) stimulate the economy without being 'too' time inconsistent?

What we do

- Model TBFG as a temporary policy to improve outcomes at ZLB
- Use standard NK model with full-information rational expectations
  - Facilitates comparison with literature
- Fully stochastic global solution
  - Necessary ingredient to study state-contingent policy
- Compare various TBFG policies to CBFG and optimal policy

What we find

1. Credible TBFG can improve outcomes at ZLB (relative to discretion)
   - Provides stimulus via a state-contingent 'lower-for-longer' policy
2. TBFG improves on CBFG because of its hedging property
   - TBFG narrows variance of outcomes, delivering higher welfare
   - Less time inconsistent because stimulus adjusts to state of economy
3. Equilibrium existence and uniqueness requires policymaker to be precise about what the threshold conditions mean

(Some) related literature

- Optimal policy at ZLB under discretion and commitment:
  Adam and Billi (2006, 2007); Bodenstein et al (2012)
- Proposals for policy stimulus at ZLB (via expectations manipulation):
  Krugman (1999); Eggertson & Woodford (2003); Evans (2012)
- TBFG in restricted settings:
  Coenen and Warne (2013); Florez-Jimenez and Parra-Polania (2014)

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Forward guidance in practice: Odyssean, Delphic or other?

Campbell et. al. (2012), Faust (2015)

- **Odyssean:** Central bank binds itself to the mast to avoid the siren song that draws central bankers to stifle parties
  - An optimal response according to (New Keynesian) theory (e.g., Krugman, 1998; Eggertsson & Woodford, 2003)
  - Attempt to stimulate economy by committing to low rates in future
  - Policy is time inconsistent: incentive to renege when the time comes
- **Delphic:** Central bank provides signal about outlook for macroeconomic fundamentals
  - No news about policy reaction function
  - Policymaker reveals some private information
- **Other:** Clarification of (possibly evolving) reaction function

Practice: probably not Odyssean (most likely ‘other’)

Odyssean guidance seen as incredible or unachievable

- *. . . to achieve a better path for the economy over time, a central bank may need to commit credibly to maintaining a highly accommodative policy even after the economy and, potentially, inflation picks up. Market participants may doubt the willingness of an inflation-targeting central bank to respect this commitment if inflation goes temporarily above target. These doubts reduce the effective stimulus of the commitment and delay the recovery.* (Carney, 2012)
- *This guidance is intended primarily to clarify our reaction function . . . rather than to inject additional stimulus by pre-committing to a time-inconsistent ‘lower for longer’ policy path . . . While such a time-inconsistent policy may be desirable in theory, in an individualistic committee like ours, with a regular turnover of members, it is not possible to implement a mechanism that would credibly bind future members in the manner required.* (Bean, 2013)

Our conjecture

- TBFG can be used to provide (Odyssean) stimulus
- Extent of time inconsistency reduced by a ‘hedging’ property
- In ‘good’ states of the world
    - Economy improves faster than originally expected
    - Thresholds will be breached earlier than expected
    - Policy expected to tighten sooner: stimulus is removed
- In ‘bad’ states of the world
    - Economy recovers more slowly than originally expected
    - Thresholds will be breached later
    - Policy rate expected to stay at ZLB for longer: additional stimulus

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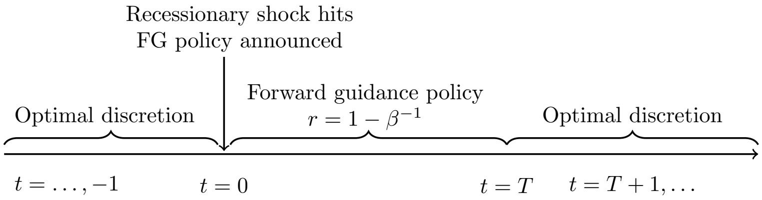
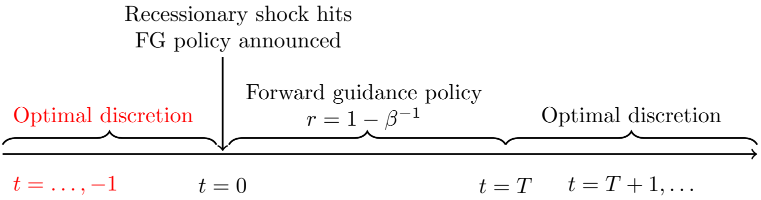
Environment

Overview of events



Environment

Pre-recession policy



- Up until period $t = 0$, policy set optimally
- No access to commitment technology: optimal discretion

Model and baseline description of policy

Solution follows Adam and Billi (2007) ‣ Details

- Linearised NK model with policymaker acting under OD s.t. ZLB

$\min_{\{y_t,\pi_t,r_t\}} \mathbb{E}_t \sum_{i=0}^{\infty} \beta^i (\pi_{t+i}^2 + \lambda y_{t+i}^2)$	Objective
$s.t \;\; r_t \geq 1 - \beta^{-1}$	ZLB constraint
$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa y_t + u_t$	Phillips curve
$y_t = \mathbb{E}_t y_{t+1} - \sigma \left(r_t - \mathbb{E}_t \pi_{t+1} \right) + g_t$	IS curve
$u_t = \rho_u u_{t-1} + \sigma_u \varepsilon_t^u$	Cost-push process
$g_t = \rho_g g_{t-1} + \sigma_g \varepsilon_t^g$	Demand process
$\varepsilon_t^u \sim iid\ N(0,1), \;\; \varepsilon_t^g \sim iid\ N(0,1)$	Shock processes
$\mathbb{E}_t \{y_{t+i}, \pi_{t+i}, r_{t+i}\}_{i=1}^{\infty}$ given	Expectations
$\{u_t, g_t\}$ given	Exogeneity and timing

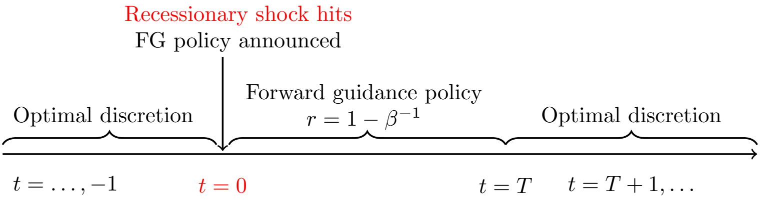
Baseline parameter values

- Follows papers in this literature, e.g. Adam & Billi (2006, 2007)

Parameter	Description	Value
β	Discount factor	0.9913
σ	Interest elasticity of output	6.2500
κ	Slope of Phillips curve	0.0240
λ	Weight on output in loss function	0.0031
b	Zero lower bound	-0.0088
ρ_u	Persistence of cost-push process	0.0000
σ_u	St. dev. of cost-push shocks	0.1540
ρ_g	Persistence of demand process	0.8000
σ_g	St. dev. of demand shocks	1.5240

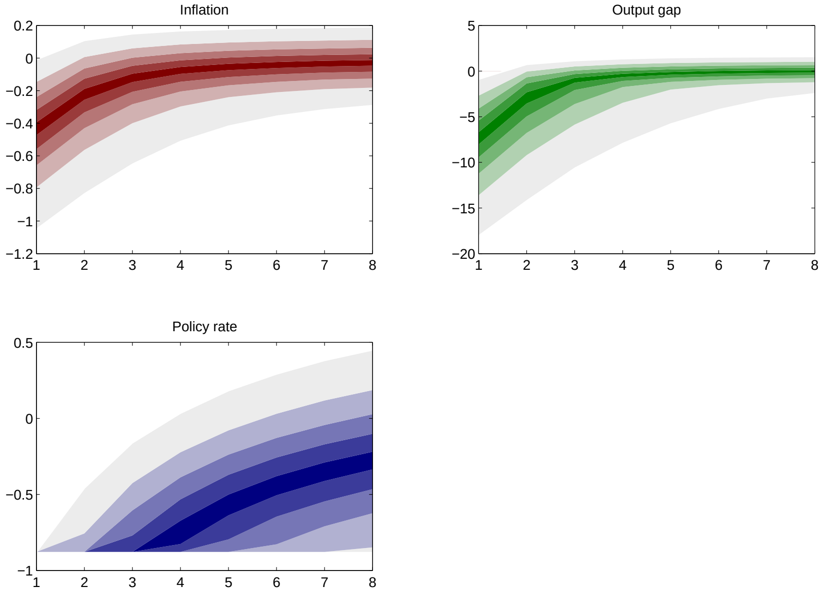
Environment

Recessionary shock



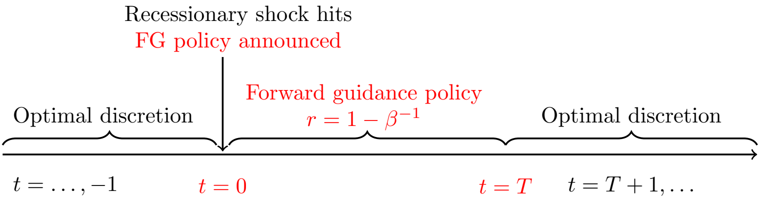
- Very bad shock arrives in period $t = 0$, driving policy rate to ZLB
- Calibration implies modal output gap is -7.5% in $t = 1$ under OD
- $\implies g_0 = -9.4$

Distributions under optimal discretion



Environment

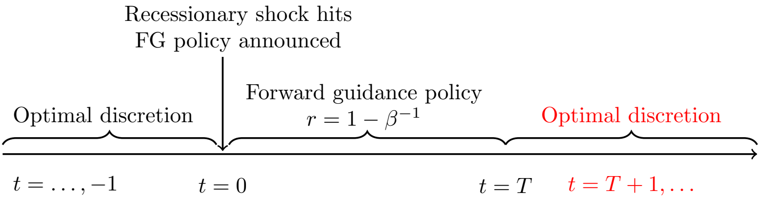
Forward guidance policies



- In period $t = 0$ policymaker announces forward guidance policy
- Policy rate held at zero bound until conditions for exit are met
  - CBFG: exit depends only on time, $T (= K)$ is deterministic
  - TBFG: exit depends only on state of the economy, T stochastic

Environment

Exit from forward guidance



- After exit, policy reverts to OD forever
  1. FG policy is transitory or 'one-off'
     - Expectations are rational given policy announcements ...
     - ... but switch to TBFG regime is a zero probability event
     - Results likely to be sensitive to this assumption (Cooley et al, 1984)
  2. FG policy is credible: policymaker fully committed to TBFG
     - Seemingly at odds with OD baseline assumption
     - We assess ex-post validity via time-inconsistency measures

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Equilibrium under TBFG

Key elements

A. Exit from TBFG at date t occurs with probability p_t

- If variable(s) have not breached threshold(s): $p_t = 0$
- If variable(s) have breached threshold(s): $p_t \in (0, 1]$

B. Requires intra-period timing assumption:

1. States (g_t, u_t) revealed to all agents
2. Private sector makes decisions (y_t, π_t)
3. Central bank sets policy:
   3.1 With probability $1 - p_t$ set $r_t = 1 - \beta^{-1}$
   3.2 With probability $1 - p_t$ set policy according to OD

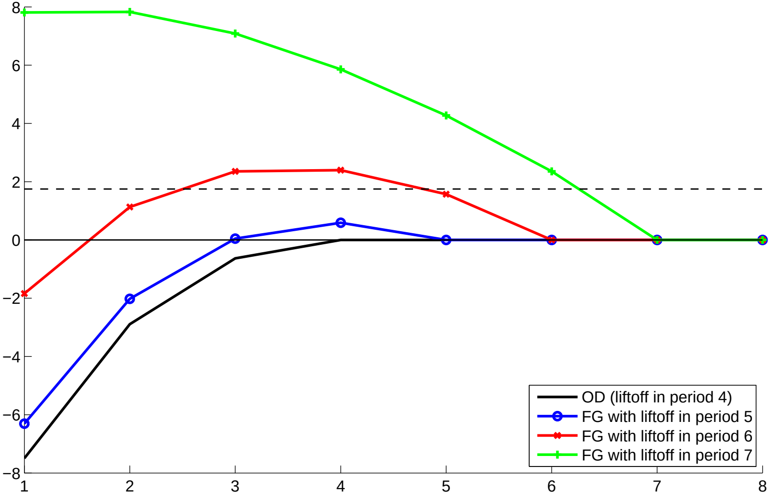
- Decisions in step 2 depend on expected policy set in step 3
- Probability in step 3 depends on private sector decisions in step 2

Intuition for probabilistic exit: a deterministic example

- Setup as before: $g_0 \ll 0$ so ZLB binds under OD
- No uncertainty: $\sigma_g = \sigma_u = 0$
- Then g evolves on deterministic path: $g_t = \rho_g^t g_0$
- Policymaker can:
  - Continue to follow optimal discretion (i.e. do nothing)
  - Announce a CBFG policy
  - Announce a TBFG policy
- Expect TBFG and CBFG to be equivalent in deterministic setting

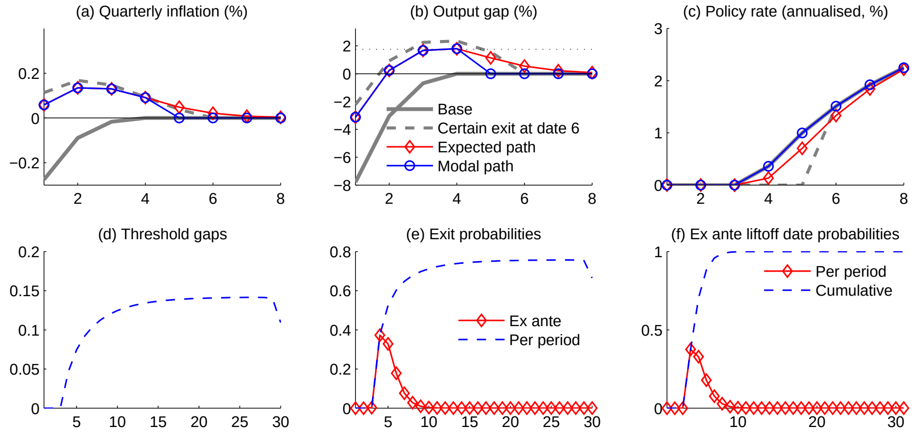
Output gap in deterministic example

When does exit occur if output gap threshold is 1.75 (dashed line)?



Probabilistic exit (using Haberis et al (2014) approach)

$p_t = 1 - \exp\left[-\alpha_y^{-1}\left(y_t - \bar{y}\right)\right], \quad \alpha_y = 0.1, \quad \bar{y} = 1.75$



Plan for talk

Solution method

- Policy function iteration using time iteration
  - Very similar to OD solution approach
- Iterations adapted to include update of exit probabilities
  - Damping used (strong feedback from probabilities to policy functions)
- At each iteration, we solve, for each state s:

$$
\begin{aligned}
y^{FG}(s) &= p(s)\,\mathbb{E}_{s'|s}y^{OD}\left(s'\right) + (1-p(s))\,\mathbb{E}_{s'|s}y^{FG}\left(s'\right) \\
&\quad - \sigma \left\{ \begin{array}{l} p(s)\,r^{OD}(s) + (1-p(s))\left(1-\beta^{-1}\right) \\ -\left[p(s)\,\mathbb{E}_{s'|s}\pi^{OD}(s') + (1-p(s))\,\mathbb{E}_{s'|s}\pi^{FG}(s')\right] \end{array} \right\} + g \\
\pi^{FG}(s) &= \kappa y^{FG}(s) \\
&\quad + \beta\left[p(s)\,\mathbb{E}_{s'|s}\pi^{OD}\left(s'\right) + (1-p(s))\,\mathbb{E}_{s'|s}\pi^{FG}\left(s'\right)\right] + u
\end{aligned}
$$

- Output gap threshold example:
  $p(s) = f(y(s) - \bar{y}) = 1 - \exp\left(-\alpha_y^{-1}\max\{y(s) - \bar{y}, 0\}\right)$

Alternative threshold specifications

- We use an exponential distribution:

$$p(y) = f(y - \bar{y}) = \begin{cases} 0 & \text{if } \; y \leq \bar{y} \\ 1 - \exp\left(-\alpha_y^{-1}(y - \bar{y})\right) & \text{if } \; y > \bar{y} \end{cases}$$

- Benefits
  - One parameter
  - Can be calibrated to be close to a 'trigger'
- We choose a calibration close to a 'trigger' ▸ Calibration details
  - Want to minimise effect of probabilistic exit on results
  - Sensitivity analysis for 'looser' variants based on survey evidence
- Examine thresholds based on single variables and 'dual thresholds'
  - 'AND' version: non-zero exit probability iff <u>both</u> thresholds breached
  - 'OR' version: non-zero exit probability iff <u>either</u> threshold breached
- 'Real world' threshold-based policies closer to 'OR' variant

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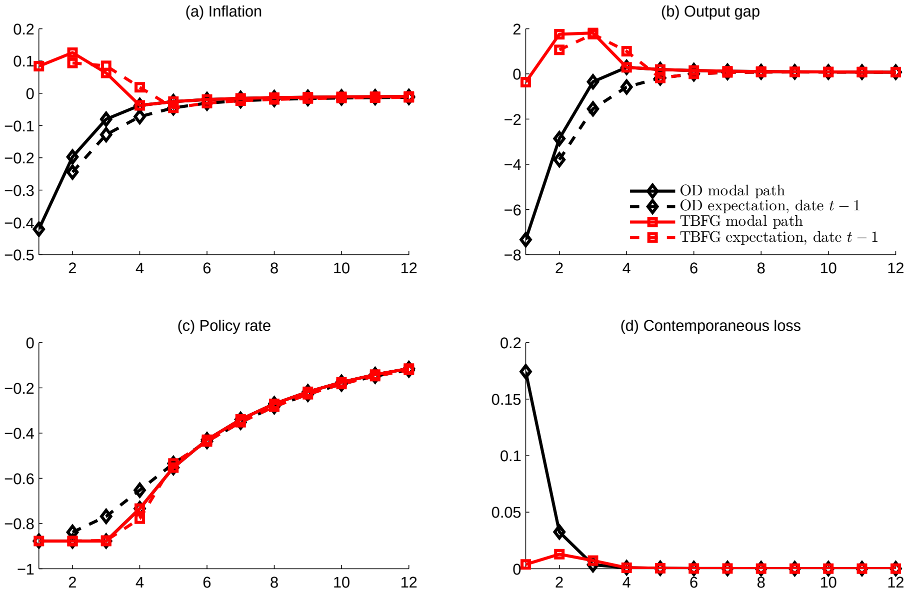
Headlines: ex ante losses $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t (\pi_t^2 + \lambda y_t^2)$

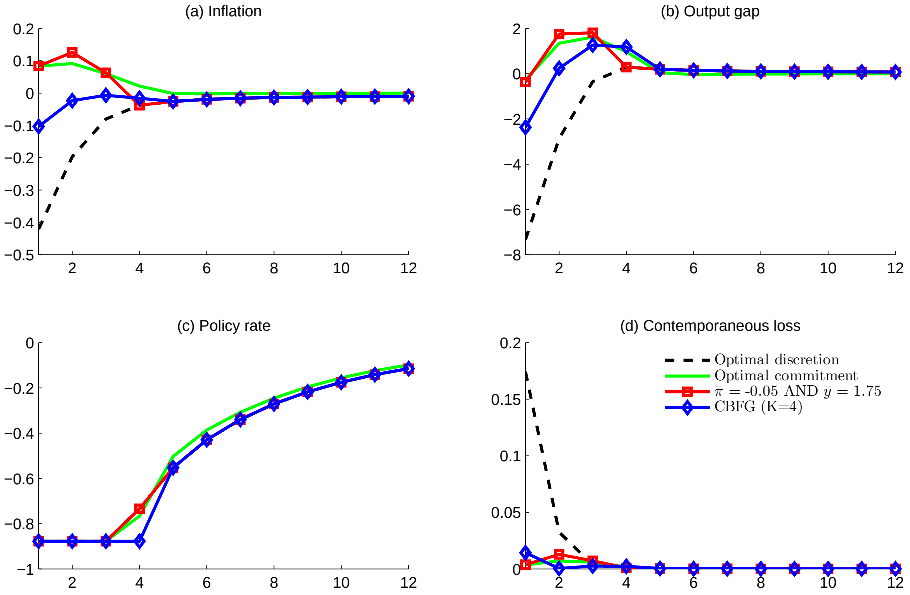
Threshold based forward guidance improves outcomes relative to optimal discretion

Threshold type	$\bar{\pi}^*$	$\bar{y}^*$	Loss	$\frac{\text{Loss}}{\text{Loss(OD)}}$
Inflation threshold	0.15	–	0.377	0.444
Output gap threshold	–	2	0.334	0.394
Dual OR threshold	0.3	2.25	0.333	0.392
Dual AND threshold	-0.05	1.75	0.332	0.391

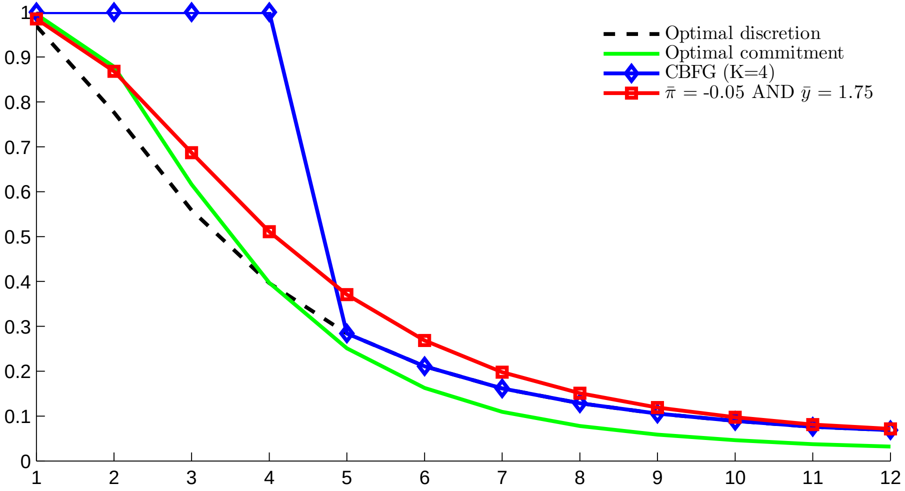
Guidance works via expectations



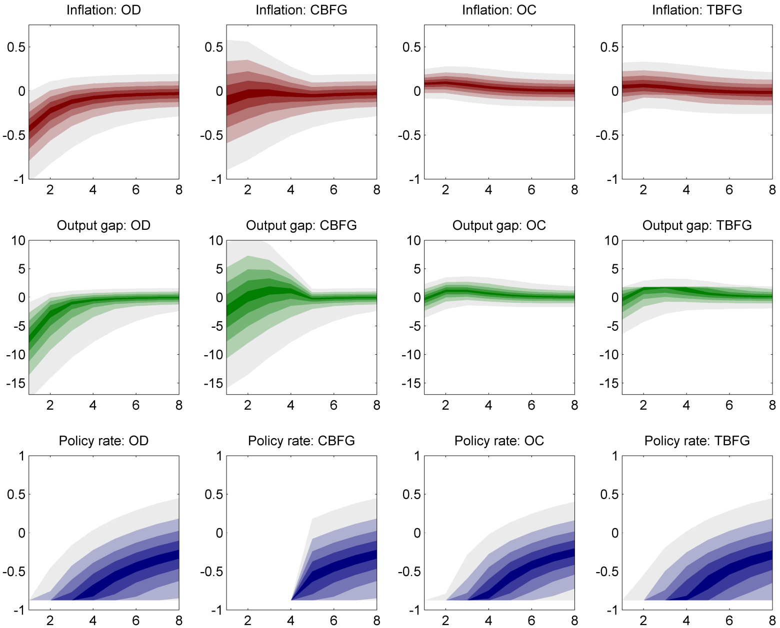
Threshold-based guidance versus other policies



Probabilities of being at the ZLB for alternative policies

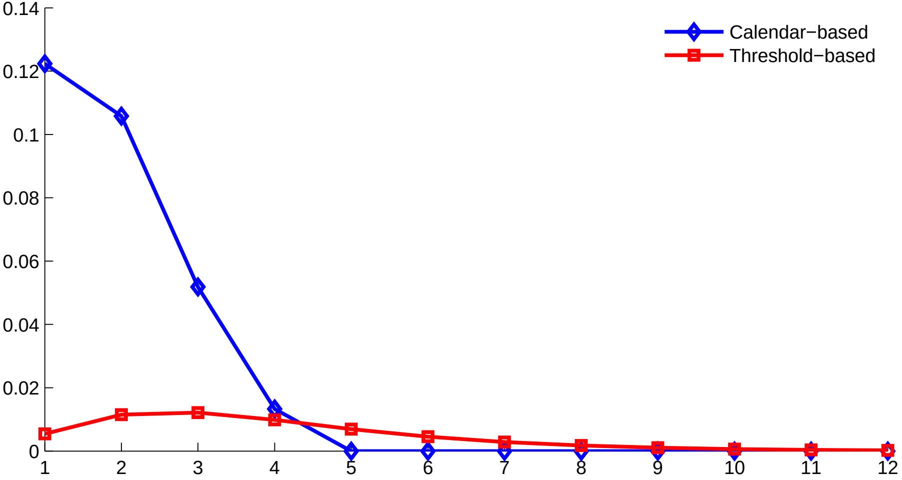


Distributions for alternative policies



Time inconsistency

$$\mathbb{T}_t^P = \int_u \int_g \psi_t^P(u,g)\left(\mathbb{L}_t^P(u,g) - \mathbb{L}_t^{OD}(u,g)\right)\mathbb{I}\left(\mathbb{L}_t^P(u,g) - \mathbb{L}_t^{OD}(u,g) > 0\right)$$



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Concluding remarks

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2. TBFG improves on CBFG because of its hedging property
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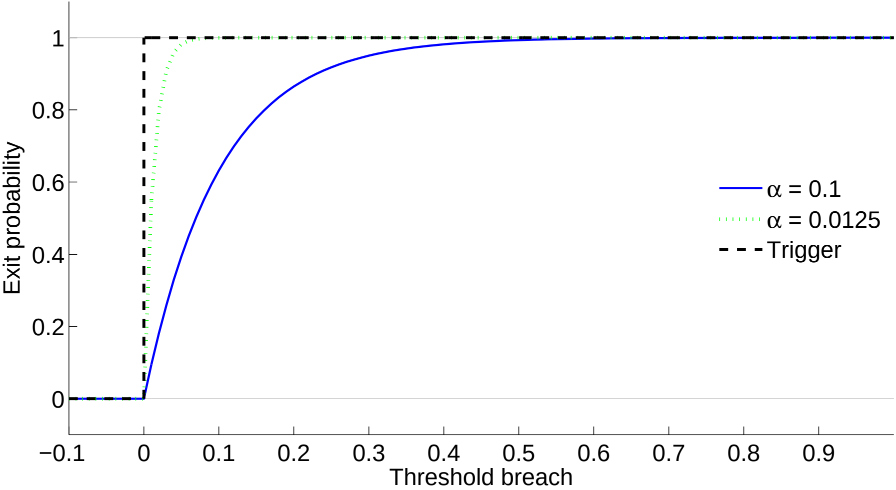
Threshold calibration ‣ Back



- New York Fed Primary Dealer Survey implies that market participants interpreted FOMC threshold-based guidance was far from a trigger

Solution method (Adam and Billi, 2007) ▸ More details ▸ Back

- In absence of ZLB policymakers' FOC is

$$y_t = -\frac{\kappa}{\lambda}\pi_t$$

- Perfect stabilisation in response to demand shocks; manage trade-off in response to cost-push shocks
- In presence of ZLB constraint, no analytical solution
- Use projection methods to approximate 'policy functions': $\pi^{OD}(u,g)$ and $y^{OD}(u,g)$
- Key ingredients
  - FOC still applies if ZLB is not binding
  - Expectations approximated by quadrature

$$\mathbb{E}^{OD}(u,g)\,y' = \int_{\epsilon^{u'}} p\left(\epsilon^{u'}\right) \int_{\epsilon^{g'}} p\left(\epsilon^{g'}\right) y^{OD}\left(u',g'\right) d\epsilon^{g'} d\epsilon^{u'}$$

OD solution method details ‣ Back

0. Create finite (tensor product) grid of cost-push and demand states
1. Take guess for $\pi^{OD}(u,g)$ and $y^{OD}(u,g)$ that solve problem on the grid (using solution to problem with no ZLB)
2. Insert this guess in place of next period's policy functions and evaluate expectations on the grid using a finite sum approximation to e.g.:

$$\mathbb{E}^{OD}(u,g)\,y' = \int_{\epsilon^{u'}} p\left(\epsilon^{u'}\right) \int_{\epsilon^{g'}} p\left(\epsilon^{g'}\right) y^{OD}\left(u',g'\right) d\epsilon^{g'} d\epsilon^{u'}$$

3. Compute outcomes conditional on expectations:
   - 3.1 Assume ZLB is not binding and use FOC of policymaker that to solve for $\pi^{OD}(u,g)$ and $y^{OD}(u,g)$
   - 3.2 Compute policy rate implied by that solution: if $r^{OD}(u,g) \geq b$, then solution is valid; if not, recompute outcomes by setting $r^{OD}(u,g) = b$
4. If $\pi^{OD}(u,g)$ and $y^{OD}(u,g)$ have both converged, stop; else, update guess and return to step 2