The Negative Mean Output Gap

Shekhar Aiyar and Simon Voigts (both IMF)

2022 Congress of the European Economic Association

Motivation

The output gap is a central feature of modern macroeconomics and its estimates are a key input to policy-making.

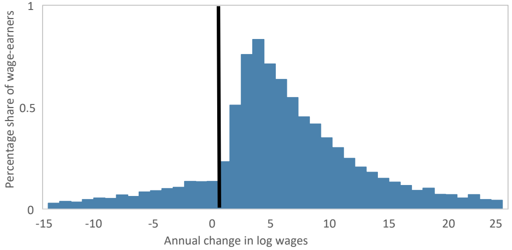
A common view posits that the output gap is zero on average, as a result of symmetric fluctuations of output around potential.

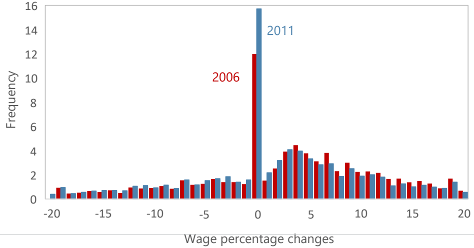
How plausible is this view, and what are the consequences if it was wrong?

- The mean gap is negative in a search-and-matching NK model with downard nominal wage rigidity.
- This leads to a ‘symmetry bias’: Most output gap filters assume symmetry and therefore underestimate potential, especially after grave downturns.
- The bias impedes the calibration of counter-cyclical policies, leading to large output costs in deep recessions.

Motivation: Downward nominal wage rigidity (DNWR)

There is overwhelming empirical evidence for DNWR. If nominal wage cuts are rare, the distribution of nominal wage changes is extremely non-normal.





Charts from Dickens et al. (2007) and Daly et al. (2013)

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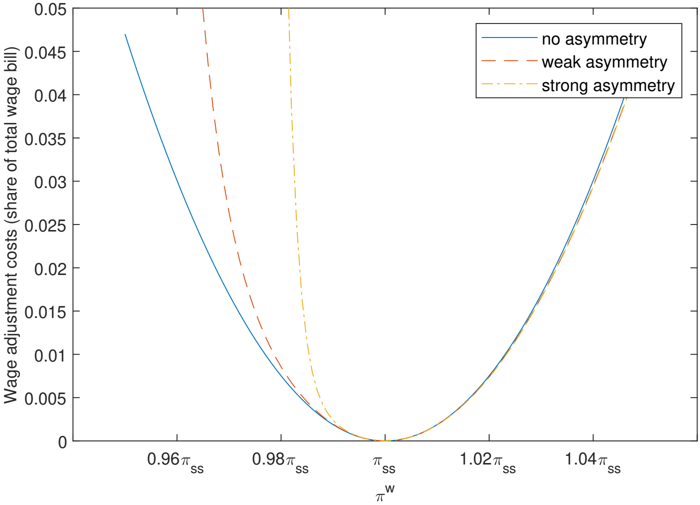
Model description: Overview

We build on the Abbritti and Fahr (2013) New-Keynesian DSGE model.

- Households are large families whose members pool consumption and insure each other against employment risk.
    - Access to risk-free nominal bonds yields a standard Euler Equation.
    - Risk-premium shocks induce variations in consumption as in Smets and Wouters (2007).
- Wholesale firms produce a homogeneous good from capital and labor.
    - Standard production function with shocks to TFP.
- Retail firms apply price markup subject to nominal rigidity.
- Wage rigidity where adjusting downwards is more costly than upwards.
- Standard Taylor Rule.

We add a stylized fiscal sector as in Monacelli, Perotti and Trigari (2010).

Illustration of wage adjustment costs



Model description: Output gap

Potential output Y_t^{flex} in NK models is output under price and wage flexibility.

We use a modified measure of potential, $\tilde{Y}_t^{flex} = Y_t^{flex} - \Lambda$, where Λ is a constant to correct for the risk-channel of nominal rigidity (discussed later).

The output gap is then given by:

$$gap_t = \frac{Y_t^{rigidity} - \tilde{Y}_t^{flex}}{\tilde{Y}_t^{flex}}.$$

Model description: Monetary policy

Monetary policy is follows standard Taylor rule with interest rate smoothing. ω_{gap} governs the weight of the output gap.

$$i_t = i_{t-1}^{\omega_r} \left(\frac{1}{\beta} \pi_t^{\omega_\pi} \text{gap}_t^{\omega_{\text{gap}}} \right)^{\omega_r - 1}$$

$\omega_{\text{gap}} = 0$ in all simulation other than those on the implications of the bias for monetary policy calibration.

Model description: Fiscal policy

For $\phi < 0$, G_t moves in the opposite direction than the output gap. It is fully financed by lump-sum taxes $T_t = G_t$ in each period.

$$G_t = \phi \, gap_t$$

Since the fiscal multiplier is about 0.25, the rule moves actual output closer to potential, i.e. stabilizes fluctuations in the output gap.

$\phi = 0$ in all simulation other than those on the implications of the bias for fiscal policy calibration.

All parameter values other than those of exogenous shocks processes are from Abbritti and Fahr (2013) and fit an representative advanced economy.

Under the original calibration, the standard deviation of the gap is 0.55 percent of potential, which is at odds with estimates (typically 3 to 4 times larger).

$\Rightarrow$ Shocks processes are calibrated such that the standard deviation and first-order autocorrelation of potential output and of the output gap are in line with IMF estimates.

Model description: Calibration of output gap and potential dynamics

Calibration targets are based on IMF estimates for G7 countries from 1981-2017.

- Target for output gap dynamics: 1.77% standard deviation and an autocorrelation of 0.61.

  Replicated by risk-premium shocks with a variance of 0.33 and and an AR(1) coefficient of 0.85.

- Target for standard deviation of potential fluctuations around trend: 0.3% of trend potential (informed by residuals from regressing potential estimates on a time trend).

  Replicated by a productivity shock variance of 0.05 (standard parameter 0.95 for AR(1) coefficient).

$\Rightarrow$ Supply shocks induce mild and persistent variations of potential.
Demand shocks cause higher-frequency fluctuations of output around potential.

Model description: Impact of demand (risk-premium) shocks

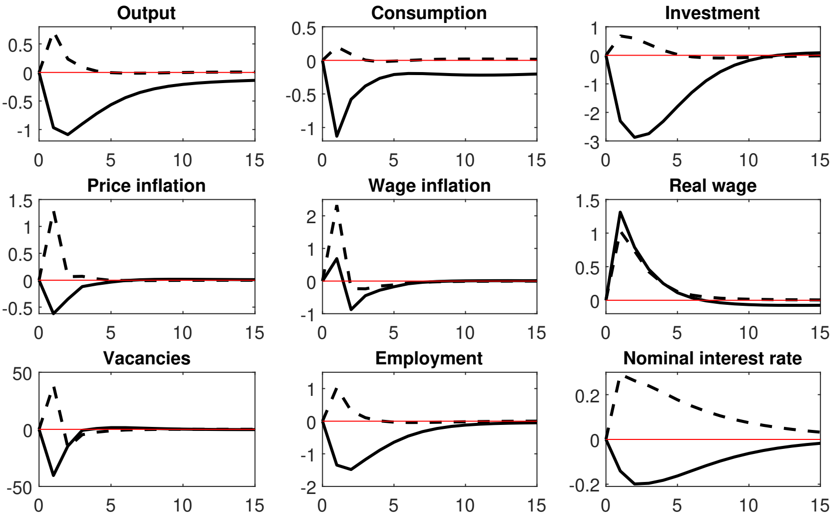
One-standard deviation demand (i.e. risk-premium) shock. What to expect:

- Contractionary demand shocks impact output more than expansionary shocks.
  - Expansionary shock: Wages rise more than prices
    $\Rightarrow$ Real wage increases
    $\Rightarrow$ Disincentive for hiring cushions shock-induced expansion
  - Contractionary shock: DNWR dampens decline in nomnal wages
    $\Rightarrow$ Wage decline falls short of price decline: Real wage increases
    $\Rightarrow$ Disincentive for hiring amplifies shock-induced contraction

- Demand are shocks neutral to real variables under nominal flexibility. (Potential constant, so any output deviation corresponds to a gap.)

Model description: Impact of demand (risk-premium) shocks

Solid is contractionary, dashed expansionary.



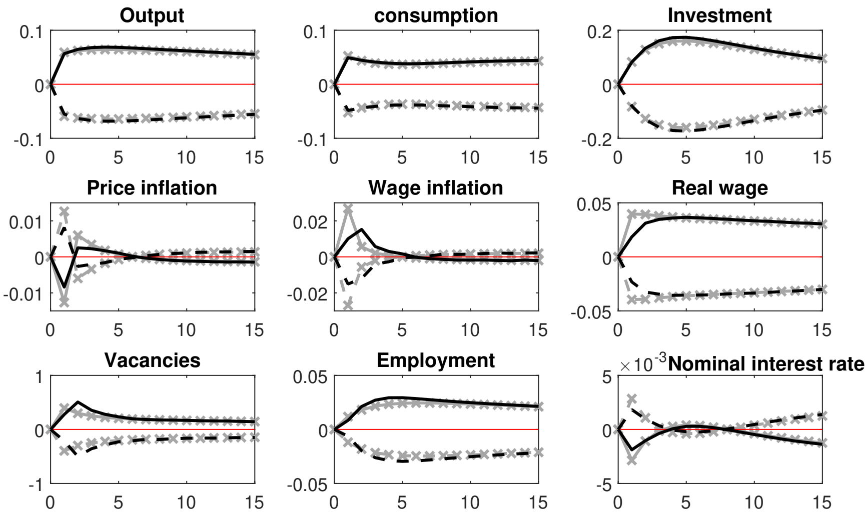
Model description: Impact of supply (productivity) shocks

One-standard deviation supply (i.e. productivity) shock. What to expect:

- For supply shocks, nominal rigidity plays no significant role. (Supply shocks do not open up output gaps.)
    - Whether or not the real wage can adjust freely only matters for the *flow* of newly hired workers, but not for the *stock* of workers in employment.
    - Nominal rigidity only negligibly impacts labor supply.

Model description: Impact of supply (productivity) shocks

Solid is positive, dashed negative. Grey lines are adjustment w/o nominal rigidity.



Part 2: Simulation exercises

- The risk-channel of nominal rigidity: Why it affects potential and motivates an adjusted definition.
- Simulations to compute the mean output gap.
- Simulations to assess accuracy of output gap filers.

Simulations: The risk-channel of nominal rigidity

The mean output gap is negative also under symmetric wage adjustment. In the second-order approximation of the model, uncertainty effects drive a wedge between the output distribution under nominal rigidity and flexibility.

- Demand shocks move output only under nominal rigidity, so output volatility is significantly higher than absent rigidity.
- Higher output volatility increases firms' option value of not hiring workers (uncertainty effect). This lowers output.

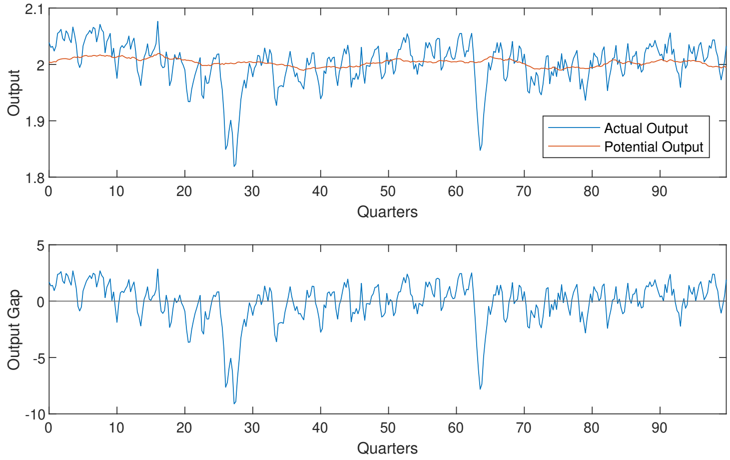
To focus on the consequences of DNWR for the mean output gap, the uncertainty-driven component is filtered:

Λ in the potential measure $\tilde{Y}_t^{flex} = Y_t^{flex} - \Lambda$ is set equal to the distance between mean output under flexibility and rigidity when wage adjustment is symmetric.

$\Rightarrow$ Uncertainty effects are incorporated in potential and drop out in $Y_t^{rigidity} - \tilde{Y}_t^{flex}$.

Simulations: Mean output gap

Mean output gap is -0.46% on average over the 30,000 simulated periods.



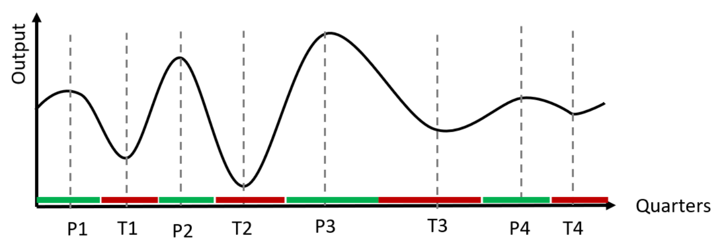
Simulations: Analysis of subsamples

Partitioning into expansionary and contractionary subsamples is based on the Harding-Pagan business cycle dating algorithm.

- Expansionary subsamples (green bars) consist of periods whose closest extrema is a peak.
- Contractionary subsamples (red bars) consist of periods closer to a trough than to a peak.

Results are also reported for subsets with a given share of the deepest recessions respectively highest expansions.

Illustration showing 4 full cycles:



Simulations: Analysis of subsamples

The negative mean gap is predominantly driven by periods of strong disruptions.

Included share of deepest contractions and highest expansions	Mean output gap in % of potential
Full sample	-0.46%
50%	-0.65%
25%	-0.90%
10%	-1.12%

$\Rightarrow$ In shallow downturns, real wages decline when nominal wage growth falls short of inflation (DNWR not binding).

Simulations: Accuracy of output gap filters

There are two approaches to assess the accuracy of filters:

- Historical perspective (common): Real-time estimates are compared to final estimates, which are interpreted as true output gap. The lesser the 'corrections' from real-time to final, the more accurate a filter.
- Analytical perspective (rare): Filters are applied on simulated data from a model (in which potential is observable).

We argue that the historical perspective is of limited use: E.g., a filter that estimates potential to be 10 USD at all times is deemed perfectly accurate.

$\Rightarrow$ We chose the analytical perspective, which has not yet been done with a non-linearized model.

Simulations: Accuracy of output gap filters

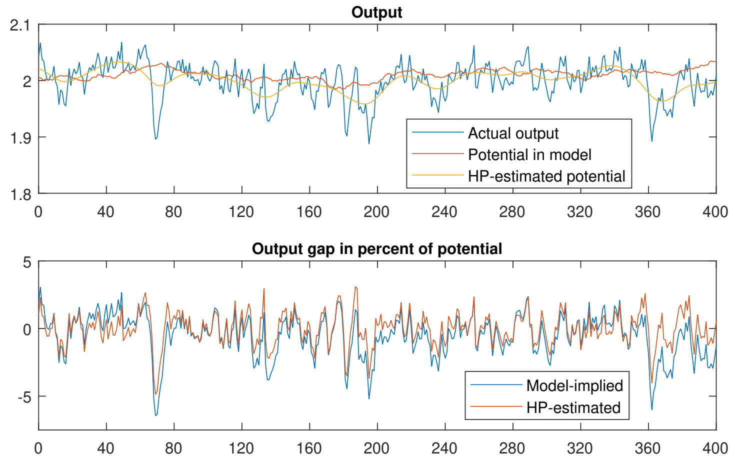
We analyze the accuracy of two illustrative zero-mean filters:

- Hodrick-Prescott Filter: We provide a simple proof that are zero on average, regardless of the sample size.
- IMF's multivariate filter (Blagrave et al., 2015): Estimates zero on average because gap is modelled as $gap_t = \phi\, gap_{t-1} + \epsilon_t$ with $0 < \phi < 1$.

$\Rightarrow$ Symmetry bias of HP is enormous, the multivariate filer performs better but is sill highly inaccurate during deep recessions.

Simulations: Hodrick-Prescott Filter

During large negative gaps, the zero-mean property of the HP filter 'drags down' estimated potential.



Simulations: Hodrick-Prescott Filter

Symmetry bias in subsamples with same partitioning as before.

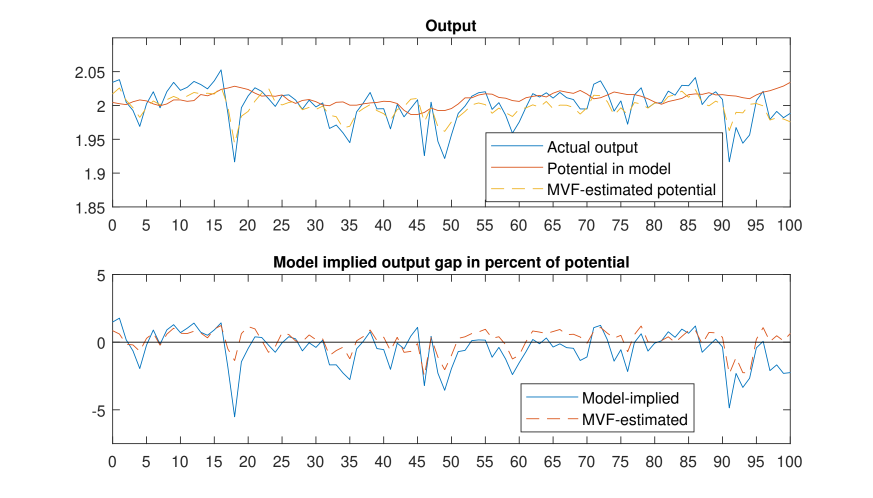
$\Rightarrow$ Bias largest in deep recessions.

	True gap	Estimated gap	Bias	Estimated gap closing
Expansionary Subsamples				
All expansions	0.19%	0.34%	0.14%	0.4 quarters too soon
50% highest	0.67%	0.25%	-0.41%	2.0 quarters too soon
25% highest	0.88%	0.22%	-0.66%	3.1 quarters too soon
10% highest	1.04%	0.19%	-0.85%	3.5 quarters too soon
Contractionary Subsamples				
All recessions	-1.13%	-0.34%	0.78%	4.1 quarters too soon
50% deepest	-1.98%	-0.43%	1.54%	8.2 quarters too soon
25% deepest	-2.68%	-0.53%	2.14%	11.4 quarters too soon
10% deepest	-3.28%	-0.58%	2.69%	14.0 quarters too soon

A positive bias value indicates underestimation of potential.

Simulations: The IMF's multivariate Filer

Incorporating an Okun's law relationship and a Phillips curve improves accuracy, but gap is still significantly underestimated in deep recessions.



Simulations: The IMF's multivariate Filer

Underestimation of negative gaps large in deep slumps.

	True gap	Estimated gap	Bias	Estimated gap closing
Expansionary Subsamples				
All expansions	0.22%	0.69%	0.48%	0.62 years too late
50% highest	0.70%	1.06%	0.36%	0.53 years too late
25% highest	0.89%	1.21%	0.31%	0.40 years too late
10% highest	1.12%	1.38%	0.26%	0.15 years too late
Contractionary Subsamples				
All recessions	-1.16%	-0.68%	0.48%	1.54 years too soon
50% deepest	-1.95%	-1.33%	0.62%	2.59 years too soon
25% deepest	-2.54%	-1.81%	0.73%	3.02 years too soon
10% deepest	-3.10%	-2.24%	0.86%	3.48 years too soon

A positive bias value indicates underestimation of potential.

Part 3: Policy implications

- Monetary policy: Closing the gap is part of the mandate in many countries.
- Fiscal policy: Gap matters for many fiscal rules (e.g., the EU's Stability and Growth Pact) and for countercyclical calibration in general.

What are the macroeconomic implications of calibrating policies on estimates suffering from the symmetry bias?

$\Rightarrow$ To answer this, we make monetary respectively fiscal policy depended on the output gap. Then, we compare simulations where policy is based on the true gap with simulation where the gap is estimated.

Policy implications

The following results are based on the HP filter.

Policymaking is based on real-time estimates, which are influenced by forecasts of future output.

We examine two illustrative polar cases to examine the role of the forecast:

- 2-sided HP with perfect foresight.
- 1-sided HP filter (no forecast).

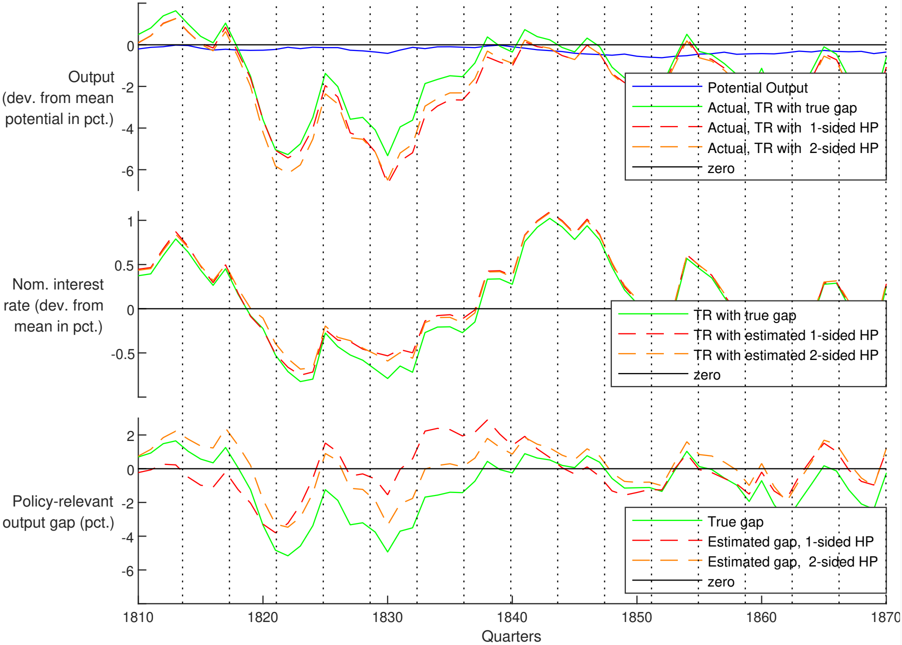
$\Rightarrow$ Results are broadly similar under both assumptions.

Monetary policy:

To make closing the output gap part of the central bank mandate, we use the standard parameter $\omega_{gap} = 0.125$ (see e.g. Gopinath et al., 2020) in the Taylor Rule:

$$i_t = i_{t-1}^{\omega_r} \left(\frac{1}{\beta} \pi_t^{\omega_\pi} \mathrm{gap}_t^{\omega_{\mathrm{gap}}} \right)^{\omega_r - 1}$$

Illustrative subset with deep recession where the bias weakens policy response.



Policy implications Event-style Analysis

Our event-style analysis allows to analyze average business cycle peaks and troughs. Based on the Harding-Pagan algorithm to identify peaks and troughs:

For the peak event:

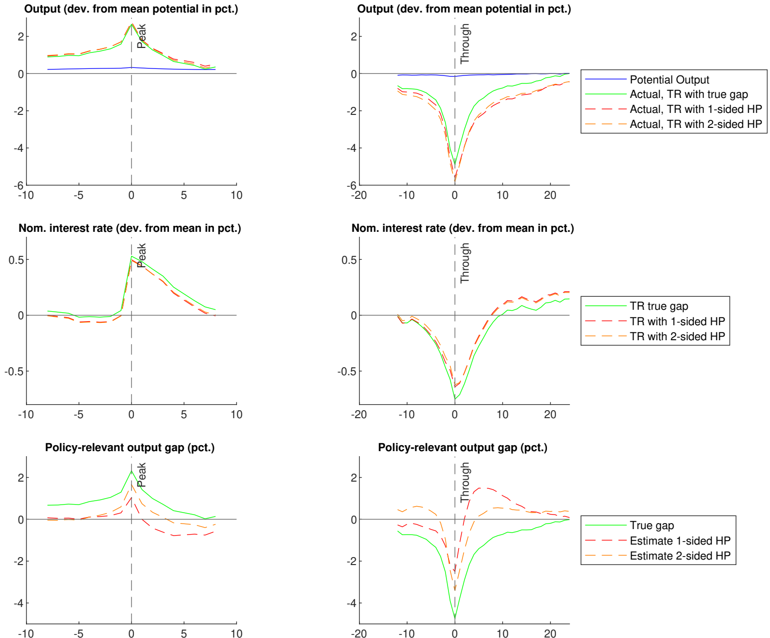
- Partition sample into subsamples from trough to trough (each has 1 peak).
- Center all subsamples around their peak (so peaks are at $t = 0$).
- average across subsamples.

For the trough event:

- Partition into subsamples peak to peak (so each has one trough).
- Center all around their troughs.
- average across subsamples.

We also report events where only a subset of the higher peaks / deepest troughs enter the average.

Monetary policy, 25% most extreme peaks (left) and troughs (right).



Policy implications Monetary Policy

We compute present values of output gaps from the perspective of the trough period (expressed in % of mean potential).

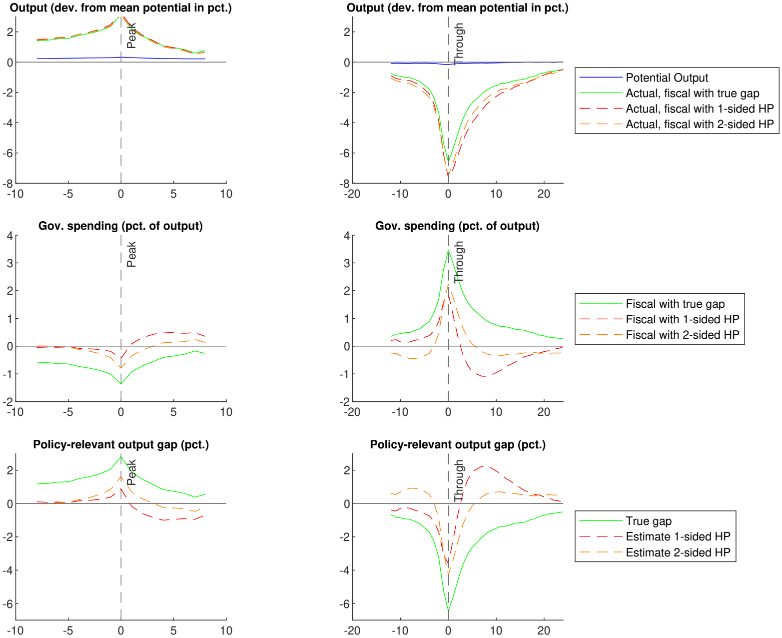
Share deepest troughs	True gap	1-sided HP	2-sided HP
Full sample	-7.0	-10.9	-10.3
50%	-17.4	-30.0	-29.1
25%	-24.1	-40.7	-39.5
10%	-32.0	-55.3	-53.7

Fiscal policy:

$\phi = 0.5$ is a illustrative scenario where fiscal policy is counter-cyclical to close the output gap (multiplier is about 0.25).

$$G_t = \phi \, gap_t$$

Fiscal policy, 25% most extreme peaks (left) and troughs (right).



PVs of output gaps are again from the perspective of the trough period.

Share deepest troughs	True gap	1-sided HP	2-sided HP
Full sample	-10.5	-15.5	-13.0
50%	-28.8	-38.3	-34.4
25%	-44.6	-58.5	-53.7
10%	-63.2	-83.6	-77.8

Conclusion

- Output gap negative on average in a NK model with labor search frictions and DNWR.
- Filters are unable to accommodate this negative mean gap, leading to a symmetry bias.
- Countercyclical policy is weaker if informed by a biased estimates, with significant output costs.