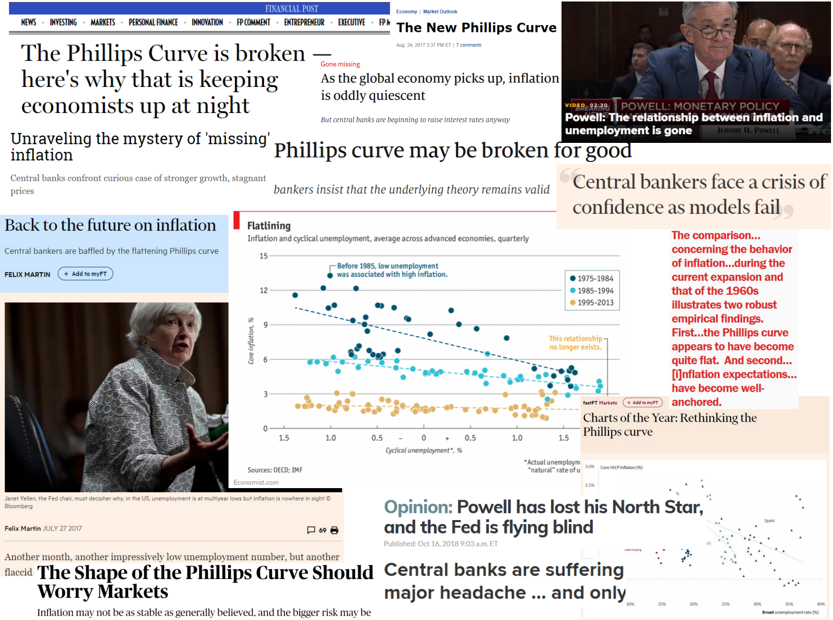
Did Monetary Policy Kill The Phillips Curve?

– Some Simple Arithmetics –

Drago Bergholt[†], Francesco Furlanetto[†], Etienne Vaccaro-Grange[‡]

[†]Norges Bank, [‡]NYU Abu Dhabi

EEA-ESEM conference, Milan
August 23, 2022



FINANCIAL POST

NEWS · INVESTING · MARKETS · PERSONAL FINANCE · INNOVATION · FP COMMENT · ENTREPRENEUR · EXECUTIVE · FP M

The Phillips Curve is broken — here's why that is keeping economists up at night

Economy | Market Outlook

The New Phillips Curve

Aug. 24, 2017 3:37 PM ET | 7 comments

Gone missing

As the global economy picks up, inflation is oddly quiescent

But central banks are beginning to raise interest rates anyway

VIDEO 02:30

POWELL: MONETARY POLICY

Powell: The relationship between inflation and unemployment is gone

JEROME H. POWELL

Unraveling the mystery of 'missing' inflation

Central banks confront curious case of stronger growth, stagnant prices

Phillips curve may be broken for good

bankers insist that the underlying theory remains valid

"Central bankers face a crisis of confidence as models fail"

Back to the future on inflation

Central bankers are baffled by the flattening Phillips curve

FELIX MARTIN + Add to myFT

Flatlining

Inflation and cyclical unemployment, average across advanced economies, quarterly

*Actual unemploym "natural" rate of u

Sources: OECD; IMF

Economist.com

The comparison… concerning the behavior of inflation…during the current expansion and that of the 1960s illustrates two robust empirical findings. First…the Phillips curve appears to have become quite flat. And second… [i]nflation expectations… have become well-anchored.

Janet Yellen, the Fed chair, must decipher why, in the US, unemployment is at multiyear lows but inflation is nowhere in sight © Bloomberg

Felix Martin JULY 27 2017

69

Another month, another impressively low unemployment number, but another flaccid

fastFT Markets + Add to myFT

Charts of the Year: Rethinking the Phillips curve

Opinion: Powell has lost his North Star, and the Fed is flying blind

Published: Oct 16, 2018 9:03 a.m. ET

Central banks are suffering major headache … and only

The Shape of the Phillips Curve Should Worry Markets

Inflation may not be as stable as generally believed, and the bigger risk may be

What has happened to the US Phillips curve?

The US price Phillips curve

A Friedman (1968)-type, expectations-augmented price Phillips curve:

$$\pi_t = \pi_{t+1}^e + \kappa y_t + s_t$$

Widely held view: *the Phillips curve has flattened or even died*

- Ball and Mazumder (2011), Blanchard (2016), Stock and Watson (2019), Del Negro, Lenza, Primiceri and Tambalotti (2020)
- Open economy factors: Forbes (2019), Obstfeld (2020), Heise, Karahan and Sahin (2020), Ascari and Fosso (2021)

Recently, this view has been questioned

- Coibion and Gorodnichenko (2015), Barnichon and Mesters (2020), Hazell, Herreno, Nakamura, Steinsson (2021), McLeay and Tenreyro (2020), Jorgensen and Lansing (2022)

What we do

Fundamental decomposition of the unconditional data

$$\pi_t = \pi_{t|d} + \pi_{t|s}$$
$$y_t = y_{t|d} + y_{t|s}$$

What we do

Fundamental decomposition of the unconditional data

$$\pi_t = \pi_{t|d} + \pi_{t|s}$$
$$y_t = y_{t|d} + y_{t|s}$$

Why?

(A) Explicit account of supply-side variation in data. Helps to address

- ... the bias in estimated slopes
- ... weak identification

(B) Disentangle and quantify the main, competing explanations

1. Slope story: the Phillips curve has flattened
2. Policy story: the Fed has become a stricter inflation targeter
3. Shocks story: supply shocks have become more important over time

Illustration of the identification problem

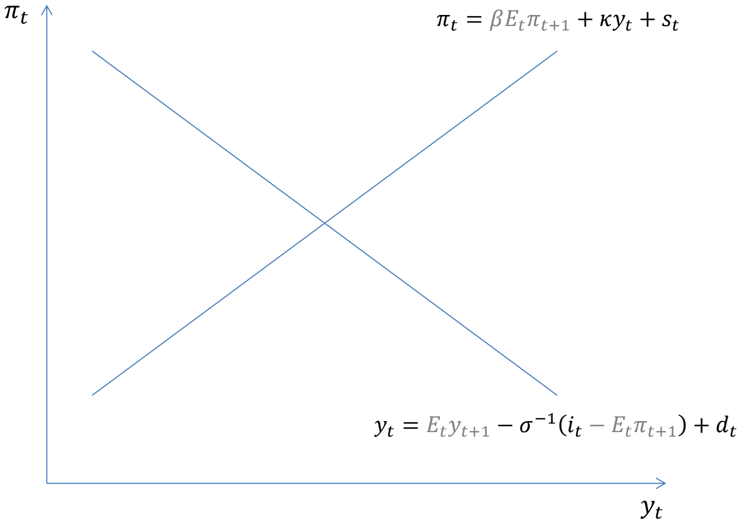
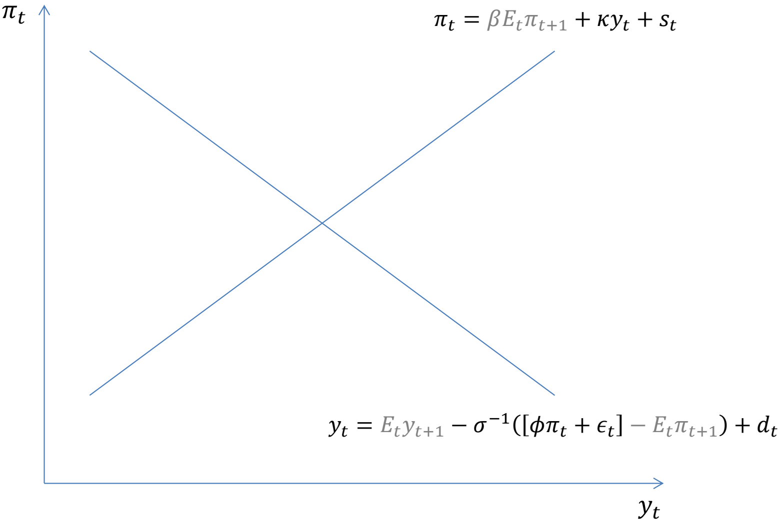


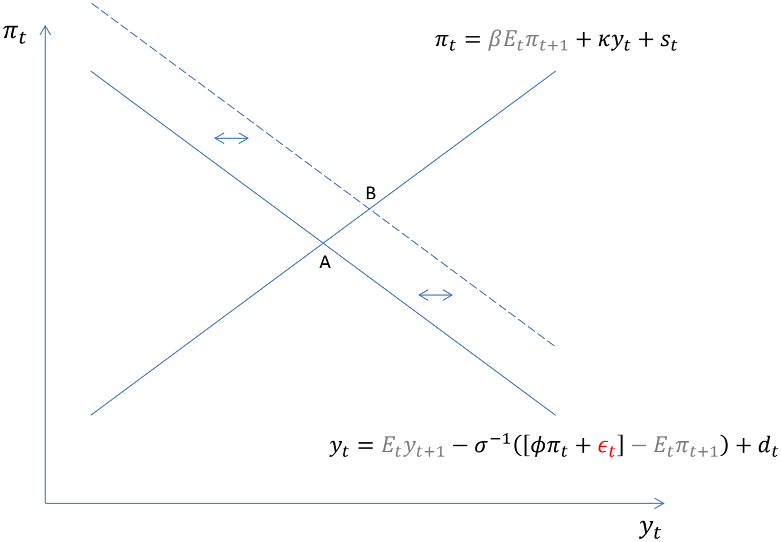
Illustration of the identification problem



$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t + s_t$$

$$y_t = E_t y_{t+1} - \sigma^{-1}([\phi \pi_t + \epsilon_t] - E_t \pi_{t+1}) + d_t$$

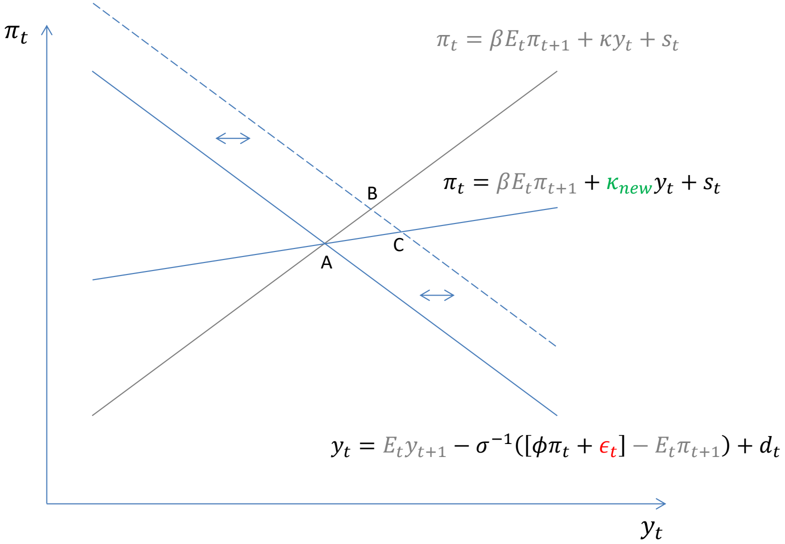
Illustration of the identification problem



$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t + s_t$$

$$y_t = E_t y_{t+1} - \sigma^{-1}([\phi \pi_t + \epsilon_t] - E_t \pi_{t+1}) + d_t$$

Illustration of the identification problem

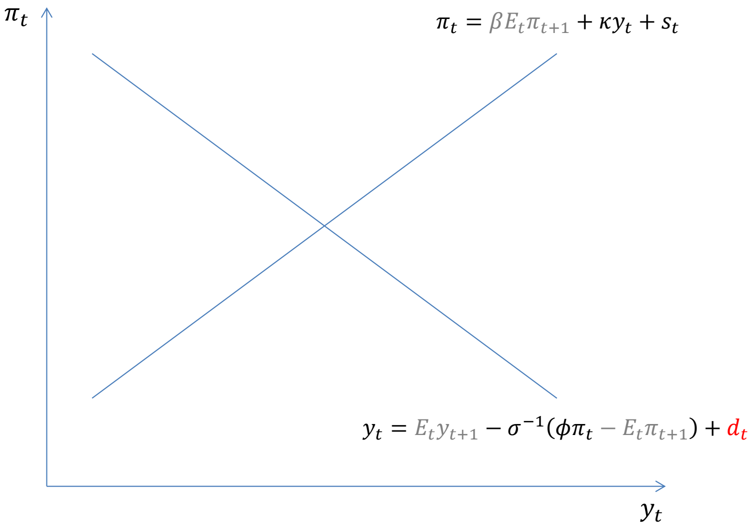


$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t + s_t$$

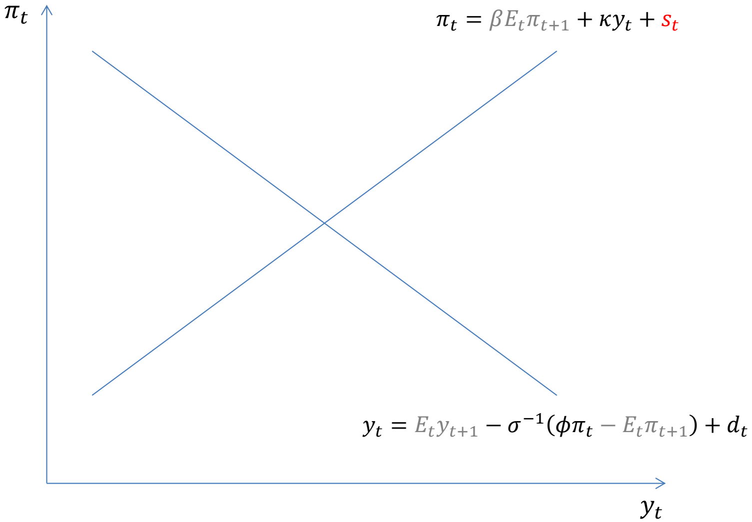
$$\pi_t = \beta E_t \pi_{t+1} + \kappa_{new} y_t + s_t$$

$$y_t = E_t y_{t+1} - \sigma^{-1}([\phi \pi_t + \epsilon_t] - E_t \pi_{t+1}) + d_t$$

Illustration of the identification problem



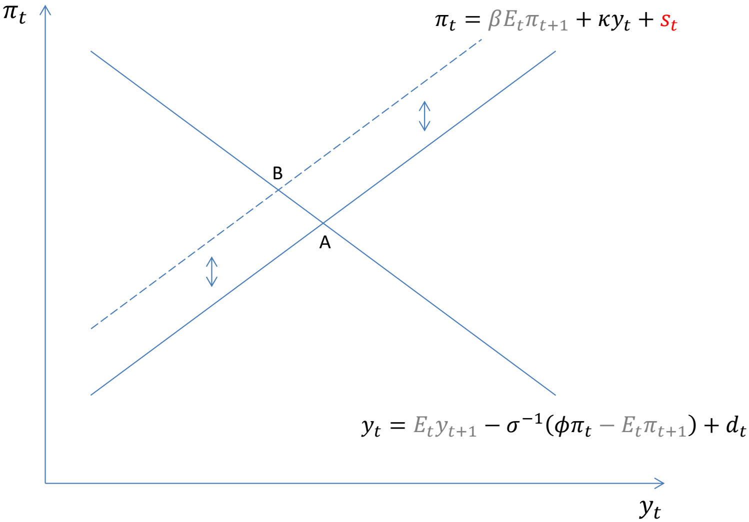
Our paper: supply shock ⇒ demand slope



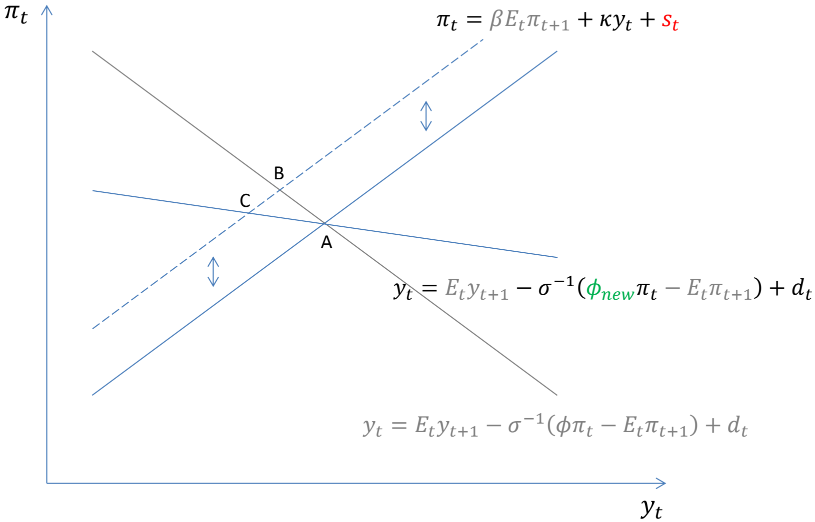
$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t + s_t$$

$$y_t = E_t y_{t+1} - \sigma^{-1}(\phi \pi_t - E_t \pi_{t+1}) + d_t$$

Our paper: supply shock ⇒ demand slope



Our paper: supply shock ⇒ demand slope



Main findings

1. Little evidence of a flatter supply curve. The PC is alive and well!
2. The demand curve, instead, has flattened substantially.
3. Slope tests and variance tests consistent with a stricter policy focus on inflation stability.

Theoretical discussion

A baseline framework

The canonical textbook model, see Galí (2015):

$$\begin{aligned} y_t &= \mathbb{E}_t y_{t+1} - \sigma^{-1} \left(i_t - \mathbb{E}_t \pi_{t+1} \right) \\ \pi_t &= \beta \mathbb{E}_t \pi_{t+1} + \kappa y_t + s_t \\ i_t &= \phi_\pi \pi_t + \phi_y y_t + d_t \end{aligned}$$

Remarks:

(a) y_t is the output gap from *steady state* or trend (the flex-price gap is a different concept not discussed here)

(b) s_t may be an entire vector of supply shocks.

The OLS estimate of κ

Suppose d_t and s_t are iid shocks with variances σ_d^2 and σ_s^2, respectively. ▸ The case of persistent shocks

Closed form solution:

$$y_t = \frac{1}{\sigma + \phi_y + \kappa\phi_\pi}\left(d_t - \phi_\pi s_t\right)$$
$$\pi_t = \frac{1}{\sigma + \phi_y + \kappa\phi_\pi}\left[\kappa d_t + \left(\sigma + \phi_y\right) s_t\right]$$

Implied OLS estimator:

$$\hat{\kappa} = \frac{\kappa - \phi_\pi\left(\sigma + \phi_y\right)\frac{\sigma_s^2}{\sigma_d^2}}{1 + \phi_\pi^2\frac{\sigma_s^2}{\sigma_d^2}} < \kappa$$

From unconditional to conditional slopes

A. Unconditional: $$\hat{\kappa}_u = \frac{\kappa - \phi_\pi \left(\sigma + \phi_y\right) \frac{\sigma_s^2}{\sigma_d^2}}{1 + \phi_\pi^2 \frac{\sigma_s^2}{\sigma_d^2}} < \kappa$$

B. Conditional on demand: $$\hat{\kappa}_d = \kappa$$

C. Conditional on supply: $$\hat{\kappa}_s = -\frac{\sigma + \phi_y}{\phi_\pi}$$

Implications:

- κ-estimators:
  - $\hat{\kappa}_u < \kappa$ is downward biased
  - $\hat{\kappa}_d = \kappa$ is unbiased
  - $\hat{\kappa}_s < 0$ is unrelated to κ and depends instead on policy
- An observed flattening of $\hat{\kappa}_u$ is consistent both with the “slope story”, the “policy story”, and the “shocks story”

From unconditional to conditional slopes

A. Unconditional: $$\hat{\kappa}_u = \frac{\kappa - \phi_\pi \left(\sigma + \phi_y\right) \frac{\sigma_s^2}{\sigma_d^2}}{1 + \phi_\pi^2 \frac{\sigma_s^2}{\sigma_d^2}} < \kappa$$

B. Conditional on demand: $$\hat{\kappa}_d = \kappa$$

C. Conditional on supply: $$\hat{\kappa}_s = -\frac{\sigma + \phi_y}{\phi_\pi}$$

If the “slope story” is true ($\kappa \downarrow$):

- Should observe a flattening of $\hat{\kappa}_d$
- ... combined with unchanged $\hat{\kappa}_s$

From unconditional to conditional slopes

A. Unconditional: $$\hat{\kappa}_u = \frac{\kappa - \phi_\pi \left(\sigma + \phi_y\right) \frac{\sigma_s^2}{\sigma_d^2}}{1 + \phi_\pi^2 \frac{\sigma_s^2}{\sigma_d^2}} < \kappa$$

B. Conditional on demand: $$\hat{\kappa}_d = \kappa$$

C. Conditional on supply: $$\hat{\kappa}_s = -\frac{\sigma + \phi_y}{\phi_\pi}$$

If the “policy story” is true ($\phi_\pi \uparrow$):

- Should observe an unchanged $\hat{\kappa}_d$
- ... combined with a flattening of $\hat{\kappa}_s$

From unconditional to conditional slopes

A. Unconditional: $$\hat{\kappa}_u = \frac{\kappa - \phi_\pi \left(\sigma + \phi_y\right) \frac{\sigma_s^2}{\sigma_d^2}}{1 + \phi_\pi^2 \frac{\sigma_s^2}{\sigma_d^2}} < \kappa$$

B. Conditional on demand: $$\hat{\kappa}_d = \kappa$$

C. Conditional on supply: $$\hat{\kappa}_s = -\frac{\sigma + \phi_y}{\phi_\pi}$$

If the “shocks story” is true ($\sigma_s^2/\sigma_d^2 \uparrow$):

- Only the “shocks story” implies unchanged $\hat{\kappa}_d$ and $\hat{\kappa}_s$ over time
- Should instead see greater (smaller) movements along the supply (demand) curve

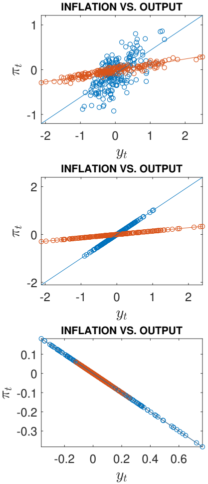
From unconditional to conditional variances

We also show that:

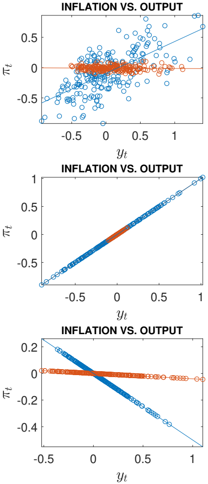
- Changes in unconditional variances are not informative about the different explanations
- However, the (relative) importance of *supply shocks* for output gap volatility
  - (a) should decline if the slope story is dominant
  - (b) should rise if the policy story is dominant

Simulated data

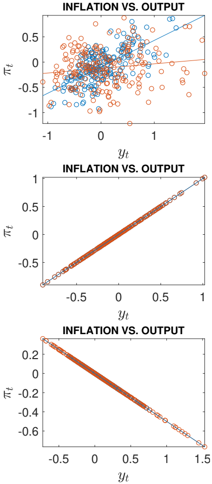
(a) Slope story



(b) Policy story



(c) Shock story



Empirical Methodology

Step I: the VAR model

- Consider the following reduced form VAR:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_p Y_{t-p} + u_t$$

  where $u_t \sim N(0, \Sigma)$, $u_t = S\epsilon_t$, and $\epsilon_t \sim N(0, I)$.

- Identification with sign restrictions a la Arias, Rubio-Ramirez and Waggoner (2018).
- Baseline data:

$$Y = \begin{bmatrix} \text{CBO output gap} \\ \text{GDP deflator} \end{bmatrix}$$

- Sample 1: 1969Q4-1994Q4. Sample 2: 1995Q1-2019Q4

Step I: theory consistent sign restrictions

A. Baseline	Demand ↑	Supply ↓	
Inflation	+	+	
Output gap	+	-	
B. Interest rate	Demand ↑	Supply ↓	Monetary Policy ↑
Inflation	+	+	+
Output gap	+	-	+
Interest rate	+	⋆	-
C. Inflation expectations	Demand ↑	Supply ↓	Residual
Inflation	+	+	+
Output gap	+	-	⋆
Inflation expectations	+	+	-

Note: Restrictions are imposed on impact. ⋆ means no restriction is imposed.

▸ Sign restrictions in small-scale NK-model

▸ Sign restrictions in medium-scale NK-model

Step II: Empirical tests

Step IIA: conditional correlations (slope regressions)

- A joint test: we compare results from unconditional data with results conditional on supply and demand
- We compare the estimated κ across different sub-samples

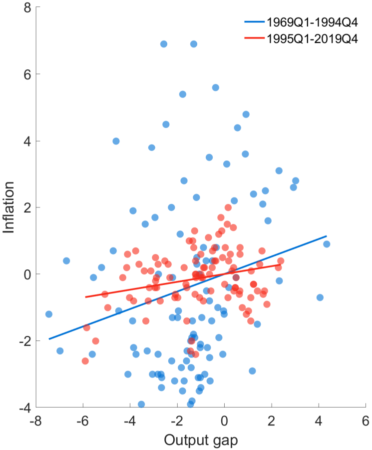
Step IIB: conditional variances

- Check whether supply shocks have become less (slope story) or more (policy story) important for real economic activity

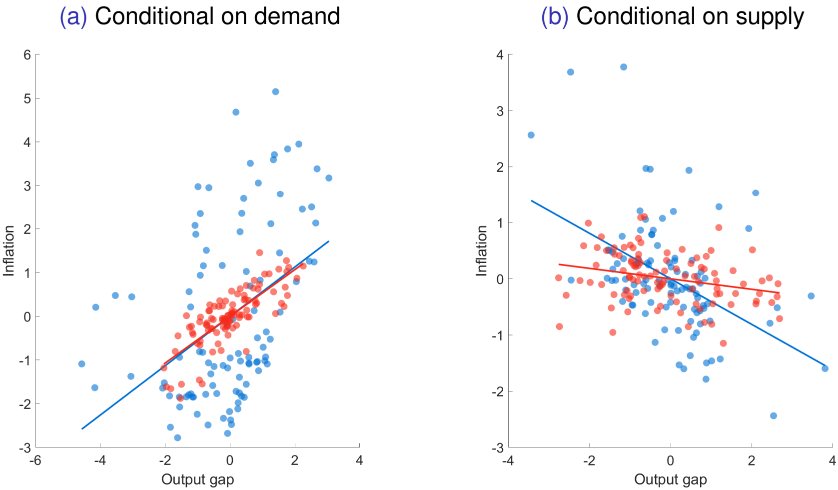
Results

Q: *Has the Phillips curve flattened (or even died)?*

Unconditional data: the PC has flattened

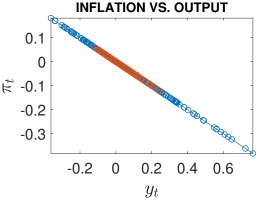


Conditional: unchanged supply slope, flatter demand

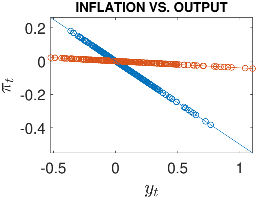


Supply only: the relationship has disappeared!

This is inconsistent with a flattening of the structural PC...

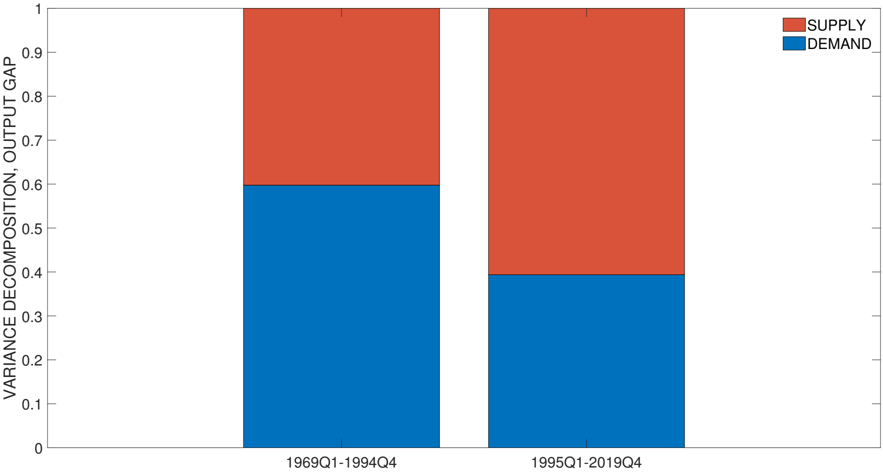


... but very much in line with stricter inflation targeting



Q: *Have supply shocks become more important for output?*

The CBO output gap more driven by supply



Robustness

Robustness I: measurement

- Cyclically sensitive inflation (Stock and Watson, 2020) as a measure of inflation
- Unemployment rate as a measure of real economic activity
- Unemployment gap from u^* (trend) as a measure of real economic activity

Robustness II: accounting for interest rates and monetary policy shocks

- The Federal funds rate
- The shadow rate as computed by Wu and Xia (2016)

Robustness III: Alternative sample periods

- Sample split in 1998Q4 as in Jorgensen and Lansing (2022)
- End estimation after 2008Q4 in order to leave out the ZLB

Robustness IV: the role of expectations

- Expectations in the Survey of Professional Forecasters
- Michigan expectations
- Consumer prices and household expectations

Robustness: results

	$\hat{\gamma}_u$		$\hat{\gamma}_d$		$\hat{\gamma}_s$		$VD(y\|s)$	
	S1	S2	S1	S2	S1	S2	S1	S2
(a)	0.26	0.12	0.56	0.53	-0.41	-0.09	0.40	0.61
(b)	0.23	0.21	0.43	0.79	-0.40	0.12	0.28	0.78
(c)	0.14	0.11	0.39	0.50	-0.21	-0.04	0.47	0.71
(d)	0.39	0.14	0.81	0.63	-0.15	-0.04	0.51	0.70
(e)	0.26	0.12	0.40	0.38	-0.62	-0.07	0.22	0.47
			0.77*	0.92*				
(f)	0.26	0.12	0.39	0.35	-0.63	-0.11	0.22	0.45
			0.76*	0.78*				
(g)	-0.04	0.19	0.25	0.50	-0.36	-0.04	0.43	0.50
(h)	0.26	-0.01	0.57	0.64	-0.41	-0.14	0.41	0.69
(i)	0.26	0.12	0.56	0.39	-0.80	0.06	0.19	0.45
(j)	0.25	0.12	0.50	0.66	-0.46	-0.05	0.19	0.54
(k)	0.44	0.19	0.81	1.02	-0.88	0.04	0.19	0.60

*Conditional on identified monetary policy shocks.

Robustness V: set identification

	$\hat{\gamma}_u$		$\hat{\gamma}_d$		$\hat{\gamma}_s$	
	S1	S2	S1	S2	S1	S2
(a)	0.26	0.12	0.61 [0.29, 0.89]	0.51 [0.15, 0.83]	−0.59 [−1.32, 0.13]	−0.14 [−0.34, 0.09]
(b)	0.23	0.21	0.41 [0.20, 0.62]	0.52 [0.24, 0.81]	−0.54 [−1.26, 0.08]	0.12 [0.04, 0.23]
(c)	0.14	0.11	0.18 [0.88, −0.51]	0.43 [0.69, 0.13]	−0.35 [0.42, −1.12]	−0.07 [0.12, −0.21]
(d)	0.39	0.14	0.59 [1.28, −0.20]	0.54 [0.87, 0.18]	−0.31 [0.54, −1.11]	−0.09 [0.15, −0.26]
(e)	0.26	0.12	0.34 [0.12, 0.56]	0.34 [0.12, 0.52]	−0.42 [−1.01, 0.14]	−0.10 [−0.27, 0.09]
(f)	0.26	0.12	0.33 [0.11, 0.56]	0.34 [0.11, 0.54]	−0.41 [−0.99, 0.14]	−0.12 [−0.32, 0.09]
(g)	−0.04	0.19	0.12 [−0.16, 0.40]	0.54 [0.24, 0.76]	−0.51 [−1.08, 0.06]	−0.07 [−0.29, 0.17]
(h)	0.26	−0.01	0.62 [0.29, 0.91]	0.33 [0.02, 0.62]	−0.59 [−1.29, 0.12]	−0.11 [−0.29, 0.10]
(i)	0.26	0.12	0.49 [0.21, 0.77]	0.40 [0.11, 0.66]	−0.56 [−1.17, 0.01]	0.02 [−0.14, 0.19]
(j)	0.25	0.12	0.43 [0.24, 0.61]	0.49 [0.15, 0.79]	−0.14 [−0.60, 0.34]	−0.07 [−0.24, 0.10]
(k)	0.44	0.19	0.90 [0.41, 1.35]	0.73 [0.19, 1.25]	−0.28 [−0.86, 0.27]	0.03 [−0.13, 0.22]

Note: Posterior mean across 10,000 slope estimates. 68% HPD in brackets.

Comparison with the literature

- McLeay and Tenreyro (2020): focus on optimal policy. Here: sub-optimal policy rule.
- Barnichon and Mester (2020): monetary policy shocks as instruments. Here: supply shocks are as informative, if not more.
- Hazell, Herreno, Nakamura and Steinsson (2021) and Jorgensen and Lansing (2022): anchoring of inflation expectations. Here: anchoring induced by more aggressive monetary policy.
- Coibion and Gorodnichenko (2015): oil shocks in 2009-2011. Here: we also stress the joint role of demand and supply shocks for macroeconomic dynamics.
- Good luck vs good policy explanations of the Great Moderation: our results are consistent with the good policy explanation.

Conclusions

We estimate the empirical relationship between output gap and inflation (the Phillips curve slope)

- Unconditional slope has flattened
- But this is not driven by changes in the structural PC
- The demand (IS) curve, instead, has flattened rather substantially
- When *evaluated jointly*, changes in the stance of monetary policy seems a likely source of the disconnect between output and inflation

Did the Fed kill the Phillips curve?

Appendix

Model with persistent shocks

Suppose shocks follow separate AR(1) process:

$$
\begin{aligned}
d_t &= \rho_d d_{t-1} + \varepsilon_{d,t} \qquad \varepsilon_{d,t} \sim N\left(0, \sigma^2_{\varepsilon,d}\right) \\
z_t &= \rho_z z_{t-1} + \varepsilon_{z,t} \qquad \varepsilon_{z,t} \sim N\left(0, \sigma^2_{\varepsilon,z}\right)
\end{aligned}
$$

Model solution:

$$
\begin{aligned}
y_t &= \frac{\sigma\left(1 - \beta\rho_d\right) d_t}{\Psi_d} - \frac{\left(\phi_\pi - \rho_z\right) z_t}{\Psi_z} \\
\pi_t &= \frac{\sigma\kappa d_t}{\Psi_d} + \frac{\left[\sigma\left(1 - \rho_z\right) + \phi_y\right] z_t}{\Psi_z}
\end{aligned}
$$

where

$$
\begin{aligned}
\Psi_d &= \left[\sigma\left(1 - \rho_d\right) + \phi_y\right]\left(1 - \beta\rho_d\right) + \left(\phi_\pi - \rho_d\right)\kappa > 0 \\
\Psi_z &= \left[\sigma\left(1 - \rho_z\right) + \phi_y\right]\left(1 - \beta\rho_z\right) + \left(\phi_\pi - \rho_z\right)\kappa > 0
\end{aligned}
$$

◂ Back

OLS estimators with persistent shocks

(a) Unconditional data:

$$\kappa^{OLS} = \frac{cov\left(\pi_t - \beta\mathbb{E}_t\pi_{t+1}, y_t\right)}{var\left(y_t\right)}$$

$$= \frac{\left(\frac{\sigma(1-\beta\rho_d)}{\Psi_d}\right)^2 \kappa - \left(\frac{1}{\Psi_z}\right)^2 \left(\phi_\pi - \rho_z\right)\left[\sigma\left(1-\rho_z\right)+\phi_y\right]\left(1-\beta\rho_z\right)\frac{\sigma_z^2}{\sigma_d^2}}{\left(\frac{\sigma(1-\beta\rho_d)}{\Psi_d}\right)^2 + \left(\frac{\phi_\pi-\rho_z}{\Psi_z}\right)^2 \frac{\sigma_z^2}{\sigma_d^2}} \leq \kappa$$

where $\sigma_d^2 = \frac{\sigma_{\varepsilon,d}^2}{1-\rho_d^2}$ and $\sigma_z^2 = \frac{\sigma_{\varepsilon,z}^2}{1-\rho_z^2}$.

(b) Purged for supply shocks, but ignoring expectations:

$$\kappa^{OLS} = \frac{cov\left(\pi_t, y_t\right)}{var\left(y_t\right)} = \frac{\kappa}{1-\beta\rho_d} \geq \kappa$$

(c) Purged for supply shocks and accounting for expectations:

$$\kappa^{OLS} = \frac{cov\left(\pi_t - \beta\mathbb{E}_t\pi_{t+1}, y_t\right)}{var\left(y_t\right)} = \kappa$$