Networks, Phillips curves, and Monetary Policy

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New Keynesian framework

- Textbook model:
  - stabilize output and prices
  - "divine coincidence" $\rightarrow$ optimal policy via inflation targeting
- With many sectors:
  - relevant measure of aggregate inflation for monetary policy (CPI? PPI? Other?)
  - how to trade off inflation in different sectors?

Key objects

1. Phillips curve:

$$\underbrace{\bar{\pi}_t}_{\text{inflation}} = \rho \mathbb{E} \bar{\pi}_{t+1} + \kappa \underbrace{\tilde{y}_t}_{\text{output gap}} + u_t$$

- many inflation measures
- slope and residual

Key objects

1. Phillips curve:

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- many inflation measures
- slope and residual

2. Loss function:

$$\mathbb{W} = \frac{1}{2}\left[\zeta \tilde{y}^2 + \epsilon \pi^2\right] \dashrightarrow \mathbb{W} = \frac{1}{2}\left[\zeta \tilde{y}^2 + \pi^T \mathcal{D} \pi\right]$$

- full distribution of sectoral inflation rates

Theoretical results

1. Phillips curve(s):

$$\underbrace{\bar{\pi}_t}_{\text{inflation}} = \rho \mathbb{E} \bar{\pi}_{t+1} + \kappa \underbrace{\tilde{y}_t}_{\text{output gap}} + u_t$$

- intermediate inputs → flattening
- endogenous cost-push shocks
- "divine coincidence" inflation index
  - sufficient statistic for aggregate output gap
  - preserves the "positive" properties of inflation in the baseline model

Theoretical results

2. Loss function:

$$\mathbb{W} = \frac{1}{2}\left[\zeta \tilde{y}^2 + \pi^T \mathcal{D} \pi\right]$$

- aggregate vs relative output
- inflation target for optimal policy
  - "divine coincidence" index only captures aggregate output

Quantitative results

3. Phillips curve(s)

- calibrated model predicts coefficients correctly
- R-squared 2 to 4 times larger with "divine coincidence" index
- flattening of the CPI Phillips curve over time (NOT wage)

Quantitative results

4. Welfare loss from business cycles

- 1.12% of per-period GDP if target consumer inflation
- reduced to 0.28% with optimal policy
- closing output gap $\sim$ optimal policy
- benchmark: Lucas' estimate (0.05% per-period GDP)

Related literature

- **Markup distortions and aggregate productivity** Baqaee and Farhi (2018), Hsieh and Klenow (2009), Edmond, Midrigan and Xu (2018)
- **Input-output: simple models** Basu (1995), Erceg et al (1999), Aoki (2001), Woodford (2003), Blanchard and Gali (2007), Gali and Monacelli (2008)
- **Input-output: quantitative** Carvalho (2006), Klenow and Kryvtsov (2008), Nakamura and Steinsson (2008, 2013), Carvalho and Nechio (2011), Bouakez, Cardia, and Ruge-Murcia (2014), Pasten, Schoenle and Weber (2016, 2017), Castro Cienfuegos (2019), Höynk (2019)
- **Optimal indicators** Mankiw and Reis (2002), Benigno (2004), Gali (2008), Eusepi, Hobjin, Tambalotti (2010)
- **Networks and optimal policy** La'O and Tahbaz-Salehi (2019)
- **Empirics** Gali and Gertler (1997), Mavroeidis, Plagborg-Muller, Stock (2013), Blanchard, Cerutti, Summers (2015), Bullard (2018), McLeay and Tenreyro (2019)

Roadmap

1. Key elements of network model
2. Phillips curve(s)
   - sketch of derivation
   - "divine coincidence" index
3. Optimal policy
   - loss function
   - optimal inflation target

Outline

Setup

Sectoral inflation and Phillips curve(s)

- Calibration: slope & monetary non-neutrality

"Divine coincidence" index

Optimal policy

- Calibration: welfare loss from business cycles

Conclusion

Consumption

- Utility from consumption (C), homothetic preferences over bundle of all goods produced in the economy
- Disutility from labor supply (L)

$$U = \frac{C^{1-\gamma}}{1-\gamma} - \frac{L^{1+\varphi}}{1+\varphi}$$

- Nominal expenditure (PC) cannot exceed money supply (M):

$$PC \leq M$$

policy instruments timing

Production

- N sectors
  - continuum of firms within sectors, CES bundle
  - CRS production function F_i

$$Y_i = \overbrace{A_i}^{\text{Hicks-neutral shifter}} F_i(\underbrace{L_i}_{\text{labor}}, \{\underbrace{x_{ij}}_{\text{intermediate inputs}}\})$$

  - fraction δ_i of producers adjust price after seeing A
- Sticky wages: add labor sector with sticky price
- Undistorted steady state (optimal subsidies)

Log-linearized model

Parameters:

- Labor, input, consumption shares: α, Ω, β
- adjustment probabilities: $\Delta = diag(\delta_1 ... \delta_N)$ distribution
- elasticities of substitution in production and consumption

Variables:

- Aggregate output gap

$$\tilde{y} = y - y_{nat}$$

- Sectoral inflation rates

$$\pi = \begin{pmatrix} \pi_1, & ..., & \pi_N \end{pmatrix}^T$$

Outline

Sectoral vs aggregate

- Sectoral Phillips curves:

$$\underbrace{\pi}_{N\times 1} = \underbrace{\mathcal{B}}_{N\times 1} \tilde{y} + \underbrace{\mathcal{V}}_{N\times N} \underbrace{d\log A}_{N\times 1}$$

- Aggregate Phillips curve (weights ϕ):

$$\pi^{AGG} \equiv \phi^T \pi = \underbrace{\phi^T \mathcal{B}}_{\text{slope}} \tilde{y} + \underbrace{\phi^T \mathcal{V} d\log A}_{\text{residual}}$$

Phillips curve: $\pi^C = \kappa^C \tilde{y} + u^C$

- $\tilde{y} \uparrow \Rightarrow$ labor demand$\uparrow \Rightarrow rw \uparrow$:

$$\kappa^C = \underbrace{\frac{\bar{\delta}_w}{1-\bar{\delta}_w}}_{\frac{d \log P}{d \log rw}} \underbrace{(\gamma + \varphi)}_{\frac{d \log rw}{d \log y}}$$

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- Pass-through of nominal wages into consumer prices:

$$\bar{\delta}_w = \underbrace{\beta^T \Delta}_{\text{direct pass-through}} \underbrace{(I - \Omega\Delta)^{-1} \alpha}_{<1} < \mathbb{E}_\beta(\Delta)$$

- No input-output: $\bar{\delta}_w = \mathbb{E}_\beta(\delta)$
- Dampened with IO linkages

Outline

Setup

Sectoral inflation and Phillips curve(s)

Calibration: slope & monetary non-neutrality

"Divine coincidence" index

Optimal policy

Calibration: welfare loss from business cycles

Conclusion

Slope (calibration)

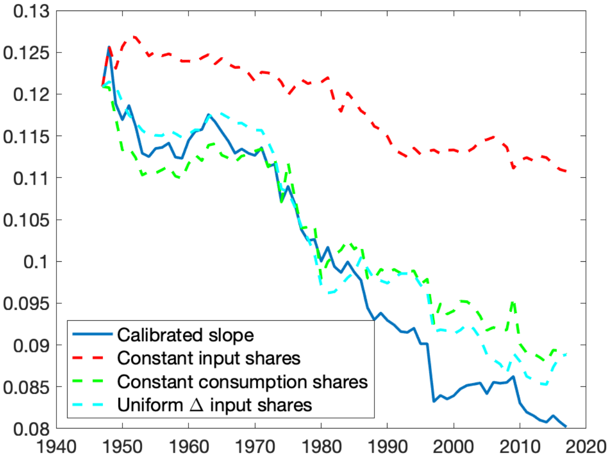
- Input-output data from the BEA
- Sector-level price adjustment frequencies from Pasten, Schoenle and Weber (2016)

	full model	no IO, flex w	no IO
slope	0.09	1.16	0.22
full/alt calibration	1.00	0.07	0.38

Table: Slope in the full calibration and alternative calibrations

dynamics

Slope over time



Phillips curve: $\pi^C = \kappa^C \tilde{y} + u^C$

- Productivity pass-through:

$$\bar{\delta}_A \left(d \log A \right) \equiv \overbrace{\beta^T}^{\text{consumption shares}} \overbrace{\Delta}^{\text{mc} \to \text{price}} \overbrace{(I - \Omega\Delta)^{-1} \frac{d \log A}{\lambda^T d \log A}}^{\text{productivity} \to \text{mc}}$$

- Wage response (efficient equilibrium):

$$d \log rw = \underbrace{\lambda^T d \log A}_{\text{aggregate productivity}}$$

- Consumer inflation:

$$u^C = \frac{\bar{\delta}_w - \bar{\delta}_A}{1 - \bar{\delta}_w} \lambda^T d \log A$$

TFP vs labor shocks

Calibration

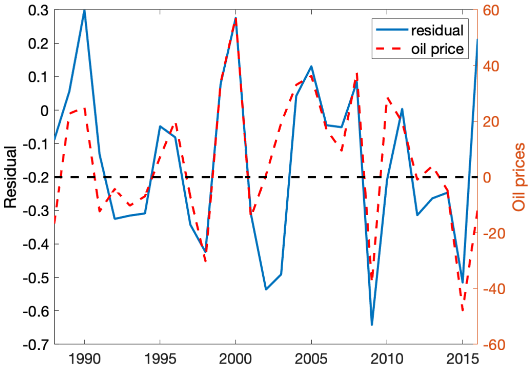


Figure: Residual constructed from sector-level TFP shocks (BEA-KLEMS data), 1988-2016

- Standard deviation: 25 bp

Outline

"Divine coincidence" inflation index

$$DC \equiv \underbrace{\lambda^T}_{\text{sales}} \quad \underbrace{(I - \Delta)\,\Delta^{-1}}_{\text{discount flex sectors}} \quad \pi$$

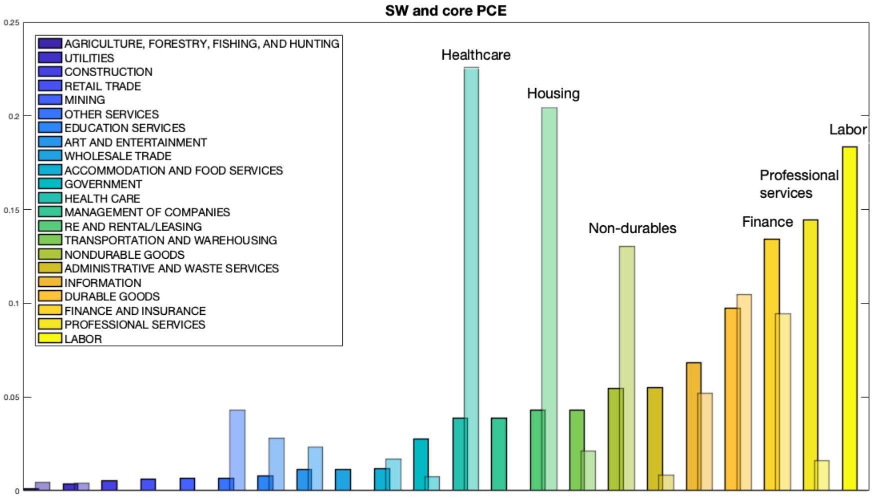
Proposition

$$DC = \quad \underbrace{(\gamma + \varphi)}_{\textit{indep of network}} \quad \tilde{y}$$

- Sales shares: full role in production chain
- Flexible price $\Rightarrow$ smaller markup response given cost shock

derivation | desired markups | dynamics

SW and consumer prices



Phillips curve regressions (1984-2017)

	SW	consumer prices
κ	-3.00	-0.09

Table: Calibrated slope of the Phillips curve ($\gamma = 1$, $\varphi = 2$)

	DC	CPI	core CPI	PCE	core PCE
gap	-3.8814**	-0.2832**	-0.1839**	-0.1667**	-0.1007*
	(0.6329)	(0.0729)	(0.0642)	(0.0628)	(0.0565)
intercept	1.9842**	2.9052**	2.9021**	2.3978**	2.372**
	(0.0475)	(0.1196)	(0.1052)	(0.103)	(0.0926)
R-squared	0.2154	0.0991	0.0566	0.0489	0.0227

Table: Regression results for the CBO unemployment gap

oil prices other gaps

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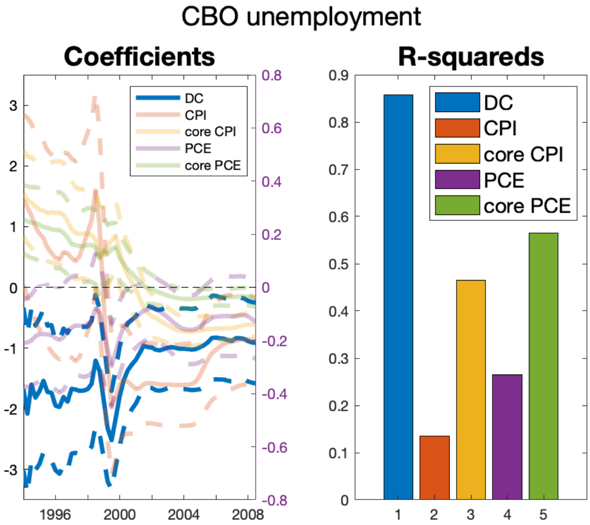
20y rolling regressions



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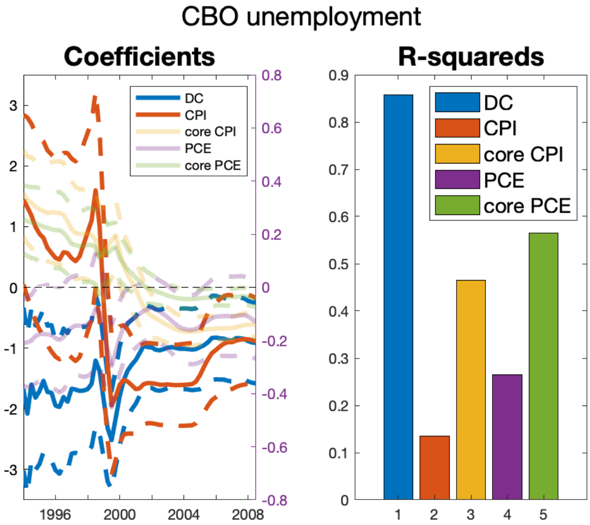

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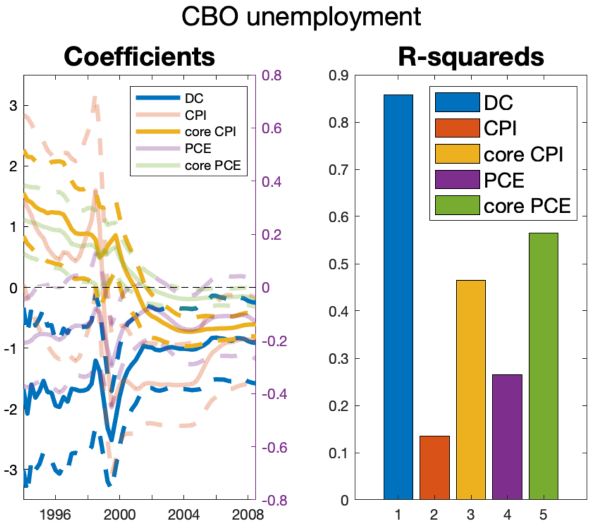

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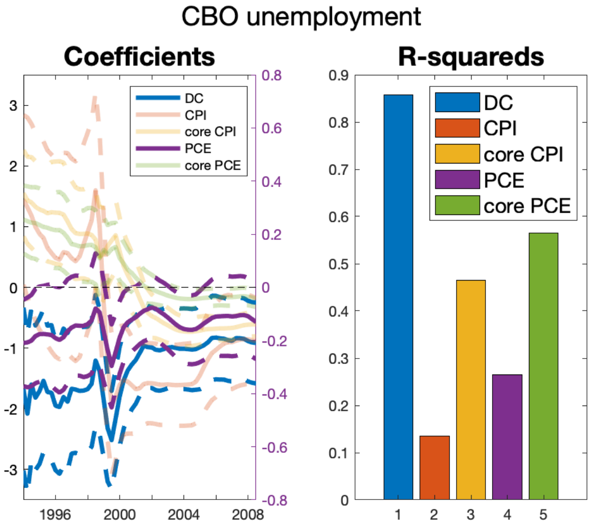

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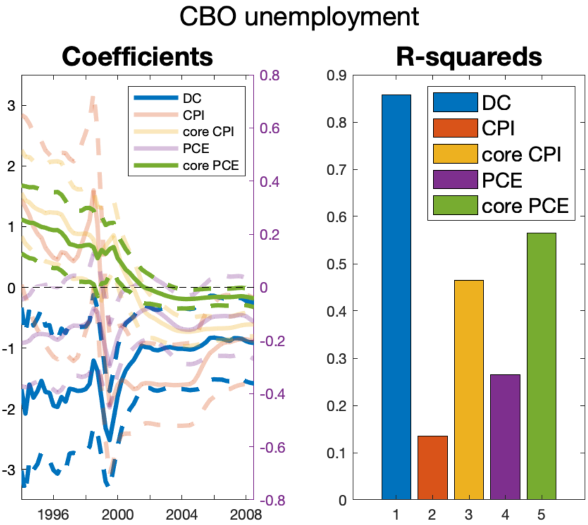

Outline

Welfare function

- Second order approximation around the flex price outcome:

$$\frac{U - U^*}{U_c C} \simeq -\frac{1}{2}\left[\underbrace{(\gamma + \varphi)\,\tilde{y}^2}_{\text{aggregate demand}} + \underbrace{\pi^T \mathcal{D} \pi}_{\text{welfare cost of inflation}} \right]$$

- Price distortions $\Longrightarrow$ substitution $\Longrightarrow$ productivity loss

$$\mathcal{D} = \underbrace{\mathcal{D}_1}_{\text{within sectors}} + \underbrace{\mathcal{D}_2}_{\text{across sectors}}$$

  - higher ES $\rightarrow$ more substitution
  - IO linkages $\rightarrow$ propagation

derivation

Central bank's problem

$$min\ \mathbb{W} = \frac{1}{2}\left[(\gamma + \varphi)\,\tilde{y}^2 + \pi^T \mathcal{D} \pi\right]$$

$$s.t.\ \ \underbrace{\pi = \mathcal{B}\tilde{y} + \mathcal{V} d \log A}_{\text{full vector}}$$

Central bank's problem

$$min\ \mathbb{W} = \frac{1}{2}\left[(\gamma+\varphi)\,\tilde{y}^2 + \pi^T \mathcal{D}\pi\right]$$

$$s.t.\ \ \pi = \mathcal{B}\tilde{y} + \mathcal{V}d\log A$$

Marginal gain from raising $\tilde{y}$ given current inflation π:

$$(\gamma+\varphi)\,\tilde{y}^* + \mathcal{B}^T\mathcal{D}\pi^* = 0$$

Central bank's problem

$$min \ \mathbb{W} = \frac{1}{2}\left[(\gamma + \varphi)\,\tilde{y}^2 + \pi^T \mathcal{D} \pi\right]$$

$$s.t. \ \ \pi = \mathcal{B}\tilde{y} + \mathcal{V} d \log A$$

Marginal cost of raising $\tilde{y}$:

$$(\gamma + \varphi)\,\tilde{y}^* + \mathcal{B}^T \mathcal{D} \pi^* = 0$$

A new inflation target

- Optimal tradeoff:

$$\underbrace{(\gamma + \varphi)}_{\text{marginal cost}} \tilde{y}^* + \underbrace{\mathcal{B}^T \mathcal{D}}_{\text{marginal benefit}} \pi^* = 0$$

- Optimal target:

$$\pi_T \equiv \left[\lambda^T (I - \Delta) \Delta^{-1} + \mathcal{B}^T \mathcal{D} \right] \pi$$

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Proposition

$$\pi_T > 0 \iff \tilde{y} > \tilde{y}^*$$

dynamics with CP shocks

Outline

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Sectoral inflation and Phillips curve(s)

Calibration: slope & monetary non-neutrality

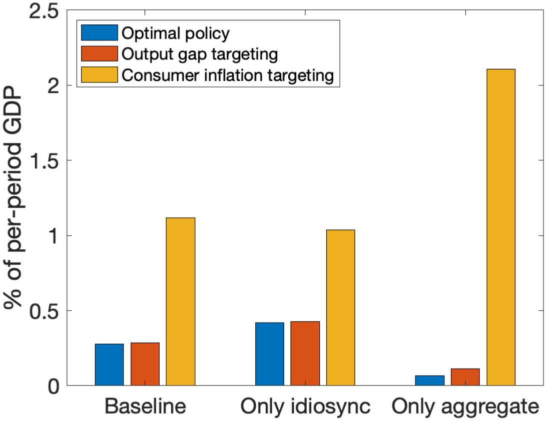
"Divine coincidence" index

Optimal policy

Calibration: welfare loss from business cycles

Conclusion

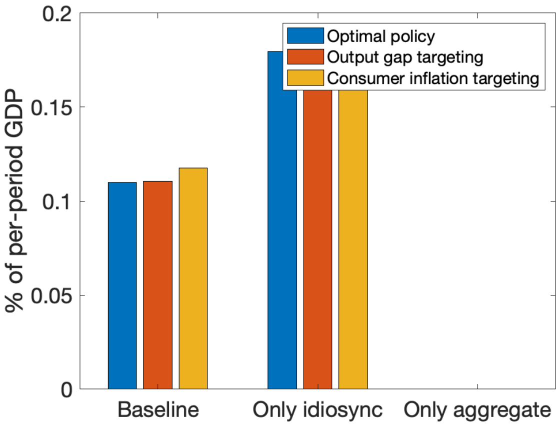
Calibration: welfare loss from business cycles



- Consumer prices poor target
  - also with aggregate shocks only

within vs cross-sector component

Model with no IO linkages



- Loss entirely from idiosyncratic component
- Consumer inflation good target

Outline

Conclusion

Framework for monetary policy in disaggregated economy

1. Phillips curve(s)
    - intermediate inputs $\rightarrow$ flattening
    - endogenous cost-push shocks
    - "divine coincidence" index
2. Welfare
    - new inflation target
    - output gap good target, not consumer inflation

Extensions

- No rep consumer: segmented labor markets in currency union
  - local vs aggregate Phillips curve
  - local vs aggregate fiscal multipliers
- Open economy: add exchange rates and independent CBs
  - monetary policy spillovers, competitive devaluations...under intermediate goods trade/global production chains

Thank you!

Timing

One-period model. Same results in dynamic setting

- Period 0: prices are pre-set
- Period 1: unanticipated shock
  - only a fraction of producers can adjust prices
  - production and consumption take place
  - the world ends

back

Policy instruments

Money supply

- Equivalent to interest rates in dynamic setting
- Cash-in-advance constraint

$$PC \leq M$$

- Map into output gap for given productivity (in the background)

$$d \log M = \pi^C + \tilde{y} + \frac{1+\varphi}{\gamma+\varphi}\lambda^T dlogA =$$

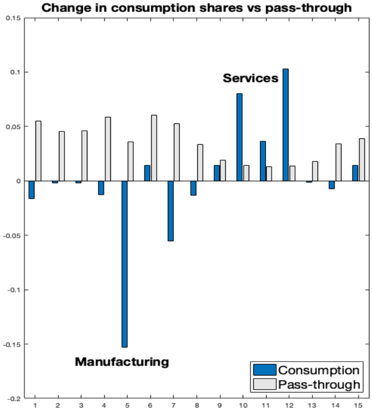
$$= \left(1 + \kappa^C\right)\tilde{y} + u^C + \frac{1+\varphi}{\gamma+\varphi}\lambda^T dlogA$$

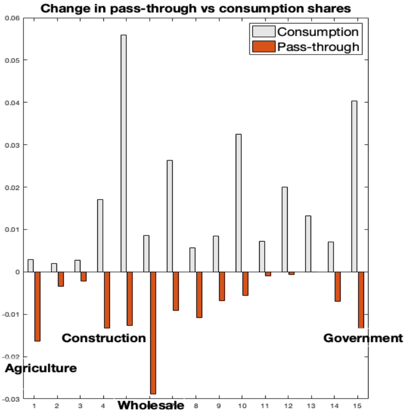
back

Decomposition

back

$$\bar{\delta}_w = \overbrace{\beta^T}^{\text{consumption shares}} \overbrace{\Delta\left(I - \Omega\Delta\right)^{-1}\alpha}^{\text{pass-through}}$$

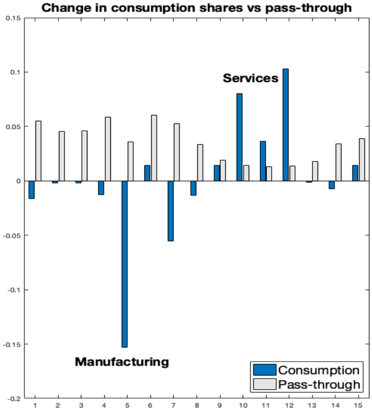


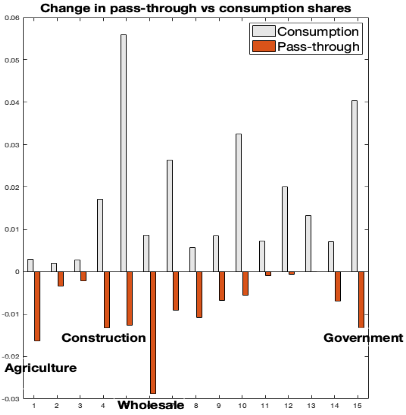


Decomposition

back

$$\bar{\delta}_w = \underbrace{\beta^T}_{21\%} \underbrace{\Delta\left(I - \Omega\Delta\right)^{-1}\alpha}_{79\%}$$



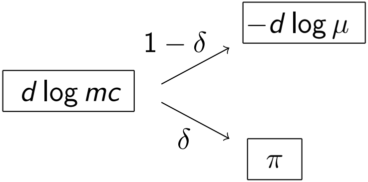


Markups, output gap and inflation

- Markups $\uparrow \implies$ labor share $\downarrow \implies$ labor supply $\downarrow$:

$$(\gamma + \varphi)\, \tilde{y} = -\lambda^T d \log \mu$$

- Markups and inflation:



$$d \log \mu = -\left(I - \Delta\right) \Delta^{-1} \pi$$

back

Dynamics

- Dynamic system:

$$\begin{cases} \pi_t = \mathcal{B}\tilde{y}_t + \mathcal{V}\log\mu_{t-1} + \rho\mathcal{M}\mathbb{E}\pi_{t+1} \\ -(I-\Delta)^{-1}\Delta\log\mu_t = \mathcal{B}(\tilde{y}_t - \tilde{y}_{t-1}) + \mathcal{V}[(logA_t - logA_{t-1}) + \\ +(I-\Omega)\rho\mathbb{E}\pi_{t+1}] - \mathcal{M}(I-\Delta)^{-1}\Delta\log\mu_{t-1} \end{cases}$$

- Past markups are state variable
- $\mathcal{M}$: propagation

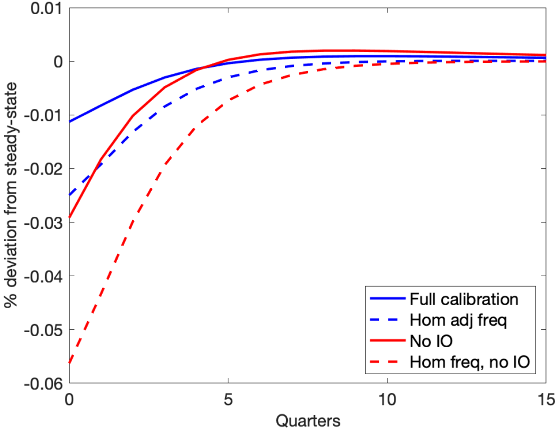
Propagation

$$\mathcal{M} \equiv \left(\frac{\mathcal{B}\lambda^T}{\gamma + \varphi} - \mathcal{V} \right) (I - \Delta)\, \Delta^{-1}$$

- Impact response:

$$\pi_t^C = \sum_{s \geq 0} \rho^s \left[\beta^T \mathcal{M}^s \mathcal{B} \mathbb{E}_t \tilde{y}_{t+s} + \beta^T \mathcal{M}^s \mathcal{V} \mathbb{E}_t \log \mu_{t+s-1} \right]$$

Full impulse-response



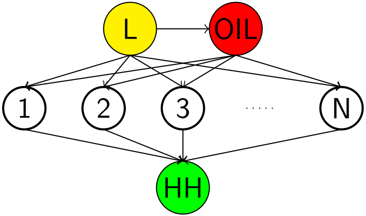
back

TFP vs labor augmenting shocks

- Labor augmenting shock $\implies$ "divine coincidence"
  - wage $\downarrow$ = productivity $\downarrow$ **for every sector**
- Aggregate TFP shock (-1%): $\pi^C \uparrow$ by 0.26%
  - wage pass-through vs productivity pass-through

back

Oil shocks - a simple model



- vertical chain + horizontal economy

$$\pi^C = -\frac{Cov_\beta(\delta, \omega_{oil}) + (1 - \delta_L)\,\mathbb{E}_\beta(\delta)\mathbb{E}_\beta(\omega_{oil})}{1 - \delta_L \mathbb{E}_\beta(\delta)} d \log A_{oil}$$

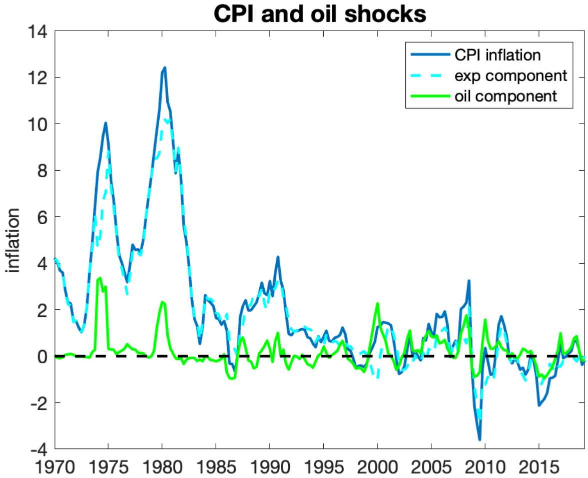
- Flex oil prices, sticky wages $\Longrightarrow$ "downstream" shock
- $Cov_\beta(\delta, \omega_{oil}) > 0$

Oil shocks: calibration

	$\delta =$ actual	$\delta \equiv \delta_{mean}$, $\delta_{oil} = 1$	$\delta \equiv \delta_{mean}$
sticky wages	0.22	0.07	-0.00
flexible wages	0.18	0.01	-0.06

Table: Consumer inflation after a 10% negative shock to the oil sector (full model)

- Both wage rigidity and correlation matter
- Opposite prediction if ignore that oil price is flexible



- Match observed path of inflation and oil prices with shocks to:
  - oil productivity
  - rational expectations
- Oil prices explain too little of early inflation, more later

Substitution within sectors

- Customers buy too much of the varieties with lower price

$$\pi^T \mathcal{D}_1 \pi = \sum_i \underbrace{\lambda_i}_{\text{sales share}} \frac{\overbrace{1-\delta_i}^{\text{discount flex sectors}}}{\delta_i} \underbrace{\epsilon_i}_{\text{substitution}} \underbrace{\pi_i^2}_{\text{price distortion}}$$

- Same intuition as one-sector model
- Aggregation

Substitution across inputs

- High demand for inputs with relative price $<$ efficient outcome
- Depends on ES across inputs and relative price distortions
- Distortion across inputs $\simeq$ negative productivity shock
  - $\pi_i \Rightarrow$ price distortion between k and $h \Longrightarrow$ substitution in t

$$(\text{distortion})_{k,h} = \left(\underbrace{(I-\Omega)^{-1}_{ki} - (I-\Omega)^{-1}_{hi}}_{\text{relative exposure}} \right) \underbrace{\frac{1-\delta_i}{\delta_i}}_{\text{discount flex sectors}} \pi_i$$

Substitution across inputs

- Loss $\Phi_t \simeq$ covariance between distortions from π_i, π_j

$$\Phi_t(i,j) = \frac{1}{2}\sum_k \sum_h \underbrace{\omega_{tk}\omega_{th}}_{\text{shares}} \underbrace{\theta^t_{kh}}_{\text{substitution}} (\text{distortion from } i)_{kh} (\text{distortion from } j)_{kh}$$

- Aggregate with sales shares:

$$\pi^T \mathcal{D}_2 \pi \equiv \sum_t \lambda_t \underbrace{\sum_{i,j} \Phi_t(i,j)}_{\text{productivity loss in } t}$$

back

Cost-push shocks

- SW Phillips curve:

$$SW = (\gamma + \varphi)\,\tilde{y} + \lambda^T dlog\,\mu^D$$

- CPI Phillips curve:

$$CPI = \kappa^C \tilde{y} + u + v$$

where

$$v = \frac{\bar{\delta}_\mu}{1 - \bar{\delta}_w} \lambda^T dlog\,\mu^D$$

$$\delta_\mu = \frac{\beta^T \Delta (I - \Omega\Delta)^{-1} dlog\,\mu^D}{\lambda^T dlog\,\mu^D}$$

back

Optimal policy

- Optimal output gap:

$$\tilde{y}^*_{CP} = \frac{\mathcal{B}^T \left(\mathcal{D} \left(\overbrace{\frac{\mathcal{B}\lambda^T}{\gamma + \varphi}}^{\text{inflation-output tradeoff}} - \overbrace{\mathcal{V}}^{\text{propagation}} \right) - \overbrace{\mathcal{D}_2 \Delta (I - \Delta)^{-1}}^{\text{direct effect}} \right)}{(\gamma + \varphi) + \mathcal{B}^T \mathcal{D} \mathcal{B}} dlog \mu^D$$

Proposition

$$y > y^* \iff \pi_T > \left(\lambda^T - \mathcal{B}^T \mathcal{D}_2 \Delta (I - \Delta)^{-1} \right) dlog \mu^D$$

back dynamics

Dynamics

- SW Phillips curve

$$SW_t = (\gamma + \varphi)\,\tilde{y}_t + \rho\mathbb{E}\,(SW_{t+1})$$

$$\hat{\delta}_i = \frac{\delta_i\,(1 - \rho(1 - \delta_i))}{1 - \rho\delta_i(1 - \delta_i)}$$

Dynamics

- CPI Phillips curve:

$$CPI_t = \kappa_t^C \tilde{y}_t + u_t + \tilde{v}_t$$

where

$$\tilde{v}_t = v_t - \frac{\bar{\delta}_\mu - \bar{\delta}_w}{1 - \bar{\delta}_w} \lambda^T dlog \mu_{t-1} - \frac{\bar{\delta}_\pi - \bar{\delta}_w}{1 - \bar{\delta}_w} \rho \mathbb{E} CPI_{t+1}$$

$$\bar{\delta}_\pi = \frac{\beta^T \Delta \left(I - \Omega \hat{\Delta} \right)^{-1} \mathbb{E} \pi_{t+1}}{\mathbb{E} CPI_{t+1}}$$

back

Optimal policy and implementation

- Interest rate rule (for $\zeta > 1$)

$$i_t = \underbrace{\overbrace{r_t^n + \gamma \left[\mathbb{E}\widetilde{y}_{t+1}^* - \widetilde{y}_t^*\right]}^{\text{real rate under opt policy}} + \beta^T \mathbb{E}\pi_{t+1}^*}_{\text{nominal rate under optimal policy}} + \zeta \underbrace{\left(\phi_t \pi_t + \phi_{t+1} \rho \mathbb{E}\pi_{t+1}\right)}_{\text{inflation target}}$$

- Inflation target:

$$\phi_t = \frac{\lambda^T (I - \hat{\Delta}) \hat{\Delta}^{-1}}{\gamma + \varphi} + \frac{\mathcal{B}^T \mathcal{D}}{\gamma + \varphi + \mathcal{B}^T \mathcal{D} \mathcal{B}}$$

$$\phi_{t+1} = \underbrace{\left(\lambda^T \left(I - \hat{\Delta}\right) \hat{\Delta}^{-1} - \mathcal{B}^T \mathcal{D}_2\right)}_{\text{inflation response to cp shock under optimal policy}}$$

back cost push shocks

Within- and cross-sector misallocation

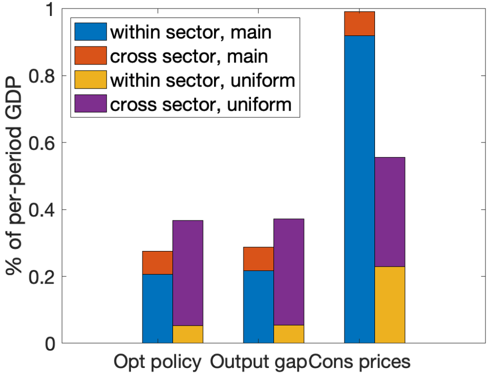


Figure: Main calibration: $\epsilon = 8, \sigma = 0.9, \theta_L = 0.5, \theta = 0.001$; uniform elasticities: $\epsilon = \sigma = \theta_L = \theta = 2$

back

With oil prices

	SW	CPI	core CPI	PCE	core PCE
gap	-3.6385**	-0.2198**	-0.2038**	-0.1194**	-0.1066*
	(0.6294)	(0.0655)	(0.0643)	(0.0584)	(0.0573)
intercept	1.9532**	2.7286**	2.9576**	2.266**	2.3883**
	(0.0483)	(0.1099)	(0.1078)	(0.0979)	(0.0961)
oil prices	0.0032**	0.0185**	-0.0058*	0.0138**	-0.0017
	(0.0013)	(0.003)	(0.0029)	(0.0027)	(0.0026)
R-squared	0.2488	0.2959	0.0829	0.2049	0.0257

Table: Regression results for the CBO unemployment gap , with oil prices

back

With endogenous cost-push

	SW	CPI	core CPI	PCE	core PCE
cost-push	0.5627**	2.5545**	0.4886	2.3948**	1.1224**
	(0.2345)	(0.565)	(0.4768)	(0.4745)	(0.4102)
gap	-3.7586**	-0.1906**	-0.2175**	-0.0783	-0.0886
	(0.6872)	(0.0758)	(0.064)	(0.0637)	(0.0551)
intercept	2.0842**	3.2239**	2.8559**	2.6509**	2.397**
	(0.058)	(0.1398)	(0.118)	(0.1174)	(0.1015)
R-squared	0.3317	0.2782	0.142	0.2558	0.1275

Table: Regression results for the CBO unemployment gap , with CP shock

back

With oil prices and cost-push

	SW	CPI	core CPI	PCE	core PCE
cost-push	0.2874	1.1895**	0.99*	1.4128**	1.3585**
	(0.265)	(0.5943)	(0.5409)	(0.5123)	(0.4707)
gap	-3.8932**	-0.2211**	-0.2062**	-0.1003*	-0.0833
	(0.6795)	(0.0698)	(0.0635)	(0.0602)	(0.0553)
intercept	2.0185**	2.8983**	2.9754**	2.4167**	2.4533**
	(0.065)	(0.1458)	(0.1327)	(0.1257)	(0.1155)
oil prices	0.0034**	0.0167**	-0.0062*	0.012**	-0.0029
	(0.0016)	(0.0036)	(0.0033)	(0.0031)	(0.0028)
R-squared	0.3581	0.399	0.1692	0.3472	0.1358

Table: Regression results for the CBO unemployment gap (CP shock and oil prices)

back

With expectations

	SW	CPI	core CPI	PCE	core PCE
gap	-1.1054**	-0.1613**	-0.0344	-0.062	0.0047
	(0.3275)	(0.0809)	(0.052)	(0.0487)	(0.0368)
inflation expecations	0.8287**	0.4846**	0.5446**	0.6364**	0.6406**
	(0.0383)	(0.1557)	(0.0559)	(0.0621)	(0.045)
intercept	0.3484**	1.3851**	1.3193**	0.5522**	0.8388**
	(0.0789)	(0.5021)	(0.1818)	(0.196)	(0.1228)
R-squared	0.8234	0.159	0.4425	0.4635	0.6072

Table: CBO unemployment gap

back

Other gaps

	SW	CPI	core CPI	PCE	core PCE
gap	1.0861**	0.1881**	0.0412	0.0881**	0.0084
	(0.2714)	(0.0678)	(0.0449)	(0.0417)	(0.032)
inflation expecations	0.8297**	0.4412**	0.5398**	0.6231**	0.6365**
	(0.0368)	(0.1515)	(0.0561)	(0.0617)	(0.0455)
intercept	0.3668**	1.6124**	1.3548**	0.6459**	0.8614**
	(0.0772)	(0.4987)	(0.1892)	(0.2005)	(0.1291)
R-squared	0.8288	0.1808	0.4442	0.4744	0.6073

Table: CBO output gap

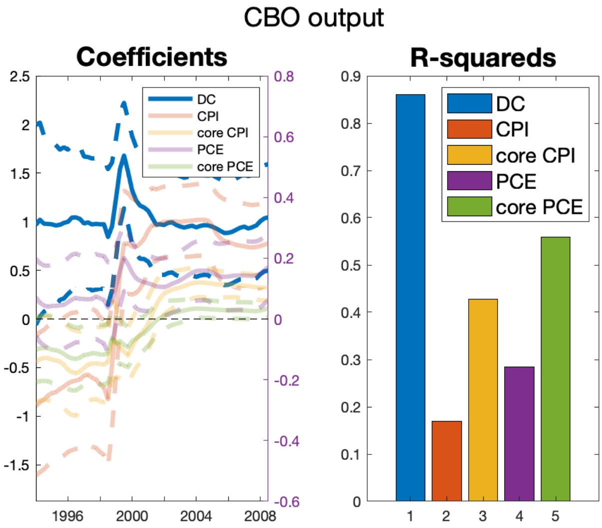
Other gaps

	SW	CPI	core CPI	PCE	core PCE
gap	-0.9404**	-0.0049	0.0781	-0.0505	0.0757**
	(0.3185)	(0.0788)	(0.0499)	(0.0477)	(0.0355)
inflation expecations	0.8468**	0.6312**	0.5668**	0.6549**	0.6432**
	(0.0372)	(0.1518)	(0.0537)	(0.0608)	(0.0434)
intercept	0.3108**	0.8344*	1.1705**	0.4941**	0.7757**
	(0.0762)	(0.4879)	(0.1711)	(0.1851)	(0.1155)
R-squared	0.8202	0.1344	0.4507	0.4616	0.6198

Table: unemployment rate

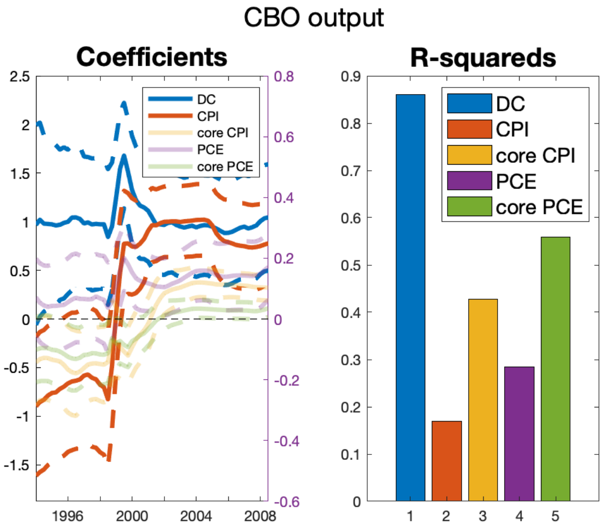
back

Other gaps

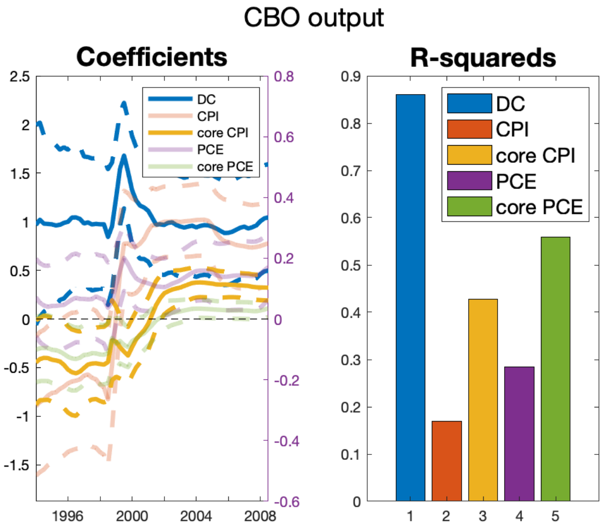


CBO output
Coefficients
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1996
2000
2004
2008
DC
CPI
core CPI
PCE
core PCE
R-squareds
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
DC
CPI
core CPI
PCE
core PCE

Other gaps


CBO output
Coefficients
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1996
2000
2004
2008
DC
CPI
core CPI
PCE
core PCE
R-squareds
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
DC
CPI
core CPI
PCE
core PCE

Other gaps



CBO output
Coefficients
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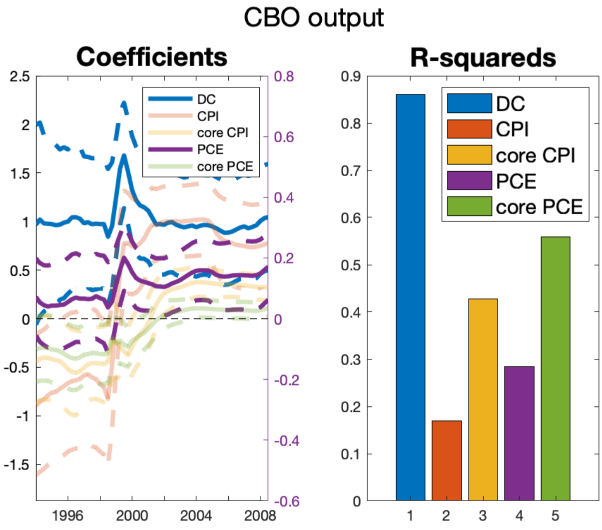
2
1.5
1
0.5
0
-0.5
-1
-1.5
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1996
2000
2004
2008
DC
CPI
core CPI
PCE
core PCE
R-squareds
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
DC
CPI
core CPI
PCE
core PCE

Other gaps



CBO output
Coefficients
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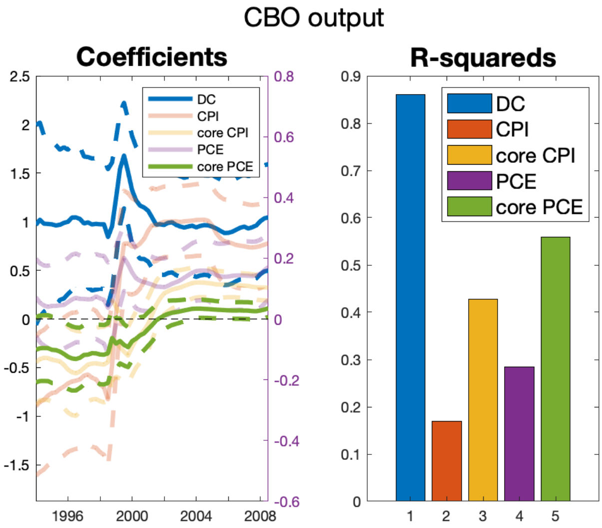
1.5
1
0.5
0
-0.5
-1
-1.5
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1996
2000
2004
2008
DC
CPI
core CPI
PCE
core PCE
R-squareds
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
DC
CPI
core CPI
PCE
core PCE

Other gaps



CBO output
Coefficients
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1996
2000
2004
2008
DC
CPI
core CPI
PCE
core PCE
R-squareds
0.9
0.8
0.7
0.6
0.5
0.4
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2
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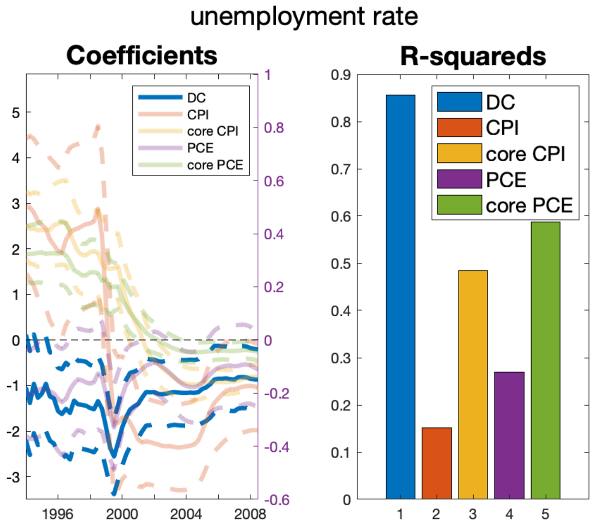
5
DC
CPI
core CPI
PCE
core PCE

Other gaps



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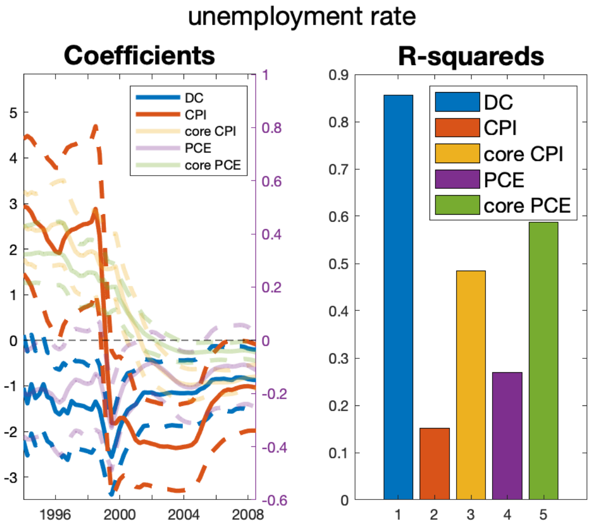
Other gaps



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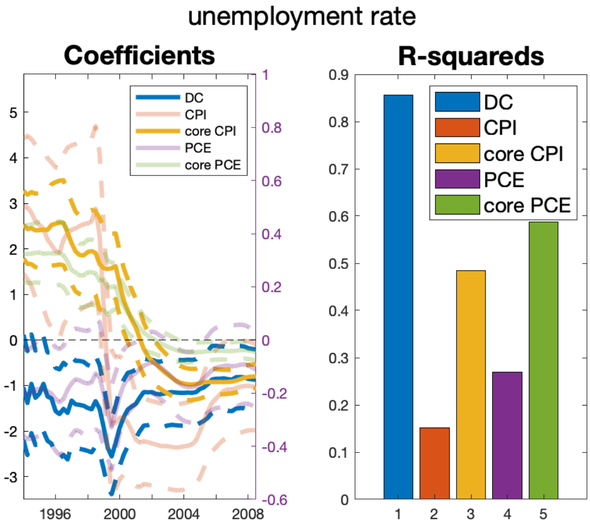
Other gaps



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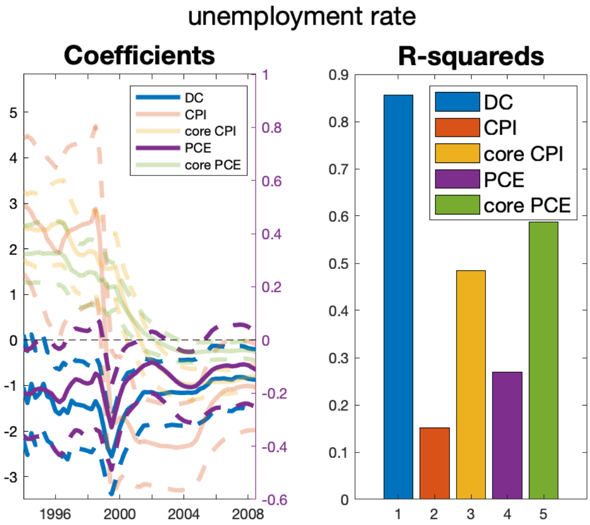
Other gaps



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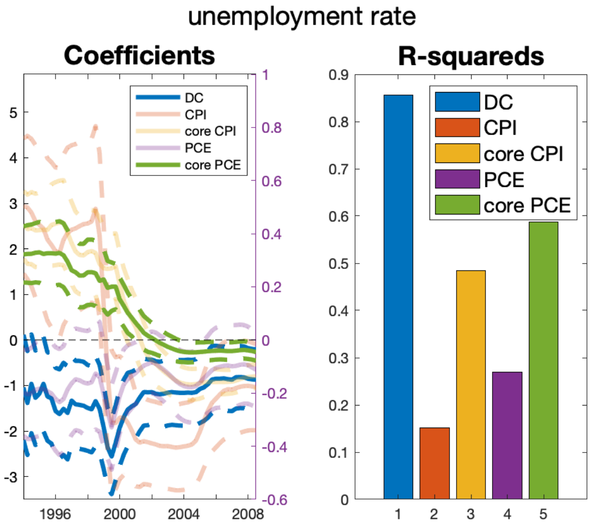
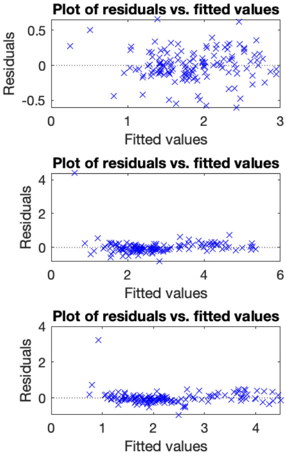
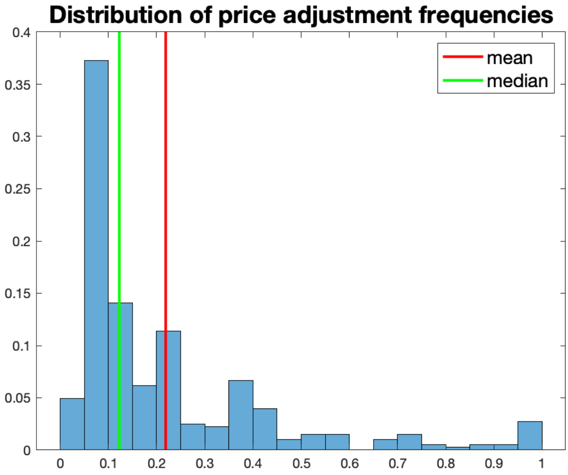
Other gaps



back

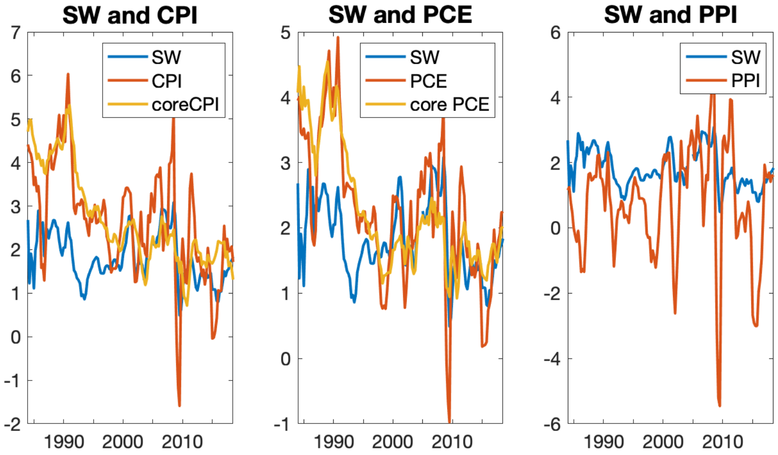
Residuals


Plot of residuals vs. fitted values
Residuals
0.5
0
-0.5
0
1
2
3
Fitted values
Plot of residuals vs. fitted values
Residuals
4
2
0
-2
-2
0
2
4
6
Fitted values
Plot of residuals vs. fitted values
Residuals
4
2
0
0
2
4
6
Fitted values
Plot of residuals vs. fitted values
Residuals
4
2
0
-2
0
2
4
6
Fitted values
Plot of residuals vs. fitted values
Residuals
4
2
0
0
1
2
3
4
Fitted values


Distribution of price adjustment frequencies
mean
median
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

back

SW and consumer prices



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Model comparison

- Mis-measurement:

$$\pi^C_{mis} = SW - \pi^C$$

- Model 1:

$$\tilde{y} = \alpha_0 + \alpha_1 \pi^C + u$$

- Model 2:

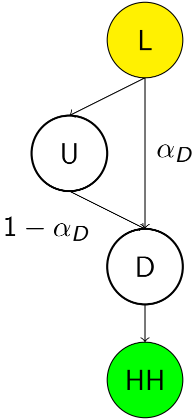
$$\tilde{y} = \beta_0 + \beta_1 \pi^C + \beta_2 \pi^C_{mis} + v$$

Model comparison

		CPI	core CPI	PCE	core PCE
Model 1 (nested)	α_1	-0.35	-0.30	-0.29	-0.22
	R^2	0.10	0.05	0.05	0.02
Model 2 (full)	β_1	-1.21	-1.22	-1.28	-1.19
	β_2	-1.22	-1.16	-1.48	-1.33
	R^2	0.22	0.22	0.23	0.22
	F-stat	20.20	28.30	31.80	34.90
	p-value	< 0.001	< 0.001	< 0.001	< 0.001

back

Vertical chain, $A_D \downarrow$



- Inflation upstream?

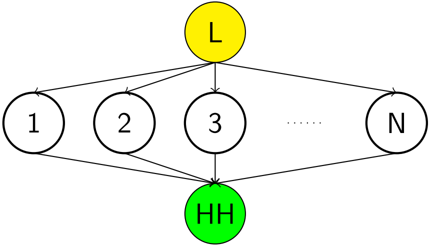
$$\pi_U = \delta_U d \log w < 0$$

- Consumer inflation?

$$\bar{\delta}_w = \delta_D \left(\underbrace{\alpha_D}_{\text{direct labor share}} + \underbrace{(1-\alpha_D)\,\delta_U}_{\text{labor from U}} \right) < \delta_D = \bar{\delta}_A$$

$$\implies \pi^C = \pi_D > 0$$

Horizontal economy



- Wages:

$$d \log rw = \mathbb{E}_\beta \left[d \log A \right]$$

- Prices respond more in flexible sectors:

$$\pi^C > 0 \iff Cov_\beta \left(\delta, d \log A \right) < 0$$