The Inflation Accelerator

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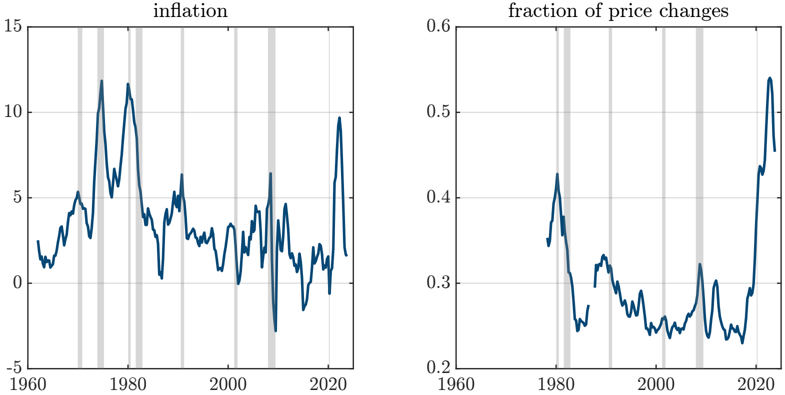
Motivation

- Dynamics of inflation shaped critically by the slope of the Phillips curve
  - key determinant: fraction of price changes
- Empirical evidence: fraction of price changes increases with inflation
  - Gagnon (2009), Alvarez et al. (2018), Blanco et al. (2024)

Evidence from the U.S.



Source: Nakamura et al. (2018), Montag and Villar (2023). Fraction quarterly.

Motivation

- Dynamics of inflation shaped critically by the slope of the Phillips curve
  - key determinant: fraction of price changes
- Empirical evidence: fraction of price changes increases with inflation
  - Gagnon (2009), Alvarez et al. (2018), Blanco et al. (2024)
- How does the slope of the Phillips curve fluctuate in U.S. time series?
  - answer using model that reproduces this evidence

Existing Models

- Calvo model
  - widely used due to its tractability
  - constant fraction of price changes

- Menu cost model
  - less tractable: state of the economy includes distribution of prices
  - calibration consistent with micro price data: fraction nearly constant

- Our model
  - tractable model with time-varying endogenous fraction of price changes
  - multi-product firms choose *how many*, but not *which*, prices to change
  - exact aggregation: reduces to one-equation extension of Calvo

Findings

- Our model predicts highly non-linear Phillips curve
  - slope fluctuates from 0.02 in 1990s to 0.12 in 1970s and 1980s

- Mostly due to a feedback loop between inflation and frequency
  - higher inflation increases frequency of price changes
  - higher frequency further increases inflation
  - *inflation accelerator*

- Absent feedback loop slope would increase to only 0.04 in 1970s and 1980s

Model

Model Overview

- Multi-product firms: each sells continuum of goods
  - decreasing returns labor-only technology
  - cost of changing prices

- Monetary policy targets growth rate of nominal spending $M_t = P_t c_t$
  - evolves according to $\log M_{t+1}/M_t = \mu + \varepsilon_{t+1}$, $\varepsilon_{t+1} \sim N(0, \sigma)$
  - only source of aggregate uncertainty

- Golosov-Lucas log-linear assumptions on preferences
  - imply that $W_t = M_t$

Technology

- Final good used for consumption, produced using CES aggregator

$$y_t = \left(\int_0^1 \int_0^1 (y_{ikt})^{\frac{\theta-1}{\theta}} \, \mathrm{d}k \mathrm{d}i \right)^{\frac{\theta}{\theta-1}}$$

  - y_{ikt} output of good k produced by firm i, sold at price P_{ikt}

- Individual goods produced with decreasing returns technology

$$y_{ikt} = (l_{ikt})^{\eta}$$

- Aggregate price index

$$P_t = \left(\int_0^1 \int_0^1 (P_{ikt})^{1-\theta} \, \mathrm{d}k \mathrm{d}i \right)^{\frac{1}{1-\theta}}$$

Price Adjustment Costs

- Firm chooses fraction of prices to change n_{it} ▸ profits
  - but not which prices to change (similar to Greenwald 2018)
  - if adjust $P_{ikt} = P^*_{it}$, otherwise $P_{ikt} = P_{ikt-1}$
- Price adjustment cost, denominated in units of labor

$$\frac{\xi}{2}\left(n_{it} - \bar{n}\right)^2, \quad \text{if } n_{it} > \bar{n}$$

Firm-Level Aggregation

- Firm-level output y_{it} and labor l_{it}

$$y_{it} = \left(\int_0^1 (y_{ikt})^{\frac{\theta-1}{\theta}} \, \mathrm{d}k \right)^{\frac{\theta}{\theta-1}} \qquad \text{and} \qquad l_{it} = \int_0^1 l_{ikt} \mathrm{d}k$$

- Firm-level production function

$$y_{it} = \left(\frac{X_{it}}{P_{it}} \right)^{\theta} l_{it}^{\eta}$$

  - price index P_{it} and losses from misallocation X_{it}

$$P_{it} = \left(\int_0^1 (P_{ikt})^{1-\theta} \, \mathrm{d}k \right)^{\frac{1}{1-\theta}} \qquad \text{and} \qquad X_{it} = \left(\int_0^1 (P_{ikt})^{-\frac{\theta}{\eta}} \, \mathrm{d}k \right)^{-\frac{\eta}{\theta}}$$

  - absent price dispersion $X_{it}/P_{it} = 1$, otherwise $X_{it}/P_{it} < 1 \rightarrow$ misallocation

Firm Problem

- Choose reset price P_{it}^{*} and fraction of prices to change n_{it} to maximize

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left[\left(\frac{P_{it+s}}{P_{t+s}} \right)^{1-\theta} - \tau \left(\frac{X_{it+s}}{P_{t+s}} \right)^{-\frac{\theta}{\eta}} y_{t+s}^{\frac{1}{\eta}} - \frac{\xi}{2} \left(n_{it+s} - \bar{n} \right)^2 \right]$$

- Choices at t affect firm price index and misallocation at all future dates

$$\begin{aligned} \left(P_{it+s}\right)^{1-\theta} = {} & n_{it+s} \left(P_{it+s}^{*}\right)^{1-\theta} + \left(1 - n_{it+s}\right) n_{it+s-1} \left(P_{it+s-1}^{*}\right)^{1-\theta} + \cdots \\ & + \prod_{j=1}^{s} \left(1 - n_{it+j}\right) n_{it} \left(P_{it}^{*}\right)^{1-\theta} + \prod_{j=1}^{s} \left(1 - n_{it+j}\right) \left(1 - n_{it}\right) \left(P_{it-1}\right)^{1-\theta} \end{aligned}$$

misallocation

- History encoded in two state variables: P_{it-1} and X_{it-1}
  - exact aggregation because adjustment hazard does not depend on P_{ikt-1}

Optimal Reset Price

- Present value of output and production costs in future dates

$$b_{1it} = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \prod_{j=1}^{s} (1 - n_{it+j}) \left(\frac{P_{t+s}}{P_t} \right)^{\theta - 1}$$

$$b_{2it} = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \prod_{j=1}^{s} (1 - n_{it+j}) \left(\frac{P_{t+s}}{P_t} \right)^{\frac{\theta}{\eta}} (y_{t+s})^{\frac{1}{\eta}}$$

- Optimal reset price

$$\frac{P_{it}^*}{P_t} = \left(\frac{1}{\eta} \frac{b_{2it}}{b_{1it}} \right)^{\frac{1}{1+\theta\left(\frac{1}{\eta}-1\right)}}$$

- Present value of future marginal costs, weighted appropriately
  - similar to Calvo, except n_{it} time-varying

Optimal Fraction of Price Changes

- Equate marginal cost to marginal benefit

$$\xi\left(n_{it}-\bar{n}\right)=b_{1it}\left(\left(\frac{P_{it}^{*}}{P_t}\right)^{1-\theta}-\left(\frac{P_{it-1}}{P_t}\right)^{1-\theta}\right)-\tau b_{2it}\left(\left(\frac{P_{it}^{*}}{P_t}\right)^{-\frac{\theta}{\eta}}-\left(\frac{X_{it-1}}{P_t}\right)^{-\frac{\theta}{\eta}}\right)$$

- Marginal benefit: higher n_{it}
  - changes firm price index
  - and reduces misallocation
  - weighted by the same terms b_{1it} and b_{2it} that determine P_{it}^{*}

Symmetric Equilibrium

- Since firms are identical, in equilibrium $P_{it}^* = P_t^*$, $n_{it} = n_t$, $\ldots$

- Let $p_t = P_t/M_t$, $p_t^* = P_t^*/M_t$, $x_t = X_t/P_t$, $\pi_t = P_t/P_{t-1}$

- Optimal choices

  – reset price

$$\frac{p_t^*}{p_t} = \left(\frac{1}{\eta}\frac{b_{2t}}{b_{1t}}\right)^{\frac{1}{1+\theta\left(\frac{1}{\eta}-1\right)}}$$

  – fraction of price changes

$$\xi\left(n_t - \bar{n}\right) = b_{1t}\left(\left(\frac{p_t^*}{p_t}\right)^{1-\theta} - \left(\frac{1}{\pi_t}\right)^{1-\theta}\right) - \tau b_{2t}\left(\left(\frac{p_t^*}{p_t}\right)^{-\frac{\theta}{\eta}} - \left(\frac{x_{t-1}}{\pi_t}\right)^{-\frac{\theta}{\eta}}\right)$$

Symmetric Equilibrium

- Inflation pinned down by definition of price index

$$1 = n_t \left(\frac{p_t^*}{p_t}\right)^{1-\theta} + (1 - n_t)\,\pi_t^{\theta-1}$$

- Losses from misallocation

$$x_t^{-\frac{\theta}{\eta}} = n_t \left(\frac{p_t^*}{p_t}\right)^{-\frac{\theta}{\eta}} + (1 - n_t)\,x_{t-1}^{-\frac{\theta}{\eta}}\pi_t^{\frac{\theta}{\eta}}$$

- Model reduces to one-equation extension of Calvo
  - as $\xi \to \infty$, $n_t = \bar{n}$ so our model nests Calvo

Computation

- Two state variables
  - previous period price level: $s_t = P_{t-1}/M_t = p_{t-1}/\exp(\mu + \varepsilon_t)$
  - previous period misallocation: x_{t-1}
- Solve for equilibrium functions $p_t = \mathcal{P}\left(s_t,\, x_{t-1}\right)$, $x_t = \mathcal{X}\left(s_t,\, x_{t-1}\right)$, ...
  - use projection methods to solve globally
  - third-order perturbation also provides accurate approximation

Parameterization

Strategy

- Assigned parameters
  - period 1 quarter so $\beta = 0.99$
  - demand elasticity $\theta = 6$ and span of control $\eta = 2/3$
- Calibrated parameters
  - mean and standard deviation of nominal spending growth μ and σ
  - fraction of free price changes $\bar{n}$
  - price adjustment cost ξ
- Calibration targets
  - mean and standard deviation of inflation
  - mean fraction of price changes
  - slope of fraction of price changes on absolute value of inflation

Calibrated Parameters

A. Targeted Moments

	Data	Our model	Calvo
mean inflation	3.517	3.517	3.517
s.d. inflation	2.739	2.739	2.739
mean frequency	0.297	0.297	0.297
slope of n_t on $\lvert\pi_t\rvert$	0.016	0.016	–

B. Calibrated Parameter Values

		Our model	Calvo
μ	mean spending growth rate	0.035	0.035
σ	s.d. monetary shocks	0.022	0.024
$\bar{n}$	fraction free price changes	0.241	0.297
ξ	adjustment cost	1.767	–

- Price adjustment costs account for 0.65% of all labor costs

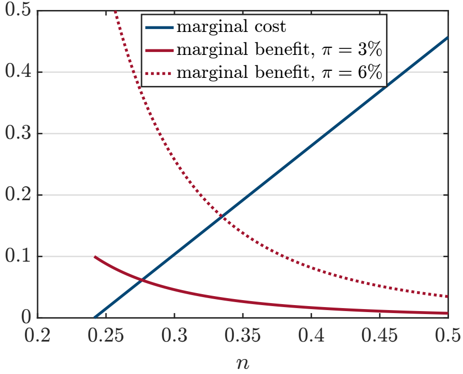
Steady State Analysis

Overview

- Show how steady-state outcomes vary with trend inflation
- Responses to small and large monetary shocks
- Derive Phillips curve

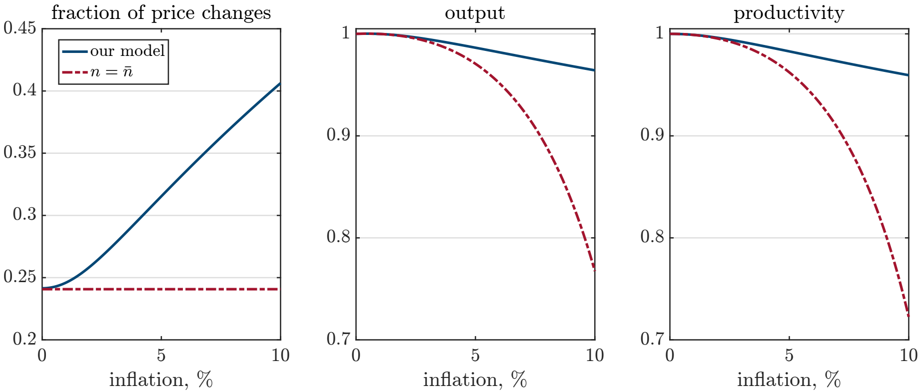
Fraction of Price Changes

$$\xi\left(n-\bar{n}\right)=\frac{1}{1-\beta\left(1-n\right)\pi^{\theta-1}}\frac{1}{n}\left(1-\pi^{\theta-1}-\tau\eta\frac{1-\left(1-n\right)\pi^{\theta-1}}{1-\left(1-n\right)\pi^{\frac{\theta}{\eta}}}\left(1-\pi^{\frac{\theta}{\eta}}\right)\right)$$



Fraction of price changes increases with inflation

Steady-State Output and Productivity



- Inflation less distortionary in our model

 equations

  - because more frequent price changes, as in menu cost models

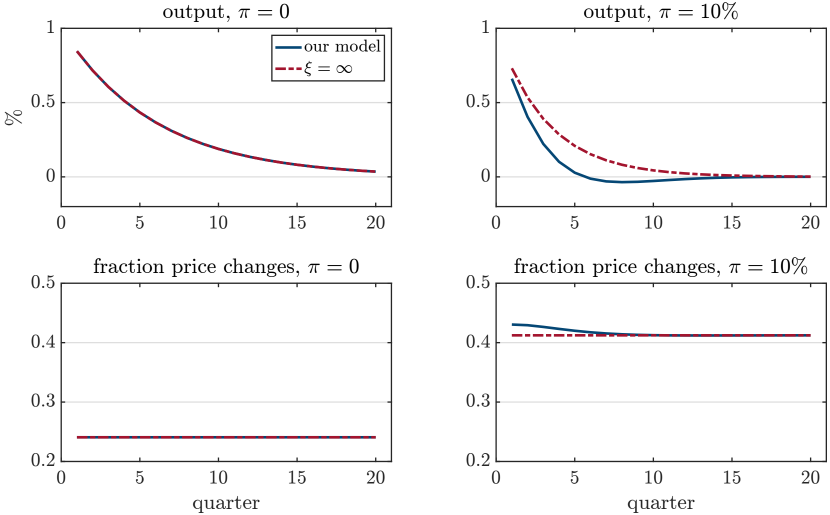
Real Effects of Monetary Shocks

- Responses to small monetary shocks
  - in economies with 0 and 10% trend inflation
  - compare to economy with $\xi = \infty$, frequency as in steady state of our model
  - use first-order approximation to build intuition

- Responses to large monetary shocks
  - use non-linear solution

- Focus on output response
  - $\Delta M_t = \Delta P_t + \Delta y_t$, so output response depends on how sticky prices are

Response to 1% Monetary Shock



Response to 1% Money Shock

- Absent trend inflation, our model responses identical to Calvo

- Output responds less in economy with 10% trend inflation
  - impact response: 0.66% vs. 0.85%
  - cumulative response: 1.22% vs. 5.5%

- Partly due to higher steady-state frequency: in $\xi = \infty$ economy
  - impact response: 0.73%
  - cumulative response: 2.72%

- Remaining difference due to increase in fraction of price changes
  - 0.43 to 0.45 on impact

Intuition

- Jump in frequency (0.43 to 0.45) has large effect on price level
  - 0.27% to 0.34% on impact

- To see why, log-linearize expression for aggregate price index

$$\hat{\pi}_t = \underbrace{\frac{1}{(1-n)\,\pi^{\theta-1}}\frac{\pi^{\theta-1}-1}{\theta-1}}_{\mathcal{M}}\hat{n}_t + \underbrace{\frac{1-(1-n)\,\pi^{\theta-1}}{(1-n)\,\pi^{\theta-1}}}_{\mathcal{N}}\left(\hat{p}_t^* - \hat{p}_t\right)$$

- Elasticity $\mathcal{N}$ to reset price changes: identical to Calvo
  - increases with n, decreases with π (lower weight on new prices)

- Elasticity $\mathcal{M}$ to frequency: zero if $\pi = 1$, increases with inflation

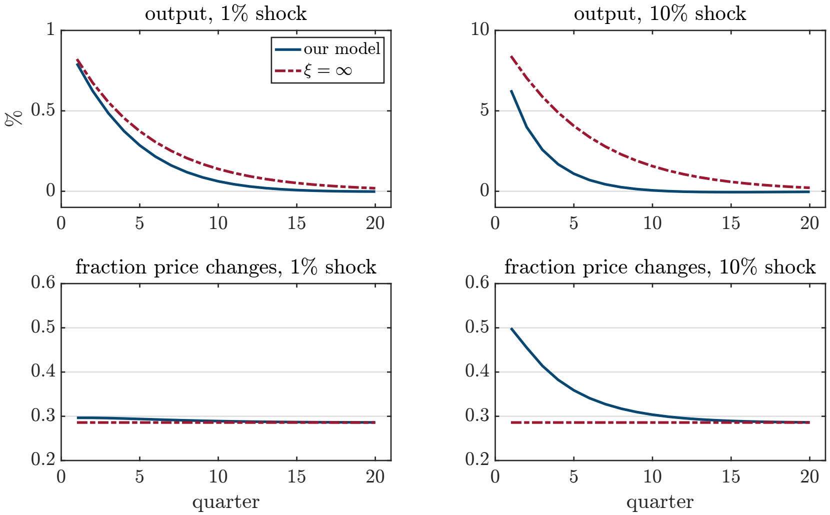
Intuition

- Why is price level more responsive to changes in n at high inflation?

$$\mathcal{M} = \frac{1}{(1-n)\,\pi^{\theta-1}} \frac{\pi^{\theta-1}-1}{\theta-1}$$

- Inflation $\approx$ average price change $\times$ fraction of price changes
  - $\pi = 0$: average price change $= 0$ so fraction inconsequential
  - $\pi = 10\%$: average price change $= 4\%$
    - so $\Delta n = 0.02$ increases price level by 0.1%
    - mechanism in Caplin and Spulber (1986) menu cost model
- To a first-order, newly reset prices respond to trend inflation, not shock
  - prices even more responsive to large shocks using non-linear solution

Response to Large Shock, Baseline Model



Strong non-linearities, as in menu cost model of Blanco et al. (2024)

Slope of the Phillips Curve

- Log-linearize optimal fraction of price changes

$$\hat{n}_t = \mathcal{A}\hat{\pi}_t + \mathcal{B}\left(\hat{p}_t^* - \hat{p}_t\right) - \mathcal{C}\hat{x}_{t-1} + \frac{n-\bar{n}}{n}\hat{b}_{1t}$$

- Elasticities $\mathcal{A}$ and $\mathcal{B}$ increase with trend inflation

$$\mathcal{A} = \frac{\theta-1}{\xi n}\frac{1}{1-\beta\left(1-n\right)\pi^{\theta-1}}\frac{\pi^{\frac{\theta}{\eta}}-\pi^{\theta-1}}{1-\left(1-n\right)\pi^{\frac{\theta}{\eta}}}$$

$$\mathcal{B} = \left(1-\tau\eta\right)\frac{\theta-1}{\xi n}\frac{1-\left(1-n\right)\pi^{\theta-1}}{1-\beta\left(1-n\right)\pi^{\theta-1}}\frac{1}{n}\frac{\pi^{\frac{\theta}{\eta}}-1}{1-\left(1-n\right)\pi^{\frac{\theta}{\eta}}}$$

  - zero when $\pi = 1$, so our model identical to Calvo up to a first-order

Inflation Accelerator

- Expression for price index: higher frequency increases inflation

$$\hat{\pi}_t = \mathcal{M}\hat{n}_t + \mathcal{N}\left(\hat{p}_t^* - \hat{p}_t\right)$$

- Optimal frequency increases with inflation

$$\hat{n}_t = \mathcal{A}\hat{\pi}_t + \mathcal{B}\left(\hat{p}_t^* - \hat{p}_t\right) - \mathcal{C}\hat{x}_{t-1} + \frac{n - \bar{n}}{n}\hat{b}_{1t}$$

- Feedback loop amplifies inflation response to changes in reset price

$$\hat{\pi}_t = \frac{\mathcal{M}\mathcal{B} + \mathcal{N}}{1 - \mathcal{M}\mathcal{A}}\left(\hat{p}_t^* - \hat{p}_t\right) - \frac{\mathcal{M}\mathcal{C}}{1 - \mathcal{M}\mathcal{A}}\hat{x}_{t-1} + \frac{\mathcal{M}}{1 - \mathcal{M}\mathcal{A}}\frac{n - \bar{n}}{n}\hat{b}_{1t}$$

Phillips Curve

- Let $\widehat{mc}_t = \frac{1}{\eta}\hat{y}_t$ aggregate real marginal cost

- Phillips curve

$$
\begin{aligned}
\hat{\pi}_t &= \mathcal{K}\widehat{mc}_t + \beta(1-n)\left(\frac{\frac{\theta}{\eta}\pi^{\frac{\theta}{\eta}} - (\theta-1)\pi^{\theta-1}}{1+\theta\left(\frac{1}{\eta}-1\right)}\frac{\mathcal{MB}+\mathcal{N}}{1-\mathcal{MA}} + \pi^{\frac{\theta}{\eta}}\right)\mathbb{E}_t\hat{\pi}_{t+1} \\
&+ \beta(1-n)\left(\frac{\pi^{\frac{\theta}{\eta}} - \pi^{\theta-1}}{1+\theta\left(\frac{1}{\eta}-1\right)}\frac{\mathcal{MB}+\mathcal{N}}{1-\mathcal{MA}} - \pi^{\frac{\theta}{\eta}}\frac{\mathcal{M}}{1-\mathcal{MA}}\frac{n-\bar{n}}{n}\right)\mathbb{E}_t\hat{b}_{1t+1} \\
&- \beta n\frac{\pi^{\frac{\theta}{\eta}} - \pi^{\theta-1}}{1+\theta\left(\frac{1}{\eta}-1\right)}\frac{\mathcal{MB}+\mathcal{N}}{1-\mathcal{MA}}\mathbb{E}_t\hat{n}_{t+1} \\
&+ \beta(1-n)\pi^{\frac{\theta}{\eta}}\frac{\mathcal{MC}}{1-\mathcal{MA}}\hat{x}_t - \frac{\mathcal{MC}}{1-\mathcal{MA}}\hat{x}_{t-1} + \frac{\mathcal{M}}{1-\mathcal{MA}}\frac{n-\bar{n}}{n}\hat{b}_{1t}
\end{aligned}
$$

Slope of the Phillips Curve

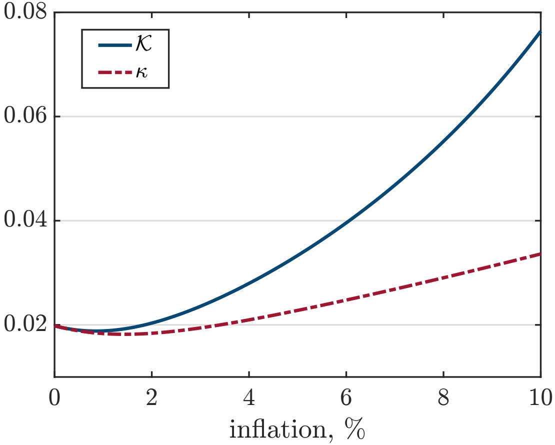
$$\mathcal{K} = \underbrace{\frac{1}{1+\theta\left(\frac{1}{\eta}-1\right)}}_{\text{complementarities}} \quad \times \quad \underbrace{\left(1-\beta\left(1-n\right)\pi^{\frac{\theta}{\eta}}\right)}_{\text{horizon effect}} \quad \times \quad \underbrace{\frac{\mathcal{MB}+\mathcal{N}}{1-\mathcal{MA}}}_{\text{reset price}}$$

- If $\xi = \infty$, reduces to slope in Calvo

$$\kappa = \frac{1}{1+\theta\left(\frac{1}{\eta}-1\right)}\left(1-\beta\left(1-n\right)\pi^{\frac{\theta}{\eta}}\right)\frac{1-\left(1-n\right)\pi^{\theta-1}}{\left(1-n\right)\pi^{\theta-1}}$$

- Difference between $\mathcal{K}$ and κ captures inflation accelerator

Slope of the Phillips Curve



Much steeper at high inflation, mostly due to inflation accelerator

Phillips Curve in the Time-Series

Approach

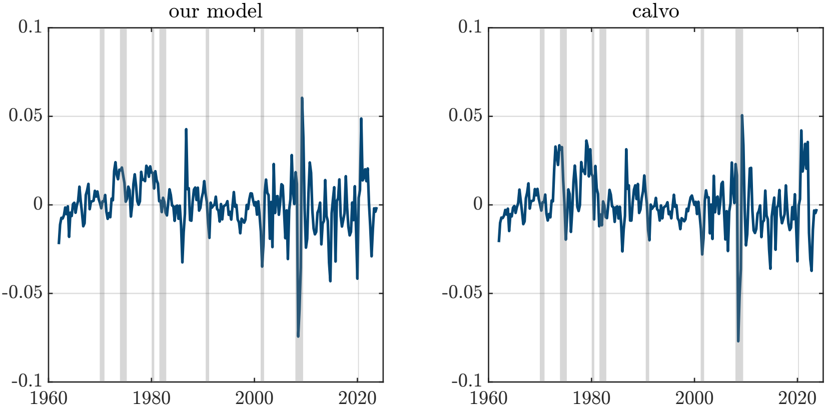
- Use non-linear solution to back out shocks that match U.S. inflation series

$$\pi_t = \pi\left(\frac{p_{t-1}}{\exp\left(\mu + \varepsilon_t\right)}, x_{t-1}\right)$$

  – initialize 1962 in stochastic steady state

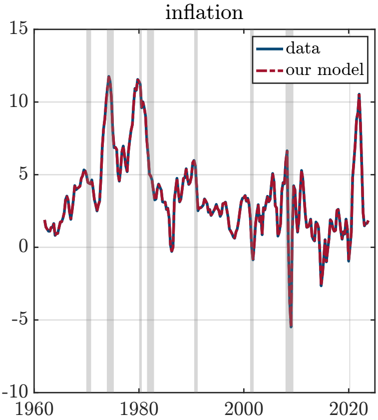
- Derive Phillips curve by perturbing equilibrium conditions at each date

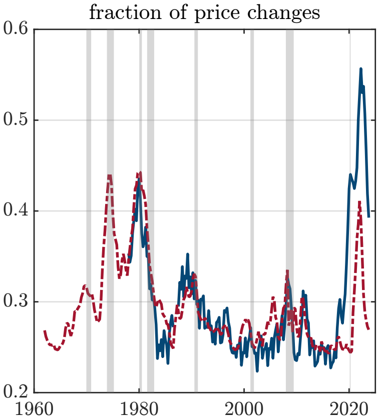
Monetary Policy Shocks



Our model requires small monetary shocks to explain 1970s and 1980s

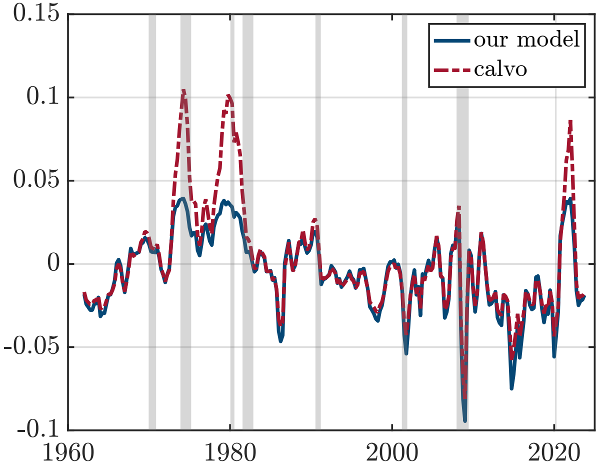
Fraction of Price Changes





Reproduces fraction well, except post-Covid because lower inflation

Output Gap



Our model: smaller increase in output gap in periods of high inflation

Slope of the Phillips Curve

- First-order perturbation around equilibrium point at date t

$$\hat{\pi}_t = \underbrace{\frac{1}{(1-n_t)\,\pi_t^{\theta-1}}\frac{\pi_t^{\theta-1}-1}{\theta-1}}_{\mathcal{M}_t}\,\hat{n}_t + \underbrace{\frac{1-(1-n_t)\,\pi_t^{\theta-1}}{(1-n_t)\,\pi_t^{\theta-1}}}_{\mathcal{N}_t}\,(\hat{p}_t^* - \hat{p}_t)\,.$$

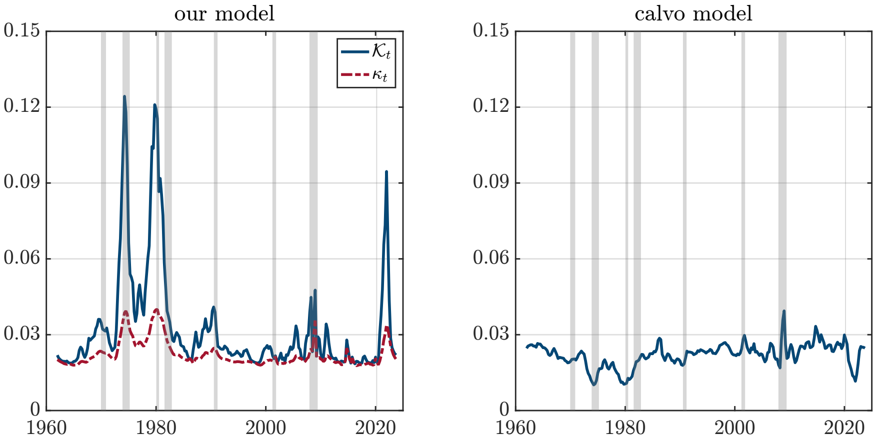
- Slope of the Phillips curve

$$\mathcal{K}_t = \frac{1}{1+\theta\left(\frac{1}{\eta}-1\right)}\frac{y_t^{\frac{1}{\eta}}}{b_{2t}}\frac{\mathcal{M}_t\mathcal{B}_t+\mathcal{N}_t}{1-\mathcal{M}_t\mathcal{A}_t}$$

- Absent endogenous frequency response

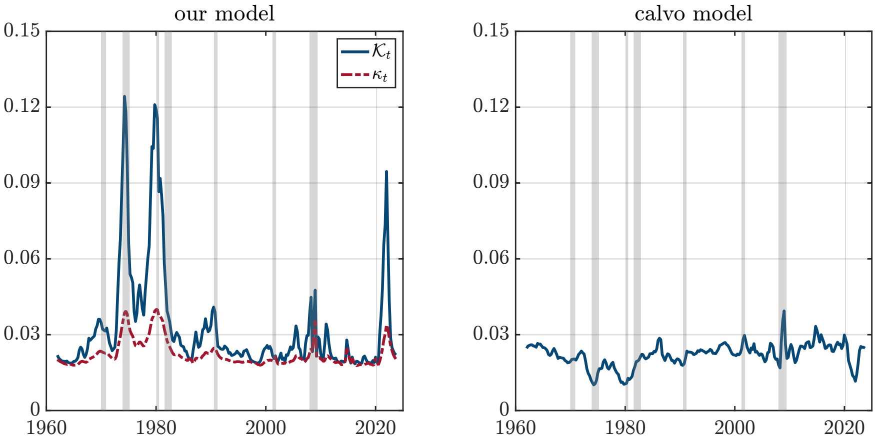
$$\kappa_t = \frac{1}{1+\theta\left(\frac{1}{\eta}-1\right)}\frac{y_t^{\frac{1}{\eta}}}{b_{2t}}\frac{1-(1-n_t)\,\pi_t^{\theta-1}}{(1-n_t)\,\pi_t^{\theta-1}}$$

Time-Varying Slope of the Phillips Curve



Ranges from 0.02 to 0.12, mostly due to inflation accelerator

Time-Varying Slope of the Phillips Curve



In Calvo model slope falls in periods of high inflation

Time-Varying Responses to Monetary Shocks

- Build intuition by computing log-linear approximation

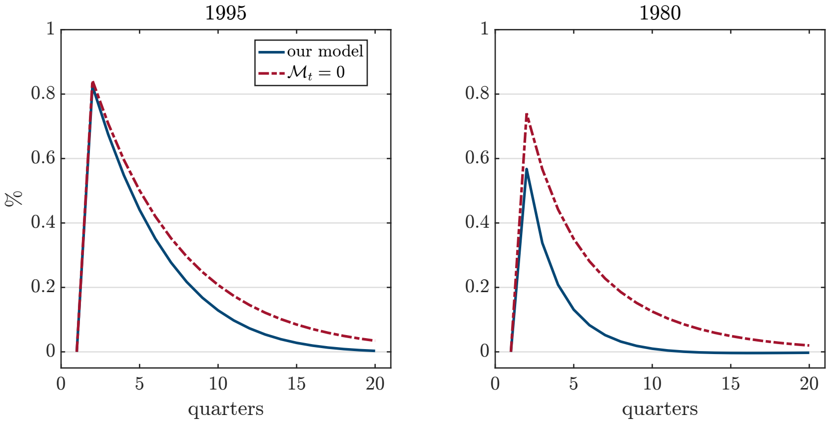
$$\mathbf{A}_t \mathbf{z}_t = \mathbf{B}_t \mathbf{z}_{t-1} + \mathbf{C}_t \mathbf{z}_{t+1}$$

  - $\mathbf{z}_t$ log-deviations from initial equilibrium point
  - $\mathbf{A}_t$ to $\mathbf{C}_t$ collect time-varying elasticities, including $\mathcal{M}_t$
  - compute using ε_t that match U.S. inflation up to that date, zero after

- Solution $\mathbf{z}_t = \mathbf{Q}_t \mathbf{z}_{t-1}$, where $\mathbf{Q}_t = \left(\mathbf{A}_t - \mathbf{C}_t \mathbf{Q}_{t+1}\right)^{-1} \mathbf{B}_t$

- Repeat setting $\mathcal{M}_t = 0$ to isolate inflation accelerator

Time-varying IRF to 1% Money Shock

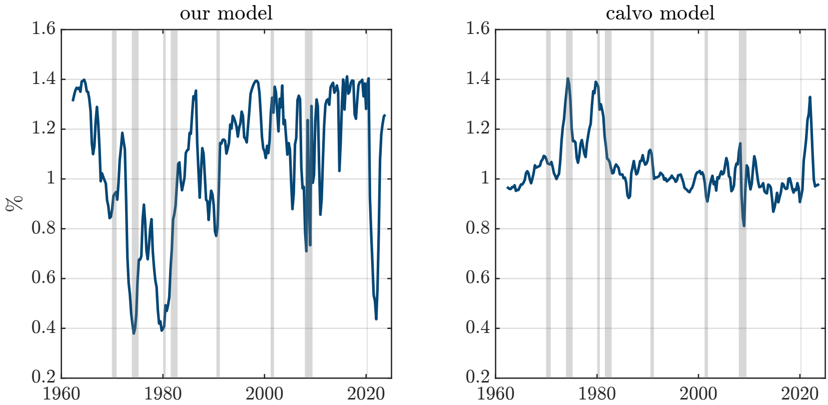


Cumulative IR: 4.1% in 1995 vs. 0.9% in 1980, mostly due to accelerator

Sacrifice Ratio

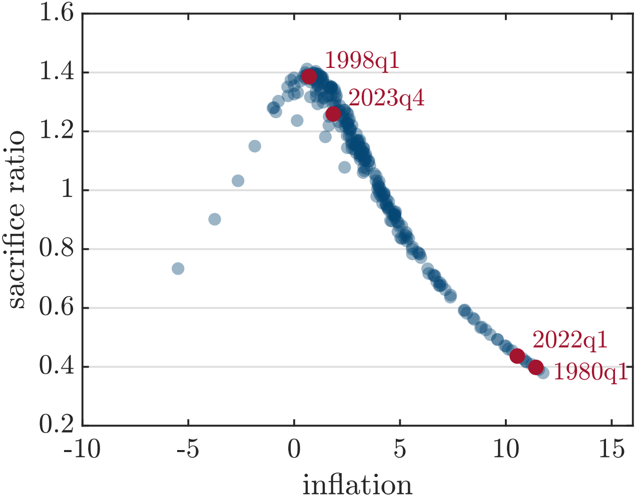
- Time-varying slope: reducing inflation less costly when inflation is high
- Calculate average drop in output needed to reduce π by 1% over a year
  - use non-linear solution of the model
  - report average decline in output over 4 quarters of that year

Sacrifice Ratio



Ranges from 0.3% (high inflation) to 1.4% (low inflation), opposite of Calvo

Inflation and the Sacrifice Ratio



Robustness

Eliminate Strategic Complementarities

- Set $\eta = 1$, recalibrate model

A. Targeted Moments

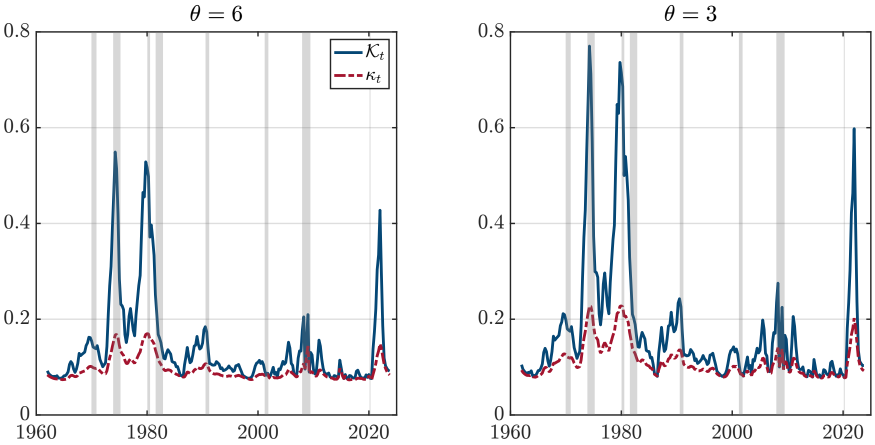
	Data	$\theta = 6$	$\theta = 3$
mean inflation	3.517	3.517	3.517
s.d. inflation	2.739	2.739	2.739
mean frequency	0.297	0.297	0.297
slope of n_t on $\lvert\pi_t\rvert$	0.016	0.016	0.016

B. Calibrated Parameter Values

		$\theta = 6$	$\theta = 3$
μ	mean spending growth rate	0.035	0.035
σ	s.d. monetary shocks	0.019	0.018
$\bar{n}$	fraction free price changes	0.232	0.227
ξ	adjustment cost	0.365	0.109

- Smaller price adjustment costs because less curvature in profit function

Slope of the Phillips Curve



Larger absent complementarities, but fluctuates as much

Taylor Rule

- Replace nominal spending target with Taylor rule

$$\frac{1+i_t}{1+i} = \left(\frac{1+i_{t-1}}{1+i}\right)^{\phi_i} \left(\left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\phi_y}\right)^{1-\phi_i} u_t$$

- Two versions
  - u_t shocks iid
  - serially correlated with persistence ρ to match autocorrelation inflation
- Use Justiniano and Primiceri (2008) estimates
  - $\phi_i = 0.65$, $\phi_\pi = 2.35$, $\phi_y = 0.51$

Calibration of Economy with a Taylor Rule

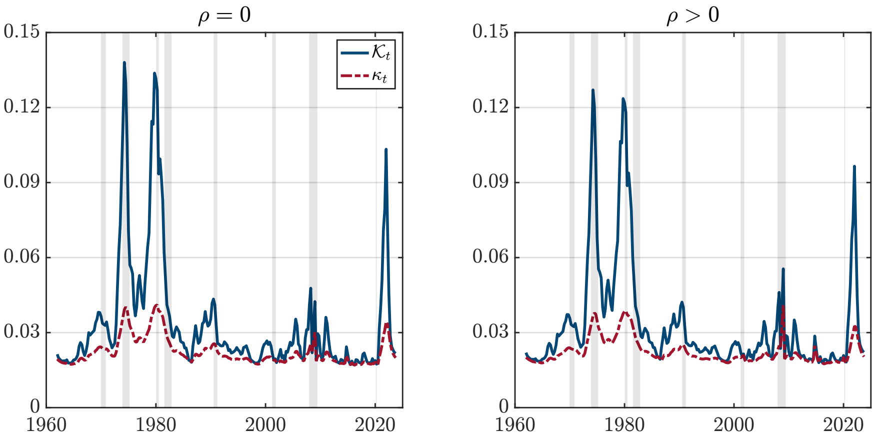
A. Targeted Moments

	Data	$\rho = 0$	$\rho > 0$
mean inflation	3.517	3.517	3.517
s.d. inflation	2.739	2.739	2.739
mean frequency	0.297	0.297	0.297
slope of n_t on $\lvert\pi_t\rvert$	0.016	0.016	0.016
autocorr. inflation	0.942	*0.913*	0.942

B. Calibrated Parameter Values

		$\rho = 0$	$\rho > 0$
$\log \pi$	inflation target	0.040	0.037
σ	s.d. monetary shocks $\times 100$	2.626	0.551
ρ	persistence monetary shocks	–	0.685
$\bar{n}$	fraction free price changes	0.241	0.241
ξ	adjustment cost	1.671	1.688

Slope of the Phillips Curve



Our results robust to assuming a Taylor rule

Conclusions

- Data: fraction of price changes rises with inflation

- Developed tractable model consistent with this evidence
  - firms choose how many, but not which prices to change
  - reduces to one-equation extension of Calvo

- Implies slope of Phillips curve increases considerably with inflation
  - partly because more frequent price changes
  - primarily due to endogenous frequency response – *inflation accelerator*

Flow Profits

- Demand for individual product

$$y_{ikt} = \left(\frac{P_{ikt}}{P_t}\right)^{-\theta} y_t$$

- Real flow profits of firm i

$$\int_0^1 \left(\left(\frac{P_{ikt}}{P_t}\right)^{1-\theta} y_t - \tau \frac{W_t}{P_t}\left(\frac{P_{ikt}}{P_t}\right)^{-\frac{\theta}{\eta}} y_t^{\frac{1}{\eta}}\right) \mathrm{d}k$$

  - subsidy to eliminate markup distortion $\tau = 1 - 1/\theta$

back

Losses from Misallocation

$$\left(X_{it+s}\right)^{-\frac{\theta}{\eta}} = n_{it+s}\left(P^*_{it+s}\right)^{-\frac{\theta}{\eta}} + \left(1-n_{it+s}\right)n_{it+s-1}\left(P^*_{it+s-1}\right)^{-\frac{\theta}{\eta}} + \cdots$$

$$+ \prod_{j=1}^{s}\left(1-n_{it+j}\right)n_{it}\left(P^*_{it}\right)^{-\frac{\theta}{\eta}} + \prod_{j=1}^{s}\left(1-n_{it+j}\right)\left(1-n_{it}\right)\left(X_{it-1}\right)^{-\frac{\theta}{\eta}}$$

back

Steady-State Output and Productivity

$$y^{\frac{1}{\eta}} = \eta \frac{1-\beta\left(1-n\right)\pi^{\frac{\theta}{\eta}}}{1-\beta\left(1-n\right)\pi^{\theta-1}} \left(\frac{n}{1-\left(1-n\right)\pi^{\theta-1}}\right)^{\frac{1+\theta\left(\frac{1}{\eta}-1\right)}{\theta-1}}$$

$$x^{\theta} = \left(\frac{1-\left(1-n\right)\pi^{\frac{\theta}{\eta}}}{n}\right)^{\eta} \left(\frac{1-\left(1-n\right)\pi^{\theta-1}}{n}\right)^{-\frac{\theta}{\theta-1}}$$

back