Optimal monetary policy under menu costs

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▸ motivation

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$\Longrightarrow$ **Optimal policy:** Inflation targeting *[Woodford 2003; Rubbo 2023]*

Criticism:

1. Theoretical critique: Not microfounded
2. Empirical critique: State-dependent pricing is a better fit

   [Nakamura et al 2018; Cavallo and Rigobon 2016; Alvarez et al 2018; Cavallo et al 2023]

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    - Motive for relative prices to change

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2. **Quantitative model**

Related literature

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[Wolman 2011, Nakov-Thomas 2014, Blanco 2021]

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$\implies$ no direct costs, first-order approximation

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4. Non-normative menu cost literature

Roadmap

1. Baseline model & optimal policy
2. Extensions
3. Quantitative model
4. Comparison to Calvo model
5. Conclusion and bigger picture

Model setup + household's problem

General setup:

- Off-the shelf sectoral model with S sectors
- Each sector is a continuum of firms, bundled with CES technology
- Static model (& no linear approximation)

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$$\max_{C,N,M} \ln(C) - N + \ln\left(\frac{M}{P}\right)$$

$$\text{s.t. } PC + M = WN + D + M_{-1} - T$$

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Optimality conditions:

$$c_i = \frac{1}{S}\frac{PC}{p_i}$$

$$PC = M$$

$$W = M$$

Intermediate firms: price setting with menu costs

▸ more production structure

Technology: In given sector i, continuum of firms $j \in [0,1]$ with technology

$$y_i(j) = A_i \cdot n_i(j)$$

Demand: $y_i(j) = y_i \left(\frac{p_i(j)}{p_i}\right)^{-\eta}$

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$\Longrightarrow$ **Direct cost of menu costs:** excess disutility of labor

$$N = \sum_i n_i + \psi \sum_i \chi_i$$

- Other specifications do not affect result ▸ more

Menu costs induce an inaction region

▸ Full equilibrium characterization

Objective function of sector i firm: $\left(p_i y_i - \frac{W}{A_i} y_i (1-\tau)\right) - W\psi\chi_i$

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Inaction region: don't adjust iff $p_i^* = \frac{W}{A_i}$ close to p_i^{old}

Optimal policy after a productivity shock

▸ Formal planner's problem

- Start at steady state: all sectors have $A_i^{ss} = 1 \ \forall i$, so $p_i^{ss} = W^{ss} \equiv 1$

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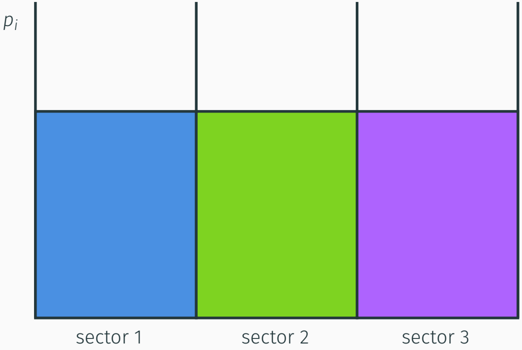
2. If shock is small, $A_1 < \bar{A}$, then optimal policy is to ensure no sector adjusts:
$$p_i = p_i^{ss} \;\; \forall i$$

Large-enough shocks

math more math

Recall: $p_i^* = MC_i = \frac{W}{A_i}$



Prices initially

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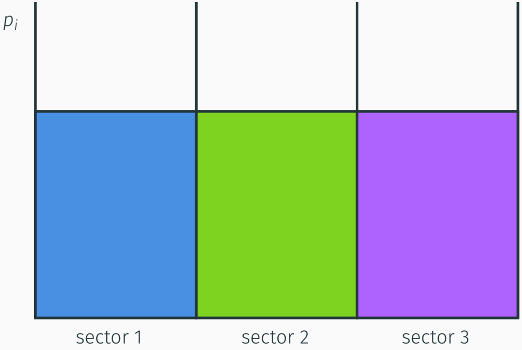

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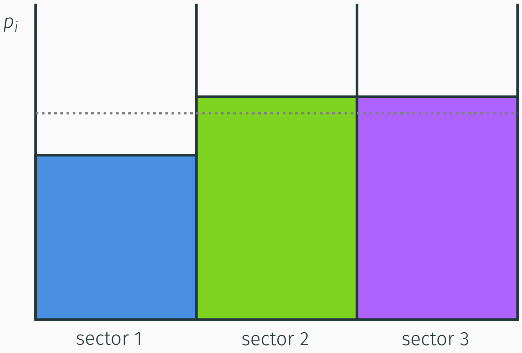

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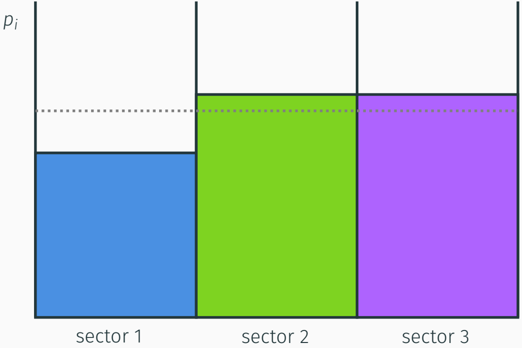

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$\mathbb{W}^f - S\psi$

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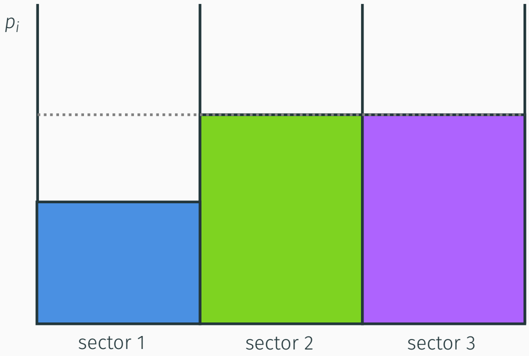

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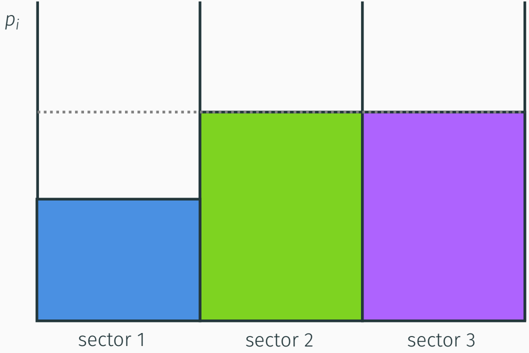

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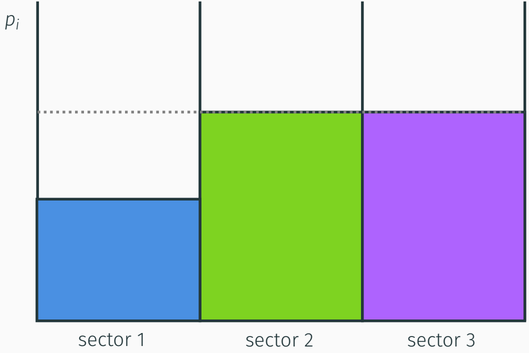

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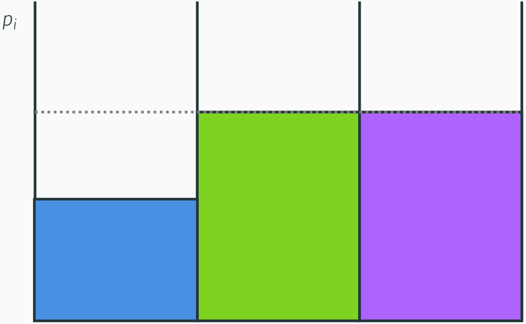

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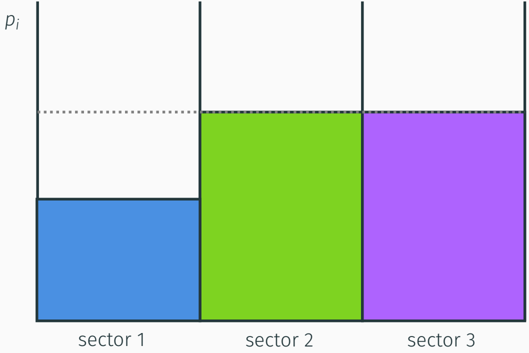

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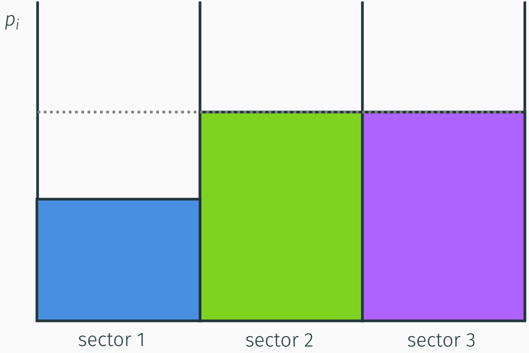

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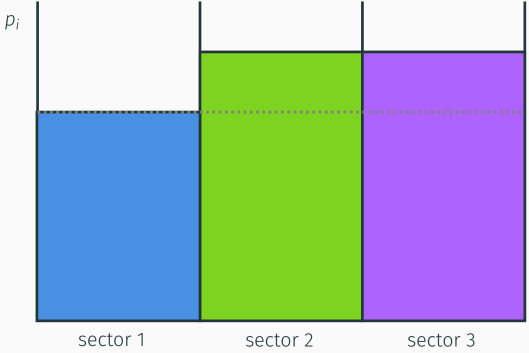

Only sectors k adjusts

$\mathbb{W}^f - (S-1)\psi$

Small shocks: state dependence of optimal policy

▸ math ▸ more math

	Sectors k adjust	Sectors k not adjust
Sector 1 adjusts		
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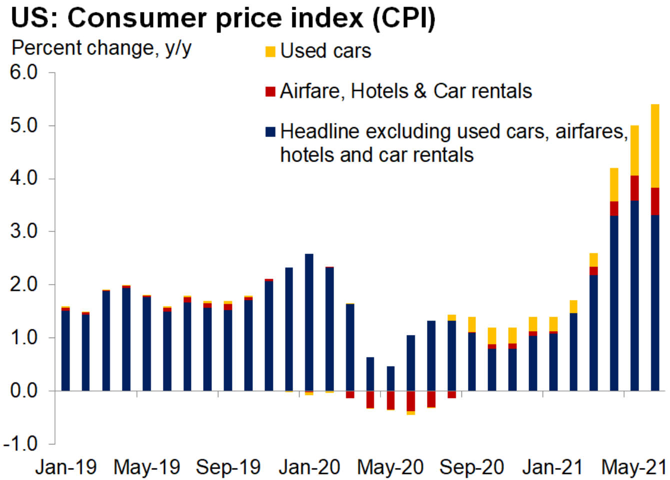
Lemma 2: $\exists\, \bar{A}$ such that

$$\mathbb{W}_{\text{only 1 adjusts}} > \mathbb{W}_{\text{none adjust}}$$

iff $A_1 > \bar{A}$. Furthermore, $\bar{A}$ is increasing in ψ.

Interpretation: “looking through” shocks

Example: used cars (2021)



Source : Oxford Economics/BLS

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welfare loss of inflatino targeting

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(1) Measure *frequency of price adjustment*

(2) Build structural model

(3) $\Longrightarrow$ *calibrate* menu costs to fit

Nakamura and Steinsson (2010):

- 0.5% of firm revenues

Blanco et al (2022):

- 2.4% of revenues

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2. Direct measurement. For *physical* adjustment costs,

Levy et al (1997, QJE): 5 grocery chains

- 0.7% revenue

Dutta et al (1999, JMCB): drugstore chain

- 0.6% revenue

Zbaracki et al (2003, Restat): mfg

- 1.2% revenue

Generalized model: stabilize nominal MC of unshocked firms

Generalized model:

1. Any (HOD1) aggregator: $C = F(c_1, ..., c_S)$
2. Potentially DRS production technology: $y_i(j) = A_i n_i(j)^{1/\alpha}$ with $1/\alpha \in (0, 1]$
3. Any preferences quasilinear in labor: $U\left(C, \frac{M}{P}\right) - N$

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Nominal MC:

$$MC_i(j) = \left[\alpha \frac{W}{A_i^\alpha} \left(y_i p_i^\eta\right)^{\alpha - 1}\right]^\theta$$

$$\theta \equiv [1 - \eta(1 - \alpha)]^{-1}$$

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Nominal MC:

$$MC_i(j) = \left[\alpha \frac{W}{A_i^\alpha} \left(y_i p_i^\eta\right)^{\alpha-1}\right]^\theta$$

$$\theta \equiv [1 - \eta(1 - \alpha)]^{-1}$$

Proposition 1 extended: optimal policy stabilizes **nominal marginal costs of unshocked firms**

$\implies Y \uparrow, P \downarrow$

"Macro functional forms"

More general example:

1. $C = \prod c_i^{1/S}$

2. DRS production technology:
   $y_i(j) = A_i n_i(j)^{1/\alpha}$ with $1/\alpha \in (0,1)$

3. CRRA preferences:
   $\frac{1}{1-\sigma} C^{1-\sigma} + \frac{1}{1-\sigma} \left(\frac{M}{P}\right)^{1-\sigma} - N$

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Nominal MC:

$$MC_i(j) = k \frac{W^{\lambda} P^{1-\lambda}}{A_i}$$

$$\lambda \equiv \frac{\sigma + \alpha - 1}{\sigma \alpha}$$

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Proposition 1 extended: optimal policy stabilizes **nominal marginal costs of unshocked firms**

$\Longrightarrow$ stabilize a weighted average of wages and prices, $W^{\lambda}P^{1-\lambda}$

Production networks: stabilize a weighted average of P and W

Baseline model:

- Production technology:

$$y_i = A_i n_i$$

Roundabout production network:

- Production technology:

$$y_i = A_i n_i^{\beta} I_i^{1-\beta}$$
$$I_i = \prod_{k=1}^{S} I_i(k)^{1/S}$$

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$$MC_i = \frac{W}{A_i}$$

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- Optimal policy: stabilize nominal MC of unshocked sectors: stabilize W

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$$MC_i = \kappa \frac{W^{\beta} P^{1-\beta}}{A_i}$$

- Optimal policy: stabilize nominal MC of unshocked sectors: stabilize $W^{\beta} P^{1-\beta}$

Perfectly uniform shocks

▸ multiple shocks

Proposition 3: Consider any shock not affecting relative prices, e.g. a perfectly uniform shock: $A_1 = \ldots = A_S \equiv A$.

Perfectly uniform shocks

multiple shocks

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Proof idea:

- Relative prices don't need to change

Perfectly uniform shocks

▸ multiple shocks

Proposition 3: Consider any shock not affecting relative prices, e.g. a perfectly uniform shock: $A_1 = ... = A_S \equiv A$. Then optimal policy is to stabilize *inflation*.

Proof idea:

- Relative prices don't need to change
- Stable prices thus guarantee:
  1. Correct relative prices
  2. Zero direct costs

Additional extensions

1. Heterogeneity across sectors: a monetary "least-cost avoider" principal

   ▸ more

2. Optimal policy is not about selection effects: a CalvoPlus model + a Bertrand menu cost model

   ▸ more

3. Under sticky prices *and* sticky wages due to menu costs, optimal policy still stabilizes W;

   ▸ more

Quantitative model: setup

Does W target dominate P target in a dynamic **quantitative model**?

Household: **dynamic** problem

$$\max_{\{C_t, N_t, B_t, M_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\gamma}}{1-\gamma} - \omega \frac{N_t^{1+\varphi}}{1+\varphi} + \ln\left(\frac{M_t}{P_t}\right) \right]$$

$$\text{s.t.} \qquad P_t C_t + B_t + M_t \leq R_t B_{t-1} + W_t N_t + M_{t-1} + D_t - T_t$$

Quantitative model: intermediate firms

Intermediate firms: **idiosyncratic** shocks, **Calvo+** price setting

$$\max_{p_{it}(j),\chi_{it}(j)} \sum_{t=0}^{\infty} \mathbb{E}\left[\frac{1}{R^t P_t}\left\{p_{it}(j)\, y_{it}(j) - W_t n_{it}(j)\,(1-\tau) - \chi_{it}(j)\psi W_t\right\}\right]$$

s.t.

$$y_{it}(j) = A_{it} a_{it}(j)\, n_{it}(j)^{\alpha}$$

$$\psi_{it}(j) = \begin{cases} \psi & \text{w/ prob. } 1-\nu \\ 0 & \text{otherwise} \end{cases}$$

Productivity distribution: mixture between AR(1) and uniform (**fat tail**)

$$\log\left(a_{it}(j)\right) = \begin{cases} \rho_{\text{idio}} \log\left(a_{it-1}(j)\right) + \varepsilon_{it}^{\text{idio}}(j) & \text{with prob. } 1-\varsigma \\ \mathcal{U}\left[-\log\left(\underline{a}\right), \log\left(\overline{a}\right)\right] & \text{with prob. } \varsigma \end{cases}$$

Calibration

(1) drawn from literature vs.

	Parameter (monthly frequency)	Value	Target
β	Discount factor	0.99835	2% annual interest rate
ω	Disutility of labor	1	standard
φ	Inverse Frisch elasticity	0	Golosov and Lucas (2007)
γ	Inverse EIS	2	standard
S	Number of sectors	6	Nakamura and Steinsson (2010)
η	Elasticity of subst. between sectors	5	standard value
α	Returns to scale	0.6	standard value

Calibration

(1) drawn from literature vs. (2) calibrated by SMM targeting

	Parameter (monthly frequency)	Value	Target		
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α	Returns to scale	0.6	standard value		
σ_{idio}	Standard deviation of idio. shocks	0.058	menu cost expenditure / revenue	1.0	(1.1%)
ρ_{idio}	Persistence of idio. shocks	0.992	share of price changers	9.7	(10.1%)
ψ	Menu cost	0.1	median absolute price change	8.3	(7.9%)
ν	Calvo parameter	0.09	Q1 absolute price change	4.2	(5.6%)
ς	Fat tail parameter	0.001	Q3 absolute price change	12.0	(12.5%)
			kurtosis of price changes	5.4	(5.1)

Exercise: perfect foresight sectoral shock

▸ more

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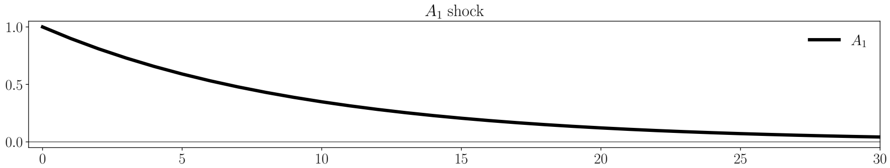
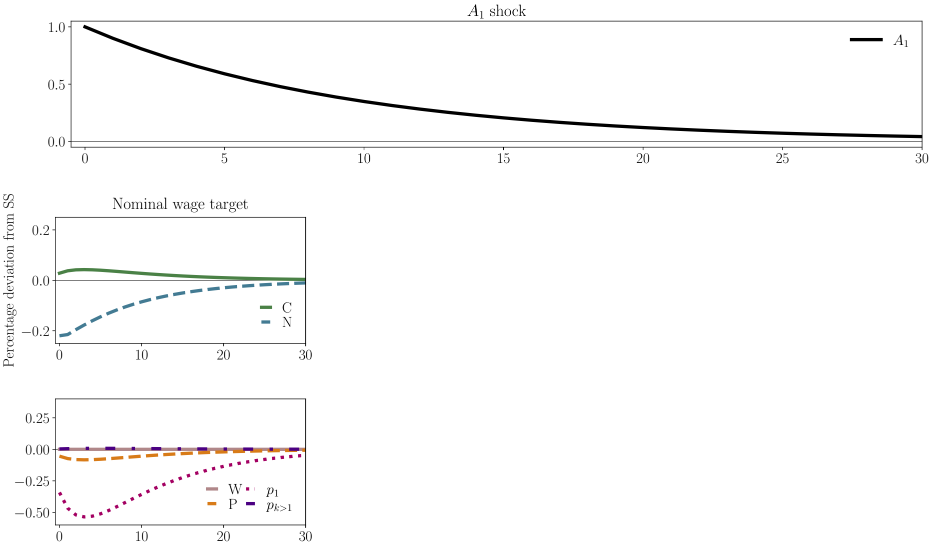
▸ more



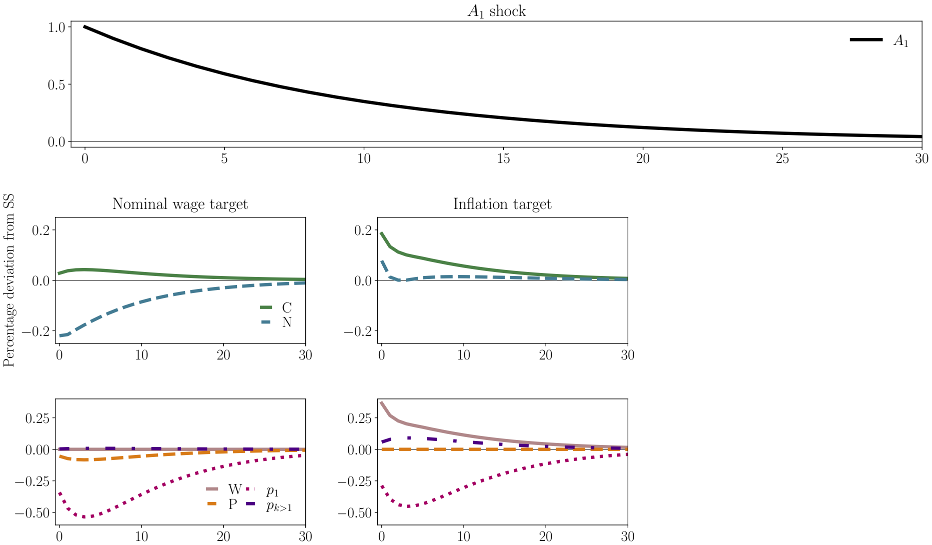
Exercise: perfect foresight sectoral shock

▸ more



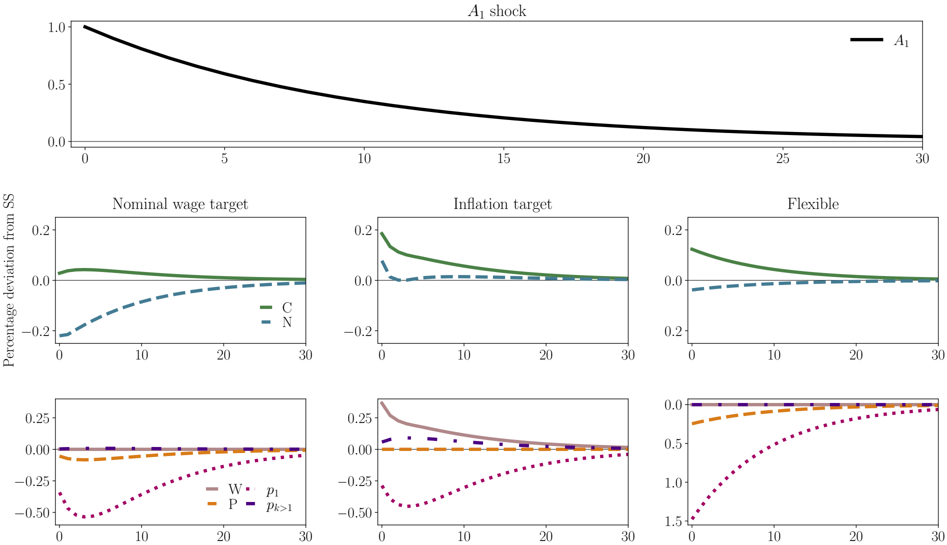
Exercise: perfect foresight sectoral shock

more

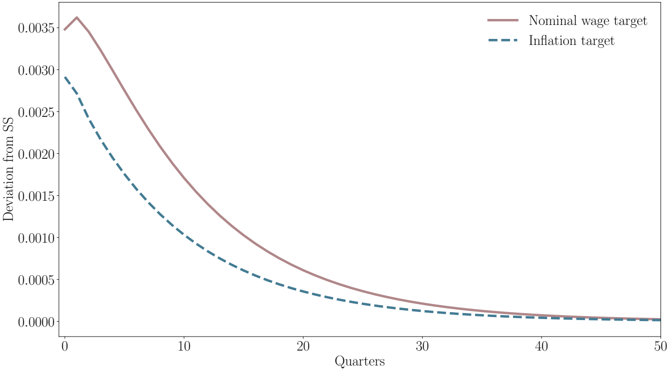


Exercise: perfect foresight sectoral shock

more



Policy comparison: welfare



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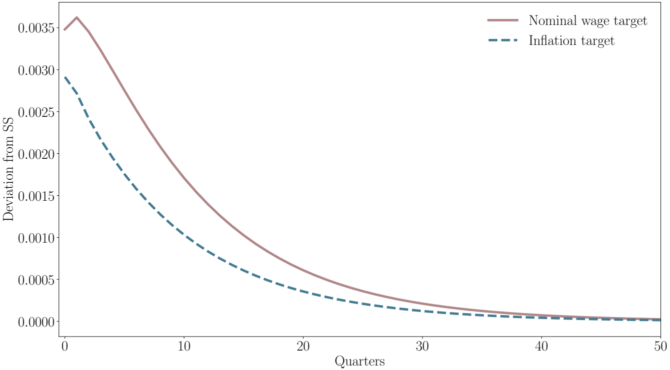
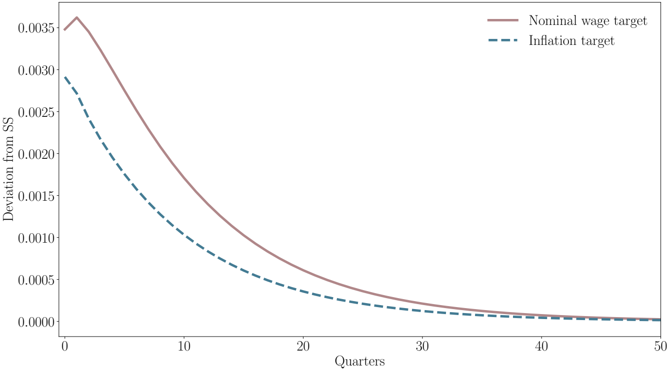


1. Consider welfare under P targeting

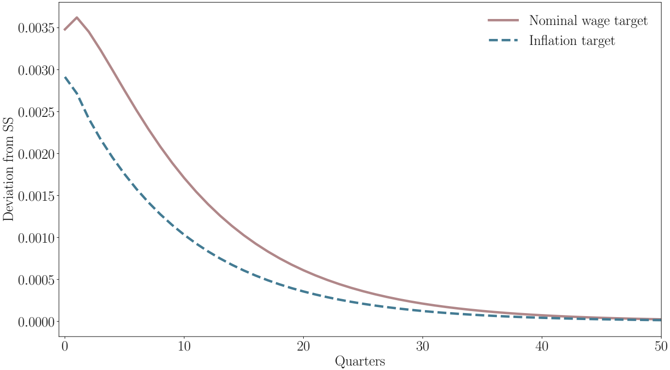
Policy comparison: welfare



1. Consider welfare under P targeting
2. How much extra C is needed to match welfare under wage targeting?

$$\sum_t \beta^t \, U\left((1+\lambda)C_t^P, \; N_t^P\right) = \sum_t \beta^t \, U\left(C_t^W, \; N_t^W\right)$$

Policy comparison: welfare



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$$\sum_t \beta^t U\left((1+\lambda)C_t^P,\ N_t^P\right) = \sum_t \beta^t U\left(C_t^W,\ N_t^W\right)$$

3. Require consumption to be permanently $\lambda = 0.008\%$, for P targeting to match W targeting

Welfare over the business cycle

1. Shock sector productivities according to

$$\log(A_t) = \rho_A \log(A_{t-1}) + \varepsilon_A$$

2. $\rho_A = 0.962 \qquad \varepsilon_A \sim \mathcal{N}(0, 0.003) \rightarrow$ match U.S. output dynamics 1984-2019

[Garin, Pries, and Sims 2018]

3. Welfare gain of nominal wage targeting over inflation targeting: $\lambda = 0.32\%$

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$\Rightarrow$ Nominal wage targeting dominates inflation targeting in quantitative model

1. Baseline model & optimal policy

2. Extensions

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4. Comparison to Calvo model

5. Conclusion and bigger picture

Appendix

Why not inflation targeting?

more

- **Multisector Calvo optimal policy: inflation targeting,** $P = P^{ss}$. Why?

  [Woodford; Rubbo; Aoki; cf Guerrieri-Lorenzoni-Straub-Werning]

Why not inflation targeting?

▸ more

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$$\psi \cdot \mathbb{I}\{p_i \neq p_i^{ss}\}$$

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- **Contrast with *convex* menu costs:** e.g.,

$$\psi \cdot (p_i - p_i^{ss})^2$$

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- Nonconvex labor market clearing:

$$N = \sum n_i + \psi \sum \mathbb{I}\{p_i \neq p_i^{ss}\}$$

- Rotemberg labor market clearing:

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Convex costs $\Longrightarrow$ *smooth* price changes across sectors

Comparison with Calvo model

▸ more

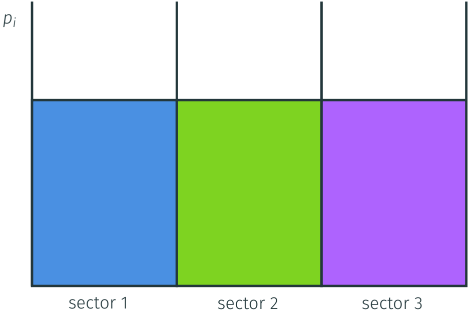
Calvo: Likewise, *welfare cost of price dispersion is convex*:

$$\Delta \equiv \sum_{i=1}^{S} \int_0^1 \left[\frac{p_i(j)}{p_i}\right]^{-\eta} dj$$

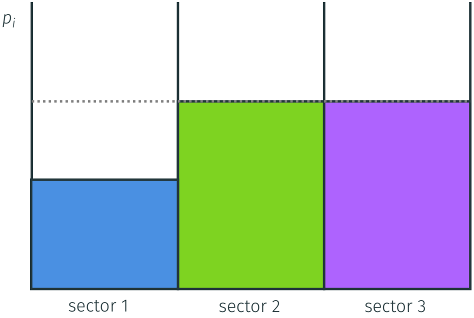
where $\eta > 1$ is the within-sector elasticity of substitution

Calvo diagram: shocking sector-1 productivity

▸ math



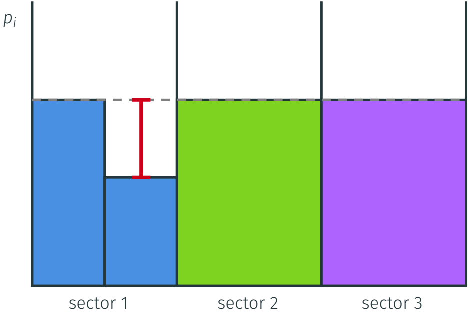
Steady state



Flexible prices, after shock

Calvo diagram: shocking sector-1 productivity

▸ math



Nominal wage targeting under Calvo

Lots of price dispersion: *only* one sector

Calvo diagram: shocking sector-1 productivity

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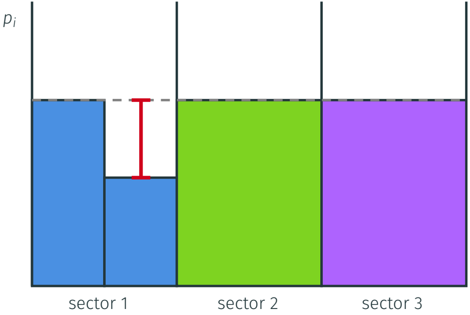

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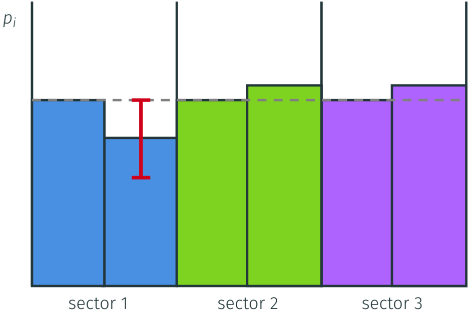

Inflation targeting under Calvo

Lots of price dispersion: *only* one sector

Little price dispersion: *all* sectors

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Appendix

“Robustly” optimal monetary policy?

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- RBC + cash = Friedman rule
- RBC + Calvo = inflation targeting
- RBC + menu costs = countercyclical inflation

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- RBC + ...

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1. Sticky wages
2. Incomplete markets/financial frictions: Sheedy (2014), Werning (2014)
3. Information frictions: Angeletos and La’O (2020)

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2. Incomplete markets/financial frictions: Sheedy (2014), Werning (2014)
3. Information frictions: Angeletos and La’O (2020)
4. Sticky prices [**new**]: **Caratelli and Halperin (2024)**

Summary

In baseline menu cost model, **inflation should be countercyclical** after sectoral shocks

Rationale:

- Inflation targeting **forces firms to adjust unnecessarily**, which is costly with menu costs
- Nominal wage targeting does not

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Future work:

- Convexity of menu costs
- Better direct measurement of menu costs
- “Unified theory of optimal monetary policy”?

Thank you!

Appendix

Equilibrium characterization

Back

Sectoral packagers:

$$y_i = \left[\int_0^1 y_i(j)^{\frac{\eta-1}{\eta}} dj\right]^{\frac{\eta}{\eta-1}}$$

$$y_i(j) = y_i \left[\frac{p_i(j)}{p_i}\right]^{-\eta}$$

$$p_i = \left[\int_0^1 p_i(j)^{1-\eta} dj\right]^{\frac{1}{1-\eta}}$$

Intermediate producers:

$$y_i(j) = A_i n_i(j)$$

$$p_i(j)^{\text{opt}} = \frac{\eta}{\eta-1}(1-\tau)\frac{W}{A_i}$$

$$\chi_i = \mathbb{I}\left\{\frac{1}{\eta} > y_i \left[\frac{p_i^{\text{old}}}{p_i}\right]^{-\eta} \left(p_i^{\text{old}} - \frac{W}{A_i}\frac{\eta-1}{\eta}\right)\right\}$$

Household:

$$M = PC$$

$$M = W$$

$$C = \prod C_i^{1/S}$$

$$P = S \prod p_i^{1/S}$$

Government:

$$1 - \tau = \frac{\eta - 1}{\eta}$$

$$-T + (M - M_{-1}) = \tau W \sum n_i$$

Market clearing:

$$N = \sum n_i + \psi \sum \chi_i$$

Production structure

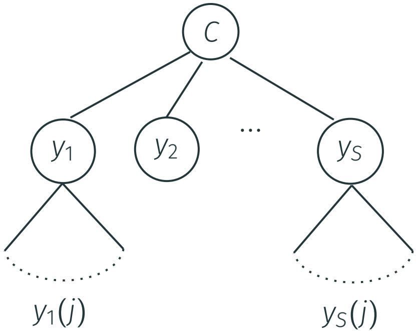
back

Final goods demand:

$$C = \prod y_i^{1/S}$$
$$P = S \prod p_i^{1/S}$$
$$y_i = \frac{1}{S}\frac{PC}{p_i}$$

Sectoral packagers (competitive):

$$y_i = \left[\int_0^1 y_i(j)^{\frac{\eta-1}{\eta}} dj\right]^{\frac{\eta}{\eta-1}}$$
$$y_i(j) = y_i \left[\frac{p_i(j)}{p_i}\right]^{-\eta}$$
$$p_i = \left[\int_0^1 p_i(j)^{1-\eta} dj\right]^{\frac{1}{1-\eta}}$$



Formally: Social planner's problem

back

$$\max_{X\in\{A,B,C,D\}} \mathbb{U}^X$$

$$\mathbb{U}^A = \left\{ \begin{array}{cc} \underset{M}{\max} & \ln[M] - M\left[S - 1 + 1/\gamma\right] \\ \text{s.t.} & \min(\gamma\lambda_1, \lambda_2) \leq M \leq \max(\gamma\lambda_1, \lambda_2) \end{array} \right\}$$

$$\mathbb{U}^B = \left\{ \ln\left[\frac{1}{S}\gamma^{1/S}\right] - 1 - \psi \right\}$$

$$\mathbb{U}^C = \left\{ \begin{array}{cc} \underset{M}{\max} & \ln\left[\left(\frac{\gamma}{S}\right)^{\frac{1}{S}} \cdot M^{\frac{S-1}{S}}\right] - \left[(S-1)M + \frac{1}{S}\right] - \frac{1}{S}\psi \\ \text{s.t.} & \lambda_1 < M < \min(\gamma\lambda_1, \lambda_2) \end{array} \right\}$$

$$\mathbb{U}^D = \left\{ \begin{array}{cc} \underset{M}{\max} & \ln\left[S^{\frac{1-S}{S}} M^{\frac{1}{S}}\right] - \left[\frac{S-1}{S} + \frac{M}{\gamma}\right] - \frac{S-1}{S}\psi \\ \text{s.t.} & \max(\gamma\lambda_1, \lambda_2) < M < \gamma\lambda_2 \end{array} \right\}$$

where $\lambda_1 = \frac{1}{S}\left(1 - \sqrt{\psi}\right), \quad \lambda_2 = \frac{1}{S}\left(1 + \sqrt{\psi}\right)$

Adjustment externalities

back

Example: Social planner's *constrained* problem for "neither adjust"

$$\max_M U\left(C(M), N(M)\right) \tag{1}$$

$$\text{s.t. } D_1^{\text{adjust}} < D_1^{\text{no adjust}} \tag{2}$$

$$D_k^{\text{adjust}} < D_k^{\text{no adjust}} \tag{3}$$

$\Longrightarrow M^*_{\text{unconstrained}}$

Social planner's *unconstrained* problem: maximize (1), without constraints

$\Longrightarrow M^*_{constrained}$

Adjustment externality: $M^*_{\text{unconstrained}} \neq M^*_{\text{constrained}}$

Alternative menu cost formulations

back

Labor costs: Welfare mechanism is *higher labor*

$$\text{profits}_i - W\psi \cdot \chi_i$$
$$\implies N = \sum n_i + \psi \sum \chi_i$$

Real resource cost: Welfare mechanism is *lower consumption*

$$\text{profits}_i \cdot (1 - \psi \cdot \chi_i)$$
$$\implies C = Y \left(1 - \psi \sum_i \chi_i\right)$$

Direct utility cost: Welfare mechanism is *direct*

$$\text{utility} - \psi \cdot \sum \chi_i$$

More Calvo math

back

Nominal wage targeting:

$$\hat{W} = 0$$

$$\hat{p}_1(A) = -\hat{\gamma}$$

$$\hat{p}_k(A) = 0$$

$$\hat{P} = -\frac{1}{S}(1-\theta)\hat{\gamma}$$

$$\hat{C} = \frac{1}{S}(1-\theta)\hat{\gamma}$$

$$\hat{N} = -\frac{1}{S}\theta\hat{\gamma}$$

Inflation targeting:

$$\hat{W} = \frac{\hat{\gamma}}{S}$$

$$\hat{p}_1(A) = -\hat{\gamma} + \frac{1}{S}\hat{\gamma}$$

$$\hat{p}_k(A) = \frac{\hat{\gamma}}{S}$$

$$\hat{P} = 0$$

$$\hat{C} = \hat{C}^f = \frac{\hat{\gamma}}{S}$$

$$\hat{N} = \hat{N}^f = 0$$

Sticky wages: monopsony

back

Sticky prices model:
differentiated output + homogenous labor

$$p_1 = \frac{W}{A_1}$$
$$p_k = \frac{W}{A_k}$$

With shock to A_1, want:

- p_1 adjusts
- W stabilized, so p_k doesn't have to change

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Monopsony sticky wage model:
homogeneous output + differentiated labor

$$P = \frac{W_1}{A_1}$$
$$P = \frac{W_k}{A_k}$$
$$W_1 = W_k$$

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$$W_1 = W_k$$

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Monopsony model is anti-Keynesian: inverted NKPC (Rowe 2014; Dennery 2021)

Sticky wages

▸ back

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Sticky wages

back

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Standard sticky wage model:
differentiated output + *differentiated* labor

$$p_1 = \frac{W_1}{A_1}$$
$$p_k = \frac{W_k}{A_k}$$
$$W_1 = W_k$$

With shock to A_1, want:

- p_1 adjusts, so $W_1 = W_k = p_k$ doesn't have to adjust
- Wages, $W_1 = W_k$, stabilized

Sticky wages *and sticky prices*

back

- Suppose ψ_P if any *price* p_i changes
- Suppose ψ_W if any *wage* W_i changes

Model:

$$p_1 = \frac{W_1}{A_1}$$

$$p_k = \frac{W_k}{A_k}$$

$$W_1 = W_k$$

Sticky wages *and sticky prices*

back

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Shock: $A_1 \uparrow$

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back

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Shock: $A_1 \uparrow$

1. **Option 1:** p_1 adjusts
   - ψ_P

Sticky wages *and sticky prices*

back

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$$W_1 = W_k$$

Shock: $A_1 \uparrow$

1. **Option 1:** p_1 adjusts
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2. **Option 2:** W_1 adjusts
   $\implies W_k$ adjusts $\implies p_k$ adjusts
   - $(S-1)\psi_P + S\psi_W$

Sticky wages *and sticky prices*

back

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3. **Option 3:** p_k adjusts $\implies W_k$ adjusts
   - $(S-1)\psi_W$ and $W_1 \neq W_k$

Sticky wages *and sticky prices*

back

- Suppose ψ_P if any *price* p_i changes
- Suppose ψ_W if any *wage* W_i changes

Model:

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$$p_k = \frac{W_k}{A_k}$$

$$W_1 = W_k$$

Shock: $A_1 \uparrow$

1. **Option 1:** p_1 adjusts
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Optimal policy: p_1 adjusts, $W = W_1 = W_k$ stable

Optimal policy is not really about selection effects

▸ back

Consider two model variants:

1. **CalvoPlus model:** Random fraction ν of firms allowed to change prices for free, *dampening* selection effects

Optimal policy is not really about selection effects

back

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- $\Longrightarrow$ Statement of proposition 1 unchanged, with $\overline{A}$ reduced (and decreasing in ν)

Optimal policy is not really about selection effects

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2. **Menu cost model *without any* selection effects:**
    - Firms *always* set price equal to ideal price
    - Must pay a menu cost if doing so rquires change in price

Optimal policy is not really about selection effects

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Optimal policy is not really about selection effects

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Selection effects show up in $\overline{A}$

Heterogeneity: a monetary "least-cost avoider principle"

back

Proposition 5: Suppose sector i has mass S_i and menu cost ψ_i. Suppose further

$$S_1\psi_1 < \sum_{k>1} S_k\psi_k.$$

Then optimal policy is exactly as in proposition 1, modulo changes in $\bar{A}$.

- *Proof:* Follows exactly as in proof of proposition 1.

Heterogeneity: a monetary "least-cost avoider principle"

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- *Proof:* Follows exactly as in proof of proposition 1.

Interpretation 1: monetary "least-cost avoider principle"

Interpretation 2: "stabilizing the stickiest price"

Multiple shocks: general case

back

Proposition 7: Consider an arbitrary set of productivity shocks to the baseline model, $\{A_1, ..., A_S\}$.

1. Conditional on sectors $\Omega \subseteq \{1, ..., S\}$ adjusting, optimal policy is given by setting $M = M^*_\Omega \equiv \frac{S-\omega}{\sum_{i \notin \Omega} \frac{1}{A_i}}$, where $\omega \equiv |\Omega|$.
2. The optimal set of sectors that should adjust, Ω^*, is given by comparing welfare under the various possibilities for Ω, using $\mathbb{W}^*_\Omega$ defined in the paper.
3. Nominal wage targeting is exactly optimal if the set of sectors which should not adjust are unshocked: $A_i = 1 \;\; \forall i \notin \Omega^*$.

Multiple shocks

▸ back

Proposition 6: Suppose:

1. Some strict subset $\Omega \subset \{1, \dots, S\}$ of sectors is shocked, with "heterogeneous enough" $A_i \neq 1$ for all shocked sectors.

Multiple shocks

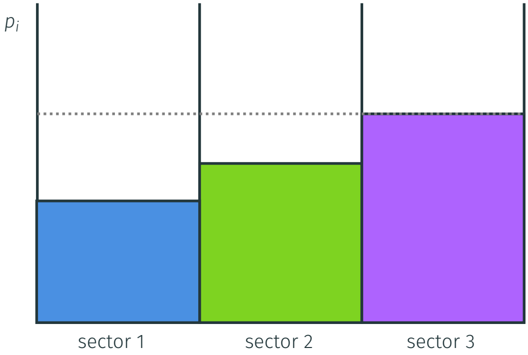
back

Recall: $p_i^* = MC_i = \frac{W}{A_i}$

Proposition 6: Suppose:

1. Some strict subset $\Omega \subset \{1, \ldots, S\}$ of sectors is shocked, with "heterogeneous enough" $A_i \neq 1$ for all shocked sectors.

Then optimal policy sets $W = W^{ss}$.



Price adjustment frequency tracks inflation in the timeseries

back

Calvo/TDP models: frequency of price adjustment is exogenous to inflation

Menu cost models: frequency of price adjustment ↑ if inflation ↑

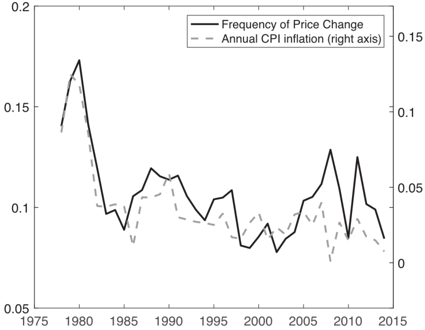


FIGURE XIV

Frequency of Price Change in U.S. Data

Figure 3: Nakamura et al (2018)

Price adjustment frequency tracks inflation in the timeseries

back

Calvo/TDP models: frequency of price adjustment is exogenous to inflation

Menu cost models: frequency of price adjustment ↑ if inflation ↑

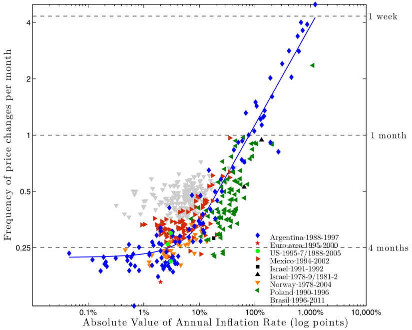


FIGURE VI

The Frequency of Price Changes (λ) and Expected Inflation: International Evidence

Figure 3: Alvarez et al (2018)

Price adjustment frequency tracks inflation in the timeseries

back

Calvo/TDP models: frequency of price adjustment is exogenous to inflation

Menu cost models: frequency of price adjustment ↑ if inflation ↑

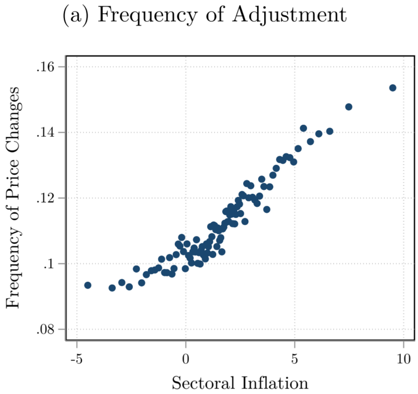


Figure 3: Blanco et al (2022)

Price adjustment frequency tracks inflation in the timeseries

back

Calvo/TDP models: frequency of price adjustment is exogenous to inflation

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Figure 1: Frequency of price changes

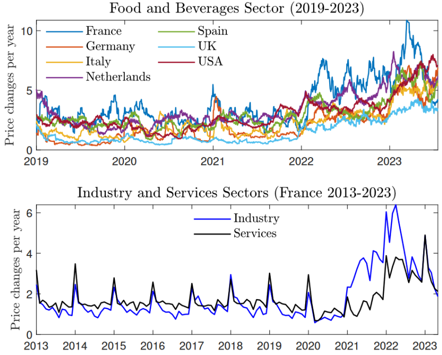
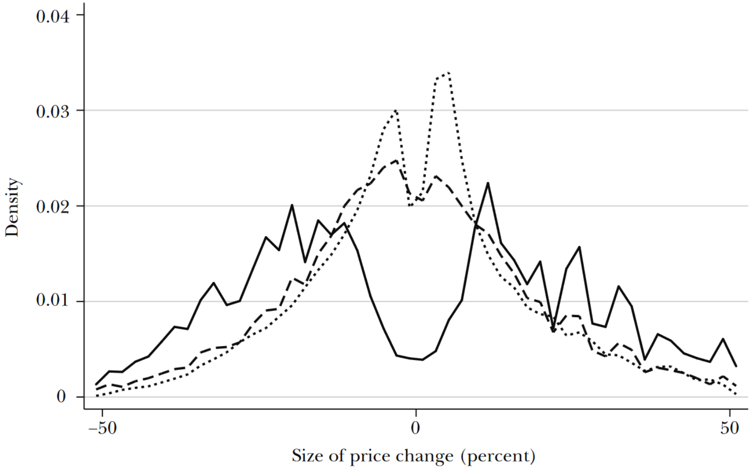


Figure 3: Cavallo et al (2023)

Evidence of inaction regions

Figure 8

The Distribution of the Size of Price Changes in the United States



What should central banks do?

back

What should central banks do?

back

Background: **Why does monetary policy matter?**

What should central banks do?

back

Background: **Why does monetary policy matter?**

Benchmark: monetary policy *doesn't* matter

What should central banks do?

▸ back

Background: **Why does monetary policy matter?**

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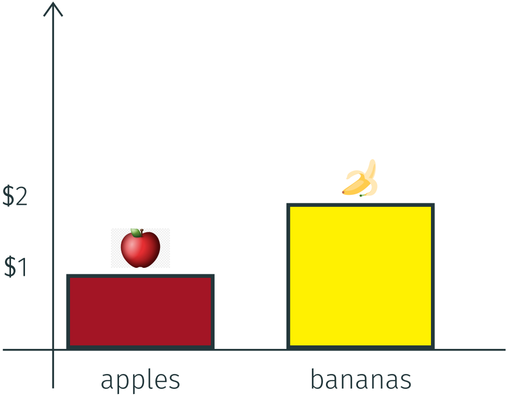


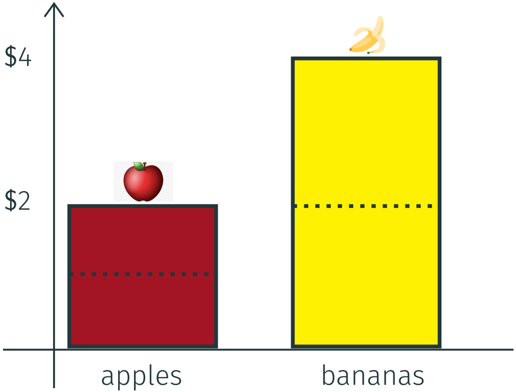
What should central banks do?

▸ back

Background: **Why does monetary policy matter?**

Benchmark: monetary policy *doesn't* matter

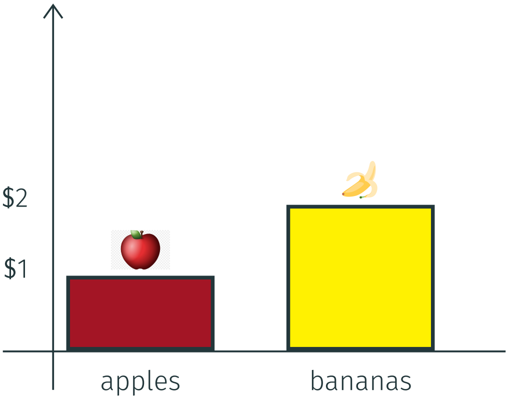
- Money supply doubles
  $\Longrightarrow$ all prices double
  $\Longrightarrow$ nothing *real* affected by monetary policy



What should central banks do?

back

Background: **Why does monetary policy matter?**

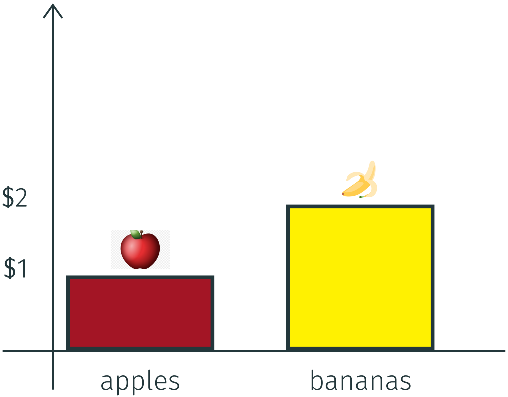


What should central banks do?

back

Background: **Why does monetary policy matter?**

Prices are *sticky*



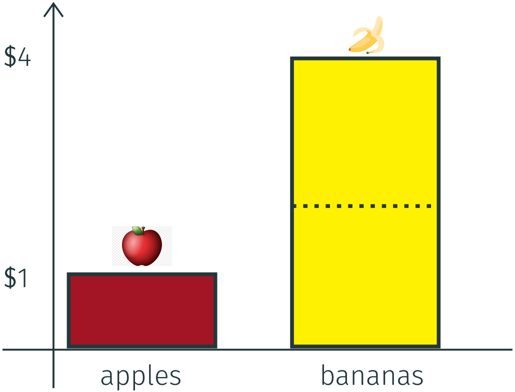
What should central banks do?

back

Background: **Why does monetary policy matter?**

Prices are *sticky*

- Money supply doubles
  $\Longrightarrow$ some prices are stuck
  $\Longrightarrow$ **distorted** relative prices



What should central banks do?

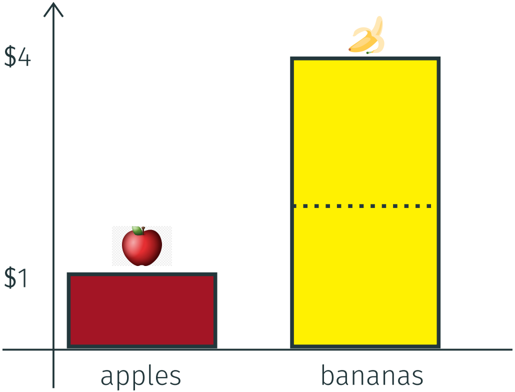
▸ back

Background: **Why does monetary policy matter?**

Prices are *sticky*

- Money supply doubles
  $\implies$ some prices are stuck
  $\implies$ **distorted** relative prices
- Large empirical literature

▸ more



The welfare loss of inflation targeting

▸ back

"Inflation targeting": $P = P^{ss}$ (while having correct relative prices)

Proposition 2: Suppose $A_1 > \overline{A}$. Then:

1. Inflation targeting requires all sectors adjust their prices
2. Welfare loss from inflation targeting $\propto$ size of menu costs

$$\mathbb{W}^* - \mathbb{W}^{IT} = (S-1)\psi$$

The welfare loss of inflation targeting

back

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What are menu costs?

1. **Physical adjustment costs.** Baseline interpretation.

The welfare loss of inflation targeting

back

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$$\mathbb{W}^* - \mathbb{W}^{IT} = (S - 1)\psi$$

What are menu costs?

1. **Physical adjustment costs.** Baseline interpretation.
2. **Information costs.** Fixed costs of information acquisition / processing.
   - Results unchanged
3. **Behavioral costs.** Consumer *distaste* for price changes.
   - Results unchanged

Additional MIT shock figures

back