Optimal Monetary Policy with Redistribution

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June 19, 2026

Differences in labor earnings are relatively forecastable

- There are large, systematic, forecastable differences in labor earnings
- Households face heterogeneous exposure of labor earnings to the business cycle
  - earnings of low-income households exhibit a greater covariance with aggregate fluctuations than that of high-income households
  - countercyclical earnings inequality
  - Guvenen et al (2017); Parker Vissing-Jorgenson (2009)

How should monetary policy incorporate distributional concerns?

- HANK literature incorporates heterogeneous households
  - Bewley-Imrohoroglu-Huggett-Aiyagari economies $\rightarrow$ uninsurable idiosyncratic income risk
  - Optimal Policy: Bhandari, Evans, Golosov, Sargent (2021); Acharya, Challe, and Dogra (2023); Bilbiie (2008, 2024); LeGrand, Martin-Baillon, Ragot (2021); Davila Schaab (2023)
  - monetary policy compensates for missing insurance markets
  - optimal monetary policy places greater weight on output stabilization
- but "ex-ante" systematic heterogeneity is also quantitatively important

What We Do

- We write down a general equilibrium business cycle model with systematic heterogeneity
  - households differ in type-specific labor productivities (skills) and initial firm shares
  - skills are state-contingent, but markets are complete
- We take the Ramsey approach to redistribution (not insurance)
- Given a restricted set of available tax instruments:
- We solve for optimal fiscal & monetary policy following the primal approach
  - Lucas Stokey (1983); Werning (2007); Correia, Nicolini, Teles (2008)

What We Show

- Optimal markup co-varies positively with a sufficient statistic for labor income inequality
- When we calibrate the labor income distribution to match "worker betas" Guvenen et al (2017):
  - countercyclical earnings inequality $\rightarrow$ countercyclical optimal markups
  - unlike in HANK, optimal monetary policy is destabilizing!
- Optimal markups in our model are consistent with Bils (1987); Rotemberg and Woodford (1999); Bils, Klenow, Malin, (2018); Chari, Kehoe, McGrattan (2007)

The Environment

- $t = 0, 1, \ldots$
- finite states $s_t \in S$
- history $s^t = (s_0, ..., s_t) \in S^t$
  - conditional probabilities $\mu(s^t | s^{t-1})$
  - unconditional probabilities $\mu(s^t)$

Household preferences

- unit mass continuum of households
- identical preferences over consumption and effort

$$U(c,h) = \frac{c^{1-\gamma}}{1-\gamma} - \frac{h^{1+\eta}}{1+\eta}$$

Household types

- finite types $i \in I$ of relative size π^i
- types correspond to workers' state-contingent skill and initial firm ownership

$$\theta^i(s_t) > 0 \qquad \text{and} \qquad 1 + \sigma_0^i \geq 0 \text{ initial shares}$$

- efficiency units of labor

$$\ell^i(s^t) = \theta^i(s_t) h^i(s^t)$$

- expected lifetime utility

$$\sum_t \sum_{s^t} \beta^t \mu(s^t) U\left(c^i(s^t), \frac{\ell^i(s^t)}{\theta^i(s_t)}\right)$$

Household budget set

$$(1+\tau_c)P(s^t)c^i(s^t)+b^i(s^t)+\sum_{s^{t+1}|s^t}Q(s^{t+1}|s^t)z^i(s^{t+1}|s^t)+V(s^t)[\sigma^i(s^t)-\sigma^i(s^{t-1})]$$

$$\leq(1-\tau_\ell)W(s^t)\ell^i(s^t)+P(s^t)T(s^t)+z^i(s^t|s^{t-1})+(1+i(s^{t-1}))b^i(s^{t-1})+(1-\tau_\Pi)(1+\sigma^i(s^{t-1}))\Pi(s^t)$$

Firms

- intermediate good firms

$$y^j(s^t) = A(s_t)n^j(s^t)$$

$$\text{profits}^j(s^t) = (1 - \tau_r)p_t^j(\cdot)y^j(s^t) - W(s^t)n^j(s^t)$$

- final good firm

$$Y(s^t) = \left[\int_{j\in J} y^j(s^t)^{\frac{\rho-1}{\rho}} \mathrm{d}j\right]^{\frac{\rho}{\rho-1}} \qquad \rightarrow \qquad y^j(s^t) = \left(\frac{p_t^j(\cdot)}{P(s^t)}\right)^{-\rho} Y(s^t)$$

Government Budget Constraint

$$(1+i(s^{t-1}))B(s^{t-1})+Z(s^t)+P(s^t)T(s^t)$$

$$=B(s^t)+\sum_{s^{t+1}|s^t}Q(s^{t+1}|s^t)Z(s^{t+1})+\tau_c P(s^t)C(s^t)+\tau_\ell W(s^t)L(s^t)+\tau_r P(s^t)Y(s^t)+\tau_\Pi \Pi(s^t)$$

$$C(s^t)=\sum_{i\in I}\pi^i c^i(s^t), \qquad L(s^t)=\sum_{i\in I}\pi^i \ell^i(s^t), \qquad \Pi(s^t)\equiv\int_0^1 \text{profits}^j(s^t)\mathrm{d}j$$

Nominal Rigidity = Informational Friction

- Nature draws the aggregate state

$$s_t \in S$$

- state determines

$$A(s_t), (\theta^i(s_t))_{i \in I}$$

- $\kappa \in [0,1)$ of intermediate-good firms are "inattentive" to the current state
- $1 - \kappa$ of intermediate-good firms are "attentive" to the current state

Nominal Rigidity = Informational Friction

- κ inattentive, "sticky-price" firms do not observe s_t
  - make their pricing decisions based on knowledge of past states

$$p_t^s(s^{t-1}), \qquad \forall j \in \mathcal{J}^s \subset \mathcal{J}$$

- $1-\kappa$ attentive, "flexible-price" firms observe s_t perfectly
  - make their pricing decisions under complete information

$$p_t^f(s^t), \qquad \forall j \in \mathcal{J}^f \subset \mathcal{J}$$

Feasible Allocations: satisfy technology and resource constraints

- allocation

$$x \equiv \{(c^i(s^t), \ell^i(s^t))_{i \in I}, (y^j(s^t), n^j(s^t))_{j \in \mathcal{J}}, C(s^t), Y(s^t), L(s^t)\}_{t \geq 0, s^t \in S^t}$$

Definition

An allocation x is feasible if it satisfies, for all $s^t \in S^t$:

$$y^j(s^t) = A(s_t) n^j(s^t), \qquad \forall j \in \mathcal{J};$$

$$Y(s^t) = \left[\int_{j \in J} y^j(s^t)^{\frac{\rho-1}{\rho}} \mathrm{d}j\right]^{\frac{\rho}{\rho-1}}; \qquad L(s^t) = \int_{j \in J} n^j(s^t) \mathrm{d}j;$$

$$C(s^t) = \sum_{i \in I} \pi^i c^i(s^t); \qquad L(s^t) = \sum_{i \in I} \pi^i \ell^i(s^t); \qquad C(s^t) = Y(s^t).$$

Let $\mathcal{X}$ denote the set of all feasible allocations.

We are interested in allocations that can be supported in equilibrium

Definition

An equilibrium is an allocation x, prices, policy, and financial positions such that:

(i) $p_t^s(s^{t-1})$ solves the sticky-price firm's problem; $p_t^f(s^t)$ solves the flex-price firm's problem;

(ii) prices and allocations jointly satisfy the CES demand function;

(iii) the allocation and financial asset holdings solve household i's problem, for each $i \in I$;

(iv) the government budget constraint is satisfied;

(v) markets clear.

Equilibrium Characterization

There exists a "Fictitious" Representative Household

Lemma

(Negishi, 1960; Werning, 2007)

For any equilibrium there exist "market" or "Negishi" weights $\varphi \equiv (\varphi^i)_{i \in I}$ *with* $\varphi^i \geq 0$ *such that*

$$\{c^i(s^t), \ell^i(s^t)\}_{i \in I}$$

solve the following static sub-problem

$$U^m(C(s^t), L(s^t); \varphi) \equiv \max \sum_{i \in I} \varphi^i \pi^i U(c^i(s^t), \ell^i(s^t)/\theta^i(s_t))$$

subject to

$$C(s^t) = \sum_{i \in I} \pi^i c^i(s^t), \qquad \text{and} \qquad L(s^t) = \sum_{i \in I} \pi^i \ell^i(s^t)$$

Equilibrium prices thereby satisfy

$$-\frac{U_L^m(s^t)}{U_C^m(s^t)} = \left(\frac{1-\tau_\ell}{1+\tau_c}\right)\frac{W(s^t)}{P(s^t)}$$

$$\frac{U_C^m(s^t)}{P(s^t)} = \beta(1+i(s^t))\sum_{s^{t+1}|s^t}\mu(s^{t+1}|s^t)\frac{U_C^m(s^{t+1})}{P(s^{t+1})}$$

$$Q(s^{t+1}|s^t) = \beta\mu(s^{t+1}|s^t)\frac{U_C^m(s^{t+1})}{U_C^m(s^t)}\frac{P(s^t)}{P(s^{t+1})}$$

$$V(s^t) = \sum_{s^{t+1}|s^t} Q(s^{t+1}|s^t)[(1-\tau_\Pi)\Pi(s^{t+1}) + V(s^{t+1})].$$

Solution to sub-problem with iso-elastic utility:

$$c^i(s^t) = \omega_C^i(\varphi)C(s^t) \qquad \text{and} \qquad \ell^i(s^t) = \omega_L^i(\varphi, s_t)L(s^t)$$

$$\omega_C^i(\varphi) \equiv \frac{(\varphi^i)^{1/\gamma}}{\sum_{j\in I}\pi^j(\varphi^j)^{1/\gamma}}, \qquad \omega_L^i(\varphi, s_t) \equiv \frac{(\varphi^i)^{-1/\eta}\theta^i(s_t)^{\frac{1+\eta}{\eta}}}{\sum_{k\in I}\pi^k(\varphi^k)^{-1/\eta}\theta^i(s_t)^{\frac{1+\eta}{\eta}}}$$

Budget Implementability Conditions. For every $i \in I$:

$$\sum_t \sum_{s^t} \beta^t \mu(s^t) \left[U_C^m(s^t)\omega_C^i(\varphi)C(s^t) + U_L^m(s^t)\omega_L^i(\varphi, s_t)L(s^t) \right] = U_C^m(s_0)\bar{T} + \sigma_0^i \frac{1-\tau_\Pi}{1+\tau_c} \sum_t \sum_{s^t} \beta^t \mu(s^t) U_C^m(s^t) \frac{\Pi(s^t)}{P(s^t)}$$

where

$$\bar{T} \equiv \frac{1}{1+\tau_c} \sum_t \sum_{s^t} \mu(s^t) \frac{\beta^t U_C^m(s^t)}{U_C^m(s_0)} \left[T(s^t) + (1-\tau_\Pi) \frac{\Pi(s^t)}{P(s^t)} \right]$$

- one for each type $i \in I$
- similar to Lucas Stokey (1983), Werning (2007)
- heterogeneous exposure σ_0^i to real profits $\Pi(s^t)/P(s^t)$

Baseline Model: Full Profit Taxation

- baseline model: assume $\tau_\Pi = 1$
- then heterogeneity in firm ownership is irrelevant
- budget implementability conditions reduce to:

$$\sum_t \sum_{s^t} \beta^t \mu(s^t) \left[U_C^m(s^t) \omega_C^i(\varphi) C(s^t) + U_L^m(s^t) \omega_L^i(\varphi, s_t) L(s^t) \right] = U_C^m(s_0) \bar{T}$$

- in extensions we consider $\tau_\Pi < 1$

Firm Optimality

- flex-price firm: price = mark-up over marginal cost

$$p_t^f(s^t) = \left[(1-\tau_r)\left(\frac{\rho-1}{\rho}\right)\right]^{-1} \frac{W(s^t)}{A(s_t)}$$

- sticky-price firm: price = mark-up over expected marginal cost

$$p_t^s(s^{t-1}) = \left[(1-\tau_r)\left(\frac{\rho-1}{\rho}\right)\right]^{-1} \sum_{s^t|s^{t-1}} \left[\frac{W(s^t)}{A(s_t)}\right] q(s^t|s^{t-1})$$

Proposition

A feasible allocation $x \in \mathcal{X}$ *is implementable as an equilibrium iff* $\exists\ \varphi \equiv (\varphi^i)$, $\bar{T} \in \mathbb{R}$, $\chi \in \mathbb{R}_+$ *such that:*

(i) for all $s^t \in S^t$*:*

$$\begin{aligned} y^j(s^t) &= y^f(s^t), \qquad && \forall j \in \mathcal{J}^f \\ y^j(s^t) &= y^s(s^t), \qquad && \forall j \in \mathcal{J}^s \end{aligned}$$

(ii) for all $s^t \in S^t$*:*

$$\chi U_C^m(s^t)\left(\frac{y^f(s^t)}{Y(s^t)}\right)^{-1/\rho} + U_L^m(s^t)\frac{1}{A(s_t)} = 0,$$

for all $s^{t-1} \in S^{t-1}$*:*

$$\sum_{s^t|s^{t-1}} y^s(s^t)\left\{\chi U_C^m(s^t)\left[\frac{y^s(s^t)}{Y(s^t)}\right]^{-1/\rho} + U_L^m(s^t)\frac{1}{A(s_t)}\right\}\mu(s^t|s^{t-1}) = 0,$$

(iii) for all $i \in I$*:*

$$\sum_t \sum_{s^t} \beta^t \mu(s^t)\left[U_C^m(s^t)\omega_C^i(\varphi)C(s^t) + U_L^m(s^t)\omega_L^i(\varphi, s_t)L(s^t)\right] = U_C^m(s_0)\bar{T}$$

What can fiscal and monetary policy do?

$$p_t^f(s^t) = \left[(1-\tau_r)\left(\frac{\rho-1}{\rho}\right)\right]^{-1}\frac{W(s^t)}{A(s_t)} \qquad \text{and} \qquad p_t^s(s^{t-1}) = \left[(1-\tau_r)\left(\frac{\rho-1}{\rho}\right)\right]^{-1}\varepsilon(s^t)\frac{W(s^t)}{A(s_t)}$$

$$-\frac{U_L^m(s^t)}{U_C^m(s^t)} = \underbrace{\chi\left[\kappa\varepsilon(s^t)^{1-\rho} + (1-\kappa)\right]^{-\frac{1}{1-\rho}}}_{\text{labor wedge}} \times A(s_t)$$

- fiscal policy: non-state-contingent wedge χ

$$\chi \equiv \frac{\rho-1}{\rho}\frac{(1-\tau_\ell)(1-\tau_r)}{1+\tau_c}$$

What can fiscal and monetary policy do?

$$p_t^f(s^t) = \left[(1-\tau_r)\left(\frac{\rho-1}{\rho}\right)\right]^{-1}\frac{W(s^t)}{A(s_t)} \quad \text{and} \quad p_t^s(s^{t-1}) = \left[(1-\tau_r)\left(\frac{\rho-1}{\rho}\right)\right]^{-1}\varepsilon(s^t)\frac{W(s^t)}{A(s_t)}$$

$$-\frac{U_L^m(s^t)}{U_C^m(s^t)} = \underbrace{\chi\left[\kappa\varepsilon(s^t)^{1-\rho} + (1-\kappa)\right]^{-\frac{1}{1-\rho}}}_{\text{labor wedge}} \times A(s_t)$$

- monetary policy: state-contingent wedge $\varepsilon(s^t)$
  - cost of using monetary policy is loss in production efficiency: $y^s(s^t) \neq y^f(s^t)$
  - constraint on $\varepsilon(s^t)$: forecast error $\rightarrow$ on average, equal to 1

The Ramsey Problem

Utilitarian Welfare Function

- social welfare function with Pareto weights $\lambda^i > 0$

$$\mathcal{U} \equiv \sum_{i \in I} \lambda^i \pi^i \sum_t \sum_{s^t} \beta^t \mu(s^t) U(c^i(s^t), \ell^i(s^t)/\theta^i(s_t))$$

Primal Approach to the Ramsey Problem

- let $\mathcal{X}^e \subset \mathcal{X}$ denote the set of equilibrium allocations

Definition

A Ramsey optimum x^* is an allocation that maximizes welfare subject to $x^* \in \mathcal{X}^e$.

- let $\pi^i v^i$ be the Lagrange multiplier on:

$$\sum_t \sum_{s^t} \beta^t \mu(s^t) \left[U_C^m(s^t) \omega_C^i(\varphi) C(s^t) + U_L^m(s^t) \omega_L^i(\varphi, s_t) L(s^t) \right] = U_C^m(s_0) \bar{T}$$

Implicit Monetary Wedge

- we define an implicit monetary wedge $1-\tau_M^*(s^t)$ by

$$-\frac{U_L^m(s^t)}{U_C^m(s^t)} = \chi^*(1-\tau_M^*(s^t))\frac{Y(s^t)}{L(s^t)}$$

- portion of the labor wedge implemented by monetary policy at the Ramsey optimum

The Optimal Monetary Wedge and Income Inequality

Theorem

Let $\mathcal{I} : S \to \mathbb{R}_+$ be the function defined by:

$$\mathcal{I}(s_t) \equiv \frac{\sum_{i\in I} \tilde{\pi}^i (\varphi^i)^{-1/\eta} (\theta^i(s_t))^{\frac{1+\eta}{\eta}}}{\sum_{i\in I} \pi^i (\varphi^i)^{-1/\eta} (\theta^i(s_t))^{\frac{1+\eta}{\eta}}} > 0, \qquad \text{where} \qquad \tilde{\pi}^i \equiv \pi^i \left[\frac{\lambda^i}{\varphi^i} + \nu^i (1+\eta)\right]$$

There exists a threshold $\bar{\mathcal{I}}(s^{t-1}) > 0$ such that:

$$\begin{aligned}
\tau_M^*(s^t) > 0 \qquad & \text{if and only if} \quad \mathcal{I}(s_t) > \bar{\mathcal{I}}(s^{t-1}), \\
\tau_M^*(s^t) = 0 \qquad & \text{if and only if} \quad \mathcal{I}(s_t) = \bar{\mathcal{I}}(s^{t-1}), \\
\tau_M^*(s^t) < 0 \qquad & \text{if and only if} \quad \mathcal{I}(s_t) < \bar{\mathcal{I}}(s^{t-1}).
\end{aligned}$$

- $\mathcal{I}(s_t)$ is a sufficient statistic for labor income inequality

Optimal Monetary Policy

- define the aggregate markup as:

$$\mathcal{M}(s^t) \equiv \frac{P(s^t)}{W(s^t)/A(s^t)}$$

Theorem

Let $\bar{\mathcal{M}} > 0$. Let x^* be a Ramsey optimum; x^* can be implemented with tax rates that satisfy:

$$(1-\tau_r)^{-1}\frac{\rho}{\rho-1} = \bar{\mathcal{M}}, \qquad \text{and} \qquad \frac{1-\tau_\ell}{1+\tau_c}(\bar{\mathcal{M}})^{-1} = \chi^*.$$

and a monetary policy that targets a markup $\mathcal{M}^*(s^t)$ that satisfies:

$$\begin{array}{lll} \log\mathcal{M}(s^t) > \bar{\mathcal{M}} & \text{if and only if} & \mathcal{I}(s_t) > \bar{\mathcal{I}}(s^{t-1}), \\ \log\mathcal{M}(s^t) = \bar{\mathcal{M}} & \text{if and only if} & \mathcal{I}(s_t) = \bar{\mathcal{I}}(s^{t-1}), \\ \log\mathcal{M}(s^t) < \bar{\mathcal{M}} & \text{if and only if} & \mathcal{I}(s_t) < \bar{\mathcal{I}}(s^{t-1}). \end{array}$$

Special case: proportional shocks to the labor skill distribution

Proposition

Suppose shocks to the skill distribution are proportional:

$$\theta^i(s_t) = \vartheta^i \Theta(s_t), \qquad \forall s_t \in S,$$

then

$$\tau_M^*(s^t) = 0, \qquad \forall s_t \in S$$

- with proportional shocks to the skill distribution:
  - fiscal policy alone ($\chi = \chi^*$) achieves the optimal level of redistribution
  - it is optimal for monetary policy replicate flexible prices
- similar to special case in Lucas Stokey (1983) of perfect tax smoothing

Proportional shocks, but what if fiscal policy is set suboptimally?

Proposition

Suppose shocks to the skill distribution are proportional and

$$\chi \neq \chi^*.$$

Then it remains optimal for monetary policy to replicate flexible prices.

- even if tax rate is suboptimal, monetary policy is unable to substitute for the missing tax
- why? the missing tax rate is constant, but $\varepsilon(s^t)$ is a forecast error!

Disproportional shocks to the labor skill distribution

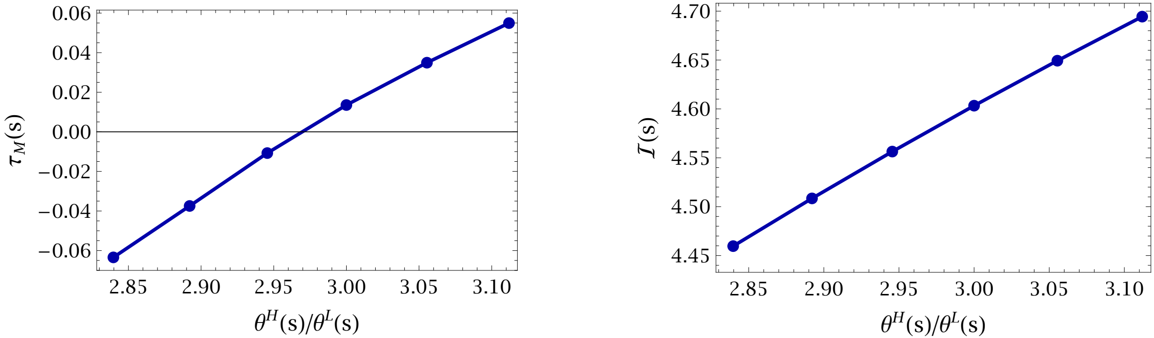

Figure: Left: $\tau^*_M(s^t)$ as a function of $\theta^H(s_t)/\theta^L(s_t)$. Right: $\mathcal{I}(s_t)$ as a function of $\theta^H(s_t)/\theta^L(s_t)$.

Intuition

- at the Ramsey optimum:

$$-\frac{U_L^m(s^t)}{U_C^m(s^t)} = \chi^*(1-\tau_M^*(s^t))\frac{Y(s^t)}{L(s^t)}$$

  - the markup resembles a labor income tax

- the Ramsey planner can distort the labor wedge
  - fiscal power: can move the labor wedge in a constant way
  - monetary power: can move the labor wedge across states, but doing so leads to loss in production efficiency

- when does the planner want a greater tax vs a lower tax?
  - the optimal tax should rise in states where the high-type works and earns relatively more, and should fall in states where the high-type is closer to the low-type

Implementation: Price Level and Interest Rate

- let $i^n(s^t)$ denote the interest rate consistent with flexible prices, i.e. the "natural" rate

Proposition

A price level, $P(s^t)$, and nominal interest rate, $i(s^t)$, consistent with the Ramsey optimum satisfy:

$$\begin{array}{llll} P(s^t) < P(s^{t-1}) & \textit{and} \quad i(s^t) > i^n(s^t) & \textit{if and only if} & \mathcal{I}(s_t) > \bar{\mathcal{I}}(s^{t-1}), \\ P(s^t) = P(s^{t-1}) & \textit{and} \quad i(s^t) = i^n(s^t) & \textit{if and only if} & \mathcal{I}(s_t) = \bar{\mathcal{I}}(s^{t-1}), \\ P(s^t) > P(s^{t-1}) & \textit{and} \quad i(s^t) < i^n(s^t) & \textit{if and only if} & \mathcal{I}(s_t) < \bar{\mathcal{I}}(s^{t-1}). \end{array}$$

Extension: Constrained Profit Taxation and Heterogeneous Shares

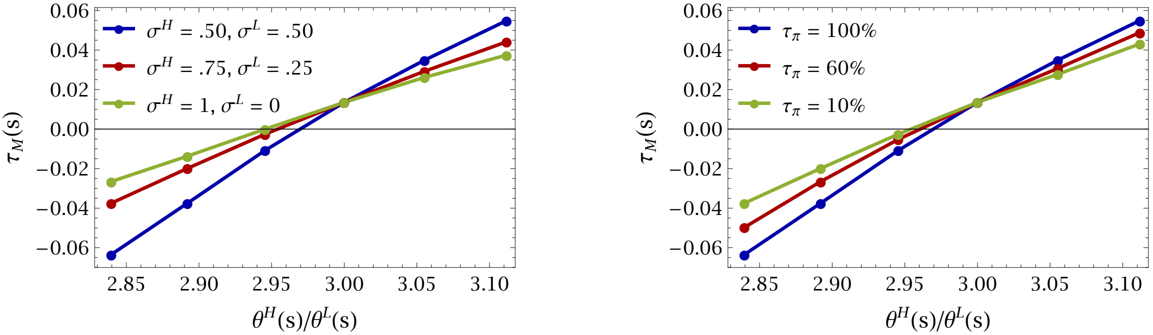

Figure: Optimal $\tau_M^*(s^t)$ as a function of $\theta^H(s_t)/\theta^L(s_t)$.

Quantitative Illustration: we calibrate to Guvenen et al (2017) Worker Betas

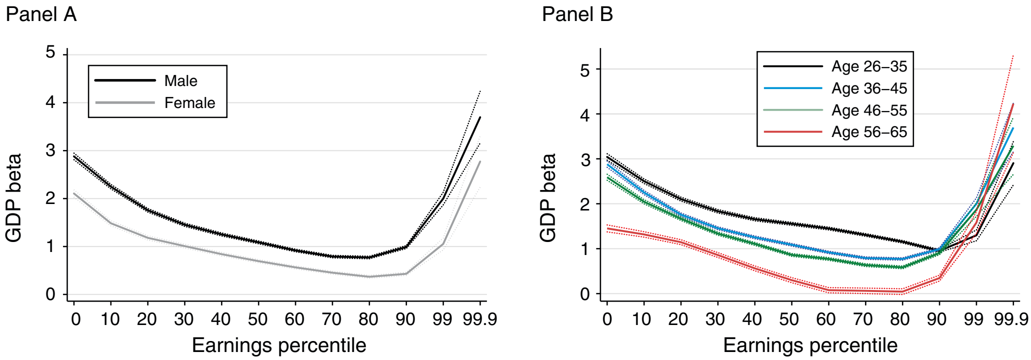

Figure 1. GDP Beta at Age 36–45 by Gender and for Males by Age Group

Figure: Guvenen, Schulhofer-Wohl, Song, Yogo (2017)

Worker Betas imply Countercyclical Optimal Markups

Table 1. Model-implied optimal markups and elasticities

			$\kappa = .25$		$\kappa = .06$	
State	$d \log Y$	μ	$d \log \mathcal{M}$	Elasticity	$d \log \mathcal{M}$	Elasticity
severe recession	–5.23	.09	1.32	–.25	.22	–.04
mild recession	–3.30	.09	1.30	–.39	.20	–.06
normal times	0	.49	0	—	0	—
high growth	3.21	.33	–.8	–.25	–.15	–.05

Notes. This table reports model-implied optimal markups and elasticities when price change frequencies are calibrated to match Nakamura and Steinsson (2008) ($\kappa = .25$) and Bils and Klenow (2004) ($\kappa = .06$), respectively.

Conclusion

- When markets are complete but there exists systematic heterogeneity:
- The optimal markup co-varies positively with labor income inequality
- When calibrated to Guvenen et al (2017) worker betas:
- Countercyclical earnings inequality $\rightarrow$ Countercyclical optimal markups
- Optimal markups in our model are consistent with Bils (1987); Rotemberg and Woodford (1999); Bils, Klenow, Malin, (2018)

Thank you very much!