Redistributive Inflation and Optimal Monetary Policy

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Redistributive Impact of Inflation & Monetary Policy Design

- Inflation has heterogeneous impacts on households.
- "Inclusive goal" of central banks' monetary policy framework, in particular for the low- and moderate-income (Powell, 2020, 2021; Schnabel, 2021).
- Q: how redistributive consequences of inflation affect optimal monetary policy design?
- This paper:
  1. Consider inflation's redistributive impacts through multiple channels.
  2. Study optimal monetary policy rule in a quantitative dynamic model with these channels.

Three Redistributive Channels of Inflation

1. Expenditure channel:
   - Households differ in consumption bundles with heterogeneous price rigidity.
   - Empirics: low-income have higher inflation. (e.g. Jaravel '21)
2. Revaluation (Fisher) channel:
   - Unexpected inflation redistributes from net nominal creditors to borrowers.
   - Empirics: low & middle income are net nominal borrowers. (e.g. Doepke-Schneider '06)
3. Earnings channel:
   - Inflation comoves with real output through Phillips curve. Households have heterogeneous earning responses to business cycle.
   - Empirics: earnings of bottom & very top income are more sensitive to aggregate output. (e.g. Guvenen et al '17)

This Paper

- Develop a general framework to study optimal policy rules with redistributive inflation.
- Quantitative two-sector Heterogeneous Agent New Keynesian (HANK) model:
  1. Non-homothetic preference & different price rigidity across sectors $\Rightarrow$ expenditure channel.
  2. Households face income risk, and save & borrow in nominal asset $\Rightarrow$ revaluation channel.
  3. Household earnings have heterogeneous elasticity to business cycle $\Rightarrow$ earnings channel.
- Revisit and match empirical facts on three channels for quantitative analysis.
- Study optimal nonlinear monetary policy rules in this model.
  - Compute social welfare with nonlinear transition dynamics with aggregate shocks.

literature

A Framework to Study Optimal Policy with Redistributive Inflation

HANK with non-homothetic preference: household's preference

- Continuum of ex ante identical households. HH utility from consumption & labor supply:

$$\max_{\{c_{h,t},\ell_{h,t},b_{h,t+1}\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_{h,t}^{1-\gamma}}{1-\gamma} - \varphi \frac{\ell_{h,t}^{1+\psi}}{1+\psi} \right],$$

- Nonhomothetic preference over two types of goods: A is necessity good ($\underline{c} > 0$).

$$c_{h,t} \equiv \left[(1-\alpha)^{\frac{1}{\eta}} \left(c_{h,t}^{A} - \underline{c}\right)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} \left(c_{h,t}^{B}\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

$\Rightarrow$ household expenditure share in A decreases with income.

Household budget constraint and income process

- Households are exposed to idiosyncratic shocks $\xi_{h,t}$.
- Households save/borrow in nominal asset $b_{h,t+1}$ with fixed supply. Budget constraint:

$$c_{h,t} + b_{h,t+1} = \underbrace{b_{h,t}\frac{1+i_t}{1+\pi_t}}_{\text{gross asset return}} + \underbrace{(1-\tau_t)w_t e_{h,t}\ell_{h,t}}_{\text{post-tax labor income}} + \underbrace{T_t}_{\text{lump-sum transfer}} + \underbrace{d_t(\xi_{h,t})}_{\text{profit distribution}} .$$

- Borrowing constraint $b_{h,t+1} \geq \underline{b}$.
- Effective labor productivity $e_{h,t}$:

$$\log e_{h,t} = \underbrace{\log \xi_{h,t}}_{\text{idiosyncratic state}} + \underbrace{\zeta(\xi_{h,t}) \log(Y_t)}_{\substack{\text{heterogeneous response}\\ \text{to aggregate output}}} \underbrace{- \log \mathbb{E}_\xi[\xi_{h,t} Y_t^{\zeta(\xi_{h,t})}]}_{\text{normalization}} .$$

$\zeta(\xi_{h,t})$ calibrated to match heterogeneous earning elasticity to output/inflation.

Production: 2-sector NK with heterogeneous levels of price rigidity

- Final goods in sector $s \in \{A, B\}$: $Y_t^s = \left(\int_0^1 (y_{j,t}^s)^{\frac{1}{\mu_t}} dj \right)^{\mu_t}$.
- Each sector, intermediate producers $y_{j,t}^s = Z_t n_{j,t}^s$ with common TFP Z_t.
  - Set price with Rotemberg adjustment cost $\frac{\mu_t}{\mu_t - 1} \frac{1}{2\kappa^s} \left(\log \frac{p_{jt}^s}{p_{jt-1}^s} \right)^2 Y_t^s$.
  - κ^s: heterogeneous levels of price rigidity for each sector.
- Sectoral level New Keynesian Philips curve with $w_t^s = \frac{W_t}{P_t^s}$: Firm's problem

$$\log(1 + \pi_t^s) = \kappa^s \left(\frac{(1 - \tau_p) w_t^s}{Z_t} - \frac{1}{\mu_t} \right) + \frac{1}{1 + r_{t+1}} \frac{Y_{t+1}^s}{Y_t^s} \log(1 + \pi_{t+1}^s).$$

- Profit from two sectors distribute to households: $\Xi_t^A + \Xi_t^B = \int_h d_t(\xi_{h,t}) dh$.

Fiscal policy: taken as given

- Proportional labor income tax τ_t and lump-sum transfer T_t on households.
- Proportional labor subsidy τ_p and lump-sum tax T_t^p on intermediate producers.
- Government spending G_t.
- Government budget constraint:

$$\tau_t w_t N_t + B_{g,t+1} + T_t^p = \frac{1+i_t}{1+\pi_t} B_{g,t} + G_t + T_t + \tau_p w_t N_t.$$

- Set $\tau_p = 1 - \frac{1}{\mu}$ and $T_t^p = \tau_p w_t N_t$ to fix monopoly power distortion in steady state.
- Note: Inflation would have redistributive impact through fiscal policy.

Optimal monetary policy rule to maximize social welfare

- Monetary policy: family of nonlinear Taylor rules $\Phi = \{\phi_\pi^+, \phi_\pi^-, \phi_y\}$ w/ determinacy:

$$i_t = r^* + \phi_\pi^+ \pi_t^+ + \phi_\pi^- \pi_t^- + \phi_y \widehat{y}_t,$$ index definition

- Given Φ, solve perfect foresight nonlinear $\{c_{h,t}, \ell_{h,t}\}$ w/ agg shock $\{\mathcal{E}_t\}$ to steady state.
- Social welfare with Pareto weight ω_h: comparison to literature

$$\Omega(\Phi, \{\mathcal{E}_t\}) \equiv \mathbb{E}\left[\int_h \omega_h \sum_{t=0}^{\infty} \beta^t u(c_{h,t}, \ell_{h,t}) dh \middle| \{\mathcal{E}_t\}; \Phi\right] - \chi \sum_{t=0}^{\infty} \pi_t^2$$

- $\chi \geq 0$ allows for possible special emphasis on price stabilization like ECB.
- Optimal monetary policy rule Φ^* solves:

$$\max_{\Phi} \mathbb{E}_{\{\mathcal{E}_t\}} \Omega(\Phi, \{\mathcal{E}_t\}).$$

- Baseline: **demand shocks** $\{\mathcal{E}_t\}$ as Euler equation wedge.

Empirical evidence (in the paper) and calibration

Other parameters

Parameter	Interpretation	Value	Target
$\alpha, \underline{c}$	Expd share and subsistence	$0.3, 0.2$	Expd share along income
κ_A, κ_B	Price adj cost in each sector	$0.15, 0.05$	Adjust frequency empirics
B	Bond supply	5.6	Liquid assets/GDP
$\underline{b}$	Borrowing constraint	-1	Asset Gini
$\zeta(\xi_{h,t})$	Earnings elasticities for each state	6, 0.5, 0.5, 1	Empirical estimates empirics
p	Prob to enter superstar state	1/99	Top 1% income as star
q	Prob to stay in superstar state	0.99	Top 1% income as star
e_{star}	labor productivity in superstar state	20	Boar & Midrigan '22
τ	Labor tax rate	0.3	Kaplan-Moll-Violante
T	Lump-sum transfer to HH at ss	0.27	T_t balance gov't budget fiscal
G	Government spending	0	
ρ_r	Persistence of demand shock	0.55	US inflation persistence
σ_r	Volatility of demand shock	1.175%	US inflation volatility
$\phi_\pi^+, \phi_\pi^-, \phi_y$	Baseline Taylor rule coefficients	$1.5, 1.5, 0$	Auclert et al. '21
χ	Social cost of inflation	120 different χ	10% inflation $\approx 4.6\%$ C↓

Results on Optimal Monetary Policy Rule

Models for comparison and aggregate shock

- **Full model:** Two-sector HANK with all three channels.
- Counterfactuals for comparison (add one channel each time):
  1. No redistributive channel: Two-sector RANK.
  2. Add revaluation channel: Two-sector HANK with heterogeneous price adjustment cost.
  3. Add expenditure channel: Two-sector HANK with heterogeneous price adjustment cost + non-homothetic preference.

  Finally add earnings channel: Two-sector HANK with all three channels.
- Policy parameter search range: $[\text{determinacy bound}, 3]$ (Schmit-Grohe and Uribe, 2007).

Social welfare and optimal monetary policy for utilitarian planner

- ϕ_y has negligible welfare effect. Plot on welfare with ϕ_y

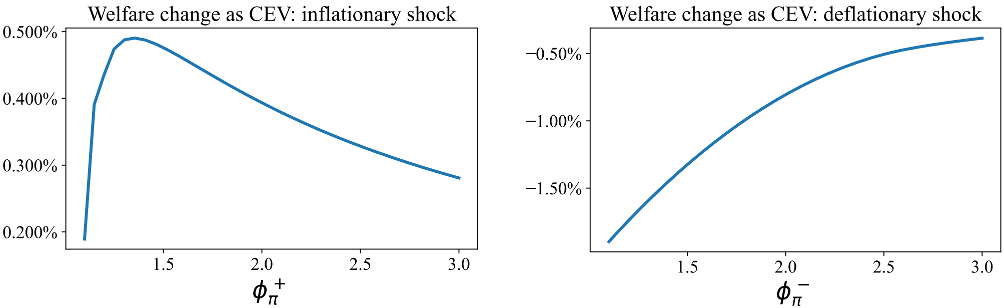

Figure 1: Welfare change with ϕ_π^+, ϕ_π^- as consumption equivalent variation (CEV) to steady state

- $\phi_\pi^{+,*} = 1.36, \phi_\pi^{-,*} = 3$: accommodative to inflation, but aggressive to deflation.

Optimal monetary policy rules with alternative objective functions: $\chi = 0$, 1000, McKay-Wolf (2022) Impulse response comparison

Alternative calibration: optimal monetary policy with $\chi = 0$

$$\Omega(\Phi, \{\mathcal{E}_t\}) \equiv \mathbb{E}\left[\int_h \omega_h \sum_{t=0}^{\infty} \beta^t u(c_{h,t}, \ell_{h,t}) dh \,\middle|\, \{\mathcal{E}_t\}; \Phi\right] - \chi \sum_{t=0}^{\infty} \pi_t^2$$

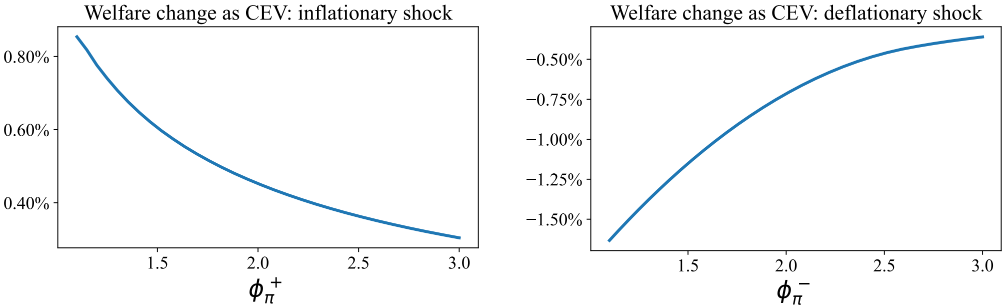

Figure 2: Welfare change with ϕ_π^+, ϕ_π^- as consumption equivalent variation (CEV) to steady state

Optimal monetary policy in different models with baseline calibration

	Redistributive channels	Optimal ϕ_π^+	Optimal ϕ_π^-
RANK	None	3 (boundary)	3 (boundary)
Counterfactual 2	Revaluation	1.41 link	3
Counterfactual 3	Revaluation, expenditure	1.52 link	3
Full model	Revaluation, expenditure, earnings	1.36	3

- Overall: compared to RANK, optimal policy in HANK models is more accommodative towards inflation, and as aggressive towards deflation. Average inflation bias Alternative objective function
- To inflation: earnings & revaluation $\Rightarrow$ accommodative, expenditure $\Rightarrow$ aggressive.
- Inflation: benefit the low income through nominal debt $\downarrow$ & earnings growth $\uparrow$, hurt them with consumer price $\uparrow$ more. First two dominate quantitatively.
- Deflation: hurt the low income through nominal debt $\uparrow$ & earnings growth $\downarrow$.

Distribution and Sources of Welfare Gain

- Consider a policy change from the optimal RANK policy $\phi_\pi^{+,-} = 3$ to the optimal (full) HANK policy $\phi_\pi^+ = 1.36, \phi_\pi^- = 3$.
- Computing conditional welfare gain along income and wealth distribution (ξ, b): welfare of income and wealth poor $\uparrow$, welfare of other people $\downarrow$.
- Welfare gain decomposition for policies $j = R \rightarrow H$:
    1. Efficiency: difference between average consumption and labor supply. 9%
    2. Insurance: welfare gain due to reduction of risk for each agent. 19%
    3. Redistribution: welfare gain due to reduction of inequality across all agents. 72%

Conclusion

- Redistributive channels of inflation affect optimal monetary policy design.
  1. Optimal policy is asymmetric, accommodative to inflation, aggressive to deflation.
  2. Revaluation & earnings channels $\Rightarrow$ accommodative, expenditure channel $\Rightarrow$ aggressive.
  3. Benefit low-income households through debt devaluation and higher earnings growth.
- I provide a general framework allowing for future extensions: real assets; types of shocks; different fiscal rules and optimal fiscal rule.
- Future work:
  1. Global solution to account for stochastic steady state inflation, among other factors.
  2. Use deep learning-based global solution methods like DeepHAM (Han, Yang, and E, 2021).

THANKs!

Comments and questions are welcome!

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Appendix

Inflation and stock return

- The beta of stock market return on headline inflation is negative but insignificant. back

Table: average portfolio exposures to inflation risks. Source: Fang, Liu, and Roussanov (2022)

	Mean	S.D.	A. Headline		B. Core and Energy			
			headline β	t-stat	core β	t-stat	energy β	t-stat
Stock	6.80	16.79	-1.33	(-1.38)	-5.60	(-3.69)	0.21	(1.81)
Treasury	2.07	6.90	-2.53	(-7.06)	-2.51	(-4.27)	-0.20	(-4.57)
Agency	2.44	5.10	-1.62	(-5.42)	-2.25	(-4.28)	-0.09	(-2.75)
Corporate	3.08	6.39	-1.60	(-4.38)	-2.98	(-4.91)	-0.05	(-1.08)
Currency	1.76	7.05	1.04	(2.02)	-1.04	(-0.65)	0.13	(2.54)
Commodity	4.47	21.90	8.59	(7.53)	-0.07	(-0.04)	1.10	(8.21)
REIT	7.96	17.46	0.31	(0.27)	-6.54	(-3.30)	0.31	(2.48)
Intl Stock	6.09	16.53	-1.20	(-1.23)	-5.78	(-3.74)	0.19	(1.70)

Notes: This table reports the regression results of the specification $r^e_{i,t} = \alpha_i + \beta^i_\pi \varepsilon_{\pi,t} + u_{i,t}$ for 8 average portfolios in each asset class. $r^e_{i,t}$ is the return of asset i in excess of the risk-free rate in the US. $\varepsilon_{\pi,t}$ is the shock to respective inflation extracted from the VAR system. Panel A uses headline inflation shock as the risk factor. Panel B uses core and energy inflation jointly as risk factors. The t-statistics are in the parentheses. The first two columns report the mean and standard deviation of returns in each row. All returns and inflation variables are annualized and span 1963 to 2019 at the quarterly frequency.

Inflation and stock return

- To think about the redistributive effects of inflation through heterogeneous real asset holding, we need to develop a HANK model with a realistic asset price component, which is something that has not been done yet.
- This also requires a global solution method like my DeepHAM method, and is on my research agenda.

back

Main Findings

- Optimal monetary policy rule for utilitarian central bank is asymmetric.
- Accommodative to inflation, aggressive to deflation.
- Key mechanism: redistributive motive.
  1. Inflation: benefit the low income through nominal debt $\downarrow$ & earnings growth $\uparrow$, hurt them with consumer price $\uparrow$ more. First two channels dominate quantitatively.
  2. Deflation: hurt the low income through nominal debt $\uparrow$ & earnings growth $\downarrow$, benefit them with consumer price $\downarrow$ more. First two channels dominate quantitatively.
- Welfare gain mostly on the income and wealth poor, due to insurance and redistribution.

Literature

- (Normative) Optimal monetary policy with HA and sectors:
  1. Bhandari-Evans-Golosov-Sargent (2021), Le Grand et al (2022), Nuno-Thomas (2022); McKay-Wolf (2022), Davila-Schaab (2022); Bilbiie-Ragot (2021); Acharya, Challe, Dogra (2023). comparison
  2. Aoki (2001), Benigno (2004), Guerrieri-Lorenzoni-Straub-Werning (2021).
  3. Optimal rule: Rotemberg and Woodford (1999), Schmitt-Grohe and Uribe (2007).

  This paper: first paper on optimal practical rule in HANK, with three channels & arbitrary Pareto weight.

- (Positive) Monetary policy with heterogeneous agents and sectors:
  1. Brunnermeier and Sannikov (2012), Kaplan, Moll, Violante (2018), Auclert (2019);
  2. Clayton, Jaravel, Schaab (2018), Cravino, Lan, Levchenko (2020).

  This paper: HANK with three channels of redistributive inflation.

- (Empirical) Redistributive effects of inflation:
  1. Expenditure: Jaravel (2021), Cavallo (2020), Argente-Lee (2021), Orchard (2022). Revaluation: Doepke-Schneider (2006), Adam-Zhu (2016), Pallotti (2022). Earning: Blanco et al (2022).
  2. Channels through budget constraint: del Canto-Grigsby-Qian-Walsh (2022), Cardoso et al (2022).

  This paper: integrate them in quantitative model. back

Normative HANK literature

- Bhandari et al. (2021), Le Grand et al. (2021), Davila and Schaab (2022): unconstrained Ramsey problem, optimal policy as IRF to shocks.

  This paper: optimal policy in a family of simple practical rules with comprehensive analysis of redistributive inflation.

- McKay and Wolf (2022):
  1. Linear quardratic problem, use deterministic steady state policy to reverse engineer Pareto weights that makes DSS efficient - higher weight on the rich.
  2. Optimal policy rule is “forecast targeting criteria”.

  This paper: arbitrary Pareto weights, global solution of individual paths in transition dynamics after MIT shock, instead of first order perturbation.

- Bilbiie and Ragot (2021); Acharya, Challe, Dogra (2021): analytical framework.

  This paper: optimal monetary policy rule with holistic redistributive channels in place. literature

Intermediate firm's problem

Each final goods retailer demands intermediate input j according to the standard demand function with the elasticity of substitution $\epsilon_t = \frac{\mu_t}{\mu_t - 1}$:

$$Y_{j,t}^s = \left(\frac{P_{j,t}^s}{P_t^s}\right)^{-\epsilon_t} Y_t^s, \quad \text{where} \quad P_t^s = \left(\int_0^1 (P_{j,t}^s)^{1-\epsilon_t} dj\right)^{\frac{1}{1-\epsilon_t}}.$$

The intermediate goods producers set prices with the Rotemberg price adjustment cost:

$$\max_{\{P_{j,t}^s\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \frac{1}{\Pi_{s=1}^t (1+r_s)} \left\{ \left(\frac{P_{j,t}^s}{P_t^s} - \frac{(1-\tau_p)W_t}{P_t^s}\right) \left(\frac{P_{j,t}^s}{P_t^s}\right)^{-\epsilon_t} Y_t^s - \phi_s \left(\frac{P_{j,t}^s}{P_{j,t-1}^s}\right) Y_t^s - T_p \right\}$$

Solving for the symmetric equilibrium where $P_{j,t}^s = P_t^s$, the first-order condition delivers the New Keynesian Phillips curve (NKPC) for each sector.

back

Price and output deviation

- Inflation $\pi_t = \frac{P_t}{P_{t-1}} - 1$ with aggregate price index defined as

$$P_t \equiv \left[(1-\alpha) \left(P_t^A \right)^{1-\eta} + \alpha \left(P_t^B \right)^{1-\eta} \right]^{\frac{1}{1-\eta}} .$$

- Output deviation

$$\widehat{y}_t = \frac{1}{2} (\widehat{y}_t^A + \widehat{y}_t^B).$$

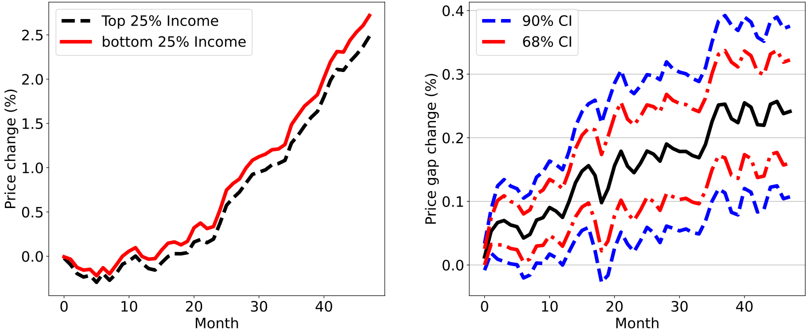
with sectoral level output deviation $\widehat{y}_t^s = \log \frac{y_t^s}{y_{ss}^s}$.

back

Expenditure channel: Inflation of the poor responds more

Local projection of income group inflation on Romer-Romer monetary shock: data construction

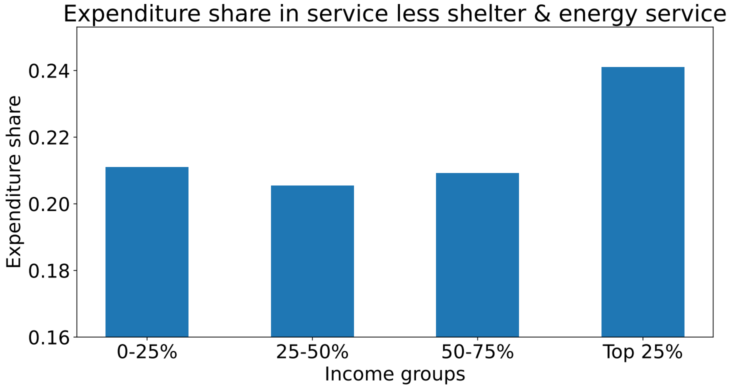
$$p^h_{t+s} - p^h_t = \alpha_s + \theta_s shock^{RR}_t + \sum_{j=1}^{J} \beta_{s,j} \left(p^h_{t-j} - p^h_{t-j-1} \right) + \sum_{i=1}^{I} \gamma_{s,i} shock^{RR}_{t-i} + \epsilon_{t+s},$$



(a) IRFs by income group **(b)** Gap between bottom vs top 25%

Expenditure channel: high-income groups consume more rigid products

- Nakamura-Steinsson (2008): average price adjustment frequency for service less shelter and energy service: 15.6, average for other categories: 29.7. calibration
- Other categories: durable goods, non-durable goods, energy services, shelter.



Earnings channel: heterogeneous earning response

Estimate income group level earnings growth elasticity with "Real-Time Inequality" (Blanchet, Saez and Zucman, 2022) monthly data from 1977 to 2022:

$$\Delta y_{q,t} = \alpha_q + \beta_q \Delta X_t + \epsilon_{q,t}$$

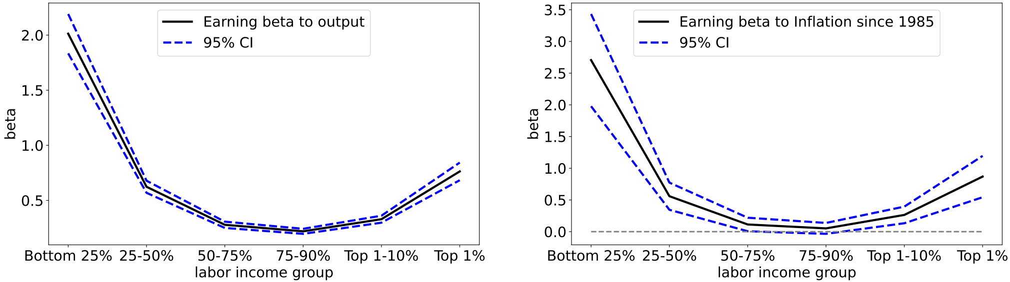


Figure 4: Elasticity of individual earning to aggregate output & inflation, by income group.

results with Guvenen et al annual data

calibration

Welfare approximation with nonlinear transition dynamics

- For given Taylor rule Φ, with decaying aggregate shock path $\{\mathcal{E}_t\} = \{\xi_0, \rho\xi_0, \rho^2\xi_0, ..., 0\}$ hitting steady state, solve nonlinear dynamics $\{c_{h,t}, \ell_{h,t}\}$, calculate $\Omega(\Phi, \{\mathcal{E}_t\})$.
- Do this for many $\mathcal{E}_t$, and evaluate $\mathbb{E}_{\{\mathcal{E}_t\}}\Omega(\Phi, \{\mathcal{E}_t\})$.
- Previous work: 1st-order linearized equilm to approx welfare, only work at efficient steady state $\Rightarrow$ reverse engineer Pareto weight s.t. ss is efficient $\Rightarrow$ higher weight on the rich.
- By solving nonlinear transition dynamics, my approach allows for arbitrary Pareto weights. back

Expenditure channel: household expenditure and CPI

- 1997-2021 CEX data (interview & diary) on income & expenditure: construct expenditure shares at income percentiles.
- 1969-2021 BLS data on prices at item level: construct CPI at income level.
- Törnqvist approach: use concurrent expenditure weight. details

back

Construction of income group CPI

Consumer price index for household at percentile h at time t:

$$\log \frac{PIX_t^h}{PIX_v^h} = \cdot \sum_{j \in J} \left(\omega_{j,\beta}^h \times \log \frac{P_{j,t}}{P_{j,v}} \right)$$

β: reference period of expenditure share $\omega_{j,\beta}^h$. $P_{j,t}$: price of item j at time t. v: pivot period.

- BLS and Cravino et al. (2020): use expenditure share two years ago. $\beta \approx t - 2$ years.
- Törnqvist approach: $\omega_{j,\beta}^h = \frac{1}{2}(\omega_{j,t-1}^h + \omega_{j,t}^h)$, and $v = t - 1$.

Adjustment on homeowners' equivalent rent of primary residence:

- BLS and Cravino et al. (2020): impute it as an expenditure class of homeowners. (large share of rich people)
- My approach: test both impute and not impute. back

Long run facts of inflation inequality

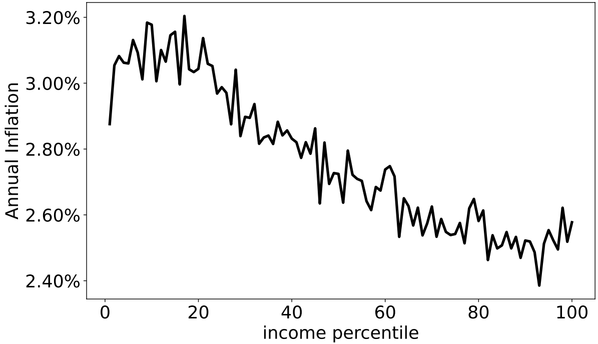


Figure 5: Average annual inflation by income group: 1997-2021

In the long run, inflation is monotone decreasing with income percentile. back

Earnings channel: left and right tail are more elastic

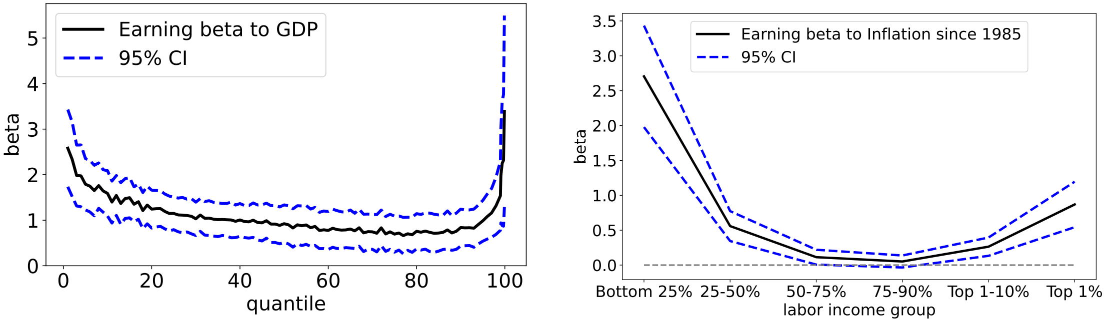


Figure 6: Elasticity of individual earning to GDP and Inflation by income percentile.

Left: SSA data (Guvenen et al., 2014), right: real-time inequality data (Blanchet, Saez and Zucman, 2022). Earning growth very elastic to aggregate economic condition at bottom and very top (0.5%) income percentiles, while insensitive in the middle income. back

estimates with real time inequality data | Elasticity to inflation and aggregate earning | back

Earnings channel: heterogeneous earning response

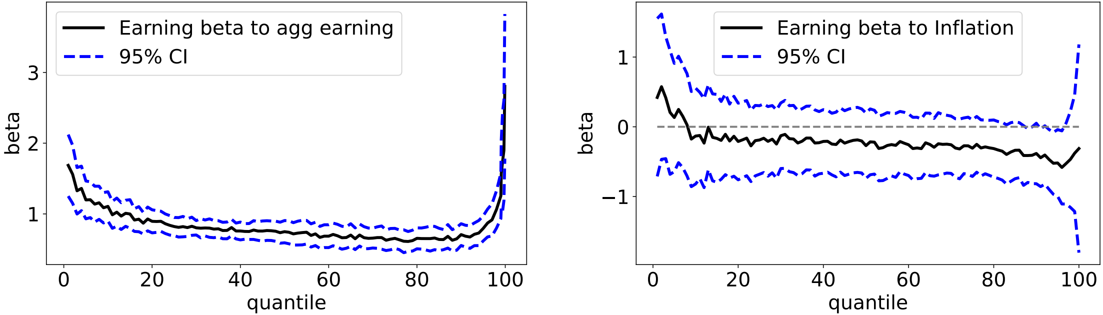


Figure 7: Elasticity of individual earning to aggregate earning & inflation, by income group (SSA data).

back

Earnings channel: heterogeneous earning response

Estimate income group level earnings growth elasticity with monthly "Real-Time Inequality" (Blanchet, Saez and Zucman, 2022) data from 1977 to 2022: back

$$\Delta y_{q,t} = \alpha_q + \beta_q \Delta X_t + \epsilon_{q,t}$$

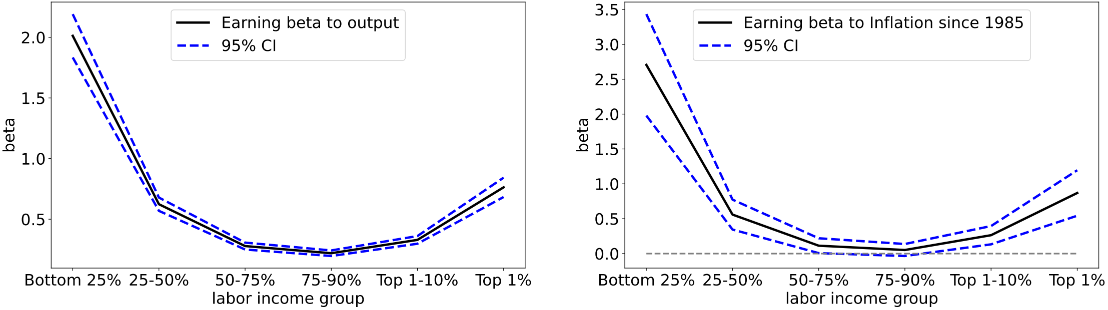


Figure 8: Elasticity of individual earning to aggregate earning & inflation, by income group.

Revaluation channel: income poor are net nominal borrowers

Average NNP in 1000$ for each group:

Income groups	bottom 20%	middle class	top 10%
Short-term	7.9	32.8	346.7
Bonds	9.4	45.1	589.9
Mortgages	-17	-91.4	-341.8
equity	-1.7	1.1	-70.1
Total NNP	-1.3	-12.4	524.7

Data: 2019 SCF, Financial Accounts. calibration

Calibration Details back

Parameter	Interpretation	Value	Target
Households			
β	Discount factor	0.982	$r^* = 0.5\%$
φ	Disutility of labor	0.786	$N = 1$
γ	Inverse IES	1	log utility for welfare gain decomposition
ψ	Inverse Frisch	2	
$\underline{b}$	Borrowing constraint	-1	Quarterly labor income
Markov chain for $\xi_{h,t}$	Idiosyncratic shock process	see text	
Firms			
μ	Steady-state markup	1.2	
Z	Steady-state TFP	1	
Gov't policy			
B	Bond supply	5.6	Liquid assets/GDP
τ	Labor tax rate	0.3	
T	Lump-sum transfer to HH at ss	0.27	Balance gov't budget
G	Government spending	0	
ϕ_π^+, ϕ_π^-	Baseline Taylor rule coefficients	1.5	
ϕ_y	Baseline Taylor rule coefficient	0	
Discretization			
n_e	Points in Markov chain for e	4	3 + 1 superstar state
n_a	Points on asset grid	200	

Redistributive channels of inflation and households budget constraint

$$c_{h,t} + b_{h,t+1} = b_{h,t}\frac{1+i_t}{1+\pi_t} + (1-\tau)w_t e_{h,t}\ell_{h,t} + T_t + d_t(\xi_{h,t}).$$

- Expenditure channel
- Revaluation (Fisher) channel
- Earnings channel
- Additional effects through fiscal policy back

Welfare change with ϕ_y

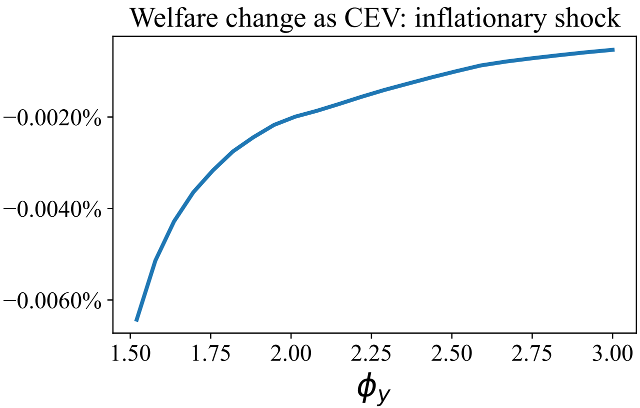


Figure 9: Welfare change with ϕ_y as consumption equivalent variation (CEV) to steady state

back

Optimal monetary policy in HANK with smaller inflation cost $\chi = 0$

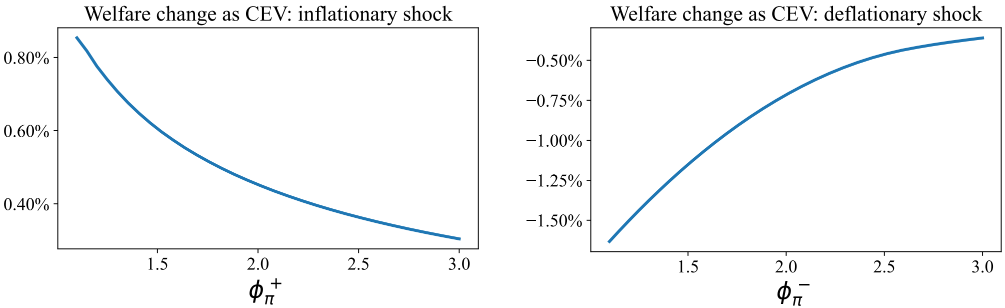


Figure 10: Welfare change with ϕ_π^+, ϕ_π^- as consumption equivalent variation (CEV) to steady state

$\phi_\pi^{+,*} = 1.1, \phi_\pi^{-,*} = 3$: accommodative to inflation/expansion, but aggressive to deflation.

back

Optimal monetary policy in HANK with large inflation cost $\chi = 1000$

$\chi = 1000$: very large social cost of inflation. Price stability as the top priority, such as ECB.

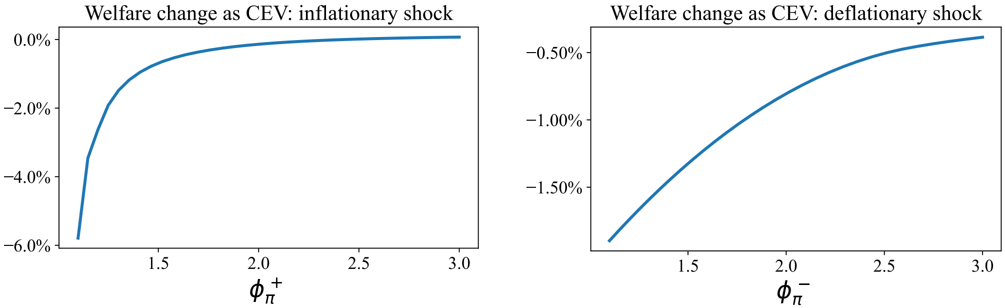


Figure 11: Welfare change with ϕ_π^+, ϕ_π^- as consumption equivalent variation (CEV) to steady state

back

Optimal monetary policy in HANK with McKay-Wolf Pareto weight

McKay and Wolf (2022): pick Pareto weights that makes DSS efficient - higher weight on the rich.

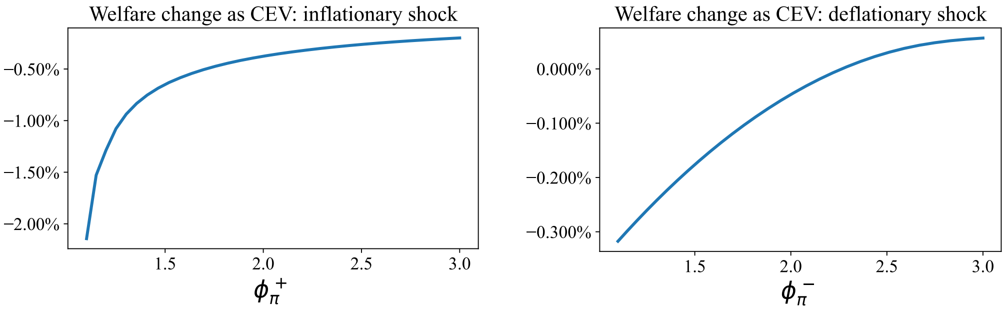


Figure 12: Welfare change with ϕ_π^+, ϕ_π^- as consumption equivalent variation (CEV) to steady state

back

Optimal monetary policy in HANK with revaluation channel

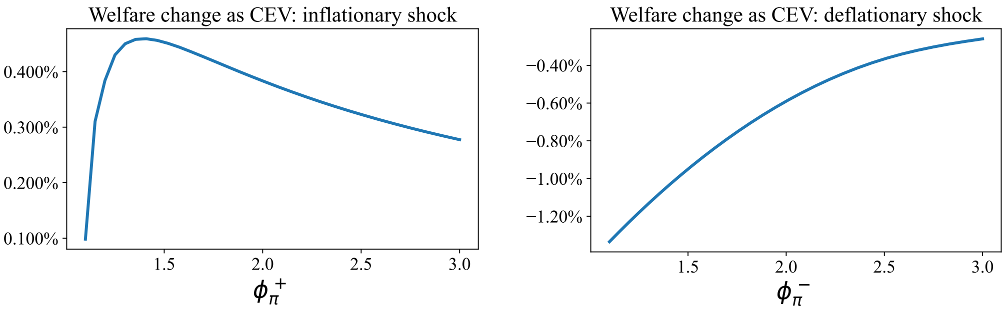


Figure 13: Welfare change with ϕ_π^+, ϕ_π^- as consumption equivalent variation (CEV) to steady state

$\phi_\pi^{+,*} = 1.41, \phi_\pi^{-,*} = 3$: accommodative to inflation/expansion, but aggressive to deflation.

back

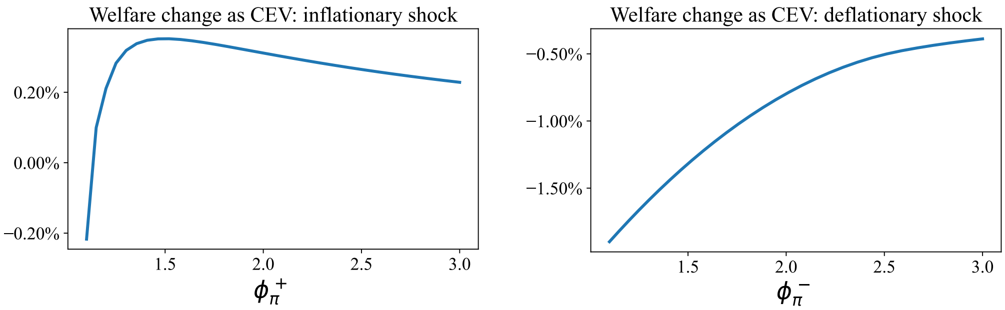


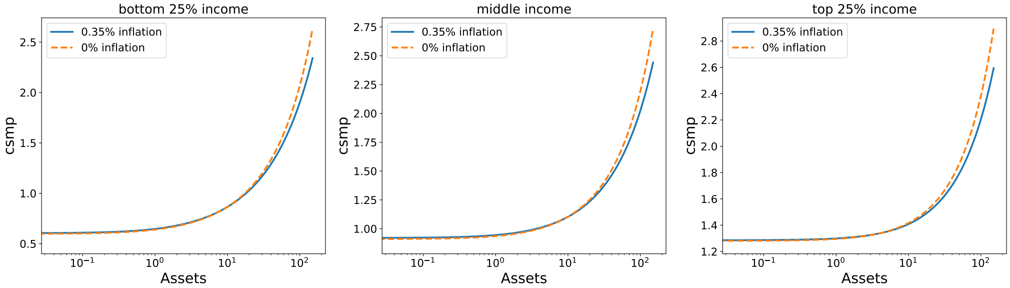
Figure 14: Welfare change with ϕ_π^+, ϕ_π^- as consumption equivalent variation (CEV) to steady state

$\phi_\pi^{+,*} = 1.52, \phi_\pi^{-,*} = 3$: accommodative to inflation/expansion, but aggressive to deflation.

back

Average inflation and time inconsistency

- Optimal policy rule in full model is asymmetric: $\phi_\pi^{+,*} = 1.821, \phi_\pi^{-,*} = 3$. Accommodative to inflation, but aggressive to deflation.
- This implies positive average inflation bias in stochastic steady state $\overline{\pi} = 0.35\%$.
- If households rationally expect $\overline{\pi}$ at the steady state, their decision choice does not change much from the deterministic steady state with $\overline{\pi} = 0$. back



Benabou-Floden welfare gain decomposition: details

We decompose welfare gain Δ due to consumption and labor supply difference:

$$\int \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^H(b,\xi), \ell_t^H(b,\xi), 0) d\lambda_0 = \int \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u((1+\Delta) c_t^R(b,\xi), \ell_t^R(b,\xi), 0) d\lambda_0,$$

λ_0: initial distribution over (b,e).Δ can be decomposed into three components.

1. **Efficiency gain.** Under policy $j \in \{H,R\}$, let the aggregate level of c_t and ℓ_t at each t be

$$C_t^j \equiv \int c_t^j(b,\xi) d\lambda_t^j(b,\xi), \qquad L_t^j \equiv \int \ell_t^j(b,\xi) d\lambda_t^j(b,\xi),$$

where $\lambda_t^j(b,\xi)$ is the distribution over (b,ξ). The efficiency gain, Δ_E, is then given by

$$\sum_{t=0}^{\infty} \beta^t u\left((1+\Delta_E) C_t^R, L_t^R, 0\right) = \sum_{t=0}^{\infty} \beta^t u\left(C_t^H, L_t^H, 0\right).$$

back

Benabou-Floden welfare gain decomposition: details

2. Insurance effect. Average welfare increases if, conditional on a household's initial asset and productivity state, the riskiness of its future consumption and labor paths is reduced.

Let $\left\{\bar{c}_t^j\left(b_0, \xi_0\right), \bar{\ell}_t^j\left(b_0, \xi_0\right)\right\}_{t=0}^{\infty}$ denote a certainty-equivalent sequence of consumption and labor conditional on a household's initial state that satisfies

$$\sum_{t=0}^{\infty} \beta^t u\left(\bar{c}_t^j\left(b_0, \xi_0\right), \bar{\ell}_t^j\left(b_0, \xi_0\right), 0\right) = \mathbb{E}_0\left[\sum_{t=0}^{\infty} \beta^t u\left(c_t^j, \ell_t^j, 0\right)\right].$$

$$\text{Let } \bar{C}_t^j = \int \bar{c}_t^j\left(b_0, \xi_0\right) d\lambda_0, \quad \text{and} \quad \bar{L}_t^j = \int \bar{\ell}_t^j\left(b_0, \xi_0\right) d\lambda_0, \quad \text{for } j \in \{H, R\}.$$

The insurance effect, Δ_I, is defined by

$$1 + \Delta_I \equiv \frac{1 - p_{risk}^H}{1 - p_{risk}^R}, \quad \text{where } \sum_{t=0}^{\infty} \beta^t u\left(\left(1 - p_{risk}^j\right) C_t^j, L_t^j, 0\right) = \sum_{t=0}^{\infty} \beta^t u\left(\bar{C}_t^j, \bar{L}_t^j, 0\right).$$

Here p_{risk}^j is the welfare cost of risk under policy regime $j \in \{H, R\}$. back

Benabou-Floden welfare gain decomposition: details

3. Redistribution effect. Utilitarian welfare also increases if inequality across households with different initial states (b_0, ξ_0) is reduced. The redistribution effect, Δ_R is defined as

$$1+\Delta_R \equiv \frac{1-p^H_{\text{ineq}}}{1-p^R_{\text{ineq}}}, \text{where} \sum_{t=0}^{\infty} \beta^t u\left(\left(1-p^j_{\text{ineq}}\right)\bar{C}^j_t, \bar{L}^j_t, 0\right) = \int \sum_{t=0}^{\infty} \beta^t u\left(\bar{c}^j_t\left(b_0,\xi_0\right), \bar{\ell}^j_t\left(b_0,\xi_0\right), 0\right.$$

Here p^j_{ineq} denotes the welfare cost of inequality under policy regime j.

Proposition: For balanced-growth-path preferences, the components defined above satisfy the following relationship:

$$1+\Delta = \left(1+\Delta_E\right)\left(1+\Delta_I\right)\left(1+\Delta_R\right).$$

back