Transfer Payments, Sacrifice Ratios, and Inflation in an Active-Fiscal HANK

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June 13, 2024

Fiscal and Monetary Policy, Output, and Inflation

If the government

1. Send transfers to households
2. Issues debt
3. Does not raise future taxes to pay down debt

Trade-off between output and inflation?

- Does it matter who receives transfers?

A model for answering these questions

This paper:

- Canonical heterogeneous agent New Keynesian model (HANK)
  - Uninsurable income risk, incomplete markets
  - Endogenous savings, consumption
  - Nominal rigidities (sticky wages)
  - Long-term nominal gov. bonds
- "Active"/"passive" fiscal and monetary policy
  - Depends on choice of policy parameters
- Shocks come from policy
  - Fiscal Transfers:
    - To all households
    - To only below-median income
    - To only above-median income
- Linearized sequence space solutions
  - Auclert, Bardóczy, et al. (2021)

In this paper...

- Does it matter for this trade-off who receives the checks?
  - **NO for inflation**, **YES for output**
  - High MPC agents receive transfers → output boom is larger
    - But price level rises by similar amount regardless of targeting
  - **Lower** sacrifice ratios when net transfers to the rich are cut, relative to the poor
- If mon pol is passive, doesn't quantitatively matter if fiscal policy is
  - active
  - passive via very slow auto fiscal adjustments

Using Leeper (1991) terminology

- Consider government debt equation:

$$\frac{d(\tilde{B}_t/p_t)}{dt} = -T_t + r_t \frac{\tilde{B}_t}{p_t} \tag{1}$$

  - $B_t \equiv \tilde{B}_t/P_t$: Real value of government debt
    - $\tilde{B}_t$: Value of nominal government liabilities
    - p_t: The price level
  - $r_t \equiv i_t - \pi_t$: Real interest rate
    - i_t: Nominal interest rate
    - $\pi_t \equiv$: Rate of inflation
  - T_t: Taxes net of transfers, where

$$T_t = \text{Exog. Taxes}_t + \kappa \times (B_t - B_{NSS})$$

    - B_{NSS}: Real debt in the the non-stochastic steady state (NSS)
    - $\kappa >> r_{NSS} \Rightarrow$ **Passive Fiscal**
    - $\kappa = 0 \Rightarrow$ **Active Fiscal**

A Heterogeneous Agent New Keynesian Model

HANK Model overview:

- Households: incomplete markets, heterogeneous agents
  - hold gov bonds as assets ($r = 0.005$ quarterly)
  - income risk calibrated as in McKay, Nakamura, and Steinsson (2016)
  - borrowing constraint (assets ≥ 0)
- Federal government
  - collects income taxes proportional to household labor income
  - Issues nominal long-term bonds
    - can be inflated away
  - Transfers shocks direct 1% of annual steady-state GDP to households (targeted or not)
  - Passive Fiscal: $\kappa = 0.01$, Active Fiscal: $\kappa = 0$
- Central Bank: $i_t = r + \phi_\pi \pi_t$
  - Passive $\phi_\pi = 0$, Active $\phi_\pi = 1.05$
- Decentralized unions and nominal wage rigidities as in Auclert, Rognlie, and Straub (2023b)
  - Competitive final goods sector: wage π = price π
- All production through labor, $Y_t = L_t$

!∃?

- When is does the HANK model have a determinate equilibrium?

	Active Fiscal	Passive Fiscal
Active Monetary	**No Eqm.**	**Standard NK**
Passive Monetary	**Determinate**	**Determinate**

- Model is determinate in all scenarios *except when both policies are active*
  - See Hagedorn (2023) for details
  - **Can separate implications of active monetary vs passive fiscal**
- Test the model's determinacy 3 different ways
  - Onatski (2006) criterion methods
    - Hagedorn (2023)
    - Auclert, Rognlie, and Straub (2023a)
  - State-space version
    - Bayer and Luetticke (2020)

Metrics for Assessing Output and Inflation

- Cumulative quarterly output gaps (as percent of steady-state) as of time t:

$$\mathcal{C}Y_t = \frac{1}{Y_{NSS}} \int_0^t (Y_\tau - Y_{NSS}) d\tau$$

  - As a percent of annual GDP: $\mathcal{C}Y_t/4$

- Cumulative inflation (change in the price level) up until time t:

$$1 + \mathcal{C}\pi_t = \exp\left(\int_0^t \pi_\tau d\tau\right)$$

- Sacrifice Ratio: $(\mathcal{C}Y_t/4)/\mathcal{C}\pi_t$

Numerical Simulations: Active Fiscal/Passive Monetary

	Transfers to **All**		Transfers to **Low-Income**		Transfers to **High-Income**	
	1 yr	50 qtrs	1 yr	50 qtrs	1 yr	50 qtrs
$\mathcal{C}Y_t/4$	0.66%	0.59%	0.90%	0.73%	0.43%	0.46%
$\mathcal{C}\pi_t$	1.58%	1.47%	1.85%	1.40%	1.34%	1.54%
Sac. Ratio	0.42	0.40	0.49	0.52	0.32	0.30

Table: Cumulative Output, Inflation, and Sacrifice Ratios for Active Fiscal Transfers

- $\mathcal{C}Y_t/4$ essentially fiscal transfer multiplier
- Transfers to high-MPC low income vs low-MPC high income:
  - Substantially more output (59%), slightly *less* inflation (9%)
- Sacrifice ratios much smaller for high-income transfers

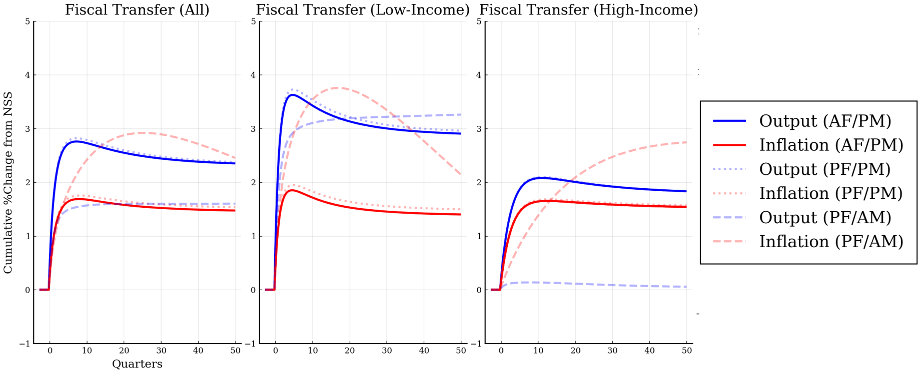
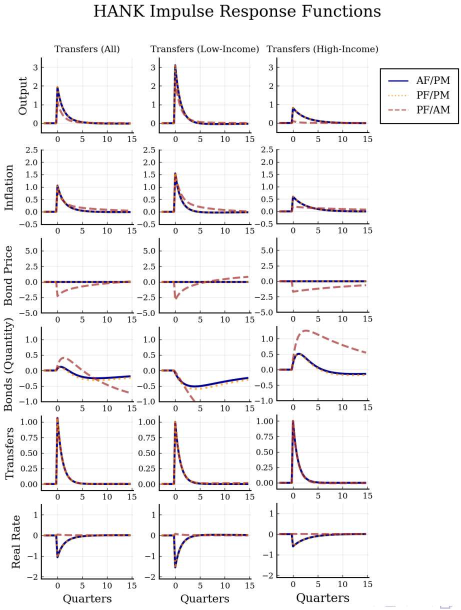


Figure: Cumulative Impulse Response Functions ($\mathcal{C}Y_t$, $\mathcal{C}\pi_t$)

- Passive fiscal/passive monetary IRFs very similar to active fiscal/passive monetary ones

Impulse Response Functions



Decomposition of Output Impulse Responses

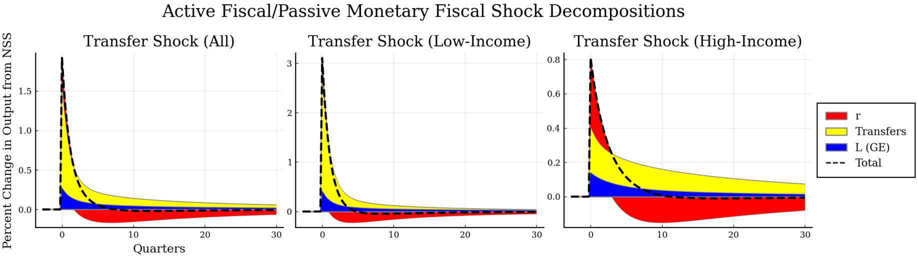


Figure: Decomposition of output IRF to transfers

- Mostly direct effect of the transfers
- Transfers to low-MPC: indirect effects more of smaller response

Intuition

PV of Inflation = PV of Deficits

- Solve forward $\frac{d(\tilde{B}_t/p_t)}{dt} = -T_t + r_t \frac{\tilde{B}_t}{p_t}$
- Say $\kappa = 0$ and $i_t = \text{const.}$ (active fiscal, passive monetary)
- Price level, real debt cannot jump on impact
  - Inflation stabilizes debt, assets
- Shock to $(T_s)_{s \geq t}$ at time t
- First-order linearization:

$$\mathbb{E}_t \int_t^\infty e^{-(s-t)r} \pi_s ds = -\mathbb{E}_t \left[\frac{T_{NSS}}{B_{NSS}} \int_t^\infty e^{-(s-t)r} \widehat{T}_s ds \right] \tag{2}$$

  - Het. only affects timing of inflation
    - If r small, timing barely matters
  - Present value of deficits as pct of debt = overall rise in price level

What about the Phillips Curve?

- Common "Sacrifice Ratio" Intuition
  - Cumulative $\%\Delta$ in annual GDP output gap per percentage point of inflation abatement
  - Constant relationship, static model
  - Tight link between ratio and inverse slope of the Phillips Curve
  - See Ball (1994) for survey of estimates
    - Large variance
- **However** the New Keynesian Phillips Curve (NKPC) is more subtle

$$\rho\pi_t = \frac{\mathbb{E}[d\pi_t]}{dt} + \nu\widehat{Y}_t$$

  - Integrate twice:

$$\int_t^\infty \pi_s ds = \nu \int_t^\infty (s-t)e^{-\rho(s-t)}\widehat{Y}_s ds$$

  - Sacrifice ratio is inversely related to the slope of the Phillips curve ν
  - But also positively related to the speed with which output gaps accumulate!
    - Firms are forward looking and take time to adjust prices
    - Fall behind the curve of fast-moving output expansions

Conclusions

- Fiscal transfers: household heterogeneity matters a lot for output
- But with active fiscal policy, it appears to matter less for inflation
  - Nominal assets are nominal anchor
  - Hagedorn (2024): "Sufficient statistic" to describe inflation
- See my paper online for more, including monetary policy experiments!
  - noahkwicklis.com/research
- Future work: My model assumes iMPCs integrate in NPV to 1
  - Eventually agents want to spend down assets
  - But other models make other assumptions
    - Auclert, Rognlie, and Straub (2023b): "Trickling up of excess savings"
    - Some households with MPC of 0
- Future work: Benefits of surprise?
  - Forward guidance maybe bad idea for fiscal stimulus

Appendix

Sequential household's problem

$$
\begin{aligned}
V_t(a_0, z_0) = \max_{\{c_t\}_{t\geq 0}} \mathbb{E}_0 \int_0^\infty e^{-\rho t} \left[\frac{c_t^{1-\gamma}}{1-\gamma} - \frac{h_t(a,z)^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} \right] dt \\
\text{s.t. } \frac{q_t}{q_{NSS}} \frac{da_t}{dt} + \frac{dq_t}{dt} \frac{1}{q_{NSS}} a_t = (1-\tau) w_t z_t h_t(a,z) + r_t \frac{q_t}{q_{NSS}} a_t + M_t(z_t; \zeta_t) - c_t \\
d\log(z_t) = -\theta_z \log(z_t) dt + \sigma_z dW_{t,z} \\
a_t \geq 0.
\end{aligned}
\tag{3}
$$

Recursive household's problem

- Hamilton-Jacobi-Bellman equation (HJB):

$$\rho V_t(a,z) = \max_c \Bigg\{ \left[\frac{c^{1-\gamma}}{1-\gamma} - \frac{h_t(a,z)^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} \right] + \frac{\partial V_t}{\partial a}(a,z)\frac{q_{NSS}}{q_t}\left[(1-\tau)w_t z h_t(a,z) + M_t(z_t;\zeta_t) - c + \left(r_t - \frac{dq_t}{dt}\frac{1}{q_t}\right)\frac{q_t}{q_{NSS}}a\right] + \frac{\partial V_t}{\partial z}(a,z) z\left[\frac{1}{2}\sigma_z^2 - \theta_z \log(z)\right] + \frac{\partial^2 V_t}{\partial z^2}(a,z)\frac{1}{2}\sigma_z^2 z^2 + \frac{\partial V_t}{\partial t}(a,z)\Bigg\}. \tag{4}$$

Distribution of households

- Standard Kolmogorov Forward Equation (KFE)

$$\frac{\partial \mu_t}{\partial t}(a,z) = -\frac{\partial}{\partial a}\left(\frac{da_t}{dt}\mu_t(a,z)\right) - \frac{\partial}{\partial z}\left(\frac{\mathbb{E}_t[dz_t]}{dt}\mu_t(a,z)\right) + \frac{1}{2}\frac{\partial^2}{\partial z^2}\left(\sigma^2 z^2 \mu_t(a,z)\right) \tag{5}$$

- "Free" to compute in continuous time
  - Maximized HJB infinitessimal generator (expresses how optimal value function is expected to change over time) is the L^2 adjoint of the KFE operator $\mathcal{D}^*$, where $\partial_t \mu = \mathcal{D}^* \mu$

Active Fiscal Policy in HANK

- Taxes and transfers free to follow whatever scheme policymakers set
  - In this model, balance budget in the steady-state

$$T_{nss} + \tau w_{nss} L_{nss} = r_{nss} B_{nss}$$

  - Outside of the steady state, set

$$T_t(\zeta_t) = \int_0^\infty \int_{\underline{a}}^\infty T_t(a, z; \zeta_t) \mu_t(a, z) da\ dz + \tau w_t L_t + \kappa(B_t - B_{nss})$$

    where

$$T_t(a, z; \zeta_t) = T_{nss} + 4Y_{nss} \times \Big(T_t^{\text{All}}(a, z; \zeta_t^{\text{All}}) + T_t^{\text{High}}(a, z; \zeta_t^{\text{High}}) + T_t^{\text{Low}}(a, z; \zeta_t^{\text{Low}}) + T_t^{\text{BB}}(a, z; \zeta_t^{\text{BB}}) \Big)$$

  - $\kappa = 0 \;\Rightarrow\;$ *active* fiscal policy
    - baseline specification
    - inflation stabilizes real debt, assets
  - $\kappa >> r_{nss} \;\Rightarrow\;$ *passive* fiscal policy
    - Model becomes more "traditional" HANK if $\phi_\pi >> 1$

Three different fiscal policy shocks

- $\zeta_t < 0 \;\Rightarrow\;$ mean-reverting stimulus checks
- Stimulus checks for everybody

$$T_t^{\text{All}}(a, z; \zeta_t^{\text{All}}) = \zeta_t^{\text{All}}$$

- Stimulus checks only for high-earners (cutoff $\bar{z}$, $\int_{\underline{z}}^{\bar{z}} \mu_{nss}(z)dz = 0.5$)

$$T_t^{\text{High}}(a, z; \zeta_t^{\text{High}}) = \mathbf{1}_{\{z \geq \bar{z}\}} \zeta_t^{\text{High}}$$

- Stimulus checks only for low-earners

$$T_t^{\text{Low}}(a, z; \zeta_t^{\text{Low}}) = \mathbf{1}_{\{z < \bar{z}\}} \zeta_t^{\text{Low}}$$

Interpretation and persistence

- Set mean reversion of fiscal shocks to 1
- After starting at some ζ_0^{Tax}, shocks follow

$$\zeta_t^{\text{Tax}} = e^{-t}\zeta_0^{\text{Tax}}$$

Integrate to see

$$\int_0^\infty e^{-t}\zeta_0^{\text{Tax}} = \zeta_0^{\text{Tax}}$$

- A 1% jump in ζ_0^{Tax} is an announcement of a plan to spend 1% of annual GDP, almost entirely in the current year
  - Half life of 0.7 quarters
  - Getting money out of the door *fast*

Government debt

- Similar structure to Cochrane (2018)
- Government issues long-term nominal debt $\tilde{B}_t$
- Nominal price q_t
- Borrows at nominal rate i_t
  - (Ex-ante expected real rate $r_t = i_t - \pi_t$, with π_t being inflation)
- Pays geometrically declining nominal coupon payment $\omega e^{-\omega t}$ in each time increment
  - ω determines the maturity of government debt
  - $\omega \to 0$: perpetuity
  - $\omega \to \infty$: instantaneously rolled over
- Intuition:
  - Government debt issued to have an exponential maturity structure
  - Competitive mutual fund sector purchases debt, maximizes the present discounted value of expected profits
  - Households own shares of the mutual fund

Government debt equations

- Like households' assets, government debt is also affected by ex-ante revaluations

$$dB_t = -(T_t - G_t)dt + B_t\left[i_t - \pi_t\right]dt + d\delta_{q,t}B_t \tag{6}$$

  - $B_t \equiv \frac{q_t \tilde{B}}{p_t}$ is the real value of government debt
  - G_t are government expenditures (=0)
  - T_t are total net taxes and transfers
- Nominal bond prices evolve according to

$$\mathbb{E}_t[dq_t] = q_t\left(i_t + \omega - \frac{\omega}{q_t}\right)dt \tag{7}$$

- Unanticipated (time-0) jumps in bond prices are then

$$d\delta_{q,t} \equiv \frac{dq_t - \mathbb{E}[dq_t]}{q_t}$$

- Notice: nominal bond prices only affected by the nominal interest rate, and $d\delta_{q,t}$ by its unexpected movements
  - Ex: If $i = 10\%$ and a zero-coupon bond pays off a face value of \$100 next quarter, then $q = \$10$. If i rises to 20%, $dq = -50\%$.

Market clearing (HANK)

- Wage Phillips curve becomes

$$\frac{\mathbb{E}_t[d\pi_t^w]}{dt} = \rho\pi_t^w - \frac{\varepsilon_\ell}{\theta_w} L_t \int\int \left(\frac{1}{Z} h_t(a,z)^{\frac{1}{\eta}} - \frac{\varepsilon_\ell - 1}{\varepsilon_\ell}(1-\tau) z w_t c_t(a,z)^{-\gamma} \right) da\ dz \quad (8)$$

- Total output

$$Y_t = L_t \quad (9)$$

- Goods market

$$Y_t = C_t \equiv s \int_0^\infty \int_{\underline{a}}^\infty c_t(a,z)\mu_t(a,z) da\ dz$$

- Total assets A_t is equal to the total amount of government debt

$$A_t = \int_0^\infty \int_{\underline{a}}^\infty a\mu_t(a,z) da\ dz$$
$$A_t = B_t \quad (10)$$

The Non-Stochastic Steady-State ($\zeta_t = 0$)

Calibrating the income process

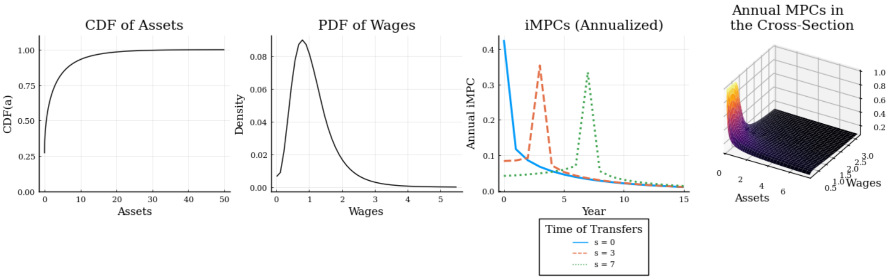
- Kept largely as in McKay, Nakamura, and Steinsson (2016)
- Simulated method of moments:
  - Select mean-reversion and variance parameters (θ_z, σ_z)
  - Draw a set of Brownian innovations to get panel of log-Ornstein-Uhlenbeck idiosyncratic productivities
  - Integrate to the annual frequency to get annual "wages"
  - Regress
    $$\text{wage}_{it}^{\text{Annual}} = \beta_0 + \beta_1 \text{wage}_{it-1}^{\text{Annual}} + \epsilon_{it}$$
  - Fit empirical Floden and Lindé (2001) estimates of residualized wage autocorrelation and dispersion $\beta_1 = 0.9136$ and $\text{var}(\epsilon_{it}) = 0.0426$
- Probably understates kurtosis of actual earnings, employment/unemployment transitions
  - Very important for the counter-cyclicality of income risk (re: Acharya and Dogra (2020))
  - But I leave this out for now

Calibrated Parameters

Table: General HANK Model Parameters

Parameter	Symbol	Value	Source or Target
Households			
Internally Calibrated:			
Quarterly Time Discounting	ρ	0.021	$r = 2\%$ Annually
Idiosyncratic Income Shock Variance	σ_z^2	0.017	Floden and Lindé (2001)
Idiosyncratic Shock Mean Reversion	θ_z	0.034	Floden and Lindé (2001)
Assumed from Literature:			
Relative Risk Aversion	γ	2.0	McKay et al (2016)
Frisch Elasticity of Labor	η	0.5	Chetty (2012)
Labor Market			
Labor Elasticity of Substitution	ε_L	10	Philips Curve slope of 0.07
Rotemberg wage adjustment cost	θ_w	100	Philips Curve slope of 0.07
Government			
Steady-state government debt	B_{NSS}	2.63	HANK $iMPC_0 \approx 0.40$
Geometric maturity structure of debt	ω	0.043	Avg. maturity of 70 months
Income Tax Rate	τ	0.25	
Shocks			
Mean reversion of fiscal shocks	θ_{Tax}	1.0	
Mean reversion of fiscal shocks	θ_{MP}	0.175	Half life of 4 quarters

Distribution of Assets, Income, iMPCs and MPCs



Steady-state moments

Table: HANK Non-Stochastic Steady-State Statistics

Description	Symbol	Value
Contemporaneous iMPC (Annual)		0.43
Debt to Annual Income	$B_{NSS}/(4Y_{NSS})$	0.67
Correlation btw. Income and Assets	$\mathrm{Corr}(a, z)$	0.56
Share of households with $a = 0$	$\int \mu_{NSS}(0, z)dz$	0.27
Asset Gini Coefficient		0.75
Income Gini Coefficient		0.31

- 27.6% of agents with zero wealth
- Half of the assets of my previous calibration
  - Auclert, Rognlie, and Straub (2018) shock-contemporaneous MPC of 0.5
  - Empirical MPC estimated by Fagereng, Holm, and Natvik (2021)

Robustness Exercises

Varying the Slope of the Phillips Curve (AF/PM)

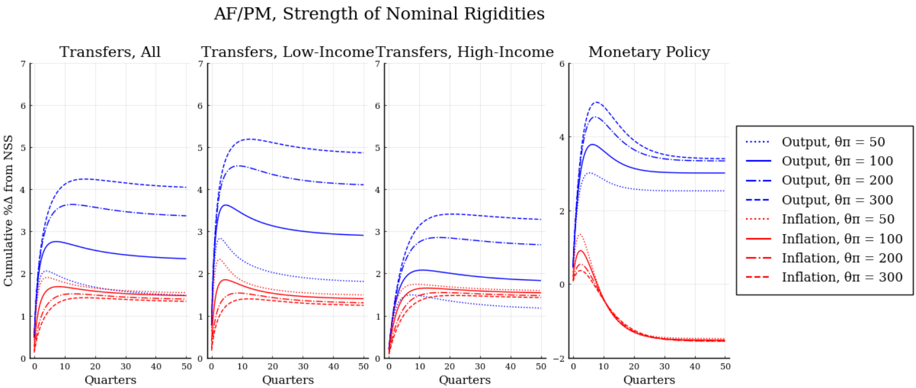


Figure: Cumulative IRFs by Strength of Nominal Rigidities

Varying the Slope of the Phillips Curve (AF/PM)

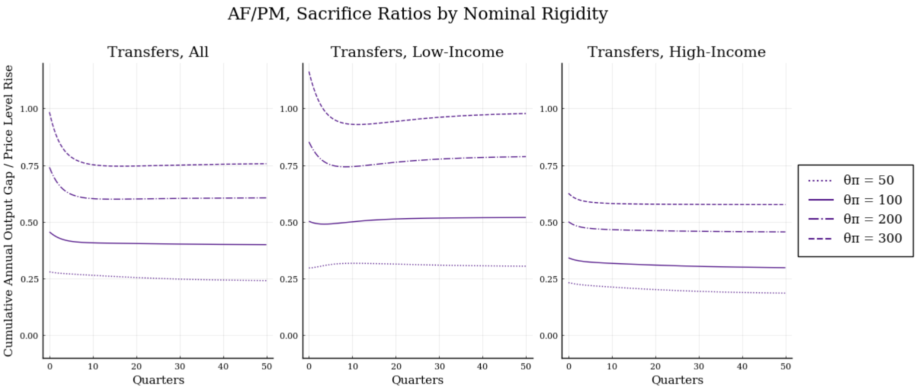
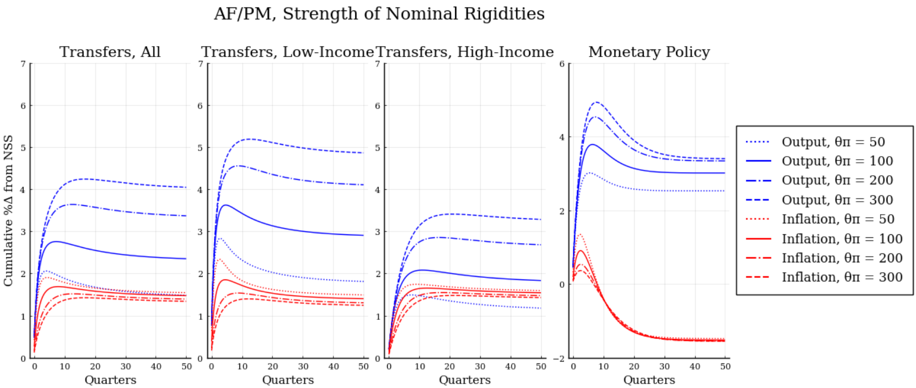


Figure: Sacrifice Ratios by Strength of Nominal Rigidities

Varying the Slope of the Phillips Curve (PF/AM)



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