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FEDERAL RESERVE BANK *of* NEW YORK

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Abstract

We use an estimated medium-scale HANK model to investigate how the tradeoff between stabilizing inflation and consumption volatility varies for households with different levels of wealth. Consumption for the rich is mostly affected by demand shocks via their exposure to highly procyclical profits—for them, stabilizing consumption and inflation coincide. The poor are more vulnerable to supply shocks, hence aggressively stabilizing inflation is costly in terms of their consumption volatility. While they dislike inflation because it erodes real wages, they are hurt even more by an aggressive monetary policy response to inflation, which reduces real wages further while increasing unemployment.

JEL classification: E12, E31, E52, E58
Key words: inflation, inequality, monetary policy, HANK models

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1 Introduction

Monetary policymakers face a tradeoff between the variability of inflation and real activity: a single-minded pursuit of inflation stabilization may imply more volatile output and employment, and *vice versa*. However, both the experience of recent decades and the heterogeneous agent New Keynesian (HANK) literature developed over the same period make it clear that such tradeoffs may be very different for different households. The same shocks which give rise to aggregate fluctuations can have very different effects on the rich and the poor: an increase in firms' desired profit margins, for example, besides its effect on inflation, may increase profits for the richest households and reduce real wages for the poor and middle class. At the same time, monetary policy's response to these shocks also has distributional effects. In this paper, we use a medium scale HANK model to understand how the tradeoffs between inflation stabilization and other objectives differ for households at different points in the wealth distribution.

We begin by documenting the welfare effect of monetary policy shocks, measured in consumption equivalent terms, for households with different wealth levels. Consistent with the empirical findings of Holm et al. [2021], the effect of a contractionary policy shock have an inverse U-shape across the wealth distribution. Such a shock reduces welfare for the poor, who suffer from both the deterioration in the labor market and the higher interest rates on debt. Rich households benefit from higher interest rates, as they are net savers, but are hurt by the decline in profits, which are strongly procyclical in our model. Households in the middle of the distribution are not very much affected by the increase in rates as they own less wealth, but are in a better position than the poor hand-to-mouth to cushion themselves from the worsening of the labor market.

Next, we document the welfare effects of supply and demand shocks across the wealth distribution. A contractionary supply shock, modeled as an increase in firms' desired markups, has very uneven effects: the poor lose while the very rich benefit. Higher markups increase profits and depress real wages via their effect on activity; the decline in real wages is persistent, since nominal wages are sticky. This fall in real wages especially hurts poor hand-to-mouth households, as it translates almost one to one into a decline in consumption. At the same time, the falling labor costs translate into increases in corporate profits, and benefit the very rich who receive these profits. The Fisherian effect of surprise inflation (the fact that debt is worth less in real terms), which in principle goes in the opposite direction, is offset by the higher interest rates associated with the policy response to higher inflation.

In contrast, a contractionary demand shock, modeled as an increase in households' discount factor, decreases welfare for all households but primarily for the rich. The fall in demand reduces profits, which are highly procyclical in our model, and accrue overwhelmingly to the richest households.

Since households with different levels of wealth are affected very differently by supply and demand shocks, a more aggressive response of monetary policy to inflation affects them in very different ways. To examine this, we explore how varying ϕ_π, the coefficient on inflation in a Taylor-type interest rate rule, affects the volatility of both aggregate and distributional variables. A more aggressive response to inflation always reduces the volatility of inflation, but its effect on real activity depends crucially on whether the economy is experiencing demand or supply shocks. In response to supply shocks, a more aggressive response to inflation increases the volatility of unemployment, wages, and profits, as the central bank contracts income and employment. But in response to demand shocks, a more aggressive response to inflation *reduces* the volatility of consumption and output, as the central bank offsets the effect of these shocks, stabilizing both inflation and real activity.

After studying the distributional impact of various shocks, we use model simulations to assess their combined contribution to consumption volatility for households with different wealth levels, and how this volatility varies with the strength of the monetary policy response to inflation ϕ_π.[1] We find that while demand shocks explain the majority of aggregate fluctuations according to our estimated model, for the poor, supply shocks are almost as important. A contractionary supply shock harms the poor even under our baseline policy, substantially reducing real wages. A more aggressive monetary policy response to this shock only makes things worse, further reducing real wages and reducing the job finding rate. Thus, consumption volatility for the poorest is sharply increasing in ϕ_π. For the richest households, a more contractionary monetary response to a positive price markup shock reduces profits, but this does not make their consumption more volatile because these profits are already elevated following a positive price markup shock. Meanwhile, in response to deflationary demand shocks, a higher ϕ_π leads the central bank to *cut* rates more aggressively, stabilizing economic activity and profits. While all households benefit from a higher ϕ_π in response to demand shocks, this benefit is especially large for the richest households, who are more

[1] While we are able to compute a first-order approximation to the welfare effect of *specific* shocks, given the model's size, it is too computationally challenging to compute an accurate second-order approximation to welfare given a *distribution* of shocks. Doing so would require accurately approximating the model's dynamics up to second order, which is technically difficult in HANK models [Bhandari et al., 2023].

exposed to these shocks owing to their disproportionate share of profits.

In the New Keynesian literature, the tradeoffs faced by a monetary policymaker are often summarized in 'frontier curves' which show the combinations of output and inflation volatility that can be implemented by some interest rate rule [Taylor, 1979, Fuhrer, 1997, Levin et al., 1999]. In our model, the tradeoffs differ markedly for households at different points in the wealth distribution (specifically, we focus on the bottom 10 percent, middle quintile, and top 10 percent of the distribution). We summarize these different tradeoffs by plotting consumption volatility for each group households against the volatility of aggregate inflation. For poor households, the curve is sharply decreasing, for the reasons described above: a more aggressive response to inflation is extremely costly in terms of consumption volatility. The same tradeoff is present for the middle class, but is far less severe. For the rich, instead, the curve is essentially flat and slightly increasing for values of ϕ_π near the estimated value. While monetary policy rules involve a significant tradeoff between stabilizing real activity and inflation from the perspective of the poor, for the rich the tradeoff is insignificant. In this sense, the 'divine coincidence' holds for the rich.

Related Literature. Our paper contributes to a large, primarily empirical, literature studying the distributional effects of inflation and monetary policy. One strand of this literature regresses moments of the distribution of earnings, employment, consumption, etc. on identified monetary policy [Coibion et al., 2017, Amberg et al., 2022, Mitman et al., 2022] or oil [Drossidis et al., 2024, Broer et al., 2024] shocks. These papers generally find that contractionary monetary policy shocks and inflationary oil shocks have more severe effects on lower income households relative to the median. Del Canto et al. [2023] instead draw on the Envelope Theorem to estimate the welfare effect of macroeconomic shocks. Since a shock only affects welfare by affecting various terms in the household's budget constraint (goods and asset prices, labor and dividend income, transfers), its welfare effect for a particular household can be estimated by combining sectional data and aggregate empirical impulse response functions. Consistent with the literature cited above, Del Canto et al. [2023] find that inflationary supply shocks are regressive, while expansionary monetary policy shocks are progressive. Our approach is conceptually similar except that we also rely on our estimated model to compute the response of aggregate variables to shocks. Pallotti et al. [2024] use a similar approach to measure the distributional welfare effects of the post-Covid surge in Euro-area inflation.

The theoretical HANK literature has primarily studied the way in which inequality mediates the effect of macroeconomic shocks on aggregate variables, rather than studying the distributional effect of shocks in their own right. For example, while Kaplan et al. [2018] document how the response of consumption to a monetary policy shock differs throughout the income and wealth distribution, their focus is on how this helps explain the aggregate effect of the shock and its decomposition into direct and indirect effects. Bayer et al. [2024] use an estimated HANK model to explore how business cycle shocks have contributed to the evolution of income and wealth inequality in the US. Bardóczy and Velásquez-Giraldo [2024] use a HANK model with a realistic demographic structure to document how the effect of a monetary policy shock on household consumption and welfare varies throughout the age distribution.

A recent literature studies optimal policy in HANK economies, both theoretically and quantitatively. Acharya et al. [2023] find that flexible price level targeting remains optimal in their analytically tractable HANK model; however, distributional concerns lead a utilitarian social planner to put less weight on stabilizing prices relative to the output gap, and some weight on stabilizing the output level, as opposed to just the output gap. Among the literature studying optimal policy numerically in richer models, Bhandari et al. [2021] find sizable deviations between optimal policy in HANK and RANK, while Le Grand et al. [2021] find smaller differences—highlighting that it remains an open question how much HANK matters quantitatively for optimal policy. Relative to this literature, we do not directly study the effect of alternative rules on household welfare. Instead, our contribution is to study the aggregate and distributional consequences of inflation stabilization in a richer HANK environment with two assets and search and matching frictions.

In this regard, our analysis of alternative rules is most closely related to Gornemann et al. [2016]. They investigate the welfare implications of changing the response to unemployment in a Taylor-like rule for households with different wealth levels using a simpler, one-asset, calibrated model solved using second-order perturbation methods. They find that poorer households generally prefer a higher weight on unemployment stabilization, while richer households prefer strict inflation targeting. There are a number of important differences between our work and theirs. First, we study the tradeoffs associated with inflation (rather than unemployment) stabilization. Second, we explain our results by analyzing the dynamic responses to shocks and how these differentially affect households across the wealth distribution, highlighting how more/less wealthy households are exposed to demand/supply shocks. Relatedly, our somewhat richer model features highly procyclical profits, which is important for determining the effect of the shocks on the rich. The analysis in Gornemann et al. [2016] instead mainly considers the combined effect of all shocks. Finally, an important set of the parameters of our model are estimated on U.S. data, which is key in determining the relative importance of the various shocks affecting the economy.

Alves and Violante [2023] use a HANK model with a rich 3-state model of the labor market to evaluate a 'lower for longer' monetary policy rule capturing two aspects of the Federal Reserve's monetary policy framework introduced in 2020: an asymmetric form of average inflation targeting, and a focus on shortfalls, rather than deviations, of employment from target. Crucially, their model features 'scarring' effects of nonemployment (idiosyncratic productivity declines when a worker is nonemployed), and more cyclically sensitive movements in labor market flows for low-productivity individuals. They find that the two new features of the Fed's 2020 framework significantly improve outcomes, especially for low-skill workers, albeit at the cost of somewhat above-target average inflation. Given our focus on the distributional effects of inflation and inflation stabilization, our model does not incorporate scarring effects of unemployment or heterogeneous cyclical sensitivities of labor market flows, and we do not study the effect of moving from a 'deviations' to a 'shortfalls'-based rule, or from inflation targeting to average inflation targeting. Instead, our focus is on the heterogeneous tradeoffs between inflation and consumption volatility for different groups.

2 The HANK model, calibration, and estimation

This paper quantitatively evaluates the distributional impacts of inflation stabilization. To this end, we adopt the medium-sized HANK model developed by Lee [2024]. The model augments a standard New Keynesian DSGE model by incorporating heterogeneous agents, incomplete markets with both liquid and illiquid assets, search-and-matching labor market frictions with wage rigidity, and financial institutions. These features allow the model to capture the various channels through which aggregate shocks and macroeconomic policies influence household consumption. Furthermore, the estimated model generates dynamics for key aggregate variables—such as interest rates, inflation, wages, profits, job-finding rates, and asset returns—that align with empirical evidence on their responses to monetary policy.[2]

[2]For empirical evidence on the effects of monetary policy shocks on these variables, see Christiano et al. [2005], Lenza and Slacalek [2024], and Lee [2024].

2.1 The model

In this section, we provide a brief overview of the model's key features, focusing on how they serve the purpose of this paper while referring to the online appendix and Lee [2024] for a more complete and detailed description. The model consists of households, labor agencies, goods producers, a capital firm, mutual funds, financial institutions, and fiscal and monetary authorities. Households consume goods, save in different types of assets, and supply labor when employed. Labor agencies post vacancies to match with households and provide labor services to goods producers. Since shocks and macroeconomic policies affect the value of vacancies, the unemployment rate in the model is endogenously determined. Financial institutions earn excess returns on equity by taking deposits and investing in equity; their profits are distributed to a small subset of households, generating significant wealth and income inequality. The monetary authority sets the nominal interest rate according to a rule that determines how aggressively it responds to inflation and the unemployment gap.

1) Households

There is a unit mass of households who are *ex-ante* identical but *ex-post* heterogeneous due to the evolution of their idiosyncratic productivity, holdings of illiquid and liquid assets, and employment status. Households determine their consumption, real equity holding, nominal deposit/debt holding, and hours worked to maximize their lifetime utility. The household's value function is given by

$$V(a_t, b_t | s_t, e_t) = \max_{a_t, b_t, c_t, n_t} u(c_t, n_t) - \mathbb{1}_{\{a_{t+1} \neq a_t\}} \chi_t + \beta_t (1-\zeta) \mathbb{E}_t \Big[V(a_{t+1}, b_{t+1} | s_{t+1}, e_{t+1}) \Big] \tag{1}$$

s.t.

$$c_t + q_t a_{t+1} + b_{t+1} = (1-\tau) y_t + (q_t + r^a_t) a_t + R_t b_t + T_t \quad , \; a_{t+1} \geq 0 \; , \quad b_{t+1} \geq \underline{\mathrm{b}} \tag{2}$$

with

$$u(c_t, n_t) = \frac{\left[c_t - \psi s_t \frac{n_t^{1+\xi}}{1+\xi} \right]^{1-\sigma}}{1-\sigma} \quad , \tag{3}$$

$$y_t = \begin{cases} w_t s_t n_t & \text{for employed} \quad (e_t = 1) \\ w v \min\{s_t, \bar{s}\} & \text{for unemployed} \quad (e_t = 2) \\ \nu \Pi_t + \Pi_t^{\text{FI}} & \text{for business owners} \quad (e_t = 3) \end{cases} \tag{4}$$

where a_t represents illiquid equity holdings, b_t denotes liquid deposit holdings, and c_t represents consumption. Equity holdings are illiquid in the sense that adjusting them incurs stochastic utility costs, denoted by χ_t. The variable q_t denotes the price of illiquid assets, while r_t^a represents the corresponding dividend rate. Due to the illiquid nature of equity, only a small subset of households invest in equity and earn dividends, which are a fraction of total profits, despite the higher return relative to liquid deposits. Households can also borrow up to an exogenous limit $\underline{b}$, incurring a borrowing premium $\bar{i}$. That is, the gross return on deposits is given by $R_t = \dfrac{1 + i_t + \bar{i}\mathbb{1}_{\{B_t<0\}}}{\pi_t}$.

Idiosyncratic productivity, denoted by s_t, follows a first-order Markov process, while e_t denotes households' working status. Each period, households are employed ($e_t = 1$), unemployed ($e_t = 2$), or business owners ($e_t = 3$). Employed households earn labor income, which depends on their productivity level, the real wage w_t, and hours worked n_t. Unemployed households receive government-provided unemployment benefits, which are a fraction of the steady-state labor income they would have earned if employed. Business owners, in contrast, receive a share of firm profits as income. All sources of income are subject to a tax rate τ, and the government provides lump-sum transfers T_t. Importantly, the transition from unemployment to employment is determined endogenously based on the aggregate state of the economy.

Lastly, households' discount factor β_t evolves according to the following stochastic process

$$\log(\beta_t) = (1 - \rho_\beta)\log(\beta) + \rho_\beta \log(\beta_{t-1}) + \epsilon_{\beta,t}, \tag{5}$$

where β is the steady-state level of the discount factor, ρ_β is the AR(1) coefficient, and $\epsilon_{\beta,t}$ represents an i.i.d. discount factor shock. A positive shock increases households' valuation of future consumption, leading them to reduce current consumption while increasing saving.

Because of the two-asset structure and time-varying working status, households in the model can have different levels and compositions of wealth (deposits/equity) and income (labor, asset, and business income), along with varying exposures to labor and financial market fluctuations. Given that liquid assets (deposits and debt) are nominal while equity holdings are real, households also exhibit heterogeneous exposures to inflation, depending on their portfolio composition as well as whether they are savers or borrowers in nominal assets.

2) Labor agencies

Labor agencies act as intermediaries between households and goods producing firms. They post vacancies to hire households and provide labor services to firms. A household can supply labor only through a labor agency. The value of a labor agency matched with a household of productivity s_t is given by

$$J^L(s_t) = (r_t^l - w_t - \Xi_L)s_t n_t + \mathbb{E}_t\Big[\Lambda_{t,t+1}(1-\zeta)(1-\lambda)(1-P_e)J^L(s_{t+1})\Big] \tag{6}$$

where r_t^l is the labor rental rate, and Ξ_L is the fixed cost of maintaining a match. We assume that the labor agencies' discount factor $\Lambda_{t,t+1}$ corresponds to the average marginal rate of substitution (MRS) of business owners.[3] Households are separated from a match with an exogenous probability λ each period. Additionally, if a household dies with probability ζ or transitions to business ownership with probability P_e, the match is terminated.

Following Gornemann et al. [2016] and Nakajima [2023], we adopt an ad-hoc wage function to circumvent computational difficulties associated with implementing Nash bargaining for wage determination. Specifically, the real wage w_t is determined by

$$\frac{w_t}{w} = \left\{\Psi_{w,t}\left(\frac{r_t^l}{r^l}\right)\right\}^{(1-\rho_w)} \times \left\{\frac{w_{t-1}}{w} \times \left(\frac{\pi_{t-1}}{\pi_t}\right)^{\iota_w} \times \left(\frac{\pi}{\pi_t}\right)^{1-\iota_w}\right\}^{\rho_w} \quad , \quad 0 < \rho_w \ , \ \iota_w < 1. \tag{7}$$

This equation implies that the real wage is a convex combination of the labor rental rate and the previous period's nominal wage, adjusted for past and steady-state inflation rates. Specifically, ι_w represents the degree of indexation to the previous period's inflation rate, while $1-\iota_w$ represents the degree of indexation to the steady-state inflation rate. The real wage is also subject to an i.i.d. wage markup shock, $\Psi_{w,t}$.[4]

The equilibrium number of vacancies is determined by the free entry condition, which states that the expected value of posting a vacancy must equal the fixed cost of doing so.

$$\iota = \frac{M_t}{V_t}\bar{J}, \tag{8}$$

[3] Due to this assumption, a discount factor shock affects both households' and firms' behaviors.

[4] Even though shocks are i.i.d., they have persistent effects due to the sluggish adjustment of the real wage implied by the adopted wage function.

where ι is the vacancy posting cost, M_t represents matches, and V_t denotes vacancies. The expected value of a vacancy is given by $J_t = \sum \mu(s_t) J^L(s_t)$, where $\mu(s_t)$ represents the mass of households with productivity level s_t.

The number of matches is determined by the following matching function:

$$M_t = \frac{\big(U_t + \lambda N_t\big) V_t}{\Big\{\big(U_t + \lambda N_t)^{\alpha} + V_t^{\alpha}\Big\}^{1/\alpha}} \ , \tag{9}$$

where U_t and N_t represent the beginning-of-period mass of unemployed and employed households, respectively.[5] Exogenous shocks and macroeconomic policies, including monetary policy, influence the unemployment rate by affecting the value of a vacancy and, consequently, the number of matches. The degree of wage rigidity and the level of vacancy posting costs determine how responsive the unemployment rate is to shocks and policies.

3) Financial institutions

Financial institutions borrow from households at the nominal interest rate set by the central bank and invest in equity, as in Gertler and Karadi [2011]. The value of financial institution j, with net worth N_{jt}, is given by

$$J^b(N_{jt}) = \max_{\{A^b_{jt+1}, B^b_{jt+1}, N_{jt+1}\}} \mathbb{E}_t \Big[\Psi_{b,t} \Lambda_{t,t+1} \big\{(1-\theta_b) N_{jt+1} + \theta_b J^b(N_{jt+1})\big\}\Big] \tag{10}$$

s.t.

$$q_t A^b_{jt+1} = N_{jt} + B^b_{jt+1} \quad , \quad N_{jt+1} = R^a_{t+1} q_t A^b_{jt+1} - R_{t+1} B^b_{jt+1} \ , \tag{11}$$

$$J^b(N_{jt}) \geq \Delta q_t A^b_{jt+1} \ , \tag{12}$$

where θ_b represents the survival rate, A_{jt} denotes equity holdings, B_{jt} represents deposits, R^a_t is the gross rate of return on equity, and R_t is the realized real rate of return on deposits in period t. The last inequality reflects the constraint financial institutions face due to the moral hazard problem described in Gertler and Karadi [2011]. Specifically, the value of the financial institution must exceed the value of a fraction Δ of its assets. Financial institutions are also subject to risk premium shocks, $\Psi_{b,t}$, where a negative shock reduces their valuation of future returns and consequently decreases equity investment.

[5] In each period, the labor market opens after exogenous separations occur. Transitions between workers and business owners also take place at the end of the previous period, meaning that the beginning-of-period mass of employed and unemployed households differs from their levels in the middle of the previous period.

As in Gertler and Karadi [2011], financial institutions invest in equity by taking deposits up to the point where constraint (12) becomes binding, as long as there is an excess return on equity. Additionally, since the value of a financial institution is proportional to its net worth N_{jt}, we have

$$q_t A_{jt+1} = \Theta_t N_{jt}, \tag{13}$$

where Θ_t is an endogenously determined leverage ratio. Equation (13) implies a financial accelerator mechanism: a shock to financial institutions' net worth propagates through its impact on investment and feeds back into net worth. Due to this feature, risk premium shocks play a crucial role as a demand shock, leading to substantial fluctuations. Moreover, since the net worth of exiting institutions, i.e., $(1-\theta_b)N_t$, is distributed to business owners as financial sector profits, and net worth moves procyclically with demand shocks, the financial sector makes wealthy households' income and consumption strongly procyclical, consistent with existing empirical evidence.[6]

4) Monetary authority

The monetary authority sets the nominal interest rate according to the following rule with interest rate smoothing:

$$i_{t+1} = \min\{0, \hat{i}_{t+1}\} \quad \text{with} \quad \frac{1+\hat{i}_{t+1}}{1+\hat{i}} = \left(\frac{1+\hat{i}_t}{1+\hat{i}}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\phi\pi} \exp -\phi_u(u_t - u)\right]^{1-\rho_R} \exp(\epsilon_{R,t}) \ , \tag{14}$$

where $\epsilon_{R,t} \sim N(0, \sigma_R^2)$ represents a monetary policy shock, $0 < \rho_R < 1$ indicates the degree of interest rate smoothing, and $\hat{i}t+1$ and $it+1$ are the shadow and actual policy rates, respectively. The parameters ϕ_π and ϕ_u determine the responsiveness of the nominal rate to inflation and the unemployment gap. As shown in Equation (14), the policy rate is subject to the zero lower bound (ZLB). If the monetary policy rule prescribes a negative interest rate, the ZLB binds, and the interest rate is set to zero instead.

In addition to conventional interest rate policy, the monetary authority conducts quantitative easing (QE) by issuing bonds and purchasing equity, as outlined in Gertler and Karadi [2011]. We treat QE policy as an exogenous process, except during periods when the Federal Funds rate was set to zero in the data used for estimation. During those periods, QE policy

[6] See, for instance, Parker and Vissing-Jørgensen [2009].

responds to inflation and unemployment dynamics according to a rule detailed in Lee [2024]. Notably, despite following this rule, the assumed QE policy remains only weakly responsive to economic conditions. As a result, the central bank's balance sheet primarily evolves due to exogenous shocks in the model.

5) Numerical method

When the ZLB on the nominal rate is not binding, the model solution is obtained using the perturbation method of Reiter [2009], extended by Winberry [2018] and Bayer and Luetticke [2020]. First, the steady state is computed using the endogenous grid method of Carroll [2006]. The model is then linearized around its steady state for perturbation. To address the high dimensionality arising from idiosyncratic states (e.g., asset holdings, skill level, work status), the state space is reduced following Bayer et al. [2019] and Bayer and Luetticke [2020].

In contrast, when the ZLB becomes binding, we adopt two approaches. For estimation, we follow the methodology of Kulish et al. [2014] and Jones [2017], which treat the binding ZLB as a temporary alternative regime with exogenous durations. Specifically, in each period, the number of periods for which the nominal rate is expected to remain constrained by the ZLB is specified exogenously. For simulations, we apply the approach of Guerrieri and Iacoviello [2015], which characterizes the policy rule at the binding ZLB with endogenously determined durations.

2.2 Calibration and estimation

We adopt a two-stage approach for model parametrization,. In the first stage, the model's steady state is calibrated to match key features of household inequality in micro data as well as macroeconomic aggregates. In the second stage, parameters governing the model's dynamics are estimated using Bayesian methods, leveraging time-series data on aggregate macro variables. The estimation explicitly accounts for occurrences of the binding ZLB constraint in the data, following the method described in the previous section.

Table 1: Calibrated parameters

Parameter	Value	Description	Reference or targets
β	0.9932	Household's discount factor	Wealthy hand-to-mouth share
μ_χ	9.0490	Mean of χ dist	SS adj. prob. of 6.5%
σ_χ	3.4205	Scale parameter for χ dist	Top 10% illiquid asset share
$\tilde{P}_e$	20.6%	Prob. of losing business	Top 10% liquid asset share
ν	0.2380	Fraction of profits given to business owners	Gini Net worth
$\underline{\mathrm{i}}$	0.0253	Borrowing premium	Mass of households with zero assets
$\underline{\mathrm{b}}$	1.3006	Borrowing limit	Mass of households with debt
π	1.0050	Inflation target	Fed's target
$1+i$	1.0100	SS nominal rate	Households' liquid to illiquid asset ratio

Calibration

The model is calibrated to ensure that it matches key moments regarding households' wealth distribution and income composition in the micro data. Lee [2024] primarily utilizes data from the 2007 Survey of Consumer Finances (SCF) for the calibration.[7]

To map the model to the data, liquid assets are defined as the sum of checking, savings and money market deposits, call accounts, certificates of deposits, bonds net of credit card balances, and other lines of credit. Illiquid assets are defined as the sum of all financial assets other than liquid assets, plus 40% of net housing wealth, business interest in corporate and non-corporate business, minus installment loans. Consumer durables, such as vehicles, are also excluded from illiquid assets.

Income is categorized into three types: labor income, capital income, and transfer income. Labor income includes wages and salaries in the data. Capital income is the sum of business income and asset income, comprising interest and dividend income and capital gains. Transfer income encompasses unemployment benefits, social benefits (e.g., food stamps), and other miscellaneous transfers.

Table 1 presents a set of calibrated parameters and their associated targets in the data. A complete list of calibrated parameters, including the calibrated income process, is provided in Lee [2024].[8] Figure 1 shows that the model matches reasonably well the heterogeneity in

[7]The main goal of Lee [2024] is to study the distributional consequences of unconventional monetary policies conducted during the Great Recession and its aftermath. Thus, the paper uses the last survey results before the Great Recession.

[8]The model's income process includes two additional states, a 'super productive' and a least productive state, to improve its alignment with the data.

the sources of income across the wealth distribution.

Table 2: Targeted moments and model fit

	Liquid Assets		*Illiquid Assets*	
Moments	Data	Model	Data	Model
Top 0.1 percent share	19	10	15	3
Top 1 percent share	45	39	38	19
Top 10 percent share	**84**	**84**	**74**	**73**
Bottom 50 percent share	-4	-3	3	1
Bottom 25 percent share	-5	-3	0.2	0
Gini Coefficient	0.97	0.95	0.82	0.85

Data : SCF 2007, *Notes* : The blue color indicates targeted moments. ,

Figure 1: Income composition in the data and the model

Data : SCF 2007, *Notes* : household groups are defined by their wealth levels.

Estimation

To discipline the model dynamics with the data, we estimate the remaining model parameters using Bayesian methods. The following set of observables is used:

$$\left[\Delta \log Y_t, \Delta \log C_t, \Delta \log \tilde{I}_t, \log \pi_t, \log(1+i_t), \log u_t, \Delta \log w_t, \log T_t^g, \log \Pi_t, \log A_t^{\mathrm{CB}}\right], \quad (15)$$

where Y_t, C_t, $\tilde{I}_t$, π_t, $1+i_t$, u_t, w_t, T_t^g, Π_t, and A_t^{CB} correspond to 1) output, 2) consumption, 3) investment, 4) the inflation rate, 5) the nominal interest rate, 6), the real wage, 7) the unemployment rate, 8) lump-sum transfers, 9) corporate profits, and 10) the central bank's assets, respectively. The data is primarily sourced from FRED and BEA, covering the first quarter of 1992 to the last quarter of 2019. The exception is the central bank's assets, for which data is available only from 2003 onward. For the exogenous expected ZLB durations, we use results from the Federal Reserve Bank of New York's Survey of Primary Dealers. The appendix provides additional details on data construction.

Table 3 shows the estimated posterior distribution of a set of parameters. The slope of the Phillips curve is about 0.05 at the posterior mode. The estimated nominal wage rigidity is also relatively high, with a posterior mode of about 0.87. The vacancy posting cost is slightly lower than its prior mode, with a posterior mode of 0.074. Combined with high wage rigidity, the relatively low vacancy posting cost implies flexible extensive margin adjustment in the labor market. As explained in Lee [2024], such flexible adjustment in the unemployment rate contributes to a procyclical response of profits to demand shocks.

Table 3: Prior and posterior distributions of structural parameters

Symbol	Description	Prior			Posterior		
		Prior Density	Mean	Std	Mode	10%	90%
		Frictions					
κ	Slope of the Phillips Curve	Gamma	0.10	0.02	0.0527	0.0449	0.0759
ρ_w	Nominal wage rigidity	Beta	0.50	0.10	0.8686	0.8323	0.8976
ι	Vacancy posting cost	Gamma	0.10	0.02	0.0742	0.0573	0.0940
ρ_R	Interest rate smoothing	Beta	0.50	0.20	0.8337	0.8099	0.8564
ϕ_π	Inflation gap response	Normal	2.0	0.20	1.8533	1.6891	2.0826
ϕ_u	Unemployment gap response	Gamma	0.10	0.05	0.3595	0.3255	0.4073

3 The distributional impact of monetary policy, supply, and demand shocks

In this section we discuss impulse responses that illustrate how both exogenous supply and demand shocks, and monetary policy shocks, affect households differently depending on their wealth. The first set of responses we consider is that to a contractionary monetary policy shock. As is customary in the literature, when we conduct simulations to study how different policy reaction functions affect the economy in Section 4, we exclude these shocks. Nonetheless, the responses to policy shocks help illustrate how monetary policy has heterogeneous effects throughout the wealth distribution. Moreover, there is a growing empirical literature studying the distributional impact of monetary policy shocks, which we can use to assess the model's realism.

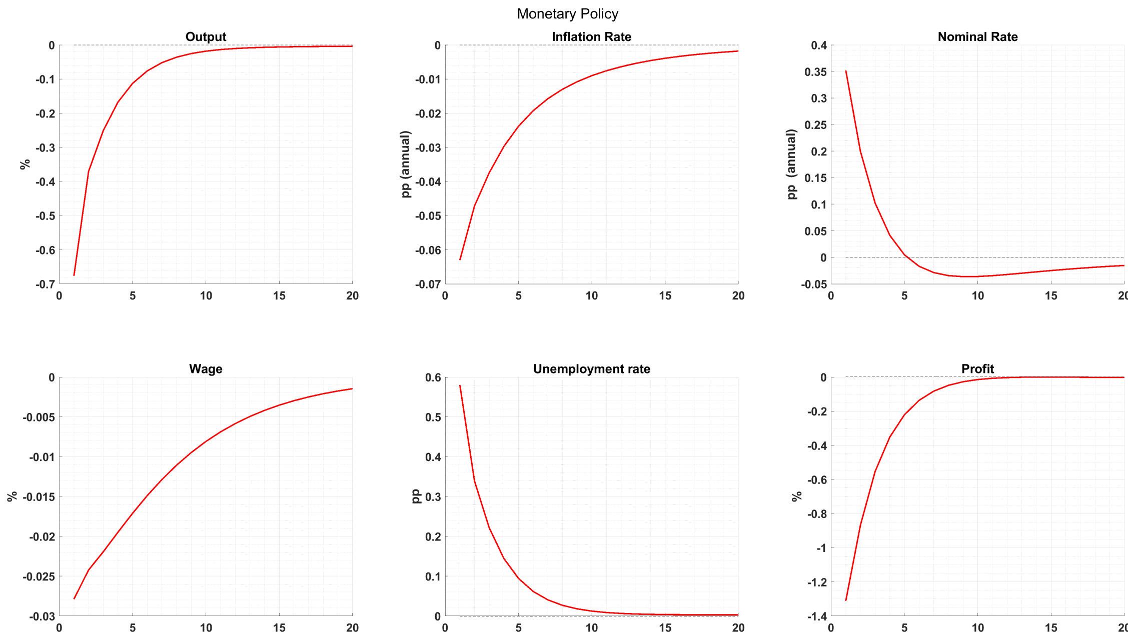
The second set of responses we analyze is that to a prototypical supply shock, namely an increase in firms' markups. We discuss the responses under the estimated policy reaction function and under an alternative reaction function that responds more aggressively to inflation. Finally, the third set of responses we study is that to a prototypical demand shock—a discount rate shock. While the model has many more shocks, as discussed in the previous section, these two shocks provide a clear illustration of how supply and demand shocks, and the monetary policy response to these shocks, affect households across the wealth distribution in disparate ways. The intuition developed in this section is key to understanding the results of the simulations in section 4.

3.1 Monetary policy shocks

Figure 2 shows the responses of aggregate variables to a one standard deviation contractionary policy shock. The point of the figure is to show that this HANK model features fairly standard responses for aggregate variables: as interest rates increase by about 35 basis points on impact, both output and inflation fall, although the response of inflation (6 basis points) is small relative to the decline in output (almost 70 basis points) highlighting the fact that the model's price Phillips curve is rather flat. As economic activity declines, the labor market worsens, with unemployment increasing by about .6 percentage points and real wages declining slightly. Profits are strongly countercyclical, in line with the data [Christiano et al., 2005], declining by more than 1 percent.

Figure 3 shows the distributional consequences of the policy shock, shown for households in the bottom (B10) and top (T10) 10 percent of the wealth distribution, as well as for the five quintiles (Q1 through Q5) of the wealth distribution. For each quantile of the wealth distribution, the effect of the policy shock on the household's welfare is measured in consumption equivalent terms. That is, each household belonging to a given quantile of the (steady state) wealth distribution is asked how much consumption they would be willing to

Figure 2: Responses to monetary policy shocks: aggregate variables



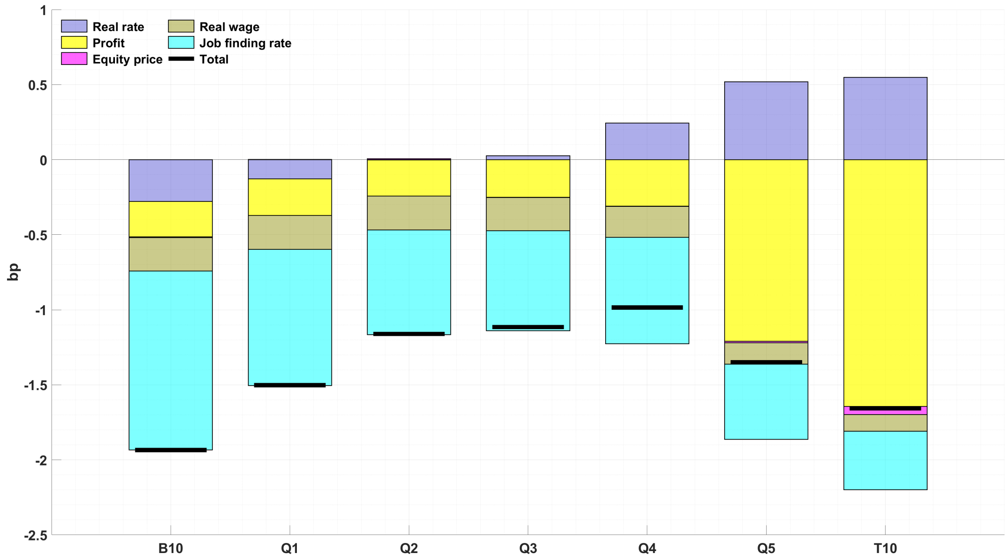
Note: Impulse responses to a one standard deviation contractionary policy shock in terms of percent and percentage point change up to 20 quarters ahead

forgo forever in order to avoid the consequences of the shock. The result is then averaged across all households belonging to that quantile at date 0.[9] The black lines measure the total effect, while the colored bars decompose the total into components due to 1) the increase in the real rate, and the decline in 2) labor income/wages, 3) profits, 4) the job finding rate, and 5) equity prices.

We perform these decompositions as follows. We compute the expected path of each of the endogenous variables that households take as given (real interest rates, job finding rates, etc.) following the monetary policy shock. For each household, and each of these variables (say, real interest rates) we solve the household's problem in a fictitious economy where *only* real interest rates follow this path while all other variables remain at their steady state values, and households perfectly forsee the path of all aggregate variables. We then compute the household's consumption-equivalent welfare in this fictitious economy where

[9]The fact that all households suffer from an contractionary monetary policy shock does not imply that systematic expansionary policy would increase welfare. As an analogy, in the standard New Keynesian model, steady-state output is inefficiently low due to monopolistic distortions, and a one-time expansionary shock increases welfare; but systematic expansionary policy does not do so (hence the gains from commitment to a policy rule) [Clarida et al., 1999]. HANK introduces additional reasons, besides monopolistic distortions, why potential output might be inefficiently low [Acharya et al., 2023].

Figure 3: The distributional consequences of monetary policy shocks



Note: Distributional consequences of monetary policy shocks shown for various households across the wealth distribution. B10/T10 refer to the bottom/top 10% of the distribution and Q1-Q5 refer to quintiles.

only real interest rates are changing, and average welfare across each quintile (etc.) of the wealth distribution. These welfare effects from the change in real interest rates are shown by the lavender bars in Figure 3. We do the same for each of the relevant variables.[10]

Figure 3 shows that the poorest households suffer the most from the rate hike. This is because the increase in rates increases their financial burden to the extent that they are debtors. Poor households' primary source of income is labor, and the decline in the job finding rate and the associated increase in unemployment also hurt them. As we move up the wealth distribution the effect of higher interest rates switches sign: it is close to zero for households in the middle of the distribution, as they have little wealth, and becomes positive for rich households.[11] The rich are not particularly affected by the worse labor market outcomes, but they do derive a substantial fraction of their income from profits, and hence they are adversely affected by the fall in profits, which are highly countercyclical.[12]

[10]Since we solve the household problem nonlinearly, the colored bars, which measure the welfare effect of each change in aggregate variables taken in isolation, do not exactly sum to the black line, which measures the welfare effect of the change in all variables. In practice, though, the difference is very small.

[11]Wealthy households holding equity are hurt by the increase in the discount rate, which leads to a decline in equity prices (pink bars). Quantitatively the effect is small both because the interest rate shock is transitory, and because equity is illiquid.

[12]Any claim about the exposure of households with different wealth levels to various sources of income applies to averages within each bin—the exposure of individual households can be quite different. Also,

The overall impact of the shock as a function of the level of wealth therefore has an inverted U-shape, with poor and very rich households being affected the most, although the effect on the bottom 10 percent households is larger than that on the top 10 percent households. This U-shaped pattern is broadly consistent with the growing empirical literature on the distributional effect of monetary policy shocks, which generally finds that contractionary/expansionary shocks disproportionately hurt/benefit low-income households by increasing their employment, and the very rich, by increasing capital income, and is hard to replicate in HANK models where profits are not procyclical enough, as is arguably the case in most existing literature. Using Norwegian administrative data, Holm et al. [2021] find that contractionary monetary policy shocks decrease consumption the most, at 2-5 year horizons, for households in the highest and lowest levels of the liquid wealth distribution. Using Swedish data, Amberg et al. [2022] find that expansionary shocks increase income the most for households in the highest and lowest income deciles; this is driven by labor income for the lowest decile, and capital income for the highest.

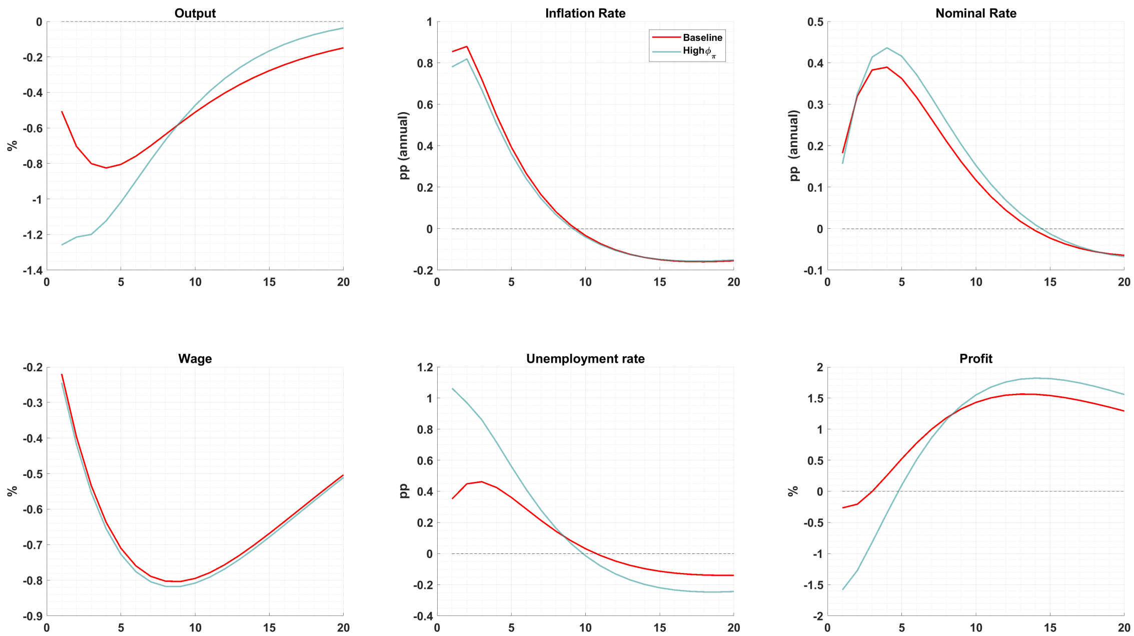
3.2 Markup shocks

Figure 4 shows the responses of aggregate variables to a one standard deviation markup shock. As standard in the New Keynesian literature, we model this shock as an increase in firms' desired markup originating from a decline in the substitutability across products. This fall in competitiveness leads to prices rising.

The red lines show the response under the estimated policy reaction function, with $\hat{\phi}_\pi = 1.85$, and the blue lines show the responses obtained under an alternative reaction function that responds more aggressively to inflation ($\phi_\pi = 3$). Focusing on the red lines first, we see that the shock generates a sizable response of inflation, which rises by almost 90 basis points, a .75 percent decline in output at the trough, and a deterioration in the labor market, with unemployment rising and real wages falling by 80 basis points two years after the shock and remaining depressed throughout the forecast horizon. While unemployment rises on impact and for the first two years after the shock, it falls below steady state afterwards because real wages are low and firms therefore find it attractive to post vacancies. Profits decline on impact in spite of the higher desired markup because of the fall in economic

the effect of wealth is by no means 'causal', e.g., poor households may be more exposed to changes in the job finding rate not because they are poor, but because unemployed households are of course poorer than employed ones *ceteris paribus*.

Figure 4: Responses to markup shocks: aggregate variables



Note: Impulse response functions of aggregate variables to a one standard deviation markup shock given policy rules with the estimated (red lines, $\phi_\pi = 1.85$) or the alternative, stronger (blue lines, $\phi_\pi = 3$) policy reaction function coefficient on inflation. Each displays percent (%) or percentage point (pp) change relative to their respective steady state values over 20 periods.

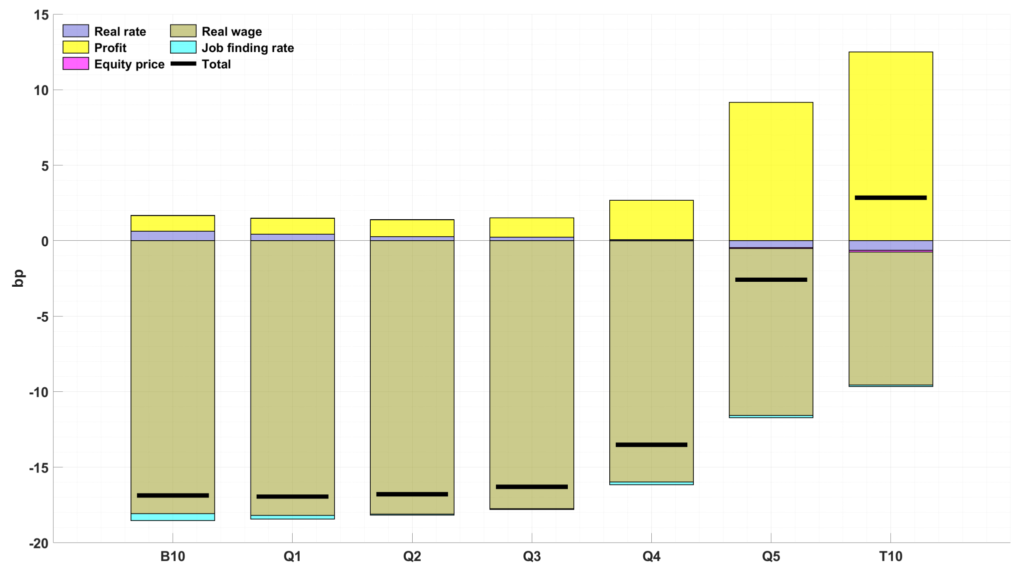
activity, but rebound soon after, however, because labor costs remain low. As we will see, the disparate path of real wages and profits is key for understanding the distributional impact of markup shocks.

Figure 5 shows the distributional consequences of markup shocks using the same 'consumption equivalent' approach as in the previous section. The message is clear: most households, except the very rich, are worse off following a positive markup shock. This loss is due to the fact that real wages fall substantially in the aftermath of the shock and this reduces welfare, especially for the hand-to-mouth. Arguably, this is the 'hardship that high inflation is causing' often mentioned by Federal Reserve Chair Powell during the post-COVID inflationary episode. The very rich people gain from the shock, however, because they accrue all the extra profit that the low cost of labor implies after the first few quarters.

When policy responds more aggressively to inflation (blue lines in Figure 4), inflation rises less following the cost push shock, but the differences are small due to the very flat Phillips curve. The output and labor market costs of containing inflation are conversely large, with output falling by about 50 basis points more than under the baseline rule and unemployment also rising by about .5 percentage points more.[13]

[13]The 'Phillips curve slope' in this model (i.e. the sensitivity of inflation to the unemployment rate)

Figure 5: The distributional consequences of markup shocks

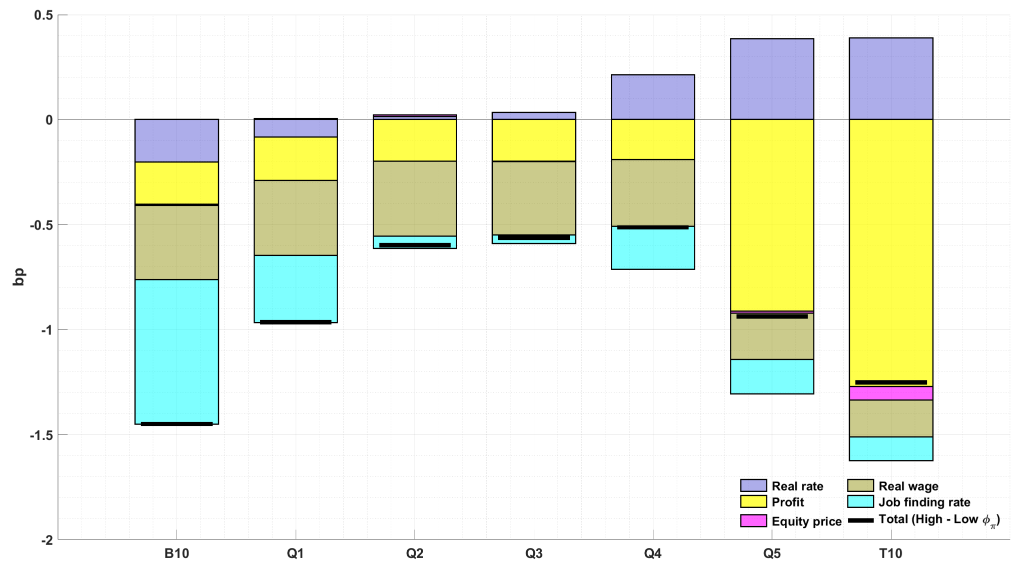


Note: All values displayed are averages across the wealth group described, with groups as previously defined.

Figure 6 shows the distributional consequences of a stronger policy response to cost push shocks, i.e. the difference between the distributional consequences of these shocks under $\phi_\pi = 3$ and $\phi_\pi = 1.85$. Broadly speaking, the impact of a stronger policy response is very similar to that of a contractionary policy shock shown in Figure 3, and for the same reasons. While poor households are those that are most negatively affected by the cost push shock, they are even more negatively affected when the central bank tries to fight inflation more aggressively. A more aggressive policy response entails higher interest rates, which hurts debtors, and lower wages. Households with some wealth are not much affected by the more aggressive policy because the lower labor income is partially offset by higher financial income. Very rich households are also hurt by the more aggressive response to inflation as this causes a lower stream of profits. For these households, the fall in profits induced by aggressive policy can be thought of as 'insurance' against the shock, since it offsets the *increase* in profits caused by the shock itself. (A more aggressive reaction to inflation would also mitigate the fall in their profits following a *fall* in markups, and thereby smooth out the fluctuations in their income over the business cycle.) But for poorer households, the deleterious effect of higher interest rates compounds the damage caused by the original

depends on both the sensitivity of inflation to marginal costs κ, and the sensitivity of marginal costs to the unemployment rate. The estimated value of κ is not particularly low (0.05) compared to many estimates of the Phillips curve slope. However, because marginal costs are relatively unresponsive to the unemployment rate (due to low vacancy posting costs), inflation is still relatively insensitive to the unemployment rate.

Figure 6: The distributional consequences of a stronger policy response to markup shocks



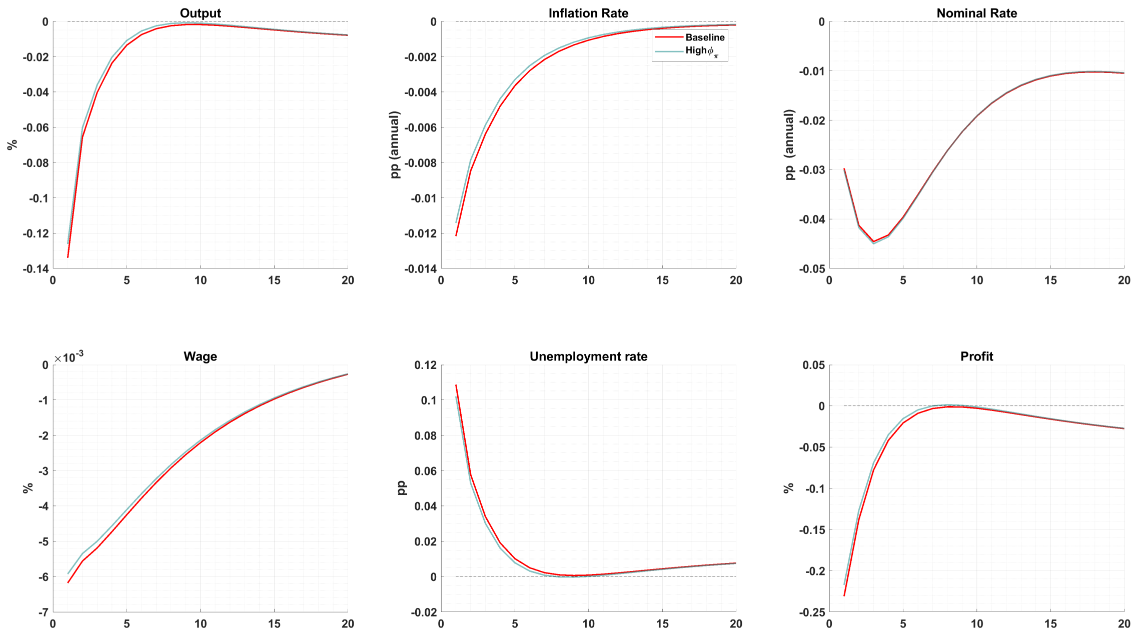
Note: Values displayed are differences between the scenario with a more aggressive policy reaction function subtracted from the baseline scenario with a lower, estimated inflation response.

shock. This is one reason why Bhandari et al. [2021] find that the optimal policy response to a positive shock is to *lower* interest rates, contrary to the standard prescription in a RANK model, in order to 'insure' poorer households against the lower real wages caused by this shock.

3.3 Demand shocks

Figure 4 shows the responses of aggregate variables to a one standard deviation contractionary discount rate shock. As before, the red lines show the response under the estimated policy reaction function, with $\hat{\phi}_\pi = 1.85$ and the blue lines show the responses obtained when monetary policy responds more aggressively to inflation ($\phi_\pi = 3$). A first observation is that there is virtually no difference between the two lines. This is because the inflation response is small enough—about 1 basis point—that even a substantial change in the response of policy to inflation does not significantly alter the path of nominal rates and other variables. In line with standard results in simple RANK models, the small impact of the shock on inflation translates into a relatively muted impact on most aggregate variables, such as output and wages. The unemployment rate increases by only 10 basis points. The impact on profits however is quite substantial, at least relative to the impact on other aggregate variables, as profits drop by .25 percent on impact and remain subdued for two years after the shock.

Figure 7: Responses to demand (discount rate) shocks: aggregate variables

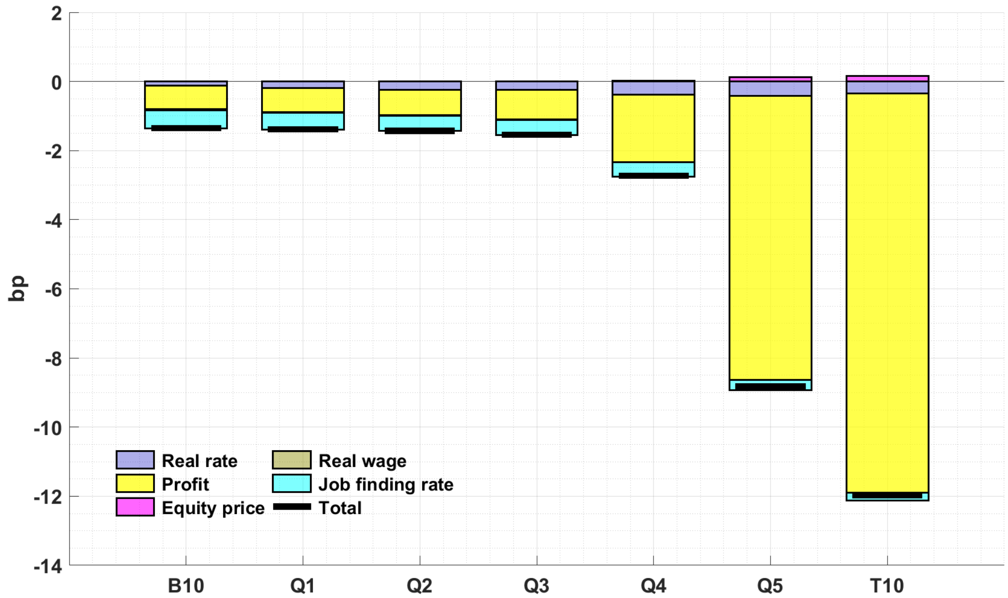


Note: Impulse response functions of aggregate variables to a demand (discount rate) shock given policy rules with the estimated (red lines, $\phi_\pi = 1.85$) or the alternative, stronger (blue lines, $\phi_\pi = 3$) policy reaction function coefficient on inflation. Each displays percent (%) or percentage point (pp) change relative to their respective steady state values over 20 periods.

The distributional consequences of discount rate shocks shown in Figure 8 are in line with this result: most of the brunt of the shock is born by wealthier households because of the fall in profits.[14] We do not show the distributional impact of a stronger policy response to demand shocks because the difference is negligible.

[14]The impulse responses to a one standard deviation risk premium shock, shown in Figure A1 of the appendix, have a very similar shape to those of in Figure 4 but are about eight times larger. We chose not to show these impulse responses as prototypical demand shocks because the welfare impact of these shocks on wealthier households is mostly driven by their very prolonged effect on financial profits, which make the present discounted value computations hard to interpret. But the bottom line is similar to the case of discount rate shocks: demand shocks have a particularly strong effect on profits in the model, and are therefore disproportionately impact the rich.

Figure 8: The distributional consequences of demand (discount rate) shocks



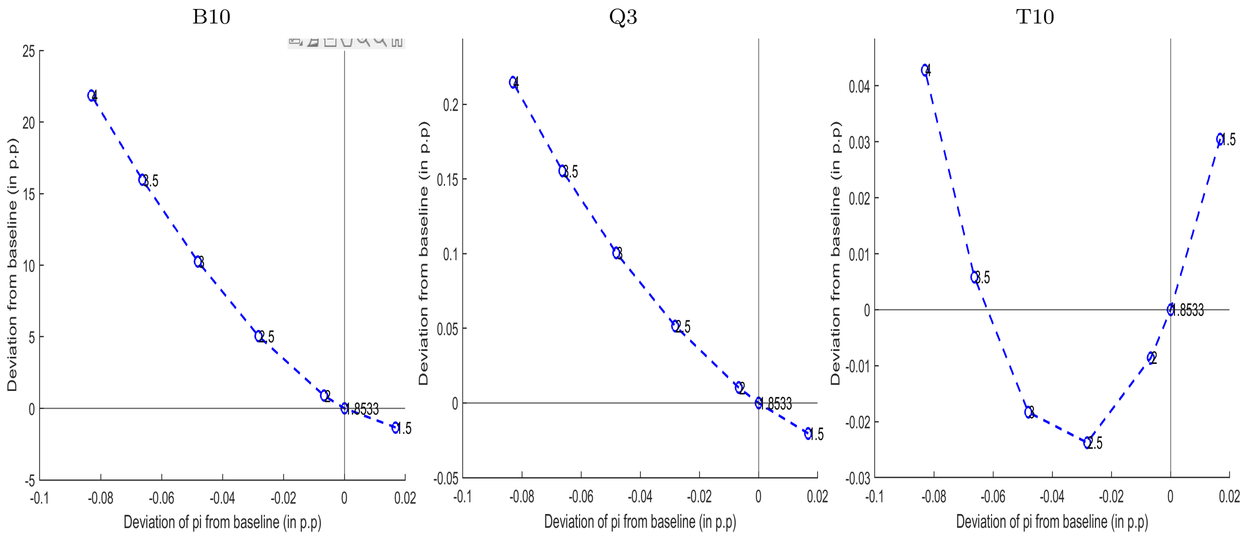
Note: All values displayed are averages across the wealth group described, with groups as previously defined.

4 The inflation-volatility tradeoffs across the wealth distribution

This section argues that the tradeoff between stabilizing inflation and real activity differs markedly across the wealth distribution. The blue lines in Figure 9 show how inflation volatility and consumption volatility for different quantiles of the wealth distribution change as we vary the response to inflation ϕ_π in the Taylor-like interest feedback rule (14). We refer to these lines as 'frontier curves' as they describe the frontier faced by policymakers as they decide how strongly they should respond to inflation.[15] There is a long tradition of plotting similar frontier curves showing the tradeoff between variability in *aggregate output* and inflation [Taylor, 1979, Fuhrer, 1997, Levin et al., 1999]. The slope of such a curve describes the cost of reducing inflation volatility, in terms of higher output volatility. In this paper we are interested in how this cost differs for households at different points in the distribution. In our model, all households consume the same bundle of goods, and therefore

[15]Figure A2 in the appendix shows that changing the response to unemployment in the reaction function (14) does not change the shape of the frontier curves with respect to ϕ_π.

Figure 9: Frontier curves: consumption vs inflation volatility by wealth



Note: Tradeoff between the standard deviation of consumption for households in the lowest tenth, third quintile, and top tenth of the wealth distribution, respectively, and the standard deviation of inflation. The curves are obtained by varying the response to inflation ϕ_π in the interest feedback rule (14).

face the same inflation volatility.[16] However, the cost of reducing aggregate inflation volatility can differ markedly between households as their exposure to wages, unemployment, and so forth varies with wealth, as discussed in the previous section. We choose to display the frontier curves in terms of consumption volatility, as opposed to a different variable such as income, because consumption volatility is a more directly comparable, welfare-relevant way to summarize these costs for different groups of households.[17]

Inflation and consumption volatility are measured as standard deviations of inflation and the (log) *level* of consumption, respectively, both in percent, and they are shown in Figure 9 in terms of differences with respect to the standard deviations obtained under the estimated value of ϕ_π, which is 1.85.[18] The standard deviations are computed by generating 60k periods

[16] This would not be true in richer models which capture the fact that households differ in their consumption bundles and inflation rates differ across products [Orchard, 2022, Yang, 2023].

[17] Consumption volatility is more welfare-relevant than income volatility because welfare depends on consumption, not income. If poor and rich households face the same increase in *income* volatility, but the rich use financial markets to smooth consumption while the poor are hand to mouth, welfare will fall more for the poor. That said, consumption volatility is not a sufficient statistic for welfare. We do not take a full second-order approximation to welfare as is common in the NK literature, because doing so accurately would require approximating the model's dynamics up to second-order (since our model has a distorted steady state), which is technically challenging in HANK models such as ours [Bhandari et al., 2023].

[18] We compute the volatility of consumption of each group (say, the bottom 10 percent of households) as

of simulated data from the model, constructed by drawing 200 300-quarter-long sequences of shocks (75 years, about the length of the post-war period). In each of these sequences, shocks are generated by a mixture: with a probability of 1/20 (every five years on average) we have either a COVID (we use the estimated shocks from the 2021Q2-2022Q3 period) or a Great Recession (we use the estimated shocks from 2008Q1-2009Q2) episode; otherwise shocks are drawn independently from their estimated distribution. We use this mixture to ensure we have both high inflation and ZLB episodes in our simulated sample, allowing us to evaluate how alternative monetary policy rules would perform both in situations like the 2010s with low demand, and in situations like the early 2020s with recurrent adverse supply shocks.[19]

Event frequency under the estimated parameters	
Event	Frequency (%)
ZLB	6.3
Inflation $\geq$ 5%	15.1
Inflation $\geq$ 7%	5.4
Inflation $\geq$ 10%	0.2

When policymakers face a tradeoff between stabilizing inflation and stabilizing real activity—here measured as consumption volatility, as explained above—the frontier plots are downward sloping: increasing the response to inflation ϕ_π leads to a decline in inflation volatility but a corresponding increase in consumption volatility (ϕ_π ranges from 1.5 to 4 in the plots). When there is no tradeoff between stabilizing inflation and real activity—the so-called 'divine coincidence' case—the frontier plots are upward sloping: stabilizing inflation and real activity go hand-in-hand. Frontier plots tend to be convex, which in the downward sloping case means that further declines in inflation volatility comes at an increasing cost in terms of higher consumption volatility.

follows. In our simulation, at each point in time, we compute average consumption among households in the bottom 10 percent of the wealth distribution, $\overline{C}_t^{B10}$. We then compute the mean and standard deviation of $\log \overline{C}_t^{B10}$. These objects are not the same as the mean and standard deviation of log consumption for those households who are *currently* among the poorest 10 percent, because households move through the wealth distribution.

[19]For robustness we also consider simulations where we only draw shocks from their estimated distribution, as discussed below. Section A.4 in the appendix describes the simulations in more detail.

Our main result is that the tradeoffs are very different for the poor (the bottom ten percent of the wealth distribution), the middle class (the third quintile), and the rich (the top ten percent).[20] In spite of the fact that these households are subject to exactly the same shocks, for the poor there is a very large tradeoff: as ϕ_π rises and inflation volatility declines, consumption volatility increases substantially. For the middle class there is also a tradeoff, but the changes in volatility are an order of magnitude smaller relative to the poor, partly reflecting the relative stability in their income. Finally, for the rich the frontier is even flatter (note the y-axis scale) and upward sloping, at least for modest values of ϕ_π below 2.5. As the title of the paper states: tradeoffs for the poor, but divine coincidence for the rich— the rich do not suffer much, and may even gain a little, from an increased response to inflation.[21]

One policy implication of our findings is that a dual mandate, such as that followed by the U.S. Federal Reserve, delivers better outcomes for most households than a single-minded focus on inflation stabilization (captured here by a much higher value of ϕ_π), which would substantially increase consumption volatility and reduce welfare for the poorest households. A related implication is that navigating the tensions between the two prongs of the dual mandate is a delicate exercise in that it has very different implications for households with different levels of income and wealth.

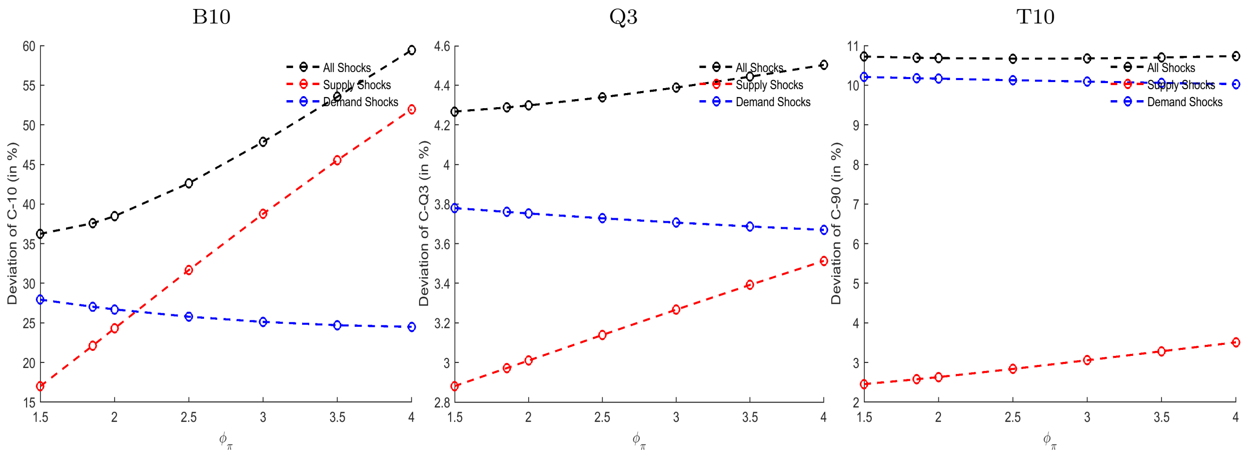
4.1 Explaining the frontier curves

In order to understand the frontier plots, Figure 10 shows how consumption volatility varies with ϕ_π—the response to inflation in the Taylor-type rule (14)—distinguishing between demand and supply shocks. The black lines show volatility when the economy is subject to

[20] The labels 'poor', 'rich', and 'middle class' for the bottom and top 10 percent and for the middle quintile of the wealth distribution are of course arbitrary. At the same time, the results are fairly robust to changing the definitions (e.g., using the bottom and top 5 percent, or the bottom and top 20 percent *et cetera*) so we do not feel particularly uncomfortable in using them.

[21] Whether the frontier curves are slightly upward or slightly downward sloping for the rich—the top 10 percent of the distribution—in the neighborhood of $\hat{\phi}_\pi$ depends on the specifics of the simulations. We find that when we do not impose the ZLB constraint (Figure A3 in the appendix) the curve is a bit more upward sloping than in Figure 9, but when we run simulations without Covid or Great Recession episodes (Figure A4) the curve is very slightly downward sloping in the neighborhood of $\hat{\phi}_\pi$. We should mention that in this latter simulations the frequency of ZLB episodes is only 3 percent, much lower than in the data, which is why our baseline simulations feature Great Recession episodes. What is consistent across all simulations is that for the rich the curve is essentially flat: unlike the poor or to a much lesser extent the middle class, the rich are not meaningfully harmed in terms of consumption volatility by a stronger reaction to inflation.

Figure 10: Standard deviation of consumption by wealth



Note: Standard deviation of consumption for households in the lowest tenth, third quintile, and top tenth of the wealth distribution, respectively, as a function of ϕ_π, in the baseline economy with all shocks (black lines), a counterfactual economy with only supply shocks (red lines), and a counterfactual economy with only demand shocks (blue lines).

all shocks. Since the volatility of inflation, as we will show below, naturally declines as ϕ_π rises, the black lines do not contain any new information relative to the frontier plots: consumption volatility rises steeply with ϕ_π for the poor, less steeply for the middle class, and is U-shaped, but basically flat, for the rich.

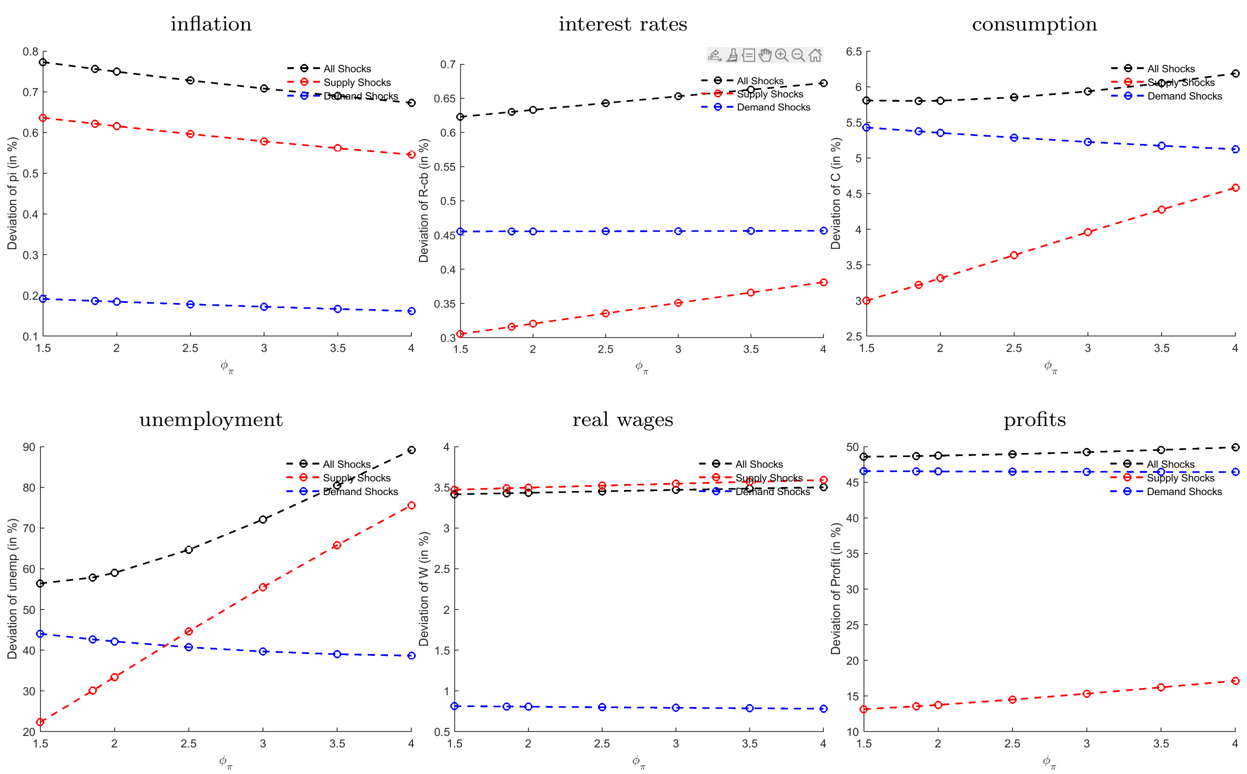
The decomposition between supply (red lines) and demand (blue lines) shocks sheds some light on the rationale behind these patterns. First of all, for all households, irrespective of their wealth, increasing ϕ_π always decreases consumption volatility in response to demand shocks—which generate a "divine coincidence"—and increases consumption volatility in response to supply shocks.[22] Therefore, any difference in the frontier curves across households has to arise because of i) the different exposure for poor and rich households to demand and supply shocks, and ii) the relative steepness of the two lines.

Starting with the former, under the estimated value of ϕ_π—that is, in actuality according to the model—for all households demand shocks are more important than supply shocks in terms of generating consumption volatility. This is in line with the fact that arguably most recent recessions have been driven by demand-like shocks, such as the 2008 financial crisis.

[22]Figure A5 in the appendix shows the frontier curves separating demand and supply shocks: for all households, at any point in the wealth distribution, the frontier is downward sloping for supply shocks and upward sloping for demand shocks. It also shows that these frontier curves are for the most part roughly linear so that any convexity is due to the relative importance of supply and demand shocks as a function of $\phi_p i$ across the wealth distribution.

But while middle class and rich households are clearly more exposed to demand than supply shocks, for poor households the difference is much smaller even under the estimated value of ϕ_π. Moreover, for poor households the volatility due to supply shocks rises rapidly with ϕ_π—much more rapidly than the decline in the volatility due to demand shocks. For middle income households, this is also the case, but less dramatically so. For rich households instead, at least for low values of ϕ_π, the volatility due to demand shocks falls faster than the increase due to supply shocks, leading to a decline in overall volatility. As a result of these differences, for rich and middle class households demand shocks are always clearly more important than supply shocks— across all of the ϕ_π values we consider— while for poor households supply shocks become more important than demand shocks as ϕ_π increases above 2.

Figure 11: Standard deviation of aggregate variables



Note: Standard deviation of aggregate variables as a function of ϕ_π in the baseline economy with all shocks (black lines), a counterfactual economy with only supply shocks (red lines), and an economy with only demand shocks (blue lines).

Figure 11 performs a similar decomposition of the volatility of *aggregate* variables. Inflation is mostly driven by supply shocks (unsurprisingly, given the low estimated slope of our Phillips curve). Interest rates are instead mostly driven by demand shocks, although supply shocks become more important as ϕ_π increases and the central bank reacts more strongly to (supply shock-driven) fluctuations in inflation.[23] The composition of the volatility of aggregate consumption looks like that of the wealthier part of the population–not surprisingly, since wealthier households account for most of total consumption.

The decompositions for the variables in the last row of Figure 11 provide some explanation for the differences in the drivers of consumption volatility across the wealth distribution. For poor people, especially those who are hand to mouth, unemployment and real wages are the key determinants of consumption. Unemployment is mostly driven by demand shocks under the estimated ϕ_π, but as ϕ_π increases supply shocks rapidly become more important. Real wages are also mostly driven by supply shocks. Conversely, profits—a key source of income for wealthy individuals—are mostly driven by demand shocks.[24] These findings are in line with the impulse responses discussed in the previous section which show that when ϕ_π rises, unemployment, wages, and consumption, especially for poorer households, all become more responsive to supply shocks. Profits, which are most important for wealthier households, conversely become less responsive to demand shocks as ϕ_π increases.[25]

4.2 Robustness: results with higher Phillips curve slope

The estimated slope of the Phillips curve in the model is not particularly low ($\kappa = .05$) compared to estimates in the literature, but sill implies that it is costly for monetary policy to stabilize inflation in the face of supply shocks. This may be an important reason why the consumption of low income households becomes very volatile as ϕ_π rises. This section investigates whether a higher slope of the Phillips curve would change the results. We therefore repeat the simulations using $\kappa = .1$, that is, doubling the slope κ.[26]

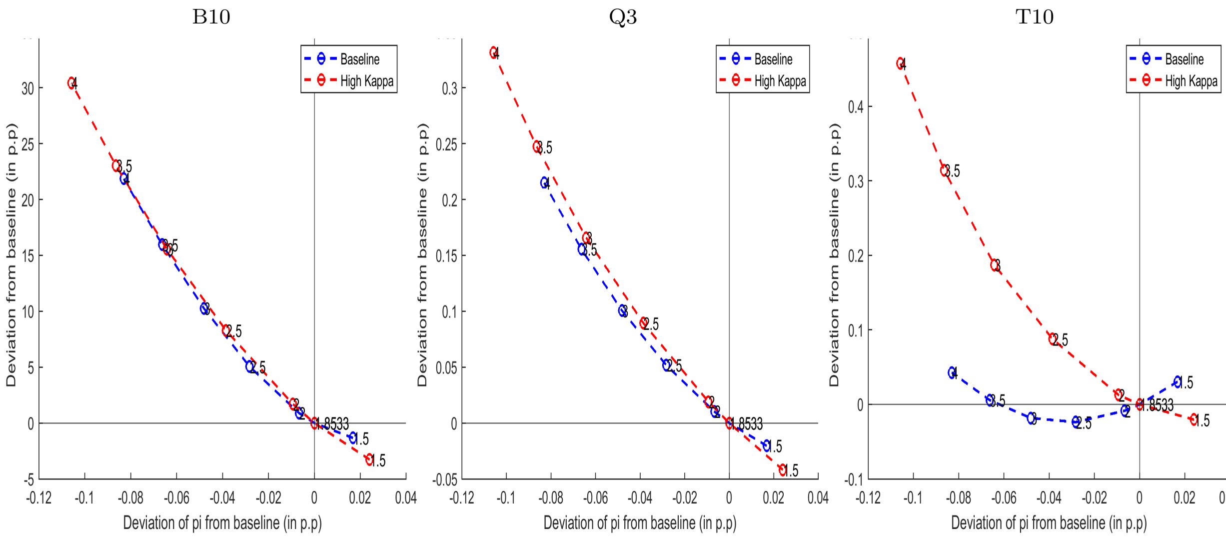
[23]Note that while supply shocks account for most of the variation in inflation and unemployment, they move these variables in the same direction, leading to only a muted response of interest rates. Demand shocks move inflation and unemployment in opposite directions, leading to larger fluctuations in interest rates.

[24]It might appear puzzling that the volatility of wages in a counterfactual economy with only supply shocks is slightly higher than the volatility with both demand and supply shocks. In a linear model, this would not be possible since the variance due to all shocks (the square of the black line) equals the sum of the variance due to supply and demand shocks separately (the squares of the blue and red lines, respectively). This is not necessarily true in our experiment, since the ZLB makes the model nonlinear.

[25]Section B.2 shows the frontier curves for some aggregate variables, such as consumption, output, and unemployment.

[26]This value is loosely motivated by Blanco et al. [2024], who present a model with a time-varying slope of the Phillips curve, disciplined by time series data on the average frequency of price changes, and find that

Figure 12: Frontier curves: baseline vs high PC slope



Note: Tradeoff between standard deviation of consumption for households in the lowest tenth, third quintile, and top tenth of the wealth distribution, respectively, and standard deviation of inflation, in the baseline with Phillips curve slope $\kappa = 0.05$ (blue lines) and an alternative calibration with $\kappa = 0.1$ (red lines).

The blue lines in Figure 12 are the same frontier curves shown in Figure 9. The red lines show the frontier curves under $\kappa = .1$. With a steeper Phillips curve, the same increase in ϕ_π elicits a larger fall in inflation volatility (i.e. the red line is 'stretched out' relative to the blue line). But the tradeoffs for the poor and the middle class are no better with a higher κ, and they are worse for the rich in that consumption volatility now increases as inflation volatility decreases. We should stress that this finding is largely driven by the presence of the ZLB. When we run simulations without imposing the ZLB, we generally find that a higher κ *does* improve the tradeoffs for the central bank slightly (Figure A6 in the appendix). Still, our main result is unchanged: the tradeoffs differ substantially throughout the wealth distribution, and are much worse for the poor than they are for the middle class or the rich.

5 Conclusions

We use an estimated HANK model [Lee, 2024] to investigate how the tradeoff between stabilizing inflation and consumption volatility change across the wealth distribution. Specifically,

κ has fluctuated between a normal value around 0.03 and highs around 0.1 in periods of high inflation (the 1970s and 2021-22).

we vary the response to inflation in the central bank's interest feedback rule and assess the effects on inflation volatility and consumption volatility by wealth cohort. We find that stabilizing consumption and inflation go hand in hand for the rich, who are particularly exposed to demand-driven fluctuations in profits, which are highly procyclical. For the poor, in contrast, aggressively stabilizing inflation has a severe cost in terms of higher consumption volatility. While they dislike inflation because it erodes real wages, they are hurt even more by an aggressive monetary policy response to supply shocks, which reduce real wages further while increasing unemployment and real interest rates.

In the paper we study the tradeoffs in the context of a Taylor-type rule—that is, of a central bank that pursues flexible inflation targeting. Different monetary policy frameworks, such as price level targeting or flexible average inflation targeting, may change the tradeoffs and shift the frontier curves. We leave it to future research to investigate whether such polices represent improvements relative to flexible inflation targeting—as we know is the case in standard RANK models—across the wealth distribution. We also leave to future research the normative question of how the tradeoffs we highlight should inform optimal policy.

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Appendix

Appendix A Additional model details

A.1 Model description

In this section, we provide further details of the model, including equations that describe the problems of entities not covered in the main body of the paper.

1) Final good firm

The final good is a standard CES aggregator,

$$Y_t = \left[\int Y_{jt}^{\frac{\eta_t - 1}{\eta_t}} dj \right]^{\frac{\eta_t}{\eta_t - 1}} ,$$

where Y_{jt} is firm j's intermediate good, and η_t is the time-varying elasticity of substitution. Profit maximization yields individual demand and the associated aggregate price index,

$$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\eta_t} Y_t$$

$$P_t = \int P_{jt}^{1-\eta_t} dj$$

where P_{jt} is good j's price.

2) Intermediate goods firms

There is a continuum of intermediate good firms that produce differentiated products using labor and capital rental services in a monopolistically competitive environment. The production technology is characterized by a standard Cobb-Douglas production function and firms set the price for their goods subject to price adjustment costs a lá Rotemberg [1982]. In a symmetric equilibrium where all firms set the same price, firms' cost minimization and optimal pricing decision lead to the following Phillips curve.

$$\log \pi_t - \log \pi_{t-1}^{\iota_p} \pi^{1-\iota_p} = \mathbb{E}_t \Big[\Lambda_{t,t+1} \big(\log \pi_{t+1} - \log \pi_t^{\iota_p} \pi^{1-\iota_p} \big) \Big] + \kappa \left(\text{MC}_t - \frac{1}{\Psi_t^p} \right) ,$$

where $\Psi_t^p = \dfrac{\eta_t}{\eta_t - 1}$ represents the price markup shock, π_t denotes the inflation rate in period t, ι_p refers to the indexation to the current inflation rate, $\Lambda_{t,t+1}$ denotes the firms' discount factor, MC_t stands for the real marginal cost, and κ represents the slope of the Phillips curve.

3) Capital firm

A representative capital firm determines the capital utilization rate and accumulates capital. The optimal level of capital utilization is governed by the following first-order condition.

$$r_t^k = \delta'(v_t)$$

where r_t^k represents the capital rental rate, v_t denotes the utilization rate, and $v(\cdot)$ represents the depreciation rate of capital as a function of the utilization rate. For variable depreciation, the model employs a standard functional form found in Greenwood et al. [1988],

$$\delta(v_t) = \delta_0 v_t^{\delta_1} \quad , \quad \delta_1 > 1 \ ,$$

where δ_0 is the depreciation rate under full utilization and δ_1 governs the degree of acceleration of depreciation.

The optimality condition regarding capital accumulation implies the following equation describing the capital/equity price dynamics.[27]

$$q_t = \Psi_{k,t}\left\{1 + \phi \log \frac{K_{t+1}}{K_t} + \frac{\phi}{2}\left(\log \frac{K_{t+1}}{K_t}\right)^2\right\} - \mathbb{E}_t\left[\Lambda_{t,t+1}\Psi_{k,t+1}\phi\left(\log \frac{K_{t+2}}{K_{t+1}}\right)\frac{K_{t+2}}{K_{t+1}}\right]$$

where q_t represents equity price, ϕ is the coefficient in capital adjustment costs, and $\Psi_{k,t}$ denotes the investment technology shock, which follows an AR(1) process.

4) Equity mutual fund

There exists a hypothetical mutual fund that owns all firms in the model, which we refer to as the equity mutual fund. The roles of the equity mutual fund include collecting profits from firms, paying out dividends to shareholders, and issuing new equity for capital accumulation. We assume that the fund operates in a perfectly competitive environment. Thus, there are no retained earnings, and the fund pays out all profits as dividends. The funds acquired

[27] In the model, one unit of equity is the claim for the same amount of capital stock.

through equity issuance are transferred to the capital firm for the purchase of capital. The period cash-flow constraint of the equity mutual fund is as follows:

$$(1-\tau)(1-\nu)\Pi_t - q_t(K_{t+1}-K_t) + q_t(A_{t+1}-A_t) = r_t^a A_t \quad , \tag{A.1}$$

where Π_t denotes the total profits of all firms, and ν represents the share of profits distributed to business owners.[28] The corporate tax rate is denoted by τ. Given that aggregate capital equals total equity in the model, the price of equity equals the price of new capital, and the dividend rate is

$$r_t^a = \frac{(1-\tau)(1-\nu)\Pi_t}{K_t} \ , \tag{A.2}$$

that is, the dividend rate equals profits net of taxes and the portion allocated to business owners, divided by total equity.

5) Money market mutual fund

The model also features another hypothetical mutual fund, referred to as the money market mutual fund (MMMF), which primarily serves to provide liquidity to the financial sector.[29] The fund receives contributions from the government and invests in liquid assets. Using these contributions, along with proceeds from its investments, the fund makes lump-sum transfers to households. I also assume that the fund smooths the flow of lump-sum transfers.

$$\max_{\{T_t^m, B_{t+1}^m\}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta_m^t \frac{(T_t^m)^{1-\sigma}}{1-\sigma} \right] \tag{A.3}$$

subject to

$$T_t^m + B_{t+1}^m = C_t^g + (1+r_t^b) B_t^m \ , \tag{A.4}$$

[28] We assume that the fund itself is owned by business owners, and thus a fraction of profits is distributed to them regardless of their equity holdings.

[29] Since banks are leveraged investors, there must be a corresponding amount of liquid assets backing their illiquid asset holdings in the model. If households were the sole providers of funds to banks, the share of liquid assets in household portfolios would need to be high. However, data from the SCF shows that households hold only about 10% of their total assets as liquid assets. Additionally, according to Financial Accounts data (formerly the Flow of Funds), the share of household liquid assets (e.g., checkable and time deposits, and corporate bonds) in the domestic financial sector's liabilities—which include deposits, bonds, open market paper, loans, and other liabilities—has remained around 25% since 2000. Based on these facts, I assume the presence of a significant non-household liquidity provider, represented by the MMMF.

where T_t^m and B_{t+1}^m denote the fund's lump-sum transfer and liquid asset holdings, respectively. The MMMF's intertemporal elasticity of substitution (IES) is denoted by σ.[30] The contribution from the government to the fund is denoted by C_t^g. Unlike other entities in the model, I assume that the fund discounts future lump-sum transfers using its own discount factor, β_m.[31]

6) Fiscal authority

The fiscal authority collects taxes and issues bonds to finance government purchases, unemployment benefits, lump-sum transfers, and contributions to the money market mutual fund. To ensure price level determinacy, I assume that the fiscal authority controls its debt according to the following simple autoregressive rule, as in Woodford (1995).

$$\frac{B_{t+1}^g}{B^g} = \left(\frac{R_t/\pi_t \times B_t^g}{R/\pi \times B^g}\right)^{\rho_B} \quad , \ 0 \leq \rho_B < 1 \quad , \tag{A.5}$$

where $\rho_B \in (0,1)$ is the pace of debt adjustment.

Since economic agents in the model form rational expectations, the government should meet the following inter-temporal budget constraint.

$$B_t^g = \sum_{l \geq t}^{\infty} \left\{ \prod_{i=t}^{l} \left(\frac{\pi_i}{R_i}\right) \right\} \left\{ \mathbb{T}_l - (G_l + T_l^g + D_l + T_l^{CB} + C_l^g) \right\} \quad , \tag{A.6}$$

where $\mathbb{T}$, G, T^g, D, and C^g are tax revenues, government purchases, lump-sum transfers (or taxes) to households, unemployment benefits, and contributions to the MMMF, respectively. $T_t^{\text{CB}} = q_t A_{t+1}^{\text{CB}} - (q_t + r_t^a) A_t^{\text{CB}} + R_t B_t^{\text{CB}} - B_{t+1}^{\text{CB}}$ is the transfer from (or to) the monetary authority.

Equation ((A.6)) implies that in each period, the debt level must be equal to the present discounted value of all future government surpluses. When the real value of government debt changes, at least one fiscal instrument must adjust to meet the solvency condition. In this paper, I assume that the fiscal authority adjusts its contribution to the MMMF to balance

[30] In principle, the MMMF's IES does not need to equal the household's IES. However, to simplify notation, I assume that the MMMF and households share the same IES.

[31] The steady-state optimality condition of the MMMF requires its discount factor to equal the inverse of the steady-state real interest rate. However, due to idiosyncratic income risk, the average marginal rate of substitution (MRS) of business owners does not equal the inverse of the real interest rate in steady state.

the budget, while government purchases are fixed and lump-sum transfer to households varies according to the following stochastic process.[32]

$$T_t^g = \left(1 - \frac{1}{\Psi_t^g}\right) Y \ , \tag{A.7}$$

where Ψ_t^g is a lump-sum transfer shock and Y is the steady state output.

A.2 Numerical method

We provide further detail on the numerical methods employed to address the occasionally binding constraint on the policy rate, both for estimation and simulations. Formally, when the nominal rate is not constrained by the ZLB, the linearized model can be written as:

$$A\mathbb{E}_t\big[X_{t+1}\big] + BX_t + CX_{t-1} + E\epsilon_t = 0, \tag{A.8}$$

where X_t is a vector of endogenous variables, and ϵ_t is a vector of exogenous shocks in period t. From this linearized system of difference equations, we obtain a linear solution:

$$X_t = PX_{t-1} + Q\epsilon_t. \tag{A.9}$$

If the ZLB is binding, i.e., the net nominal interest rate is fixed at zero, the model no longer admits a simple linear solution but can still be linearized around the steady state as:

$$\widetilde{A}\mathbb{E}_t\big[X_{t+1}\big] + \widetilde{B}X_t + \widetilde{C}X_{t-1} + \widetilde{D} + \widetilde{E}\epsilon_t = 0. \tag{A.10}$$

Suppose the ZLB is expected to bind for T periods starting in period t. Then, in period $t+T+1$, the model economy is expected to revert to the linearized solution obtained from the model without the ZLB. That is, in the absence of exogenous shocks,

$$X_{t+T+1} = PX_{t+T}. \tag{A.11}$$

[32]Because markets are incomplete and households value liquidity, the model is non-Ricardian. Thus, the fiscal responses matter, especially for the distributional effects of monetary policy. Given that there is only short-term government debt, the effects of these fiscal responses can be particularly strong, as shown in **?**. However, the assumption that I adopt in this paper dampens the effect of the fiscal response. An increase in contributions to the MMMF will increase lump-sum transfers from it, but the responses are modest since I assume that the MMMF smoothes out lump-sum transfer flows.

At period $t+T$, we have:

$$\widetilde{A}\mathbb{E}_t\left[X_{t+T+1}\right] + \widetilde{B}X_{t+T} + \widetilde{C}X_{t+T-1} + \widetilde{D} = \widetilde{A}PX_{t+T} + \widetilde{B}X_{t+T} + \widetilde{C}X_{t+T-1} + \widetilde{D} = 0. \quad \text{(A.12)}$$

Rearranging this equation, we obtain:

$$X_{t+T} = \left(\widetilde{A}P + \widetilde{B}\right)^{-1} X_{t+T-1} - \left(\widetilde{A}P + \widetilde{B}\right)^{-1} \widetilde{D}. \quad \text{(A.13)}$$

By iterating this process backward to period t, we derive the following policy rule:

$$X_t = P(T)X_{t-1} + J(T) + Q(T)\epsilon_t. \quad \text{(A.14)}$$

As shown in this expression, the matrices $P(T)$, $J(T)$, and $Q(T)$ depend on the expected ZLB duration T, i.e., the number of periods the policy rate is expected to remain constrained in the absence of future shocks in period t. For estimation, we assume that these expected ZLB durations are exogenously given. For simulations, however, we determine the expected ZLB duration T based on the actual evolution of the model without future shocks. That is, the realized path of the nominal rate, absent future shocks, should be constrained by the ZLB for exactly T periods.

A.3 Parametrization

Below, we describe the sources of the data used as observables in the estimation.

1. Output
    - Model : $\tilde{Y}_t^{\text{obs}} = \log\left(\frac{Y_t}{Y_{t-1}}\right)$
    - Data : Nominal GDP (FRED, GDP), divided by GDP deflator (FRED, GDPDEF) and civilian non-institutionalized population (FRED, CNP16OV), log-transformed, first-differenced and de-meaned.
2. Consumption
    - Model : $\tilde{C}_t^{\text{obs}} = \log\left(\frac{C_t}{C_{t-1}}\right)$
    - Data : The sum of PCE on non-durable goods and services (BEA NIPA Table 2.3.5, item 8 & 13), divided by GDP deflator and civilian non-institutionalized population, log-transformed, first-differenced and de-meaned.

3. Investment

- Model : $\tilde{I}_t^{\text{obs}} = \log\left(\frac{I_t}{I_{t-1}}\right)$
- Data : The sum of private fixed investment (BEA NIPA Table 5.3.5, all types) and PCE on durable goods (BEA NIPA Table 2.3.5, item 3), divided by GDP deflator nd civilian non-institutionalized population, log-transformed, first-differenced and de-meaned.

4. Inflation rate

- Model : $\tilde{\pi}_t^{\text{obs}} = \log\left(\frac{\pi_t}{\pi}\right)$
- Data : Log difference of GDP Implicit Price Deflator minus 0.5 percentage point (2 percent inflation target).

5. Interest rate

- Model : $\tilde{i}_t^{\text{obs}} = \log\left(\frac{R_t}{R}\right)$
- Data : Effective Federal Funds Rate, divided by 400 to express in quarterly units minus logarithm of the model's steady state nominal rate.

6. Real wage

- Model : $\tilde{w}_t^{\text{obs}} = \log\left(\frac{w_t}{w_{t-1}}\right)$
- Data : Average hourly earnings of production and non-supervisory employees in total private sector (FRED, AHETPI), divided by GDP deflator, log-transformed, first-differenced and de-meaned.

7. Unemployment rate

- Model : $\tilde{u}_t^{\text{obs}} = \log\left(\frac{u_t}{u}\right)$
- Data : Unemployment as the number of unemployed as a percentage of the labor force (FRED, UNRATE) minus 5.5 percent (steady state value) divided by 100.

8. Lump-sum transfer

- Model : $\tilde{T}_t^{\text{obs}} = \log\left(\frac{T_t^g}{T_{t-1}^g}\right)$

- Data : The sum of government's current transfer payment (BEA NIPA table 3.2, item 26), capital transfer payments (item 22), net of current transfer receipts (item 19), capital transfer receipts (item 42), and unemployment benefit (NIPA underlying table 3.12U, item 7), divided by GDP deflator and civilian non-institutionalized population, log-transformed, first-differenced and de-meaned.

9. Profits
   - Model : $\tilde{\Pi}_t^{\text{obs}} = \log\left(\frac{\Pi_t}{\Pi_{t-1}}\right)$
   - Data : Corporate profits after tax with inventory valuation adjustment and capital consumption adjustment (BEA account code: A551RC), divided by GDP deflator, and civilian non-institutionalized population, log-transformed, first-differenced and de-meaned.

10. Central bank's assets
    - Model : $\tilde{A}_{t+1}^{\text{CB,obs}} = \log\left(\frac{A_{t+1}^{\text{CB}}}{A_{2007}^{\text{CB}}}\right)$
    - Data : All Federal Bank's assets (FRED, WALCL), divided by GDP deflator, civilian non-institutionalized population, and its end of 2007 level. Log-transformed

Table A1: Prior and posterior distributions of structural parameters

Symbol	Description	Prior			Posterior		
		Prior Density	Mean	Std	Mode	10%	90%
		Frictions					
κ	Slope of the Phillips Curve	Gamma	0.10	0.02	0.0527	0.0449	0.0759
ι_p	Price indexation	Gamma	0.50	0.10	0.2632	0.1895	0.3579
ρ_w	Nominal wage rigidity	Beta	0.50	0.10	0.8686	0.8323	0.8976
ι_w	Wage indexation	Beta	0.50	0.10	0.2214	0.1674	0.2930
ϕ	Capital adjustment cost	Normal	30.00	5.00	49.406	44.826	54.955
ι	Vacancy posting cost	Gamma	0.10	0.02	0.0742	0.0573	0.0940
		Government policy					
ρ_g	Lump-sum transfer shock AR	Beta	0.50	0.20	0.8292	0.7783	0.8563
σ_G	Lump-sum transfer shock std dev	Inverse-Gamma	0.10	2.00	0.3205	0.2979	0.3555
ρ_R	Interest rate smoothing	Beta	0.50	0.20	0.8337	0.8099	0.8564
σ_R	Interest rate shock std dev	Inverse-Gamma	0.10	2.00	0.1249	0.1144	0.1422
ϕ_π	Inflation gap response	Normal	2.0	0.20	1.8533	1.6891	2.0826
ϕ_u	Unemployment gap response	Gamma	0.10	0.05	0.3595	0.3255	0.4073
		Structural Shocks					
ρ_z	TFP shock AR	Beta	0.50	0.20	0.9699	0.9580	0.9808
σ_z	TFP shock std dev	Inverse-Gamma	0.10	2.00	0.5512	0.5123	0.6108
ρ_b	Risk premium shock AR	Beta	0.50	0.20	0.9905	0.9838	0.9954
σ_b	Risk premium shock std dev	Inverse-Gamma	0.10	2.00	0.1400	0.1279	0.1612
ρ_k	Investment shock AR	Beta	0.50	0.20	0.9676	0.9471	0.9831
σ_k	Investment shock std dev	Inverse-Gamma	0.10	2.00	0.0527	0.0490	0.0583
ρ_p	Price mark-up shock AR	Beta	0.50	0.20	0.9185	0.8858	0.9320
σ_p	Price mark-up shock std dev	Inverse-Gamma	0.10	2.00	1.6374	1.4435	2.1991

Notes: The values for the standard deviations and the measurement error are multiplied by 100.

A.4 Details on model simulations

As discussed in the paper, we generate 60k periods of simulated data from the model, constructed by drawing 200 300-quarter-long sequences of shocks (75 years, about the length of the post-war period). In each of these sequences shocks are generated by a mixture: with a probability of 1/20 (every five years on average) we have either a COVID (we use the estimated shocks from the 2021Q2-2022Q3 period) or a Great Recession (we use the estimated shocks from 2008Q1-2009Q2) episode; otherwise shocks are drawn independently from their estimated distribution.

Because the COVID and Great Recession shocks are large in magnitude and one-sided (the former mostly negative supply shocks, the latter mostly negative demand shocks), we face two challenges during simulations. First, the mean of some shocks deviates substantially from zero due to the inclusion of COVID/Great Recession shocks. In particular, price and wage markup shocks display large non-zero means, which can significantly affect the simulation outcomes. Second, the model sometimes exhibits explosive behavior, i.e., unrealistically large responses of variables, when the ZLB binds, especially during periods of prolonged expected ZLB durations. Although these explosive behaviors occur infrequently, accounting for only a small percentage of the entire simulation, they can distort the overall simulation results.

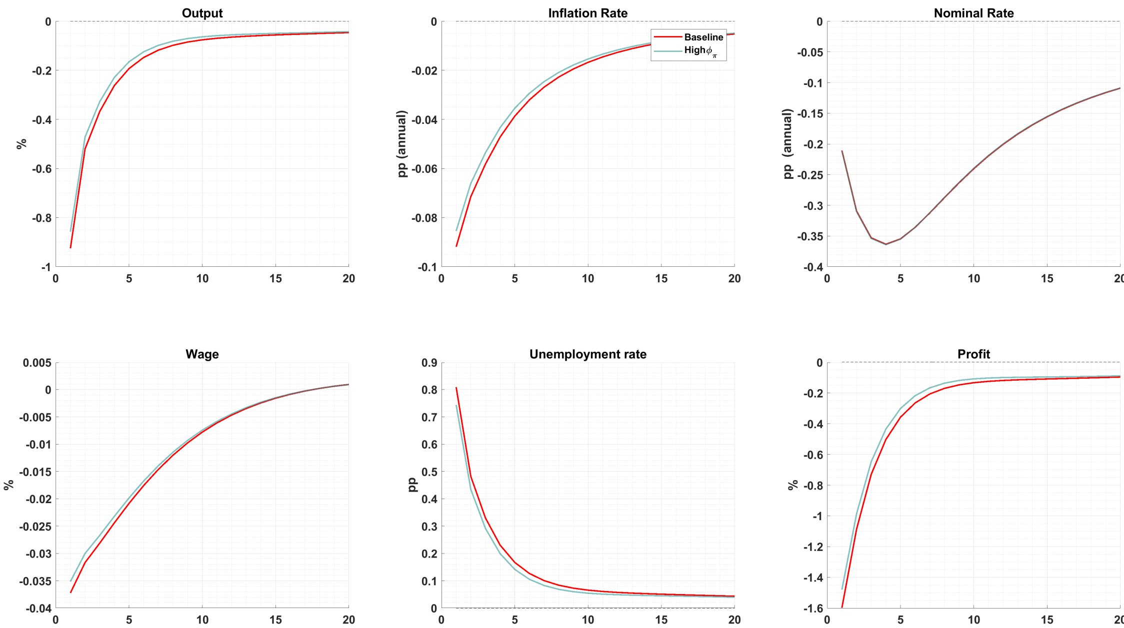
To address these two challenges, we implemented the following procedures in generating shocks for the simulations. First, we introduce "cool down" shocks following any occurrence of COVID or Great Recession shocks during simulations. Specifically, each instance of COVID or Great Recession shocks is followed by six periods of randomly generated shocks, constructed such that their mean offsets that of the preceding shocks. Consequently, over the 12 period window, including both the COVID/Great Recession and cool down shocks, the mean is zero by construction. Additionally, each 300 period sequence of shocks is augmented by its sign-reversed counterpart, ensuring that the overall mean across all shocks used in the simulations is exactly zero."

Second, to prevent a few explosive episodes from distorting the results, we exclude certain simulated data sets from the final analysis. Specifically, we run many sets of 300 period simulations and exclude any set in which key variables exhibit explosive behavior. We check two variables, the consumption of the bottom 10% wealth group and the unemployment rate, and classify their behavior as explosive if they deviate from their respective steady state values by more than 1,500%.

Appendix B Additional results

B.1 Additional impulse responses

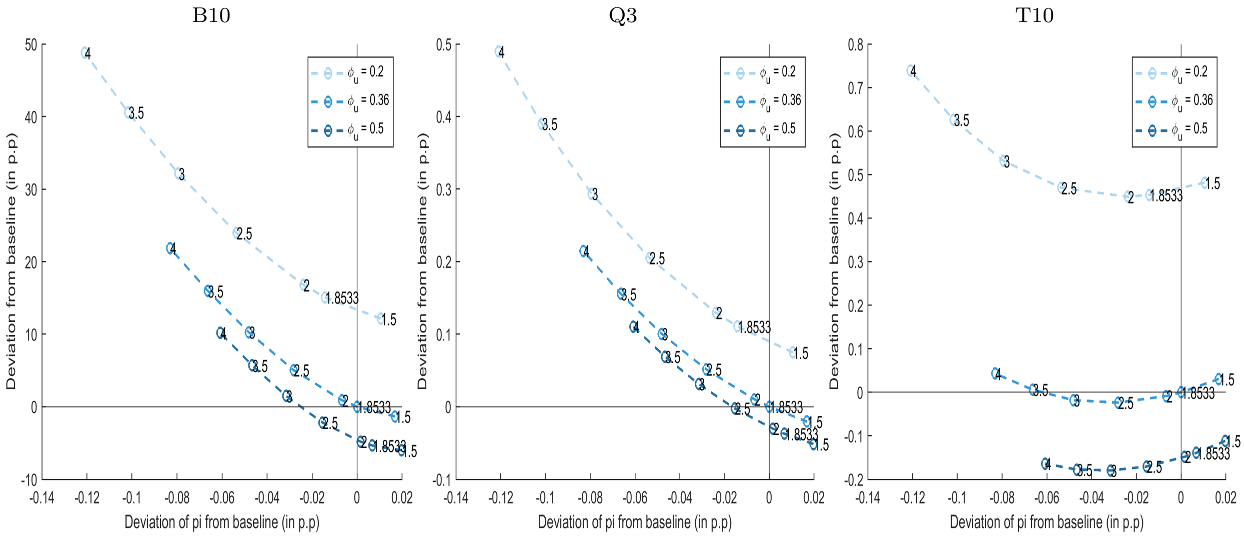
Figure A1: Responses to risk premium shocks: aggregate variables



Note: Impulse response functions of aggregate variables to a risk premium shock given policy rules with the estimated (red lines, $\phi_\pi = 1.85$) or the alternative, stronger (blue lines, $\phi_\pi = 3$) policy reaction function coefficient on inflation. Each displays percent (%) or percentage point (pp) change relative to their respective steady state values over 20 periods.

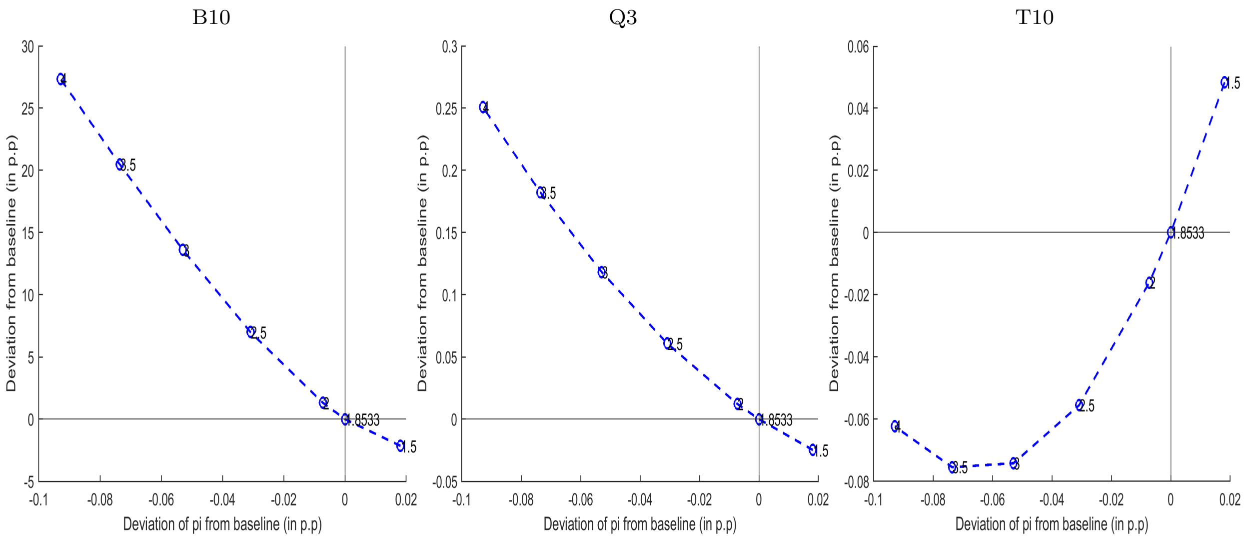
B.2 Additional frontier curves

Figure A2: Frontier curves for different values of the response to unemployment ϕ_u



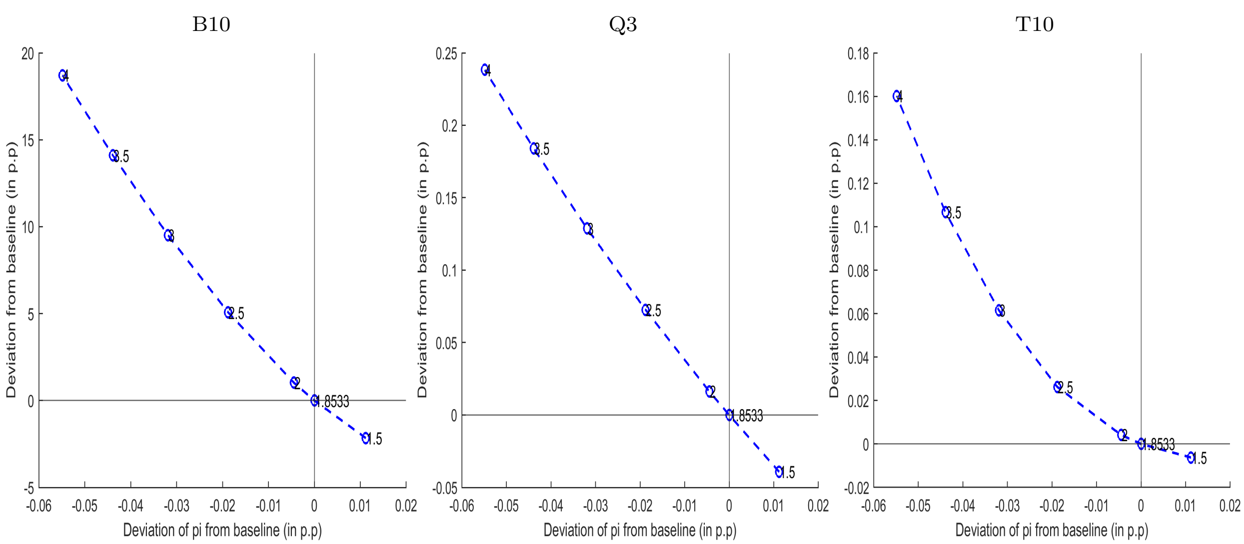
Note: Tradeoff between the standard deviation of consumption for households in the lowest tenth, third quintile, and top tenth of the wealth distribution, respectively, and the standard deviation of inflation, for different values of the parameter ϕ_u.

Figure A3: Frontier curves: consumption vs inflation volatility by wealth—simulations without imposing the ZLB



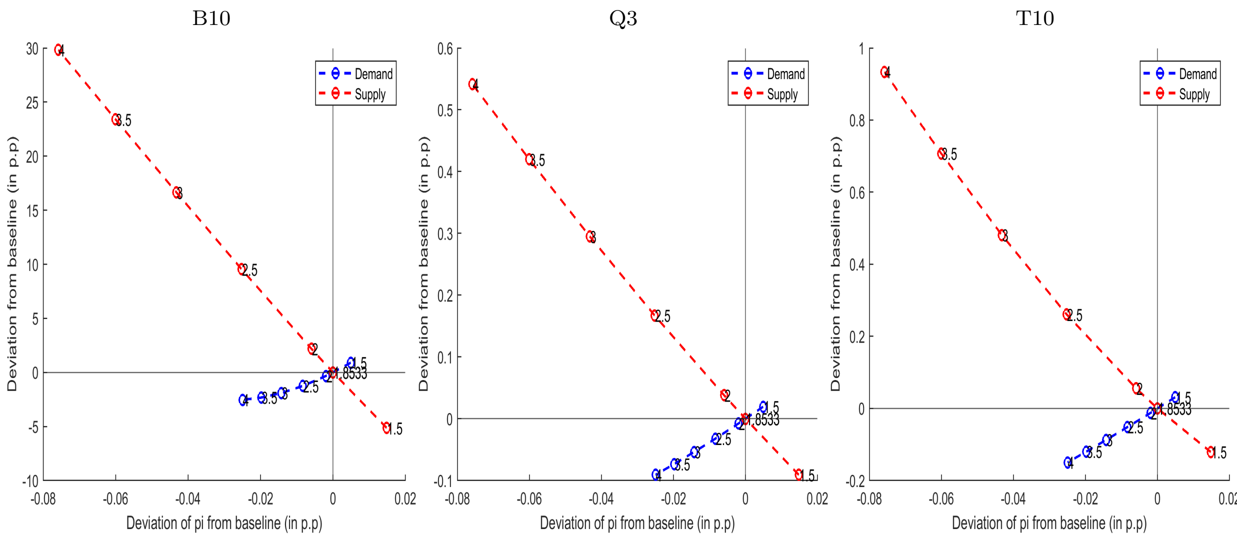
Note: Tradeoff between the standard deviation of consumption for households in the lowest tenth, third quintile, and top tenth of the wealth distribution, respectively, and the standard deviation of inflation. The curves are obtained by varying the response to inflation ϕ_π in the interest feedback rule 14. Simulations without imposing the ZLB.

Figure A4: Frontier curves: consumption vs inflation volatility by wealth—simulations without Covid or GR episodes



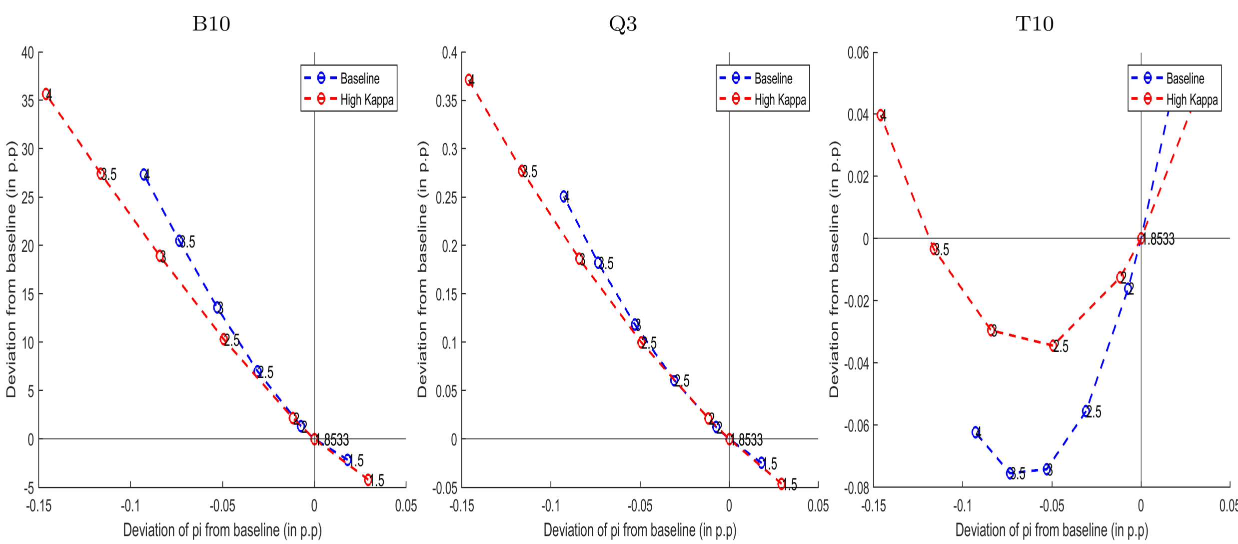
Note: Tradeoff between the standard deviation of consumption for households in the lowest tenth, third quintile, and top tenth of the wealth distribution, respectively, and the standard deviation of inflation. The curves are obtained by varying the response to inflation ϕ_π in the interest feedback rule 14. Simulations without Covid or GR episodes.

Figure A5: Frontier curves for supply and demand shocks



Note: Tradeoff between the standard deviation of consumption for households in the lowest tenth, third quintile, and top tenth of the wealth distribution, respectively, and the standard deviation of inflation, for different values of the parameter ϕ_u.

Figure A6: Frontier curves: baseline vs high PC slope—simulations without imposing the ZLB



Note: Tradeoff between standard deviation of consumption for households in the lowest tenth, third quintile, and top tenth of the wealth distribution, respectively, and standard deviation of inflation, in the baseline with Phillips curve slope $\kappa = 0.05$ (blue lines) and an alternative calibration with $\kappa = 0.1$ (red lines). Simulations without imposing the ZLB.