Intergenerational Redistribution and Monetary Policy[*]

Christian Bustamante[†]
Bank of Canada

Heejeong Kim[‡]
Concordia University

December 2021

Abstract

Monetary policy changes bring redistributive consequences. This paper investigates how these redistributive effects vary across different wealth and age groups and how persistent they are. We build a heterogeneous agent New Keynesian overlapping generations (HANK-OLG) model where households can save in both liquid and illiquid assets. The model also allows various fiscal responses to monetary surprises and isolates households' responses to a monetary policy shock from adjustments in transfers, taxes, or government spending. We find that an expansionary monetary policy shock benefits younger households as the increased aggregate economic activity boosts their labor income. In contrast, older households whose primary income source is capital income suffer from a fall in the return on assets.

Keywords: monetary policy, incomplete markets, portfolio choice, life-cycle.
JEL Codes: E21, E32, E52.

---

[*] The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the the Bank of Canada.

[†] E-mail: mail@cbustamante.co

[‡] E-mail: heejeong.kim.macro@gmail.com.

1 Introduction

Central banks have rarely considered the redistributive effects of monetary policy across households when implementing interest rate changes. However, monetary policy interventions almost inevitably lead to redistributional consequences, which disproportionately affect households with different levels of wealth and age. Some recent research has identified redistributive effects associated with monetary policy across households (see Auclert, 2019). However, most of this work has relied on models with infinitely-lived agents so that these effects tend to be short-lived.[1] Furthermore, there is little work studying the disproportionate effects of monetary policy on different age groups and how persistent they can be when households live for a finite lifetime.

To fill this gap, in this paper, we quantitatively study the redistributive effects of monetary policy across households with different ages and wealth, and across generations. In particular, we explore which age and wealth groups benefit the most following an expansionary monetary policy shock and how persistent the effects of monetary policy are when households live for a finite number of periods. Finally, we disentangle the effects of monetary policy into two channels - heterogeneous asset portfolios and life-cycle dynamics.

We build a heterogeneous agent New Keynesian overlapping generations (HANK-OLG) model. In the model, households live for a finite number of periods, giving rise to a more realistic consumption-saving behavior over their lifetime. During their working lives, households face uninsurable idiosyncratic risk alongside labor supply decisions, generating a rich distribution of households over asset holdings. As in Kaplan et al. (2018), households choose how to allocate their portfolios among two assets - liquid and illiquid assets - with a fixed cost of adjusting the illiquid asset holdings. Differences in

---

[1] Consequently, some policy-makers think about the redistributional effects of monetary policy as low-persistence, short-term fluctuations (BIS, 2021).

portfolios across households, both in size and composition, generate unequal responses to a shock as households face distinct levels of liquidity risk (Kim, 2021). In the model, inflation risk also affects households' portfolio choices. Liquid assets are nominal, and any shocks generating unexpected changes in inflation revalue households' balance sheets. An increase in inflation is beneficial for net nominal debtors as the real value of debt falls through a debt-deflation effect (Auclert, 2019).

The interaction between fiscal and monetary policies is an additional source of redistribution. Ricardian equivalence does not hold in our model, not only because of the presence of uninsurable idiosyncratic risk and occasionally binding borrowing constraints (Alves et al., 2020), but also because of its life-cycle dynamics. In our analysis, we consider various fiscal policy changes in response to monetary policy shocks, that range from keeping government debt fixed to maintaining net public expenditure constant. Crucially, this allows us to isolate the redistributive effects of monetary policy from changes in taxes or transfers that could also affect households decisions.

We calibrate the model to reproduce the most salient moments of the distribution of wealth, liquid assets, and illiquid assets in the 2007 Survey of Consumer Finances (SCF). We introduce a leptokurtic distribution of earnings shocks that matches the empirical findings in Guvenen et al. (2015). While not targeted, the model successfully explains the share of illiquid assets, as a fraction of total assets, across the distribution of households, over wealth and age, that resemble the data.

We simulate the model's response to a one-time, unexpected expansionary monetary policy shock. As discussed before, the fiscal policy response to monetary policy changes can potentially have a significant effect on how the economy and individual households respond to aggregate shocks. We start by assuming that the government keeps the supply of bonds fixed so that any changes in the government budget constraint come from adjusting the primary government deficit. This implies that the aggregate supply of liquid assets that households accumulate remains constant and that the return on liquid assets does not fall as much as when the government retires some debt. Overall, the responses of macroeconomic aggregates are similar to the ones in a standard New Keynesian model. Expansionary monetary shocks increase economic activity as interest rates fall. More importantly, wages rise with the increasing labor demand required to satisfy the aggregate demand.

Households' responses to an expansionary monetary policy shock significantly vary by their wealth and age. For example, we find that the lower return on illiquid assets mainly adversely affects old households, as they rely more on capital income from savings they accumulated over their lifetime. In contrast, younger households benefit from an expansionary monetary policy shock as it increases wages. This allows them to consume more, work less, and accumulate net worth faster than what they would have without the change in monetary policy.

The rest of the paper is structured as follows. Section 2 presents the model. Section 3 describes the calibration strategy and shows how well the model fits the observed distribution of wealth and portfolios across households of different ages and wealth. Section 4 discusses the main results of the paper. There, we show how the aggregate economy and heterogeneous households respond to monetary policy shocks. Section 5 offers some concluding remarks and proposes some ideas for future research.

2 Model

To study the effects of monetary policy across different generations, we build a heterogeneous agents New Keynesian overlapping generations (HANK-OLG) model with two assets: real illiquid asset and nominal liquid asset. The model economy is populated by (1) a measure one of overlapping generations of households, (2) a set of monopolistically competitive intermediate goods producers that face quadratic price adjustment costs (à la Rotemberg, 1982), (3) a representative final good producer that aggregates intermediate goods into the final good, (4) a perfectly competitive investment firm who owns the technology to create capital and sells shares of intermediate firms to households, (5) a monetary authority that sets the nominal interest rate following a Taylor rule, and (6) a government that sets fiscal policy and issues government debt.

2.1 Households

This is a life-cycle model where households live for a finite number of periods. Using j to index their years of life, they start working at $j = 1$, retire at J_r, and their last period is J. Households differ by age j, illiquid assets a, liquid assets b, idiosyncratic labor productivity ε, and in their subjective time discount factors $\beta \in \{\beta_l, \beta_m, \beta_h\}$.[2]

During the working lives, households face idiosyncratic productivity shocks ε and choose their labor supply n. The productivity shocks follow a Markov chain $\varepsilon \in \{\varepsilon_1, ..., \varepsilon_{n_\varepsilon}\}$, where $\Pr(\varepsilon' = \varepsilon_k | \varepsilon = \varepsilon_l) = \pi_{lk} \geq 0$ and $\sum_{k=1}^{n_\varepsilon} \pi_{lk} = 1$. After retirement, households receive lump-sum social security benefits proportional to their last earnings shock $s(\varepsilon^{Jr-1}) = \varsigma_s w \varepsilon^{Jr-1}$ with replacement rate ς_s.[3]

Households can save using two assets: high-yield illiquid assets a and low-yield nominal liquid assets b. The real return on illiquid assets r^a is higher than the real interest rate on liquid assets r^b. Following Kim (2021), adjusting illiquid assets involves

---

[2] We assume that $\beta \in \{\beta_l, \beta_m, \beta_h\}$ is uniformly distributed. Note that, for each household, a time discount factor is fixed over its lifetime. Preference heterogeneity is introduced to match the observed distribution of wealth, as in Krusell and Smith (1998) and Krueger et al. (2016).

[3] In the U.S., social security benefits are paid based on the average of the highest 35 years of earnings by the Social Security Administration (SSA). In the model, calculating the average earnings requires one more state variable, making computation more challenging. Given the high persistence of earnings, I proxy the history of earnings over a worker's life-cycle using the level of earnings in the last working period.

the following fixed adjustment cost

$$\xi\left(\kappa, a\right) = \xi_0 + \xi_1 \left|\kappa\right| a \tag{1}$$

where $\kappa = \frac{a}{a+b}$. Households paying these costs adjust illiquid wealth to the desired value; otherwise, the ex-post return on illiquid assets and principal are re-invested in illiquid assets. Borrowing is only allowed in the liquid asset and is subject to the borrowing limit $\underline{b}$.

Each period, a household makes the following discrete portfolio adjustment choice

$$v_j\left(a, b, \varepsilon, \beta\right) = \max\left\{v_j^a(a, b, \varepsilon, \beta), v_j^n(a, b, \varepsilon, \beta)\right\} \tag{2}$$

where v_j^a is the value of a household adjusting its illiquid assets, while v_j^n is the value when a household dose not adjust its illiquid assets.

The Bellman equation of a household that adjusts its illiquid asset holdings is given by

$$\begin{aligned} v_j^a\left(a, b, \varepsilon, \beta\right) &= \max_{\{c, n, a', b'\}} u\left(c, n\right) + \beta E_\varepsilon\left[v_{j+1}\left(a', b', \varepsilon, \beta\right)\right] \\ \text{s.t.} \quad & c + a' + b' \leq (1 + r^a)a + (1 + r^b)b + x - \xi\left(\kappa, a\right) \\ x &= \begin{cases} (1 - \tau_n)\varepsilon w n & \text{if } j < J_r \\ (1 - \tau_n)s(\varepsilon^{Jr-1}) & \text{otherwise} \end{cases} \\ b' &\geq \underline{b}, \quad a' \geq 0, \quad c \geq 0, \quad n \geq 0 \end{aligned} \tag{3}$$

where x is labor income before retirement and social security income after retirement, that are taxed at τ_n.

Similarly, the Bellman equation of a household that dose not adjust illiquid assets is given by

$$v_j^n\left(a,b,\varepsilon,\beta\right) = \max_{\{c,n,b'\}} u\left(c,n\right) + \beta E_\varepsilon\left[v_{j+1}\left(a',b',\varepsilon,\beta\right)\right] \tag{4}$$

$$\text{s.t.} \quad c + b' \leq (1+r^b)b + x$$

$$x = \begin{cases} (1-\tau_n)w\varepsilon n & \text{if } j < J_r \\ (1-\tau_n)s(\varepsilon^{Jr-1}) & \text{otherwise} \end{cases}$$

$$a' = (1+r^a)a$$

$$b' \geq \underline{b}, \quad c \geq 0, \quad n \geq 0.$$

2.2 Final goods produces

A competitive representative final good firm produces a homogeneous output Y_t by aggregating intermediate goods, indexed by $i \in [0,1]$, using a standard Dixit-Stiglitz aggregator

$$Y_t = \left[\int_0^1 y_{i,t}^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}} \tag{5}$$

where $\theta > 0$ is the elasticity of substitution. The profit maximization problem of this firm implies a demand for each variety $i \in [0,1]$ as

$$y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} Y_t, \text{ where } P_t = \left(\int_0^1 P_{i,t}^{1-\theta} di\right)^{\frac{1}{1-\theta}}. \tag{6}$$

Here, P_t is the aggregate price index and $P_{i,t}$ is the price of intermediate good i.

2.3 Intermediate goods producers

Each intermediate good $i \in [0,1]$ is produced by a monopolistic competitive firm. An intermediate good producer hires capital $k_{i,t}$ and labor $n_{i,t}$ from competitive markets and produces output using the CRS production function

$$y_{i,t} = k_{i,t}^{\alpha} n_{i,t}^{1-\alpha}. \tag{7}$$

Given the competitive capital and labor markets, all the intermediate firms face a common rental rate of capital r_t^k and real wage w_t. This leads all intermediate firms to face the same real marginal cost

$$\varphi_t = \left(\frac{r_t^k}{\alpha}\right)^{\alpha} \left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}. \tag{8}$$

We assume that intermediate firms set the price of their goods subject to a quadratic price adjustment cost à la Rotemberg (1982)

$$\frac{\psi_p}{2}\left(\frac{P_{i,t}}{P_{i,t-1}} - 1\right)^2 Y_t. \tag{9}$$

Then, the profit maximization problem of an intermediate firm is given by

$$\max_{\{P_{i,t}\}} E_0 \sum_{t=0}^{\infty} \left(\frac{1}{1+r_{0,t}^a}\right) \left\{ \left(\frac{P_{i,t}}{P_t}\right)^{1-\theta} Y_t - \varphi_t \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} Y_t - \frac{\psi_p}{2}\left(\frac{P_{i,t}}{P_{i,t-1}} - 1\right)^2 Y_t \right\} \tag{10}$$

where $\left(1 + r_{0,t}^a\right) \equiv \prod_{\tau=0}^{t} \left(1 + r_t^a\right)$.[4]

---

[4] An intermediate firm discounts its future profit by the return on illiquid wealth r_t^a. This will be justified in Subsection 2.4.

Solving the price-setting problem, we derive the nonlinear forward-looking New Keynesian Phillips curve

$$\pi_t\left(1+\pi_t\right)=\left(\frac{1-\theta}{\psi_p}\right)+\left(\frac{\theta}{\psi_p}\right)\varphi_t+E_t\left(\frac{1}{1+r_{t+1}^a}\right)\pi_{t+1}\left(1+\pi_{t+1}\right)\frac{Y_{t+1}}{Y_t} \tag{11}$$

where $\pi_t=\frac{P_t}{P_{t-1}}-1$ is the net inflation rate.[5]

2.4 Competitive investment firm

Following Alves et al. (2020) and Kim (2021), we assume that a competitive investment firm owns technology that creates capital and rents its capital to an intermediate producer firm at a rental rate r^k. The investment firm faces a convex capital adjustment cost

$$\Phi\left(k',k\right)=\left(\frac{k'-k}{k}\right)^2 k.$$

An investment firm also sells shares of future monopoly profits s_t to households at an ex-dividend price q_t.

Below, I explicitly describe the optimization problem of the investment firm

$$\begin{aligned}J\left(k_t,s_t\right)=\max_{\{k_{t+1},s_{t+1}\}}\Bigg(&\left(r_t^k+1-\delta\right)k_t-\Phi\left(k_{t+1},k_t\right)+\left(q_t+\Pi_t\right)s_t\\&-k_{t+1}-q_t s_{t+1}+\frac{1}{1+r_t^a}J\left(k_{t+1},s_{t+1}\right)\Bigg)\end{aligned} \tag{12}$$

where Π_t is the monopoly profit.

---

[5] The derivation is available in Appendix A.

Given the free allocation of resources between capital and shares, the return on equity must be the same as the return on capital.[6]

$$\frac{\Pi_{t+1}+q_{t+1}}{q_t}=\frac{\left(r^k_{t+1}+1-\delta\right)-\Phi_2\left(k_{t+2},k_{t+1}\right)}{1+\Phi_1\left(k_{t+1},k_t\right)}\equiv 1+r^a_t \tag{13}$$

where $\Phi_1=\partial\Phi(k',k)/\partial k'$ and $\Phi_2=\partial\Phi(k',k)/\partial k$. Iterating Eq. (13) forward, the price of shares is $q_t=\sum_{s=0}^{\infty}\left[\prod_{\tau=0}^{s}\left(\frac{1}{1+r^a_{t+\tau}}\right)\right]\Pi_{t+s}$. This validates the use r^a_t as the discount factor for intermediate goods producers.

2.5 Monetary authority

We assume that monetary policy follows a conventional Taylor rule for the nominal interest rate on liquid assets

$$\left(\frac{1+i_t}{1+\bar{i}}\right)=\left(\frac{1+\pi_t}{1+\overline{\pi}}\right)^{\phi_\pi}\exp\left(\epsilon^i_t\right) \tag{14}$$

where $\phi_\pi>1$. Here, $\bar{i}$ is the steady-state nominal interest rate, $\overline{\pi}$ is the inflation target, and ϵ^i_t is a monetary policy shock.[7] The real return on liquid assets is given by the Fisher equation: $r^b_t=i^b_t-\pi_t$.

2.6 Government

The government supplies liquid assets B_t as a form of government bond.[8] Labor income and social security benefits are taxed at $\tau_n>0$. Government revenues are used to finance social security benefit payments, interest payments on debt, and government spending

---

[6] As pointed out by Kaplan et al. (2018), a no-arbitrage condition between capital and shares eliminates the need to separately model capital and equity for a households problem.

[7] Note that $\epsilon^i_t=0$ in the steady state. We also assume that the inflation target is 0 in the steady state.

[8] If $B_t<0$, it is government debt.

$G_t \geq 0$. Every period, the government budget constraint holds:

$$\left(1+r_t^b\right) B_t + G_t + \underbrace{\sum_{j=J_r}^{J} \int s\left(\varepsilon\right) \mu_t}_{T \equiv \text{transfers}} = \underbrace{\tau_n \left(\sum_{j=1}^{J_r-1} \int w_t n_t \varepsilon \mu_t + \sum_{j=J_r}^{J} \int s_t\left(\varepsilon\right) \mu_t \right)}_{\Psi \equiv \text{taxes}} + B_{t+1} \tag{15}$$

where μ_t is the distribution of households defined over $(j, a, b, \varepsilon, \beta)$.

3 Taking the model to the data

In this section, we describe how we discipline our model using the data. We first discuss our calibration strategy. Next, we explain how we estimate the earnings shock process. Finally, we demonstrate that the model can explain the observed distribution of wealth, illiquid wealth, and liquid wealth as well as a realistic portfolio choice behavior of households of different wealth and age.

3.1 Calibration

We assume that a model period is one year and calibrate the model economy to the 2007 U.S. data.[9] Households enter the labor market at age 25, retire at age 65, and live until age 84 with certainty.

Households face a additive separable utility function

$$u\left(c, n\right) = \frac{c^{1-\sigma}}{1-\sigma} - \psi_l \frac{n^{1+\nu}}{1+\nu}$$

---

[9] In the real world, monetary policy changes at a higher frequency than a year. However, given that the model has a deterministic life-cycle, calibrating the model at a higher frequency requires a large state space for age, leading to the curse of dimensionality. Stochastic aging may alleviate the issue. (TBA)

with the coefficient of relative risk aversion γ set to 2. As shown in Table 2, we calibrate ψ_l and ν to match the male average hours worked and Frisch elasticity of male labor supply. The replacement rate of social security benefits ς_s is 40% of average pre-tax earnings. Labor income is taxed at 27% (Domeij and Heathcote, 2004).

For the production, the elasticity of substitution for a final good producer θ is set to 10 to imply a 11 percent of markup in the steady-state.[10] Following Kaplan et al. (2018), the parameter ψ_p for the price adjustment cost function for intermediate firms is set to 100. The capital share of output is $\alpha = 0.36$, and the annual depreciation rate of capital is $\delta = 0.069$. We set the steady-state inflation rate to zero and the real return on liquid assets to 1%. Lastly, we set the Taylor rule ϕ_π to 1.5. See Table 1 for the summary of parameters set outside the model.

Table 1: Parameters set externally

Parameters	Value	Description
σ	Coefficient of relative risk aversion	2.0
ς_s	Replacement rate of social security benefits	0.4
τ_n	Labor income tax rate	0.26
α	Capital income share	0.36
δ	Capital depreciation rate	0.069
θ	Elasticity of substitution (Kaplan et al., 2018)	10.0
ψ_p	Price adjustment cost (Kaplan et al., 2018)	100
$\underline{b}$	Borrowing limit	-0.05
ϕ_π	Taylor rule coefficient (Kaplan et al., 2018)	1.5

Next, we calibrate seven parameters to match seven moments in data as shown in Table 2. We first calibrate the model economy to match the illiquid wealth-to-output ratio of 2.8. Following Kaplan et al. (2018), illiquid wealth is measured as the sum of business equity, stocks, and net equity in non-residential real estate as well as net housing and net consumer durables.[11] Liquid assets include all deposits in transaction accounts

---

[10] The steady-state mark up is $\frac{\theta}{\theta-1}$.

[11] Stocks are considered illiquid, as most of them are held in retirement accounts or involve management fees. Following Glover et al. (2020), money market mutual funds and quasi-liquid retirement accounts are included in stocks. To be consistent with the model economy, which does not involve collateralized

(checking, savings, money market accounts, and call accounts), certificates of deposits, savings bonds, and directly held bonds minus revolving consumer credit. Given that a sampling unit in the SCF is a household, the total value of illiquid assets is divided by the average family size in 2007 to make it comparable to GDP per capita. The calibrated economy gives rise to a 5% return on illiquid wealth in the steady state when a 1% return on liquid wealth is targeted.

Table 2: Calibrated parameters

Parameters	Moments to match	Data	Model
β_l	Illiquid wealth to output ratio	2.80	2.73
β_m	Share of liquid asset to output	0.25	0.25
β_h	Share of hhs holding illiquid wealth	0.80	0.79
ξ_0	Fraction of hhs with positive illiquid wealth but no liquid wealth	0.22	0.08
ξ_1	Fraction of hhs holding zero or negative net worth	0.10	0.18
ψ_l	Average hours worked	0.33	0.33
ν	Frisch elasticity of labor supply	0.48	0.50

Lastly, the model economy is also calibrated to match the two types of liquidity-constrained households: households with positive illiquid wealth but no liquid wealth (wealthy hand-to-mouth households) and households with zero or negative net worth (poor hand-to-mouth households).[12]

3.2 Earnings shock process

We introduce a leptokurtic distribution of earnings shocks that matches the recent evidence from Guvenen et al. (2015) using the approach in Khan and Lidofsky (2019) and

---

borrowing, I measure residential property net of all debt secured by residential property (mortgages, home equity loans, and HELOCs) as illiquid wealth, as in Kaplan and Violante (2014). Using the net value of housing wealth, I abstract from the issuance of home equity loans, which provide liquidity. Introducing home equity loans in the model would provide an additional incentive to hold illiquid assets, making households somewhat less responsive to the fall in their expected return.

[12] These liquidity-constrained households are comparable to the poor and wealthy hand-to-mouth households defined in Kaplan and Violante (2014) and Kaplan et al. (2018). Kaplan and Violante (2014) define wealthy hand-to-mouth households as those with liquid wealth less than half of their earnings but holding positive balances of illiquid wealth. I instead define wealthy hand-to-mouth households as those with no liquid wealth but with positive illiquid wealth.

Kaplan et al. (2018). I assume that individual idiosyncratic earnings shock ε consists of two processes:

$$\log \varepsilon = \log \varepsilon_1 + \log \varepsilon_2$$

$$\log \varepsilon_i' = \rho_i \log \varepsilon_i + \zeta_i, \; i = 1, 2,$$

where $\zeta_i \sim N\left(0, \sigma_i^2\right)$ is a jump process with an arrival rate of ν_i. Khan and Lidofsky (2019) and Kaplan et al. (2018) estimate these earnings shock processes to match eight key moments on male earnings in Guvenen et al. (2015) (see Table 4). The parameters, estimated for this earnings shock process in Khan and Lidofsky (2019), which is also an annual model, are summarized in Table 3.

Table 3: Earnings shock process estimates

ρ_1	ρ_2	ν_1	ν_2	σ_1	σ_2
-0.05	0.97	0.016	0.695	2.61	0.22

Khan and Lidofsky (2019)

Table 4 compares eight moments of the male earnings distribution in Guvenen et al. (2015) to those from the estimated earnings shock process. Following the approach in Khan and Lidofsky (2019), we discretize this estimated continuous process as a finite-state Markov chain. For comparison, the simulated 8 moments from discretized process are also listed in the right column of Table 4.

3.3 Distribution of wealth and portfolio choice

To show how well the model explains the wealth inequality, Table 5 compares the distribution of net worth, illiquid wealth, and liquid wealth in the 2007 SCF to those in the benchmark economy. The model economy reproduces much of the dispersion in wealth and illiquid wealth without targeting.

Table 4: Moments of the earnings distribution

	Guvenen et al. (2015)	Continuous	Discrete
Variance annual log earnings	0.70	0.70	0.70
Variance 1 year change	0.23	0.26	0.26
Variance 5 year change	0.46	0.38	0.63
Kurtosis 1 year change	17.80	17.81	17.7
Kurtosis 5 year change	11.60	11.60	11.65
Fraction 1 year $\leq$ 10%	0.54	0.53	0.56
Fraction 1 year $\leq$ 20%	0.71	0.72	0.66
Fraction 1 year $\leq$ 50%	0.86	0.96	0.94

Khan and Lidofsky (2019)

Table 5: Distribution of net worth, illiquid wealth, and liquid wealth

Net worth	Q1	Q2	Q3	Q4	Q5	≤ 0	Gini
2007 SCF	-0.3	1.4	5.7	14.1	79.1	10.0	0.78
Benchmark	-0.0	0.3	3.6	15.6	80.8	18.0	0.77
Illiquid wealth	Q1	Q2	Q3	Q4	Q5		Gini
2007 SCF	0.1	1.6	5.9	14.4	78.0		0.76
Benchmark	0.0	0.2	3.5	15.5	80.8		0.77
Liquid wealth	Q1	Q2	Q3	Q4	Q5		Gini
2007 SCF	-7.4	0.0	1.1	7.6	99.0		0.91
Benchmark	-5.9	-2.3	1.9	11.1	95.3		0.86

Note: Table 5 shows the share of net worth, illiquid wealth, and liquid wealth across wealth quintiles. It also reports the fraction of households with zero or negative net worth and the Gini coefficients in the 2007 SCF and model economies.

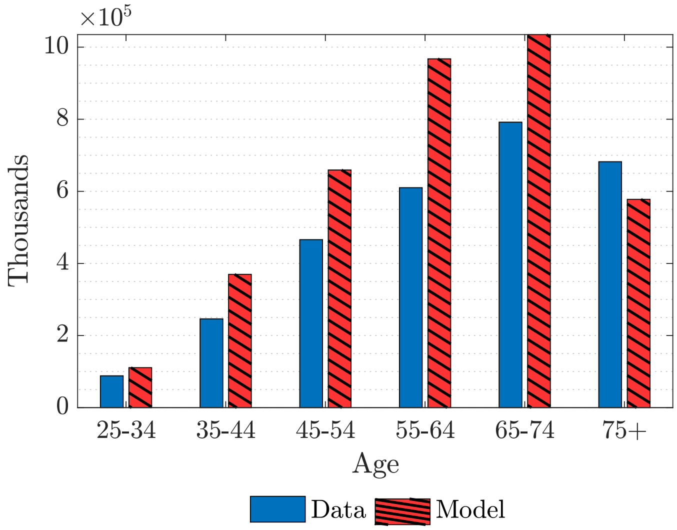
Figure 1 compares the average level of households' wealth in the data to those in the model over age groups. Although there is a relatively fast de-accumulation of wealth for the old in the model compared to the data, the hump-shaped life-cycle profile of wealth in the model aligns well with that in the data.[13]

The calibrated model is also broadly consistent with portfolio choice behavior of households. To show this, Figure 2 shows the fraction of households holding positive illiquid asset over wealth quintiles (left panel) and over age groups (right panel) in the

---

[13] Without any mortality risk and bequest motive, it is hard to explain households' savings behavior after retirement. See De Nardi (2004) and De Nardi et al. (2016) for further discussion.

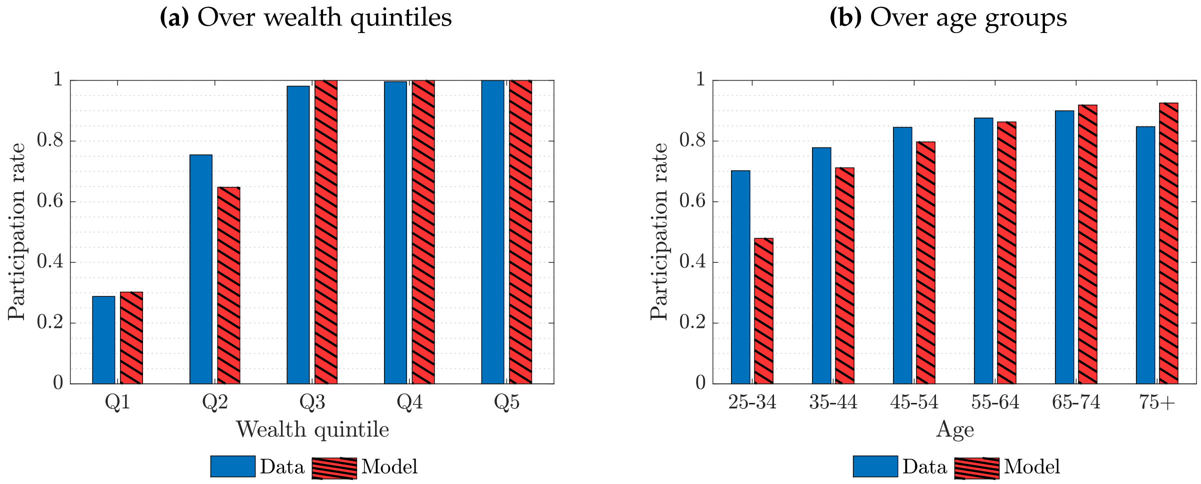
Figure 1: Average net worth over age groups



Note: The average level of wealth over age groups in the 2007 SCF (blue bars) and the benchmark economy (red bars). The wealth is expressed in 2009 U.S. dollars.

model to those in the 2007 SCF data. The model successfully explains the increasing illiquid asset market participation rate in wealth and age without targeting.

Figure 2: Participation rate in illiquid asset market

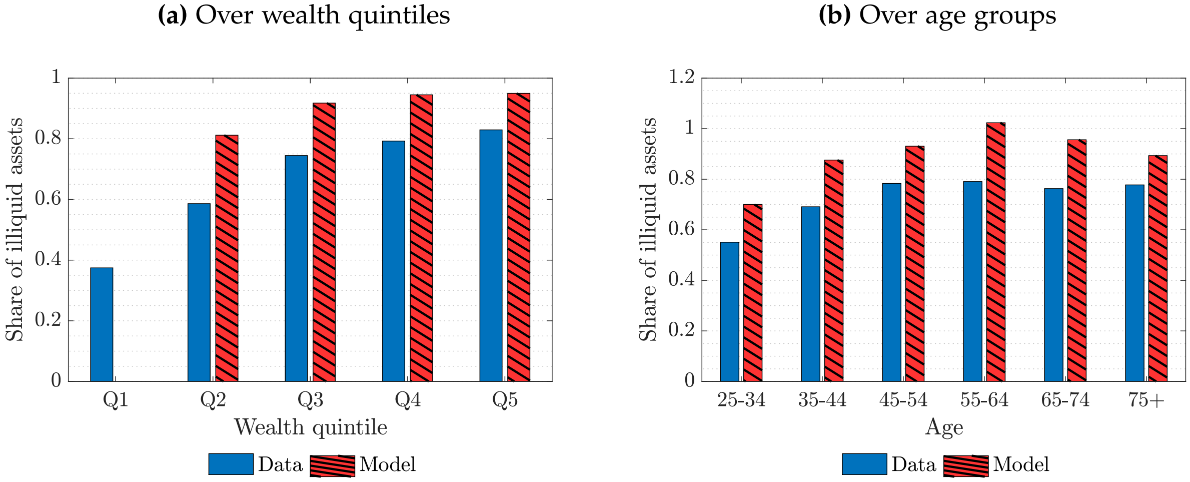

(a) Over wealth quintiles

(b) Over age groups

Note: Participation rate in illiquid asset market over wealth quintiles in the 2007 SCF (blue bars) and the benchmark economy (red bars).

Figure 3 shows the average shares of illiquid assets to total assets over wealth quintiles (left panel) and age groups (right panel) in the model and in the 2007 SCF data. Wealthy households hold more of their savings in illiquid assets as they pay a higher return and the households can afford adjustment costs more easily. The model also successfully reproduces the observed increasing share of risky illiquid assets for the young until the age 64 and the subsequent decline after retirement.

Figure 3: Share of illiquid assets to total assets


(a) Over wealth quintiles

(b) Over age groups

Note: The average shares of illiquid assets as a fraction of total assets over wealth quintiles in the 2007 SCF (blue bars) and the benchmark economy (red bars).

4 Quantitative results

To study redistributive effects of monetary policy, we simulate the model economy with a one-time, unexpected expansionary monetary policy shock. This section discusses how aggregates and heterogeneous households respond to this monetary shock. As for now, preference heterogeneity is removed for the results presented below. We assume that the total supply of government bonds remains fixed at its stationary equilibrium level B.

From (15), this implies that

$$r_t^b B_t + G_t + T_t = \Psi_t$$

4.1 Aggregate responses

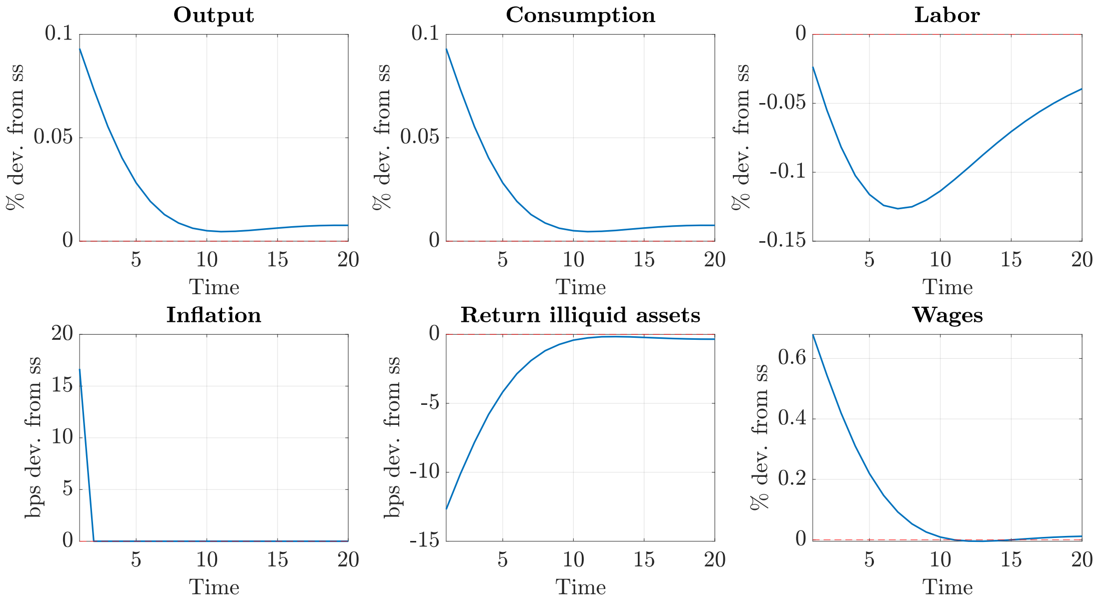
Figure 4 shows the responses of macroeconomic aggregates and prices to an expansionary 25 basis-point monetary policy shock. Similar to a canonical New Keynesian model, this monetary shock decreases interest rates, raises inflation, and boosts consumption and total output. Given that we are assuming a constant government debt, the contraction in the rate of return on illiquid assets is more moderated compared to a situation in which the government was able to adjust the supply of bonds downwards.

Wages also rise as firms increase their demand for labor, and households are less willing to work because of income effects associated with the monetary easing. As shown below, the increase in earnings benefits younger and less wealthy households as they have higher marginal propensities to consume and are more liquidity constrained.

4.2 Responses by age groups

How does an expansionary monetary policy shock affect households with different levels of wealth and age? To answer this question, we simulate a large number of households and track their consumption, savings, labor supply, and portfolio composition over the transition. Figure 5 presents the percentage change in average consumption and net worth across different age groups with a monetary shock relative to when there is no monetary change. Here, the composition of households in each age group remains the same along the transition. Note that the response of households that are 75 years old or more at the impact date stops at year 10, as that is how many years they have left in their

Figure 4: Responses of aggregate variable to monetary shock

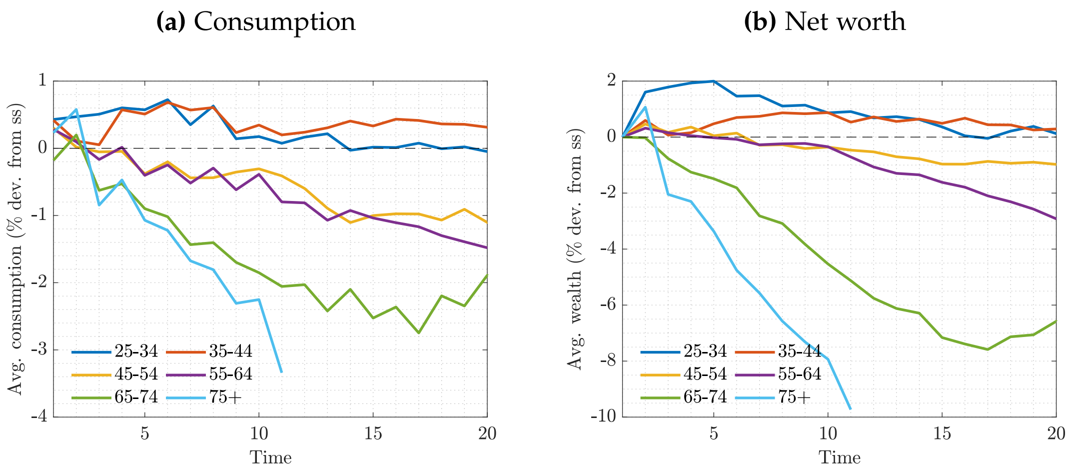


Note: Responses of aggregates to a one-time, unexpected 25 bps expansionary monetary policy shock while assuming perfect foresight.

lifetime when the monetary shock hits. Something similar happens with the following ages groups every decade.

We find that an expansionary monetary policy shock benefits younger households the most. Although most households increase their consumption on the impact date, the monetary policy shock has persistent positive effects on households who are between 25 and 44 years old. High labor earnings from an expansionary monetary policy allow them to increase their consumption, as shown in Figure 5(a). They also save a fraction of these additional earnings, leading to faster growth in the net worth over their lifetime than without a monetary policy shock (see Figure 5(b)). In contrast, households aged 65 or more lose the most, as they are retired and rely heavily on capital income. When the returns on liquid and illiquid assets fall, their disposable income shrinks, and they have to reduce consumption as their net worth contracts rapidly.

Figure 5: Responses to monetary policy shock by age groups


(a) Consumption

(b) Net worth

Note: Responses of average consumption and average net worth by age groups. Age groups are fixed to the ones on the impact date.

Table 6: Changes over remaining lifetime by age groups

	25-34	**35-44**	**45-54**	**55-64**	**65-74**	**75+**
Consumption	0.12	0.25	-0.87	-0.78	-1.31	-0.7
Labor	-0.08	-0.1	0.1	0.09	-	-
Net worth	0.51	0.22	-0.81	-0.72	-2.06	-1.8

Note: Percentage change in cumulative average consumption, labor and net worth over the entire lifetime of households in each age group. Households 65-74, and 75+ have already retired from the labor market. Age groups are fixed to the ones on the impact date.

The results in Figure 5 provide a good picture of how households change their consumption-saving behavior period by period. However, it is also important to understand how persistent those effects are and if the changes we observe at the impact date can be offset later in life. To measure how much of these responses persist in households' lifetime, Table 6 presents percentage changes in the average lifetime consumption, labor, and net worth across different age groups. Along the transition in Figure 5, Table 6 shows that younger households increase their lifetime consumption and accumulate more net worth following an expansionary monetary policy shock. Furthermore, Table 6 shows that monetary shocks have long-lasting effects on households in contrast to the prediction in an infinite-live horizon model without life-cycle features.

5 Concluding remarks

In this paper, we discuss the redistributive effect associated with monetary policy. In particular, we focus on the role of the life cycle in transmitting the effects of monetary shocks to different groups of households. We build a New Keynesian overlapping generations model where heterogeneous households face uninsurable idiosyncratic risk and can save in liquid and illiquid assets.

Using our model, we find that monetary policy has redistributive effects among different age groups, and that those effects tend to persist over time. In particular, younger households benefit from expansionary monetary policy shocks, as labor income increases with a boost in economic activity from a monetary easing. In contrast, older households, which tend to hold more financial assets, experience a contraction in their capital income that forces them to reduce consumption and deplete their savings more rapidly.

References

Alves, F., G. Kaplan, B. Moll, and G. L. Violante (2020). A Further Look at the Propagation of Monetary Policy Shocks in HANK. *Journal of Money, Credit and Banking 52*(S2), 521–559.

Auclert, A. (2019). Monetary Policy and the Redistribution Channel. *American Economic Review 109*(6), 2333–67.

BIS (2021). Annual Economic Report 2021. Technical report, Bank for International Settlements.

De Nardi, M. (2004). Wealth Inequality and Intergenerational Links. *The Review of Economic Studies 71*(3), 743–768.

De Nardi, M., E. French, and J. B. Jones (2016). Savings After Retirement: A Survey. *Annual Review of Economics 8*, 177–204.

Domeij, D. and J. Heathcote (2004). On the Distributional Effects of Reducing Capital Taxes. *International Economic Review 45*(2), 523–554.

Glover, A., J. Heathcote, D. Krueger, and J.-V. Ríos-Rull (2020). Intergenerational Redistribution in the Great Recession. *Journal of Political Economy 128*(10), 3730–3778.

Guvenen, F., F. Karahan, S. Ozkan, and J. Song (2015). What Do Data on Millions of U.S. Workers Reveal about Life-Cycle Earnings Risk? *NBER Working Papers 20913*.

Holm, M. B., P. Paul, and A. Tischbirek (2021). The Transmission of Monetary Policy under the Microscope. *Journal of Political Economy 129*(10), 2861–2904.

Kaplan, G., B. Moll, and G. L. Violante (2018). Monetary Policy According to HANK. *American Economic Review 108*(3), 697–743.

Kaplan, G. and G. L. Violante (2014). A Model of the Consumption Response to Fiscal Stimulus Payments. *Econometrica 82*(4), 1199–1239.

Khan, A. and B. Lidofsky (2019). Growth, Uncertainty and Business Cycles in an Overlapping Generations Economy. In *2019 Meeting Papers*, Number 1459. Society for Economic Dynamics.

Kim, H. (2021). Inequality, Disaster Risk, and the Great Recession. *Review of Economic Dynamics*.

Krueger, D., K. Mitman, and F. Perri (2016). Macroeconomics and Household Heterogeneity. In *Handbook of Macroeconomics*, Volume 2, pp. 843–921. Elsevier.

Krusell, P. and A. A. Smith, Jr (1998). Income and Wealth Heterogeneity in the Macroeconomy. *Journal of Political Economy 106*(5), 867–896.

Rotemberg, J. J. (1982). Sticky Prices in the United States. *Journal of Political Economy 90*(6), 1187–1211.

A Derivation of New Keynesian Phillips curve

The first-order condition of equation Eq. (11) is

$$(\theta - 1)\left(\frac{P_{i,t}}{P_t}\right)^{-\theta}\frac{Y_t}{P_t} = \theta\varphi_t\left(\frac{P_{i,t}}{P_t}\right)^{-\theta-1}\frac{Y_t}{P_t} - \psi_p\left(\frac{P_{i,t}}{P_{i,t-1}} - 1\right)\frac{Y_t}{P_{i,t-1}} \tag{A.1}$$

$$+ E_t\left(\frac{1}{1+r^a_{t+1}}\right)\psi_p\left(\frac{P_{i,t+1}}{P_{i,t}} - 1\right)\frac{P_{i,t+1}}{P_{i,t}}\frac{Y_{t+1}}{P_{i,t}} \tag{A.2}$$

Imposing a symmetric equilibrium condition $P_{i,t} = P_t$ for all $i \in [0,1]$ and $\pi_t = \frac{P_t}{P_{t-1}} - 1$, the equation (A.2) can be written as

$$(\theta - 1)\frac{Y_t}{P_t} = \theta\varphi_t\frac{Y_t}{P_t} - \psi_p\pi_t\frac{Y_t}{P_{t-1}} + E_t\left(\frac{1}{1+r^a_{t+1}}\right)\psi_p\pi_{t+1}(1+\pi_{t+1})\frac{Y_{t+1}}{P_t} \tag{A.3}$$

$$(\theta - 1) = \theta\varphi_t - \psi_p\pi_t(1+\pi_t) + E_t\left(\frac{1}{1+r^a_{t+1}}\right)\psi_p\pi_{t+1}(1+\pi_{t+1})\frac{Y_{t+1}}{Y_t} \tag{A.4}$$

The New Keynesian Phillips curve is

$$\pi_t(1+\pi_t) = \left(\frac{1-\theta}{\psi_p}\right) + \left(\frac{\theta}{\psi_p}\right)\varphi_t + E_t\left(\frac{1}{1+r^a_{t+1}}\right)\pi_{t+1}(1+\pi_{t+1})\frac{Y_{t+1}}{Y_t} \tag{A.5}$$

At the stationary equilibrium,

$$\overline{\pi}(1+\overline{\pi}) = \frac{1+r^a}{r^a}\left[\left(\frac{1-\theta}{\psi_p}\right) + \left(\frac{\theta}{\psi_p}\right)\overline{\varphi}\right] \tag{A.6}$$

where $\overline{x}$ is the steady-state value for a variable x.