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Contents

Abstract

We study the distributional consequences of the recent inflationary surge and the subsequent monetary policy response in the euro area. Using an estimated two-asset Heterogeneous Agent New Keynesian model with an overlapping generations structure, we analyze the macroeconomic shocks driving inflation between 2021 and 2022. We find that these shocks generated substantial redistribution from young and poor households toward older and wealthier ones. By keeping interest rates unchanged until mid-2022, monetary policy largely offset these distributional effects. A policy response based solely on a standard Taylor rule would have failed to mitigate the redistribution.

JEL codes: E31, E52, E58, D31

Keywords: Monetary policy, Redistribution, HANK, OLG, Euro area, Great Inflation

1 Introduction

In 2021–22, the euro area economy was hit by large inflationary shocks of unprecedented scale and nature. This episode had the potential to generate substantial distributional effects, with large and heterogeneous impacts on the wealth and welfare of different households. At the same time, monetary policy tightened only from mid-2022 onward, when inflation had already exceeded 8%. Who gained and who lost as a result of these macroeconomic developments? What were the main drivers and channels of redistribution? And did the timing of the monetary policy response amplify or mitigate these effects? In this paper, we examine the sources of redistribution during the 2021–22 inflation surge, with particular emphasis on the role played by monetary policy.

We find that, in the absence of expansionary monetary policy, the 2021–22 inflationary episode would have generated significant redistributive effects, benefiting older and richer households at the expense of younger and poorer ones. The mechanism is straightforward: inflation erodes real disposable income, a channel to which younger and poorer workers are disproportionately vulnerable. In contrast, older and wealthier households hold a large share of real assets, which partially insulate them from the adverse effects of inflationary shocks. By keeping interest rates unchanged, however, monetary policy almost completely offset the redistribution generated by other macroeconomic forces. Unlike the inflationary shocks that hit the economy during this period, loose monetary policy—by supporting labor income and depressing asset returns—redistributes toward younger and poorer households. Although counteracting the redistributive effects of macroeconomic shocks comes at the cost of higher inflation, our findings align with the literature on optimal monetary policy, which argues that central banks should mitigate redistribution to some extent.[1]

To address the problem, we develop and estimate a medium-scale heterogeneous-agent new Keynesian model (HANK) with an overlapping generations (OLG) dimension. In our model, households enter the economy at age 20, and decide each period how much to consume and to save in liquid and illiquid assets. Households are subject to idiosyncratic labor productivity and mortality shocks, both of which have an age-dependent component. At age 65, households retire and begin receiving government pension benefits, as well as dividends from their illiquid assets. Illiquid assets therefore partly represent long-term retirement savings—such as pension funds—while liquid assets are available for short-term consumption smoothing. Households are assumed to live for at most 100 years. We calibrate the model's household structure to match the

[1] See Gornemann et al. (2016); Acharya et al. (2023); Bhattarai et al. (2023); Davila and Schaab (2023); Bilbiie et al. (2024).

life-cycle profile of asset accumulation in the euro area as documented by the Household Finance and Consumption Survey, which is essential for analyzing redistribution across cohorts. The model also performs well in replicating marginal propensities to consume (MPC) out of both disposable income and capital gains, which are key moments for understanding the transmission of different shocks to consumption.

Beyond the rich household structure, our model features the standard building blocks of medium-scale DSGE models.[2] Nominal rigidity arises through both price and wage stickiness: firms set prices subject to Calvo (1983) frictions, and unions face an analogous friction when setting nominal wages. Capital goods producers operate under to convex adjustment costs, and final goods producers combine capital and labor using a Cobb-Douglas production function subject to total factor productivity (TFP) shocks. There is a monetary authority that sets nominal interest rates according to a Taylor (1993) rule, and a fiscal authority that chooses taxes to finance government consumption, transfers to households, and to service public debt. Finally, a financial intermediary holds firm equity and government debt and supplies liquid and illiquid assets to households.

Next, we estimate our model, which allows us to credibly recover the set of shocks that affected the euro area economy during the recent inflationary episode. We linearize the model around its deterministic steady state using the Sequence-Space Jacobian method (Auclert et al., 2021). The model is specified at annual frequency and includes eight aggregate shocks. We estimate it using eight macroeconomic time series over the 2000–2023 period. To address the limited number of observations—only 24 data points per variable—we estimate only the parameters governing the exogenous shock processes, namely their persistence and standard deviations, a procedure that is highly efficient in sequence space.[3] All other parameters are either calibrated to match microdata on household balance sheets and inequality or taken directly from the existing literature.

With the estimated model in hand, we conduct the following exercise. First, we filter the underlying shocks that drove the economy over our sample period and find that monetary and price-markup shocks were the main contributors to inflation in 2021–22. We then examine the welfare effects of these macroeconomic shocks across cohorts and wealth deciles, showing that, in the absence of expansionary monetary shocks, the period would have featured a strong redistribution from younger and poorer households toward older and wealthier ones. However, by keeping interest rates low for an extended period, monetary policy largely offset this redistribution.

[2] See Smets and Wouters (2007a).

[3] As shown in Auclert et al. (2021) and discussed in more detail later, it is only necessary to solve the model once to estimate shock processes with the Sequence Space Jacobian.

To better understand the mechanisms behind this result, we decompose the welfare effects of macroeconomic shocks into five channels: liquid returns, illiquid returns, labor income and pensions, taxes, and government transfers. The price markup shock hurts the young mostly through lower labor income and higher taxes. Middle-aged and older households are also negatively affected by these channels, though to a much smaller extent. Moreover, they benefit from a positive contribution from illiquid returns, reflecting both the predominantly real nature of illiquid assets in our model and the mechanical transmission of the price-markup shock to firms' dividends.

When we conduct the same analysis for monetary shocks, we find that their life-cycle redistribution profile almost perfectly mirrors that of the other macroeconomic shocks in this period. A monetary easing not only raises labor demand and real wages but also lowers expected future taxes. Taken together, these effects on disposable labor income generate disproportionately large welfare gains for younger and poorer households. For middle-aged and older households—whose capital income constitutes a larger share of total disposable income—monetary easing has the negative welfare effect of reducing asset returns.

Beyond our main result, the paper provides two additional findings. First, we document how the systematic monetary policy response to inflation (as opposed to the shocks discussed above) affects redistribution, and show that the mechanism is nonlinear and shock-specific. For instance, a weak systematic policy response to a negative TFP shock generates sizable redistribution from young (poor) to old (rich) households: capital owners benefit from higher ex post real interest rates, while lower economic growth depresses labor income. In contrast, for other shocks—such as price-markup shocks—the ability of systematic policy to influence, let alone offset, redistribution is very limited. In consequence the redistribution due to 2021-22 shocks would have remained almost unchanged under different systematic monetary policy reactions to inflation. Overall, there is no universal relationship between the responsiveness of policy rates to inflation and the degree of redistribution generated by economic shocks. Put differently, if the central bank cares about redistribution, it must rely on indicators other than inflation alone.

Second, we compare two alternative metrics of redistribution. Following part of the literature, our main results are expressed in terms of model-consistent welfare, whereas many others focus instead on consumption. These metrics are not equivalent, and in our setting the main conclusion depends critically on which one is used. When we examine current consumption rather than welfare, it is no longer possible to conclude that the 2021–22 monetary policy easing prevented redistribution.

Related literature Our paper contributes to two streams of the literature. First, it is related to the quickly growing literature on the distributional effects of inflation and monetary policy. Doepke and Schneider (2006) show that unexpected inflation transferred resources from the old (typically the bondholders) to the young (with fixed-rate mortgage debt) in the postwar U.S. economy. Similar conclusions have been reached for other countries. For the OECD economies, the evidence is provided by Albanesi (2007), who demonstrates the positive relationship between inflation and income inequality. For the euro area, Adam and Zhu (2016) use the Household Finance and Consumption Survey (HFCS) data to show that unexpected inflation generates a quantitatively significant redistribution of wealth. Pallotti et al. (2023) use the same data to measure the welfare effects of inflation between 2021 and 2022, identifying those aged 25-44 as net winners.

Turning to monetary policy, Coibion et al. (2017) find that contractionary monetary policy increases inequality in labor earnings and total income. Dossche et al. (2021) document that a monetary policy easing has an inequality-reducing impact that works mainly by reducing unemployment among the poorest households. Auclert (2017) accentuates the role of unhedged interest rate exposures (URE) and shows that an unexpected tightening of monetary policy raises real interest rates and hurts those households whose maturing liabilities are higher than maturing assets, since they will have to acquire new debt at a higher cost. Bielecki et al. (2022), Bardóczy and Velásquez-Giraldo (2024) and Braun and Ikeda (2025) show that a monetary expansion benefits young households at the cost of older generations.

We also relate to the quickly growing literature on optimal monetary policy in economies with heterogeneous agents (Gornemann et al., 2016; Acharya et al., 2023; Bhattarai et al., 2023; Davila and Schaab, 2023; Bilbiie et al., 2024). While this literature is still in an early stage, several important findings have been made, with profound implications for our research problem. First, and foremost from our perspective, optimal policy in a world with heterogeneous agents takes into account distributional issues. While these are best addressed using fiscal instruments, in the absence of adequate fiscal policy, monetary policy should provide insurance against aggregate shocks, as they redistribute across agents. This modifies the trade-off faced by policymakers from stabilizing inflation and the output gap (see e.g. Galí, 2015) to include a measure of redistribution as well. As a consequence, divine coincidence does not hold even for demand or TFP shocks. In reaction to price markup shocks (which we find to be an important driver of redistribution in our case), optimal policy behaves in a less hawkish way than a representative agent model would prescribe. For instance in Acharya et al., 2023 the central bank aggressively cuts interest rates (and hence allows for inflation to increase substantially) in an effort to insure credit constrained agents against a sharp contraction of consumption.

Against this background, our paper broadens the understanding of the redistributive consequences of macroeconomic shocks and monetary policy by discussing - in the context of the inflationary shocks of 2021-22 - the complete set of redistribution sources and the role of the central bank's reaction. In the latter context we analyze the distributional consequences not only of monetary policy shocks, but also of systematic monetary policy based on standard Taylor rules.

The second area where we offer a contribution is on the modeling front. So far redistribution has been analyzed in the context of inflation and monetary policy either from a purely empirical perspective (e.g. Doepke and Schneider 2006; Pallotti et al. 2023) or through lenses of structural frameworks: HANK models (e.g. Kaplan et al. 2018; Bayer et al. 2024) and New Keynesian Overlapping Generations (NK-OLG) models (e.g. Bielecki et al., 2022, Braun and Ikeda, 2025).

To the best of our knowledge the only study with a modeling approach similar to ours is Bardóczy and Velásquez-Giraldo (2024), who introduced a HANK-OLG model to investigate the transmission and redistributive effects of monetary policy shocks. Our findings regarding the redistributive aspects of monetary policy are qualitatively similar to theirs. However, our paper differs along two main dimensions. On the modeling front, our framework features two assets (liquid and illiquid), as opposed to a single one. As we show, the transmission of shocks along liquid and illiquid returns may differ substantially. Illiquid assets also allow us to match the MPCs out of capital gains, which affects the propagation of shocks to consumption. Moreover, we provide a Bayesian estimation of the model using business cycle data. Estimation of business cycle models with heterogeneity was so far limited to infinitely-lived HANK (Auclert et al., 2020; Bayer et al., 2024) or OLG models (Bielecki et al., 2026). On the economic front, estimation allows us to study the redistributive effects of a complete set of business cycle shocks in the historical context. This in turn, allows to assess the role played by monetary policy during the Great Inflation period and to study counterfactuals with respect to policy responses (both ad-hoc and systematic).

Why is it important to analyze both sources of heterogeneity (i.e. HANK and OLG type)? This is because they interact with each other and only when taken together can offer a complete view of optimization problems faced by households and of welfare consequences of shocks and policies. Let us explain. Adding intra-cohort heterogeneity to an OLG framework has strongly differentiated consequences for various cohorts. As agents accumulate assets over their lifetime, the consequences of borrowing constraints and incomplete markets differs with age. In a pure OLG framework marginal propensities to consume (MPC) are low for young agents and grow with age. If intra-cohort heterogeneity is added, young agents (who are generally poor) are more frequently constrained, and as a result have relatively high MPCs. These decline for (relatively rich) middle-aged households and grow again for older cohorts as their life horizon shortens and assets decline.

Adding a realistic life cycle to the HANK model allows to take into account the role of asset accumulation (and decumulation) over a lifetime. This, as shown by Auclert (2017) and Bielecki et al. (2022), is an important channel which can even invert the welfare consequence of asset price changes compared to pure HANK frameworks. For instance, over the life-cycle agents accumulate assets. As a consequence higher asset prices make them worse (and not better) off, as a framework without the accumulation pattern would suggest. Another important feature of our framework is that young agents work while older cohorts are retired. As a consequence they are differently affected by labor market developments. Third, tax incidence differs between agents with different survival probabilities, leaving most of the tax burden on the young. In Section 5.2 we provide in a detailed presentation of the interactions between the HANK and OLG dimensions of our model.

The rest of the paper is structured as follows. Section 2 presents the model and Section 3 explains how we calibrate and estimate its parameters. In Section 4 we document our main results on how and why redistribution occurred during the inflation surge of 2021–22. Section 5 shows additional results, in particular the role played by systematic monetary policy and the heterogeneous consumption responses across cohorts. Section 6 concludes.

2 Model

In this section, we introduce an overlapping generations model with incomplete markets and nominal rigidities. Time t is discrete, and each period corresponds to one year. The model consists of several different types of agents: households, firms, unions, a financial intermediary, and monetary and fiscal authorities. We describe each one next.

2.1 Households

There is a continuum of households indexed by i. Households are heterogeneous in four dimensions: labor productivity z_{it}, illiquid asset holdings a_{it}, liquid asset holdings b_{it}, and age $j \in \{1, \ldots, J\}$. In the beginning of each period, a new cohort of households joins the economy at age $j = 1$, while at the end of the period all households of age j are subject to mortality probabilities ψ_j, with $\psi_J = 1$.

Households derive utility from consumption c_{it} and disutility from hours worked n_{it} according to the lifetime preferences

$$\mathbb{E}_t \sum_{j=1}^{J} \beta^j \Psi_j \exp(-\varepsilon^C_{t+j}) \left[u(c_{i,t+j}) - v(n_{i,t+j}) \right].$$

Households discount future utility according to a constant factor β, as well as the probability of surviving up to age j, given by $\Psi_j = \prod_{k=1}^{j}(1-\psi_j)$. The term ε^C_t is a standard aggregate shock that affects private consumption demand.

Agents in the model retire at age j^{ret}. At age j, household i's earnings are given by

$$e_{it} = \begin{cases} (1-\tau_t) w_t n_{it} z_{it} z^{age}_j & j < j^{ret} \\ (1-\tau_t)\nu_t z_{it} & j \geq j^{ret} \end{cases}.$$

The upper term in the expression above is the after-tax labor income of working households, determined by a linear tax rate τ_t, the real wage w_t, the number of hours worked n_{it}, idiosyncratic labor productivity z_{it}, and an age-specific labor productivity term z^{age}_j calibrated to match the observed age-income profile in the data. We assume that $\log z_{it}$ follows an AR(1) process before retirement, after which is remains constant:

$$\log z_{it} = \begin{cases} \rho^z \log z_{i,t-1} + \sigma^z \varepsilon_{it} & j < j^{ret} \\ \log z_{i,t-1} & j \geq j^{ret} \end{cases},$$

where $\varepsilon_{it} \sim NID(0,1)$. Upon entering the economy at age $j = 1$, each agent draws a value of z_{it} from the stationary distribution of the AR(1) process above.

As we shall explain in more detail below, the model features wage rigidity, so households commit to working as many hours as demanded by firms at the prevailing wage, which is determined by unions. Following Auclert et al., 2024b, we make the simplifying assumption that unions split hours equally among households, i.e., $n_{it} = n_t$ is the same for all working age agents.

Retired agents receive government benefits, with a replacement rate determined by ν_t. Since z_{it} remains constant after retirement, pre-tax benefits do not change over time due to idiosyncratic shocks. The positive autocorrelation of z_{it} during working age, on the other hand, ensures that agents' retirement benefits are positively correlated with past labor income. To capture the effects of inflation on the real income of retired households, we assume that pension benefits are indexed to inflation with a one-period delay. Therefore, the pension replacement rate ν_t is given by its steady state value ν but reduced by current inflation:

$$\nu_t = \frac{\nu}{1 + \pi_t}.$$

Turning to portfolio choices, agents can save both in liquid and illiquid assets. We model portfolio adjustment frictions as in Bayer et al. (2024): households can only move funds across liquid and illiquid assets with an exogenous probability χ. This lottery is i.i.d. across agents and happens every period. Real ex-post returns on illiquid and liquid assets are denoted, respectively, by r_t^a and r_t^b. In steady state, households will only hold illiquid assets if they yield higher returns, which must be the case in equilibrium. Since we later linearize the model around a deterministic steady state, this also means that $r_t^a > r_t^b$ on average. Following an aggregate shock, however, it may be the case that r_t^a falls temporarily below r_t^b. Last, to take into account that a substantial fraction of household illiquid assets corresponds to retirement savings, we assume that after retirement a fraction ξ of illiquid assets is unconditionally transferred to the liquid account.

In summary, a household who is able to rebalance their portfolio can freely choose illiquid (a_{it}) and liquid (b_{it}) asset holdings subject to the budget constraint

$$a_{it} + b_{it} + c_{it} = e_{it} + (1 + r_t^a)a_{i,t-1} + (1 + r_t^b)b_{i,t-1} + \varepsilon_t^T.$$

If not eligible to rebalance, a household of age j faces instead the constraints:

$$b_{it} + c_{it} = e_{it} + \xi(1 + r_t^a)a_{i,t-1}1(j \geq j^{ret}) + (1 + r_t^b)b_{i,t-1} + \varepsilon_t^T$$

$$a_{it} = \left[1 - \xi 1(j \geq j^{ret})\right](1 + r_t^a)a_{i,t-1},$$

where $1(j \geq j^{ret})$ is an indicator function for retired agents. Households are also not allowed to borrow in either asset: $a_{it}, b_{it} \geq 0$. In the budget constraint above, ε_t^T is a government transfers shocks, which we assume to be lump-sum. There were substantial government transfers to the household sector in our estimation sample, in particular following the Great Financial Crisis and during the COVID pandemic. As explained later, we map this shock to data on social benefit payments in order to capture its effects on business cycles.

Finally, because of mortality risk households may leave accidental bequests to future generations. These bequests are, however, small, as agents do not internalize them in their own welfare, and do not vary much over business cycles. Therefore, we assume for simplicity that these accidental bequests are fully taxed by the government.

2.2 Firms

There are three types of firms in our model: intermediate goods producers, final goods producers, and capital goods producers. Intermediate goods producers are identical and perfectly competitive, and can thus be treated as a representative firm. Intermediate goods are produced according to a Cobb-Douglas production function:

$$Y_t = \exp(\varepsilon_t^Z) Z K_t^{\alpha} N_t^{1-\alpha}.$$

The total capital and labor input amounts are denoted by K_t and N_t, respectively, while total factor productivity is determined by its steady state level Z and transitory aggregate shocks ε_t^Z.

Intermediate goods producers rent capital from capital producers at rate r_t^K and labor from unions at real wage w_t. Their real marginal cost, which due to perfect competition equals the real price they charge, is given by

$$mc_t = \frac{1}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}} \frac{(r_t^K)^{\alpha} w_t^{1-\alpha}}{\exp(\varepsilon_t^Z) Z}.$$

Final goods producers purchase intermediate goods, which they use to produce different varieties of final goods. Their output, aggregated according to a CES aggregator as in Dixit and Stiglitz (1977) with elasticity of substitution ϑ^p, is used for both final consumption and investment. Final goods producers face nominal price stickiness as in Calvo (1983) with indexation. Every period, a firm can adjust its price with i.i.d. probability θ^p. Log lizearizing the model around steady state delivers the following Phillips

Curve:

$$\pi_t = \frac{1}{1+r}\mathbb{E}_t\pi_{t+1} + \kappa^p \widehat{mc}_t + \varepsilon_t^p,$$

where π_t is the inflation rate and ε_t^p is a price markup shock. We use hats to denote log deviations from steady state and variables without subscripts to refer to steady state values, hence r is the steady state real interest rate. The Phillips curve slope is $\kappa^p = {}^{(1-\theta^p)(1-\theta^p/(1+r))}/_{\theta^p}$.

Capital goods producers transform final goods into investment goods subject to investment adjustment costs. They own the capital stock and rent it to firms at the rate r_t^K, and maximize

$$\mathbb{E}_t \sum_{s=0}^{\infty} \frac{1}{R_{t,t+s}} \left(r_{t+s}^K K_{t+s} - I_{t+s} \right),$$

where $R_{t,t} = 1$ and, for $s \geq 1$,

$$R_{t,t+s} = \prod_{k=1}^{s}(1 + r_{t+k}).$$

The capital stock evolves according to

$$K_{t+1} = (1-\delta)K_t + I_t \left[1 - \frac{1}{2}\gamma^I \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right] \exp(\varepsilon_t^I).$$

Above, I_t denotes investment, δ is the depreciation rate, γ^I is the adjustment cost parameter, and ε_t^I is an investment-specific technology shock.

2.3 Unions

We model unions as in Auclert et al. (2024a). There is a continuum of unions, each one providing to firms differentiated labor services under monopolistic competition. Labor services are aggregated according to a CES aggregator with elasticity of substitution ϑ^w. Similarly to firms, unions set nominal wages subject to Calvo frictions with indexation. We assume unions maximize the welfare of an infinitely-lived agent with average consumption (which equals aggregate consumption C_t), resulting in the following linearized Phillips Curve:

$$\pi_t^w = \beta\mathbb{E}_t\pi_{t+1}^w + \kappa^w \widehat{\mu}_t^w + +\varepsilon_t^w,$$

where π_t^w is nominal wage inflation and

$$\mu_t^w = \frac{\vartheta^w}{\vartheta^w - 1}\frac{v'(n_t)}{(1-\tau_t)w_t u'(C_t)}$$

is the standard wage Phillips Curve intercept (Smets and Wouters, 2007b). The slope is $\kappa^{w} = {}^{(1-\theta^{w})(1-\beta\theta^{w})}/_{\theta^{w}}$ and ε_t^{w} is a wage markup shock.

2.4 Fiscal and monetary policies

The government collects income taxes and accidental bequests, and uses this revenue to finance spending and service its debt. Government debt consists of long-term nominal bonds that pay coupons that decay exponentially at a rate ρ^B. The nominal price of government bonds is given by

$$P_t^g = \frac{1 + \rho^B \mathbb{E}_t P_{t+1}^g}{1 + i_t}.$$

The ex-post real rate of return on government bonds is given by

$$1 + r_t^g = \frac{1 + \rho^B P_t^g}{P_{t-1}^g (1 + \pi_t)}.$$

The government intertemporal budget constraint is, therefore,

$$B_t^g = (1 + r_t^g) B_{t-1}^g + G_t - R_t,$$

where B_t^g is the real value of outstanding debt, and R_t denotes government revenues net of transfers and pension payments. To ensure determinacy in the model, we assume that the fiscal authority adjusts taxes in response to changes in debt according to the rule

$$\tau_t = \tau + \phi^B \frac{B_{t-1}^g - B^g}{Y},$$

where ϕ^B is a parameter that captures the responsiveness of taxes to debt.

Turning to monetary policy, we assume the monetary authority follows a standard Taylor rule:

$$i_t = \phi^i i_{t-1} + \left(1 - \phi^i\right) (i + \phi^\pi \pi_t) + \varepsilon_t^i$$

The monetary authority adjusts short term nominal interest rates i_t in response to inflation and ε_t^i is a monetary shock.

2.5 Financial intermediary

We model household balance sheets as in Auclert et al. (2024b). There is a risk-neutral financial intermediary that holds all household assets in illiquid form and supplies liquid assets to households. The financial intermediary prices firm equity according to

$$p_t^e = \mathbb{E}_t \frac{d_{t+1} + p_{t+1}^e}{1 + r_{t+1}},$$

where dividends d_t is the sum of the profits of final goods producers, $Y_t - r_t^K K_t - w_t N_t$, and of capital goods producers, $r_t^K K_t - I_t$, totaling

$$d_t = Y_t - w_t N_t - I_t,$$

and r_t is the ex-post real interest rate:

$$1 + r_t = \frac{1 + i_{t-1}}{1 + \pi_t}.$$

Dividends d_t can be obtained by summing the profits of final goods producers, $Y_t - r_t^K K_t - w_t N_t$, and the ones from capital goods producers, $r_t^K K_t - I_t$. The ex-post real return on equities is

$$1 + r_t^e = \frac{d_t + p_t^e}{p_{t-1}^e}.$$

The financial intermediary incurs a cost ω of supplying liquid assets to households. The real returns on liquid assets are, therefore, $r_t^b = r_t - \omega$. The returns households receive on their illiquid assets are then the return on the financial intermediary's portfolio, which is a weighted average of r_t^e, r_t^g, and r^b according to each asset's weight on its portfolio (or liability, in case of the liquid assets supplied to households).

3 Calibration and estimation

We pursue the following approach for defining model parameters. First, we calibrate a subset of parameters that define household behavior and portfolio choice using euro area micro data. This is important for understanding the redistribution effects of shocks across cohorts, as well as the transmission to aggregate consumption. Then, we calibrate the parameters that govern the dynamic responses of macroeconomic aggregates to shocks. Ideally, we would like to estimate all these parameters using time series data, which would allow us to speak accurately about the recent inflation episode. However, each period in our model corresponds to a year, which limits the sample size and, therefore, the number of parameters we can estimate.

Given the limited sample, we estimate only the parameters related to the exogenous shock processes and calibrate the remaining ones, namely those related to fiscal and monetary reaction function, price stickiness, and investment adjustment costs. This is computationally very efficient, while still giving us enough flexibility to filter in the data the structural shocks behind the recent inflation surge. The reason why this approach is efficient is that we solve our model using the Sequence Space Jacobian toolbox. This solution method gives us Jacobians that map paths of exogenous shocks to the responses of endogenous variables. Changing shock processes only amounts changing the shock paths to which we apply the same set of Jacobians. This allows us to solve the model only once regardless of the number of times we evaluate the the log likelihood function. See Auclert et al. (2021) for more details.

3.1 Demographics and life-cycle profiles data

We start with a brief description of the life cycle data used in the calibration. Mortality risk is calibrated to the average age-specific death rates from the 2000-2023 period (applying exponential extrapolation when data for the oldest cohorts are missing; the data source is Eurostat). To calibrate age profiles of assets and labor productivity, we use data from the Household Finance and Consumption Survey (HFCS) (HFCN, 2016). Age-specific productivity is calculated by dividing labor income from wage- and self-employment by hours worked (time spent at the main occupation). We set the retirement age to 65 years.

We use the life cycle profiles of liquid and illiquid assets in our calibration. The former are assumed to consist of current deposits and government bonds net of non-mortgage loans. Illiquid assets are calibrated to the sum of the housing stock, term deposits, business assets, mutual fund holdings and voluntary pensions/life insurance net of mortgage loans, in a classification similar to that of Kaplan et al. (2018). While the age profile of each sub-category is taken from the HFCS, the respective sums are weighted by the share of the respective category in total liquid or illiquid assets as derived from Eurostat statistics on financial and non-financial asset holdings. Table 3 presents the mapping between our categories and HFCS codes, table 4 documents the size of each sub-category as a share of GDP.

3.2 Calibration

We first describe the calibration of the parameters related to household income and behavior. Households have log utility over consumption ($u(c) = \log c$) and labor disutility given by $v(n) = {}^{n^{1+\varphi}}/_{(1+\varphi)}$.The parameter φ, which in the absence of wage rigidity corresponds to the inverse of the Frisch elasticity of labor supply, is set to $\varphi = 1$, as in Auclert et al. (2018). We calibrate the parameters governing households' idiosyncratic labor productivity process using the estimates from Floden and Lindé (2001): $\rho^z = 0.91$ and σ^z is chosen so as to generate a standard deviation of the stationary distribution of the z_{it} process equal to 0.51. The parameter ν is calibrated so that retirement benefits correspond to 55% of the average gross labor income of households between 50 and 60 years old, in line with the average replacement ratio for pensions in the euro area between 2010 and 2023 (source: Eurostat). Since we normalize the average of the transitory component z_{it} to be one, it depends only on the age-dependent component z_j^{age}, as well as on wages and hours worked.

The real interest rate r, which in steady state also equals the returns on government bonds, equity, and therefore on illiquid assets, is set to $r = 5\%$, as in Auclert et al. (2018). We also set the intermediation spread $\omega = 5\%$, generating a steady state real return on liquid assets $r^b = 0$. This is close to the average ex-post real interest rate of -0.1% in the euro area in the pre-COVID period, calculated using the same data as in the estimation process described below.

Given the real interest rates above, three parameters governing household saving behavior are calibrated internally: the discount factor β, the probability of accessing illiquid assets χ, and the coupon on illiquid assets received after retirement ξ, which we calibrate to match the following moments computed using using HFCS data. We use β to target a value for total household wealth of 285% of GDP, which requires $\beta = 0.974$. We then use χ, which relates to the attractiveness of illiquid relative to liquid assets, to match a value for total household liquid asset holdings of 45% of GDP, obtaining $\chi = 16.1\%$. The coupon ratio ξ influences the wealth accumulation pattern over the life-cycle, and in particular immediately prior to retirement. Therefore, it is set so that the ratio of average liquid asset holdings at age 65 (the model retirement age) relative to age 50 is 1.39, giving us $\xi = 2.43\%$.

Figure 1 shows average holdings of liquid and illiquid assets across the life-cycle both in the model and in HFCS data. Average holdings between ages 40 and 50 are normalized to be 1. The only moment we target in our calibration related to this figure is the ratio of liquid asset holdings of ages 65 and 50. The general pattern displayed here should, therefore, be interpreted as untargeted moments. The model fares well in matching the increasing pattern of liquid asset holdings. The kink in the model implied liquid asset holdings at age 65 arises because retired agents in the model receive dividends from their illiquid account, which they invest in liquid assets during early retirement to smooth consumption over time. Regarding illiquid assets, the model is able to match the hump-shaped profile observed in the data.

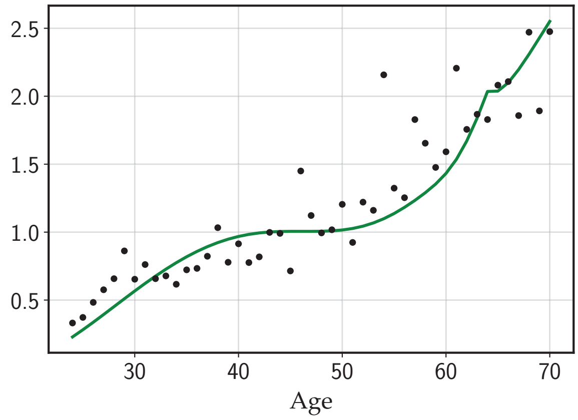
Another set of untargeted moments related to life cycle wealth accumulation is MPCs. As is well known, representative agent models suffer from counterfactually low marginal propensities to consume (MPC). While in life cycle frameworks MPCs increase due to mortality risk, they nevertheless remain very low for young agents, whose probability of survival is high, and increase only slowly with age. This remains detached from empirical evidence, which points at MPCs strongly dependent on wealth and only mildly affected by age (Jappelli and Pistaferri, 2014; Fagereng et al., 2021).

How does our model fare in this context? Figure 2 shows annual MPCs out of income and capital gains for various cohorts[4]. On the left panel, MPCs out of disposable income are calculated as the partial equilibrium response of consumption to a lump-sum cash transfer. It displays an approximately U-shaped pattern, with MPCs highest for the young. This is the outcome of two forces: mortality risk and the share of households at (or close to) the borrowing limit. The former increases with age. The latter is high for young agents, falls until the retirement age and then increases again as retired agents decumulate assets. The average MPC in 0.39, in line with empirical evidence.

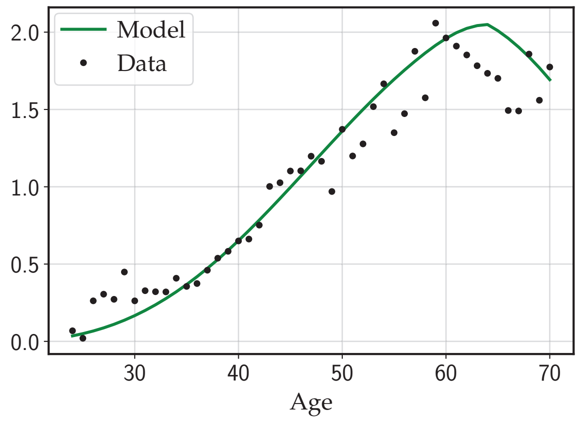
The MPCs out of capital gains on the right panel of figure 2 are calculated as the partial equilibrium response of consumption to an increase in the return of illiquid assets, which is normalized so that total wealth increases by 1 unit. This normalization allows us to more clearly contrast the implications of our model to empirical evidence. Chodorow-Reich et al. (2021) find annual MPCs out of increases in stock market valuations of 0.032, while our model generates a value of 0.035. The life-cycle pattern is simply a consequence of exposure to asset valuations: Cohorts with higher average illiquid asset holdings display stronger consumption responses to changes in illiquid returns.

[4]When documenting distributional features we concentrate on cohorts aged 80 and below. This follows the fact that we lack empirical evidence for the oldest cohorts regarding e.g. their asset holdings. It should, however be noted, that the oldest cohorts are relatively small and do not affect aggregate outcomes significantly.

Figure 1: Average liquid and illiquid asset holdings by age.



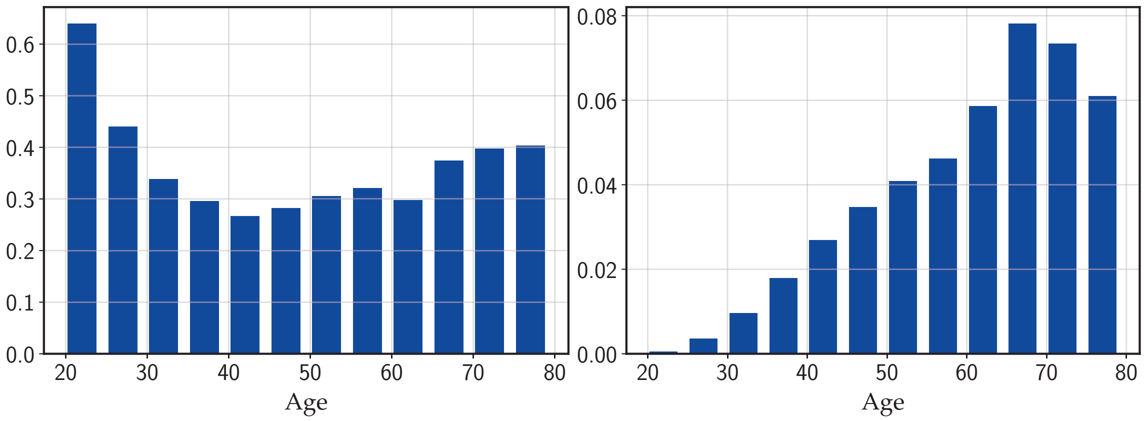
(a) Liquid assets



(b) Illiquid assets

Notes: Both graphs were computing using the stationary distribution of agents given calibrated parameter values. Average holdings between age 40 and 50 were normalized to 1.

Figure 2: Marginal propensities to consume



(a) MPCs out of disposable income (b) MPCs out of capital gains

Turning to supply-side and business cycle parameters, the capital-output ratio is set to 194%, in line with the data on fixed nonresidential assets in the euro area (source: Eurostat statistics on non-financial assets). The steady state share of investment in GDP is set to 22%, in line with the average for the euro area in our estimation sample. Matching these values require a capital share $\alpha = 0.32$ and a depreciation rate $\delta = 0.11$. We calibrate the investment adjustment cost $\gamma = 1.25$. This delivers a response of investment to a monetary shock (see appendix A) similar to the ones in Warne et al. (2008).

The price and wage stickiness parameters θ^p and θ^w are both set to 0.65. This value implies annual Phillips curve slopes κ^p and κ^w close to the values typically estimated with euro area data (Bobasu et al., 2025 and Kase and Rigato, 2025).[5] We calibrate price and wage markups following the procedure in Auclert et al. (2024b). Since price markups determine firm profits, we use them to ensure that the steady state price of equities is consistent with total household wealth. This requires markups to be 2.1%, lower than estimates for the euro area (e.g. Cavalleri et al. 2019 and Kouvavas et al. 2021). Since we are interested in the redistributive effects of shocks, we prefer to match the exact value of household wealth observed in the data, even it this requires a relatively low value for steady-state markups, as these do not affect redistribution significantly). We choose the same value for wage markups.

[5] We convert quarterly to annual Phillips curves slope by ensuring that a 1-year-long increase in marginal costs (or wage markup gap) generates the same effect on (wage) inflation in both frequencies. This entails $\kappa^{annual} = (1 + \beta + \beta^2 + \beta^3)\kappa^{quarterly}$, or approximately $\kappa^{annual} \approx 4\kappa^{quarterly}$.

Steady state government spending is set to 18% of GDP, and government debt is set to 50% of GDP in line with the holdings of sovereign securities by households observed in financial national account statistics. The steady state labor tax rate consistent with these values is $\tau = 39.5\%$. We calibrate the response of taxes to government debt to $\phi^B = 0.1$, which generates a response of tax revenues close to the one in Auclert et al. (2020). Regarding the monetary rule, we set $\phi^i = 0.9^4$ and $\phi^\pi = 2$, roughly in line with Warne et al. (2008). Table 1 shows calibrated parameters.

3.3 Estimation

Next we conduct a Bayesian estimation of the remaining parameters. Our model features eight shocks, assumed to follow AR(1) processes of the form

$$\varepsilon_t^x = \rho^x \varepsilon_{t-1}^x + \eta_t^x,$$

where $x \in \{p, w, G, I, Z, C, i, T\}$ indexes the shock. For seven shocks we estimate the autocorrelation parameter and the standard deviation of innovations: wage and price markups, government spending, investment, technology, time preference, and government transfers. For the monetary policy shock we only estimate the standard deviation, as we fix $\rho^i = 0$, following Warne et al. (2008). We use the following euro area variables as observables: real GDP growth, real consumption growth, real investment growth, the growth rate of the nominal compensation per employee, HICP inflation, nominal short-term interest rates, the growth rate of total hours, and government transfers to household. For the interest rate, we use a measure of shadow interest rates which takes into account the effects of unconventional policy when the short-term rate is constrained at the effect lower bound (Wu and Xia, 2016, 2017). For government transfers we use a measure of social benefits excluding social transfers in kind as a fraction of the GDP and take its first difference. The sample covers the years 2000-2023, and all variables are demeaned.

For the autoregression parameters, we assume beta priors with mean 0.5 and standard deviation 0.1. For standard deviations of the shocks, priors follow an inverse gamma distribution with mean 1 and standard deviation 2. We use a Metropolis-Hastings algorithm to sample 400.000 draws from the posterior distribution and consider only the second half of the simulated sample. Table 2 presents the prior assumptions, posterior modes, and percentiles 10 and 90.

Comparing prior and posterior means shows that the data was informative about all estimated parameters, as most means clearly shifted away from their priors. Autocorrelation coefficients are estimated between 0.22 and 0.62 for annual data, which corresponds to the range 0.68 - 0.89 in quarterly terms - standard estimates in the DSGE literature.

Table 1: Calibrated parameter values

Parameter	Explanation	Value
Household preferences and income		
β	Discount factor	0.974
φ	Inverse Frisch elasticity	1
ρ^z	Persistence of idiosyncratic labor productivity	0.91
$\sqrt{\sigma^z/(1-\rho^z)^2}$	Standard deviation of idiosyncratic shocks	0.51
Household portfolio choices		
r^a	Real returns on illiquid assets	0.05
ω	Liquidity spread	0.05
χ	Probability of accessing illiquid assets	0.161
ξ	Illiquid asset coupons after retirement	0.0243
Firms		
α	Capital share in the production function	0.32
δ	Depreciation rate	0.11
I/Y	Investment over GDP	0.22
θ^p, θ^w	Price and wage rigidity parameters	0.65
$\frac{\vartheta^w}{\vartheta^w-1}, \frac{\vartheta^p}{\vartheta^p-1}$	Steady state price and wage markups	1.021
γ	Investment adjustment costs	1.25
Fiscal and monetary policies		
B^g/Y	Government debt over GDP	0.5
G/Y	Government spending	0.18
τ	Steady state labor tax rate	0.395
ϕ^B	Response of taxes to government debt	0.1
ϕ^i	Interest rate smoothing	0.66
ϕ^π	Interest rate response to inflation	2

Notes: Variables without time subscript denote steady state values. See text for sources and calibration targets.

Standard deviations of shocks are estimated in the range 0.67 to 6.70 which correspond to quarterly values between 0.38 for the government transfers shock to 3.35 for the investment specific shock. Again, these values are well within the range of estimates from the existing literature. These results lend indirect support for our calibration choices of the remaining parameters, as a flawed calibration would result in unusual values for estimated parameters. Appendix A contains shock decompositions of inflation and GDP growth (figure (12)), as well as impulse response functions, which are broadly in line with economic intuition.

Table 2: Estimated parameter values

Parameter	Shock	Prior			Posterior			
		Distribution	Mean	S.d.	Mode	Mean	p10	p90
Shock autocorrelation								
ρ^p	Price markup	Beta	0.5	0.1	0.22	0.23	0.13	0.34
ρ^w	Wage markup	Beta	0.5	0.1	0.27	0.28	0.15	0.43
ρ^G	Government spending	Beta	0.5	0.1	0.27	0.28	0.16	0.41
ρ^Z	Technology	Beta	0.5	0.1	0.46	0.45	0.31	0.58
ρ^I	Investment	Beta	0.5	0.1	0.62	0.60	0.49	0.69
ρ^C	Consumption	Beta	0.5	0.1	0.59	0.55	0.43	0.67
ρ^T	Government transfers	Beta	0.5	0.1	0.34	0.34	0.21	0.48
Standard deviation of innovations								
σ^p	Price markup	Inv. Gamma	1	2	2.08	2.20	1.78	2.70
σ^w	Wage markup	Inv. Gamma	1	2	3.87	3.99	3.22	4.81
σ^G	Government spending	Inv. Gamma	1	2	3.35	3.51	2.93	4.20
σ^Z	Technology	Inv. Gamma	1	2	1.26	1.36	1.10	1.63
σ^I	Investment	Inv. Gamma	1	2	6.70	7.29	5.78	9.01
σ^C	Consumption	Inv. Gamma	1	2	2.89	3.39	2.34	4.70
σ^T	Government transfers	Inv. Gamma	1	2	0.67	0.71	0.58	0.85
σ^i	Monetary	Inv. Gamma	1	2	1.64	1.72	1.43	2.05

Notes: Prior distribution and mode and percentiles 10 and 90 of posterior distribution. Posterior distribution moments are computed using a Metropolis-Hastings algorithm.

4 Macroeconomic shocks, monetary policy and redistribution

We are now ready to move to the main topic of the paper and discuss the role of inflationary shocks and monetary policy in shaping redistribution. We concentrate on the recent inflationary episode of 2021-22 and proceed as follows.[6] First, we show how economic shocks redistributed welfare between agents. Then, we move to monetary policy, explaining its redistributive effects and showing how it affected redistribution in the 2021-22 period.

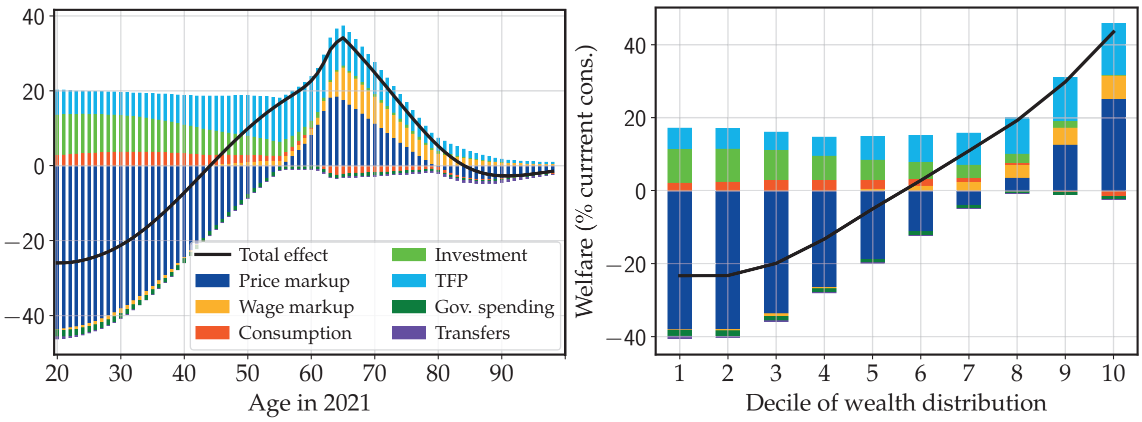
4.1 Macroeconomic shocks and redistribution

Our preferred metric of redistribution is based on household welfare, which summarizes household gains or losses in the most comprehensive manner available in microfounded models. In Section 5.3 we compare our main findings to those based on redistribution of consumption. We define welfare as consumption equivalent variation, i.e., the change in consumption that generates an equivalent effect on wealth as a given shock. We express welfare values in terms of *current* consumption, as opposed to lifetime consumption, since different cohorts have different conditional life expectancy.

We begin by showing the role of macroeconomic shocks of 2021–22, leaving, for the time being, monetary policy shocks aside. Figure 3 documents the redistribution. The left panel shows the effect of macroeconomic shocks on welfare across cohorts, while the right panel shows analogous results across the wealth distribution, defined as the sum of liquid and illiquid assets. The total impact of macroeconomic shocks (black line) displays a strong redistribution from young (poor) to old (rich) households. The decomposition shows that this effect is mainly due to price markup shocks. A minor role was also played by TFP and investment specific shocks. Let us, in the interest of brevity, concentrate on the first two, and explain why and how they redistribute. Relevant figures for other shocks can be found in the Appendix.

[6]We concentrate on the years 2021-22 as this was the period of strongest inflationary shocks. While inflation remained elevated in 2023 and 2024, this was due to its persistence, not new shocks (see Figure 12 a).

Figure 3: Redistribution due to 2021-22 shocks



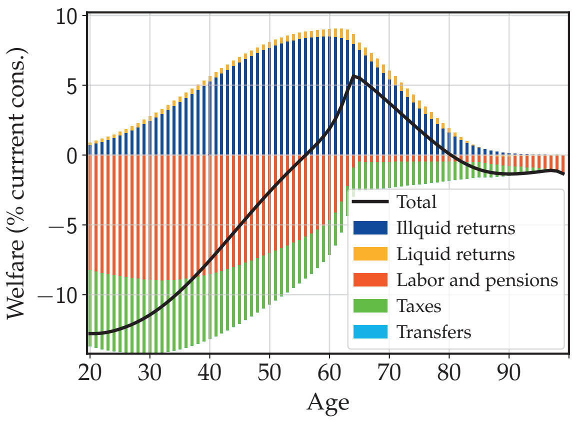
(a) Welfare redistribution by age (b) Welfare redistribution by total wealth

Figure 4 shows how the two shocks redistribute welfare. In order to understand the underlying mechanisms better, we decompose their impact into channels related to the sources of household income: returns on liquid and illiquid assets, labor and pension income, and taxes. Each component is defined as the effect on welfare of changing a given variable keeping others fixed. Since we solve the model using a first-order approximation, the sum of all components equals the total welfare effect of the shock.

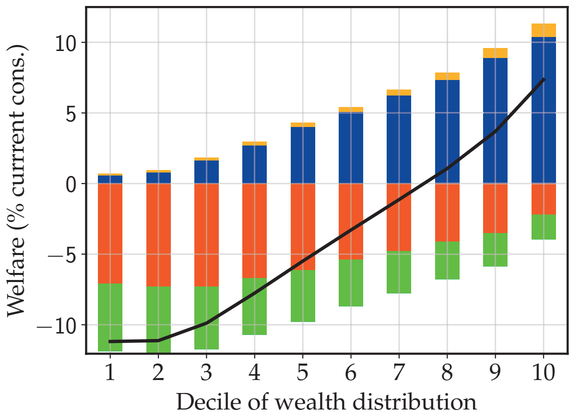
We start by analyzing price markup shocks. As shown on Figure 14 in Appendix A, a positive shock generates a positive reaction of illiquid returns, both because of the effects of markups on profits and because these are largely real assets. As a consequence, owners of illiquid assets achieve substantial welfare gains. As the ownership of illiquid assets increases until the mid-60's, so do related welfare gains. In contrast, the reaction of liquid returns is mixed. Ex-post real liquid returns initially decline after a markup shock due to the unanticipated increase in inflation, then rise due to the reaction of monetary policy. These effects largely net out and, as a consequence, this channel plays a minor role in the redistribution (also due to the fact that liquid asset holdings are much smaller). The remaining channels are related to labor market activity and tax payments. The former affects agents active on the labor market and its dominant component is related to the wage channel. Its negative welfare contribution is a direct consequence of declining real wages. Last but not least, due to the economic slowdown government debt increases and the tax rate is raised. This lowers welfare of all cohorts, with the young expected to take the biggest blow from future taxes. Given the above explanation and the strong, positive price markup shocks that hit the euro area in 2021-22, the redistributive impact of markup shocks visible on Figure 3 becomes clear.

Let us now move to TFP shocks. Here the story is somewhat different as all households gain. The biggest gains accrue to middle-aged, rich households which benefit via the labor market channel and via asset holdings (for impulse responses see Figure 16). Smallest welfare increases are registered for oldest cohorts who neither work nor hold substantial assets, however these cohorts are relatively small. As a result they do not change the overall picture that a TFP shock has a relatively low redistributive power. This can be seen even better when looking at the redistribution across the wealth deciles and explains why in the 2021-22 period all cohorts benefited from TFP shocks (which according to our estimation were positive in both years).

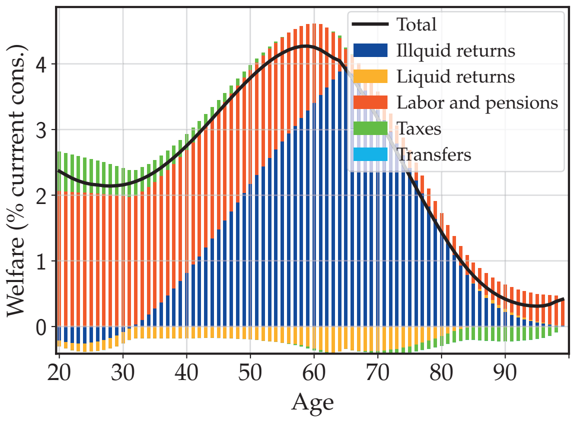
Figure 4: Redistributive effects of positive price markup and TFP shocks



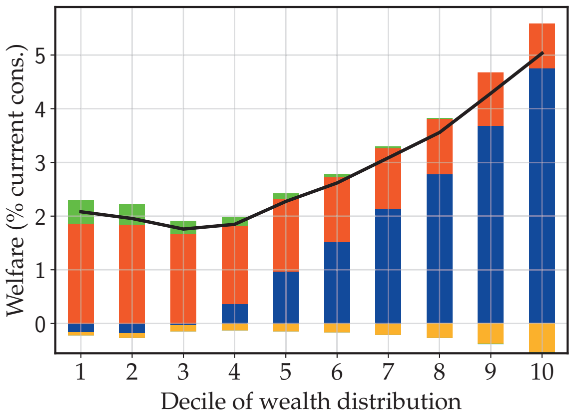
(a) Price markup shock: impact on welfare by age



(b) Price markup shock: impact on welfare by total wealth



(c) TFP shock: impact on welfare by age



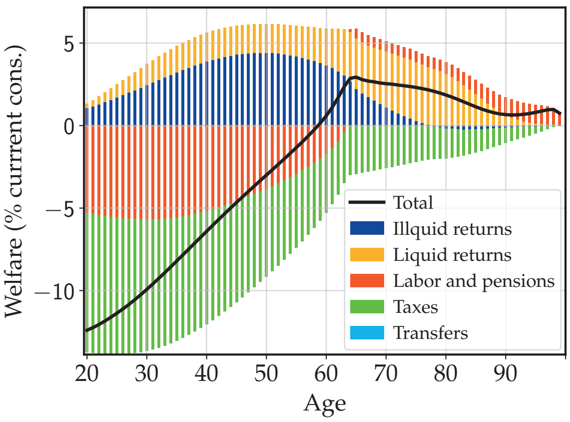
(d) TFP shock: shock: impact on welfare by total wealth

4.2 The redistributive effects of monetary policy

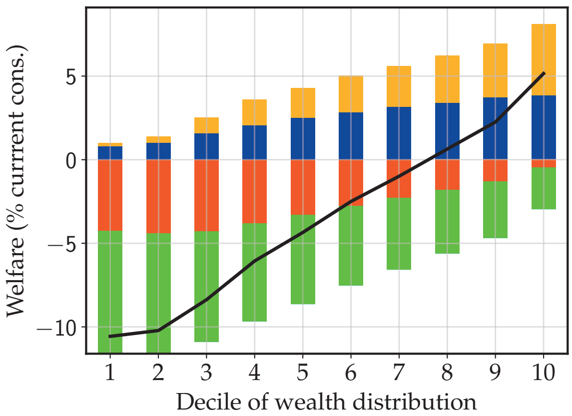
We will now discuss the role played by monetary policy. We begin by describing the redistributive effect of monetary policy. Then, we go back to the 2021-22 events and analyze how monetary policy changed the total redistribution caused by macroeconomic shocks during that period.

Figure 5 presents the redistributive consequences of a contractionary monetary policy shock. The surprise component of central bank policy has relatively strong redistributive consequences, with young (poor) agents suffering biggest losses and older (rich) agents achieving some gains. The main driver of younger cohorts losses is foregone labor income as well as higher taxes. Households gain on asset holding as liquid returns increase immediately, and illiquid returns do so after an initial decline. The right panel shows the same picture for deciles of the wealth distribution - poorest agents are most negatively affected, while gains are achieved only by the highest quintile of the distribution (see Figure 13 for impulse responses). These findings are in line with those of Bardóczy and Velásquez-Giraldo (2024), that labor income (inclusive of taxes in their case) is the main channel via which monetary policy redistributes welfare.

Figure 5: Redistributive effects of contractionary monetary policy shocks



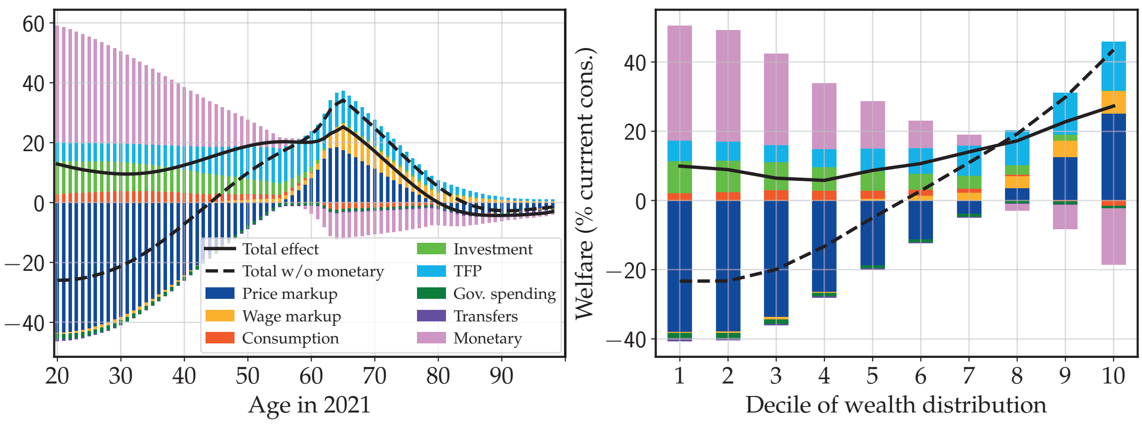
(a) By age



(b) By total wealth

We can now return to the inflationary episode of 2021-22 and check how the (relatively slow) monetary policy response affected redistribution. As can be expected, in 2021-22 we filter strong positive (expansionary) monetary policy shocks. Given the previous discussion, they can be expected to redistribute from old (rich) to young (poor) agents. This is indeed the case, as can be seen on Figure 6, which plots total redistribution due to 2021-22 events, now including monetary policy shocks, which strongly mitigate the redistribution across cohorts and wealth deciles. Overall redistribution (solid line) is much smaller than that due to macroeconomic shocks only. In other words, expansionary monetary policy prevented a large redistribution, neutralizing the negative impact of the shocks for young generations, at the cost of making older agents slightly worse-off. This is also visible for redistribution conditional on wealth holdings.

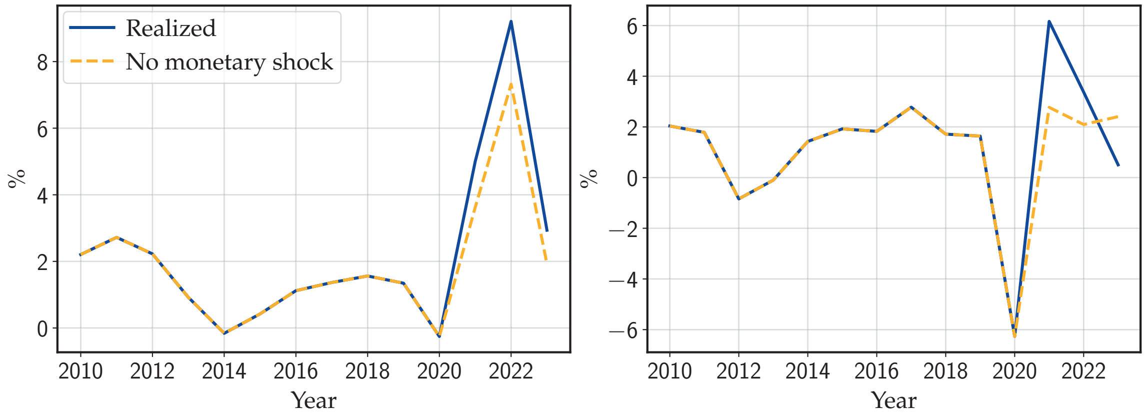
Figure 6: Redistribution due to 2021-22 shocks



(a) Welfare redistribution by age (b) Welfare redistribution by total wealth

Finally, we discuss the implications of expansionary policy for inflation and output growth. While we do not intend to offer a fully-fledged discussion of optimal monetary policy, showing the economic side-effects highlights the trade-offs involved. Figure 7 shows historical and counterfactual inflation and output growth rates under a scenario without monetary shocks in 2021–2022. Not surprisingly, a strict adherence to the Taylor rule during this period would have generated both lower inflation and GDP growth. At its peak, the inflation rate would have been reduced by 1.9 percentage points, while GDP growth would have been on average 0.9 percentage points lower in the 2021-2023 period.

Figure 7: Macroeconomic consequences of the monetary expansion



(a) Inflation

(b) GDP growth

5 Behind the scenes: systematic policy, HANK-OLG interactions and the welfare-consumption battle

Having established our main result we can now cover three additional important and related topics. First, we analyze and explain how redistribution is shaped by systematic (rule-based) monetary policy. Then we discuss the importance of having both dimensions of heterogeneity under one hood. Last but not least we compare our findings about welfare redistribution to the metric of consumption dispersion, popular in the literature. We explain why and how these metrics differ.

5.1 Systematic monetary policy and redistribution

In Section 4 we discussed the redistributive consequences of an extraordinary deviation from the monetary policy rule. However, as is well know, the impact of monetary policy on the economy is not only due to shocks, but also due to its systematic reactions to economic developments. In what follows we check to what extent this is true in the context of redistribution. Systematic monetary policy does not redistribute on its own (as a shock does), it rather has the ability to modify redistribution caused by other disturbances. To understand this process better, we first compare redistribution patterns after selected shocks for three values of monetary policy reactions to inflation $\phi^{\pi} = \{1, 2, 3\}$, the former being the weakest reaction that guarantees determinacy (we call it "Dove"), the second being our baseline and the last being a strong reaction that we call "Hawk".[7] Then, we turn back to our 2021-22 episode and check if a different choice of systematic policy reaction to inflation would have significantly affected redistribution.

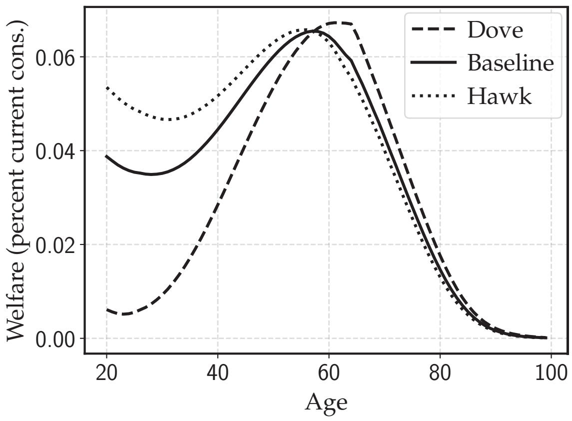
Figure 8 compares the welfare impact of TFP, price markup, monetary policy and investment specific shocks for our three policy rules. Three general conclusions stand out. First, systematic policy affects the way shocks redistribute, but its strength depends on the underlying shock. For instance, it is relatively unchanged for a price markup shock (in terms of to how much it redistributes overall), while the redistribution after TFP shocks changes significantly for the youngest cohorts.

Second, the effects of systematic policy can be strongly nonlinear. For instance, after an investment shock the redistribution changes sharply with monetary policy switching from dovish to baseline. However, the effects of switching further, to hawkish policy are negligible. Even stronger is the nonlinearity after a monetary policy shock. For instance switching from dovish to baseline makes the young (under 40) worse off. But becoming

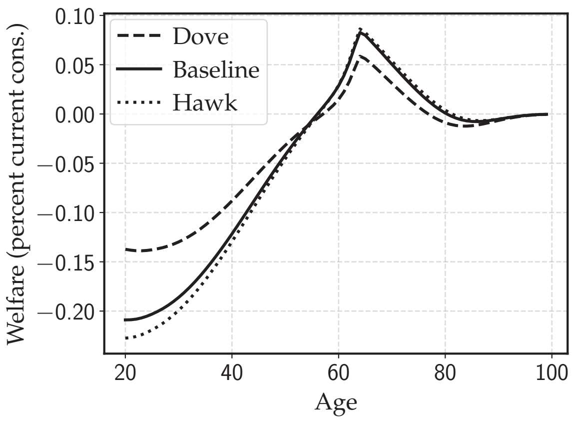
[7]The case $\phi^{\pi} = 1$ should be interpreted as a limiting case in which the Taylor rule coefficient is at the determinacy threshold. To address determinacy concerns, we checked that results are similar for $\phi^{\pi} = 1.1$.

even more hawkish makes them better off again. All in all, the pattern of redistribution changes with the monetary policy response to inflation in a shock-dependent and non-linear fashion. I other words, the standard dimension of monetary policy aggressiveness is a not a good predictor of its redistributive consequences.

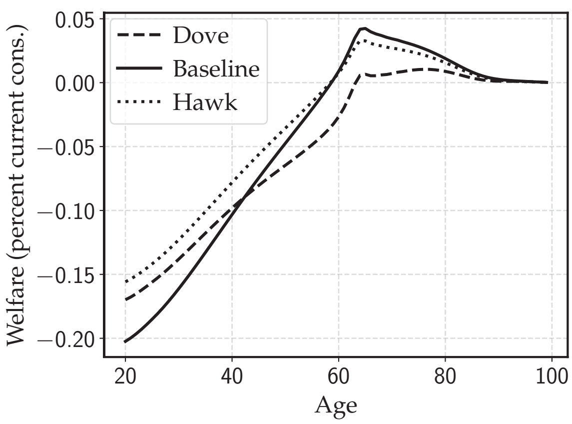
Figure 8: Redistributive effects of selected shocks conditional on systematic monetary policy reaction to inflation



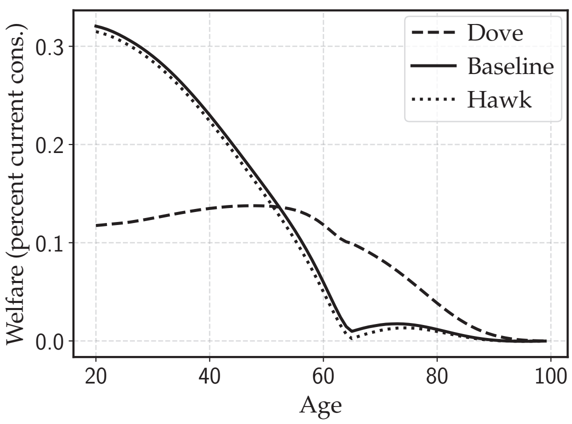
(a) TFP shock



(b) Price markup shock



(c) Monetary policy shock

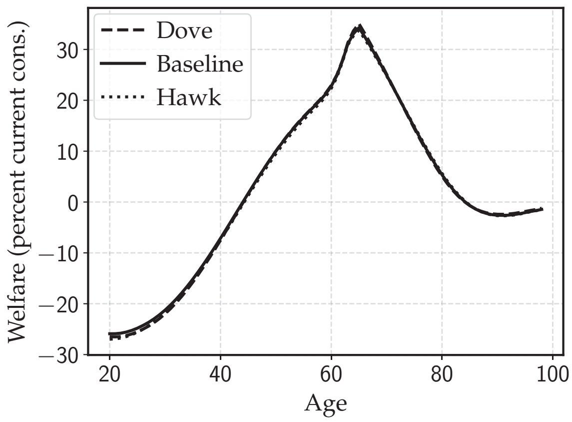


(d) Investment specific shock

Let us check this intuition in the context of the 2021-22 episode, that we analyze in this paper. How would macroeconomic shocks have redistributed under a different stance of monetary policy? To keep the exercise as clean as possible we ignore historical monetary policy shocks, as their interpretation becomes dubious under counterfactual policy parameters. We have already seen the redistribution under baseline policy - the black line on Figure 3. Now we plot it again, together with counterfactual redistribution under dovish and hawkish policy (Figure 9). The main conclusion that stands out it that the policy stance would not have affected the redistribution at all. This is the consequence of the nonlinear relationship between the policy stance and redistribution discussed earlier. The interaction between policy and various shocks that acted in 2021-22 (primarily markup and TFP) canceled out to a large extent, leaving the overall effect negligible.

The general conclusion from this section is that, if monetary policy wishes to affect redistribution (on top of standard goals like inflation or output) a standard Taylor rule does not stand out as a promising guide. This happens in spite of inflation being generally an important driver of redistribution.[8]

Figure 9: Redistribution due to 2021-22 macroeconomic shocks conditional on the monetary policy stance



5.2 Interactions between intra-cohort and life-cycle heterogeneity

Another, highly relevant question is to what extent the two dimensions of heterogeneity that we model - related to age and to idiosyncratic shocks - interact with each other. In theory both dimensions affect agents behavior and the welfare consequences of economic fluctuations. Let us begin with discussing the main mechanisms at play. Next, we turn to simulations which help demonstrate their quantitative importance.

The two relevant questions are: (i) how does adding idiosyncratic shocks to the OLG framework affect welfare of agents of a given age and (ii) how does adding the life cycle to the HANK model affect welfare of households with given wealth?

Let us start with theoretical answers to these questions. Adding idiosyncratic income shocks coupled with borrowing constraints and imperfect insurance to a life-cycle model obviously affects households, in particular poor agents at the borrowing constraint but

[8] While we do not assume a reaction to output in the baseline policy rule, we found that including it would not have substantially changed our results.

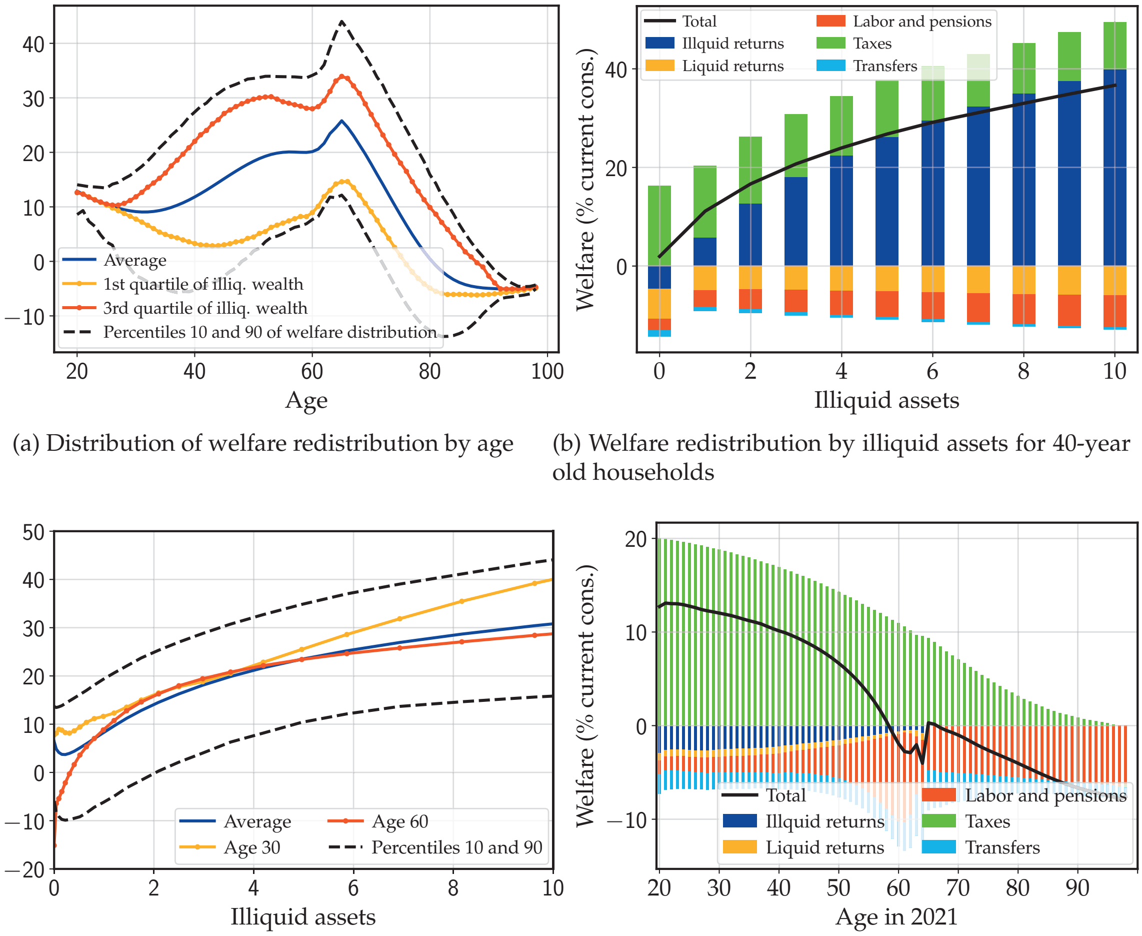
also rich agents, who are not allowed to rebalance illiquid assets. These households become similar to hand-to-mouth agents and their behavior differs from households in a pure OLG model, which refer to cohort averages and typically are assumed to be unconstrained. In our framework, these mechanisms are particularly relevant for young agents, for whom a significant part do not own liquid or illiquid wealth. The marginal propensity to consume presented in Figure 2 reflects not only the high occurrence of borrowing constraints for youngest agents, but also the general difference of our framework from a typical life-cycle model, where MPCs would be much lower for all cohorts.

How about the importance of adding the life-cycle dimension to the HANK framework? There are three most important mechanisms via which otherwise similar agents are affected differently depending on age. First, there is labor market participation. Our simulations made clear that this is an important channel of redistribution and retired agents are obviously affected differently than working age households. Second, there is the role of asset accumulation. What matters for welfare are not asset holdings *per se*, but maturing assets. A rising asset price will affect differently someone who plans to accumulate and someone who plans to decumulate wealth, even if their asset holdings are equal. This is clearly an issue along the life cycle where speeds and directions of asset accumulation depend on age. Third, taxes affect agents differently depending on age. A sudden budgetary windfall, that results in lower future taxes benefits primarily young agents. Older households discount future income streams more heavily due to higher mortality risk.

The quantitative consequences of these mechanisms can be demonstrated in our model by plotting welfare by age conditional on assets and welfare by assets conditional on age. Figure 10 (a) shows the welfare effects of 2021-22 shocks along the age dimension: average within cohorts (the same as in Section 4.2, solid line) together with the 10th and 90th percentile bounds (dashed lines) and the averages for the 1st and 3rd quartile of the illiquid asset distribution (yellow and red dotted lines). Clearly, age does not tell the whole story, as within-cohort heterogeneity is large. In general, poor agents fare worse, in some cases they even suffer welfare losses, while most households face gains. Figure 10 (b) cuts through this distribution for 40-years old households, confirming the large amount of within-cohort heterogeneity and showing that - in this particular case - it is driven mainly by capital gains. All in all, age is by far not sufficient to explain heterogeneous welfare reactions to shocks.

Figure 10 (c) shows welfare along the illiquid wealth dimension, which in our calibration corresponds to 85% of total wealth: the average (solid line), together with the 10th and 90th percentile bounds and profiles for 30 and 60 year old households. The bounds confirm that there is much heterogeneity in this dimension too. The most interesting findings are, however revealed by the selected age profiles. For instance a 60-year old without illiquid assets would be affected more strongly than a equally 30-year old in the same situation, but the difference disappears for agents with medium wealth levels, only to reappear for the richest households. It is instructive to look at Figure 10 (d) which presents the welfare redistribution for agents with zero total wealth (having neither liquid nor illiquid wealth) in all cohorts. Clearly, in spite of being equally poor, households at different age are affected differently. Three reasons explain this. First, young agents expect to profit more from the future tax windfall (which itself is the consequence of government debt being partly inflated away). Second, the labor market channel affects households differently, with biggest losses incurred by the 60-year old agents, who have little time left to accumulate assets for retirement. Third, asset accumulation along the life-cycle (i.e. role of maturing assets mentioned earlier) plays a role as well. As these agents own no assets, the only reason the young suffer losses via asset returns is their plan to accumulate them, now at a higher price. This motive is missing for our oldest agents, who generally decumulate, but since the asset-less have nothing to sell they achieve no gains. All in all, our simulations show, that asset ownership is not sufficient to understand redistribution either - age plays an important role as well.

Figure 10: Redistribution due to 2021-22 shocks conditional on age and wealth



(a) Distribution of welfare redistribution by age

(b) Welfare redistribution by illiquid assets for 40-year old households

(c) Distribution of welfare redistribution by illiquid assets

(d) Welfare redistribution by age for zero-assets agents

5.3 Welfare vs. consumption

So far our considerations were based on the notion of model-consistent welfare. While this metric is central to modern macroeconomics, it should be noted that the literature (especially based on HANK models) also uses consumption dispersion to illustrate distributional issues. Let us, hence, switch to this metric, show how and explain why it differs from the notion of welfare used so far.

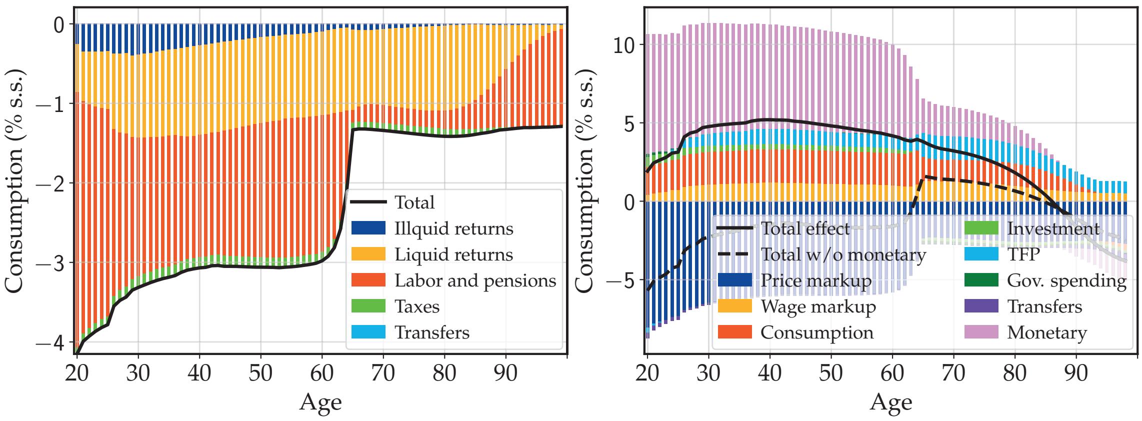
It is well known, that in the absence of frictions, consumption and welfare are strongly related. A shock that changes lifetime wealth affects welfare and, in line with the permanent income hypothesis, current and future consumption. However, our agents do not live in a frictionless world - they face borrowing and liquidity constraints and their access to insurance is mainly limited to non-state contingent government bonds. As a consequence their current consumption is linked to current income.

As an illustration, Figure 11 (a) shows the redistribution of consumption on impact due to a price markup shock. Consumption of all cohorts is affected negatively, with labor/ pension income and liquid returns playing key roles. Comparing this picture to the redistribution of welfare (Figure 4 (a)) is striking. Not only is the overall profile different, but so are the channels. The main similarity is labor income. Other than that, the role of taxes is almost negligible, as current tax incidence is small (what matters for welfare are future taxes). Liquid returns exert a strong negative impact on all cohorts consumption in line with the initial decline of ex-post real interest rates, visible in the IRFs in appendix A. In the context of welfare these returns are undone by positive future returns, due to the monetary policy reaction. Illiquid returns are almost negligible, again in line with the respective impulse response, which – on impact – is close to zero (a consequence of rising dividends amid falling capital price and return on government bonds). What determines their very different, and positive impact on welfare are positive future returns, which clearly do not affect much current consumption.

This divergent pattern is also reflected on Figure 11 (b), where we show the impact of the 2021-22 shocks on consumption over this period. Again, comparing this figure to Figure 6 (a) reveals differences, though not as stark as for the markup shock. Similarly to welfare, consumption increases for all but the oldest cohorts, although the redistribution shapes differ. Also, the decomposition by shock is similar, at least in qualitative terms. This relative similarity is partly due to the way we measure consumption, which is now over a two-year period for shocks that happened in 2021. As a result, some of the factors discussed above play a less pronounced role, for instance now we take into account the returns on liquid and illiquid assets in period two after the shocks. Nevertheless, overall the consumption and welfare redistribution patterns differ, and so does the role played by monetary policy shocks. The dashed line on Figure 11 (b) plots the counterfactual consumption redistribution without monetary policy shocks: it is much less clear than for welfare that the policy easing reduced redistribution.

The general conclusion must be that, in a world with heterogeneous households and incomplete markets, redistribution seen via the lenses of welfare and current consumption may diverge. While welfare is the best model-consistent measure of how agents perceive gains or losses, we do not exclude that certain behavioral biases may point towards current consumption as the more relevant proxy for current well-being. This is beyond the scope of the current paper, but constitutes a fascinating topic for further research.

Figure 11: Redistribution of consumption due to price markup shock and 2021-22 macroeconomic shocks



(a) Consumption redistribution: price markup shock

(b) Consumption redistribution: 2021-22 shocks

6 Conclusions

How was welfare redistributed during the recent inflation surge in the euro area? Which shocks and economic mechanisms were most important and why? How can monetary policy affect redistribution and what role was played by its relatively sluggish reaction to rising inflation? We answer these questions in a novel modeling framework that features household heterogeneity across and within the age dimension. Our model consists of components typical for HANK models (idiosyncratic income shocks, nominal and real frictions) and life cycle models (age-dependent mortality). The model can match the relevant moments related to wealth accumulation over the life cycle and is estimated using euro area data.

First, we show how welfare in the euro area was affected by macroeconomic shocks that lead to the inflation surge of 2021–22. We find a strongly redistributive picture with young and poor agents facing large welfare losses and older, richer households benefiting from the event. The main drivers of redistribution were price markup shocks, potentially capturing fluctuations in energy prices, and technology shocks, possibly related to the lifting of pandemic-related restrictions.

Then we show how the picture was affected by monetary policy. According to our model, a strong monetary policy easing happened during this period, which had a redistributive effect that almost perfectly mirrored that of the other macroeconomic shocks. As a consequence, monetary policy substantially mitigated the welfare redistribution, both across different cohorts and along the wealth distribution. On the other hand, we find the contribution of systematic policy to smoothing redistribution almost negligible: for a wide range of Taylor rule parameters welfare effects would be almost the same. This shows the inability of systematic monetary policy based on standard (Taylor-type) rules to prevent redistribution in face of strong cost-push shocks.

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Tables and figures

Table 3: Mapping between model and HFCS categories

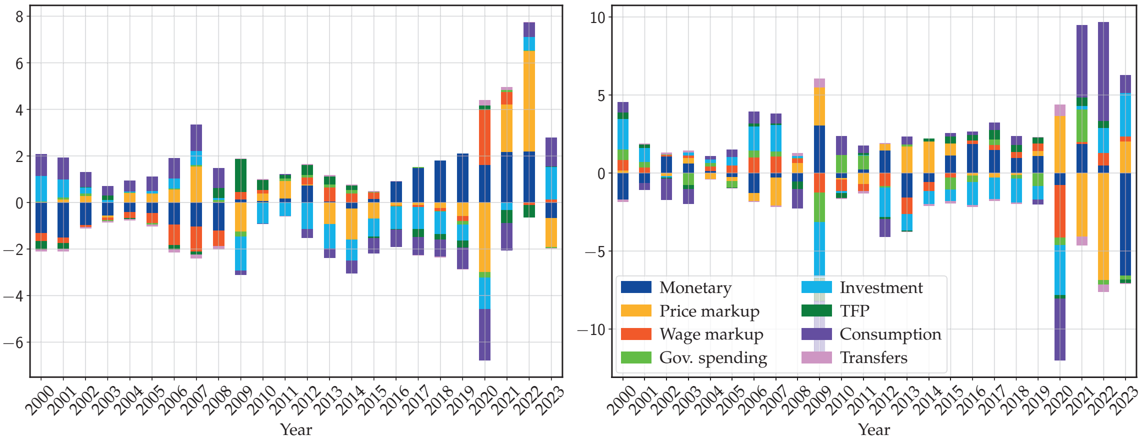
Category in the paper	Sub-category	HFCS name	HFCS code
Labor income	= Income from work	Employee income	DI1100
	+ Self-employment income	Self-employment income	DI1200
Hours worked		= Hours working a week - main job	PE0600
Illiquid assets	= Housing stock	= Value of household's main residence	DA1110
		+ Value of other real estate property not for business activities	DA1122
	+ Business assets	= Business wealth	DA1200
		+ Value of non self-employment private business	DA2104
		+ Shares, publicly traded	DA2105
	+ Mutual funds	Mutual funds	DA2102
	+ Voluntary pension & insurance	Voluntary pension/whole life insurance	DA2109
	+ Term deposits	Deposits	DA2101
	- Mortgage loans	= Outstanding balance of mortgage debt	DL1100
Liquid assets	= Government bonds	Bonds	DA2103
	+ Current deposits	Deposits	DA2101
	- Non-mortgage loans	Outstanding balance of other, non-mortgage debt	DL1200

Table 4: Aggregate asset holdings

Sub-category	Household holdings, % of GDP
Housing stock	130
Business assets	44
Mutual funds	21
Voluntary pension & insurance	69
Term deposits	30
Mortgage loans	- 55
Total illiquid	**240**
Government bonds	5
Current deposits	42
Non-mortgage loans	- 2
Total liquid	**45**

Note: Government bond holdings refer to direct ownership (i.e. not via e.g. mutual fund holdings). Current deposits are the sum of currency and short-term deposits.

Figure 12: Historical decompositions of inflation and GDP growth



(a) Inflation

(b) GDP growth

Figure 13: Impulse responses to a monetary shock

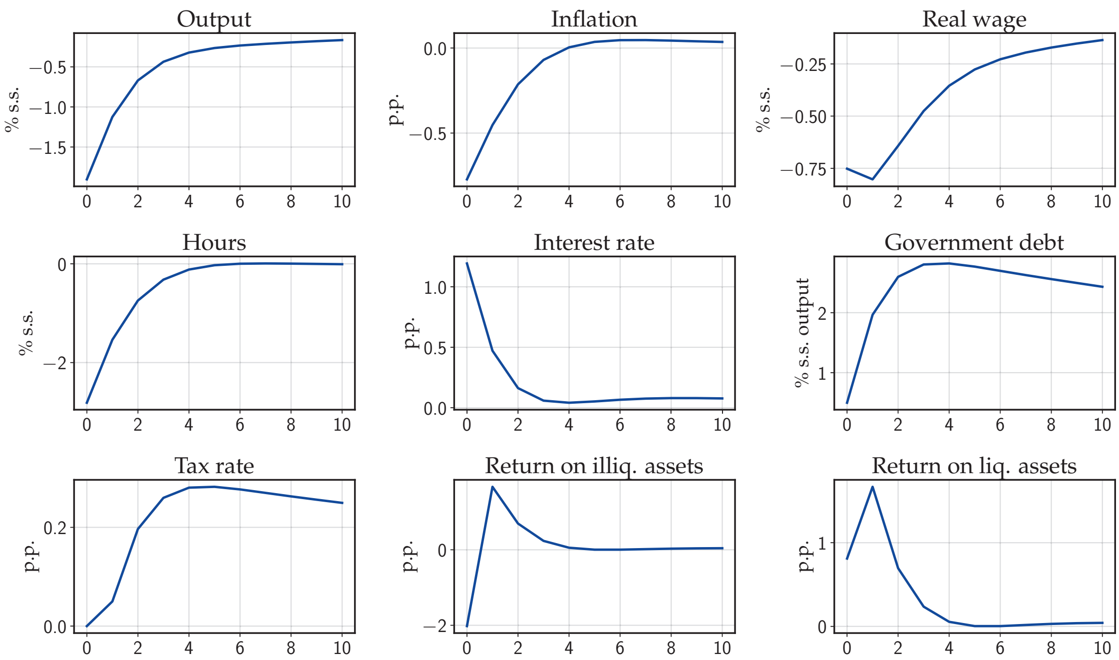


Figure 14: Impulse responses to a price markup shock

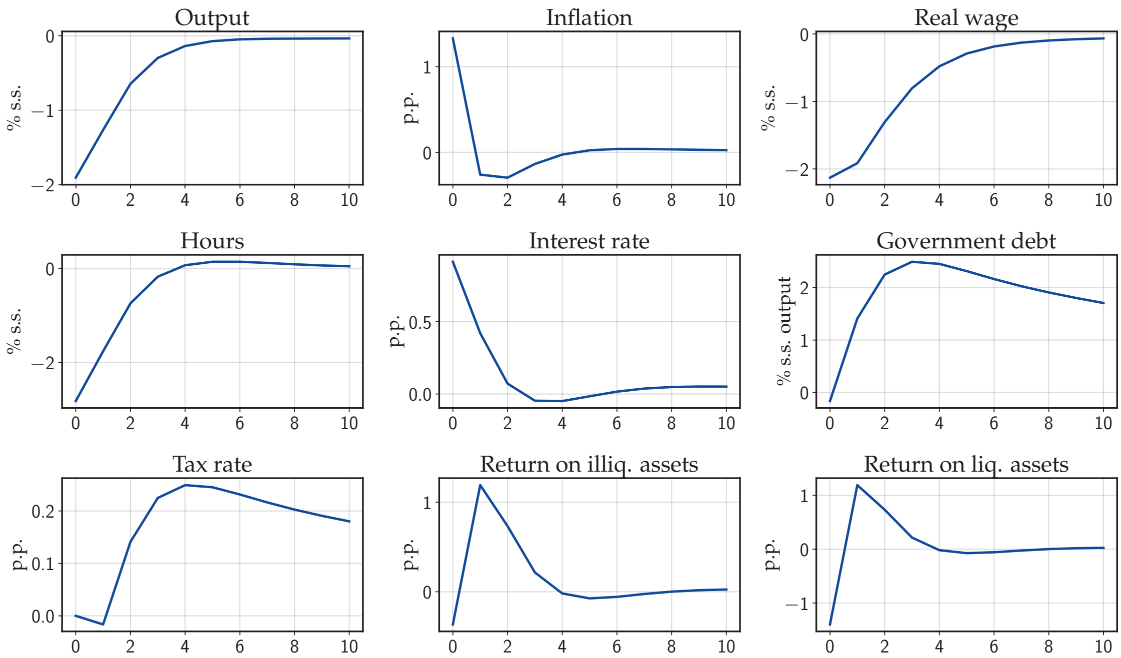


Figure 15: Impulse responses to a wage markup shock

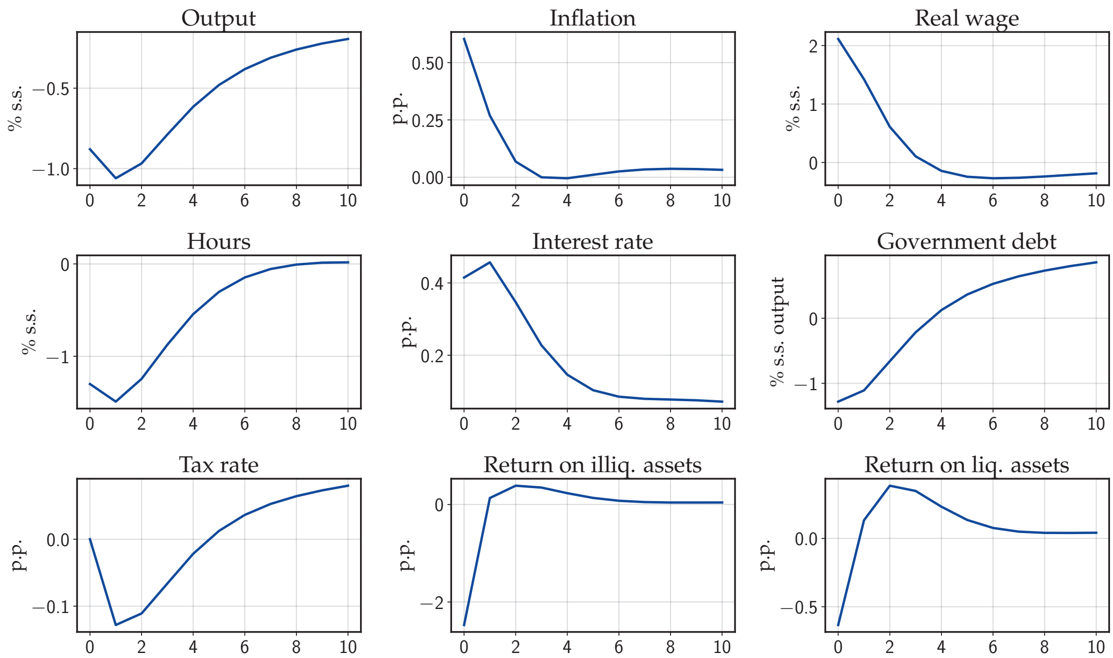


Figure 16: Impulse responses to a TFP shock

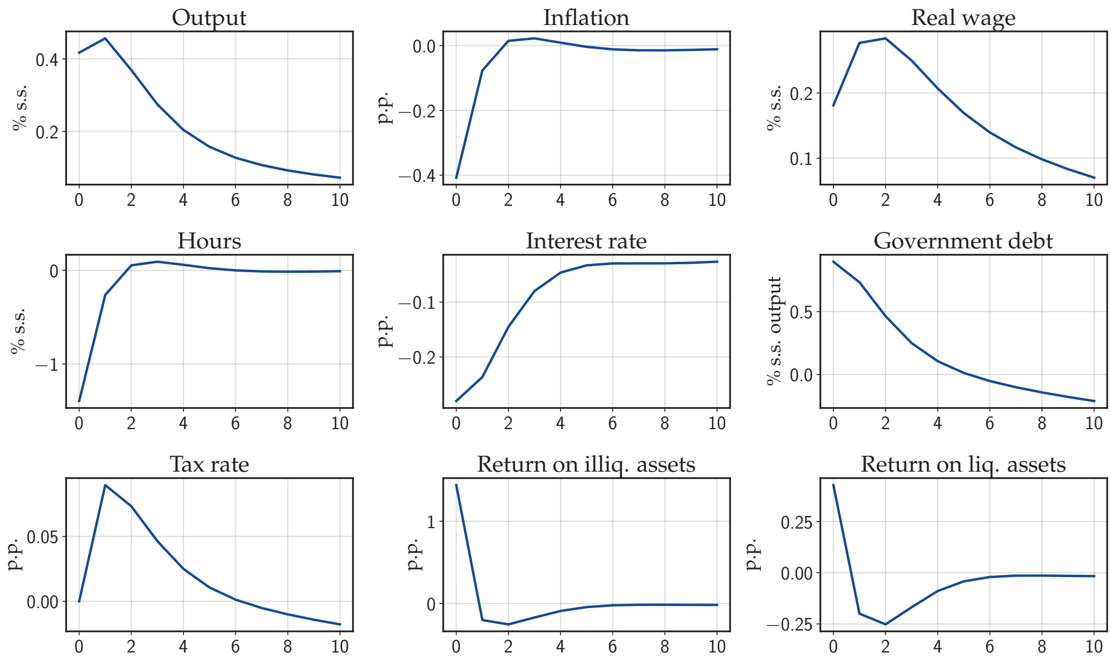


Figure 17: Impulse responses to a consumer discount factor shock

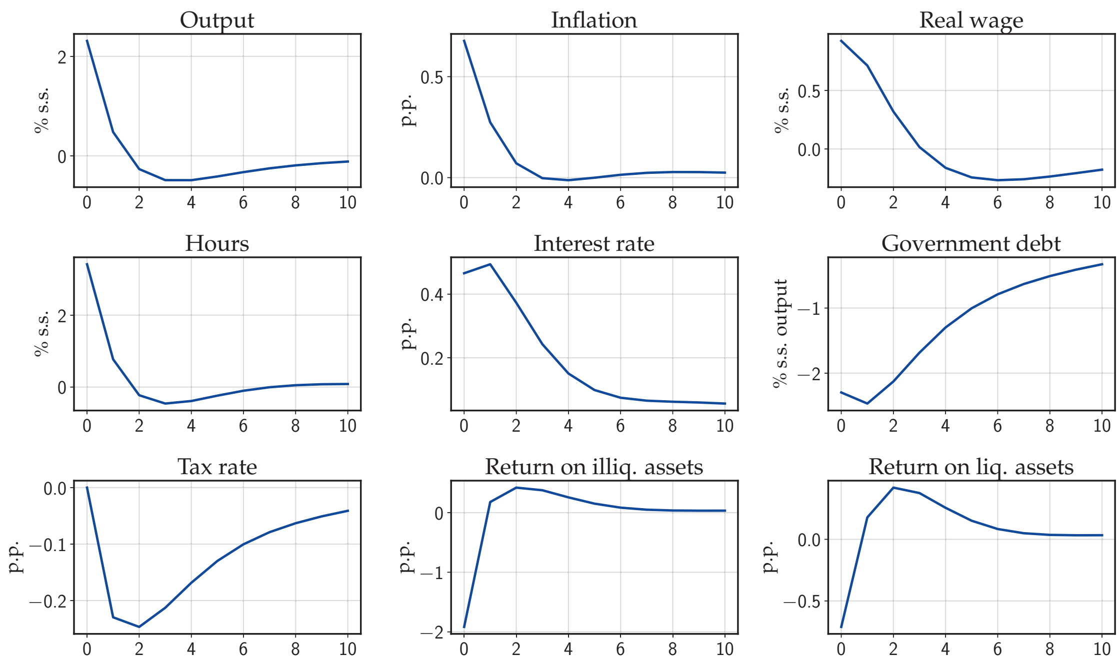


Figure 18: Impulse responses to an investment technology shock

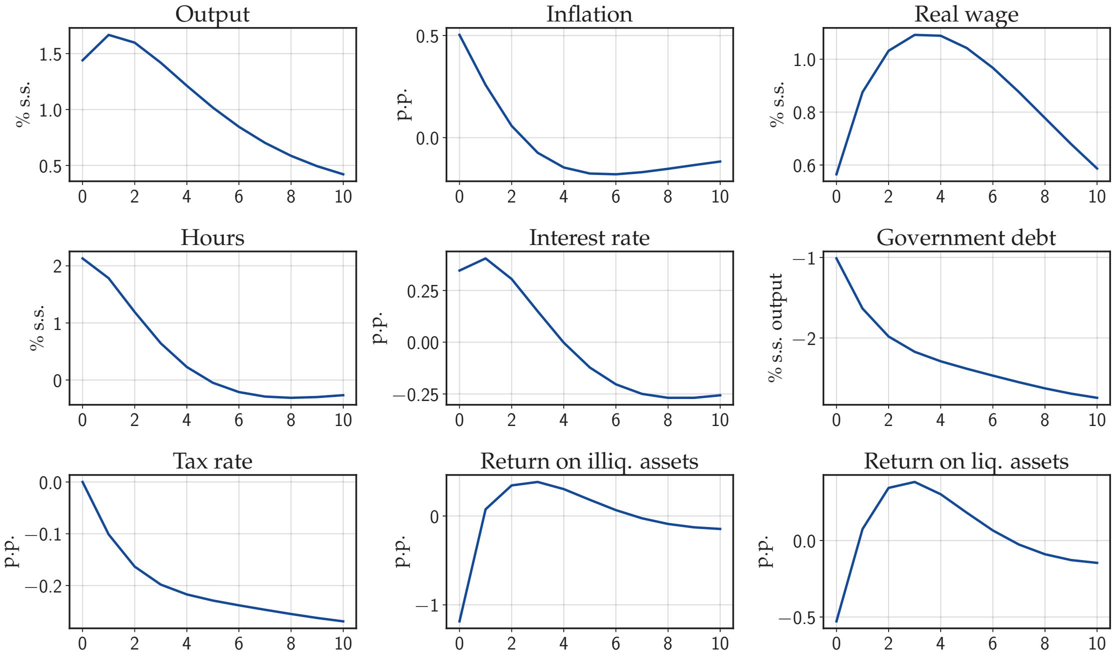


Figure 19: Impulse responses to a government consumption shock

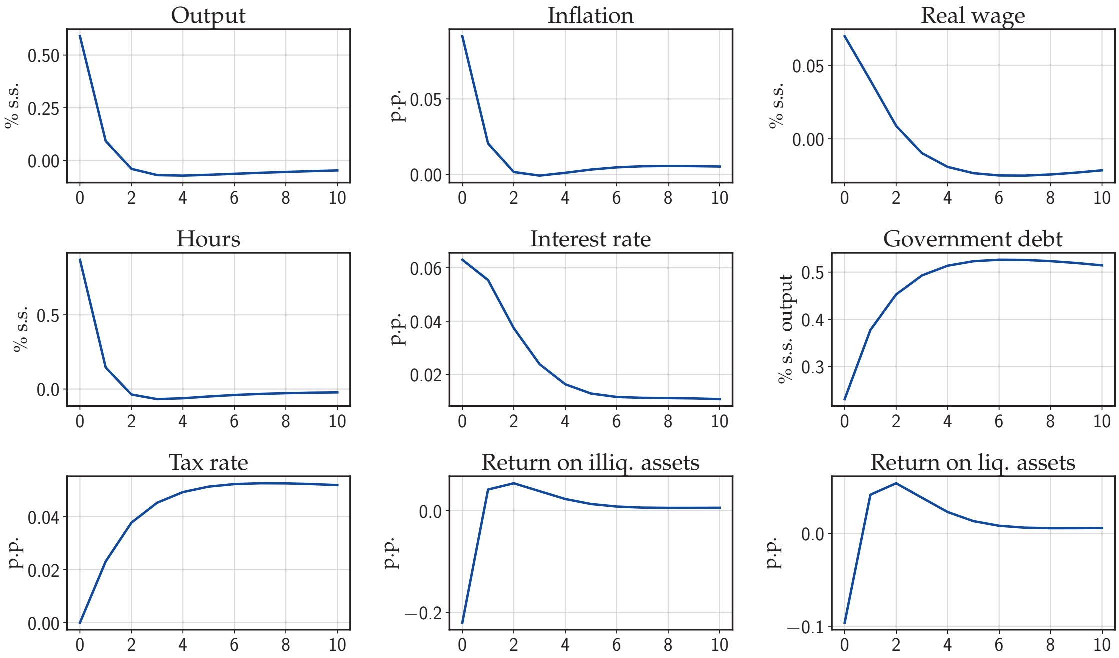


Figure 20: Impulse responses to a government transfers shock

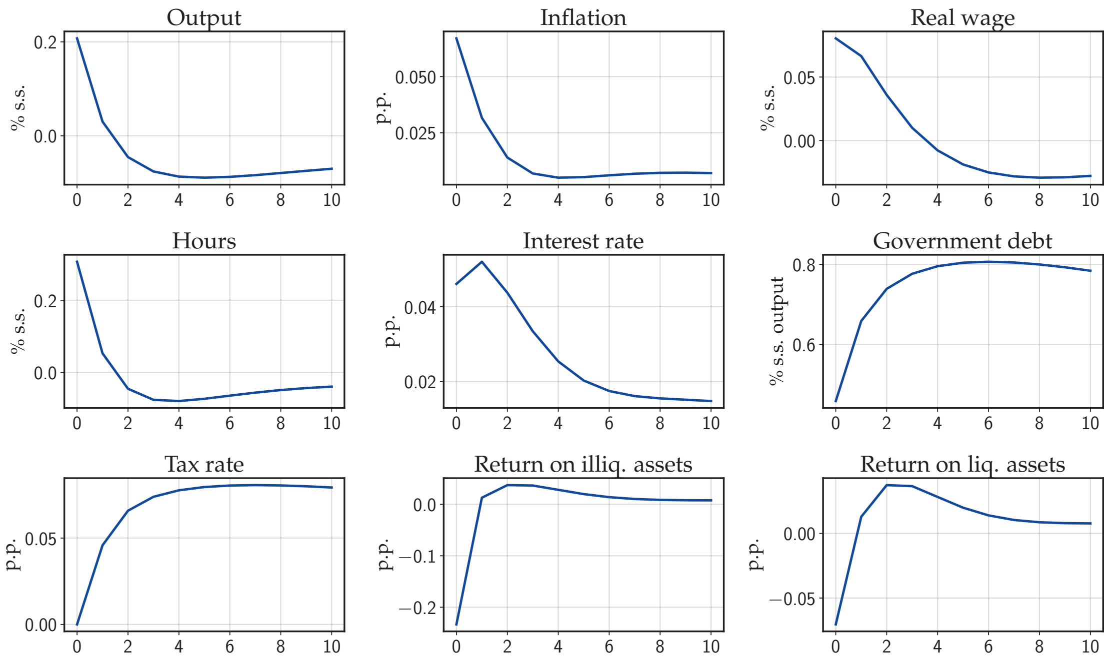
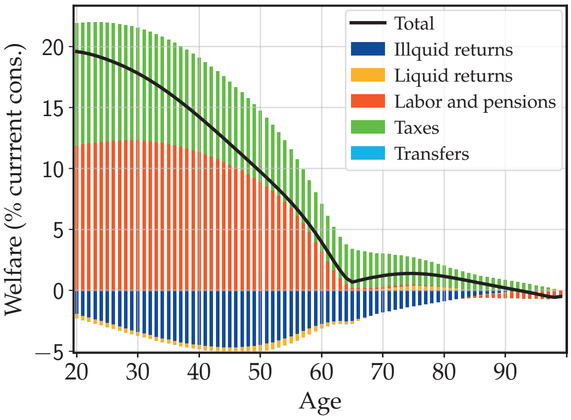
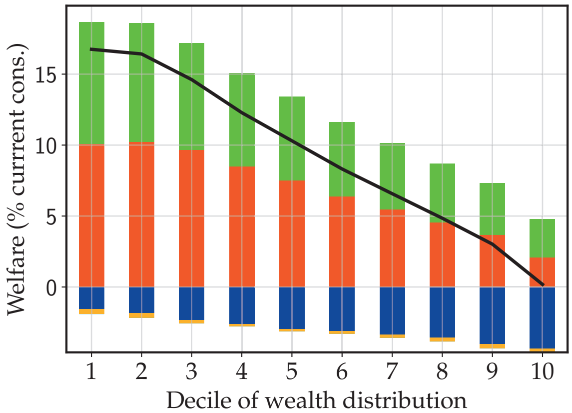


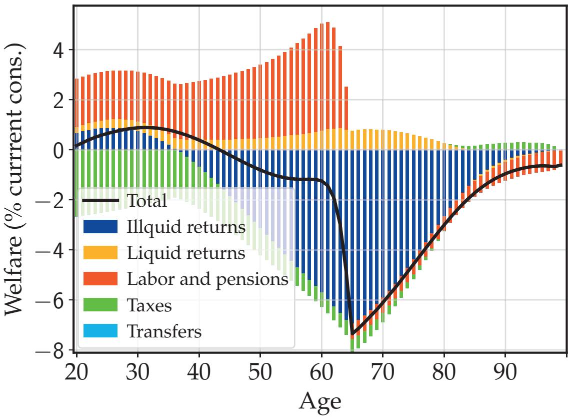
Figure 21: Redistributive effects of selected shocks



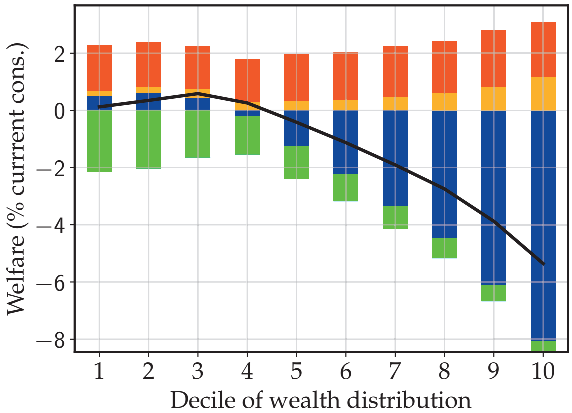
(a) Investment specific shock: impact on welfare by age



(b) Investment specific shock: impact on welfare by total wealth



(c) Wage markup shock: impact on welfare by age



(d) Wage markup shock: impact on welfare by total wealth nbp.pl