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For whom the bill tolls: redistributive consequences of a monetary-fiscal stimulus*

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Abstract

During the COVID-19 pandemic, governments in the euro area sharply increased spending, while the European Central Bank eased financing conditions. We use this episode to assess how such a concerted monetary-fiscal stimulus redistributes welfare between various age cohorts. Our assessment involves not only the income side of household balance sheets (mainly direct effects of transfers), but also the more obscure financing side that, to a substantial degree, occurred via indirect effects (with a prominent role of the inflation tax). Using a quantitative life-cycle model, we document that young households benefited from the stimulus, while the bill was mainly paid by middle-aged and older agents. Crucially, most welfare redistribution was due to indirect effects related to macroeconomic adjustment that resulted from the stimulus. As a consequence, even though all age cohorts received significant transfers, welfare of some actually decreased.

JEL: E31, E51, E52, H5, J11

Keywords: COVID-19; Fiscal expansion, Monetary policy, Redistribution;

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1 Introduction

1.1 Motivation and main results

The COVID-19 pandemic struck unexpectedly in early 2020. It brought havoc, death and suffering. Fiscal authorities around the world faced sharply increasing bills and dramatically falling income. The former resulted mainly from ballooning health-care expenditure and subsidies to struggling firms. The latter followed self-imposed restrictions of economic activity by citizens who feared the infection, as well as lockdowns imposed by governments that tried to flatten the infection curve and prevent the health-care system from collapsing. In the euro area (on which this paper concentrates), these developments brought about fiscal deficits of 7.1% and 5.2% of GDP in 2020 and 2021, respectively.[1]

The fiscal expansion was accommodated by a deep monetary easing. With interest rates close to the effective lower bound (ELB), this was implemented by introduction of a new round of quantitative easing. The European Central Bank (ECB) initiated the Pandemic Emergency Purchase Program (PEPP) with a total envelope for asset purchases of EUR 1,850 billion. This ultra-expansionary policy-mix allowed to finance the necessary expenditure and keep the economy afloat. However, it also resulted in inflationary pressures. Inflation increased from 1.2% just before the pandemic outbreak in February 2020 to 5.9% in February 2022 before the unprovoked aggression of the Russian Federation against Ukraine made food and energy prices soar and blurred the picture by further fueling inflation.

We use these developments to assess how such a massive monetary-fiscal stimulus redistributes welfare across different age cohorts. The direct effects of fiscal policy distributed income to various groups of citizens in a relatively transparent way. Various categories of transfers and expenditures are well documented in the Eurostat statistics. What is much less transparent, and at the same time arguably much more interesting, is the redistribution that happened indirectly, due to macroeconomic adjustment. By preventing a collapse in

[1] As GDP fell sharply in 2020, we calculate all GDP ratios in the paper using the 2019 GDP in the denominator.

economic activity, the monetary-fiscal stimulus increased incomes of workers and owners of capital. However, the unexpected inflation it generated hurt owners of nominal assets (cash, bonds). As official taxes have not been increased, these groups are the most likely to have implicitly financed much of the fiscal expenditures by paying an inflation tax.

To study these effects in detail, we construct a business cycle model with life-cycle features, carefully calibrate it to reflect the main distributional features of the euro area households balance sheets, and then use it to assess the redistributive consequences of the pandemic programs. Such a framework allows us not only to look at the direct redistribution due to non-uniformly allocated spending between different age cohorts, but, crucially, to asses the obscure part of the redistribution that occurred indirectly via general equilibrium effects. To the best of our knowledge, this is the first such attempt (not only for the pandemic stimulus, but also more broadly in the context of monetary-fiscal stimuli), and here we see our main contribution to the existing literature.

The aggregate implications of our analysis are as follows: without the stimulus package, the pandemic recession would have been worse and deflation would loom. However, while the expansion contributed to faster post-pandemic recovery, it also resulted in rising inflation. To assess the redistributive effects, we calculate the expected remaining lifetime welfare gain of each cohort due to the expansion. What do we find? Young European households benefited most from the stimulus as fiscal expenditures and improved labor market conditions supported their incomes. Moreover, nominal asset holdings of the young are relatively small (or even negative), so they did not pay much of the inflation tax (mortgage holders gained in fact). Older generations, on the other hand, paid most of the bill. They benefited from transfers to firms and the related stock market appreciation. However, these gains did not outweigh losses taken from the inflation tax on nominal assets, as middle-aged and old households tend to own them in substantial amounts.

Our most important finding is however that most of the redistribution occurred via indirect (general equilibrium) channels related to the labor market performance, surprise inflation, and stock market appreciation. For many cohorts these effects actually determined the sign of the total welfare effect. All these findings qualitatively hold across alternative realistic assumptions about the future paths of fiscal policy and its monetary accommodation.

1.2 Monetary and fiscal policy during the pandemic

In this section we discuss the monetary-fiscal stimulus of 2020-21. Let us start with fiscal expenditures. As is well known, governments in all euro area countries sharply increased spending without raising taxes. How expenditure was divided between government consumption and various types of transfers matters somewhat for the macroeconomic picture, and a lot for the income side of the redistribution. We analyze in detail the Eurostat statistics on the total general government expenditures by function[2], which allows to assign government spending to five groups: government consumption, wage subsidy, transfers to households, transfers to firms, and transfers to retirees. According to such obtained estimates that we report in Table 7, the increase in total government spending in 2020 amounted to 4 percent of GDP, of which the lion's share was consumed by wage subsidies (2.08 pp) and government consumption (1.03 pp). The total number for 2021 was 5.4% of GDP and had a similar composition across the five categories as in 2020.

Now let us move to monetary policy. With the macroeconomic picture griming in Winter of 2020, the ECB decided to launch a new asset-purchase program, the PEPP. In March 2020 the Governing Council decided to start asset purchases with a maximum volume of EUR 750 billion. This envelope was further increased in June and December 2020 to a total of EUR 1850 billion or almost 14% of GDP, of which EUR 1718 billion were ultimately used by March 2022, when net purchases were suspended. The PEPP was supposed to bring monetary accommodation by easing financing conditions for the private and public sectors (Lane, 2022).[3]

[2]These consist of 11 expenditure categories based on the European System of Accounts (ESA2010) and 70 functions classified according to the Classification of the functions of government (COFOG1999). Data comes from the Eurostat reports on general government expenditure by function. A detailed description of how the data was constructed can be found in the Appendix.

[3]Beyond attempting to ease policy on the aggregate, the ECB was also actively counteracting the financial fragmentation of the euro area (i.e. rising yields of certain countries government securities). This part of the story is however beyond the scope of our study and we pay attention neither to this nor to the impact

Consequently, virtually all newly created public debt was acquired by the Eurosystem (ES), resulting in the creation of central bank reserves. At the same time almost no traditional monetary policy reaction occurred. Interest rates were not lowered in the pandemic as they were already close to the lower bound. A monetary policy tightening started only in the second half of 2022. The ECB decided not to reduce PEPP related asset holdings and to reinvest all maturing principal payments at least until the end of 2024 (ECB, 2023). Figure 1 shows how all the main categories discussed above evolved.

As is known from the literature (discussed in the next section), the macroeconomic effects of government spending crucially depends on the current and expected future reaction of monetary policy as well as on whether the resulting deficits are expected to be repaid by future fiscal tightening. In this context it is important to note that, at the time the PEPP was introduced, expectations of monetary policy pointed towards a prolonged period of accommodation, while expectations of fiscal policy suggested that spending shocks were largely perceived as unfunded. In March 2020 EONIA forward rates declined below zero for a period of up to 20 years. The forecasts of primary fiscal balances declined sharply into negative territory in 2020 and surpluses are not forecasted even at the moment this paper is written (see bottom row of Figure 1).

Based on the facts described above, our baseline modeling strategy assumes a fiscal expansion unfunded by future tax increases[4] or spending cuts and accommodated by a passive monetary policy reaction in the sense of Leeper (1991). As a robustness check, we also present alternative calculations which assume partial fiscal consolidation in the future or active monetary policy subject to a prolonged ELB. It should be made clear that we think of the analyzed episode as a special feature of the pandemic times, and not necessarily as an adequate approach to modeling monetary-fiscal policy interactions in other circumstances.

of the PEPP on avoiding a possible widespread panic on financial markets.

[4]This does not preclude tax income to partly finance the stimulus, as the tax base may increase. In our baseline simulation this effect covers approximately 1/3 of the expenditures, leaving the rest unfunded.

1.3 The related literature

First, our work is related to a growing literature emphasizing the potential redistributive effects of monetary and fiscal policies. Using detailed micro-level data on income and consumption for U.S. households, 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. Lenza and Slačálek (2021) come to the same conclusion in their study of quantitative easing. Doepke and Schneider (2006) show that unexpected inflation transfers resources from the old (typically the bondholders) to the young (with fixed-rate mortgage debt) in the postwar U.S. economy. Similar conclusions can also be drawn 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 price level movements generate a quantitatively significant wealth redistribution. Pallotti et al. (2023) use the same data to measure the welfare effects of rising inflation between 2021 and 2022, identifying those aged 25-44 as net winners as they are less likely to own large balances of nominal assets and more often hold nominal debt. Heterogeneous agent New Keynesian (HANK) models are also increasingly gaining ground in the context of distributional effects, showing i.a. that poor households are more strongly affected by monetary policy shocks (see e.g. Kaplan et al., 2018; Guo et al., 2023).

Regarding distributional aspects of the pandemic fiscal stimulus, Faria-e Castro (2021) analyzes the effectiveness of various policy tools in stabilizing the incomes of household groups (borrowers vs savers), while Bayer et al. (2023) use a HANK model to calculate the effectiveness of various transfers in stabilizing the economy. Closest to our work is Bhattarai et al. (2023), who analyze the distributional consequences of various fiscal tools and discuss the role of their inflationary consequences in a two-agent (Ricardian and hand-to-mouth) model. To the best of our knowledge, discussing the distributional consequences of fiscal policy along the age dimension, their direct vs. indirect component and their dependence on the shape of monetary policy have not been studied so far.

Second, our paper is related to the theoretical and empirical literature on the macroeconomic effects of fiscal policy with particular focus on the role played by monetary policy behavior and on how the fiscal stimulus is funded. The former concurs that the effects of fiscal policy are highly dependent on how monetary policy is shaped. In particular, changes in government spending or taxes and transfers may have more significant multiplier effects under zero lower-bound conditions compared to periods when there is more room to maneuver the interest rates. Christiano et al. (2011) document that fiscal measures aimed to increase aggregate demand are particularly powerful at the effective lower bound while Erceg and Linde (2014) consider the conditions under which they may even become self-financing. Similar results are obtained by Woodford (2011), showing an increase in welfare when government purchases fill the output gap created as a consequence of the inability to reduce interest rates. More generally, empirical evidence presented by Cloyne et al. (2020) emphasizes the crucial role of monetary policy in shaping the size of fiscal multipliers.

The latter follows Leeper (1991) and Leeper and Leith (2016) who introduce the concept of an active fiscal - passive monetary policy arrangement under which fiscal deficits are accommodated by expansionary monetary policy. In a similar spirit, Bianchi et al. (2023) introduce the distinction between funded and unfunded fiscal shocks, the latter not being backed by future fiscal adjustments and consequently leading to a sharp increase in output and inflation. Focusing on the American Rescue Plan Act from 2021, that paper concludes that the program exacerbated the rise in inflation because it was partially unfunded. A related stream of literature shows similar effects of a money-financed fiscal expansion, which, as argued by Hall and Sargent (2022), was the key way of financing of the US fiscal response to COVID-19. English et al. (2017) find that money-financed fiscal programs that are seen as credible by the public can strongly boost the economy. Galí (2020) shows that under not binding ELB money-financed government initiatives give a more considerable boost to the economy compared to a debt-financed fiscal stimulus. Reis and Tenreyro (2022) discuss the impact of helicopter drops as a response to several economic shocks, including the redistribution of wealth across agents over time.

Last but not least, our work is also related to papers using an OLG setup with New Keynesian features, typically relying on the stylized Blanchard-Yaari framework. This literature includes, among others, Galí (2021) on rational bubbles, Del Negro et al. (2012) on resolving the forward guidance puzzle, Nisticó (2012) about stock prices in driving monetary policy, Eggertsson et al. (2019) on quantifying the secular stagnation hypothesis and Angeletos et al. (2023) on the possibility of fiscal deficits becoming largely self-financing due to their expansionary effect on the tax base and inflation. By incorporating a detailed life-cycle setup in which agents are characterized by age-dependent asset portfolios that closely match the distributions among euro area households, our modeling environment is closest to the framework of Bielecki et al. (2022).

2 Model

We develop a general equilibrium overlapping generations (OLG) model that features a New Keynesian production sector with sticky prices and wages, as well as government and banking sectors. Below we present its main building blocks. Further details, including the complete set of aggregate equilibrium conditions, can be found in the Appendix. A period in the model corresponds to one year. Variables without time subscripts indicate their respective steady state values.

2.1 Households

2.1.1 Demographics

We assume that households enter the labor market at the age of 20, which corresponds to index $j = 1$ in our model, and live for a maximum of $j = J = 80$ periods. In each period they face age-dependent mortality risk with age-specific probability denoted as ω_j, with $\omega_J = 1$.The size of age cohort j in period t is denoted as $N_{j,t}$ and it evolves according to the following formula

$$N_{j+1,t+1} = (1 - \omega_j) N_{j,t} \tag{1}$$

and the total population is given by

$$N_t = \sum_{j=1}^{J} N_{j,t} \tag{2}$$

We assume that the size of the youngest cohort $N_{1,t}$ changes at a constant rate n. Since the age-specific survival probabilities do not change over time, each age cohort, and hence total population, also grows at rate n.

2.1.2 Budget constraint

In each period, households decide on their consumption $c_{j,t}$ and accumulation of the following four types of assets, all expressed in real terms: housing $\chi_{j,t}$, deposits $m_{j,t}$ that yield nominal gross return R_t^m, financial assets $a_{j,t}$ that are managed by investment funds and that offer the age-specific nominal gross return $R_{j,t}^a$, and an adjustable-rate mortgage loan $s_{j,t}$ on which banks charge nominal gross interest R_t^ℓ. Households also supply differentiated labor services $h_{j,t}(\iota)$ to labor unions that pay real wage $z_j w_t(\iota)$ net of tax at rate τ, with ι indexing individual households and z_j denoting age-specific productivity. Households can work until they reach retirement age $J_R = 45$, which is operationalized in the model by assuming that $z_j = 0$ for $j \geq J_R$. Households can also receive four types of transfers $t_{j,t}^H$, $t_{j,t}^W$, $t_{j,t}^F$, and $t_{j,t}^R$, which are extended to, respectively, all households, working households, firm owners, and retired households. Finally households receive unintended bequests $beq_{j,t}$ which consist of assets left by other households that die before reaching age J, and which are distributed evenly across cohorts no older than $J_R - 10$. Due to staggered wage contracts, household labor income can differ within a cohort. However, we assume that this idiosyncratic risk can be perfectly insured so that all other allocations chosen by agents in the same cohort are identical. This allows us to omit index ι on these variables and write the budget constraint of cohort j as follows

$$
\begin{aligned}
c_{j,t} + p_{\chi,t}[\chi_{j,t} - (1-\delta_\chi)\chi_{j-1,t-1}] + m_{j,t} + a_{j,t} + \frac{R^{\ell}_{t-1}}{\pi_t} s_{j-1,t-1} = (1-\tau) w_t(\iota) z_j h_{j,t}(\iota) + \\
+ \frac{R^m_{t-1}}{\pi_t} m_{j-1,t-1} + \frac{R^a_{j,t}}{\pi_t} a_{j-1,t-1} + s_{j,t} + t^H_{j,t} + t^W_{j,t} + t^F_{j,t} + t^R_{j,t} + beq_{j,t} + \Xi_{j,t}(\iota) \quad (3)
\end{aligned}
$$

where p_χ denotes the real house of pricing, δ_χ is the annual depreciation rate of housing stock, $\pi_t = P_t/P_{t-1}$ is the gross inflation rate (with P_t denoting the aggregate price level), and $\Xi_{j,t}(\iota)$ stands for net real payments from the labor insurance scheme.

To ensure realistic dynamics of mortgage debt, we assume that housing loans are taken for multiple periods so that $s_{j,t}$ evolves according to the following formula

$$
s_{j,t} = \ell_{j,t} + \left(1 - \frac{1}{m}\right) \frac{s_{j-1,t-1}}{\pi_t} \quad (4)
$$

where $\ell_{j,t}$ denotes new loans granted in period t to households of age j and m is a parameter controlling the effective loan duration. These loans are subject to the following LTV constraint

$$
\ell_{j,t} \leq LTV_j \chi_{j,t} p_{\chi,t} \quad (5)
$$

where LTV_j is the age-specific loan-to-value ratio.

2.1.3 Wage stickiness

Differentiated labor services of variety ι are sold to perfectly competitive aggregators who bundle labor from all households of age j according to the following formula

$$
h_{j,t} = \left[\int_0^1 (z_j h_{j,t}(\iota))^{1/\mu_w} \, \mathrm{d}\iota \right]^{\mu_w} \quad (6)
$$

where μ_w determines the degree of substitutability between differentiated labor services. We assume that the thus defined effective bundles of labor services of different age cohorts are perfect substitutes, so aggregators are paid the same real wage w_t per unit of $h_{j,t}$ for all j. Labor aggregators maximize the following objective function $w_t h_{j,t} - \int_0^1 w_t(\iota) z_j h_{j,t}(\iota) \mathrm{d}\iota$.

Wage setting is performed by monopolistically competitive labor unions. For tractability, we assume that they operate on behalf of all households, implicitly aggregating the marginal rate of substitution between consumption and leisure over the whole working age population. Labor unions set wages subject to nominal rigidity a la Calvo, with reoptimization probability $1-\theta_w$. Wages that are not reoptimzed are indexed to steady state inflation.

2.1.4 Household optimization problem

In period t a household of age j solves the following problem

$$V_{j,t}(\mathcal{S}_{j-1,t-1};\iota) = \max_{\{c_{j,t},\ell_{j,t},\chi_{j,t},m_{j,t},a_{j,t},s_{j,t},h_{j,t}(\iota)\}} \{u_{j,t}(\iota) + \beta\omega^j \mathbb{E}_t V_{j+1,t+1}(\mathcal{S}_{j,t};\iota)\} \tag{7}$$

where the instantaneous utility function is given by

$$\begin{aligned} u_{j,t}(\iota) = {} & (1-\varrho)\log\left(c_{j,t} - \varrho\bar{c}_{j,t-1}\right) + \\ & + \upsilon_j \log\chi_{j,t} + \psi_j \log m_{j,t} - \phi_j \frac{h_{j,t}(\iota)^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} + (1-\varrho)\frac{g}{c_j}\log\left(g_t - \varrho g_{t-1}\right) \end{aligned} \tag{8}$$

The state space of a household aged j in period t is $\mathcal{S}_{j-1,t-1} = \{\chi_{j-1,t-1}, m_{j-1,t-j}, a_{j-1,t-1}, s_{j-1,t-j}, w_{t-1}(\iota)\}$, β denotes the discount factor, ϱ controls the degree of external habit formation, g_t is public consumption (assumed to be allocated equally across all households), and $\bar{c}_{j,t}$ denotes per capita consumption of cohort j.[5] Note that the weight on the last term in the felicity function 8 ensures that the marginal utility of private and public consumption are equal in the steady state. The optimization is subject to the sequence of budget constraints (3), collateral constraint (5), mortgage debt law of motion 4, and labor demand schedules implied by the solution to the problem of labor aggregators.

[5] Naturally, we have $\bar{c}_{j,t} = c_{j,t}$ in equilibrium.

2.2 Firms

Our model features a standard New Keynesian firm sector. There are two stages of production. Final good producers combine differentiated inputs $y_t(i)$ and produce homogeneous final product y_t according to the following CES aggregator

$$y_t = \left[\frac{1}{N_t^f} \int_0^{N_t^f} y_t(i)^{\frac{1}{\mu}} \mathrm{d}i \right]^{\mu} \tag{9}$$

where μ determines the degree of substitutability between different product varieties and N_t^f number of intermediate inputs. Their objective is to maximize $P_t y_t - \frac{1}{N_t^f} \int_0^{N_t^f} P_t(i) y_t(i) \mathrm{d}i$, where $P_t(i)$ is the price of intermediate input i. Risk-neutral intermediate goods producers rent capital $k_t(i)$ and effective labor $h_t(i)$ to produce differentiated products $y_t(i)$ with the standard Cobb-Douglas technology

$$y_t(i) = k_t(i)^{\alpha} h_t(i)^{1-\alpha} - \Phi \tag{10}$$

which features fixed cost Φ. The profit of firm i is $P_t(i)y_t(i) - W_t h_t(i) - R_{k,t} k_t(i)$, where W_t is the nominal wage rate and $R_{k,t}$ is the nominal rental rate on capital. The number of firms is such that the profits are zero in the steady state. Price setting by intermediate goods producers is subject to a Calvo rigidity. In each period, a fraction $1 - \theta$ of firms receive a signal to reoptimize their prices, , which otherwise are indexed to steady state inflation.

2.2.1 Capital good produces

Perfectly competitive and risk-neutral capital good producers purchase final goods i_t at price P_t and combine them with undepreciated capital subject to quadratic investment adjustment costs to produce new capital that can be operated in the next period. The economy-wide capital stock per capita hence evolves according to

$$(1+n)k_t = (1-\delta)k_{t-1} + \left[1 - \frac{S_k}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t \tag{11}$$

where S_k controls the degree of adjustment costs and δ is the capital depreciation rate.

2.3 Financial sector

The financial sector consists of two types of intermediaries. Banks extend mortgages to households and hold their deposits. Investment funds manage households' non-bank assets.

2.3.1 Investment funds

Perfectly competitive investment funds trade in government bonds and claims on physical capital. They invest the resources obtained from households and provide them with the return on the exogenously specified portfolio. We assume that fund managers are risk neutral. Arbitrage then implies equalization of the expected rate of return on bonds and capital $R_t = \mathbb{E}_t(R_{k,t+1} + (1-\delta)Q_{t+1})/Q_t$, where Q_t denotes the price of capital. If we denote the share of bonds in the portfolio of cohort j as $\eta_{j,t}$, we can write the gross age-specific nominal return on portfolio for cohort j as $R^a_{j,t} = \eta_{j,t}R_{t-1} + (1-\eta_{j,t})R^f_t$, where R^f_t is the gross nominal return on real assets, which consists of the return on physical capital and dividend payments from firms and banks. The dividends are distributed across households in a lump sum fashion and proportionally to their claims on capital.

2.3.2 Banks

We model the banking sector in a very simplified way. Rather than defining individual banks as profit-maximizing agents, we model them as licensed intermediaries. Each of them serves an assigned group of households, accepting all their deposits and offering any mortgages they demand. Banks also purchase government bonds that households are not willing to hold b^b_t and reserves issued by the central bank rr_t. The balance sheet of the consolidated banking sector is given by

$$m_t = rr_t + b^b_t + s_t \tag{12}$$

Since we abstract away from any defaults on mortgages and will further assume that reserves pay the same interest rate as bonds, all assets held by banks are perfect substitutes from their perspective, which in particular implies $R_t^\ell = R_t$. We also postulate the following simple rule transmitting R_t to the deposit rate R_t^m[6]

$$R_t^m = R^m + \iota_m (R_t - R) \tag{13}$$

where ι_m determines the speed of the interest rate pass-through. The profits of the consolidated financial sector are given by

$$div_t^b = \frac{R_{t-1}}{\pi_t}(rr_{t-1} + b_{t-1}^b + s_{t-1}) - \frac{R_{t-1}^m}{\pi_t} m_{t-1} \tag{14}$$

and they are transferred to the fiscal authorities.

2.4 Fiscal and monetary authorities

The government collects labor income taxes and issues debt b_t^g to finance exogenously given public consumption g_t and transfers to households. The government budget constraint is then given by the following equation

$$\frac{R_{t-1}}{\pi_t} b_t^g + g_t + t_t^H + t_t^W + t_t^R + t_t^F = (1+n)\, b_{t+1}^g + div_t^b + \tau w_t h_t \tag{15}$$

The central bank can hold government bonds b_t^c, financing its purchases by issuing reserves rr_t. Its balance sheet constraint is then simply $rr_t = b_t^c$. Since we assume for simplicity that central bank reserves are remunerated at the same rate R_t as government bonds, the central bank makes zero profits period by period.

In line with the discussion provided in the introduction, in our baseline model simulations we assume that monetary policy is passive in the sense of Leeper (1991). More specifically,

[6] A more elaborate version of the banking sector could feature an agency friction a la Gertler and Karadi (2011), which would drive an endogenous wedge between R_t^m and R_t.

whenever a change in net fiscal revenues requires an adjustment in government debt (e.g., because of a fiscal stimulus package), all of the net issuance of government bonds is absorbed by the central bank. As a result, the quantity of bonds held by the private sector b_t is constant in real terms. While describing our main results, we also consider alternative assumptions on how the fiscal stimulus is financed. One of them features active monetary policy that follows a standard Taylor-type rule with smoothing

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\gamma_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\gamma_\pi} \left(\frac{y_t}{y}\right)^{\gamma_y}\right]^{1-\gamma_R} \tag{16}$$

unless constrained by the effective lower bound.

2.5 Market clearing conditions

The model is closed with a standard set of market clearing conditions which are relegated to the Appendix.

3 Calibration

We calibrate our economy to the euro area. Since in our model one period corresponds to one year, we use annual data for calibration.

3.1 Demographics and life-cycle profiles

From the Eurostat data we obtain the age-dependent mortality risk as well as the growth rate of population, using the averages from the 1999-2018 period and applying exponential extrapolation when data for the oldest cohorts are missing. The resulting population growth rate equals 0.1% annually. Together with the mortality rates, this pins down the stationary population structure.

We use the second wave of the HFCS data that was conducted in 18 euro area countries to obtain the age profiles for labor income, hours worked, housing wealth, real assets, loans, bond and deposit holding at the households level. Labor income consists of wage employment and self-employment, while hours worked equal time spent at the main job. Housing consists of the household's main residence and other real estate property not used for business activities. Real financial assets are the sum of household's business wealth, value of non-self-employment private business, publicly traded shares, as well as 50% of mutual fund holdings and 50% of voluntary pension and life insurance contracts. Loans equal the value of mortgage and non-mortgage debt, money holdings are matched to deposits. Government bond holdings are matched to the sum of bonds and the remaining 50% of both mutual and voluntary pension funds. Table 3 presents the mapping between our categories and HFCS codes.

In order to match the steady state profile of labor income, we proceed as follows. First, we obtain from the HFCS the age profile of hourly wage, which directly pins down age-specific productivities z_j. Next, we plug them in the model and use the age-specific weights on disutility of labor ϕ_j to match the profile of hours worked observed in the data. The age profile of housing and deposits is matched using the age-specific utility-weights υ_j and ψ_j. The age profile of loans follows from the credit constraint of households and is matched to the data with age-specific loan-to-value ratios LTV_j. Finally, we impose the age profile of government bond holdings in the steady state from the data using exogenous weights η_j. The age profile of the remaining real assets is endogenous.

Figure 2 presents the age profiles of hours worked, labor productivity and asset holdings together with raw data based on HFCS statistics. The labor productivity profile follows a standard pattern, it increases up to the late middle age and than it declines slightly. The age profile of hours worked is quite flat. Regarding assets, young households tend to finance their consumption and housing expenditure with loans, therefore their net financial assets are negative. In the middle age households start to accumulate assets and then deccumulate them after retirement. The model is successful in capturing these broad features of the data.

Figure 3 plots together the distribution of assets generated by the model. It is important to note that the profiles of some assets (in particular housing) are less steep than of others (in particular real financial assets). As a consequence, the speed of their accumulation / decumulation differs, which, as explained in section 5, is an important driver of the redistributive effects.

3.2 Macroeconomic parameters and steady-state ratios

We set the discount factor β to 0.9876 to match the steady state real interest rate of 0.8 percent, which is the euro area average from the period of 1997-2012, which is when the ECB monetary policy was not constrained by the effective lower bound. As is standard in the macroeconomic literature, we set the Frisch elasticity to 0.5. The habit persistence parameter ϱ is calibrated at 0.32, which corresponds to a conventional value of 0.75 used in models operating at quarterly frequency. The curvature of the investment adjustment cost S_k is set to 4. The steady state price and wage mark-ups both equal 1.2. Furthermore, we set the Calvo probability of price change θ to 0.19 and of wage change θ_w to 0.41. They correspond to, respectively, 0.66 and 0.8 at quarterly frequency and imply price duration of, respectively, 3 and 5 quarters. All these values are well within the range of estimates in the literature.

We match the share of different asset holdings to GDP to the national accounts data as well as aggregate balance sheet statistics of financial and non-financial assets (Eurostat data). The housing depreciation rate δ_χ equals 0.04 to match the housing-to-GDP ratio of 1.3. We set the capital depreciation rate δ and capital share in output α to match the investment rate of 24 percent and the capital-to-GDP ratio of 1.97. The weights on utility of deposits ϕ_j and the loan-to-value ratios LTV_j imply the deposits-to-GDP ratio of 0.98 and the loans-to-GDP ratio of 0.87. Both are very close to the combined holdings by non-financial firms and households. The total supply of government bonds is set to 54 percent of GDP, which is the average of two statistics: holdings of government securities by households (50%) and the debt securities issued by the general government net of government debt holdings of the rest of the world (58 percent). The share of government expenditure to GDP is set to 20 percent and the steady state inflation (inflation target) to 2 percent. The debt maturity parameter

m is calibrated at 6.75 years based on averaged ECB data from the 30 months preceding the outbreak of the pandemic. It reflects the stock-to-flow ratio of lending for house purchase excluding revolving loans and overdrafts for households in the euro area.

4 Macroeconomic effects of the pandemic stimulus

4.1 How does the model work?

Before we use the model to simulate the pandemic, we present how our model economy reacts to the key ingredients of the fiscal programs that were used in most European countries during the pandemic. To this end, we discuss the transmission of two selected policies, namely an increase in government consumption and an increase in transfers to households. In the latter case, we use transfers that are uniformly distributed across all living individuals. However, their aggregate implications (but not redistributive ones, which we cover in the next section) are very similar to those associated with transfers targeting firm owners, workers or retirees.

Figure 4 plots the responses to a one period increase in government consumption equal to 1% of steady state GDP. One striking result is that output expands by more than the applied stimulus so that the impact multiplier is above unity, amounting to about 1.2. As economic activity stays elevated for the next years, the cumulative multipliers are even larger, reaching 1.9 after eight years.[7] This is because neither private consumption nor investment are crowded out, but instead persistently expand as monetary policy accommodates increased fiscal spending by purchasing bonds issued by the government. The real amount of reserves created by the central bank to finance these purchases is lower than the size of the stimulus as inflation erodes the real value of public debt and increases labor income tax revenue. As a result, the financing gap that the fiscal authority needs to bridge by additional bond issuance is much less than 1 percent of GDP. The magnitude of monetary accommodation can also be appreciated by noting that the nominal interest rates barely change despite persistently

[7]Here and below, the cumulative multipliers are calculated as the discounted sum of the changes in output divided by the initial increase in a given spending category, where the discounting uses the household discount factor β.

higher inflation. As a result, the real interest rate stays negative for an extended period of time. This together with higher tax revenues allows the fiscal authority to gradually bring the real stock of public debt back ot its steady state level. The mirror image of this deleveraging process is a fall in central bank reserves that were issued to finance purchases of government bonds. Finally, low interest rates appreciate asset prices, and especially persistently so, the prices of homes.

Very similar dynamics of macroeconomic aggregates can be observed in response to a one period increase in transfers to households, again normalized to 1% of trend GDP. As depicted in Figure 5, the key difference compared to the government consumption shock is a much lower impact response of output. This reflects the intertemporal consumption smoothing motive by households, who choose not to spend all of the additional transfer income on purchases of more goods immediately. As a result, the impact multiplier is much lower and amounts to about 0.3, but accumulates to 1.4 after eight years. Otherwise, the economy absorbs the transfer shock in a very similar way as it does in the case of a government consumption shock, thus stressing the key role of monetary accommodation provided by a passive central bank.

The presented results are broadly in line with the empirical literature estimating the dynamic effects of fiscal surprises, and in particular with most recent works showing that fiscal multipliers can be as high as two or even three if monetary policy chooses to be very accommodative (Cloyne et al., 2020; Hack et al., 2023).[8] Our model simulations are also consistent with those papers that find crowding-in of both private consumption and non-residential investment by an exogenous increase in government spending (see, e.g., Fritsche et al., 2021).

[8] In this context, it is important to distinguish these two papers that focus on the causal effect of monetary policy stance from studies showing large fiscal multipliers when the economy is at the zero lower bound (e.g., Ramey and Zubairy, 2018), the latter case being endogenous to the business cycle.

4.2 Simulating the pandemic stimulus

We now use the model to simulate the effects of the whole fiscal package as discussed in Section 1.2. The impact on key macroeconomic variables is presented in Figure 6. Recall from Table 7 that the stimulus was worth almost 10% of pre-pandemic annual GDP and was spread fairly evenly over two years. According to our model, the impact on economic activity was sizable, elevating GDP about 4% above its steady state level during the first two years. These expansionary effects were also long lasting, with GDP still staying about 1% above the steady state four years after the stimulus was withdrawn. The economic expansion was driven by both public and private consumption, the latter supported by massive transfers to households, but investment also contributed significantly. The fiscal expansion is financed in approximately 1/3 by higher labor tax proceeds, the rest is accommodated by the monetary authority, which issued reserves worth about 4.5% of GDP in the second year of the stimulus to purchase government debt. As a result, inflation went up by 3.5% and only gradually declined in the subsequent years. Persistently negative real interest rates led to a boom in asset prices and an expansion in credit.

Naturally, the stimulus in Europe was not implemented in a vacuum but was launched in response to a massive collapse in economic activity and deflationary pressures, caused by global supply disruptions, social distancing measures implemented by the authorities to contain the pandemic, and a spike in economic uncertainty. Therefore, it is instructive to set our simulation results against the backdrop of actual macroeconomic developments in the euro area. Figure 7 shows the evolution of EA inflation and GDP growth , comparing them to a counterfactual scenario that assumes no fiscal stimulus. It is clear that the fiscal package implemented in 2019-2020 prevented an even deeper contraction in economic activity and helped avoid deflation. However, it also contributed positively to the inflation surge observed two years after, adding about 1.5 percentage points to the increase in HICP observed in 2022.

5 Redistributive effects

In our life-cycle model households are heterogeneous because of age. This determines the type and quantity of income they earn as well as the type and stock of assets they hold. As we have seen from Table 7, the pandemic fiscal package in the euro area involved various types of transfers, some of which were directed to particular groups, namely workers, retirees or firm owners. Given the size and non-uniform distribution of transfers across the population, one can expect that these direct effects alone could result in non-negligible redistribution of wealth. However, as we will now show, indirect effects associated with adjustments in macroeconomic quantities, prices and asset returns were even more important and hence are crucial to assess the redistributive consequences of the stimulus across different age cohorts.

We first offer a crude assessment of the direct effects of the fiscal package, obtained simply by allocating each of its five components presented in Table 7 to the relevant population groups. More specifically, we assume that transfers to firms are allocated to individual households proportionally to their equity (claims on capital) holdings, wage subsidies and transfers to retirees are allocated equally across all working and retired persons, respectively, while general transfers to households and public consumption are distributed uniformly across all households. Figure 8 presents the outcomes, expressed in percent of cohort-specific steady state consumption. According to this measure, all households benefited from the stimulus, with biggest gains accruing to those in their early 60s. This is because these age cohorts hold much of their wealth in equity, hence being ultimate recipients of transfers to firms, and are still in the working age, hence receiving more money than older agents as the fiscal package featured higher wage subsidies per worker than per beneficiary transfers to retirees.

Naturally, the picture painted by direct effects only is too rosy as it omits the financing side of the stimulus and the macroeconomic adjustments it generates. In a microfounded model like ours, the appropriate summary metric of who eventually gains and who loses from a policy is household welfare. This is what we present in Figure 9, also breaking down the total welfare effect into the contributions of the five fiscal instruments used in the stimulus. The outcomes are in stark contrast to those arising from the direct effects alone. Most importantly, not all cohorts gain, only those aged 45 and below in the year when the stimulus was implemented, so it clearly redistributed wealth from younger to older generations. The magnitude of this redistribution is sizable, with biggest winners gaining about 15% of their annual consumption while those hurt most losing roughly a similar share.

The main element of the fiscal expansion that contributed to this redistribution were wage subsidies. Interestingly, not all of the workforce benefited from this part of the program as its impact becomes negative for cohorts in their late 40s. The impact of government consumption and general transfers to households is less pronounced but follows a strikingly similar pattern, turning from positive to negative for agents in the late 40s, even though we assumed these two types of expenditures to be uniformly allocated to all people. Not surprisingly, transfers to retirees generated welfare gains for people past their retirement age. Interestingly, however, they also benefited a bit younger households, at the expense of the middle-aged ones. Finally, transfers to firms generated welfare gains mainly to households in their 70s as these are the ones who own most of capital. However, this part of the stimulus turned out to have a detrimental effect on older cohorts while bringing some benefits to younger agents.

To understand what drives these results, it is instructive to use a welfare decomposition developed by Bielecki et al. (2022), see the Appendix C for detailed derivations and adaptations to our particular model. In a nutshell, this decomposition takes an individual household's perspective and breaks down the total welfare effects into contributions associated with all macroeconomic aggregates and prices that show up in a given household's utility and budget constraint. The results of such a decomposition are presented in Figure 10.

It is clear that the main force distributing wealth from older to younger generation are changes in the return on nominal assets. Recall that the fiscal stimulus was fully accommodated by the central bank by issuing reserves to purchase government debt. This implied a prolonged period of negative real interest rates and a surge in inflation, which benefited agents that had short positions in nominal assets and hurt those holding long positions. In our model (recall Figure 3), and as in the data, loans are mainly taken by agents when they are young while bond and money holdings are accumulated more gradually, peaking around or after the retirement age. Another channel through which younger and also middle-aged cohorts benefited is the labor market as the economic expansion generated by the fiscal stimulus pushed labor demand and hence workers' income up.

These two effects were to some extent offset by changes in the return on real assets. As the stimulus and its monetary accommodation drove equity prices up, agents holding them gained significantly. This applies in particular to older households who tend to run down their claims on capital after retiring, hence benefiting from elevated prices. In contrast, younger households who are still in the process of accumulating real financial assets lost as this accumulation became more costly when equity prices rose. For similar reasons, changes in house prices also redistributed wealth from younger to older generations, but the effects were much smaller compared to the effect associated with real assets. This is because the age profile for housing (see again Figure 3) is not very steep, meaning that changes in house prices do not dramatically affect the cost of housing accumulation.

All the four channels through which the stimulus affects household welfare work through prices, returns on assets, and wages, and hence can be characterized as indirect effects in the language of Kaplan et al. (2018). The direct effects, shown in Figure 10 as transfers and public consumption, contribute significantly and (in line with the discussion above) always positively, but they matter relatively little for intergenerational redistribution.[9] As a matter of fact, accounting for the indirect effects completely changes the assessment of who won and who lost from the pandemic fiscal stimulus in the euro area. Judging by the direct effects alone, the biggest winners were households around the age of 60, but they actually belong to the group of biggest losers when all effects are taken into account.

[9] The magnitude, but not so much the general direction of the redistribution is affected by the external habit formation, which reduces the welfare gains perceived by those cohorts that evaluate their higher consumption relative to increased consumption of the preceding generation.

6 Alternative assumptions on monetary and fiscal policies

As discussed in Section 1.3, the impact of fiscal policy on the economy strongly depends on whether the stimulus is funded or unfunded, how monetary policy reacts to the expansion, and how the public perceives the monetary-fiscal mix further down the road. In Section 1.2 we explained why our baseline scenario assumes a passive monetary - active fiscal policy arrangement under which the stimulus remains largely unfunded.

Nevertheless, as it cannot be excluded that households had expectations that either the financing would be reversed or monetary policy tightened in the future, in what follows we simulate two alternative scenarios. First, we assume that after three years the stimulus is being gradually reversed. The fiscal authority starts levying lump-sum taxes on all households and firms in proportions roughly reflecting the initial stimulus and repaying the remaining debt so that its real value is reduced by 20% per year until the steady state is reached. The second experiment assumes that monetary policy follows the rule (16), but is constrained by the lower bound on interest rates for a prolonged time. To calibrate the latter case, we analyze data on EONIA forward rates in 2020. These showed that expectations of the ECB policy rates remained close to zero for a period of up to 20 years (recall Figure 1). Based on this evidence, we assume a constant policy rate in such horizon.[10] Since this case requires introducing passive fiscal policy (see Leeper, 1991), we assume that transfers to household are gradually adjusted so that public debt is eventually stabilized, meaning that the stimulus is fully funded, even though the consolidation is postponed far into the future.

Figure 11 documents the main developments plotted against our baseline scenario. While in both cases the general pattern is similar to the baseline, clearly the magnitudes differ. In particular, all effects are smaller if either the stimulus is reversed or monetary policy becomes active. Importantly, this affects the outcome also during the pandemic years, as both the reversal and the return to active policy are fully anticipated. For instance, inflation peaks at 2% and at 2.4% respectively, instead of 3.5% under the baseline.

[10] Assuming shorter horizons of constrained monetary policy makes macroeconomic reactions to the stimulus and the redistribution smaller.

How does this affect the redistribution? This is evidenced on Figures 12 and 13. Again, while the general patterns are roughly preserved, the magnitudes differ. The most striking change to the baseline is the smaller role of the return on nominal assets. This is an obvious consequence of inflation reacting less to the stimulus, so that in particular the inflation tax paid by older cohorts is smaller in both alternative scenarios. Gains from labor income are also smaller, as output increases by less. The net outcome is that the losses of the older households are relatively smaller, though the general conclusions that younger cohorts benefit at the expense of older generations and that indirect effects matter a lot still holds.

7 Conclusions

The massive monetary-fiscal expansion during the Covid-19 pandemic allowed to finance many urgent government expenditures without raising taxes. Over two years additional debt-financed fiscal spending amounted to almost 10% of pre-pandemic GDP. The debt was almost entirely acquired by the Eurosystem. But nothing comes for free, and somebody must have paid the bill. This paper seeks, among others, to find who it was. To this end, we have constructed a life-cycle model with nominal frictions and calibrated it to match the main features of the income and asset distribution across the age cohorts in the euro area. Then we simulated the fiscal programs introduced during the pandemic and used the model to estimate their implications for the macroeconomy and for the redistribution of welfare between various age cohorts.

According to our results, young European households benefited from the monetary-fiscal stimulus, while the bill was mainly paid by middle-aged and older households. Importantly, most redistributive effects of the stimulus did not come from direct income effects of increased spending (as it was divided relatively evenly across different age cohorts), but from its indirect macroeconomic effects associated with changes in asset returns and labor market conditions, of which inflation played the dominant role by hurting households having large nominal assets holdings. In fact, for many cohorts these indirect effects turned the overall welfare impact of the stimulus negative.

The pandemic stimulus and the degree of its monetary accommodation was unprecedented in the recent European history. For this reason, its aggregate and redistributive effects may not necessarily be representative for other fiscal expansions, especially those conducted in normal times. However, we do believe that properly accounting for the indirect effects of such programs is key to identify their winners and losers. As our analysis clearly shows, the outcome of such an evaluation can be very different from what one would expect just by looking at direct income flows.

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Tables and figures

Table 1: Change in government expenditure

Expenditure	**2020**	**2021**
Transfers to employees	2.08	2.07
Government consumption	1.03	1.46
Transfers to firms	0.45	0.89
Transfers to retirees	0.34	0.40
Transfers to all households	0.13	0.53
Total	**4.03**	**5.44**

Note: Values in % of GDP in 2019, increase in percentage points relative to 2019 level.

Table 2: Calibrated structural parameters

Parameter	Value	Description
β	0.9875	Discount factor
φ	0.5	Frisch elasticity of labor supply
ϱ	0.32	Habit persistence
δ_χ	0.04	Housing depreciation rate
δ	0.12	Capital depreciation rate
α	0.25	Capital share in output
S_k	4	Investment adjustment cost curvature
μ	1.2	Steady state product markup
θ	0.19	Calvo probability (prices)
Φ	0.04	Intermediate goods producers fixed cost
μ_w	1.2	Steady state wage markup
θ_w	0.41	Calvo probability (wages)
g_y	0.2	Share of government purchases in GDP
b^g/y	0.54	Steady state government bonds to GDP ratio
γ_R	0.66	Interest rate smoothing
γ_π	1.25	Reaction to inflation
γ_y	0.5	Reaction to GDP growth
m	6.75	Debt maturity

Figure 1: Development of main economic and financial variables 2017-2022

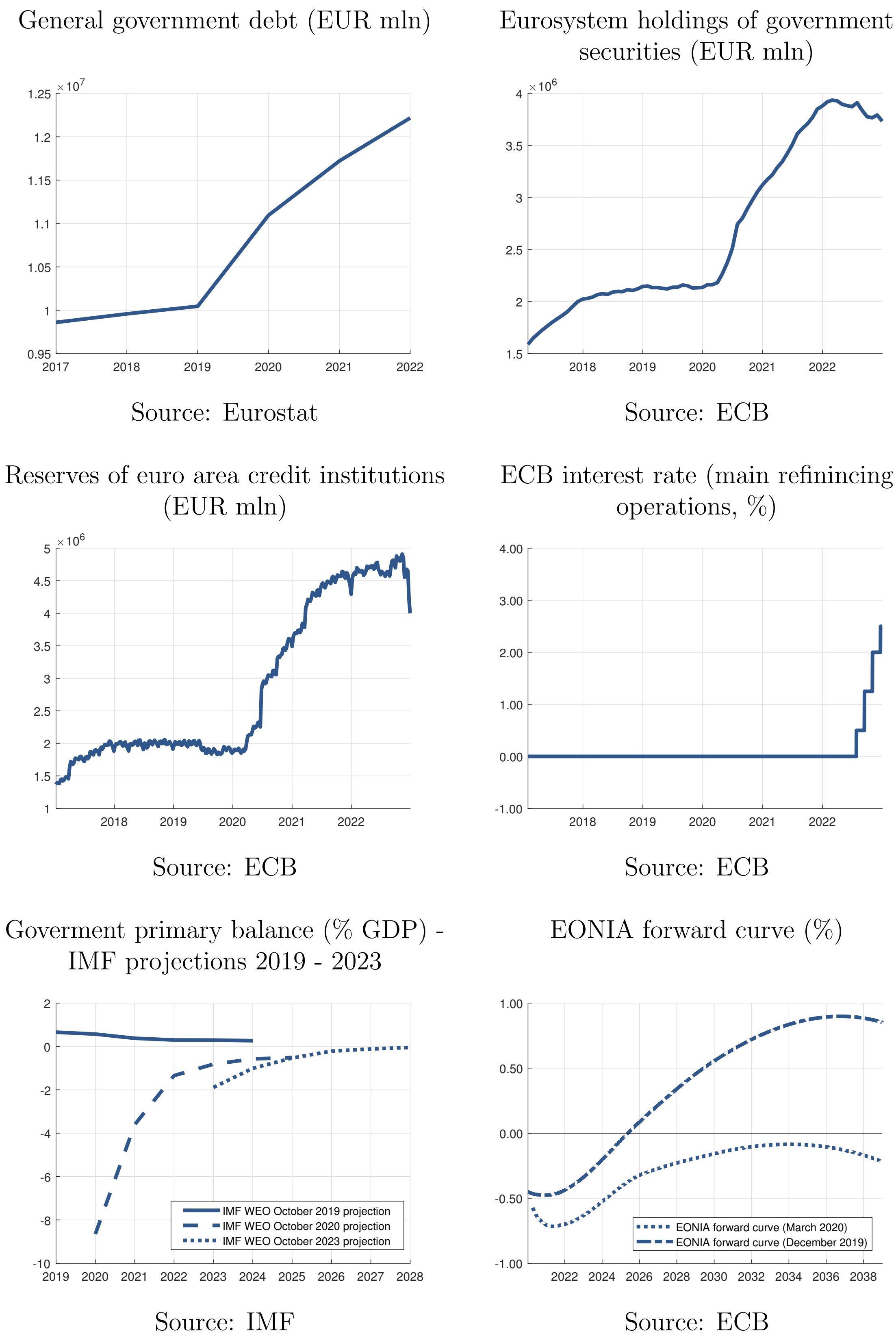
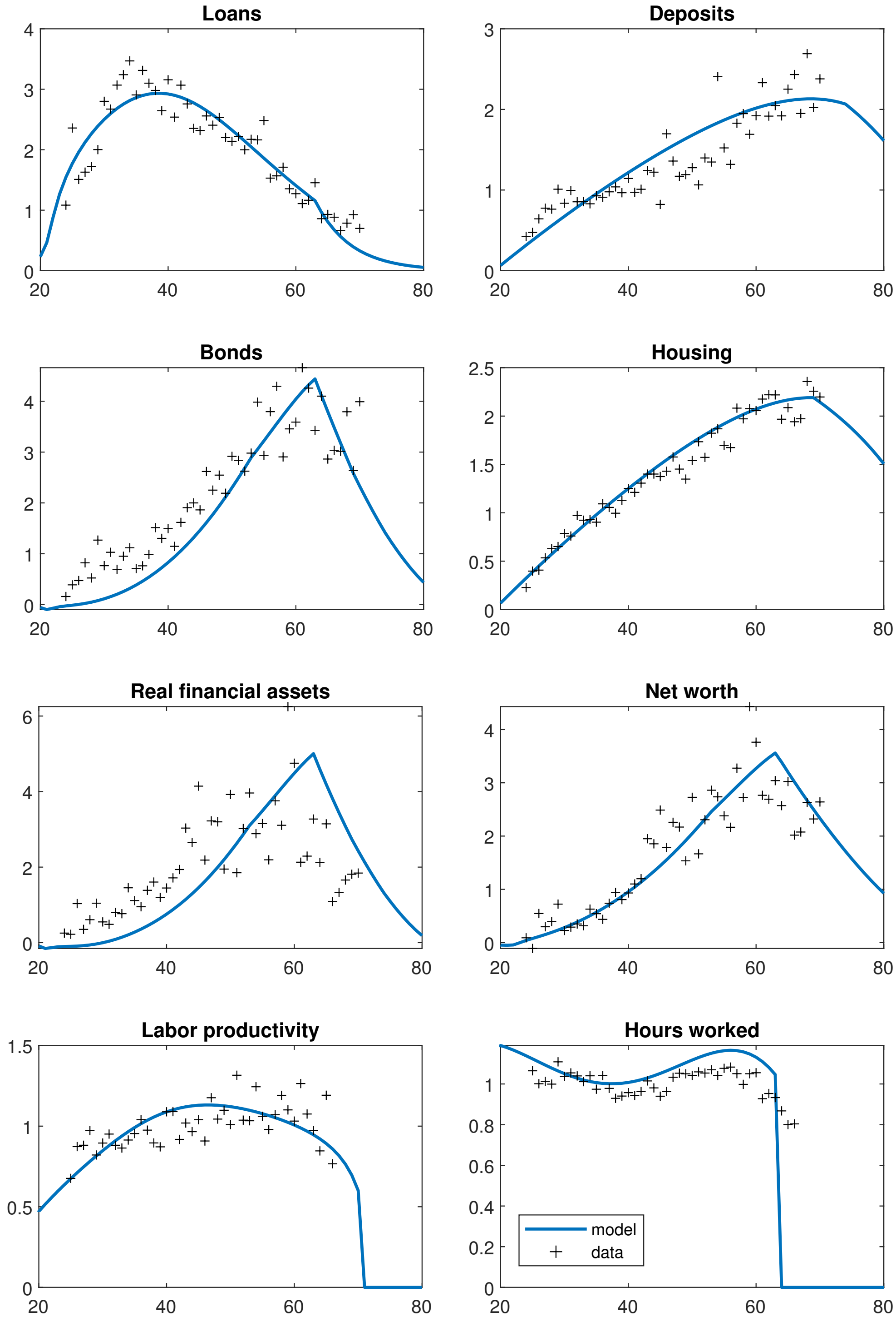
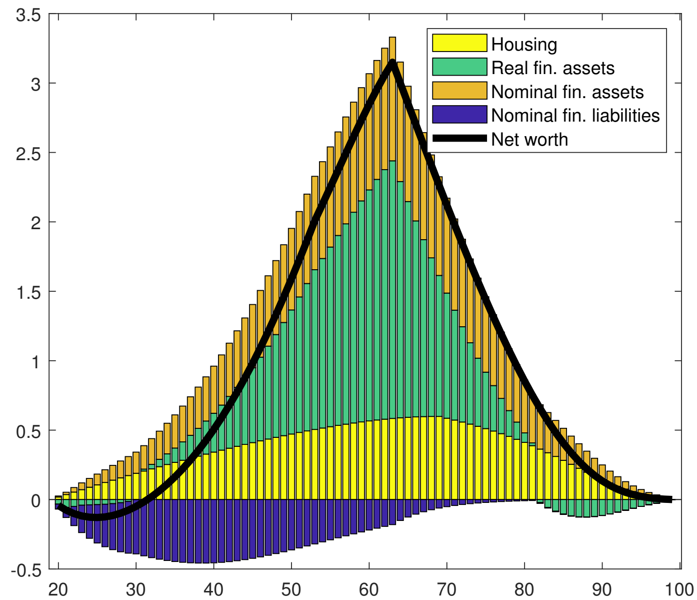


Figure 2: Model-based profiles vs. the data



Note: The average values of age profiles are normalized to unity. Crosses stand for raw HFCS data adjusted by household size and aggregated by cohorts, lines show profiles from the model.

Figure 3: Asset structure



Note: The figure presents the distribution of assets and net worth generated by the model. Average net worth accross cohorts has been normalized to unity.

Figure 4: Impulse responses to a government consumption shock

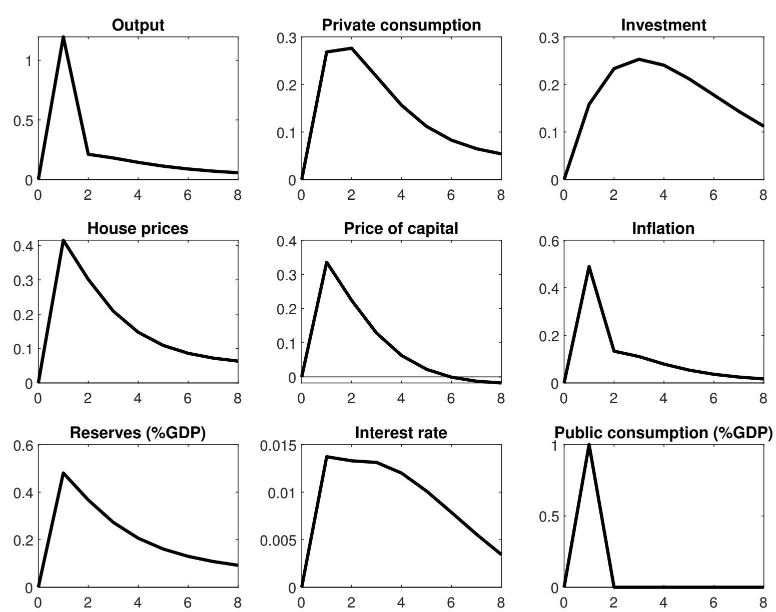


Figure 5: Impulse responses to a transfer to households shock

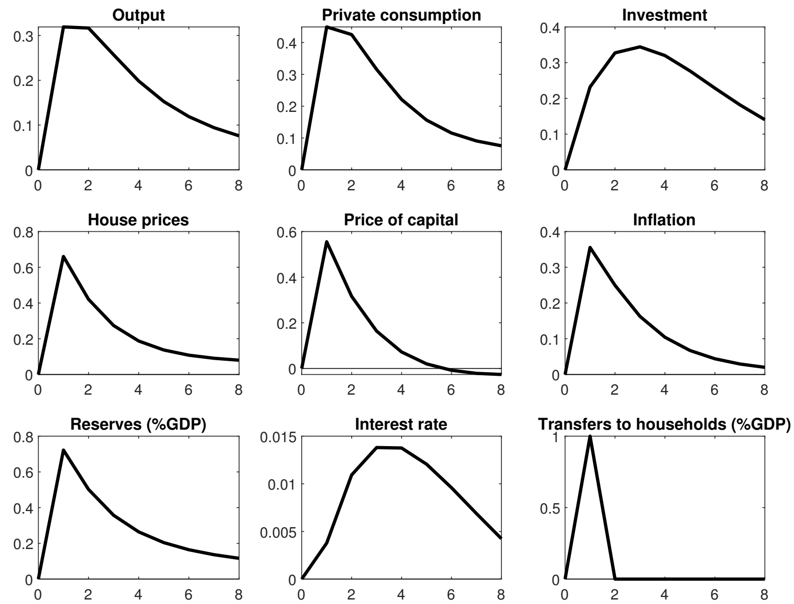


Figure 6: Aggregate effects of the pandemic stimulus

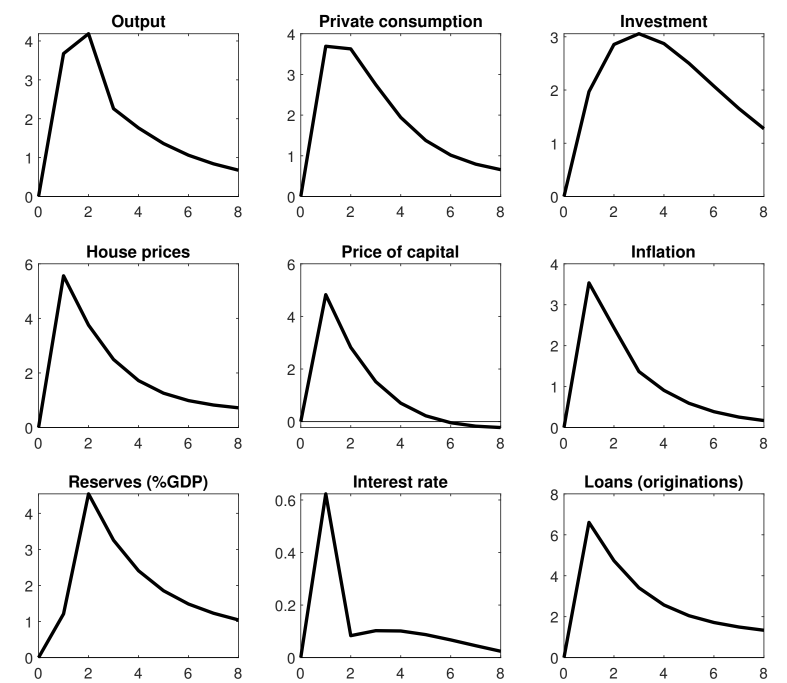


Figure 7: Data and counterfactual scenario (w/o stimulus)

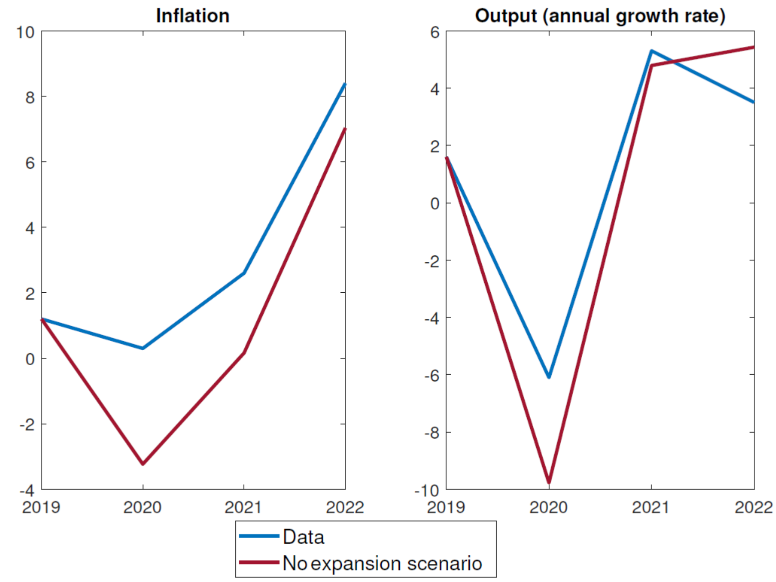
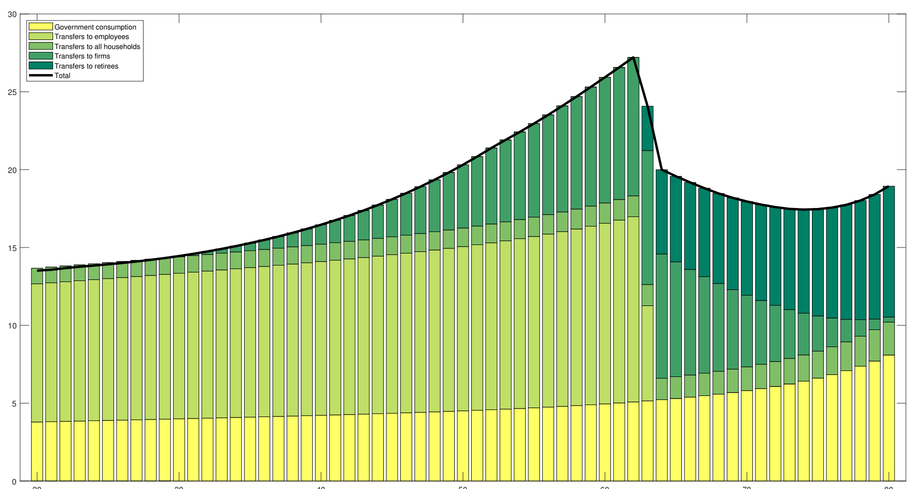
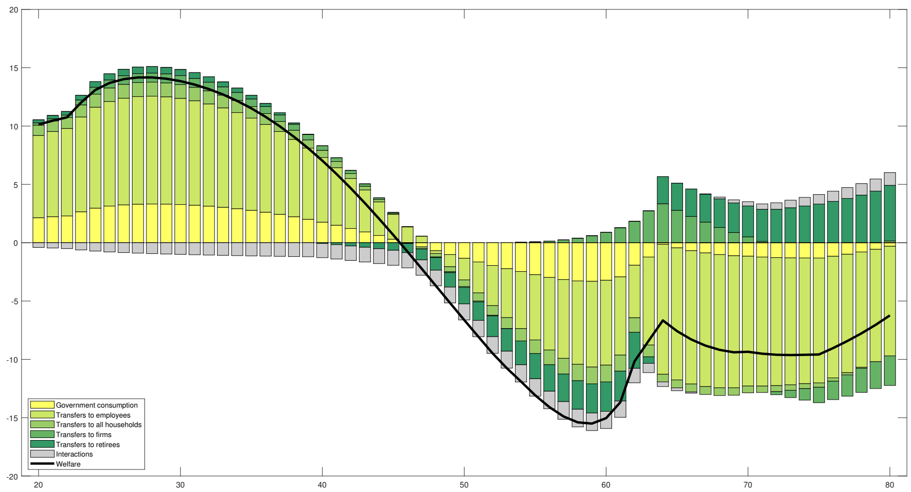


Figure 8: Fiscal transfers by age cohort



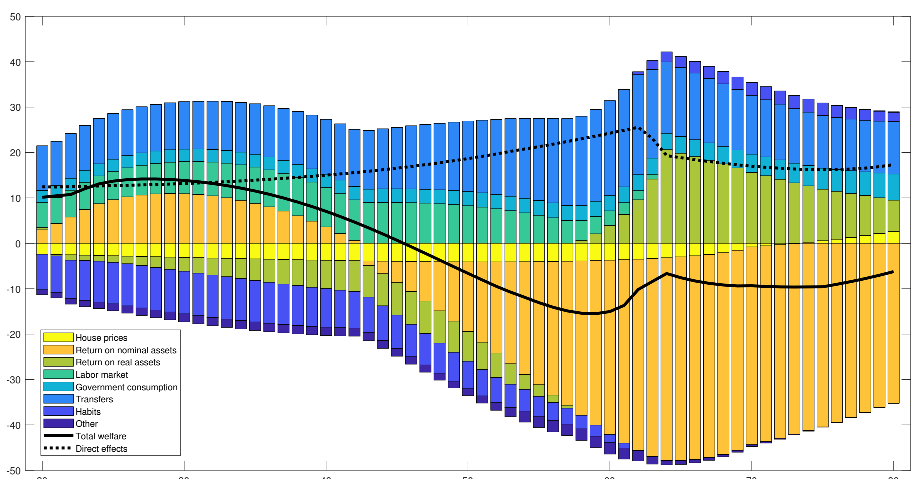
Note: cohort age in 2020 on horizontal axis, transfers in % of steady state consumption on vertical axis.

Figure 9: Welfare effects of the pandemic stimulus



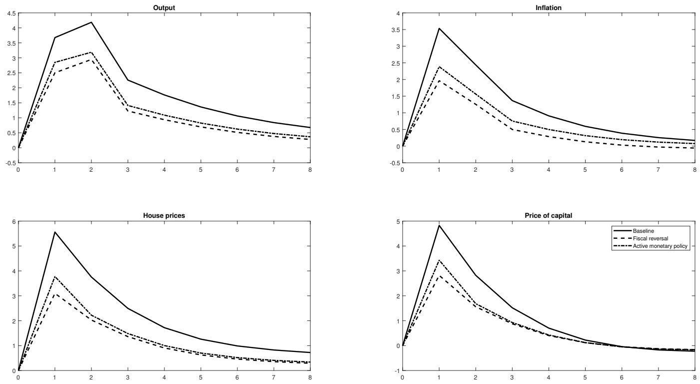
Note: cohort age in 2020 on horizontal axis, welfare gains in % of steady state consumption on vertical axis

Figure 10: Welfare effects from a household perspective



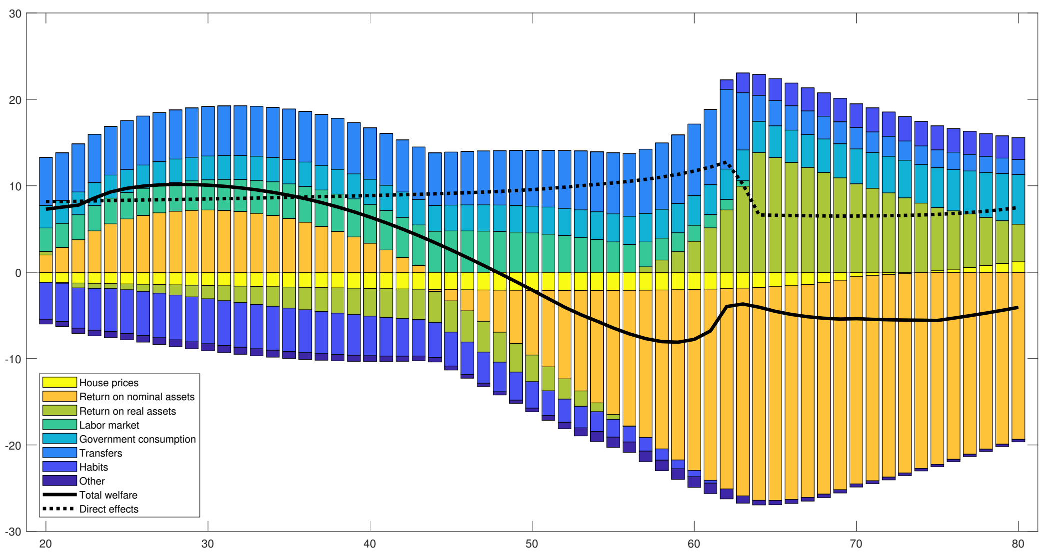
Note: cohort age in 2020 on horizontal axis, welfare gains in % of steady state consumption on vertical axis

Figure 11: Macroeconomic effects of alternative assumptions



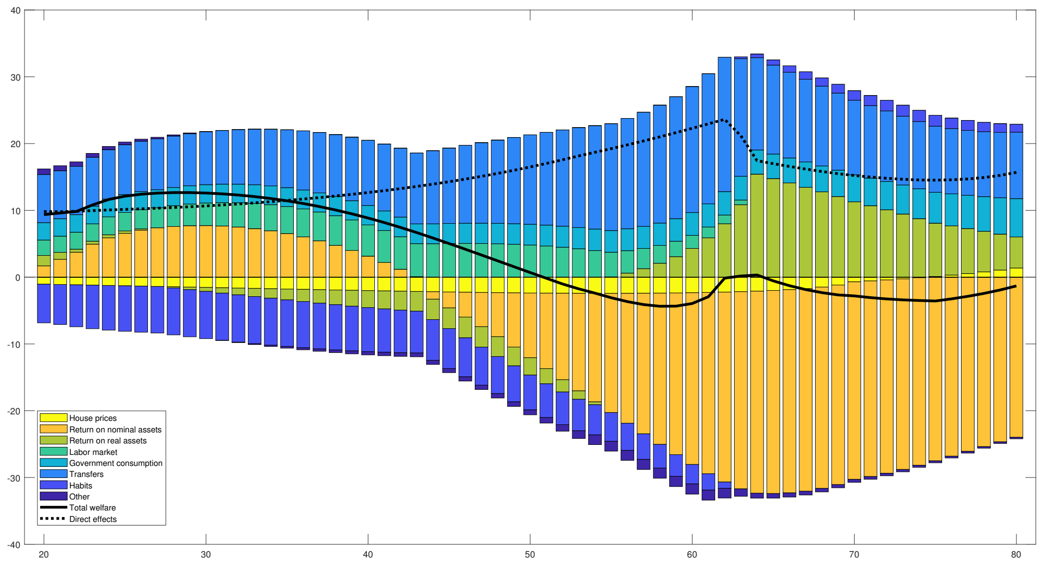
Note: the figure plots the macroeconomic impact of two alternative assumptions about future fiscal/monetary policy. The first one assumes a reversal of the fiscal stimulus, the second an active monetary policy constrained by the ELB.

Figure 12: Welfare effects of a reversed stimulus



Note: cohort age in 2020 on horizontal axis, welfare gains in % of steady state consumption on vertical axis

Figure 13: Welfare effects of return to active monetary policy



Note: cohort age in 2020 on horizontal axis, welfare gains in % of steady state consumption on vertical axis

Appendix A: Model equations

Below we present the list of equations making up the model.

Demography

$$N_{1,t+1} = (1+n)N_{1,t} \tag{A.1}$$

$$N_{j+1,t+1} = (1-\omega_j)N_{j,t} \tag{A.2}$$

$$N_t = \sum_{j=1}^{J} N_{j,t} \tag{A.3}$$

Households

Budget constraint

$$\begin{aligned} & c_{j,t} + p_{\chi,t}[\chi_{j,t} - (1-\delta_\chi)\chi_{j-1,t-1}] + m_{j,t} + a_{j,t} + \frac{R^{\ell}_{t-1}}{\pi_t} s_{j-1,t-1} = \\ & = (1-\tau_t)w_t z_j h_{j,t} + s_{j,t} + t^H_{j,t} + t^W_{j,t} + t^R_{j,t} + t^F_{j,t} + \frac{R^m_{t-1}}{\pi_t} m_{j-1,t-1} + \frac{R^a_{j,t}}{\pi_t} a_{j-1,t-1} + beq_{j,t} \end{aligned} \tag{A.4}$$

$$s_{j,t} = \ell_{j,t} + \left(1 - \frac{1}{m}\right)\frac{s_{j-1,t-1}}{\pi_t} \tag{A.5}$$

$$\ell_{j,t} = LTV_j \chi_{j,t} p_{\chi,t} \tag{A.6}$$

$$a_{J,t} = 0 \tag{A.7}$$

First order conditions

$$u^c_{j,t} = \frac{1-\varrho}{c_{j,t} - \varrho c_{j,t-1}} \tag{A.8}$$

$$1 = \beta(1-\omega_j)\mathbb{E}_t\left[\frac{u^c_{j+1,t+1}}{u^c_{j,t}}\frac{R_t}{\pi_{t+1}}\right] \tag{A.9}$$

$$\frac{\upsilon_j}{1-\varrho}\frac{1}{\chi_{j,t}} = u^c_{j,t}p_{\chi,t} - \beta(1-\omega_j)(1-\delta_H)\mathbb{E}_t\left[u^c_{j+1,t+1}\frac{p_{\chi,t+1}}{\pi_{t+1}}\right] \tag{A.10}$$

$$\frac{\psi_j}{1-\varrho}\frac{1}{m_{j,t}} = u^c_{j,t} - \beta(1-\omega_j)\mathbb{E}_t\left[u^c_{j+1,t+1}\frac{R^m_t}{\pi_{t+1}}\right] \tag{A.11}$$

Wage setting

$$h_{j,t} = \left(\frac{(1-\tau_t)z_j w_t}{\phi_j \mu_w}\frac{1-\varrho}{c_{j,t} - \varrho\bar{c}_{j,t-1}}\right)^{\frac{1}{\varphi}}\Delta_{w,t} \tag{A.12}$$

$$w_t = \left[\theta_w\left(w_{t-1}\frac{\pi}{\pi_t}\right)^{\frac{1}{1-\mu_w}} + (1-\theta_w)\left(\tilde{w}_t\right)^{\frac{1}{1-\mu_w}}\right]^{1-\mu_w} \tag{A.13}$$

$$\tilde{w}_t = \mu_w\frac{\Omega_{w,t}}{\Upsilon_{w,t}} \tag{A.14}$$

$$\Omega_{w,t} = \tilde{\phi}\left(\frac{w_t}{\tilde{w}_t}\right)^{\frac{\mu_w}{\mu_w-1}(1+\varphi)}(h_t)^{1+\varphi} + \tilde{\beta}\theta_w\mathbb{E}_t\left[\left(\frac{\pi}{\pi_{t+1}}\right)^{\frac{\mu_w}{1-\mu_w}(1+\sigma_n)}\Omega_{w,t+1}\left(\frac{\tilde{w}_{t+1}}{\tilde{w}_t}\right)^{\frac{\mu_w}{\mu_w-1}(1+\sigma_n)}\right] \tag{A.15}$$

$$\Upsilon_{w,t} = \tilde{\lambda}_t\left(\frac{w_t}{\tilde{w}_t}\right)^{\frac{\mu_w}{\mu_w-1}}h_t + \tilde{\beta}\theta_w\mathbb{E}_t\left[\left(\frac{\pi}{\pi_{t+1}}\right)^{\frac{1}{1-\mu_w}}\Upsilon_{w,t+1}\left(\frac{\tilde{w}_{t+1}}{\tilde{w}_t}\right)^{\frac{\mu_w}{\mu_w-1}}\right] \tag{A.16}$$

where

$$\tilde{\beta} = \beta\sum_{j=1}^{JR-1}\frac{N_{j+1,t+1}}{\sum_{i=1}^{JR-1}N_{i,t}} \tag{A.17}$$

$$\tilde{\lambda}_t = \sum_{j=1}^{JR-1}u^c_{j,t}\frac{N_{j+1,t+1}}{\sum_{i=1}^{JR-1}N_{i,t}} \tag{A.18}$$

Aggregation

$$c_t = \sum_{j=1}^{J} \frac{N_{j,t} c_{j,t}}{N_t} \tag{A.19}$$

$$h_t = \sum_{j=1}^{J} \frac{N_{j,t} z_j h_{j,t}}{N_t} \tag{A.20}$$

$$\chi_t = \sum_{j=1}^{J} \frac{N_{j,t} \chi_{j,t}}{N_t(1+n)} \tag{A.21}$$

$$m_t = \sum_{j=1}^{J} \frac{N_{j,t} m_{j,t}}{N_t(1+n)} \tag{A.22}$$

$$a_t = \sum_{j=1}^{J} \frac{N_j a_{j,t}}{N_t(1+n)} \tag{A.23}$$

$$\ell_t = \sum_{j=1}^{J} \frac{N_{j,t} \ell_{j,t}}{N_t(1+n)} \tag{A.24}$$

$$s_t = \sum_{j=1}^{J} \frac{N_{j,t} s_{j,t}}{N_t(1+n)} \tag{A.25}$$

$$b_t = \sum_{j=1}^{J} \frac{N_{j,t} b_{j,t}}{N_t(1+n)} \tag{A.26}$$

$$\begin{aligned} beq_t = & \sum_{j=1}^{J} \frac{[N_{j-1,t-1} - N_{j,t}(1+n)]}{N_t(1+n)} \left((1-\delta_\chi) p_{\chi,t} \chi_{j,t} + \frac{R^a_{j,t}}{\pi_t} a_{j,t} + \frac{R^m_{t-1}}{\pi_t} m_{j,t} - \frac{R^\ell_{t-1}}{\pi_t} s_{j,t} \right) \\ & + \frac{N_{J,t}}{N_t(1+n)} \left((1-\delta_\chi) p_{\chi,t} \chi_{J,t} + \frac{R^m_{t-1}}{\pi_t} m_{J,t} - \frac{R^\ell_{t-1}}{\pi_t} s_{J,t} \right) \end{aligned} \tag{A.27}$$

Financial Intermediaries

$$q_t = E_t \left[\frac{\pi_{t+1}}{q_t} (r^k_{t+1} + (1-\delta)\, q_{t+1}) \right] \tag{A.28}$$

$$a_t = b_t + [q_t(1-\delta)k_{t-1} + i_t]/(1+n) \tag{A.29}$$

$$\frac{R^f_t}{\pi_t}(a_{t-1} - b_{t-1}) = (r^k_t + (1-\delta)q)k_{t-1} + div_t + div^b_t \tag{A.30}$$

$$R^a_{j,t} = \eta_{j,t} R_{t-1} + (1-\eta_{j,t}) R^f_t \tag{A.31}$$

$$\eta_{j,t} = \frac{b_{j-1,t-1}}{a_{j-1,t-1}} \tag{A.32}$$

$$b_{j,t} = b_j \tag{A.33}$$

$$m_t = rr_t + b^b_t + s_t \tag{A.34}$$

$$R^m_t = R^m + \iota_m (R_t - R) \tag{A.35}$$

$$R^\ell_t = R_t \tag{A.36}$$

$$div^b_t = \frac{R_{t-1}}{\pi_t}(rr_{t-1} + b^b_{t-1} + s_{t-1}) - \frac{R^m_{t-1}}{\pi_t} m_{t-1} \tag{A.37}$$

Firms

Producers of goods

$$w_t = (1-\alpha) mc_t k_t^{\alpha} h_t^{-\alpha} \tag{A.38}$$

$$r_t^k = \alpha mc_t k_t^{\alpha-1} h_t^{1-\alpha} \tag{A.39}$$

$$div_t = y - w_t h_t - r_t^k k_t \tag{A.40}$$

$$1 = \theta \left(\frac{\pi}{\pi_t}\right)^{\frac{1}{1-\mu}} + (1-\theta)\left(\tilde{P}_t\right)^{\frac{1}{1-\mu}} \tag{A.41}$$

$$\Delta_t = (1-\theta)\,\tilde{P}_t^{\frac{\mu}{1-\mu}} + \theta \left(\frac{\pi}{\pi_t}\right)^{\frac{\mu}{1-\mu}} \Delta_{t-1} \tag{A.42}$$

$$\tilde{P}_t = \mu \frac{\Omega_t}{\Upsilon_t} \tag{A.43}$$

$$\Omega_t = mc_t y_t + \theta \mathbb{E}_t \left[\left(\frac{\pi_{t+1}}{R_t}\right)\left(\frac{\pi}{\pi_{t+1}}\right)^{\frac{\mu}{1-\mu}} \Omega_{t+1}\right] \tag{A.44}$$

$$\Upsilon_t = y_t + \theta \mathbb{E}_t \left[\left(\frac{\pi_{t+1}}{R_t}\right)\left(\frac{\pi}{\pi_{t+1}}\right)^{\frac{1}{1-\mu}} \Upsilon_{t+1}\right] \tag{A.45}$$

Producers of capital

$$(1+n)k_{t+1} = (1-\delta)k_t + \left[1 - \frac{S_k}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] i_t \tag{A.46}$$

$$1 = q_t \left[1 - \frac{S_k}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 - S_k\left(\frac{i_t}{i_{t-1}} - 1\right)\frac{i_t}{i_{t-1}}\right] + E_t\left[q_{t+1}\frac{\pi_{t+1}}{R_t} S_k \left(\frac{i_{t+1}}{i_t} - 1\right)\left(\frac{i_{t+1}}{i_t}\right)^2\right] \tag{A.47}$$

Government

Government budget constraint

$$\frac{R_{t-1}}{\pi_t} b_{t-1}^g + g_t + t_t^H + t_t^W + t_t^R + t_t^F = (1+n) b_t^g + \tau_t w_t h_t \tag{A.48}$$

Fiscal and monetary policy

$$b_t^g = b_y y \tag{A.49}$$

$$rr_t = b_t^c \tag{A.50}$$

Market clearing

$$y_t \Delta_t = k_{t-1}^{\alpha} h_t^{1-\alpha} - \Phi \tag{A.51}$$

$$\chi_t = \chi \tag{A.52}$$

$$y_t = c_t + i_t + \delta_\chi p_{\chi,t} \chi + g_t \tag{A.53}$$

$$b_t^g = b_t + b_t^b + b_t^c \tag{A.54}$$

Exogenous variables

The following variables are exogenous: g_t, t_t^H, t_t^W, t_t^R, t_t^F.

Appendix B: Calibration of the model and the fiscal scenario

Below, we explain how we calibrated the distributional aspects of the model and the fiscal scenario.

The distributional features of the model were calibrated on the basis of the Household Finance Consumption Survey data ((Ganoulis et al., 2016)). Since aggregate quantities of various types of assets among age profiles deviate from the national account statistics (see e.g. Hammer (2015)), we calibrate the standard macroeconomic parameters and match the key aggregate steady state proportions, including those describing the aggregate asset structure, based on the national accounts data. The age profiles, however, are taken from the HFCS. The link between model categories and HFCS codes can be found in Table 3.

Table 3: Mapping between model categories and the codes from the HFCS

Category in the paper	HFCS name	HFCS code
Labor income	= Employee income	DI1100
	+ Self-employment income	DI1200
Hours worked	= Hours working a week - main job	PE0600
Housing stock	= Value of household's main residence	DA1110
	+ Value of other real estate property not for business activities	DA1122
Real financial assets	= Business wealth	DA1200
	+ Value of non self-employment private business	DA2104
	+ Shares, publicly traded	DA2105
	+ 50% Mutual funds	DA2102
	+ 50% Voluntary pension/whole life insurance	DA2109
Nominal financial assets	+= Bonds	DA2103
	+ 50% Mutual funds	DA2102
	+ 50% Voluntary pension/whole life insurance	DA2109
Deposits	= Deposits	DA2101
Loans	= Outstanding balance of mortgage debt	DL1100
	+ Outstanding balance of other, non-mortgage debt	DL1200

Regarding the fiscal scenario, we consider five types of fiscal expenditures:

- wage subsidy covering the expenses for unemployment and various labor affairs as well as the excess compensation for employees from the public sector;
- government consumption including mainly investments and intermediate consumption;
- transfers to firms, consisting of subsidies and capital injections targeted at service and manufacturing industries;
- transfers to retirees targeted at the oldest;
- transfers to households providing medical care and countering social exclusion.

A detailed classification of expenditure categories and functions is listed in Table 7.

Next, the sum of expenditures for each category was deflated (CPI) and expressed as a % of GDP in 2019. The values of fiscal shocks are presented in Table 7.

Table 4: Categories and functions of government expenditure to calibrate the growth of government expenditure in the simulation

Expenditure	**National accounts indicator**	**Functions**
Wage subsidy	Capital transfers	General economic, commercial and labor affairs
	Compensation of employees	General services; Hospital services; Outpatient services; Police services; Pre-primary and primary education; Secondary education; Tertiary education; Unemployment
	Other current transfers	General economic, commercial and labor affairs
	Social benefits other than social transfers in kind	Unemployment
	Subsidies	General economic, commercial and labor affairs
Government consumption	Capital transfers	Foreign economic aid; Public health services
	Gross capital formation	General services; Hospital services; Medical products, appliances and equipment; Military defense Secondary education; Transport
	Intermediate consumption	Executive and legislative organs, financial and fiscal affairs, external affairs; Health (not elsewhere classified); Hospital services; Military defense; Other industries; Outpatient services; Public health services; Social exclusion (not elsewhere classified)
	Other current transfers	Executive and legislative organs, financial and fiscal affairs, external affairs; Foreign economic aid
	Social benefits other than social transfers in kind	Family and children; Sickness and disability; Social exclusion (not elsewhere classified); Survivors
Transfer to firms	Capital transfers	Economic affairs (not elsewhere classified); Fuel and energy; Hospital services; Housing development; Mining, manufacturing and construction; Other industries; Transport
	Subsidies	Fuel and energy; Hospital services; Mining, manufacturing and construction; Other industries; Outpatient services; Pollution abatement; R&D Economic affairs; Sickness and disability; Transport
Transfer to retirees	Social benefits other than social transfers in kind	Old age
	Subsidies	Old age
Transfer to households	Other current transfers	Family and children; Social exclusion (not elsewhere classified)
	Social transfers in kind - purchased market production	Hospital services; Medical products, appliances and equipment; Outpatient services; Public health services

Note: Expenditure categories are based on the European System of Accounts (ESA2010), while their functions are classified according to the Classification of the functions of government (COFOG1999). Data comes from Eurostat from the table on General government expenditure by function.

Appendix C: Welfare decomposition

In this appendix we derive the decomposition of welfare effects by economic channels as in Bielecki et al. (2022). Let us start by formally defining an indirect utility function of a j-aged household ι, as follows

$$\mathcal{W}_{j,t}(\iota) = \max \mathbb{E}_t \sum_{s=0}^{J-j} \beta^s \frac{N_{j+s,t+s}}{N_{j,t}} \left[\begin{array}{c} (1-\varrho)\log\left(c_{j+s,t+s} - \varrho \bar{c}_{j+s,t+s-1}\right) + \psi_{j+s} \log m_{j+s,t+s} - \\ +\upsilon_{j+s} \log \chi_{j+s,t+s} - \phi_{j+s} \frac{h_{j+s,t+s}(\iota)^{1+\varphi}}{1+\varphi} + \frac{g}{c_{j+s}} (1-\varrho) \log(g_{t+s} - \varrho g_{t+s-1}) \end{array} \right] \tag{A.55}$$

subject to

$$\begin{aligned} & c_{j,t} + p_{\chi,t}[\chi_{j,t} - (1-\delta_\chi)\chi_{j-1,t-1}] + m_{j,t} + \frac{R^{\ell}_{t-1}}{\pi_t} s_{j-1,t-1} + a_{j,t} = \\ & = (1-\tau_t) w_t z_j h_{j,t}(\iota)^{\frac{1}{\mu_w}} h_{j,t}^{\frac{\mu_w - 1}{\mu_w}} + t^H_{j,t} + t^W_{j,t} + t^F_{j,t} + t^R_{j,t} \\ & + \frac{R^m_{t-1}}{\pi_t} m_{j-1,t-1} + s_{j,t} + \left(\eta_{j,t} \frac{R_{t-1}}{\pi_t} + (1-\eta_{j,t}) \frac{R^f_t}{\pi_t} \right) a_{j-1,t-1} + beq_{j,t} + \Xi_{j,t}(\iota) \end{aligned} \tag{A.56}$$

where, compared to the budget constraint (3), we used the equilibrium demand condition for individual labor variety implied by aggregation (6) to eliminate $w_t(\iota)$ and omitted the collateral constraint (5) as it is slack in equilibrium. Indirect utility (A.55) is a function of (current and expected sequences of) house prices $p_{\chi,t}$, return on nominal assets R_{t-1}/π_t, return on equity R^f_t/π_t, return on money R^m_{t-1}/π_t, return on loans R^{ℓ}_{t-1}/π_t, aggregate wage rate w_t, labor income tax rate τ_t, cohort-specific bequests $beq_{j,t}$, transfers $t^H_{j,t}$, $t^W_{j,t}$, $t^F_{j,t}$, $t^R_{j,t}$, as well as cohort-specific labor $h_{j,t}$ and consumption $\bar{c}_{j,t-1}$.

Suppose that at time $t = 0$ the economy is hit by a shock. Then, up to first order of approximation, the effects of this shock on household welfare can be decomposed into the contributions of the above-listed thirteen arguments of indirect utility using its total derivative

$$\mathrm{d}\mathcal{W}_{j,0}(\iota) = \mathbb{E}_0 \sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial p_{\chi,s}} \mathrm{d}p_{\chi,s} + \dots \tag{A.57}$$

Let us denote the Lagrange multiplier on the budget constraint of cohort j as $\lambda_{j,t}$, sum of bequests and insurance payments as $bi_{j,t}(\iota) = beq_{j,t} + \Xi_{j,t}(\iota)$, the ex post real rates of return on assets $r_t \equiv R_{t-1}/\pi_t - 1$, $r_t^f \equiv R_t^f/\pi_t - 1$, $r_t^m \equiv R_{t-1}^m/\pi_t - 1$ and $r_t^\ell \equiv R_{t-1}^\ell/\pi_t - 1$, and the s-years ahead survival rate $\omega_{j,t+1}^s \equiv \frac{N_{j+s,t+s}}{N_{j,t}}$. Then we can work out all the individual components in (A.57), using the envelope theorem and taking the non-stochastic steady state as the approximation point, as follows

$$\begin{aligned}\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial p_{\chi,s}} \mathrm{d}p_{\chi,s} &= -\sum_{s=0}^{J-j} \lambda_{j+s}[\chi_{j+s} - (1-\delta_\chi)\chi_{j+s-1}]\mathrm{d}p_{\chi,s} \\ &= -\sum_{s=0}^{J-j} \beta^s \omega_j^s u_{j+s}^c [\chi_{j+s} - (1-\delta_\chi)\chi_{j+s-1}]\mathrm{d}p_{\chi,s} \\ &= u_j^c \sum_{s=0}^{J-j} (1+r)^{-s}[(1-\delta_\chi)\chi_{j+s-1} - \chi_{j+s}]\mathrm{d}p_{\chi,s}\end{aligned} \tag{A.58}$$

$$\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial r_s} \mathrm{d}r_s = u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} \eta_{j+s} a_{j+s} \mathrm{d}r_s \tag{A.59}$$

$$\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial r_s^f} \mathrm{d}r_s^f = u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} (1-\eta_{j+s}) a_{j+s} \mathrm{d}r_s^f \tag{A.60}$$

$$\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial r_s^f} \mathrm{d}r_s^m = u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} m_{j+s} \mathrm{d}r_s^m \tag{A.61}$$

$$\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial r_s^f} \mathrm{d}r_s^\ell = -u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} \ell_{j+s} \mathrm{d}r_s^\ell \tag{A.62}$$

$$\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial w_s} \mathrm{d}w_s = u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} (1-\tau) z_{j+s} h_{j+s}(\iota)^{\frac{1}{\mu_w}} h_{j+s}^{\frac{\mu_w - 1}{\mu_w}} \mathrm{d}w_s \tag{A.63}$$

$$\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial h_{j+s,s}} \mathrm{d}h_{j+s,s} = \frac{\mu_w - 1}{\mu_w} u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} (1-\tau) w z_{j+s} h_{j+s}(\iota)^{\frac{1}{\mu_w}} h_{j+s}^{-\frac{1}{\mu_w}} \mathrm{d}h_{j+s,s} \tag{A.64}$$

$$\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial \tau_s} \mathrm{d}\tau_s = -u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} w z_{j+s} h_{j+s}(\iota)^{\frac{1}{\mu_w}} h_{j+s}^{\frac{\mu_w - 1}{\mu_w}} \mathrm{d}\tau_s \tag{A.65}$$

$$\sum_{s=0}^{J-j} \frac{\partial \mathcal{W}_{j,0}(\iota)}{\partial bi_{j+s,s}} \mathrm{d}bi_{j+s,s}(\iota) = u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} \mathrm{d}bi_{j+s,s}(\iota) \tag{A.66}$$

$$\sum_{s=0}^{J-j}\frac{\partial\mathcal{W}_{j,0}(\iota)}{\partial t^H_{j+s,s}}\mathrm{d}t^H_{j+s,s} = u^c_j\sum_{s=0}^{J-j}(1+r)^{-s}\mathrm{d}t^H_{j+s,s} \tag{A.67}$$

$$\sum_{s=0}^{J-j}\frac{\partial\mathcal{W}_{j,0}(\iota)}{\partial t^W_{j+s,s}}\mathrm{d}t^W_{j+s,s} = u^c_j\sum_{s=0}^{J-j}(1+r)^{-s}\mathrm{d}t^W_{j+s,s} \tag{A.68}$$

$$\sum_{s=0}^{J-j}\frac{\partial\mathcal{W}_{j,0}(\iota)}{\partial t^F_{j+s,s}}\mathrm{d}t^F_{j+s,s} = u^c_j\sum_{s=0}^{J-j}(1+r)^{-s}\mathrm{d}t^F_{j+s,s} \tag{A.69}$$

$$\sum_{s=0}^{J-j}\frac{\partial\mathcal{W}_{j,0}(\iota)}{\partial t^R_{j+s,s}}\mathrm{d}t^R_{j+s,s} = u^c_j\sum_{s=0}^{J-j}(1+r)^{-s}\mathrm{d}t^R_{j+s,s} \tag{A.70}$$

$$\sum_{s=1}^{J-j}\frac{\partial\mathcal{W}_{j,0}(\iota)}{\partial\bar{c}_{j+s,s-1}}\mathrm{d}\bar{c}_{j+s,s-1} = -\varrho\sum_{s=1}^{J-j}\beta^s\frac{N_{j+s,t+s}}{N_{j,t}}u^c_{j+s}\mathrm{d}\bar{c}_{j+s,s-1} \tag{A.71}$$

$$\sum_{s=0}^{J-j}\frac{\partial\mathcal{W}_{j,0}(\iota)}{\partial g_s}\mathrm{d}g_s = \sum_{s=0}^{J-j}\beta^s\frac{N_{j+s,t+s}}{N_{j,t}}u^c_{j+s}\left(\mathrm{d}g_s-\varrho\mathrm{d}g_{s-1}\right) \tag{A.72}$$

where we used the steady state relationship between the marginal utilities of various cohorts implied by the Euler equations, i.e. $u^c_j = \beta^s\omega^s_j(1+r)^s u^c_{j+s}$ for $0\leq s\leq J-j$.

Let us now define the welfare effect on an average ("representative") j-aged household as

$$\mathrm{d}\mathcal{W}_{j,0} = \int_0^1 \mathrm{d}\mathcal{W}_{j,0}(\iota)\mathrm{d}\iota \tag{A.73}$$

Then, using the definition of total labor input (6), the equilibrium result $\bar{c}_{j,t}=c_{j,t}$, as well as $\int_0^1\Xi_t(\iota)\mathrm{d}\iota = 0$ so that $\int_0^1 bi_{j,t}(\iota)\mathrm{d}\iota = beq_{j,t}$, we can write (up to first order approximation)

$$\mathrm{d}\mathcal{W}_{j,0} = \Gamma^\chi_j + \Gamma^{nom}_j + \Gamma^f_j + \Gamma^w_j + \Gamma^g_j + \Gamma^t_j + \Gamma^{hab}_j + \Gamma^{other}_j \tag{A.74}$$

where

$$\Gamma^\chi_j = -\mathbb{E}_0 u^c_j\sum_{s=0}^{J-j}(1+r)^{-s}[\chi_{j+s+1}-(1-\delta_\chi)\chi_{j+s}]\mathrm{d}p_{\chi,s} \tag{A.75}$$

$$\Gamma^{nom}_j = \mathbb{E}_0 u^c_j\sum_{s=0}^{J-j}(1+r)^{-s}\left[\eta_{j+s}a_{j+s}\mathrm{d}r_s + m_{j+s}\mathrm{d}r^m_s - \ell_{j+s}\mathrm{d}r^\ell_s\right] \tag{A.76}$$

$$\Gamma_j^f = \mathbb{E}_0 u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} (1-\eta_{j+s}) a_{j+s} \mathrm{d}r_s^f \tag{A.77}$$

$$\Gamma_j^w = \mathbb{E}_0 u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} z_{j+s} \left[(1-\tau) h_{j+s} \mathrm{d}w_s + \frac{\mu_w - 1}{\mu_w} (1-\tau) w \mathrm{d}h_{j+s,s} - w h_{j+s} \mathrm{d}\tau_s \right] \tag{A.78}$$

$$\Gamma_j^g = \mathbb{E}_0 \sum_{s=0}^{J-j} \beta^s \frac{N_{j+s,t+s}}{N_{j,t}} u_{j+s}^c \left(\mathrm{d}g_s - \varrho \mathrm{d}g_{s-1} \right) \tag{A.79}$$

$$\Gamma_j^t = \mathbb{E}_0 u_j^c \sum_{s=0}^{J-j} (1+r)^{-s} \left[\mathrm{d}t_{j+s,s}^H + \mathrm{d}t_{j+s,s}^R + \mathrm{d}t_{j+s,s}^W + \mathrm{d}t_{j+s,s}^F \right] \tag{A.80}$$

$$\Gamma_j^{hab} = -\varrho \mathbb{E}_0 \sum_{s=1}^{J-j} \beta^s \frac{N_{j+s,t+s}}{N_{j,t}} u_{j+s}^c \mathrm{d}c_{j+s,s-1} \tag{A.81}$$

and where Γ_j^{other} captures the effect of bequests and higher-order terms. This is the decomposition that we use in the main text and depict in Figure 10.