Tax Structures and Fiscal Multipliers in HANK Models

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Abstract

We develop a Heterogeneous Agents New Keynesian model with a detailed outline (block) of financial intermediation and plausible marginal propensities to consume (MPC). To motivate the model, we explore household survey data for the Euro area and document substantial heterogeneity in wealthy- and poor- Hand-to-Mouth (HtM) householdes shares and in their holding of liquid and illiquid assets. Accounting for heterogeneous MPCs allows plausible predictions of the effectiveness of fiscal policy in the short and long term. Using our HANK model, we show that government spending has the largest positive short-term effect on output when financed through debt (vs. taxes) and when debt is gradually paid with lump-sum transfers. We find a novel non-linear and non-monotonic relationship between the effectiveness of the fiscal stimulus and the degree of income tax progressivity, as well as the debt-to-GDP level that is not present in representative or two-agents models. Lastly, we apply our framework and compare effectiveness of fiscal stimulus in three economies, U.S. with rising debt-to-GDP, Germany that represents European economy with moderate debt-to-GDP, and Italy that represents European economy with high debt-to-GDP ratio.

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1 Introduction

There is a long tradition in the literature of assessing the effect of an increase in government spending on aggregate economic responses. However, standard DSGE models do not capture heterogeneity, i.e., important distributional aspects such as inequality. Using the Eurosystem Household Finance and Consumption Survey, we document heterogeneity in HtM (hand-to-mouth) status and household asset holdings in liquid and illiquid accounts for a set of European countries. Further, we develop a quantitative Heterogeneous Agents New Keynesian (HANK) model successful in matching HtM shares observed in the data. Using the calibrated model, we show that financing government spending with a deficit and transfers implies the largest positive short and long-term effect on output. Lastly, we show the nonlinear and nonmonotonic relationship between the effectiveness of fiscal stimulus and debt-to-GDP level, as well as the degree of income tax progressivity.

Following Kaplan et al. (2014) and Kaplan and Violante (2014), we make an important distinction between different types of HtM households with respect to asset holdings. On the one hand, poor hand-to-mouth (pHtM) households have little or no liquid wealth and no illiquid wealth. On the other hand, the wealthy HtM (wHtM) also hold little or no liquid wealth but hold positive amounts of illiquid assets. The third group of households, non-HtM households, hold positive amounts in their liquid accounts. Both pHtM and wHtM households have a large marginal propensity to consume (MPC) out of small transitory income fluctuations. However, Kaplan et al. (2014) show that wHtM households are similar to non-HtM households along several dimensions. They emphasize the distinction between three groups of households, which we also show in our analysis as an important component. In this paper, we analyze how the fiscal multiplier (elasticity of output with respect to government spending) depends on household heterogeneity in HtM status and asset holdings.

Kaplan et al. (2014) and Slacalek et al. (2020) use HFCS and show heterogeneity in HtM status for four large countries (France, Germany, Italy, and Spain). Using

the updated HFCS, we complement their analysis by estimating shares for all available countries. Estimated shares of HtM vary substantially across countries, i.e., from shares of around 10% in Austria and Netherlands to shares of HtM households above 40% in smaller, poorer countries such as Croatia and Slovenia. Moreover, we document heterogeneity between countries in liquid and illiquid asset holdings. Using the HFCS, Carroll et al. (2014) show heterogeneity in liquid assets and wealth across countries. We add to their analysis using the most recent HFCS and show heterogeneity in liquid and illiquid asset holdings.

Usually, to answer questions regarding fiscal multipliers, the literature analyzes the U.S. economy and fixed debt-to-GDP. However, the case in Europe is different and more granular. For example, EU countries are heterogeneous in their debt-to-GDP ratios. Some countries, including Italy and France, have debt-to-GDP ratios well over 100%, while smaller countries, such as Luxembourg and Estonia, have a debt-to-GDP ratio below 30%. This raises a question of the dependence of the fiscal multipliers on the debt-to-GDP level. Evidence that fiscal multipliers tend to be lower when public debt is high has been documented in several empirical studies (Ilzetzki et al. (2013), Nickel and Tudyka (2014), Warmedinger et al (2015), Huidrom et al. (2020)) for samples of advanced economies.

Moreover, The annual report on Taxation in EU documents that European countries are heterogeneous in tax levels and income tax progressivity. Therefore, in this paper, we pose and try to address multiple questions. First, how the fiscal multiplier varies across different fiscal instruments. Second, how the fiscal multiplier depends on different sources of financing of government spending. Next, we are interested in the role of household heterogeneity and distributional moments in explaining aggregate movements. Lastly, we are interested in how the fiscal multiplier varies with debt-to-GDP level and income tax progressivity.

We build on a large body of literature exploring HANK[1] models and develop a quantitative HANK with liquid and illiquid assets and a rich set of fiscal policy instruments

[1]See Kaplan and Violante (2018) for a recent overview of the literature.

to answer these questions. We show that financing government spending through debt, in general, implies higher fiscal multipliers. Moreover, gradual payment of the extra debt with non-distortionary government transfers implies the highest positive long-term impact on output. More specifically, lump-sum transfers circumvent individual frictions in liquidity transformation and increase demand among liquidity-constrained households.

When we compare the effectiveness of the fiscal stimulus depending on different debt-to-GDP levels and income tax progressivity, we find heterogeneous implications. First, we find that higher income tax progressivity implies smaller fiscal multipliers when spending is financed with transfers. Moreover, we find that the effectiveness of financing spending with debt and transfers is non-monotonic. More specifically, the effectiveness increases with debt level for a low debt-to-GDP economy and decreases with debt for a high debt-to-GDP level economy.

Aligned with literature, e.g., Hagedorn et al. (2019) and Auclert et al. (2018), we show that RANK (Representative Agent New Keynesian) and Two Agent New Keynesian (TANK) models cannot produce the size of fiscal multipliers or consumption response consistent with the data.

Broer et al. (2023) highlight the fact that the transmission of fiscal shocks in the (New Keynesian) NK setting is rather different from that of monetary shocks for at least two reasons. First, since a fiscal shock directly affects households' budgets, its effect directly depends on other sources of income and their endogenous dynamic responses over time. Assumptions about the distribution of factor incomes thus have a first-order effect on the propagation of fiscal shocks.

It is well known that the effect of fiscal shocks depends on the response of real interest rates. Moreover, Broer et al. (2023) note that accounting for wage rigidity dampens the inflation response to fiscal shocks and, thus, the endogenous reaction of monetary policy that typically counteracts the demand effect of fiscal shocks. This raises the fiscal multiplier relative to the standard version of the model with only price rigidities but also makes it less sensitive to the current stance of monetary policy. A

recent paper supports this view: Auclert et al. (2023) show that it is impossible for NK models with flexible labor markets to simultaneously match empirical estimates for marginal propensities to earn, marginal propensities to consume, and fiscal multipliers.

Kaplan and Violante (2022) show that the HANK model with liquid and illiquid assets matches the empirical MPCs much better than the one-asset HANK model. In addition, Kaplan and Violante (2014) introduce two-asset models, and Kaplan et al. (2018) and Luetticke (2021) highlight the ability of the two-asset model to match the differential portfolio response to monetary policy shocks and provide new evidence for the importance of modeling both liquid and illiquid assets. We build on that and implement a two-asset HANK model with adjustment costs à la Kaplan et al. (2018). We rely on fast and accurate sequence-space Jacobian method implementation by Auclert et al. (2021) for the solution method.

The four papers that are most closely related to ours are Bayer et al. (2023), Hagedorn et al. (2019), Auclert et al. (2018), and Ferriere and Navarro (2024). All papers study fiscal multipliers, and models include rigid wages. Further, Bayer et al. (2023), Hagedorn et al. (2019), and Auclert et al. (2018) incorporate two-asset structure. However, Bayer et al. (2023) consider only one tax rate and simple government problem. Similarly, the government in Auclert et al. (2018) collects only progressive income taxes. The government problem in Hagedorn et al. (2019) is more elaborate and includes dividend taxes as we do. Ferriere and Navarro (2024) explore how the fiscal multiplier varies with income tax progressivity when the government spending is financed by imposing more or less progressive income taxes.

In contrast to all four papers, we combine progressive income taxes, dividend taxes, and a two-asset structure. In addition, we include distortive consumption taxes in our analysis. Moreover, in our analysis, we explore how fiscal multipliers vary with different levels of debt and tax structures. Thus, none of the papers above offer answers to how the fiscal multiplier changes in the case of government spending in a highly indebted state or in the case of a tax structure with highly progressive taxes.

The rest of the paper is organized as follows. Section 2 presents findings on HtM

shares and asset composition for a set of European countries. In Section 3, we introduce our model as well as the calibration and show model performance. Section 4 contains the quantitative analysis of the fiscal multiplier. Section 5 concludes.

2 HtM Status and Household Portfolio

This section highlights household heterogeneity by comparing households' asset holdings by asset type and HtM status across a set of European countries using the HFCS. The analysis details additional results, and variable definitions are in Appendix A.

Figure 1 shows HtM, pHtM, and wHtM shares across European countries. We observe large heterogeneity in shares across countries. First, HtM shares range from low shares in Austria and the Netherlands to high shares in smaller European countries such as Croatia and Slovenia.

Second, we can also observe heterogeneity in pHtM and wHtM shares across countries with similar shares of HtM households. For example, Germany and Italy have similar shares of HtM households, around 16%. However, Germany has a larger share of pHtM households (around 10%) while Italy has a larger share of wHtM households (around 10%).

Figure 2 documents heterogeneity in net liquid asset-to-income ratio across European countries. Moreover, Figure 2 shows heterogeneity in net liquid asset holdings relative to net income for smaller European countries. However, heterogeneity is also present for larger European countries, i.e., France (around 1.05), Germany (around 1.26), and Italy (around 1.4). The same holds for net illiquid asset holdings (see Figure 14 in Section A of the Appendix).

These findings further motivate the two-asset structure of our HANK model. They highlight the heterogeneity across HtM status and asset holdings. Our model accounts for differential HtM status and asset types and highlights their importance for the fiscal multiplier analysis.

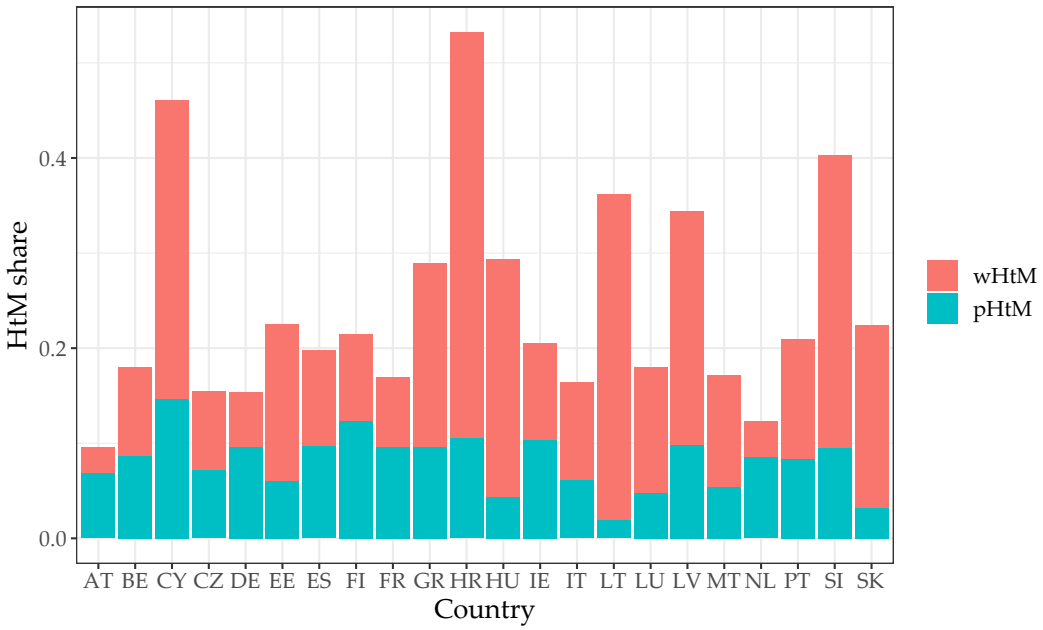


Figure 1: wHtM and pHtM shares for a set of European countries; Kaplan et al. (2014) definition. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

3 Quantitative HANK Model

In this section, we present our model blocks. The time in the model is discrete and infinite, and it is indexed with $t \in \{0, 1, 2, \dots\}$. The model consists of a continuum of households indexed by $i \in [0, 1]$ that receive utility from consumption and disutility from labor and discount future with factor $\beta_i \in \{\beta_1, \beta_2\}, \forall i$ such that $\beta_1 < \beta_2$ and $\beta_1, \beta_2 \in (0, 1)$. Households earn wages and choose between consuming and saving in two types of assets. The agents in the economy can save in liquid assets accounts that they can tap into in every period at no cost. Accumulating illiquid assets brings higher returns, but when adjusting illiquid assets, agents face monetary costs.

The rest of the economy consists of separate blocks. Financial intermediaries in the first block manage agents' assets and provide agents with returns. Financial intermediaries manage the agent's assets, i.e., manage the portfolios by investing in equity and government bonds. In addition, financial intermediaries perform liquidity transformation for households, i.e., they invest households' liquid assets directly into government bonds at a proportional cost. Other blocks are more standard in the literature and consist of intermediate and final goods-producing firms, and unions and labor pack-

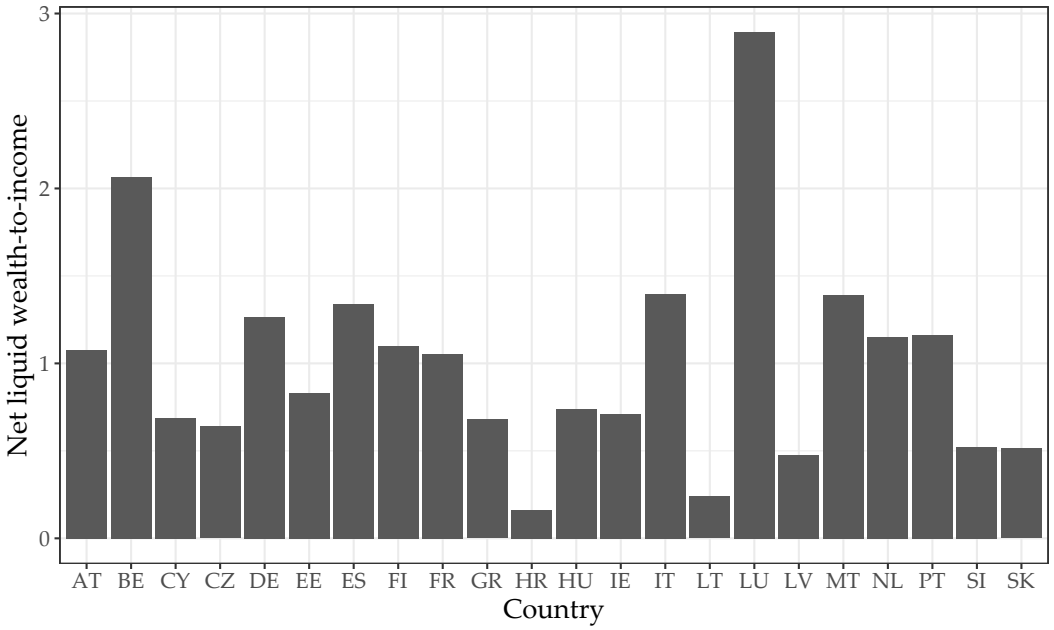


Figure 2: Net liquid wealth to income for a set of European countries. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

ers who manage labor in the economy. The last is the government block, in which the government collects taxes, supplies bonds, and controls government spending and transfers.

3.1 Households

Each household i in the economy chooses consumption $c_{i,t}$, illiquid asset $a_{i,t}$, and liquid assets $b_{i,t}$ and faces adjustment costs for managing illiquid assets à la Kaplan et al. (2018). More specifically, given initial liquid ($b_{i,-1}$) and illiquid ($a_{i,-1}$) asset positions, household i solves

$$\max_{\{c_{i,t},b_{i,t},a_{i,t},n_{i,t}\}} \mathbb{E}\sum_{t=0}^{\infty}\beta_i^t\Big[u(c_{i,t})-v(n_{i,t})\Big]$$

$$\text{such that} \tag{1}$$

$$c_{i,t}(1+\tau_t^c)+a_{i,t}+b_{i,t}=z_{i,t}+(1+r_t^a)a_{i,t-1}+(1+r_t^b)b_{i,t-1}-\Psi(a_{i,t},a_{i,t-1})$$

$$a_{i,t}\geq \underline{a},\quad b_{i,t}\geq \underline{b},$$

where $z_{i,t} = \tau_t(w_t n_{i,t} e_{i,t})^{1-\theta} + T_{i,t}$ is after-tax labor income[2]. Household income depends on individual productivity $e_{i,t}$, labor $n_{i,t}$ and wage rate $w_t = \frac{W_t}{P_t}$ that we specify later in the text. Moreover, household income depends on the level of taxes τ_t, income tax progressivity θ, and government lump-sum transfers/taxes $T_{i,t}$. When choosing optimal consumption and assets, households also face consumption tax τ_t^c. Lastly, we use $v(n_{i,t}) = \gamma n_{i,t}^{1+\frac{1}{\phi}}$, and $u(c_{i,t}) = \frac{c_{i,t}^{1-\sigma}}{1-\sigma}$ to specify households household's disutility from labor and utility from consumption, respectively.

For accumulating liquid assets, i.e., investing in government bonds, households receive a return of r_t^b, whereas for investing in liquid assets, households receive a return of r_t^a. The adjustment cost function depends on the current asset (a_-) and the choice of the asset for the next period (a), and it is specified with the following functional form

$$\Psi(a, a_-) = \frac{\chi_1}{\chi_2} \left| \frac{a - (1 + r_t^a)a_-}{(1 + r_t^a)a_- + \chi_0} \right|^{\chi_2} \left[(1 + r_t^a)a_- + \chi_0\right], \tag{2}$$

where $\chi_0, \chi_1 > 0$ and $\chi_2 > 1$.

3.2 Financial Intermediaries

A representative risk-neutral financial intermediary takes liquid and illiquid deposits from households and invests them in government bonds B_t^g and firm equity p_t. The financial intermediary's objective is to maximize the expected real rate of return r_{t+1}. It performs liquidity transformation at proportional cost $\omega \int b_{i,t} di$. No arbitrage requires that the ex-ante return $\mathbb{E}_t = [1 + r_{t+1}]$ equals the expected returns on nominal government bonds and on equity. The competitive financial intermediary passes these returns on to households subject to intermediation costs:

$$\mathbb{E}_t[1 + r_{t+1}] = \frac{1 + i_t}{\mathbb{E}_t[1 + \pi_{t+1}]} = \frac{\mathbb{E}_t[d_{t+1} + p_{t+1}]}{p_t} = \mathbb{E}_t[1 + r_{t+1}^a] = \mathbb{E}_t[1 + r_{t+1}^b] + \omega, \tag{3}$$

[2]We use progressive income taxation function proposed by Feldstein (1969) that was recently popularized by Heathcote et al. (2017)

where $d_t = \widetilde{d}_t(1-\tau_t^k)$, are after tax dividends. However, the ex-post returns r_t, r_t^a, r_t^b are subject to surprise inflation and capital gains. Assuming that capital gains accrue to the illiquid account, we have

$$1 + r_t = \frac{1+i_{t-1}}{1+\pi_t} = 1 + r_t^b + \omega \tag{4}$$

and

$$1 + r_t^a = \Theta_p\left(\frac{d_t + p_t}{p_{t-1}}\right) + (1-\Theta_p)(1+r_t) \tag{5}$$

where Θ_p denotes the share of equity in the illiquid portfolio.

3.3 Wage Setting

The labor sector in our model consists of multiple levels. On the first level, it is composed of unions that differentiate raw labor and labor packers who buy differentiated labor and then sell labor services to intermediate goods producers.

At any time t, union k sets its wage W_{kt} to maximize, on behalf of all the workers it employs, utility facing Rotemberg (1982) adjustment costs,

$$J_t^U = \max_{W_{k,t}} \int \Big(u(c_{i,t+t'}) - v(n_{i,t+t'})\Big) d\Psi_{i,t+t'} - \frac{\psi}{2}\left(\frac{W_{k,t+t'}}{W_{k,t+t'-1}} - 1\right)^2 + \frac{1}{1+r_t} J_{t+1}^U \tag{6}$$

taking as given the initial distribution of households over idiosyncratic states $\Psi_{i,t}$ as well as the demand curve for tasks coming from the labor packers, which is

$$N_{k,t} = \left(\frac{W_{k,t}}{W_t}\right)^{-\varepsilon} N_t,$$

where

$$W_t = \left(\int W_{k,t}^{1-\varepsilon} dk\right)^{\frac{1}{1-\varepsilon}}$$

is the price index for aggregate employment services. Solving the unions' problem (see

Appendix for derivations) implies wage NKPC

$$(1+\pi_t^w)\pi_t^w = \kappa^w\left(\gamma N_t^{1+\frac{1}{\phi}} - \frac{(1-\theta)}{(1+\tau_t^c)\mu^w} Z_t u'(\tilde{C}_t)\right) + \beta(1+\pi_{t+1}^w)\pi_{t+1}^w. \tag{7}$$

where $\kappa^w = \frac{\varepsilon}{\psi}$, $\mu^w = \frac{\varepsilon}{\varepsilon-1}$, $u'(\tilde{C}_t) = \int \frac{e_{i,t}^{1-\theta}}{\int e_{i,t}^{1-\theta} di} u'(c_{i,t}) di$, and Z_t is aggregate income tax (net of transfers).

3.4 Firms

In our quantitative model, the firm's sector also consists of multiple levels, i.e., intermediate and final good producers. First, intermediate goods producers hire labor services from labor packers and rent out capital to produce goods. Second, final goods producers aggregate intermediate goods with a constant elasticity of substitution $\frac{\mu_p}{\mu_p - 1} > 1$.

The equations for the model with investment are as follows. The production function of each firm is Cobb-Douglas, $F(k_{t-1}, n_t) = \Omega_t k_{t-1}^{\alpha} n_t^{1-\alpha}$. Each firm pays out wages invests in the capital that depreciates while facing capital adjustment costs $\phi\left(\frac{k_t}{k_{t-1}}\right) = \frac{1}{2\delta\varepsilon_I}\left(\frac{k_t}{k_{t-1}} - 1\right)^2$, and sets prices facing Rotemberg (1982) adjustment cost function $\xi(\mathcal{P}_t, \mathcal{P}_{t-1}) = \frac{1}{2\kappa^p(\mu^p - 1)}\left(\frac{\mathcal{P}_t - \mathcal{P}_{t-1}}{\mathcal{P}_{t-1}}\right)^2$. The Bellman equation for the intermediate good's firm is:

$$\begin{aligned} J_t(\mathcal{P}_{t-1}, k_{t-1}) = \max_{\mathcal{P}_t, k_t, n_t} \Bigg\{ & \frac{\mathcal{P}_t}{P_t} F(k_{t-1}, n_t) - \frac{W_t}{P_t} n_t - i_t - \phi\left(\frac{k_t}{k_{t-1}}\right) k_{t-1} - \xi(\mathcal{P}_t, \mathcal{P}_{t-1}) Y_t + \\ & \frac{1}{1+r_t} J_{t+1}(\mathcal{P}_t, k_t) \Bigg\}, \\ \text{subject to} \quad & F(k_{t-1}, n_t) = \left(\frac{\mathcal{P}_t}{P_t}\right)^{-\frac{\mu^p}{\mu^p - 1}} Y_t, \end{aligned}$$

where $i_t = k_t - (1-\delta)k_{t-1}$.

All intermediate goods firms are identical in the equilibrium and thus make the same choices, i.e., $k_t = K_t$, $n_t = N_t$, and $\mathcal{P}_t = P_t$. Resulting Phillips curve for inflation

(see Appendix for derivation) is given with

$$(1+\pi_t)\pi_t = \kappa_p\left(\mu_p \cdot mc_t - 1\right) + \frac{1}{1+r_t}\frac{Y_{t+1}}{Y_t}(1+\pi_{t+1})\pi_{t+1},$$

where $mc_t = \frac{W_t/P_t}{F_{n,t}}$ are marginal costs. Moreover, in the Appendix, we derive the following equations for Tobin's Q and capital

$$Q_t = 1 + \frac{1}{\delta\epsilon_I}\left(\frac{K_t - K_{t-1}}{K_{t-1}}\right)$$

and

$$(1+r_t)Q_t = \alpha\Omega_{t+1}\left(\frac{N_{t+1}}{K_t}\right)^{1-\alpha} mc_{t+1} - \left[\frac{K_{t+1}}{K_t} - (1-\delta) + \frac{1}{2\delta\epsilon_I}\left(\frac{K_{t+1}-K_t}{K_t}\right)^2\right] + \frac{K_{t+1}}{K_t}Q_{t+1}.$$

Lastly, gross dividends $\widetilde{d}_t$ satisfy

$$\widetilde{d}_t = F(K_{t-1}, N_t) - w_t N_t - I_t - \phi\left(\frac{K_t}{K_{t-1}}\right)K_{t-1} - \xi(\pi_t)Y_t.$$

3.5 Monetary and Fiscal Policy

The monetary authority now follows a Taylor rule:

$$i_t = r + \phi^\pi \pi_t.$$

Fiscal authority, i.e., government, in our model solves more complicated problems. Each period, the government covers government spending G_t and transfers T_t by collecting taxes and issuing bonds (at a price r_t). In addition to progressive income labor tax revenue Z_t specified in the household problem, the government collects dividend taxes τ_t^k, consumption taxes τ_t^c and (collects/pays out) lump-sum taxes/transfers T_t. Therefore,

in each period t, the government budget constraint is given with

$$B_t^g + \tau_t^c C_t + Z_t + \tau_t^k \widetilde{d}_t = (1 + r_{t-1}) B_{t-1}^g + G_t + T_t. \tag{8}$$

In addition to household heterogeneity described in equation (1), government problem and equation (8) are some of the most important pieces of the economy for our analysis. In policy analysis, we use a calibrated quantitative model specified in this section to analyze the effectiveness of the fiscal stimulus. More specifically, we are interested in how the economy reacts in the case of an increase in government spending G_t. Given our model's rich set of fiscal instruments, the government has multiple options. However, the government needs to balance its budget each period, i.e., the equality in equation (8) needs to hold in each period.

Thus, the government has the following options. On the one hand, the government can respond to an increase in spending by reducing transfers T_t or by increasing the revenues from consumption ($\tau_t^c C_t$), dividend ($\tau_t^k \widetilde{d}_t$), or income (Z_t) taxes. To increase revenues, the government has to increase taxes. We call this option direct financing. On the other hand, the government can also decide to increase the deficit by issuing new bonds B_t^g. In turn, to be able to repay the debt, the government resorts to using one of the four tax instruments specified above to repay the debt. We call this option debt financing.

Since changing tax levels and transfers also affect other parts of the economy, for example, households react to lower net income due to higher income tax, we calibrate the model to the U.S. economy to answer the question of the effectiveness of using different tax instruments quantitatively. In addition, we analyze how the effectiveness of the fiscal stimulus depends on income tax progressivity and the government's debt level.

3.6 Equilibrium

In this section, we provide market clearing conditions and define the equilibrium.

First, in the equilibrium, the liquid asset market must clear

$$\int b_{i,t} di = B_t^h,$$

where B_t^h are liquid assets supplied by financial intermediaries and $\int_i b_{i,t} di$ are aggregate household's liquid asset holdings. Second, household total wealth equals all assets in the economy, i.e., government bonds and equity

$$\int a_{i,t} di + \int b_{i,t} di = p_t + B_t^g.$$

From the market clearing conditions we also derive financial intermediaries portfolio share. More specifically,

$$\Theta_p = \frac{p_t}{p_t + B_t^g - B_t^h}.$$

Lastly, the goods market clearing condition is specified with the following equation:

$$Y_t = \int c_{i,t} di + G_t + I_t + \omega \int b_{i,t-1} di + \phi\left(\frac{K_t}{K_{t-1}}\right) K_{t-1} + \xi(\pi_t) Y_t + \int \Phi(a_{i,t}, a_{i,t-1}) di,$$

where $I_t = K_t - (1-\delta)K_{t-1}$.

Given a set of government policies and prices $\{G_t; B_t^G; \tau_t^c; \tau_t^k; \tau_t; T_t\}_{t=0}^{\infty}$, an equilibrium consists of a set of prices $\{Q_t; r_t; i_t; r_t^a, r_t^b; W_{k,t}; W_t; P_t; \mathcal{P}_t\}_{t=0}^{\infty}$ and of a set of allocations $\{n_{i,t}; c_{i,t}; b_{i,t}; a_{i,t}; `k_t; B^h\}_{t=0}^{\infty}$ such that: (1) households maximize their utility subject to budget constraints; (2) firms maximize profits subject to demand from final good producers; (3) unions' set wages subject to labor packers' demand for labor; (4) financial intermediaries maximize returns and returns follow their laws of motion; (5) the government budget constraint holds; and (6), all markets clear.

3.7 Calibration

This section describes the choice of model parameters and parameters that target moments from the data. Table 1 presents externally set parameters and sources from the

literature. Most of the choices for these parameters are standard in the literature, such as inverse intertemporal elasticity of substitution (IES) and inverse Frisch elasticity, which are set to value 2. Moreover, the second block of Table 1 presents external calibration of tax-related parameters in the government block. These values are specific to the U.S. economy. For example, we use the value for the progressivity parameter θ estimated by Heathcote et al. (2017), and to specify the dividend tax level, we follow Trabandt and Uhlig (2011).

Parameter	Description	Value	Source
σ	Inverse IES	2	Auclert et al. (2023)
ξ_0	Portfolio adj. cost pivot	0.25	Auclert et al. (2021)
ξ_2	Portfolio adj. cost curvature	2	Auclert et al. (2021)
ρ_e	Autocorrelation of earnings	0.966	Floden and Lindé (2001)
σ_e	Cross-sectional s.d. of log earnings	0.92	Song et al. (2019)
ϕ	Inverse Frisch elasticity	2	Chetty et al. (2011)
ϕ^π	Taylor rule coefficient	1.5	standard value
κ^w	Slope of wage Phillips curve	0.03	Hagedorn et al. (2019)
κ^p	Slope of price Phillips curve	0.03	Christiano et al. (2011)
ε_I	Investment elasticity to Q	1	Auclert et al. (2018)
θ	Income tax progressivity	0.181	Heathcote et al. (2017)
τ^k	Dividend tax level	0.36	Trabandt and Uhlig (2011)

Table 1: Externally set parameters.

In contrast to externally set parameters, we choose a set of calibrated parameters to target specific moments from the literature or the data. The last two columns present targets and resulting values in the steady state. Again, these parameters are specified for the U.S. economy.

Household parameters: First, we normalize N=1; thus, we choose $\gamma = 1.094$, disutility of labor parameter to hit wage Phillips curve given a target for employment $N = 1$. Next, we set $\beta_1 = 0.956$ to match pHtM share of 14% estimated by the Kaplan and Violante (2022), and we set $\beta_2 = 0.983$ to satisfy the aggregate asset market clearing condition. Moreover, we set ξ_1, the portfolio adjustment cost scale to 14.162 to satisfy the liquid asset market clearing condition. Further, we set $B = 1.04$, to hit liquid assets-to-output radio of $B/Y = 26\%$. Lastly, the goods market clears by Walrass law.

Technology parameters: We set $\mu^w = 1.1$, for us to get a steady state wage markup of 10% markup. In addition, we set a steady-state markup $\mu^p = 1.079$ to hit the asset-to-output ratio of $A/Y = 292\%$, an estimated value for the U.S. economy. We normalize $Y = 1$, and this set $\Omega = 0.433$, a total factor productivity to hit a normalized value of $Y = 1$. Moreover, we set a capital share $\alpha = 0.360$ to get the yearly capital-to-output ratio of $K/Y = 2.565$. Lastly, we set $\delta = 0.02$ to have an 8% yearly depreciation.

Financial parameters: We set 0.0125 and liquidity premium $\omega = 0.005$ to have 5% yearly return on illiquid portfolio and 2% yearly spread between liquid and illiquid asset returns.

Tax parameters: First, we set $G/Y = 20\%$, a standard value for spending-to-output ratio. Next, we follow Ferriere and Navarro (2024) and set transfers to hit $T/Y = 8.2\%$, a long-run average after World War II. In addition, we choose τ^c to match 8% value added tax. We set B^G to match 70% debt-to-GDP and choose $\tau_t = 0.650$ such that the government budget is satisfied.

3.8 Model Performance

Quarterly MPC is 16.56%, that is 51% in annual terms and the range of the annual empirical estimates from the literature (e.g., Johnson et al. (2006); Jappelli and Pistaferri (2014); Carroll et al. (2017)). Table 2 presents non-targeted moments. Results show that our model performs well in matching HtM and wHtM shares without targeting those. Moreover, it performs well in matching Gini coefficients for both types of assets and shares of assets in the bottom 50% of the distributions. However, the model performs less well in matching shares in assets in the top 50% of distributions. Namely, the model understates the share of assets of the top 10% and overstates the share of the next 40% in respective distributions. It is worth noting that we do not allow agents to borrow and, thus, potentially restrict model performance in matching untargeted moments for liquid wealth.

	Moment	Model	Data	Source
Liquid Assets	top 10% share	64.54	86	Kaplan et al. (2018)
	next 40% share	35.36	18	
	bottom 50% share	0.10	-4	
	Gini coefficient	0.81	0.98	
Illiquid Assets	top 10% share	48.58	70	Kaplan et al. (2018)
	next 40% share	51.23	27	
	bottom 50% share	0.19	3	
	Gini coefficient	0.74	0.81	
HtM	HtM	41.8%	41%	Kaplan and Violante (2022)
	$wHtM$	27.7%	27%	
	$pHtM^*$	14%	14%	

Table 2: Non-targeted moments: model outcomes compared to data counterparts. Note: * denotes the targeted moment used in the calibration.

4 Fiscal Multipliers

In this section, we compare the effectiveness of fiscal stimulus depending on the source of financing and the state of the economy. To do so, we assume that government spending increases by one percentage point and that it follows an AR(1)-type spending policy, $dG_t = \rho^G dG_0$. We set spending persistence $\rho^G = 0.7$. We take the following approaches to analyze the impact of different government financing sources. First, to analyze the effect of financing government spending with the deficit, we assume that transfers are chosen such that they satisfy following fiscal policy rule

$$T_t - T_{ss} = -\phi_B * (B_t^g - B_{ss}^g),$$

and we set $\phi_B = 0.1$. Thus, transfers decrease proportionally when the government increases debt to finance spending. In case the government chooses consumption tax to finance the deficit, they use the following fiscal policy rule

$$\tau_t^c - \tau_{ss}^c = \phi_B * (B_t^g - B_{ss}^g).$$

Therefore, when the government increases its deficit to finance an increase in spending, taxes increase proportionally. We define similar policy rules for financing deficits with income and dividend taxes. In our quantitative exercises, B_t^g is chosen to balance the

government budget in each period.

To assess the effect of financing government spending without the deficit, we compare the impact of each tax instrument when taxes are increased to satisfy the government budget each period without an increase in the debt level.

This section compares the heterogeneous agents model with the representative and two-agent models and further motivates the use of HANK models in analyzing fiscal multipliers. Consequently, we explore the fiscal multiplier's dependence on tax structures, government debt level, and household heterogeneity. We use two measures for the fiscal multiplier. The first measure, impact multiplier, is defined with $\frac{dY_0}{dG_0}$, whereas the second measure, cumulative fiscal multiplier, is defined as $\frac{\sum_t (1+r)^{-t} dY_t}{\sum_t (1+r)^{-t} dG_t}$.

4.1 HANK-TANK-RANK Comparison

In this section, we compare our HANK model to its representative agent (RA) and two-agent (TA) counterparts. In the calibration of two additional models, to make models as comparable as possible, we keep all aggregates the same as in the HANK model. In addition, we keep all parameters related to the supply side and fiscal and monetary authorities fixed. There is no progressive taxation in the RANK and TANK models, thus $\theta = 0$, and we use the level of income taxes τ_t to close the government budget constraint as in the case of heterogeneous agents.

The three models differ only in the household sector. The RANK, and TANK models, have access to one type of asset, that we match to the total wealth $(A + B)$ from our HANK model. Moreover, households accumulate and adjust these assets without any costs, give these assets to financial intermediaries, and get a return r^a which is a product of financial intermediaries' portfolio optimization. Next, there is only one discount factor $\beta = \frac{1}{1+r} = 0.952$, while we keep the parameter of the utility function the same as in our HANK model.

Consistent with results in the literature (e.g., (Auclert et al., 2018; Hagedorn et al., 2019; Bayer et al., 2023)), RANK and TANK cannot produce responses to government spending or fiscal multipliers as seen in the data. Figure 3 compares RANK and TANK

fiscal multipliers and impulse responses to ones resulting from our HANK model, additionally motivating the use of the HANK model in further analysis. The fiscal multiplier corresponding to the RANK model is below 1, resulting from strong crowding out of investments and consumption. Consumption response in the TANK model is positive and stronger than in the RANK model, which results in an impact fiscal multiplier larger than 1. However, consumption drops quickly, resulting in a cumulative fiscal multiplier smaller than one. Conversely, consumption response in our HANK model is larger and declines slowly to the steady state value, resulting in an impact and cumulative fiscal multiplier larger than 1.

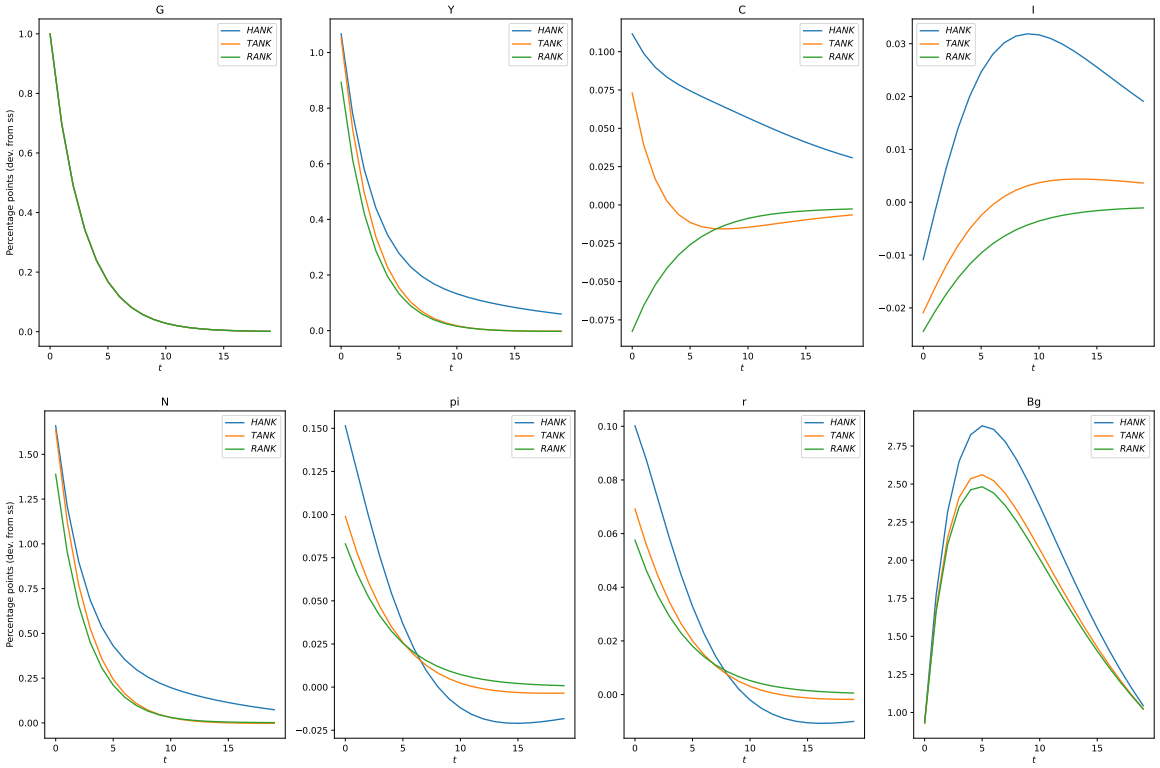


Figure 3: Impulse response functions corresponding to 1% increase in government spending financed with government debt and transfers across representative, two-agents, and heterogeneous agents models.

4.2 Consumption Decomposition

As Figure 3 highlights, the HANK model is the only one able to produce fiscal multipliers larger than one in addition to positive consumption multipliers. To explain the

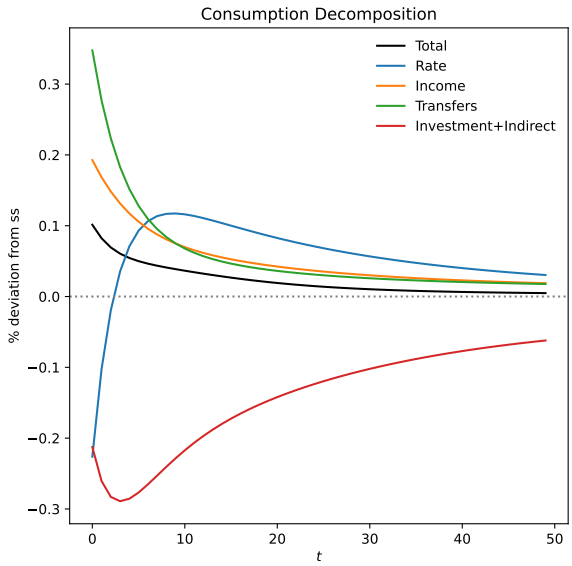


Figure 4: Aggregate consumption responses decomposition.

consumption response more intuitively, Figure 4 presents a compact decomposition of different effects relevant to the consumption response. Using the Jacobian structure of Auclert et al. (2021), we can decompose consumption responses into effects due to transfers, income, rate change, and investments coupled with indirect effects. We use this decomposition further to explain and highlight two dimensions of heterogeneity important for differential consumption responses.

First, Figure 5 decomposes the aggregate consumption response on the response of households' consumption from the bottom 50% and top 10% parts of the wealth distribution. From the bottom part of the wealth distribution, poorer households drive an initial positive consumption response due to an increase in labor income and government transfers. However, the effect is then crowded out. In contrast, wealthy households respond with a small decrease in consumption and turn to investments. Consequently, due to higher capital gains, they drive positive responses in aggregate consumption.

The second important dimension is to see how HtM status affects households' consumption decisions. Figure 6 decomposes consumption on the average consumption response of HtM households and non-HtM households. The figure shows that HtM households, after the initial increase in consumption, based on the effect of income and transfers, turn to savings/investments and reduce consumption. In contrast, non-

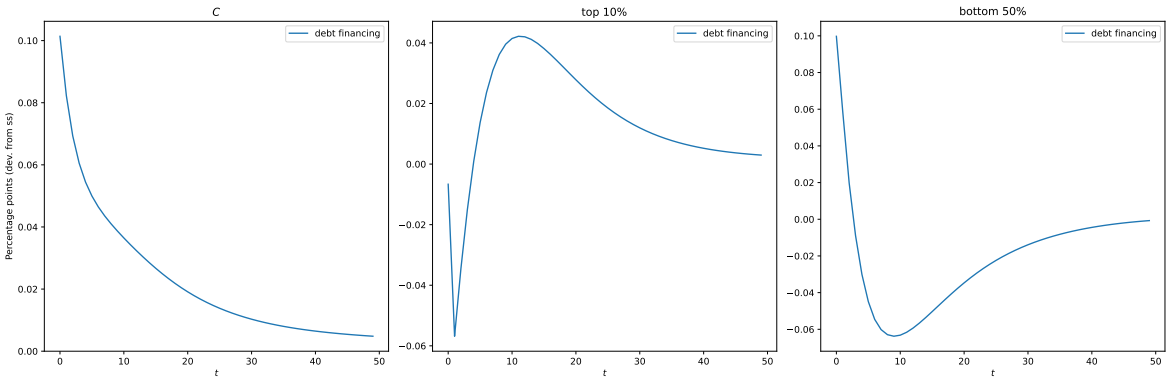


Figure 5: Consumption decomposition based on households' wealth.

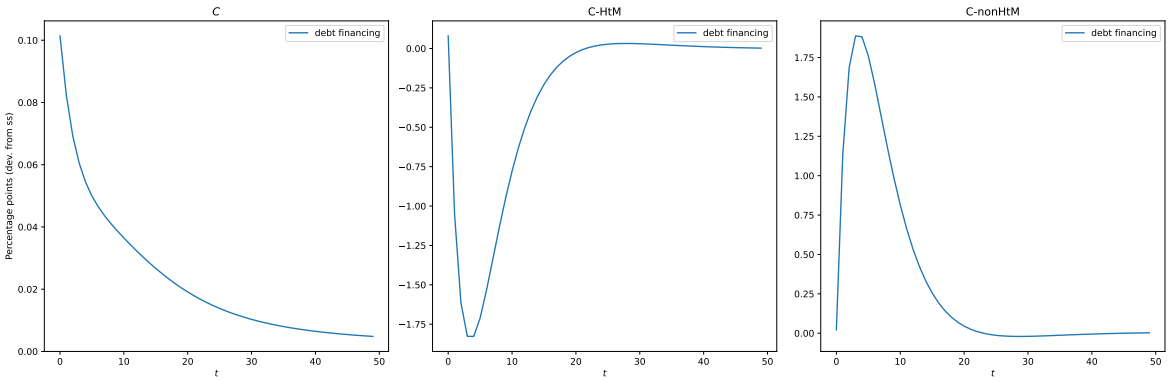


Figure 6: Consumption decomposition based on households' HtM status.

HtM households are not affected that much by constrained assets and increase their consumption throughout the period of government spending.

4.3 Sources of Financing of Government Spending: Debt vs. Direct Financing

To compare fiscal multipliers dependent on the source of financing, we compare the case when government spending is financed directly from taxes or transfers to when spending is financed from an increase in government debt. Therefore, we use the fiscal policy rules specified above. When spending is financed with an increase in debt, we compare cases when the residual in government spending is financed by raising taxes or reducing government transfers.

Figure 7 presents responses in four cases when government spending is directly financed with transfers, consumption taxes, dividend taxes, and changes in the income

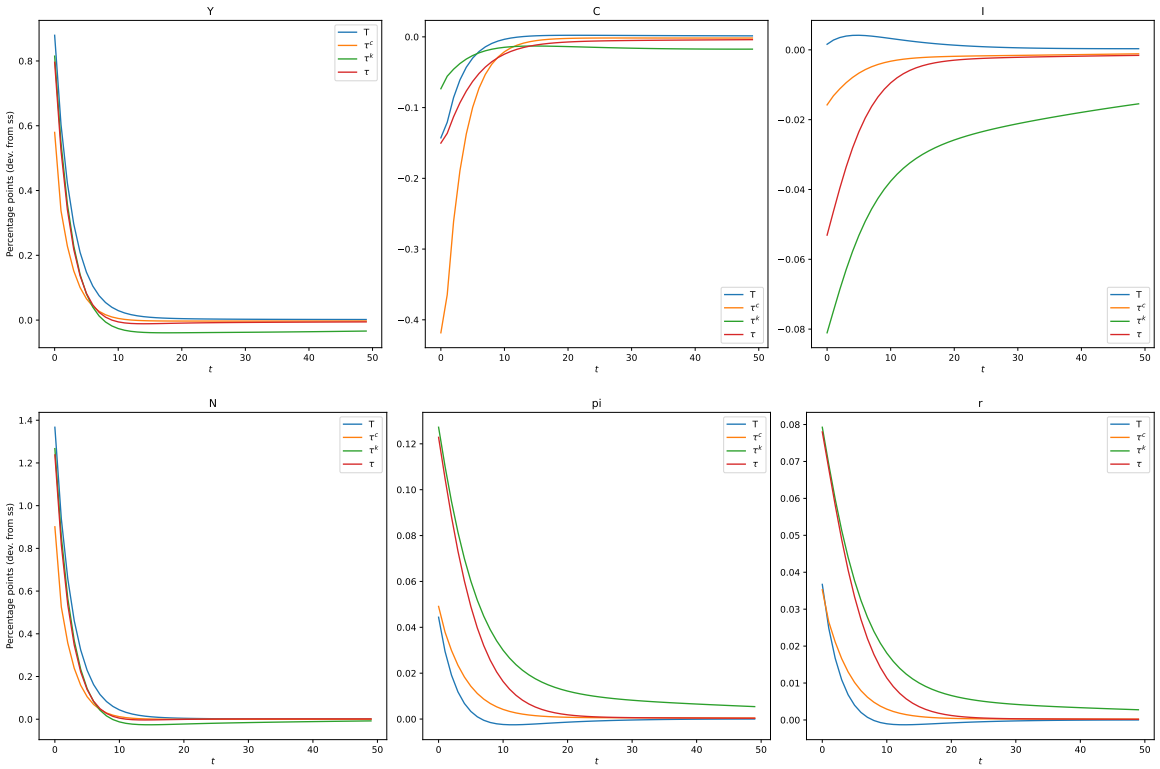


Figure 7: Impulse response functions corresponding to a 1% increase in government spending financed directly from government transfers or from consumption, dividend, and income taxes.

tax level. In all four cases, consumption is completely crowded out with investments, and the consumption response is negative. Moreover, in all cases, both impact and cumulative multipliers are less than one. On the one hand, financing with government lump sum transfers produces both the highest impact (0.88) and cumulative fiscal multiplier (0.92). On the other hand, financing government spending with an increase in consumption taxes produces the lowest impact multiplier (0.58). On impact, financing with dividend and income taxes is more effective than with consumption tax, however, at the cost of much higher inflation.

In the case of government spending being financed by raising debt (Figure 8), both impact and cumulative fiscal multipliers do not change much when using dividend tax. In contrast, using consumption taxes produces an impact fiscal multiplier (0.89). However, consumption is crowded out with investments, and the output response drops, resulting in a cumulative multiplier of around 0.69. In the case of debt financing with

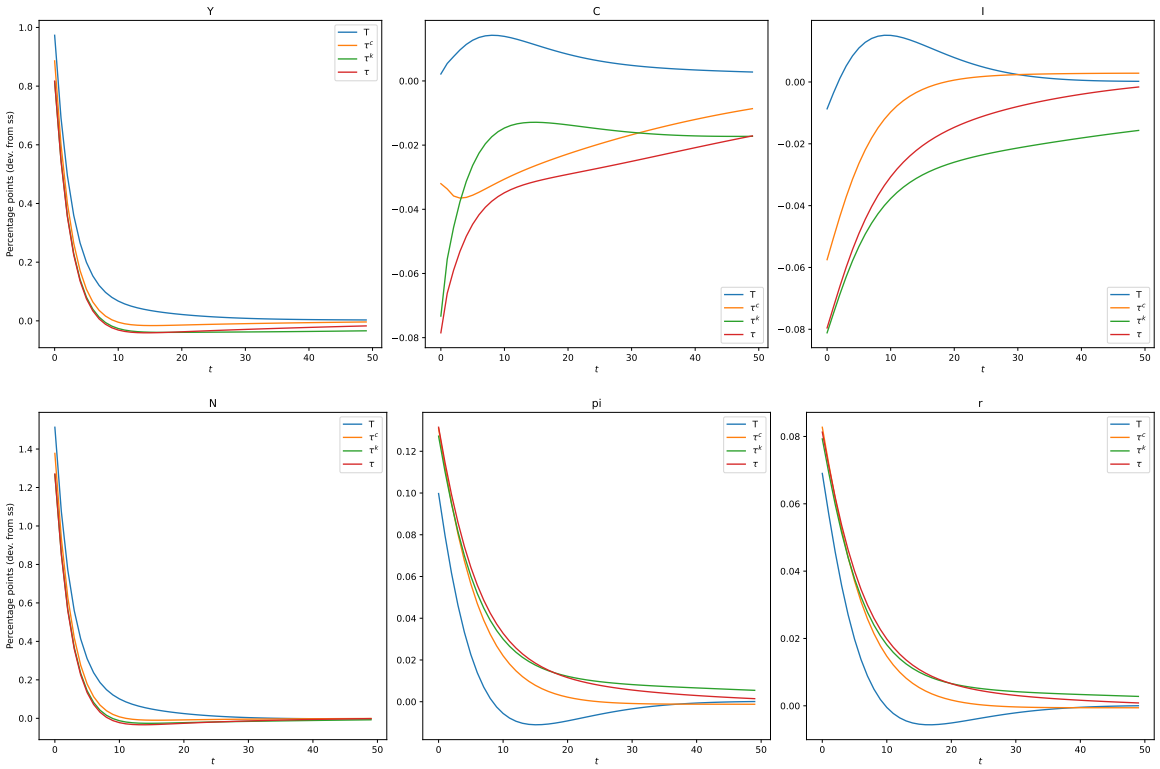


Figure 8: Impulse response functions corresponding to a 1% increase in government spending financed with debt and from government transfers or from consumption, dividend, and income taxes.

income and dividend taxes, the impact multipliers do not change significantly; however, due to strong crowding out of consumption, cumulative multipliers are low. Finally, consumption is not crowded out when the government uses transfers, which results in both the highest impact and cumulative fiscal multipliers. Table 3 summarizes all cases' impact and cumulative fiscal multipliers.

	Tax instrument	Impact multiplier	Cumulative multiplier
Direct financing	T	0.88	0.92
	τ^c	0.58	0.43
	τ^k	0.81	0.08
	τ	0.80	0.55
Debt financing	T	0.97	1.21
	τ^c	0.89	0.69
	τ^k	0.81	0.06
	τ	0.82	0.33

Table 3: Cumulative and impact fiscal multipliers depending on the source of financing of government spending.

4.4 Debt Level and Income Tax Progressivity

In this section, we analyze how the effectiveness of the fiscal policy varies with respect to debt-to-GDP and income tax progressivity. We calibrate models with the same targets as in the baseline calibration from the previous section with the exemption of B^g and income tax progressivity parameter θ. For debt-to-GDP we calibrate models for debt ranging from 30%-150% of the GDP. Moreover, we test the effectiveness of fiscal policies for progressivity parameters taking four values, $\theta \in \{0.05, 0.1, 0.18\}$.

To ensure that steady states are comparable, we assume that economies have the same spending-to-GDP ratio and transfer-to-GDP ratio, as well as other tax levels. However, we assume that to compensate for higher debt, the government uses a higher level of income tax, holding everything else fixed. Depending on the tax instrument in hand, we find heterogeneous effects of debt level and income tax progressivity.

In a recent paper, Ferriere and Navarro (2024) show that the fiscal multiplier increases when government spending is financed by changing the progressivity in income taxes. In our policy exercise, we explore how the fiscal multiplier changes in an economy with more or less progressive taxes, however, when the spending is financed through changing the lump-sum transfers/taxes or the level of other tax instruments. Moreover, we show that the economy with more progressive income taxes faces lower effectiveness of fiscal stimulus in the case of transfer financing.

This section analyzes long-term changes in fiscal policy effectiveness, i.e., changes in cumulative fiscal multipliers. Moreover, as the previous section showed that financing spending with debt is more effective, in this section, we focus only on debt financing More specifically, when the government increases spending, it increases debt as well, and in turn, debt is repaid using transfers. Figure 9 compares cumulative fiscal multipliers in the case of deficit financing with transfers for economies with different income tax progressivity and debt-to-GDP levels. Even though we use $\theta = 0.181$ in our baseline calibration, recent paper (Qiu and Russo, 2023) estimates the progressivity parameter both for U.S. and European economies to be between 0.05 and 0.1. For plausible levels

of income tax progressivity, Figure 9 shows the non-linear and non-monotonic relationship between debt-to-GDP and the long-term effectiveness of the fiscal stimulus. The effectiveness is the highest for the medium range of debt-to-GDP, i.e., 60%.

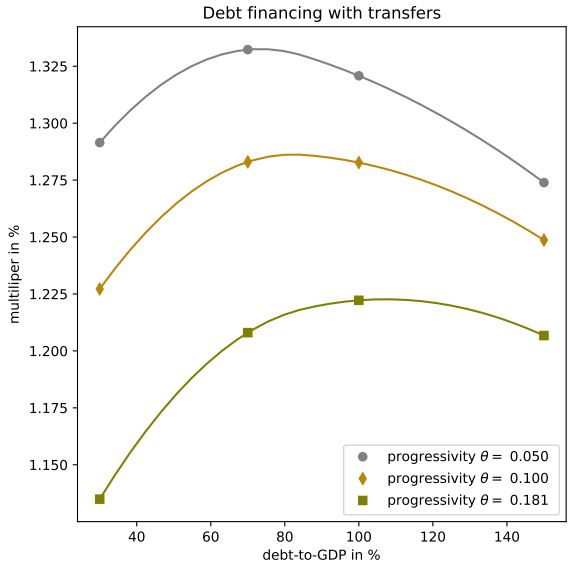


Figure 9: Cumulative fiscal multipliers in case of deficit financing with transfers for economies with different income tax progressivity and debt-to-GDP levels.

The shape of the effectiveness of fiscal stimulus in Figure 9 is governed by the differential financial intermediaries' portfolio composition. Different portfolios imply different incentives for households and their responses. In a low debt-to-GDP, more than 90% of assets are invested in equity compared to around 60% in a high debt-to-GDP state. Due to portfolio differences, consumption response is negative and completely crowded out due to investment incentives. In contrast, there is no crowding out of consumption in a high debt-to-GDP economy due to lower investment incentives. The interplay of this effect and the fact that in the high debt-to-GDP economy, transfers need to reduce much more to compensate for the increase in deficit add to the concavity of the shape of the effectiveness of the fiscal stimulus.

Dynamic Perspective

Figure 9 compares different steady states which we compare in detail in the next section. We can look at these steady states from the perspective of the same economy at different

times, depending on the debt-to-GDP level and financing strategy of the additional debt. For example, if we declare SS_L as the time when the economy was at 60% of the debt-to-GDP level and SS_H economy with 140% debt-to-GDP.

In the transition from SS_L to SS_H (abstracting from the cause), the economy needs to adjust the tax system (by assumption) through income tax level and progressivity. First, Figure 9 shows that the economy in SS_H has a lower range of the effectiveness level of the fiscal stimulus by adjusting the income tax progressivity. More specifically, the range is 5 b.p for SS_H economy whereas it is 13 b.p. for the SS_L economy. Second, the figure shows that the effectiveness, holding everything else fixed, reduces sizeably by increasing the debt-to-GDP level.

RANK and TANK Take on Effectiveness of the Fiscal Stimulus With Respect to Debt

Next, we repeat this analysis with RANK and TANK models calibrated in the previous section. In addition to the calibration described in the previous section, we do an additional one in which we fix the level of the income labor tax to the steady-state level of the 70% debt-to-GDP level. To close the budget constraint, we change the level of transfers. Figure 10 compares the short- and long-term impact of the government spending, i.e., impact and cumulative fiscal multipliers for RANK and TANK models, across debt-to-GDP levels for two calibration strategies. From Figure 10, we see that RANK and TANK models, irrespective of the calibration strategy and debt-to-GDP level, always predict the same level of effectiveness of the fiscal stimulus.

It is important to mention the caveats of this analysis. This analysis does not take into account the structure of debt, i.e., whether the debt is held mostly domestically or abroad. This would, in turn, have implications on the price of debt that could affect the effectiveness of the fiscal policies at hand. Higher debt could put upward pressure on the interest rates and thus could leave even less space for government spending. However, even though we abstract from the structure of debt and debt sustainability in this paper, we observe concave patterns in the most effective fiscal policies for financing

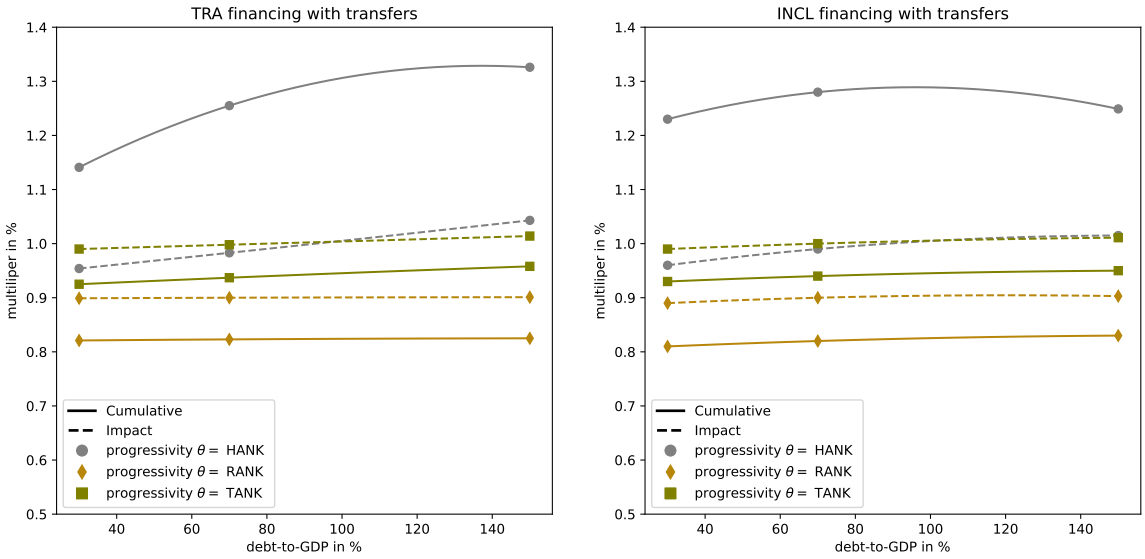


Figure 10: Impact and cumulative fiscal multipliers in case of deficit financing with transfers in HANK, TANK, and RANK models. Increase in debt-to-GDP compensated by transfers (left) and income tax level (right).

government spending (i.e., the long-term impact of deficit transfer financing (see Figure 9).

4.5 SS comparison

5 EU Core vs. Periphery vs. U.S.(baseline)

In this section, we calibrate our HANK model to two European economies, i.e., Italy and Germany, that will allow us to compare effectiveness in core economy (Germany) that follows a recommended debt-to-GDP target, and peripheral economy (Italy) with debt-to-GDP target well above the recommended value. In calibrating the model for two economies, we keep structural parameters including inverse IES, portfolio adjustment cost pivot and curvature, inverse Frisch elasticity, Taylor rule coefficient, slopes of two Phillips curves and investment elasticity to at standard values, the same as in our baseline calibration of the U.S. economy (Table 1).

The source of difference in calibrated models between three economies comes from country specific calibrated income process through parameters of autocorrelation of

earnings and cross-sectional s.d. of log earnings. Morover, economies differ in the aggregate liquid asset- and illiquid asset-to-output ratios. We use our estimates from HFCS of asset ratios as well as of HtM ratios for two European economies. Lastly, we calibrate tax-systems that are country specific with different levels of consumption, dividend and lump-sum taxes and income tax progressivity.

6 Conclusion

In this paper, we develop a heterogeneous-agents model with liquid and illiquid assets to analyze the fiscal multiplier quantitatively. Implementing a rich set of fiscal policy rules and various instruments, such as consumption, capital, progressive income taxes, and government transfers, allows us to measure fiscal multipliers in various cases.

First, when we implement the tax structure with all taxes, we show that the RANK and TANK models cannot reproduce aggregate responses as observed in the data. This finding is similar to one already noted in literature (Auclert et al., 2018; Hagedorn et al., 2019) but in an economy with less rich tax structures than ours. Second, using aggregate consumption decomposition, we highlight the role of household heterogeneity in explaining the aggregate consumption response to the increase in government spending. Third, using our HANK model calibrated to the U.S. economy, we compare fiscal multipliers depending on the source of financing. We show that financing government spending with debt and repayment with lump-sum transfers yields the highest short and long-term effects on output. Moreover, lump-sum transfers circumvent individual frictions in liquidity transformation and increase demand among liquidity-constrained households. Lastly, we show concave, i.e., a non-monotonic and non-linear relationship between the effectiveness of the fiscal stimulus and debt-to-GDP holding the price of debt fixed.

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A HFCS

In this section, we classify the three groups of households by their hand-to-mouth status using two slightly different definitions. Moreover, we outline the construction of variables used in our analysis. The variable names refer to wave 4 of the Household Finance and Consumption Survey.

We follow Kaplan et al. (2014) and Slacalek et al. (2020), and use the following definition. A household is considered as hand-to-mouth (HtM) if:

- Net liquid wealth ≥ 0 & net liquid wealth $\leq$ biweekly (net) income

  or

- Net liquid wealth < 0 & net liquid wealth $\leq$ biweekly (net) income $-$ credit limit.

Moreover, a household is:

- Poor HtM if it is HtM & net illiquid wealth ≤ 0,
- Wealthy HtM if it is HtM & net illiquid wealth > 0,
- Non-HtM if it is not HtM.

We compare the resulting HtM decomposition using the additional definition of Slacalek et al. (2020). They classify all HtM households with some housing assets as wHtM, including households whose mortgage exceeds the house's value. In addition, they classify all HtM households with some self-employment business wealth as wHtM.

As Slacalek et al. (2020) also use the HFCS, we follow their construction of liquid and illiquid asset variables. The variables used in specifying wHtM and pHtM households are defined as follows:

- Net liquid wealth = liquid assets $-$ liquid liabilities
- Liquid assets = sight and saving accounts (deposits), directly held mutual funds, bonds, and stocks

- Liquid liabilities = overdraft debt and credit card debt
- Net illiquid wealth = illiquid assets − illiquid liabilities
- Illiquid assets = illiquid real assets, the value of the household main residence and other properties and the value of self-employment businesses
- Illiquid liabilities = amount of non-collateralized loans for household main residence and other properties, mortgage debt.

We assume that the credit limit is one month of income. Moreover, we use a simplified definition of net income. For each country in the HFCS, we use the average tax wedge from the OECD Tax Database (https://www.oecd.org/tax/tax-policy/tax-database/). Specifically, we define net income as:

- net income = (1-τ)*(employment income + 2/3 self employment income) + non taxable income.

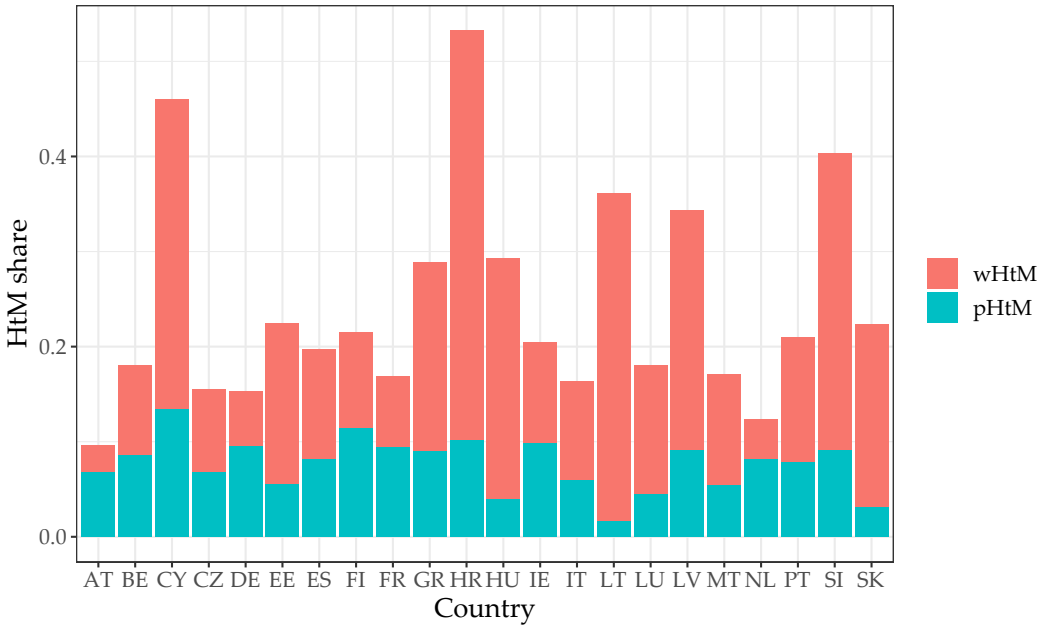


Figure 11: wHtM and pHtM shares for a set of European countries; Slacalek et al. (2020) definition. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

Figure 11 shows heterogeneity is shares of HtM, wHtM, and pHtM households across countries. The majority of countries have HtM share lower than 41%, which is

the share of HtM households in the U.S. (Kaplan and Violante, 2022). The figure also shows heterogeneity across countries in both wHtM and pHtM shares.

Country Code	HtM	wHtM	pHtM	wHtM*	pHtM*	Net liquid	Net illiquid
AT	0.10	0.03	0.07	0.03	0.07	42.82	233.03
BE	0.18	0.09	0.09	0.09	0.09	87.06	301.27
CY	0.46	0.33	0.13	0.31	0.15	18.52	312.73
CZ	0.16	0.09	0.07	0.08	0.07	12.16	118.21
DE	0.15	0.06	0.09	0.06	0.10	55.06	244.05
EE	0.22	0.17	0.06	0.16	0.06	21.50	128.80
ES	0.20	0.12	0.08	0.10	0.10	40.34	210.27
FI	0.21	0.10	0.11	0.09	0.12	46.44	152.18
FR	0.17	0.08	0.09	0.07	0.10	35.73	217.24
GR	0.29	0.20	0.09	0.19	0.10	12.79	111.58
HR	0.53	0.43	0.10	0.43	0.10	2.45	108.05
HU	0.29	0.25	0.04	0.25	0.04	9.47	87.45
IE	0.20	0.11	0.10	0.10	0.10	39.29	307.86
IT	0.16	0.10	0.06	0.10	0.06	46.99	270.95
LT	0.36	0.35	0.02	0.34	0.02	3.30	82.20
LU	0.18	0.14	0.04	0.13	0.05	255.75	949.72
LV	0.34	0.25	0.09	0.25	0.10	7.89	60.36
MT	0.17	0.12	0.05	0.12	0.05	38.59	360.68
NL	0.12	0.04	0.08	0.04	0.08	52.87	152.55
PT	0.21	0.13	0.08	0.13	0.08	25.72	156.71
SI	0.40	0.31	0.09	0.31	0.09	11.77	169.43
SK	0.22	0.19	0.03	0.19	0.03	9.49	108.21

Table 4: Htm, wHtM, and pHtM shares and net liquid and illiquid asset positions in thousands of EUR for a set of European countries. Note: * denotes wHtM and pHtM shares using the definition of Kaplan et al. (2014). Source: Eurosystem Household Finance and Consumption Survey, wave 4.

Figures 12 and Figure 13 show net liquid and illiquid asset holdings in absolute terms, i.e., in thousands of EUR.

Figure 14 shows net illiquid asset-to-income ratio heterogeneity for some European countries.

Table 4 documents shares of HtM, wHtM, and pHtM households across countries as well as net liquid and illiquid asset positions depicted in Figures 1,12,13, and 11.

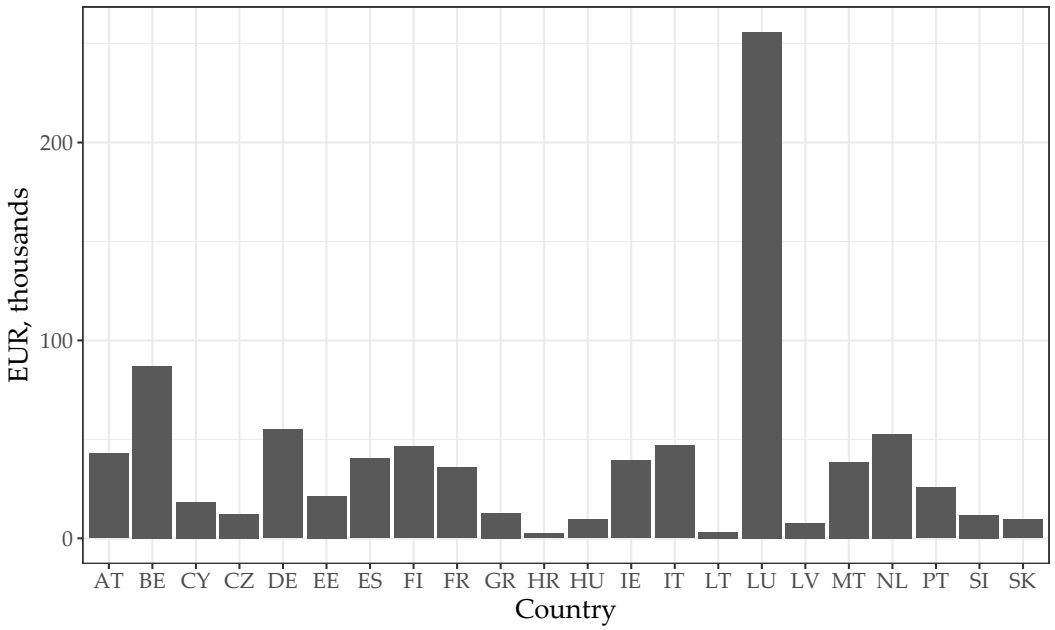


Figure 12: Net liquid asset holdings for a set of European countries. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

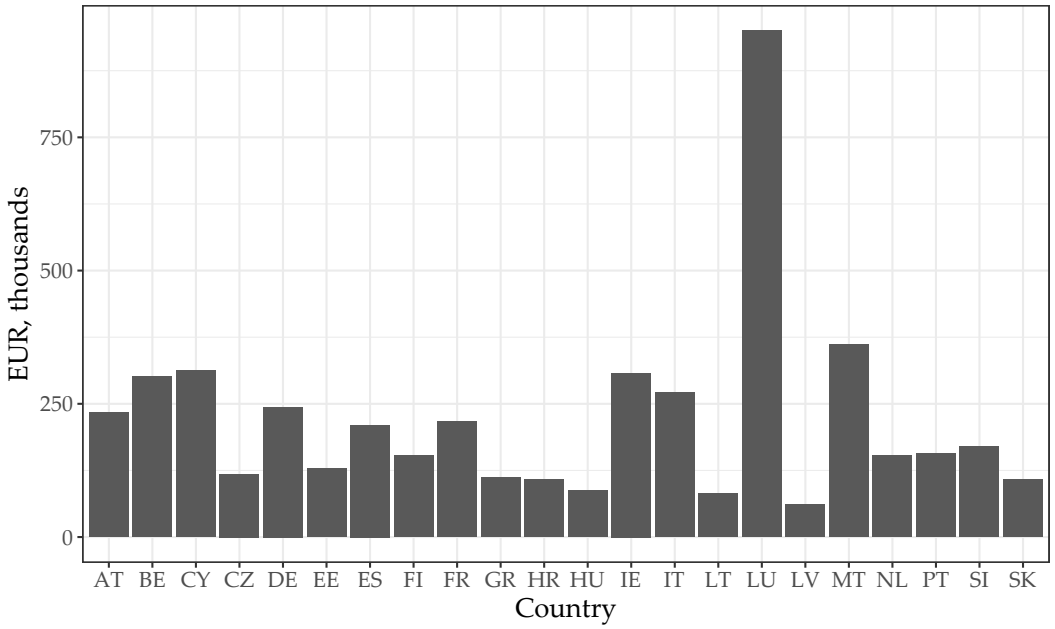


Figure 13: Net illiquid asset holdings for a set of European countries. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

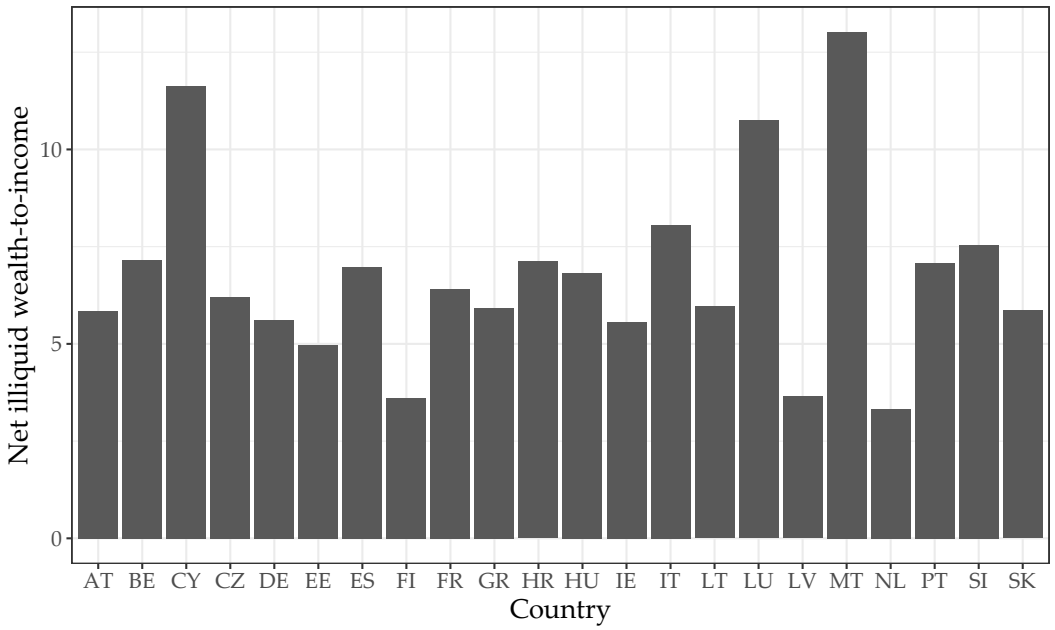


Figure 14: Net illiquid wealth to income for a set of European countries. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

B Household problem description

In this section, we derive the first order and envelope conditions. The Bellman equation can be rewritten as

$$V_t(z_{i,t}, b_{i,t-1}, a_{i,t-1}, \beta_{i,t}) = \max_{b_{i,t}, a_{i,t}} u\Bigg(\frac{1}{1+\tau^c}(z_{i,t} + (1+r_t^a)a_{i,t-1} + (1+r_t^b)b_{i,t-1} - \\ - \Psi(a_{i,t}, a_{i,t-1}) - a_{i,t} - b_{i,t})\Bigg) + \\ + \lambda_{i,t}b_{i,t} + \mu_{i,t}a_{i,t} + \beta_{i,t}\mathbb{E}V_{t+1}(z_{i,t+1}, b_{i,t}, a_{i,t}, \beta_{i,t+1}),$$

where $\lambda_{i,t}$ and $\mu_{i,t}$ are Lagrange multipliers on non-negativity constraints for both types of assets. The first order conditions with respect to $b_{i,t}$ and $a_{i,t}$ are given with

$$u'(c_{i,t})\frac{1}{1+\tau^c} = \lambda_{i,t} + \beta_{i,t}\mathbb{E}\partial_b V_{t+1}(z_{i,t+1}, b_{i,t}, a_{i,t}, \beta_{i,t+1})$$

and

$$u'(c_{i,t})\frac{1}{1+\tau^c}\Big(1 + \Psi_1(a_{i,t}, a_{i,t-1})\Big) = \mu_{i,t} + \beta_{i,t}\mathbb{E}\partial_a V_{t+1}(z_{i,t+1}, b_{i,t}, a_{i,t}, \beta_{i,t+1}).$$

Lastly, the envelope conditions are

$$\partial_b V_t(z_{i,t}, b_{i,t-1}, a_{i,t-1}, \beta_{i,t}) = (1 + r_t^b)u'(c_{i,t})\frac{1}{1+\tau^c}$$

and

$$\partial_a V_t(z_{i,t}, b_{i,t-1}, a_{i,t-1}, \beta_{i,t}) = \Big(1 + r_t^a - \Psi_2(a_{i,t}, a_{i,t-1})\Big)u'(c_{i,t})\frac{1}{1+\tau^c}.$$

To solve this part of the model, we follow Auclert et al. (2021) and use the endogenous gridpoints method of Carroll (2006). Details of the implementation can be found in the appendix of Auclert et al. (2021).

C Derivation of the nonlinear wage NKPC

To derive the wage NKPC, we first use the definition of the real wage w_t and expression for the demand curve to rewrite $z_{i,t}$:

$$\begin{aligned} z_{i,t} &= \tau_t(w_t N_{k,t} e_{i,t})^{1-\theta} + T_t = \tau_t\left(\frac{W_{k,t}}{P_t}N_{k,t}e_{i,t}\right)^{1-\theta} + T_t \\ &= \tau_t\left(\frac{W_{k,t}}{P_t}e_{i,t}\left(\frac{W_{k,t}}{W_t}\right)^{-\varepsilon}N_t\right)^{1-\theta} + T_t. \end{aligned}$$

Second, we note that applying the Euler theorem to the household's problem (1) implies $\frac{\partial c_{i,t}}{\partial W_{k,t}} = \frac{1}{1+\tau_t^c}\frac{\partial z_{i,t}}{\partial W_{k,t}}$. Using the expression derived above, and exploiting the fact that in equilibrium $W_{k,t} = W_t$ we get that

$$\begin{aligned} \frac{\partial z_{i,t}}{\partial W_{k,t}} &= (1-\theta)\tau_t\left(\frac{W_{k,t}}{P_t}N_{k,t}e_{i,t}\right)^{-\theta}\frac{e_{i,t}}{P_t}\left(N_{k,t} - W_{k,t}\varepsilon\left(\frac{1}{W_t}\right)^{-\varepsilon}N_t W_{k,t}^{-\varepsilon-1}\right) \\ &= (1 - MTR_{i,t})\frac{e_{i,t}}{P_t}N_{k,t}(1-\varepsilon), \end{aligned} \tag{9}$$

where $MTR_{i,t} = 1-(1-\theta)\tau_t\big(\frac{W_{k,t}}{P_t}N_{k,t}e_{i,t}\big)^{-\theta}$ is marginal tax rate of household i at time t. Lastly, since household i's total hours work equal $\left(\frac{W_{k,t}}{W_t}\right)^{-\varepsilon}N_t$, we have that hours worked also satisfy

$$\frac{\partial n_{i,t}}{\partial W_{k,t}} = -\varepsilon\frac{N_{k,t}}{W_{k,t}}. \tag{10}$$

Now, we take the first order condition of the union k's problem with respect to $W_{k,t}$ as well as the envelope condition and obtain

$$\int \left(u'(c_{i,t}) \frac{\partial c_{i,t}}{W_{k,t}} - v'(n_{i,t}) \frac{\partial n_{i,t}}{\partial W_{k,t}} \right) d\Psi_{i,t} - \psi \left(\frac{W_{k,t}}{W_{k,t-1}} - 1 \right) \frac{1}{W_{k,t-1}} + \frac{1}{1+r_t} \psi \left(\frac{W_{k,t+1}}{W_{k,t}} - 1 \right) \frac{W_{k,t+1}}{W_{k,t}^2} = 0.$$

Further, we plug in for expressions (9) and (10):

$$\int \left(u'(c_{i,t}) \frac{1}{1+\tau_t^c} (1 - MTR_{i,t}) \frac{e_{i,t}}{P_t} (1-\varepsilon) N_t + v'(n_{i,t}) \varepsilon \frac{N_{k,t}}{W_{k,t}} \right) d\Psi_{i,t} - \psi \left(\frac{W_{k,t}}{W_{k,t-1}} - 1 \right) \frac{1}{W_{k,t-1}} + \frac{1}{1+r_t} \psi \left(\frac{W_{k,t+1}}{W_{k,t}} - 1 \right) \frac{W_{k,t+1}}{W_{k,t}^2} = 0.$$

Next, we multiply with $\frac{W_{k,t}}{\psi}$, substitute for $\pi^w = \frac{W_t}{W_{t-1}} - 1$, and, exploiting the fact that in equilibrium $W_{k,t} = W_t$, we obtain:

$$\frac{\varepsilon}{\psi} \left(\int u'(c_{i,t}) (1 - MTR_{i,t}) w_t e_{i,t} \frac{1-\varepsilon}{\varepsilon} N_t d\Psi_{i,t} + v'(N_t) N_t \right) - (1+\pi_t^w)\pi_t^w + \frac{1}{1+r_t} (1+\pi_{t+1}^w)\pi_{t+1}^w = 0.$$

Further, note that

$$(1 - MTR_{i,t}) w_t e_{i,t} N_t = (1-\theta) \tau_t \left(w_t N_t e_{i,t} \right)^{1-\theta} = (1-\theta) \frac{e_{i,t}^{1-\theta}}{\int e_{i,t}^{1-\theta} di} Z_t,$$

where Z_t is aggregate income tax (net of transfers). Now, we define $\kappa^w = \frac{\varepsilon}{\psi}$, $\mu^w = \frac{\varepsilon}{\varepsilon - 1}$, and $u'(\tilde{C}_t) = \frac{e_{i,t}^{1-\theta}}{\int e_{i,t}^{1-\theta} di} u'(c_{i,t}) di$, and rearrange to get the final expression for our nonlinear wage NKPC

$$(1+\pi_t^w)\pi_t^w = \kappa^w \left(\gamma N_t^{1+\frac{1}{\phi}} - \frac{(1-\theta)}{(1+\tau_t^c)\mu^w} Z_t u'(\tilde{C}_t) \right) + \frac{1}{1+r_t} (1+\pi_{t+1}^w)\pi_{t+1}^w.$$

D Derivation of the nonlinear price NKPC

Recall the Bellman equation for the intermediate good's firm is:

$$J_t(\mathcal{P}_{t-1}, k_{t-1}) = \max_{\mathcal{P}_t, k_t, n_t} \left\{ \frac{\mathcal{P}_t}{P_t} F(k_{t-1}, n_t) - \frac{W_t}{P_t} n_t - i_t - \phi\left(\frac{k_t}{k_{t-1}}\right) k_{t-1} - \xi(\mathcal{P}_t, \mathcal{P}_{t-1}) Y_t + \frac{1}{1+r_t} J_{t+1}(\mathcal{P}_t, k_t) \right\},$$

$$\text{subject to} \quad \left(\frac{F(k_{t-1}, n_t)}{Y_t}\right)^{\frac{1-\mu^p}{\mu^p}} Y_t = \left(\frac{\mathcal{P}_t}{P_t}\right) Y_t.$$

If we denote the Lagrange multiplier on the production constraint with λ_t, the first order condition with respect to n_t is:

$$0 = \frac{\mathcal{P}_t}{P_t} F_{n,t}(k_{t-1}, n_t) - \frac{W_t}{P_t} + \lambda_t \left(\frac{1-\mu_p}{\mu_p}\right) \left(\frac{F(k_{t-1}, n_t)}{Y_t}\right)^{\frac{1-2\mu_p}{\mu_p}} F_{n,t}(k_{t-1}, n_t).$$

Rearranging implies

$$\frac{W_t}{P_t} \frac{1}{F_{n,t}(k_{t-1}, n_t)} = mc_t = \frac{\mathcal{P}_t}{P_t} + \lambda_t \left(\frac{1-\mu_p}{\mu_p}\right) \left(\frac{F(k_{t-1}, n_t)}{Y_t}\right)^{\frac{1-2\mu_p}{\mu_p}}. \tag{11}$$

Since in equilibrium all firms set the same wage $\mathcal{P}_t = P_t$, and $F(k_{t-1}, n_t) = Y_t$, equation (11) simplifies to

$$\frac{W_t}{P_t} \frac{1}{F_{n,t}(k_{t-1}, n_t)} = mc_t = 1 - \lambda_t \left(\frac{\mu_p - 1}{\mu_p}\right). \tag{12}$$

Condition (12) has two implications. First, higher Lagrange multiplier λ_t is associated with a lower real marginal cost mc_t, i.e.,

$$\lambda_t = 1 \implies mc_t = \frac{1}{\mu_p} \leq 1,$$

and

$$\lambda_t \to 1 \implies mc_t \to 1.$$

In order to get the price NKPC, we start by taking first order condition with respect

to $\mathcal{P}_t$ and get:

$$0 = \frac{1}{P_t}F(k_{t-1}, n_t) - \frac{1}{\kappa^p(\mu^p - 1)}\left(\frac{\mathcal{P}_t - \mathcal{P}_{t-1}}{\mathcal{P}_{t-1}}\right)\frac{1}{\mathcal{P}_{t-1}}Y_t + \frac{1}{1+r_t}J_{p,t+1}(\mathcal{P}_t, k_t) - \lambda_t\frac{Y_t}{P_t}. \quad (13)$$

The envelope condition implies that the following condition holds:

$$J_{p,t}(\mathcal{P}_{t-1}, k_{t-1}) = \frac{1}{\kappa^p(\mu^p - 1)}\left(\frac{\mathcal{P}_t - \mathcal{P}_{t-1}}{\mathcal{P}_{t-1}}\right)\frac{\mathcal{P}_t}{\mathcal{P}_{t-1}^2}Y_t. \quad (14)$$

Again, we use the fact that in equilibrium $\mathcal{P}_t = P_t$, and $Y_t = F(k_{t-1}, n_t)$. Moreover, by multiplying (13) with $\mathcal{P}_t$, rolling over one period condition (14) and substituting, we get:

$$0 = Y_t - \frac{1}{\kappa^p(\mu^p - 1)}\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)\frac{P_t}{P_{t-1}}Y_t + \frac{1}{1+r_t}\frac{1}{\kappa^p(\mu^p - 1)}\left(\frac{P_{t+1} - P_t}{P_t}\right)\frac{P_{t+1}}{P_t}Y_{t+1} - \lambda_t Y_t. \quad (15)$$

Next, we rearrange (15), divide by Y_t, and subsititue for $\pi_t = \frac{P_t}{P_{t-1}} - 1$, to get:

$$1 - \lambda_t = \frac{1}{\kappa^p(\mu^p - 1)}(\pi_t)(1+\pi_t) - \frac{1}{1+r_t}\frac{1}{\kappa^p(\mu^p - 1)}(\pi_{t+1})(1+\pi_{t+1})\frac{Y_{t+1}}{Y_t}. \quad (16)$$

Rearranging (12)

$$mc_t = 1 - \lambda_t\left(\frac{\mu_p - 1}{\mu_p}\right) \implies \lambda_t = (1 - mc_t)\frac{\mu_p}{\mu_p - 1} \implies$$
$$1 - \lambda_t = \frac{\mu_p - 1 - \mu_p + \mu_p mc_t}{\mu_p - 1} = \frac{\mu_p mc_t - 1}{\mu_p - 1},$$

and substituting the last expression to (16) yields:

$$\frac{\mu_p mc_t - 1}{\mu_p - 1} = \frac{1}{\kappa^p(\mu^p - 1)}(\pi_t)(1+\pi_t) - \frac{1}{1+r_t}\frac{1}{\kappa^p(\mu^p - 1)}(\pi_{t+1})(1+\pi_{t+1})\frac{Y_{t+1}}{Y_t}. \quad (17)$$

Lastly, by multiplying (17) with $\kappa^p(\mu^p - 1)$ and rearranging, we get the final expression

for our nonlinear price NKPC:

$$\pi_t(1+\pi_t) = \kappa^p(\mu_p mc_t - 1) + \frac{1}{1+r_t}\pi_{t+1}(1+\pi_{t+1})\frac{Y_{t+1}}{Y_t}. \tag{18}$$

Further, we take the first order condition with respect to k_t and get:

$$0 = -1 - \frac{1}{\delta\varepsilon_I}\left(\frac{k_t}{k_{t-1}} - 1\right)\frac{1}{k_{t-1}} + \frac{1}{1+r_t}J_{k,t+1}(\mathcal{P}_t, k_t),$$

which after rearranging

$$1 + \frac{1}{\delta\varepsilon_I}\left(\frac{k_t}{k_{t-1}} - 1\right) = \frac{1}{1+r_t}J_{k,t+1}(\mathcal{P}_t, k_t) \equiv Q_t, \tag{19}$$

and the fact that in the equilibrium $k_t = K_t$, gives us the equation from the text. The envelope condition with respect to k_{t-1} gives us:

$$\begin{aligned} J_{k,t}(\mathcal{P}_{t-1}, k_{t-1}) =& \frac{\mathcal{P}_t}{P_t}F_k(k_{t-1}, n_t) + (1-\delta) - \phi\left(\frac{k_t}{k_{t-1}}\right) + \frac{1}{\delta\varepsilon_I}\left(\frac{k_t}{k_{t-1}} - 1\right)\frac{k_t}{k_{t-1}} + \\ &+\lambda_t\left(\frac{1-\mu^p}{\mu^p}\right)\left(\frac{F(k_{t-1}, n_t)}{Y_t}\right)^{\frac{1-2\mu^p}{\mu^p}} Y_t F_k(k_{t-1}, n_t) \\ =& mc_t F_k(k_{t-1}, n_t) + (1-\delta) - \phi\left(\frac{k_t}{k_{t-1}}\right) + \frac{1}{\delta\varepsilon_I}\left(\frac{k_t}{k_{t-1}} - 1\right)\frac{k_t}{k_{t-1}}. \end{aligned} \tag{20}$$

We rearrange (19) and plug it in from both the left- and right-hand side of (20) and get:

$$(1+r_{t-1})Q_{t-1} = mc_t F_k(k_{t-1}, n_t) + (1-\delta) - \phi\left(\frac{k_t}{k_{t-1}}\right) + (Q_t - 1)\frac{k_t}{k_{t-1}},$$

which we can further simplify, by rearranging and using the Cobb-Douglas property of the production ($F_k(k_{t-1}, n_t) = \alpha\frac{Y_t}{k_{t-1}}$), to:

$$(1+r_{t-1})Q_{t-1} = mc_t\alpha\frac{Y_t}{k_{t-1}} - \frac{i_t}{k_{t-1}} - \phi\left(\frac{k_t}{k_{t-1}}\right) + Q_t\frac{k_t}{k_{t-1}}.$$

Finally, similar to before, using the fact that in equilibrium $k_t = K_t$, and $n_t = N_t$ yields

the final expression from the text.

E Sensitivity analysis

With respect to debt policy rule and ϕ_B.