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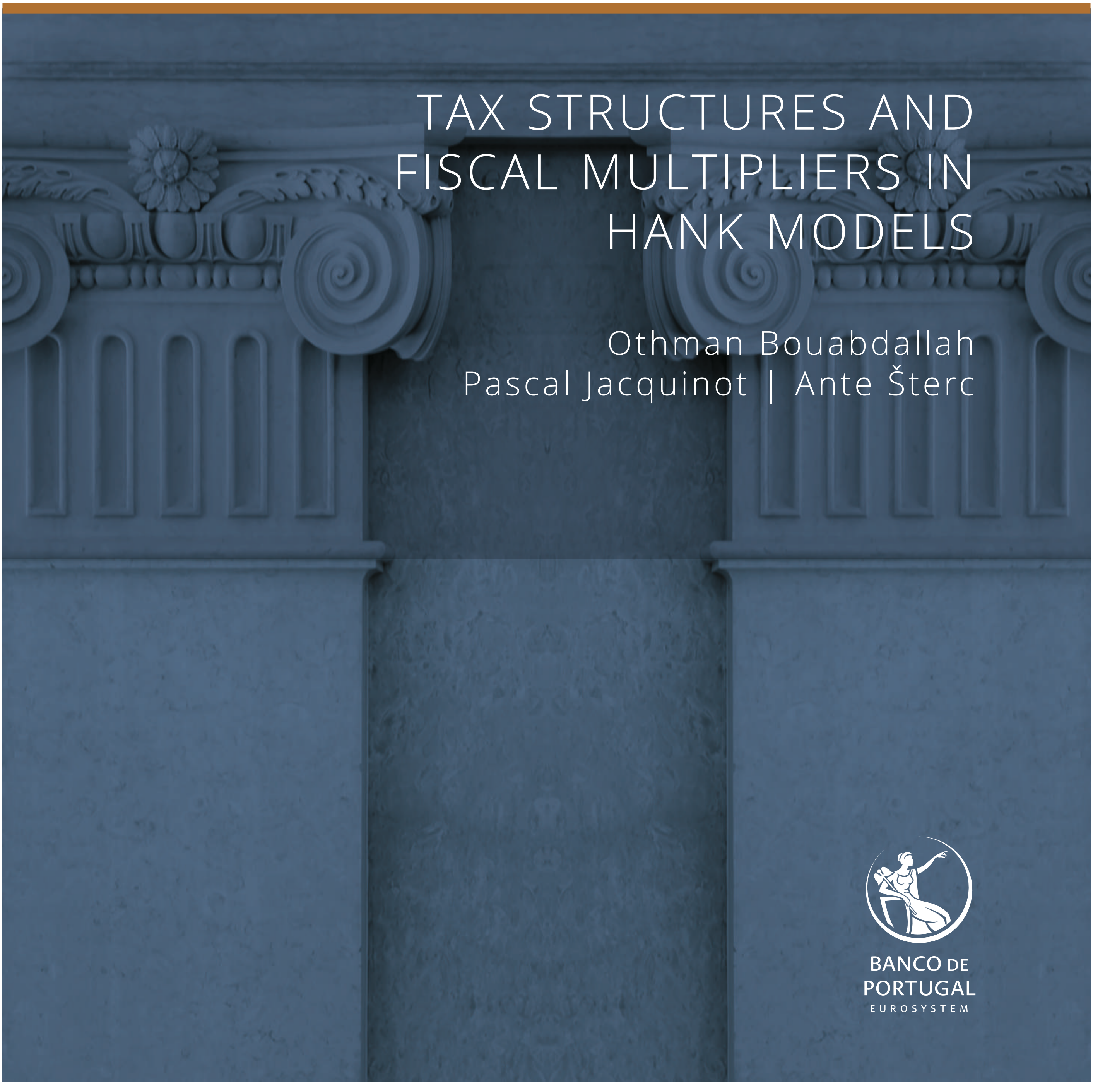

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Tax Structures and Fiscal Multipliers in HANK Models

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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). Accounting for heterogeneous MPCs allows plausible predictions of the effectiveness of fiscal policy in the short and long term. Using our model, calibrated to the U.S. economy, we show that government spending has the largest short- and long-term effect on output when financed by debt, with gradual repayment through lump-sum transfers/taxes. We find a novel, non-linear, and non-monotonic relationship between the effectiveness of the fiscal stimulus, income tax progressivity, and the debt-to-GDP ratio, absent in representative or two-agent models. Lastly, the model suggests limited effectiveness of the fiscal stimulus and higher inflationary pressure for highly indebted economies.

JEL: D31, E21, G11, H31, H63

Keywords: Fiscal Policy, Fiscal Multiplier, Heterogeneous Agents, Public debt.

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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. We develop a quantitative Heterogeneous Agents New Keynesian (HANK) model successful in matching HtM (hand-to-mouth) shares and marginal propensities to consume (MPCs) observed in the data. Using the calibrated model to the U.S. economy, we show that financing government spending with a combination of deficit and transfers implies the largest positive short- and long-term effect on output.

In the United States, government debt-to-GDP averages at 65.70% of GDP from 1940 until 2023. However, the government debt-to-GDP reached an all time high of 126.30% of GDP in 2020 and a record low of 31.80% of GDP in 1981 (Figure 1). In our analysis we focus on this dynamic evolution of debt and find that the effectiveness of fiscal stimulus depend on the debt-to-GDP. In particular, we show a novel nonlinear and non-monotonic relationship between the effectiveness of fiscal stimulus and debt-to-GDP level, as well as the degree of income tax progressivity.

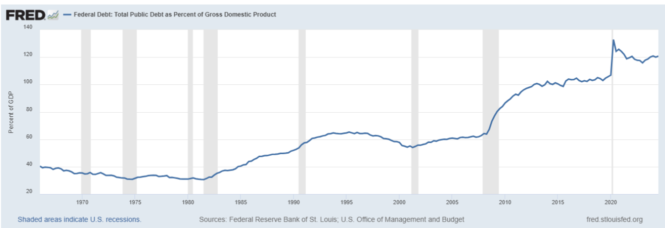

Figure 1: Total Public Debt as Percent of Gross Domestic Product for the United States. Source: U.S. Office of Management and Budget and Federal Reserve Bank of St. Louis, Federal Debt: Total Public Debt as Percent of Gross Domestic Product [GFDEGDQ188S], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GFDEGDQ188S, January 23, 2025.

There is a large variation between liquid and illiquid asset holdings and in inequality measures within a set of European economies as well as in comparison to U.S. economy. Kaplan *et al.* (2014) and Slacalek *et al.* (2020) use Household Finance and Consumption Survey (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 HtM 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. In addition, we document the heterogeneity net liquid and illiquid wealth Gini coefficients as well as in shares of assets held by bottom 50% and top 10% for a set of European economies. With our calibrated model, we show heterogeneity in response to the government spending shock depending to their wealth and their HtM status. These findings highlight the need for models that can account for different asset holdings as well as ability to match empirically observed inequality patterns.

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. Specifically, we decompose aggregate responses depending on the HtM status and wealth holdings and analyze differences and contributions to the overall response. In particular, our decomposition of the aggregate consumption response shows that the positive aggregate consumption response is driven by the response of households from middle to upper part of the wealth distribution, due to positive incentives from higher income. In contrast, households from the bottom of the wealth distribution respond by decreasing their consumption due to lower incentives from decreased transfers, used to finance raised government debt. Lastly, the consumption response of households from the top of the from the wealth distribution is limited and driven by investment incentives, i.e., changes in the interest rate and capital gains.

Usually, to answer questions regarding fiscal multipliers, the literature analyzes the U.S. economy and fixed debt-to-GDP at the long-run average value. In the United States, government debt-to-GDP averages at 65.70% of GDP from 1940 until 2023. However, in last four decades, the government debt-to-GDP reached an all time high of 126.30% of GDP in 2020 and was at a record low value of 31.80% of GDP in 1981 (Figure 1). Moreover, 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 other 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. In our analysis we focus on the dynamic evolution of the debt in the U.S. and show that the effectiveness of fiscal stimulus depends on the debt-to-GDP level. Alternatively, successful in matching inequality measures and HtM shares, our model could be calibrated to any economy and could be used for comparison of effectiveness of fiscal stimulus across countries heterogeneous in their indebtedness.

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 develop a flexible framework that can be applied to any economy, matching their tax structure as well as household heterogeneity in wealth and HtM status. More specifically, our model contains a rich set of fiscal instruments including consumption, dividend, progressive income taxes, and lump-sum transfers/taxes. Moreover, we 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, i.e., directly through one of the tax instruments at hand or by raising additional debt. 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 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, higher income tax progressivity implies smaller fiscal multipliers when spending is financed with transfers. Moreover, 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.* (2024), 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. Additionally, we show that RANK and TANK models do not predict any relationship between debt-to-GDP and fiscal multipliers. More specifically, for each of two models, fiscal multipliers take the same values, irrespective of the debt-to-GDP level.

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

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

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.* (2024), 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.* (2024) incorporate two-asset structure. However, Bayer *et al.* (2023) consider a single tax instrument with a flat tax rate. Similarly, the government in Auclert *et al.* (2024) 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. Using the Eurosystem Household Finance and Consumption Survey, we document heterogeneity in HtM status and household asset holdings in liquid and illiquid accounts for a set of European countries as well as heterogeneity in inequality measures[2].

2. The analysis details additional results, and variable definitions are in Appendix A.

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 show that plays a role in explaining aggregate responses to a shock in government spending. Figure 2 shows HtM, pHtM, and

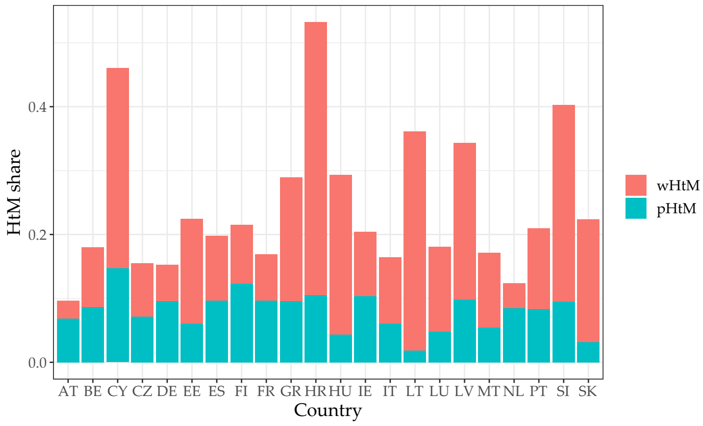

Figure 2: wHtM and pHtM shares (Kaplan *et al.* (2014) definition) for a set of European countries
Source: Eurosystem Household Finance and Consumption Survey, wave 4.

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%). Using the Survey of Consumer Finances, equivalent of HFCS for the U.S. economy, Kaplan and Violante (2022) estimate that in the U.S., share of pHtM and wHtM households is 14% and 27%, respectively. In this study, we abstract from analyzing sources of this heterogeneity. However, this difference highlights the importance of developing a flexible model that successfully matches HtM shares for plausible quantitative implications

Figure A.3 in Appendix A documents heterogeneity in net liquid asset-to-income ratio across European countries. Moreover, Figure A.3 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 A.3 in Section A of the Appendix). Additionally, in Appendix A, we document large heterogeneity in shares of net liquid and illiquid wealth held by bottom 50% and top 10% of households. For example, in the Czech Republic, share of illiquid wealth held by top 10% is around 40%, around 60% in Denmark, and slightly above 50% in Portugal. Difference in wealth inequality is observable also when measured by the Gini coefficient for both liquid and illiquid wealth. When we take a look at all European economies in the sample, on average, the share of illiquid assets held by top 10% of households is around 50%. In contrast, Kaplan *et al.* (2018) calculate this share to be around 70% for the U.S. economy. In addition, the Gini coefficient for illiquid assets, for European economies, is around 0.7, whereas it is 0.81 in the U.S. (Kaplan *et al.* 2018).

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. Even though in our quantitative analysis we focus on the U.S. economy, we build a flexible model that can be calibrated to any economy allowing application of our model on different economies and comparing effectiveness of fiscal stimulus across countries.

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 wage income and choose between consuming and saving in two types of assets. Agents in the economy can save in liquid asset 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 packers 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 monetary 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

$$\begin{aligned} &\max_{\{c_{i,t},b_{i,t},a_{i,t},n_{i,t}\}} \mathbb{E}\sum_{t=0}^{\infty}\beta_i^t\Big[u(c_{i,t})-v(n_{i,t})\Big] \\ &\qquad\qquad \text{such that} \\ &c_{i,t}(1+\tau_t^c)+a_{i,t}+b_{i,t}=z_{i,t}+(1+r_{t-1}^a)a_{i,t-1}+(1+r_{t-1}^b)b_{i,t-1}- \\ &\qquad\qquad -\Psi(a_{i,t},a_{i,t-1}) \\ &a_{i,t}\geq \underline{a},\quad b_{i,t}\geq \underline{b}, \end{aligned} \tag{1}$$

where $z_{i,t}=\tau_t(w_t n_{i,t} e_{i,t})^{1-\theta}+T_{i,t}$ is after-tax labor income[3]. 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 $v(n_{i,t})=\gamma n_{i,t}^{1+\frac{1}{\varphi}}$, and $u(c_{i,t})=\frac{c_{i,t}^{1-\sigma}}{1-\sigma}$ to specify 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 illiquid 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. It performs liquidity transformation at proportional cost $\omega\int b_{i,t}di$.

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

Financial intermediaries are managing households' accounts, i.e., their liquid and illiquid portfolio. Households supply financial intermediaries with their asset, and financial intermediaries invest these assets in equity shares and real government bonds in their name. We assume that households' liquid portfolio is invested entirely in government bonds, that promises delivering the real interest rate r^b_{t+1} in period $t+1$, and thus $v^l_{i,t}=0$, i.e., equity share is zero. More generally, for each household i, we can write account as:

$$b^l_{i,t} - (1+r^b_{t-1})b^l_{i,t-1} = \omega b^l_{i,t-1} + d^l_{i,t}, \tag{3}$$

where $b^l_{i,t-1}$ is the bond position, and ω is the liquidity transformation fee.

On the other hand, liquid portfolio is invested in two types of assets: government bonds, which promise delivering the real interest rate r^a_{t+1} in period $t+1$, and firm shares with price p_t and net dividends d_t at time t. Denoting share holdings with $v^{il}_{i,t}$, we can write individual account as:

$$p_t v^{il}_{i,t} + b^{il}_{i,t} - (p_t+d_t)v^{il}_{i,t-1} - (1+r^a_{t-1})b^{il}_{i,t-1} = d^{il}_{i,t}. \tag{4}$$

Now, due to the no arbitrage condition, we have

$$p_t + d_t = (1+r^a_{t-1})p_{t-1}. \tag{5}$$

Consolidating illiquid asset holdings into an overall illiquid asset position, and no arbitrage condition (5) imply

$$a^{il}_{i,t} - (1+r^a_{t-1})a^{il}_{i,t-1} = d^{il}_{i,t}. \tag{6}$$

Let $F_t(A^{il}_{t-1}, B^l_{t-1})$ be the maximum attainable value for the financial intermediary with aggregate illiquid asset holdings $A^{il}_{t-1} = \int a^{il}_{i,t-1}di$ and liquid asset holdings $B^l_{t-1} = \int b^l_{i,t-1}di$,:

$$F_t(A^{il}_{t-1}, B^l_{t-1}) = \max_{A^{il}_t, B^l_t} \Big\{ A^{il}_t - (1+r^a_{t-1})A^{il}_{t-1} + B^l_t - (1+r^b_{t-1}+\omega)B^l_{t-1} + \\ + \frac{1}{1+r_t}F_{t+1}(A^{il}_t, B^l_t) \Big\}.$$

First order conditions and the Envelope Theorem, imply optimal decision for financial intermediaries that yields

$$\mathbb{E}_t[1+r_t] = \mathbb{E}_t[1+r^a_t] = \mathbb{E}_t[1+r^b_t] + \omega.$$

In summary, no arbitrage requires that the ex-ante return $\mathbb{E}_t = [1+r_t]$ 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:

$$\mathbb{E}_t[1+r_t] = \frac{1+i_t}{\mathbb{E}_t[1+\pi_t]} = \frac{\mathbb{E}_t[d_{t+1}+p_{t+1}]}{p_t} = \mathbb{E}_t[1+r^a_t] = \mathbb{E}_t[1+r^b_t] + \omega,$$

where $d_t = \widetilde{d}_t(1-\tau^k_t)$, are after tax dividends.

3.2.1. Ex-post Returns. In this section, we concentrate on the ex-post returns that are subject to surprise inflation and capital gains. Since we assume that capital gains accrue to the illiquid account, we have

$$1 + r_{t-1} = \frac{1 + i_{t-1}}{1 + \pi_t} = 1 + r^b_{t-1} + \omega. \tag{7}$$

Next, let $\Theta_{p,t-1} = \frac{p_{t-1} v^i_{i,t-1} l}{a^{il}_{i,t-1}}$ denotes the fraction of individual illiquid portfolio held in equity, then from equations (4) and (6) follows that:

$$a^{il}_{i,t} - \left[\left(\frac{p_t + d_t}{p_{t-1}} \right) \Theta_{p,t-1} + (1 + r_{t-1})(1 - \Theta_{p,t-1}) \right] a^{il}_{i,t-1} = d^{il}_{i,t}. \tag{8}$$

and

$$1 + r^a_{t-1} = \Theta_p \left(\frac{d_t + p_t}{p_{t-1}} \right) + (1 - \Theta_p)(1 + r_{t-1}) \tag{9}$$

where Θ_p denotes the share of equity in the illiquid portfolio. Note, since there a unit mass of shares outstanding in the economy, market clearing condition for shares in period $t-1$ implies that $\int \Theta_{p,t-1} a^{il}_{i,t} di = p_{t-1} \int v^{il}_{i,t} di = p_{t-1}$.

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,

$$J^U_t = \max_{W_{k,t}} \int \left(u(c_{i,t+t'}) - v(n_{i,t+t'}) \right) d\Psi_{i,t+t'} - \frac{\psi}{2} \left(\frac{W_{k,t+t'}}{W_{k,t+t'-1}} - 1 \right)^2 + \\ + \frac{1}{1 + r_t} J^U_{t+1} \tag{10}$$

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

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

is the price index for aggregate employment services. Solving the unions' problem (see Appendix for derivations) implies wage NKPC

$$(1 + \pi^w_t)\pi^w_t = \kappa^w \left(\gamma N_t^{1+\frac{1}{\varphi}} - \frac{(1-\theta)}{(1+\tau^c_t)\mu^w} Z_t u'(\tilde{C}_t) \right) + \beta(1 + \pi^w_{t+1})\pi^w_{t+1}. \tag{11}$$

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 after-tax income (net of transfers), that is $Z_t = \int \tau_t (w_t n_{i,t} e_{i,t})^{1-\theta} d_i$.

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 in capital 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 $\varphi\left(\frac{k_t}{k_{t-1}}\right) = \frac{1}{2\delta\varepsilon_I}\left(\frac{k_t}{k_{t-1}} - 1\right)^2$, 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:

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

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

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

and

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

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

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

3.5. Monetary and Fiscal Policy

The monetary authority now follows a Taylor rule:

$$i_t = r + \varphi^{\pi} \pi_t.$$

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 $R_t = w_t N_T - Z_t$, where Z_t is 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

$$B_t^g + \tau_t^c C_t + R_t + \tau_t^k \widetilde{d}_t = (1 + r_{t-1}) B_{t-1}^g + G_t + T_t. \tag{12}$$

In addition to household heterogeneity described in equation (1), government problem and equation (12) 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 (12) 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 (R_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

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

where B_t^l are liquid assets held by financial intermediaries and $\int_i b_{i,t} di$ are aggregate household's liquid asset supply. Second, there is a unit mass of shares outstanding in the economy $\int v_{i,t}^{il} di = 1$, and illiquid asset market clears

$$\int a_{i,t} di = A_t^{il}.$$

Next, household total wealth equals all assets in the economy, i.e., government bonds and equity

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

where B_t^{il} are bond holdings in financial intermediary's illiquid account. Now, from the market clearing conditions we also derive financial intermediaries portfolio share. More specifically, from market clearing conditions above, it follows that

$$A_t^{il} + B_t^l = p_t + B_t^g,$$

and thus

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

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

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

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 $\{n_{i,t}; c_{i,t}; b_{i,t}; a_{i,t}; `k_t; A_t^{il}; B_t^l\}_{t=0}^{\infty}$ 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 profits 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). For the income process, we use ρ_e, autocorrelation of earnings and σ_e, cross-sectional s.d. of log earnings estimated by Floden and Lindé (2001) and Song *et al.* (2019), respectively. We use income process with 13 states.

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.* (2024)
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 $\gamma = 1.099$, disutility of labor parameter to hit wage Phillips curve given a target for employment $N = 1$. Next, we set $\beta_1 = 0.958$ 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 11.219 to satisfy the liquid asset market clearing condition. Further, we set $B = 1.04$, to hit liquid assets-to-output ratio of $B/Y = 26\%$ (Kaplan *et al.* 2018). Lastly, the goods market clears by Walras's law.

Technology parameters: We set $\mu^w = 1.1$, for us to get a steady state wage markup of 10%. 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 $K/Y = 2.565$ (Hagedorn *et al.* 2019). 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% consumption tax[4]. 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

	Moment	Model	Data	Source
Liquid Assets	top 10% share	67.91	86	Kaplan *et al.* (2018)
	next 40% share	31.96	18	
	bottom 50% share	0.13	-4	
	Gini coefficient	0.82	0.98	
Illiquid Assets	top 10% share	50.79	70	Kaplan *et al.* (2018)
	next 40% share	58.93	27	
	bottom 50% share	0.28	3	
	Gini coefficient	0.75	0.81	
HtM	HtM	44.6%	41%	Kaplan and Violante (2022)
	$wHtM$	20.6%	27%	
	$pHtM^*$	14%	14%	

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

Quarterly MPC is 14.20%, that is 45.8% 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.

4. The United States does not have standard VAT system as, for example, majority of European economies. Thus we use target of 8% that approximates the average combined state and local sales tax rate in the United States. Source: https://taxfoundation.org/.

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 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. Second, to analyze the effect of financing government spending with the deficit, we assume that transfers are chosen such that they satisfy the following fiscal policy rule

$$T_t - T_{ss} = -\varphi_B * (B_t^g - B_{ss}^g) \tag{13}$$

and we set $\varphi_B = 0.1$. 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

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

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.

In further sections, 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 $\frac{\sum_t (1+r)^{-t} dY_t}{\sum_t (1+r)^{-t} dG_t}$. In addition, we use the same formula, and calculate 1-year, 3-year, and 5-year fiscal multipliers.

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

To analyze fiscal multipliers dependent on the source of financing, we compare the case when government spending is financed directly from taxes (or transfers) to the case when spending is financed from an increase in government debt. Therefore, we use the fiscal policy rules specified above.[5] When spending is financed with an

5. Mechanically, when the government spending is financed directly, fiscal rule (13) is shut down. As depicted in Figure 3, government debt is at its steady state level. In case of financing with raising additional debt, fiscal rule (13), together with government budget constraint (12) govern movement in government debt as depicted in Figure 4.

increase in debt, we compare cases when the excess of government spending is financed by raising taxes or reducing government transfers.

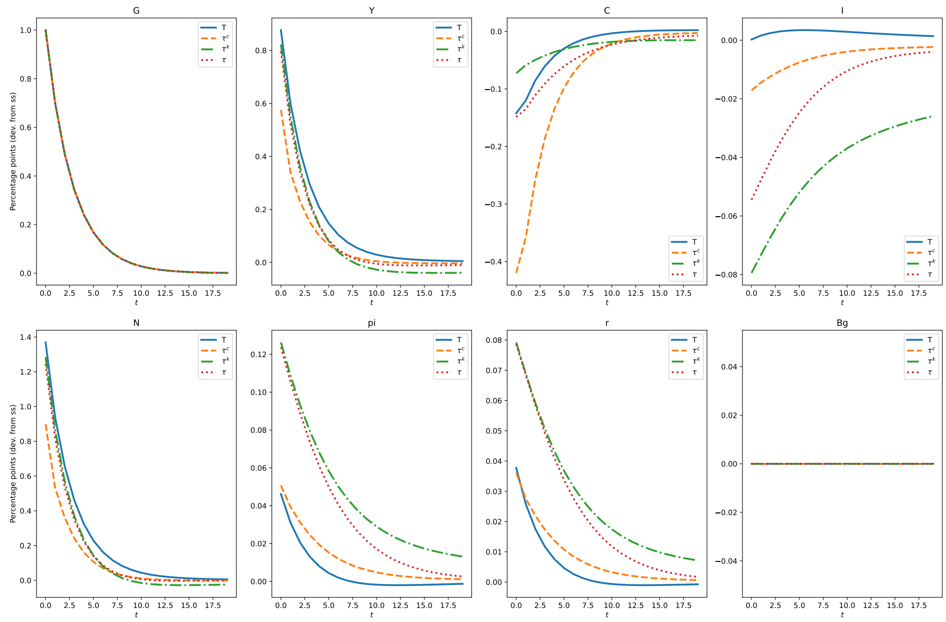

Figure 3: Impulse response functions corresponding to a 1% increase in government spending financed directly from government transfers or from consumption, dividend, and income taxes. Variables are: G-government spending, Y-output, C-aggregate consumption, I-firms' capital investment, N-aggregate labor, pi-inflation, r-interest rate, Bg-government debt. Estimates based on a simulated HANK model, calibrated using values from Table 1.

Figure 3 presents aggregate responses of the economy in four cases, that is, when government spending is directly financed with transfers, consumption taxes, dividend taxes, and changes in the income tax level. In all four cases, consumption is completely crowded out with investment incentives, 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 (0.91). On the other hand, financing government spending with an increase in consumption taxes produces the lowest impact multiplier (0.51). On impact, financing with dividend and income taxes is more effective[6] than with consumption tax, however, at the cost of much higher inflation. Moreover, we see that financing expenditure with consumption tax distorts the most consumption response, compared to other financing options.

Figure 4 presents aggregate responses in case of government spending being financed by raising debt. In this case, one of the tax instruments is used to repay

6. We measure effectiveness with the size of the fiscal multiplier.

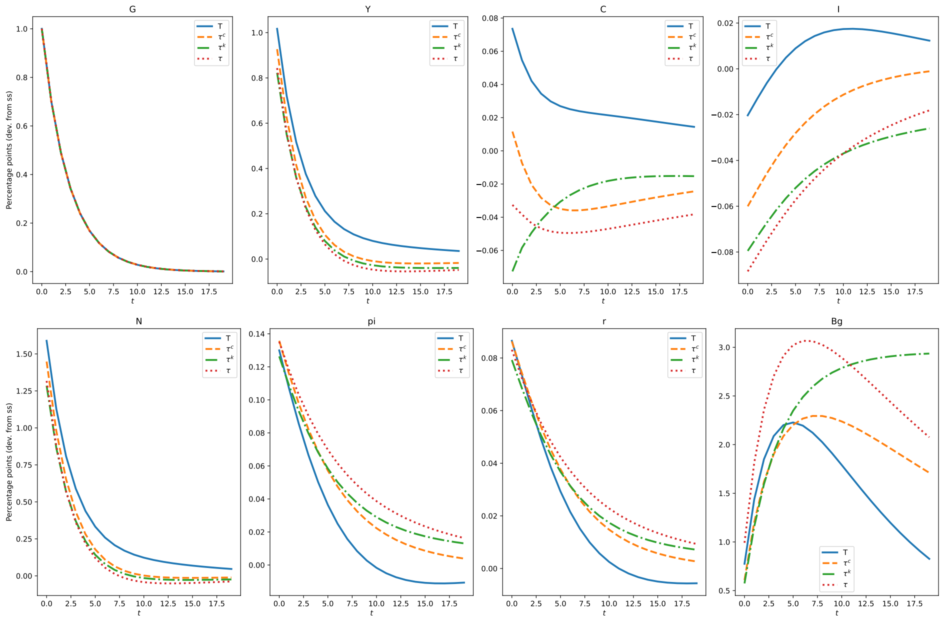

Figure 4: Impulse response functions corresponding to a 1% increase in government spending financed with debt and from government transfers or from consumption, dividend, and income taxes. Variables are: G-government spending, Y-output, C-aggregate consumption, I-firms' capital investment, N-aggregate labor, pi-inflation, r-interest rate, Bg-government debt. Estimates based on a simulated HANK model, calibrated using values from Table 1.

the debt and return it to its steady state value. Figure 4 shows that both impact and cumulative fiscal multipliers do not change much when using dividend tax. In contrast, using consumption taxes produces an impact fiscal multiplier of 0.93. However, consumption is crowded out with investment incentives, and the output response drops, resulting in a cumulative multiplier of around 0.68. In the case of debt financing with 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. Notably, inflation response is higher than in case of direct financing, independent of the fiscal instrument at hand. However, the pace of inflation returning to its steady state value depends on the fiscal instrument used. Financing deficit with transfers implies the least persistent inflation response, when compared to financing deficit with other fiscal instruments.

Table 3 summarizes all cases' impact and cumulative fiscal multipliers. Moreover, Table 3 shows the dynamics of the cumulative effect of government stimulus depending on the source of financing. More superficially, the results from the table show that only financing the fiscal stimulus with debt and lump-sum transfers has positive cumulative effect, i.e., the effect is larger after a one, three and five years after the policy. In turn, when the government stimulus is financed with debt and other sources of financing, we see the opposite effect, i.e., the cumulative effects after one, three, and five years are decreasing. In addition, we can see a similar dynamic pattern in case of direct financing with one of the four tax instruments, without running additional deficit/raising the level of debt.

	Tax instrument	Impact multiplier	Cumulative multiplier			
			1-year	3-year	5-year	∞
Direct financing	T	0.88	0.87	0.87	0.88	0.91
	τ^c	0.58	0.51	0.48	0.47	0.43
	τ^k	0.82	0.77	0.66	0.57	0.10
	τ	0.80	0.74	0.66	0.63	0.54
Debt financing	T	1.02	1.04	1.14	1.22	1.34
	τ^c	0.93	0.88	0.80	0.75	0.68
	τ^k	0.82	0.77	0.66	0.57	0.08
	τ	0.84	0.78	0.63	0.51	0.26

Table 3. Cumulative and impact fiscal multipliers depending on the source of financing of government spending. Values based on IRFs from Figures 3 and 4 using our HANK model calibrated with values from Table 1. Note, cumulative fiscal multiplier in ∞ is approximated with 300 quarters.

Further, Figure 4 shows financing government expenditure with debt that is in turn repaid with lump-sum taxes implies dampened inflation response when compared to other ways of financing. Lastly, Figure 4 shows that financing with transfers requires lowest accumulation of debt when compared to other sources of financing debt. More specifically, the debt raised to finance the government expenditure does not build up as much as with other sources of financing and it is repaid/returns sooner to its steady state value.

Additionally, following Auclert *et al.* (2024), we consider a third case where the debt path is imposed. More specifically, we assume that the government debt satisfies the following rule of motion

$$dB^g_t = \rho^B(dB^g_{t-1} + dG_t), \tag{14}$$

with $\rho^B = 0.9$. ρ^B in equation (14) is the persistence of debt, and a balanced-budget rule, i.e., direct financing, corresponds to the case when $\rho^B = 0$. Rule of motion (14) assumes that additional increase in spending relative to steady state level of spending (dB^g_t), is initially financed using an increase in government debt $(dG_t))$, which is then repaid at a rate of $1 - \rho^B$ each period. Given the rule of motion for the government debt (14) the government chooses one of four tax instruments (consumption,dividend,income tax level, or transfers) such that the government budget constraint (12) is satisfied in every period.

Notably, Figure 5 implies same response of the government debt across sources of financing of the government spending financed with debt and different fiscal instruments. However, other responses are consistent with results using the fiscal rule that governs movement in tax instrument corresponding proportionally to movement in the level of the government debt. Moreover, fiscal multiplier on impact and dynamic patterns in cumulative fiscal multipliers in Table 4 are consistent with those from Table 3.

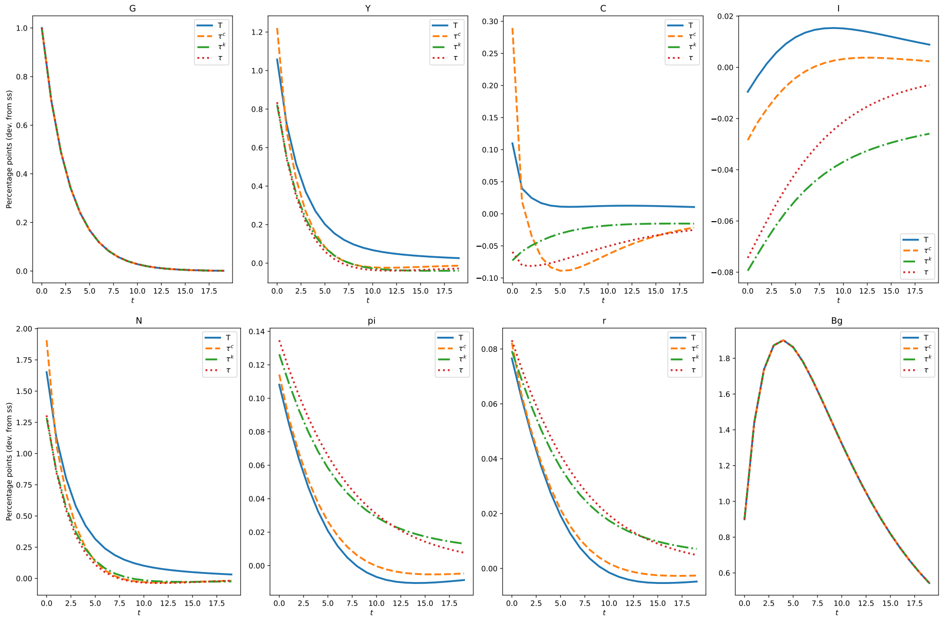

Figure 5: Impulse response functions corresponding to a 1% increase in government spending financed with debt and from government transfers or from consumption, dividend, and income taxes. Variables are: G-government spending, Y-output, C-aggregate consumption, I-firms' capital investment, N-aggregate labor, pi-inflation, r-interest rate, Bg-government debt. Estimates based on a simulated HANK model, calibrated using values from Table 1.

	Tax instrument	Impact multiplier	Cumulative multiplier			
			1-year	3-year	5-year	∞
Debt financing	T	0.98	1.05	1.12	1.19	1.28
	τ^c	0.89	1.03	0.87	0.82	0.77
	τ^k	0.82	0.77	0.66	0.57	0.10
	τ	0.82	0.76	0.62	0.54	0.40

Table 4. Cumulative and impact fiscal multipliers depending on the source of financing of government spending. Values based on IRFs from Figures 3 and 4 using our HANK model calibrated with values from Table 1. Note, cumulative fiscal multiplier in ∞ is approximated with 300 quarters.

4.2. 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.

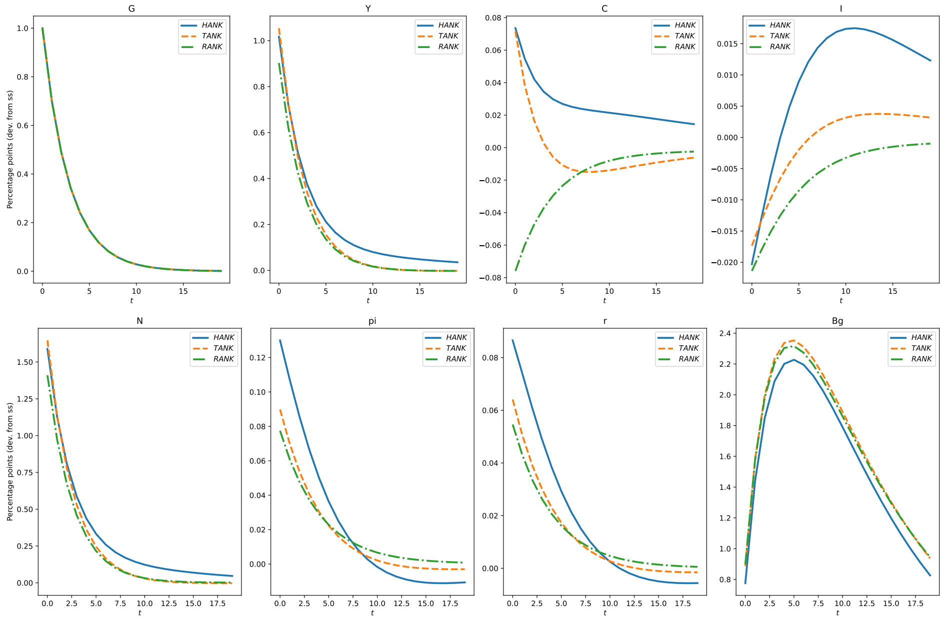

Figure 6: Impulse response functions corresponding to 1% increase in government spending financed with government debt and transfers across representative, two-agents, and heterogeneous agents models. Variables are: G-government spending, Y-output, C-aggregate consumption, I-firms' capital investment, N-aggregate labor, pi-inflation, r-interest rate, Bg-government debt.

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.* 2024; 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 6 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

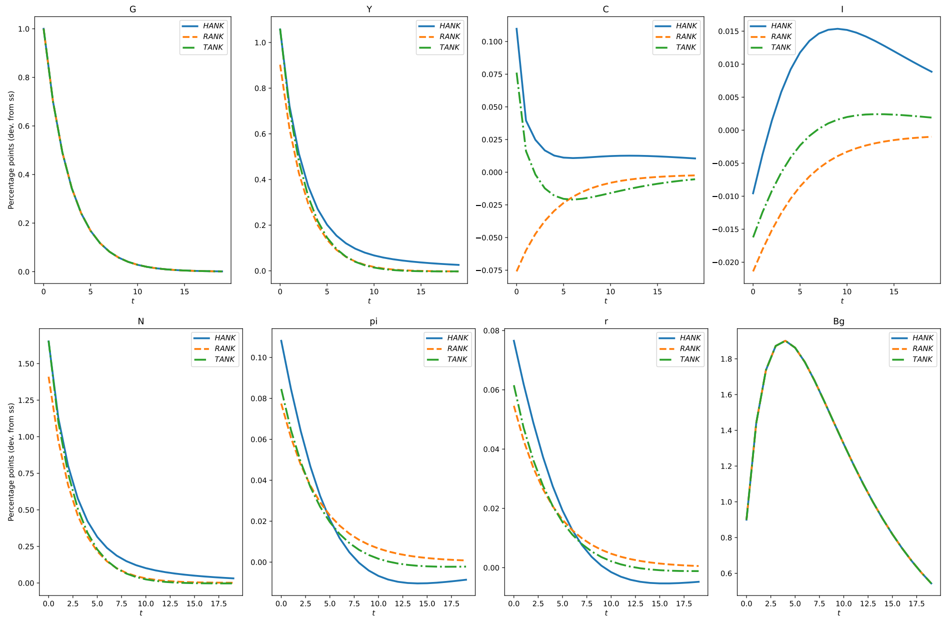

Figure 7: Impulse response functions corresponding to 1% increase in government spending financed with government debt and transfers across representative, two-agents, and heterogeneous agents models.

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. Further, Figure 6 shows that the HANK model predicts larger initial responses of the interest rate and inflation. RANK and TANK models lack anticipation and propagation effects effects(Hagedorn *et al.* 2019; Auclert *et al.* 2024) and are unable to match heterogeneous MPCs. More specifically, in RANK models, there are no HtM agents, and in TANK models, the number is fixed over time and governed by one parameter. Auclert *et al.* (2024) show that two-asset HANK model match intertemporal MPCs and thus produce aggregate patterns observed in the data.

Additionally, as a sensitivity analysis , we check if the results hold using the fiscal policy rule similar to the one used by Auclert *et al.* (2024). More specifically, we assume that the government debt satisfies the following rule of motion (14). Figure 7 presents comparison across models using the alternative fiscal rule and shows that the results hold irrelevant of the fiscal policy rule.

4.3. Decomposition of Aggregate Consumption and Asset Responses

As Figure 6 highlights, the HANK model is the only one able to produce fiscal multipliers larger than one in addition to positive consumption multipliers. Thus, in further analysis we focus on the decomposition of the aggregate effects for our HANK model. To explain the consumption response more intuitively, Figure 8 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 capital gains. We use this decomposition further to explain and highlight two dimensions of heterogeneity important for differential consumption responses.

Figure 9 decomposes the aggregate consumption response on the response of households' consumption from the bottom 50% and top 10% parts of the wealth distribution. Results suggest that positive consumption is initially driven by households from the middle to upper part of the wealth distribution. They respond to positive income incentives (Figure 8), and increase their consumption as a response to the transmission of government expenditure. In contrast, Figure 9 shows that the response of the households from the bottom 50% of the wealth distribution are responding to lower incentives due to the decrease in government transfers, and decrease their consumption response.

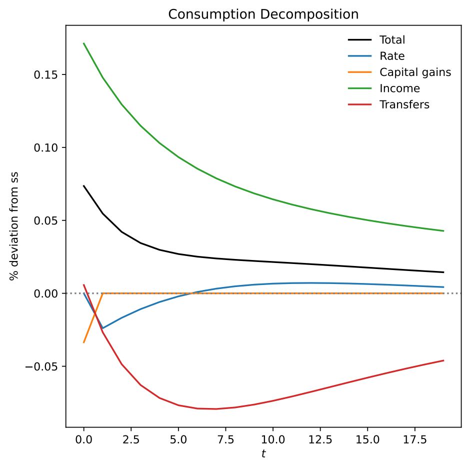

Figure 8: Aggregate consumption responses decomposition. Consumption impulse response function corresponds to a 1% increase in government spending financed with debt and from government transfers or from consumption, dividend, and income taxes. Estimates based on a simulated HANK model, calibrated using values from Table 1, using the debt-fiscal policy rule as in Figure 5.

The results for both households with bottom 50% and next 40% wealth share hold regardless of the source of the financing of the government spending and increase in government debt. Households from the top 10% of the wealth distribution are the only ones who do not respond to income and tax incentives, and their response is driven by financial investment incentives, that is capital gains' and interest rate's responses to the fiscal stimulus. Thus, median to higher wealth households drive an initial positive consumption response due to an increase in labor income. However, the effect is then crowded out. In contrast, wealthy households respond with a small decrease in consumption and turn to investments in assets.

Consequently, when investment incentives dampen, they drive prolonged positive responses in aggregate consumption (in case of financing with transfers).

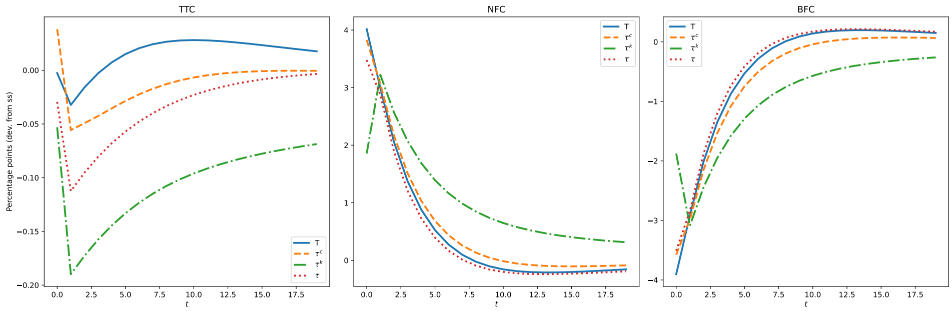

Figure 9: Consumption decomposition based on households' wealth. Consumption impulse response function corresponds to a 1% increase in government spending financed with debt and from government transfers or from consumption, dividend, and income taxes. From left to right, panels show consumption responses of households from the top 10% (TT), next 40% (NF), and bottom 50% (BF) of the wealth distribution. Estimates based on a simulated HANK model, calibrated using values from Table 1, , using the debt-fiscal policy rule as in Figure 5.

In case of financing with debt that is in turn finances with other tax instruments than transfers, Figure 4 shows lower labor response and higher interest rate response to the fiscal stimulus. Combined, these two effects, taking into consideration our decomposition of incentives, imply lower income incentives and stronger investment incentives. Thus, in case of financing the government spending with other sources than transfers, we see lower consumption response (Figure 9), for the households from the top 10% of the wealth distribution. Additionally, Figure 9 shows amplification of responses in the lower part of the wealth distribution. These effects in total contribute to negative response of consumption to the government spending shock financed with debt and income taxes, dividend taxes, and consumption taxes, and contribute to lower fiscal multipliers.

The second important dimension is to see how HtM status affects households' consumption decisions. Figure 10 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, reduce consumption due to disincentive coming from lower transfers. In contrast, non-HtM households, comprised of households from the middle and top of the wealth distribution, are not affected that much by constrained assets and increase their consumption throughout the period of government spending, coming from positive income incentive initially, and is followed by interest rate incentives.

Our last decomposition moves from consumption, and turns to wealth and inequality. Figure 11 compares the Gini coefficient corresponding to government spending financed with debt and one of the four previously mentioned fiscal instruments. In addition, Figure 11 compares average wealth responses of households from bottom 50% of the wealth distribution and one of the households

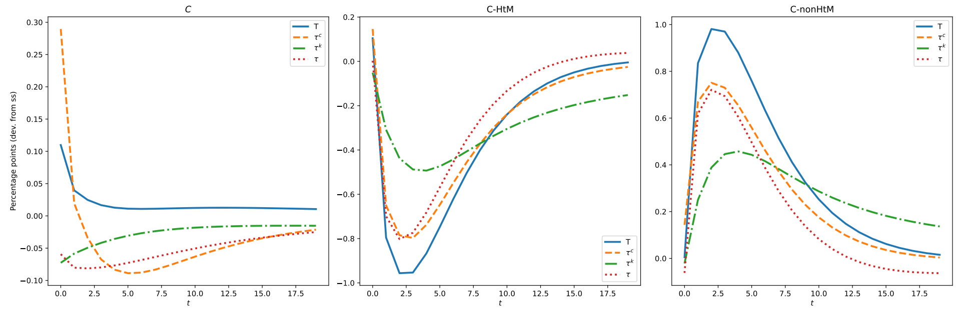

Figure 10: Consumption decomposition based on households' HtM status. Consumption impulse response function corresponds to a 1% increase in government spending financed with debt and from government transfers or from consumption, dividend, and income taxes. From left to right, panels show total consumption response (C), consumption resonse of HtM households (C-HtM), and consumption response of non-HtM (C-nonHtM) households. Estimates based on a simulated HANK model, calibrated using values from Table 1, using the debt-fiscal policy rule as in Figure 5.

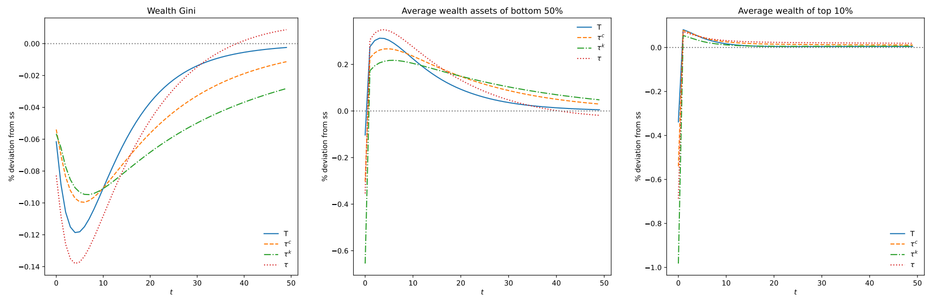

Figure 11: Economy responses corresponding to 1% increase in government spending financed with government debt and from government transfers or from consumption, dividend, and income taxes. Estimates based on a simulated HANK model, calibrated using values from Table 1, using the debt-fiscal policy rule as in Figure 5.

from the top 10% of the wealth distribution. Figure 11 shows that the change in average wealth of top 10% does not differ depending on the source of financing of the government spending. However, figure shows that bottom 50% respond by increasing their average asset holdings. They increase them the most in case when the government stimulus is financed with transfers or income taxes. Consequently, the left panel of Figure 11, shows negative impact on inequality measured by the Gini coefficient for total wealth. In addition, Figure 11 shows the largest impact on inequality in case of financing debt with income tax or transfers.

4.4. Debt Level and Income Tax Progressivity

In this section, we analyze how the effectiveness of the fiscal policy (measured by the size of the fiscal multiplier) 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, $\theta \in \{0, 0.05, 0.1, 0.18\}$.

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 by reducing transfers. Figure 12 compares cumulative fiscal multipliers in the case of deficit financing with transfers for economies with different income tax progressivity and debt-to-GDP levels. Impact fiscal multipliers are the same across all calibrations, at the level of the baseline economy. Even though we use $\theta = 0.181$ Heathcote *et al.* (2017) 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 12 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%.

The shape of the effectiveness of fiscal stimulus in Figure 12 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 assets investment incentives. In contrast, there is no crowding out of consumption in a high debt-to-GDP economy due to lower assets 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. Figures E.1 and E.2 of Appendix E compare aggregate response as

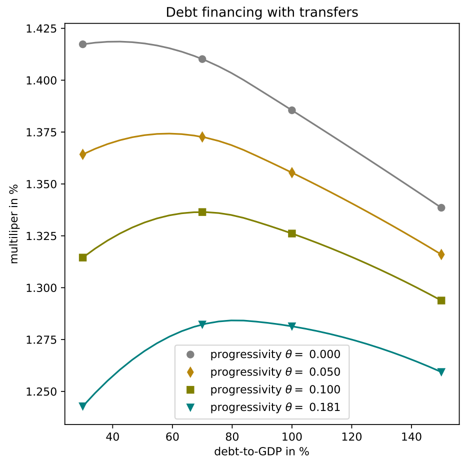

Figure 12: Cumulative fiscal multipliers in case of deficit financing with transfers for economies with different income tax progressivity and debt-to-GDP levels.

well as decomposition of the consumption response in case of low- and high-debt economy, and low progressivity relative to our baseline economy.

4.5. Dynamic Perspective - U.S. from 1980-2020

Figure 12 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 12 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 8 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 sizably by increasing the debt-to-GDP level.

Taking the motivating Figure 1 as an example, SS_L can represent U.S. economy in 1990s with debt-to-GDP level of around 60%. In contrast, SS_H can represent the U.S. economy in 2020s with debt-to-GDP level of over 120%. Going further, with possible additional accumulation of the government debt as percentage of GDP, the effectiveness of the fiscal policy could be limited.

4.6. 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. Figure 13 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 13, 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. Additionally, shaded areas in the figure highlight the finding from the previous section on dynamic decrease of the effect, i.e., impact multiplier is the highest, and one, three, and five year effects are dampened.

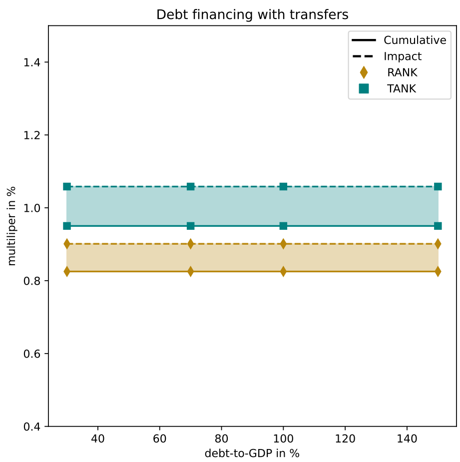

Figure 13: Impact and cumulative fiscal multipliers in case of deficit financing with transfers in TANK, and RANK models. Increase in debt-to-GDP compensated by income tax level.

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 government spending (the long-term impact of deficit transfer financing (Figure 12).

5. 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.* 2024; 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. Our model suggests limited effectiveness for highly indebted economies, with possible future implications for the U.S. economy with debt-to-GDP level of over 120%. Finally, our findings on heterogeneous effectiveness of fiscal stimulus depending on the source of financing as well as on the debt-to-GDP level and income tax progressivity together with documented heterogeneity across countries motivate further application of our model on different economies and comparing effectiveness of fiscal stimulus across countries.

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Appendix 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 $\geq$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 $\leq$ 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 A.1 shows heterogeneity is shares of HtM, wHtM, and pHtM households accross countries. The majority of countries have HtM share lower than 41%, which

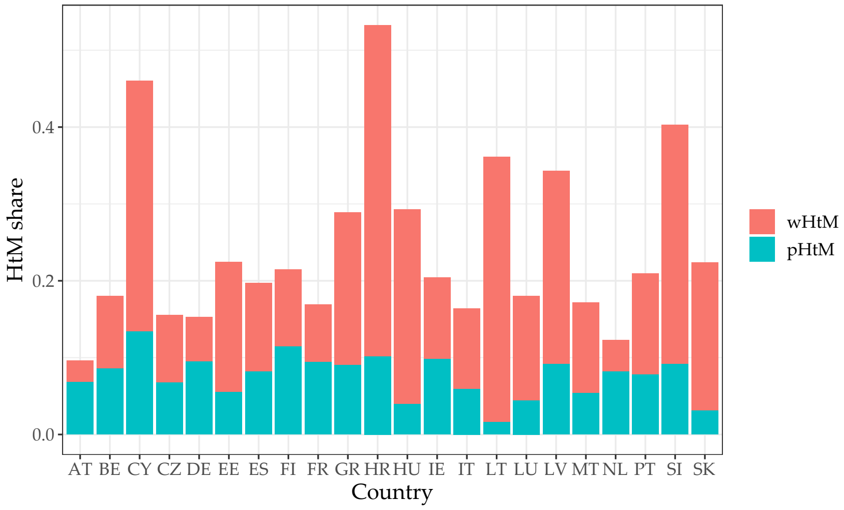
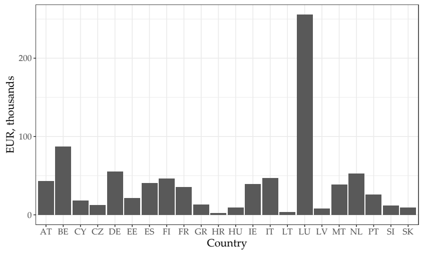


Figure A.1: wHtM and pHtM shares for a set of European countries; Slacalek *et al.* (2020) definition. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

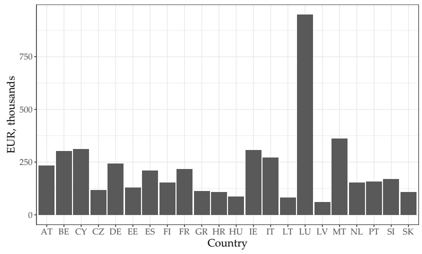
is the share of HtM households in the U.S. (Kaplan and Violante 2022). The figure also shows heterogeneity across countries in both wHtM and pHtM shares.

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 A.1. 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.



(a) Absolute net liquid asset holdings.

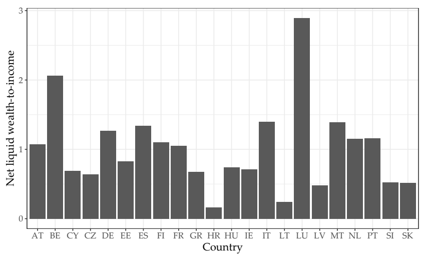


(b) Absolute net illiquid asset holdings.

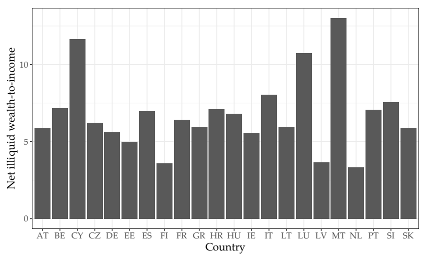
Figure A.2: Absolute net liquid (a) and illiquid (b) asset holdings for a set of European countries in thousands of EUR. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

Bar plots in Figures A.2 show net liquid and illiquid asset holdings in absolute terms, i.e., in thousands of EUR.

Bar plots in Figures A.3 show net liquid and illiquid asset-to-income ratios heterogeneity for set of European economies.



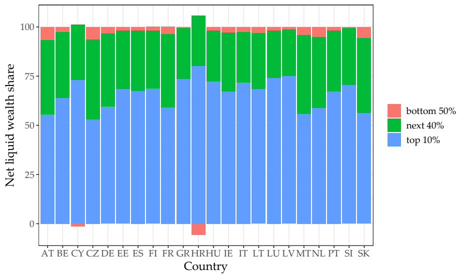
(a) Net liquid wealth to income.



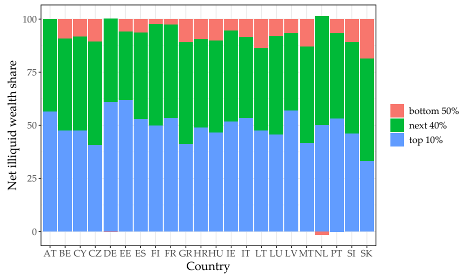
(b) Net illiquid wealth to income.

Figure A.3: Net liquid (a) and illiquid (b) wealth to income ratio for a set of European countries Source: Eurosystem Household Finance and Consumption Survey, wave 4.

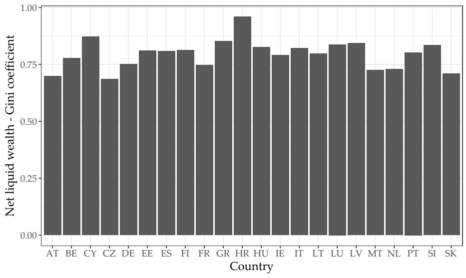
Table A.1 documents shares of HtM, wHtM, and pHtM households across countries as well as net liquid and illiquid asset positions depicted in Figures 2,A.2, and A.1.



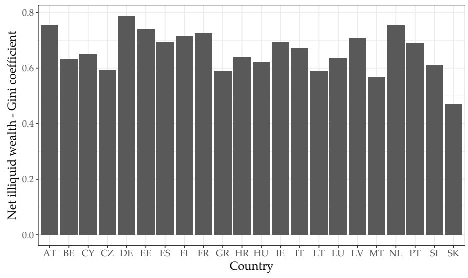
(a) Net liquid shares



(b) Net illiquid shares



(c) Net liquid wealth Gini.



(d) Net illiquid wealth Gini.

Figure A.4: Bottom 50%, next 40% and top 10% shares of net liquid (a) and net illiquid wealth (b) for a set of European countries. In addition, we calculate Gini coefficients of net liquid (c) and net illiquid (d) wealth for a set of Europen Countries. Source: Eurosystem Household Finance and Consumption Survey, wave 4.

Appendix B: Household problem description

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

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

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

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

Lastly, the envelope conditions are

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

and

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

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).

Appendix 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 $\frac{\partial c_{i,t}}{\partial W_{k,t}} = \frac{1}{1+\tau^c_t}\frac{\partial z_{i,t}}{\partial W_{k,t}}$. Using the expression derived above, and exploiting the fact that in equilibrium $W_{k,t} = W_t$ we get that

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

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

$$\frac{\partial n_{i,t}}{\partial W_{k,t}} = -\varepsilon \frac{N_{k,t}}{W_{k,t}}. \tag{C.2}$$

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

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

Further, we plug in for expressions (C.1) and (C.2):

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

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

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

where Z_t is aggregate after-tax income (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

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

Appendix D: Derivation of the nonlinear price NKPC

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

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

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

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

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

$$\frac{W_t}{P_t}\frac{1}{F_{n,t}(k_{t-1},n_t)} = mc_t = 1 - \lambda_t\left(\frac{\mu_p - 1}{\mu_p}\right). \tag{D.2}$$

Condition (D.2) 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:

$$\begin{aligned} 0 = \frac{1}{P_t}F(k_{t-1},n_t) - \frac{1}{\kappa^p(\mu^p-1)}\left(\frac{\mathcal{P}_t - \mathcal{P}_{t-1}}{\mathcal{P}_{t-1}}\right)\frac{1}{\mathcal{P}_{t-1}}Y_t + \\ + \frac{1}{1+r_t}J_{p,t+1}(\mathcal{P}_t,k_t) - \lambda_t\frac{Y_t}{P_t}. \end{aligned} \tag{D.3}$$

The envelope condition implies that the following condition holds:

$$J_{p,t}(\mathcal{P}_{t-1},k_{t-1}) = \frac{1}{\kappa^p(\mu^p-1)}\left(\frac{\mathcal{P}_t - \mathcal{P}_{t-1}}{\mathcal{P}_{t-1}}\right)\frac{\mathcal{P}_t}{\mathcal{P}_{t-1}^2}Y_t. \tag{D.4}$$

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 (D.3) with $\mathcal{P}_t$, rolling over one period condition (D.4) and substituting, we get:

$$\begin{aligned} 0 = Y_t - \frac{1}{\kappa^p(\mu^p-1)}\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)\frac{P_t}{P_{t-1}}Y_t + \\ + \frac{1}{1+r_t}\frac{1}{\kappa^p(\mu^p-1)}\left(\frac{P_{t+1} - P_t}{P_t}\right)\frac{P_{t+1}}{P_t}Y_{t+1} - \lambda_t Y_t. \end{aligned} \tag{D.5}$$

Next, we rearrange (D.5), divide by Y_t, and subsititue for $\pi_t = \frac{P_t}{P_{t-1}} - 1$, to get:

$$1 - \lambda_t = \frac{1}{\kappa^p(\mu^p-1)}(\pi_t)(1+\pi_t) - \frac{1}{1+r_t}\frac{1}{\kappa^p(\mu^p-1)}(\pi_{t+1})(1+\pi_{t+1})\frac{Y_{t+1}}{Y_t}. \tag{D.6}$$

Rearranging (D.2)

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

and substituting the last expression to (D.6) yields:

$$
\frac{\mu_p mc_t - 1}{\mu_p - 1} = \frac{1}{\kappa^p(\mu^p - 1)}(\pi_t)(1 + \pi_t) - \frac{1}{1 + r_t} \frac{1}{\kappa^p(\mu^p - 1)}(\pi_{t+1})(1 + \pi_{t+1}) \frac{Y_{t+1}}{Y_t}. \tag{D.7}
$$

Lastly, by multiplying (D.7) with $\kappa^p(\mu^p - 1)$ and rearranging, we get the final expression for our nonlinear price NKPC:

$$
\pi_t(1 + \pi_t) = \kappa^p(\mu_p mc_t - 1) + \frac{1}{1 + r_t} \pi_{t+1}(1 + \pi_{t+1}) \frac{Y_{t+1}}{Y_t}. \tag{D.8}
$$

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

$$
1 + \frac{1}{\delta \varepsilon_I} \left(\frac{k_t}{k_{t-1}} - 1 \right) = \frac{1}{1 + r_t} J_{k,t+1}(\mathcal{P}_t, k_t) \equiv Q_t, \tag{D.9}
$$

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:

$$
\begin{aligned}
J_{k,t}(\mathcal{P}_{t-1}, k_{t-1}) =& \frac{\mathcal{P}_t}{P_t} F_k(k_{t-1}, n_t) + (1 - \delta) - \varphi \left(\frac{k_t}{k_{t-1}} \right) + \\
& + \frac{1}{\delta \varepsilon_I} \left(\frac{k_t}{k_{t-1}} - 1 \right) \frac{k_t}{k_{t-1}} + \\
& + \lambda_t \left(\frac{1 - \mu^p}{\mu^p} \right) \left(\frac{F(k_{t-1}, n_t)}{Y_t} \right)^{\frac{1 - 2\mu^p}{\mu^p}} Y_t F_k(k_{t-1}, n_t) \\
=& mc_t F_k(k_{t-1}, n_t) + (1 - \delta) - \varphi \left(\frac{k_t}{k_{t-1}} \right) + \\
& + \frac{1}{\delta \varepsilon_I} \left(\frac{k_t}{k_{t-1}} - 1 \right) \frac{k_t}{k_{t-1}}.
\end{aligned} \tag{D.10}
$$

We rearrange (D.9) and plug it in from both the left- and right-hand side of (D.10) and get:

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

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:

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

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.

Appendix E: Debt and Income Tax Progressivity

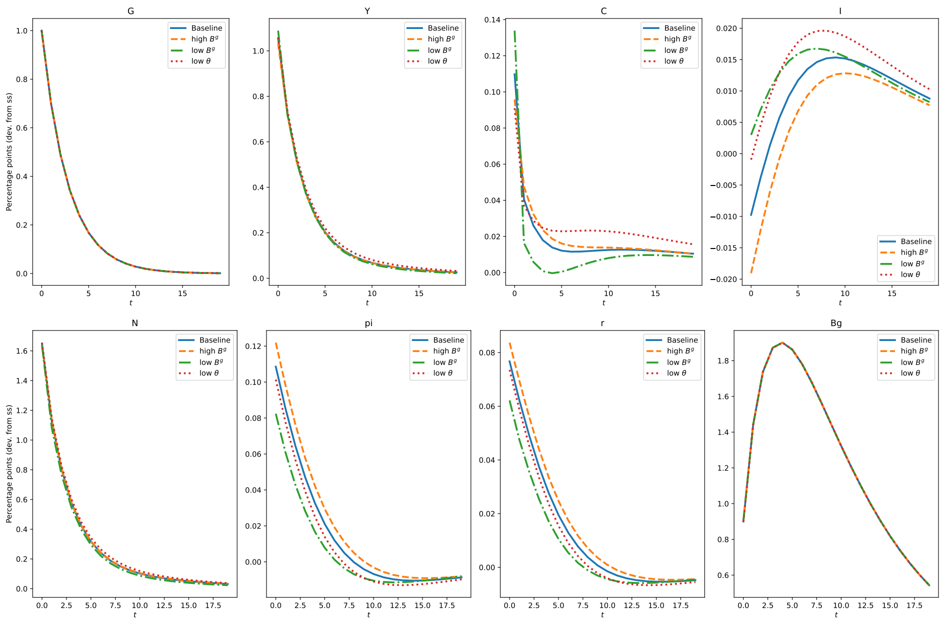


Figure E.1: Impulse response functions corresponding to a 1% increase in government spending financed from deficit and government transfers. Estimates based on a simulated HANK model: Baseline calibrated using values from Table 1, low θ economy has the same parameters with the exception of $\theta = 0.05$, and low- and high-debt economies have 30 and 150% debt-to-GDP level, respectively.

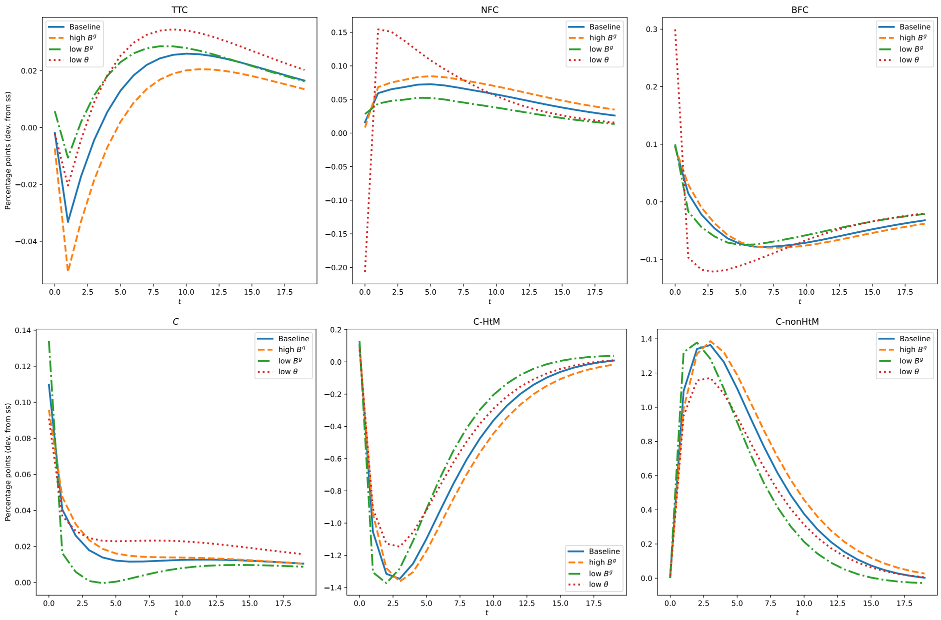


Figure E.2: Impulse response functions corresponding to a 1% increase in government spending financed from deficit and government transfers. Estimates based on a simulated HANK model: Baseline calibrated using values from Table 1, low θ economy has the same parameters with the exception of $\theta = 0.05$, and low- and high-debt economies have 30 and 150% debt-to-GDP level, respectively.

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