How much inflation can fiscal policy create? Separating household heterogeneity and liquid asset supply

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Abstract

Recent Heterogeneous Agent New Keynesian (HANK) models provide for rich monetary-fiscal interactions due to their lack of Ricardian equivalence. Yet, while related frameworks are usually motivated and calibrated relating to household (micro) data, this is insufficient to pin down a key margin of non-equivalence. I show that both in analytically tractable and quantitative 2-asset HANK models, subtle assumptions on asset market structure give rise to disparate implications of fiscal policy: for inflation, model determinacy and fiscal self-financing. This is because household heterogeneity by itself influences but doesn't pin down the liquidity value of public debt. To overcome this issue, I propose a simple model extension and discipline it using relevant macro-level evidence regarding the relationship between public debt and treasury returns. This moderates the inflationary impact of public debt dynamics, but not entirely. After large fiscal shocks, it can still generate persistently elevated "last mile" inflation.

Keywords: Monetary policy, Fiscal Policy, Inflation, HANK

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1 Introduction

In the aftermath of the Covid-19 pandemic as well as the economic shock following Russia's invasion of Ukraine, both public debt levels and inflation have rapidly risen to historic highs in many advanced countries, particularly the USA. Naturally, this has sparked renewed interest in the implications of fiscal policy for inflation and monetary policy. At the same time, the macroeconomics discipline has been rapidly adopting models with rich household heterogeneity, in particular so-called Heterogeneous Agent New Keynesian (HANK) frameworks.

Compared to standard Representative Agent (RA) models, these frameworks substantially increase the scope for fiscal expansions to matter for inflation. With an RA, transfer payments only matter for monetary policy if it is paid for with distortionary taxes or debt that is "unfunded", i.e., not backed by future government revenue. Otherwise, it does not need to affect the conduct of central bank policies. In contrast, HANK models break these implications of Ricardian Equivalence in that they provide for constrained households with a high marginal propensity to consume (MPC) out of transfer payments as well as an explicit usefulness of government debt to insure idiosyncratic risk (see, e.g., Kaplan and Violante, 2018). As detailed in Section 1.1 below, this was found to substantially increase the scope for monetary-fiscal interactions in these frameworks.

In this paper, I argue that one of these key margins of non-equivalence, the explicit usefulness of government liquidity for self-insurance, should be subject to additional discipline for conducting joint analyses of monetary and fiscal policy with common HANK models. The issue is the following: The HA part of these frameworks is typically calibrated so that it generates certain "micro moments", e.g., regarding MPCs or the wealth distribution, for given targets of net household wealth and steady state interest rate(s). This generates an imperfectly elastic demand for liquid assets, which, in turn, makes their supply important. Yet, different commonly used and seemingly reasonable assumptions on the latter can generate disparate aggregate outcomes.

To illustrate this point, I first analyze a Tractable HANK (THANK) model à la Bilbiie (2025) under two different assumptions on the supply of liquid assets. In the baseline case, I assume that the asset market is *segmented* in that public debt constitutes the only net supply of liquid assets, while stocks can only be held as illiquid asset. In a counterfactual, I assume that the asset market is *integrated* in that stocks are also useful to provide liquidity, as e.g. in the two-asset HANK model by Auclert et al. (2024). Either case can generate *identical* micro moments in the model's stationary equilibrium.

Their aggregate implications, however, differ substantially. The baseline model displays the extended scope for monetary-fiscal interactions identified by the recent HANK literature: Following a debt-financed fiscal stimulus, we observe persistently elevated output and particularly inflation. If monetary policy is not too hawkish, the shock can even be self-financing as in Angeletos et al. (2024a), in that this boom automatically generates enough tax revenue to pay for itself without further fiscal adjustments. Furthermore, the

models' determinacy properties deviate from the standard RA case, in that a unique stable equilibrium can be supported by a wider set of policy rules outside the regimes identified by Leeper (1991). Despite initially identical micro-heterogeneity, none of that is the case for the counterfactual with integrated asset markets.

Subsequently, I turn to a quantitative 2-asset HANK model in which, following Kaplan et al. (2018) and Bayer et al. (2024), households' illiquid assets consist of capital. While it may be tempting to ascribe the strong implications of the asset market structure to the relatively simple set-up of the THANK model, one can find equivalents in this substantially richer framework. The reason is that the effect of public debt on the "natural" and "neutral" rates of interest depends crucially on the asset market structure.[1] If government bonds are traded on a liquid asset market that is *segmented* from the ones for other assets, a higher stock of public debt will necessarily result in better insurance of households against idiosyncratic risk. This drives up aggregate demand in the short run and the natural rate in the long run. In fact, in either model, higher government debt supply increases the natural rate and in turn liquid bond rates *much more* in the long run than suggested by relevant empirical evidence (e.g., Laubach, 2009). In contrast, if the asset market is fully *integrated*, a higher supply of public debt can crowd out the demand for other assets, so that aggregate demand and asset returns do not need to adjust much. It turns out that in that case, the model-implied responsiveness of the natural rate to public debt is *much weaker* than suggested by the aforementioned evidence.

While the asset market structure cannot be pinned down using only household-side information alone, its importance nevertheless connects to certain micro moments. In the context of the 2-asset model, generating the above-mentioned results requires a substantial return gap between liquid and illiquid assets. As already highlighted in the previous literature, this is a key margin to combine high MPCs with a reasonable amount and distribution of aggregate wealth in HANK models (c.f. Kaplan and Violante, 2022). Thus, consistency with certain micro-moments remains key for the liquidity margin of Ricardian non-equivalence *but only conditionally* on certain asset market assumptions.

The issue remains to discipline the HANK model's asset market structure and in turn the liquidity effect of public debt. I do so by using a simple model extension that allows to move in between the polar cases of segmented and integrated asset markets *without* changing the model's steady state. Its calibration requires a single macro-level statistic, the long-run effect of public debt on treasury returns, of which various estimates are available in the literature (see, e.g., Rachel and Summers, 2019).[2]

Ultimately, is public debt's liquidity value still a relevant channel of monetary-fiscal

[1] The "natural" rate of interest is typically defined as the nominal rate consistent with a central bank's inflation target in the medium- to long term and taken to be "driven by fundamental factors in the economy, including demographics and productivity growth-the same factors that drive potential economic growth" (Powell, 2020). In contrast, the "neutral rate" is sometimes designated as the interest rate that would be consistent with target inflation in the short or medium run (see e.g. Obstfeld, 2023).

[2] However, given that it does not affect the steady state, it should also be possible to estimate the key parameter jointly with other parameters of a HANK models' "macro block".

interaction in the properly disciplined HANK model? While its effects appear small for moderate fiscal shocks, they can add up to a policy-relevant magnitude in the aftermath of big fiscal expansions. To gauge this in the light of the recent years' macroeconomic events, I extend the 2-asset HANK model with an Effective Lower Bound (ELB) and filter a series of business cycle shocks that make it align with several aggregate US time series between 2020 and 2024. Through the lens of the model, the respective "debt inflation" is unlikely to have played a big role for generating the inflation peak in 2022, but it can generate the persistent "last mile" inflation in 2023 and afterwards.

1.1 Relation to the literature

This paper connects to a long tradition in macroeconomics studying monetary-fiscal policy interactions, going back to the seminal works of Sargent and Wallace (1981) and Leeper (1991). Leeper and Leith (2016) and Cochrane (2023) offer summaries of this literature, including its modern incarnation as Fiscal Theory of the Price Level (FTPL). As already alluded to above, these works typically required public debt to be "unfunded" to become a concern for monetary policy. A relevant recent contribution of this strand is Bianchi et al. (2023), who find unfunded fiscal policy important to explain inflation persistence in the US and also study the post-pandemic inflation.

Naturally, my work connects most closely to the sprawling HANK literature. In particular, the literature has found these frameworks to have substantially different implications of fiscal policy for both real and nominal outcomes compared to the RA benchmark. Firstly, the presence of constrained households with high MPCs can substantially amplify the aggregate effects of expansionary fiscal policy, see for example Hagedorn et al. (2019) and Auclert et al. (2024). These authors, together with Hagedorn (2021) and Angeletos et al. (2024b) also emphasize that these frameworks give rise to different patterns of equilibrium determinacy. Angeletos et al. (2024b) further argue that in response to fiscal shocks, HANK models can generate as much inflation as RA models under the FTPL. Compared to these works, my paper explains that in addition to households' consumption behavior, the market for liquid assets can be crucial for HANK model's inflation responses and determinacy properties. It can (and arguably should) be considered separately from MPCs.

Some HANK papers actually focus on how public debt's liquidity value matters for the aggregate effects of fiscal policy. This includes Bayer et al. (2023a), who focus on real outcomes, and the independent contemporary work of Campos et al. (2024) analyzes some of its implications for monetary policy.[3] Additionally, Cantore and Leonardi (2025) study a New Keynesian model with limited heterogeneity and analyse how the presence of an endogenous public debt liquidity premium affects the transmission of different business

[3]Both this and and an earlier version of my paper were first publicly disseminated on March 1, 2024. My earlier version remains available at the ArXiv preprint server under https://arxiv.org/abs/2403.00471v1.

cycle shocks. My work clarifies that their results depend importantly on the assumption of certain asset market structures in addition to household heterogeneity itself.[4]

My insights on the importance of the asset market structure for liquid rate dynamics additionally bear resemblance to the findings by Chiang and Żoch (2023), who study a 2-asset HANK model with explicit financial intermediation. Comparing their structure with alternative settings, they find the calibration of the asset market to be important for the real effects of different policy shocks. Yet, they do not consider inflation as an outcome and assume real returns on liquid assets to be fixed.[5]

Finally, my work also connects to a set of previous studies analyzing fiscal policy in other settings deviating from Ricardian Equivalence. Related inflationary effects of "funded" government debt were also noticed by Ascari and Rankin (2013) and Aguiar et al. (2023) in the context of Overlapping Generations (OLG)-models with nominal rigidities and by Linnemann and Schabert (2010) in a New Keynesian framework assuming that public debt provides transaction services. Besides building on a different micro-foundation, my work also employs a richer, more quantitatively oriented model.

The remainder of the paper is structured as follows: Section 2 presents the THANK model and the respective analyses. Section 3 describes the core features of the quantitative 2-asset HANK model, which will be used in Section 4 to demonstrate equivalents to the THANK results. Section 5 expands on the mechanism and proposes a calibration of the asset market structure. Afterwards, Section 6 evaluates the implications of the asset market calibration. Section 7 concludes.

2 Monetary-fiscal interactions in a tractable HANK model

To illustrate my argument regarding the importance of the asset market structure for monetary interactions, I begin by studying a simple "Tractable HANK" (THANK) model building on Bilbiie (2025). Within this model, I will consider two different asset market structures, which, however, can provide for an observational equivalent steady state.

2.1 Households and labor supply

The model features a unit mass of households discounting the future at rate β. In contrast to textbook business cycle models, these switch between two different types called "Savers" (S) and Hand-to-Mouth (H). In particular, H and S household stay within their group

[4]While not strictly "HANK" papers, Aiyagari and McGrattan (1998), Challe and Ragot (2011) and Aguiar et al. (2024) study flexible-price incomplete markets model in which the presence of idiosyncratic risk gives rise to important liquidity effects of public debt. My work similarly suggests that in order to assess the magnitude of their respective outcomes, it is valuable to consider the empirical counterparts of public debt's accompanying interest rate effects.

[5]Their insights may thus be the reverse of mine: If changing liquidity supply would necessitate substantial interest rate adjustments for asset market clearing but this is prevented, then other parts of the economy have to adjust strongly.

with probabilities h and s, respectively. The remaining mass of households switch to the other group. These probabilities are time-invariant, so the mass of H households is always $\lambda = (1-s)/(2-s-h)$.

S and H households differ in the following way: S households can save by investing in a liquid nominal asset A and a illiquid stock I, while H households cannot save at all. Additionally, the S household switching to H can take their share of liquid savings with them, which the H agents can consume (but not reinvest). As in Bilbiie (2025), economic decisions for all households are made by a "family head" who pools resources within every group of households and maximizes average utility given the constraints of the respective groups.

The utility maximization problem of the family head can be written recursively as

$$
\begin{aligned}
W(A_t, I_t) = \max_{C_t^S, C_t^H, A_{t+1}, I_{t+1}} \; & \lambda u(C_t^H) + (1-\lambda) u(C_t^S) + \beta \mathbb{E}_t W(A_{t+1}, I_{t+1}) \qquad (1) \\
\text{s.t.} \quad & C_t^S + A_{t+1} + I_{t+1} = (1-\tau^y) w_t N_t + R_t^I I_t + s R_t^A A_t - \tau_t + T_t \\
& C_t^H = (1-\tau^y) w_t N_t \omega + \frac{(1-\lambda)(1-s)}{\lambda} R_t^A A_t + \bar{\tau}/\lambda + T_t.
\end{aligned}
$$

Both resource constraints for S and H households are stated in real terms here. $\omega \in (0,1)$ is a labor productivity parameter for H. τ_y is a proportional tax on labor income that will stay constant for the dynamic analysis below. τ_t is a lump-sum tax on the S type, while $\bar{\tau}$ is a lump-sum welfare benefit paid to the H agents. While τ_t will be more relevant for fiscal consolidation in the analysis below, having a proportional tax τ^y will be important for analyzing the mentioned self-financing result below. T_t is a lump-sum transfer to all households that will always equal 0 except in Subsections 2.6.1 and 2.6.2. Note that the returns to liquid asset holdings are scaled by s and $\frac{(1-\lambda)(1-s)}{\lambda}$ due to the switching.

From maximization problem (1), we can derive the following Euler equations for the optimal consumption and saving decisions of the family head:

$$
(C_t^S)^{-\sigma} = \beta \mathbb{E}_t R_{t+1}^A \left[s (C_{t+1}^S)^{-\sigma} + (1-s)(C_{t+1}^H)^{-\sigma} \right] \qquad (2)
$$

$$
(C_t^S)^{-\sigma} = \beta \mathbb{E}_t R_{t+1}^I (C_{t+1}^S)^{-\sigma} \qquad (3)
$$

We note that the Euler equation for the liquid asset features the switching probabilities and thus a precautionary motive. Given that the asset I is useless for insuring the consumption in the H state, its Euler equation is standard.

Regarding labor supply, I again follow the Tractable HANK literature and assume for tractability that hours worked are chosen by a representative union such that a standard labor supply conditions holds for the aggregate economy, i.e.,

$$
C_t^{-\sigma} (1-\tau^y) w_t = \varsigma N_t^{\phi}, \qquad (4)
$$

where $C_t = \lambda C_t^H + (1-\lambda) C_t^S$ is aggregate consumption. Aggregate labor supply is then given by $L_t = (1 - \lambda + \lambda\omega) N_t$.

2.2 Supply side

The production side is as in textbook New Keynesian models, featuring a unit mass of monopolistically competitive firms that produce differentiated goods using labor only. The production function is given by $Y_t = L_t$. Firms set prices in a staggered fashion à la Calvo, which will gives rise to a standard New Keynesian Phillips curve in the analyses below. Given that this part of the model is well-known, I omit related derivations. Note that in the steady state, the real wage is given by $w_{ss} = 1/\mu$ where μ is the steady state markup. The firms are owned by diversified mutual fund and their profits paid out as dividends d_t to the holders of mutual fund's shares M, see Subsection 2.4 below for more details.

2.3 Government

The government consists of a fiscal authority and a monetary authority. Outside of steady state, the monetary authority sets the nominal interest rate i_t on government debt according to a standard Taylor rule

$$\hat{i}_t = \phi_\pi \pi_t.$$

In the long run (i.e., in the steady state), it adjusts the intercept of its policy rule so that $\pi_{ss} = 0$.

The fiscal authority, in turn, levies the proportional income tax τ^y and the lump-sum tax τ_t on the rich household. The government budget constraint is given by

$$B_{t+1} = R_t^B B_t + T_t + \bar{\tau} + G - \tau^y w_t L_t + (1-\lambda)\tau_t$$

where B_t denotes the stock of government bonds and G exogenous government spending. Below, I shall assume that in the long run, the government follows a fiscal rule that keeps $\bar{\tau}$, G and B to be constant ratios of GDP, i.e. $B_{ss} = \mathcal{B}Y_{ss}$, $\bar{\tau} = \mathcal{T}Y_{ss}$ and $G = \mathcal{G}Y_{ss}$. The nominal rate interest on public debt is set by the central bank and $R_t^b := (1+i_t)/(1+\pi_t)$. The constant tax rate τ^y is set so that $\tau_{ss} w_{ss} L_{ss} = \bar{\tau} + G$, while any other changes in spending are deviation financed via the lump-sum tax τ_t.[6] For the dynamic analysis around the steady state, we will similar assume G to be constant and $T_t = 0$ except for the analysis on the effects of the one-time transfer shock below.

2.4 Asset market

The asset market structure is the crucial element of this analysis. To sharply characterize its importance, I focus on two different cases that I call the *segmented* and *integrated* asset markets. As I will argue in Section 5 below, the "truth" is likely in between the two.

[6] An argument for that assumption could be that the levels of income taxes may be harder to change in the short run that other revenue sources. Keeping the distortionary tax rate τ_y constant makes the analyses more tractable, yet studying self-financing necessitates some form of proportional tax so as to allow tax revenues to depend on economic activity. Hence, the introduction of a positive τ^y that finances the long-run level of the benefit and government consumption.

2.4.1 Baseline: Segmented asset markets

As a baseline, I consider the case in which households' liquid assets are supplied by a risk-neutral competitive Liquid Asset Fund (LAF) that can invest only in government bonds. In turn, we have the liquid asset market clearing condition $A_t = B_t$ and no-arbitrage condition

$$\mathbb{E}_t R^A_{t+1} = \varphi \mathbb{E}_t R^B_{t+1} = \varphi \mathbb{E}_t \frac{1+i_t}{1+\pi_{t+1}}. \tag{5}$$

Above, $1-\varphi \in (0,1)$ is an iceberg cost of liquidity provision, reflecting that the LAF may incur costs to provide liquidity to households. While its presence is unimportant for any results of this model version, it will be useful by allowing the same non-stochastic steady state for either asset market structure as I explain below. In turn, the asset market clearing condition for illiquid assets is $I_t = M = 1$ and $\mathbb{E}_t R^I_{t+1} = \frac{Q_{t+1}+d_{t+1}}{Q_t}$, where Q denotes the price of the mutual fund stocks and d_t the dividends paid out by the firms. Note that in this model version, the only role the illiquid Euler equation (3) is determining the price of the mutual fund stocks and that allocation-wise, we could equivalently assume profits to be paid out lump-sum to the S households.

2.4.2 Alternative: Integrated asset markets

In the alternative asset market structure, I allow the LAF to not only hold government bonds but also to invest in or short-sell the firm stocks. In that case, in addition to (5), the following no-arbitrage conditions must hold in equilibrium:

$$\mathbb{E}_t \frac{1+i_{t+1}}{1+\pi_{t+1}} = \mathbb{E}_t \frac{Q_{t+1}+d_{t+1}}{Q_t}. \tag{6}$$

Additionally, the asset market clearing is now given by

$$A_t = B_t + (MQ_t - I_t)$$

implying that liquid asset holdings generically can (but do not have to) to deviate from the stock of public debt.[7]

2.5 Steady State analysis

The non-stochastic steady state of the baseline model version is easily characterized. In that case, we know $A_{ss} = B_{ss}$, so that $C_{ss} = (1-(1-\varphi)R^B\mathcal{B} - \mathcal{G})Y_{ss}$ and given the assumptions on the income tax level, $\tau^y = \frac{(\mathcal{T}+\mathcal{G})Y_{ss}}{w_{ss}L_{ss}} = (\mathcal{T}+\mathcal{G})\mu$. Using this in the labor supply condition, one can then obtain Y, N and S in terms of parameters. In turn, the steady state liquid return R^A_t can be obtained. As I show in Appendix A.1, the resulting solution is not tractable in general, but it will generically depend on $\mathcal{B}$, s and λ. However,

[7] I note that since the mutual fund stocks are in positive net supply, having $A_t > B_t$ does not need to imply that the S households hold a negative amount of illiquid assets. While the equilibrium might involve the LAF short-selling stocks, this seems arguably not unrealistic for a financial intermediary.

a convenient expression can be obtained under the instructive special case of log utility with both $\omega \to 0$ and $\mathcal{T} \to 0$, i.e. if the H households have no labor income and can only consume the liquid wealth they receive from switching S households. In that case, we obtain the following relation between the steady state liquid return and the debt-to-GDP ratio $\mathcal{B}$:

$$R^A = \frac{1}{\beta}\frac{1-\lambda}{(s-\lambda/\varphi)} - \frac{\lambda(1-\mathcal{G})}{(s-\lambda/\varphi)\mathcal{B}}$$

Focussing on the case $s > \lambda/\varphi$, it can easily be shown that, as in richer incomplete markets models, R^A is increasing and concave in the debt-to-GDP ratio $\mathcal{B}$. Additionally, as I further show in Appendix A.1, we have $\frac{\partial^2 R^A}{\partial \mathcal{B} \partial s} < 0$, i.e., the sensitivity of the liquid return to the debt-to-GDP ratio is decreasing in s. This means that in the baseline model version with segmented asset markets, if households are less likely to switch to the constrained H state, the liquid return (and thus the long-run natural rate) reacts less to the Debt-to-GDP ratio.

Under the alternative *integrated* model, the steady state is determined somewhat differently. From the (3) and the no-arbitrage condition between the stocks and government bonds, it immediately follows that $R^A = \varphi\beta$, implying that the long-run natural rate is *completely independent* of the debt-to-GDP ratio and household heterogeneity. Given R^A, (2) then pins down the steady state ratio and it is not hard to see that if one chooses φ such that

$$\varphi = \frac{1}{((1-s)\eta^{-\sigma} + s)}, \tag{7}$$

where $\eta = \tilde{C}^H/\tilde{C}^S$ is the steady state consumption ratio from the *baseline* model version with segmented assets markets, then identical steady state allocations can be obtained under either asset market structure. Hence, the respective micro moments cannot distinguish between the two asset-market structures. This already illustrates that while the presence of idiosyncratic risk and household heterogeneity may importantly shape the relationship between public debt and the natural rate of interest, it does so only conditionally on the asset market structure. Relating just to respective household moments is not informative about the latter. However, for given micro moments, the relation between public debt and interest rates in the long run can potentially be informative about the asset market structure.

2.6 The asset market and aggregate demand

To explore the implications of the asset market structure for the monetary and fiscal policy in the dynamic economy, I will linearize the economies' equilibrium around a non-stochastic steady state with $B_{ss} = 0$, $\omega > 0$ and $\mathcal{T} > 0$ (with φ chosen so that the allocation is identical irrespective of the asset market). Furthermore, it will be assumed that the transfer $\bar{\tau}$ remains fixed outside of the steady state. As I show in Appendix A.2, the resulting log-linearized IS condition for the baseline model version with segmented

asset markets is given by

$$\hat{y}_t = \frac{\Gamma}{\Theta}\mathbb{E}_t\hat{y}_{t+1} - \frac{1}{\sigma\Theta}(\hat{i}_t - \mathbb{E}_t\pi_{t+1}) + \frac{\Gamma_a}{\Theta}\tilde{b}_{t+1} + \frac{\Theta_a}{\Theta}\tilde{b}_t \tag{8}$$

if the government sets transfer T to 0. It is derived from the log-linearized equation (2), where Θ, Θ_a, Γ and Γ_a are composite parameters depending on household heterogeneity. Θ and Θ_a reflect how the output level and liquid savings reflect the distribution of resources in period t, while Γ and Γ_a capture how they affect the S households' expected marginal utility in $t+1$ (and thus an insurance motive). If the government sets $\tilde{b}_t = 0\ \forall t$, (8) becomes isomorphic to the THANK IS condition derived by Bilbiie (2025) in which the forward-looking terms of the standard IS condition are scaled by additional terms. I shall similarly restrict attention to parameterizations such that $\Theta > 0$, which implies $\Gamma > 0$. Even in that case, it is generally ambiguous whether Γ/Θ is greater or smaller than 1. In the parlance of Bilbiie (2025), the relative size of these terms determine whether inequality is pro- or countercyclical and if the share of the time-invariant transfer in the H agents' income is relatively large, then $\Gamma/\Theta < 1$ and the Euler equation is *discounted*. Many recent analyses of monetary-fiscal interactions use models where a discounted Euler equation is present, and assuming $\Gamma/\Theta < 1$ will be helpful for some analytical arguments (but not strictly necessary for the key insights). Additionally, we notice that the time path of public debt enters the aggregate demand relation: This is because higher public debt increases consumption sharing between S and H agents.

Turning to the alternative model version with integrated asset markets, the IS condition initially appears more involved, since assuming $\tilde{b}_t = 0$ does not imply $\tilde{a}_t = 0$. In general, it will be of the form

$$\Theta\hat{y}_t = \Theta\mathbb{E}_t\hat{y}_{t+1} - \Theta_a(\tilde{a}_{t+1} - \tilde{a}_t) - \frac{1}{\sigma}\left(\hat{i}_t - \mathbb{E}_t\hat{\pi}_{t+1}\right), \tag{9}$$

where $\tilde{a}_t = A_t/Y_{ss}$ describes liquid savings which can be shown to evolve according to $\tilde{a}_{t+1} = \Lambda\mathbb{E}_t\hat{y}_{t+1}$. (9) can be derived from the illiquid asset Euler equation (3), while (2) determines Λ, a combination of parameters such that $\Lambda > 0$ if $\Gamma/\Theta < 1$ and vice versa. In turn, unless shocks hit the economy in period t so that $\mathbb{E}_{t-1}\hat{y}_t \neq \hat{y}_t$, the linearized IS relation fulfills

$$\hat{y}_t = \mathbb{E}_t\hat{y}_{t+1} - \frac{1}{\sigma\Omega}\left(\hat{i}_t - \mathbb{E}_t\hat{\pi}_{t+1}\right), \tag{10}$$

where $\Omega := \Theta - \Theta_a\Lambda$ is a positive constant fulfilling $\Omega < \Theta$ if $\Gamma/\Theta < 1$ and vice versa. Again, for details consult Appendix A.2. Clearly, (10) is isomorphic to the standard IS condition in a representative agent model, except for the scaling of the interest rate elasticity by an additional term. Such an adjusted interest rate elasticity is a feature that less sophisticated Two Agent New Keynesian (TANK) models also introduce (compare Bilbiie, 2008). Hence, the relevance of public debt for aggregate demand and discounting (or amplification) of the Euler equation are not consequences of household heterogeneity and idiosyncratic risk per se, but additionally rely on the asset market structure. Here, if

the asset markets are integrated, the Euler equation is not discounted at all, even though the model features the same degree of household heterogeneity and idiosyncratic risk in steady state as the baseline model version with segmented asset markets.[8]
Below, either version of the aggregate demand block will be combined with the standard Taylor rule $\hat{i}_t = \phi_\pi \pi_t$ and New Keynesian Phillips curve $\pi_t = \kappa_w \hat{w}_t + \beta \mathbb{E}_t \pi_{t+1}$.

Calibration of the THANK model To illustrate the further analytical results, I will use the following calibration: Household preferences are characterized by standard values $\sigma = 1.5$, $\beta = 0.99$ and $\phi = 1.0$, while ς is chosen to normalize $Y_{ss} = 1$. I set $s = 0.94$ following Bilbiie and set h so that $\lambda = 0.15$, which generates a quarterly MPC to lump-sum transfers of around 16% as in the model of Kaplan et al. (2018). As implied by the linearization around $B_{ss} = 0$, $\mathcal{B} = 0$ and regarding government consumption, I use $\mathcal{G} = 0.15$. Finally, I calibrate ω and $\mathcal{T}$ jointly for the model(s) to be consistent with a return wedge of $\varphi = 0.99$ and transfers amounting to 75% of the H agents' income.[9] The latter determines the size of Γ/Θ and the target implements a moderately discounted Euler equation in the baseline model version with $\Gamma/\Theta \approx 0.985$. However, the key insights are robust to calibrating $\mathcal{T}$ so that Γ/Θ is larger than 1. The steady state tax rate implied by $\mathcal{T}$ and $\mathcal{G}$ amounts to $\tau^y = 0.285$. Regarding the macro parameters, I consider a central bank reaction parameter of $\phi_\pi = 1.5$ and a NKPC slope of $\kappa_w = 0.085$.

2.6.1 Response to a fiscal shock

Having set up and linearized the model, we can now consider the response of inflation and output to a simple fiscal shock. I do so assuming a simple scenario for tractability: In period $t = 0$, the fiscal authority issues an amount of public debt of $\tilde{b}_1 = B_1/Y_{ss} > 0$, keeps τ_t at zero and rebates all resources not needed to cover time-invariant expenses G and $\bar{\tau}$. Subsequently, it uses the lump-sum tax τ_t to reduce public debt back to its steady state level according to the exogenous law of motion $\tilde{b}_{t+1} = \rho_b \tilde{b}_t$, a simple and tractable fiscal consolidation path.We find the following:

[8] As becomes clear in Appendix A.2, the absence of Euler discounting/amplification is because in this THANK model, the integrated asset markets eliminate cyclical variation in consumption inequality (but not income inequality) inequality. While it is not the focus of this paper, it suggests that model assumptions on liquid asset supply may also be crucial for analyses on whether household heterogeneity can amplify or resolve the so-called "forward guidance puzzle" (cf. McKay et al., 2016).

[9] Given s and λ, the equilibrium interest rate and in turn the φ fulfilling (7) is determined by consumption heterogeneity between H and S agents. The chosen value implies a return gap between liquid and illiquid assets of around 4% annually.

In the different model versions, output and inflation for periods $t \geq 1$ are given by

$$\hat{y}_t^{BL} = \left(\frac{\Theta_a(1-\rho_b\chi) + \rho_b(1-\chi)\tilde{\alpha} + \frac{\kappa_a}{\sigma}\frac{\phi_\pi - \rho_b}{1-\rho_b\beta}}{\Theta - \Gamma\rho_b + \frac{\kappa}{\sigma}\frac{\phi_\pi-\rho_b}{1-\rho_b\beta}} \right) \tilde{b}_t := \psi_y^{BL}\tilde{b}_t$$

$$\pi_t^{BL} = \left(\frac{\kappa\psi_y^{BL} - \kappa_a}{1-\rho_b\beta} \right) \tilde{b}_t := \psi_\pi^{BL}\tilde{b}_t$$

$$\hat{y}_t^{INT} = 0$$

$$\pi_t^{INT} = 0$$

For derivations and definitions of the composite parameters Θ_a, χ, $\tilde{\alpha}$ and κ_a, see Appendix A.3.

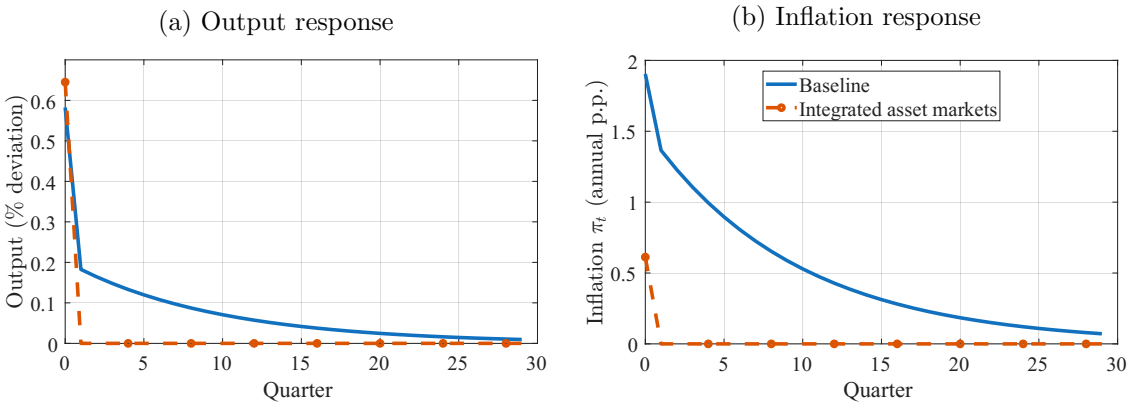
With Euler equation discounting $\Gamma < \Theta$, the baseline responses ψ_y^{BL} and ψ_π^{BL} are generically positive for any reasonable parameterization, meaning that in the aftermath of the shock, output and inflation remain elevated as long as public debt remains above its steady state level $\tilde{b}_{ss} = 0$.[10] With segmented asset markets, higher public debt necessarily leads to more redistribution towards the H agents, boosting aggregate demand and increasing the neutral rate of interest. In stark contrast, in the model version with integrated asset market, inflation and output return to their steady state level *immediately* after the shock, since higher public debt does no longer imply better consumption insurance for the H agents and thus does not affect aggregate demand. Since households and firms are forward-looking, the public debt-driven demand expansion can further amplify the impact of the shock in the setup with segmented markets, an effect that is absent with integrated asset markets.

What about the effect of the fiscal shock in period $t = 0$? One can show that, as explained in Appendix A.3, we have $\pi_0^{BL} > \pi_0^{INT}$ for any reasonable calibration, i.e., the inflation response in the segmented baseline model will exceed the one in the integrated alternative. The relative sizes of the initial output effect, is, however, ambiguous and depends on the monetary reaction ϕ_π: Intuitively, initial inflation in the baseline model is higher since price pressures are expected to remain elevated going forward. However, the higher initial inflation also implies a stronger monetary policy response, which can dampen the initial output effect under a hawkish central bank reaction.

Quantitative illustration To illustrate the above results, Figure 1a and 1b show the response of output and inflation to the fiscal shock with $\tilde{b}_1 = 0.04$ and $\rho_b = 0.9$, i.e., the government issues an amount of public debt equal to 1% of annual GDP in period $t = 0$ and reduces the excess debt by 10% every quarter from period 1 forward. We see that the initial real output response is relatively similar in either model version, but only remains elevated in the model with segmented asset markets. In addition, we notice that the initial

[10] I implicitly assume that parameters are such that the system is determinate, conditions for which will be explored below. In many calibrations with $\Gamma > \Theta$, ψ_y^{BL} and thus ψ_π^{BL} are typically positive as well, since the term $\frac{\kappa}{\sigma}\frac{\phi_\pi-\rho_b}{1-\rho_b\beta}$ keeps the denominator to be > 0 as long as $\phi_\pi > 1$.

Figure 1: Model responses to fiscal stimulus



Note: The figures display the output and inflation responses to the fiscal shock with $\tilde{b}_1 = 0.04$ and $\rho_b = 0.9$. The solid lines display the response of the baseline model and the dash-dotted line the response of the alternative model version with integrated asset markets.

inflation impact is much stronger in the baseline model and remains elevated as long as public debt is.

2.6.2 Revenue effects of the fiscal shock

We can also briefly ask to what extent the fiscal shock may be self-financing, an issue made salient by Angeletos et al. (2024a). While I considered an exogenous law of motion for public debt to keep the analysis above tractable, we can easily compute what amount of lump sum taxes τ_t needs to raise in $t \geq 1$ to implement the intended path. To do so, consider the government budget constraint linearized around the steady state with $B_{ss} = 0$

$$\tilde{b}_{t+1} = \frac{1}{\beta}\tilde{b}_t + \tilde{t}_t - (1-\lambda)\tilde{\tau}_t - \phi_\tau \underbrace{\left[(\Phi+1)\,\hat{y}_t - \frac{\sigma\tilde{\varphi}}{(1-\mathcal{G})}\tilde{a}_t\right]}_{=\hat{w}_t+\hat{n}_t},$$

where $\tilde{t}_t := T_t/Y_{ss}$ and $\tilde{\tau}_t := \tau_t/Y_{ss}$. This expression already incorporates that income taxes and government consumption are kept constant over time. Again, see Appendix A.2 for details. To implement the fiscal consolidation plan $\tilde{b}_{t+1} = \rho_b\tilde{b}_t$ in $t \geq 1$ after the fiscal shock, the government will need to set the tax to

$$\tilde{\tau}_t = \frac{1}{1-\lambda}\left[\left(\frac{1}{\beta} - \rho_b\right)\tilde{b}_t - \phi_\tau\left((\Phi+1)\,\hat{y}_t - \frac{\sigma\tilde{\varphi}}{(1-\mathcal{G})}\right)\tilde{a}_t\right].$$

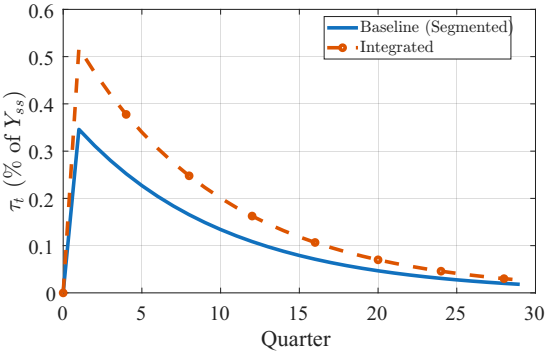
Considering the dynamics and of output and (liquid assets) characterized above, we get for the two model versions that

$$\tilde{\tau}_t^{BL} = \frac{1}{1-\lambda}\left(\frac{1}{\beta} - \rho_b - \phi_\pi(\Phi+1)\psi_y^{BL} + \frac{\sigma\tilde{\varphi}}{(1-\mathcal{G})}\right)\tilde{b}_t \quad \text{and} \quad \tilde{\tau}_t^{INT} = \frac{1}{1-\lambda}\left(\frac{1}{\beta} - \rho_b\right)\tilde{b}_t. \tag{11}$$

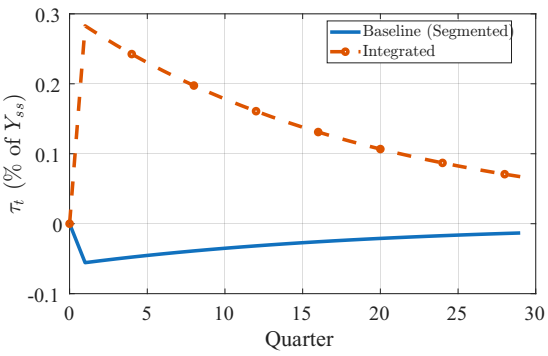
Since the persistently elevated output levels after the shock will raise revenues through the income tax without any endogenous adjustments, the government will need to levy

Figure 2: Self-financing after the fiscal shock

(a) Baseline policy



(b) Alternative policy



Note: The figures display the time path of lump-sum taxes τ_t after the the fiscal shock with $\tilde{b}_1 = 0.04$. The solid lines display the response of the baseline model and the dash-dotted line the response of the alternative model version with integrated asset markets. Subfigure 2a displays the responses under the baseline policy $\phi_\pi = 1.5$ and $\rho_b = 0.9$, while Subfigure 2b displays the responses under the alternative policy $\phi_\pi = 1.1$ and $\rho_b = 0.95$.

lower taxes $\tilde{\tau}$ on the S households in the baseline model version with segmented asset markets. This effect is absent in the model version with integrated asset markets and the difference can be substantial if ψ^y_{BL} is large, which is the case if fiscal consolidation is slow or monetary policy not very hawkish.

Quantitative illustration Figure 2a displays the time path of lump-sum taxes (11) under the baseline policy with $\phi_\pi = 1.5$ and $\rho_b = 0.9$ and we see that the levels necessary to induce the specified time path for fiscal consolidation are noticeably lower in the baseline model. As explained, this is since the debt-induced demand expansion generates higher labor income tax rates in the baseline model, even though the income tax itself is kept constant. With integrated asset markets, this effect is absent. The difference is even more pronounced if we consider a scenario with less hawkish monetary policy and slower fiscal consolidation, as shown in Figure 2b for the case $\phi_\pi = 1.1$ and $\rho_b = 0.95$. Here, the persistently elevated output levels in the baseline model version imply that the government can even reduce $\tilde{\tau}$ below zero while implementing the consolidation path, i.e. the fiscal expansion is fully self-financing in the sense of Angeletos et al. (2024a), while noticeable increases are necessary in the alternative model variant.

2.7 Determinacy properties

As mentioned, another way in which HANK models were found to distinguish themselves from standard representative agent New Keynesian models is that the policy mix yielding a unique equilibrium is less clear-cut. To illustrate this in the case of the THANK model, I deviate from the exogenous law of motion for public debt and instead introduce a feedback

policy rule $(1-\lambda)\tilde{t} = \phi_b$. This makes the amount of public debt endogenous and turns the economy into a 3-dimensional equilibrium system with one state- and two control variables.

The determinacy properties of this economy are studied in detail in Appendix A.4, which yields the following conclusions: In the model version with *integrated* asset markets, a unique determinate equilibrium can exist only if

$$\left(1 - \underbrace{\left(\frac{1}{\beta} - \phi_b\right)}_{:=\delta_b}\right)(\phi_\pi - 1) > 0.$$

This is an equivalent of the classic Leeper (1991) condition stating that determinacy is possible in two distinct parameter regions: a) An "active monetary" region in which the the monetary authority reacts more than one-to-one to inflation while the fiscal authority stabilises public debt (implied by $\delta_b < 1$) and b) an "active fiscal" with $\phi_\pi < 1$ and $\delta_b > 1$. In contrast, the corresponding condition for the baseline THANK model with segmented markets is

$$(1-\delta_b)(\phi_\pi - 1) > \frac{\sigma(1-\beta)}{\kappa}\left((\Theta_a + \Gamma_a)\phi_\tau(1+\Phi) - (\Theta - \Gamma)(1-\delta_b)\right)$$

which provides a much less clear separation also depending on the income taxes ϕ_τ and various heterogeneity-dependent composite parameters from IS relation (8). We further note that if $\Theta - \Gamma$ is large enough, i.e., there is substantial discounting of the Euler equation, the right-hand side can be negative and determinacy could arise even if neither monetary nor fiscal policy are "active" in the sense of Leeper (1991). Economically, the difference is due to public debt affecting aggregate demand (the IS curve) in this case.

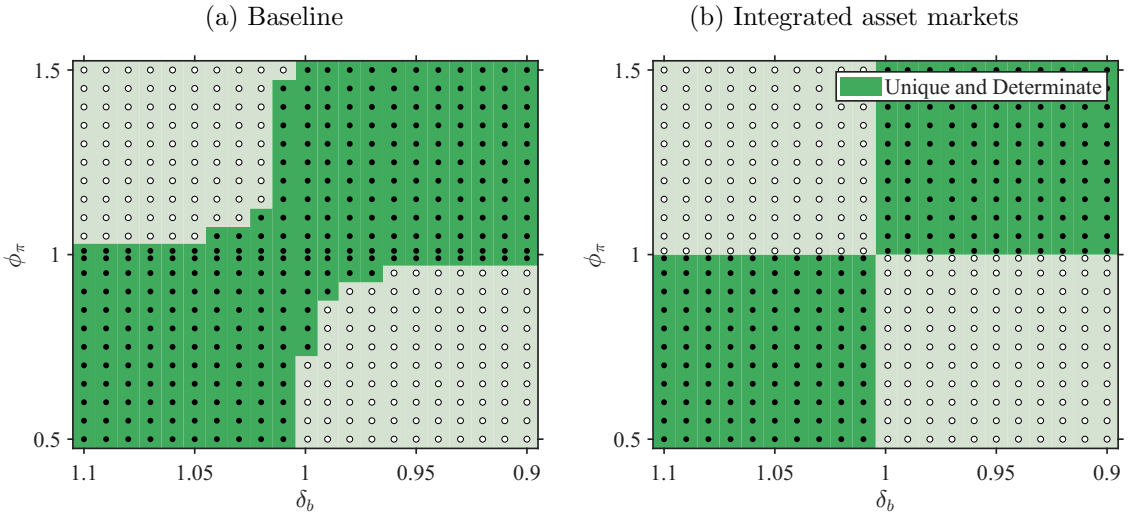
Quantitative illustration Under the calibration specified above, Figure 3 indicates which combinations of δ_b and ϕ_π yield a unique stationary equilibrium in either model version.[11] The analysis confirms the analytical results above: With segmented asset markets, there is no longer a clear separation between "active monetary" and "active fiscal" regions. With integrated markets, we obtain the well-known Leeper (1991) case.

2.8 Taking stock

This section studied monetary-fiscal interactions in a tractable HANK model that has been argued to capture the key features of richer HANK models well. As such, its baseline version was able to replicate key results from the recent literature on monetary-fiscal interactions in HANK models. Yet, contrasting it with the alternative model version with integrated asset markets, it becomes clear these results are not a consequence of allowing

[11] In contrast, for the analytical expression, which strictly provide only necessary conditions for determinacy, the results in Figure 3 are obtained by numerically checking the eigenvalues for the respective parameter combinations are thus based on sufficient conditions.

Figure 3: Determinacy properties



Note: The plot indicates whether the model provides for a unique stationary equilibrium for the different combinations of monetary and fiscal policy parameters ϕ_b and δ_b. The dots indicate the evaluated parameter combinations.

for certain patterns of household heterogeneity and idiosyncratic risk per se, but rather doing so in combination with specific assumptions on liquid asset supply. At this point, a natural concern is whether this is due to some features of the THANK model, such as the illiquid asset returns being completely independent of idiosyncratic risk or the various assumptions needed to obtain tractability. However, as will become clear, one can obtain similar results in state-of-the-art 2-asset HANK models.

3 The 2-asset HANK model

For a more quantitatively oriented analysis, I employ a 2-asset HANK model. Importantly, such models can provide for somewhat realistic level and distribution of aggregate wealth and be consistent with consumption behavior that was found important for studying fiscal policy in previous work. While most features of my set-up are deliberately similar to frameworks in the previous literature, e.g., Bayer et al. (2024) and Auclert et al. (2024), it again features a financial intermediary referred to as the *liquid asset fund*, which is now set up so that one can flexibly change the *potential* supply of liquid assets available to households without affecting its initial steady state in any way. In the main text, I will focus on the household side, policy and this non-standard feature of the model, while the details on its standard parts are relegated to Appendix B. Notice that some notation differs between the 2-asset and THANK setups.

3.1 Households

There is a unit mass of households, which I again also refer to as "agents" interchangeably. These differ ex-post by several idiosyncratic states:

Firstly, households vary in terms of their holdings of liquid and illiquid assets a_{it} and k_{it}. k_{it} represents holdings of capital and I require that $k_{it} \geq 0$ as well as $a_{it} \geq \underline{a}$, with $\underline{a}$ representing an exogenous borrowing/short-selling limit. Capital is illiquid in that a household can change her stock k_{it} only infrequently: In particular, following Bayer et al. (2024) and Auclert et al. (2024), I assume that the opportunity to do so arises randomly in an i.i.d. fashion, in that households only gets to participate in the market for illiquid assets with probability $\lambda \in (0, 1)$ every period.

Secondly, as in Bayer et al. (2024), the agents can be workers ($\Xi_{it} = 0$) or "entrepreneurs" ($\Xi_{it} = 1$). The former participate in the regular labor market, while the latter don't supply labor to the market but receive the profits generated by the firms (to be described below), which, for simplicity, are assumed to be shared equally among all households with $\Xi_{it} = 1$. Transitions to and out of the "entrepreneur" status are exogenous with probabilities ζ and ι, implying a time-invariant mass of $m^{\Xi} := \frac{\zeta}{\zeta+\iota}$ agents in that state.

Worker households ($\Xi_{it} = 0$) additionally differ by their idiosyncratic labor productivity or "skill" $s_{it} \in \mathcal{S} = \{s_1, s_2, ..., s_{ns}\}$, which evolves stochastically according to a discrete Markov chain with transition probabilities $\pi^s(s_{it+1}|s_{it})$. Workers who are selected to become entrepreneurs lose their idiosyncratic s_{it}, while exiting entrepreneurs draw a new s_{it} from the ergodic distribution of the Markov Chain.

3.1.1 The Household problem

Households gain utility from consumption c and disutility from their amount of hours worked according to the preference structure

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \prod_{\tau=0}^{t} (A_\tau) \left(\frac{c_{it}^{1-\xi} - 1}{1-\xi} - \varsigma \frac{N_t^{1+\gamma}}{1+\gamma} \right). \tag{12}$$

The above formulation allows for a time-varying demand shock A_t shifting all households' discount factor β, which are a vehicle to induce consumption restraints in Section 6.[12] As, e.g., in Auclert et al. (2024), households are *not* free to choose their own labor supply. Instead, they are required to work the number of hours demanded by their employers at the wage determined by a set of labor unions as detailed below. These will be equal in equilibrium, i.e., $N_{it} = N_t \ \forall i \in [0, 1]$.

An agent who gets to adjust her illiquid capital stock will the face budget constraint

$$c_{it} + q_t k_{it+1} + a_{it+1} = y_{it}(s_{it}, \Xi_{it}) + (1 + r_t^a(a_{it}))a_{it} + (q_t + r_t^k)k_{it} + T_{it} \tag{13}$$

while for non-adjusters, the constraint will be of the form

$$c_{it} + a_{it+1} = y_{it}(s_{it}, \Xi_{it}) + (1 + r_t^a(a_{it}))a_{it} + r_t^k k_{it} + T_{it}. \tag{14}$$

[12] This is in line with Bardóczy et al. (2024), who also use discount factor shocks in a HANK study relating to the US post-2020 period.

Both budget constraint are already written in real terms. q_t denotes the time t price of capital goods, T_{it} a transfer from the government, r_t^k the real net return of capital goods and $r_t^a(a_{it})$ the real return on bonds a_{it}. The latter depends on a_{it} due to the presence of a borrowing penalty. In particular, we have

$$r_t^a(a_{it}) = \begin{cases} r_t^l & \text{if } \ a_{it} \geq 0; \\ r_t^l + \bar{R} & \text{if } \ a_{it} < 0, \end{cases} \tag{15}$$

where r_t^l is the real return on liquid savings, which will depend on the nominal central bank rate r_t^R and inflation $\pi_t = \frac{P_t}{P_{t-1}}$ as specified below. $\bar{R}$ is a real borrowing penalty.[13] Finally, y_{it} represents a household's post-tax labor- or profit income which is given by

$$y_{it}(e_{it}, s_{it}, \Xi_{it}) = \begin{cases} (1-\tau_t^w)\left(w_t s_{it} N_t\right)^{1-\tau^p} & \text{if } \ \Xi_{it} = 0; \\ (1-\tau_t \Xi)\frac{\Pi_t}{m_t^{\Xi}} & \text{if } \ \Xi_{it} = 1. \end{cases} \tag{16}$$

Labor income is subject to an affine tax schedule in the veins of Benabou (2002) for which the parameters τ^w and τ^p determine the level and degree of progressivity, respectively. Similarly, τ^{Ξ} is the tax rate on entrepreneurs' profit income. Both level parameters may be adjusted by the government over time and thus have a time subscript.
In Appendix B.1, I state the full recursive utility maximization problem of the households.

3.2 Production

The model's supply side is similar to standard "medium scale" DSGE models: Production is vertically integrated. There is a final good that can either be consumed or used by capital goods producers to produce investment goods subject to adjustment costs. This final good is assembled by a representative final goods producer, that in turn requires differentiated inputs provided by a continuum of retailers. The retailers set prices in a monopolistic competitive fashion subject to nominal rigidities and require intermediate goods to produce their output. These are provided by a set of competitive intermediate goods producers that require capital and labor services as inputs. The latter are an aggregate of different labor varieties, the wage for is decided by monopolistic competitive unions that are also subject to nominal rigidities. This adds nominal wage rigidity to the model. Given that these ingredients are well-known, I refer to Appendix B for the details on the production side of the model.

3.3 Government

The government again consists of two branches, a monetary authority and a fiscal authority.

[13] My specification for the borrowing wedge implies that every unit of debt held by a household incurs a real resource cost of $\bar{R}$, e.g. due to costly monitoring.

3.3.1 Monetary Authority

The monetary authority sets the nominal return $1 + r^R$ on a reserve asset that is in zero net supply. Specifically, it is assumed to follow a Taylor rule of the form

$$1 + r^R_{t+1} = \max \left\{ (1 + r^R_{SS}) \left(\frac{1 + r^R_t}{1 + r^R_{SS}} \right)^{\rho^R} \left[\left(\frac{\pi_t}{\pi_{SS}} \right)^{\theta_\pi} \left(\frac{Y_t}{Y_{t-1}} \right)^{\theta_y} \right]^{1-\rho^R} \exp\left(\epsilon^R_t\right), \; 1 + r^{LB} \right\}. \tag{17}$$

which features an Effective Lower Bound (ELB) denoted as r^{LB}. The parameter ρ^R introduces rate smoothing and if $\theta_y \neq 0$, the rule reacts to output growth in addition to inflation. ϵ^R_t represents an exogenous disturbance to the rule ("monetary policy shock"). Since the calibrations will provide for a stable steady state, $1 + r^R_{SS}$ always constitutes the true long-run natural rate of interest.

3.3.2 Fiscal Authority

The fiscal authority collects taxes, pays out transfers T_{it} and engages in government consumption G_t. It also issues nominal long-term government bonds which I introduce using a simple geometric maturity structure as in Bayer et al. (2023a). Bonds are long-lived. Every period, they pay one nominal unit of return and a random fraction δ^B of them retire without repaying the principal.[14] Denoting the nominal period t price of a bond as Q^B_t, its expected nominal return is given by $\mathbb{E}_t(Q^B_{t+1}(1 - \delta^B) + 1)$.

To state the government's budget constraint in a convenient form, let us define B^g_t to denote the value of public debt outstanding at the beginning of period t in terms of its period $t-1$ real market value Q_{t-1}/P_{t-1}. The dynamics of public debt must then be consistent with

$$B^g_{t+1} = (1 - \delta^B) \frac{Q^B_t B^g_t}{Q^B_{t-1}\pi_t} + G_t + \int_0^1 T_{ti} di + \frac{B^g_t}{Q^B_{t-1}\pi_t} - \Upsilon_t, \tag{18}$$

i.e., the real period t market value of public debt outstanding at the end of period t equals the re-valued stock of public debt that did not retire plus the government's real spending obligations minus real tax revenues Υ_t. The latter equal

$$\Upsilon_t = \tau^\Xi_t \Pi_t + \int_{m^\Xi}^1 \left(w_t s_{it} N_t - (1 - \tau^w_t) \left(w_t s_{it} N_t \right)^{1-\tau^p} \right) di.$$

As baseline, I again assume both government spending items G_t and T_{it} to be solely determined by exogenous shocks. Without any occurring, they remain fixed at $G_t = G_{SS}$ and $T_{it} = 0$.

To ensure public debt stability in the face of various business cycle shocks, the fiscal authority is furthermore assumed to adjust taxes as $\tau^w_t = \tau_t \tau^w_{ss}$ and $\tau^\Xi_t = \tau_t \tau^\Xi_{ss}$. The tax level τ_t evolves according to

$$\left(\frac{\tau_t}{\tau_{ss}} \right) = \left(\frac{\tau_{t-1}}{\tau_{ss}} \right)^{\rho_\tau} \left(\frac{B^g_t}{B^g_{ss}} \right)^{(1-\rho_\tau)\psi_B}, \tag{19}$$

[14] Equivalently, such a setting can be interpreted as featuring infinitely-lived bonds with geometrically declining coupon payments. See Woodford (2001).

a functional form also used in Bianchi et al. (2023). Adjusting all tax levels proportionally by the same factor aims to reduce the distributional impact of fiscal consolidation in order to better isolate the role of the public debt level. Otherwise, the fiscal authority issues any amount of bonds B^g_{t+1} necessary to fulfill its budget constraint (18). Intuitively, policy rule (19) means that the government will eventually raise taxes to pay back debt in surplus of its long-run target, but may do so only slowly.

3.4 Liquid Asset Provision

While I assume a centralized market for claims to (illiquid) capital, households obtain liquid assets from a set of competitive *liquid asset funds* (LAFs). While such entities were already present in THANK, I now use them as a vehicle to introduce my a simple model extension. Here, in contrast to households, these funds are able to trade claims to capital every period and also have access to a technology to short-sell any asset. Their objective is to maximize expected real returns by investing the liquid savings A^l_{t+1} they receive from the households in capital, government bonds and reserves. In particular, the LAFs solve

$$\max_{B^l_{t+1},R^l_{t+1}} \left\{ \mathbb{E}_t \left[(r^k_{t+1}+q_{t+1}) \frac{A^l_{t+1}-B^l_{t+1}-R^l_{t+1}}{q_t} + \frac{Q^B_{t+1}(1-\delta^B)+1}{\pi_{t+1}} \frac{B^l_{t+1}}{Q^B_t} + \frac{1+r^R_{t+1}}{\pi_{t+1}} R^l_{t+1} \right] \right.$$
$$\left. -A^l_{t+1} \left(\varphi + \frac{\Psi}{2} \left(1 - \frac{B^l_{t+1}+R^l_{t+1}}{A^l_{t+1}} \right)^2 \right) \right\}, \tag{20}$$

where A^l_{t+1} denotes the total amount of assets intermediated by the LAF and B^l_{t+1} and R^l_{t+1} the amount of government debt and reserves it chooses to acquire. A fund faces costs for each unit of liquid asset it invests on behalf of the households. This involves a linear component φ and a part $\frac{\Psi}{2}\left(1-\frac{B^l_{t+1}+R^l_{t+1}}{A^l_{t+1}}\right)^2$ that increases in the relative amount of the fund's asset positions that are *not* in liquid government assets. This structure implies that the equilibrium government bond prices Q^B must fulfill the no-arbitrage condition

$$\mathbb{E}_t \frac{1+r^R_{t+1}}{\pi_{t+1}} = \mathbb{E}_t \frac{Q^B_{t+1}(1-\delta^B)+1}{\pi_{t+1} Q^B_t}.$$

Furthermore, the LAFs' aggregate portfolio choice can be determined from the corresponding F.O.C.

$$\mathbb{E}_t \left(\frac{r^k_{t+1}+q_{t+1}}{q_t} \right) - \Psi \left(1 - \frac{B^l_{t+1}}{A^l_{t+1}} \right) = \mathbb{E}_t \left(\frac{1+r^R_{t+1}}{\pi_{t+1}} \right) \tag{21}$$

and the ex-post real return to household's liquid savings will be given by

$$1+r^l_t = \frac{q_t+r^k_t}{q_{t-1}} \frac{A^l_t - B^l_t}{A^l_t} + \frac{Q^B_t(1-\delta^B)+1}{\pi_t Q^B_{t-1}} \frac{B^l_t}{A^l_t} - \varphi - \frac{\Psi}{2}\left(1-\frac{B^l_t}{A^l_t}\right)^2 \tag{22}$$

(anticipating that in equilibrium $R^l_t = 0$ as reserves are in 0 net supply).

A few words on the above assumptions are in order: Although the quadratic portfolio cost in (20) is reminiscent of some DSGE models featuring a financial sector (for example

Gerali et al., 2010), its aim is *not* to provide a particularly realistic model of financial intermediation. Rather, it introduces a parsimonious way to flexibly move between various assumptions on liquid asset supply in the literature. For this purpose, the parameter Ψ has a simple interpretation as determining how easily capital assets can be used for liquidity provision. In case $\Psi \to \infty$, the model nests a *segmented* markets for liquid and illiquid assets, meaning that capital is practically useless for the provision of liquid assets. In contrast, for $\Psi \to 0$ it nests an *integrated* market in which capital is a perfect substitute for government bonds for the purpose of liquidity provision and (21) collapses to a standard no-arbitrage condition.[15]

While a micro-founded models of financial intermediation, building e.g. on Gertler and Karadi (2011), could also provide for imperfect usefulness of capital for liquidity provision, the above formulation has several benefits: Importantly, if the model's steady state (SS) is again calibrated so that the household sector's net liquid asset holdings equal the net supply of government bonds, one can move "in between" the above-mentioned assumptions on asset market structure *without* changing its SS. Besides, my simple structure makes it particularly transparent how varying the usefulness of capital for liquidity provision is achieved and requires just one additional parameter Ψ to be calibrated.

3.5 Market clearing conditions and equilibrium

The Definition of Equilibrium is standard, but tedious, given that the quantitative model features multiple markets and also requires keeping track of the evolution of the aggregate distribution. In turn, I relegate these details to Appendix B.5.

3.6 Numerical Approach

To approximate the dynamic equilibrium of the model, I use established techniques that conduct first-order perturbation around the economy's non-stochastic steady state, specifically the Sequence Space Jacobian (SSJ)-method proposed by Auclert et al. (2021) and the State Space method employed by Bayer et al. (2024). Both have comparative advantages for different purposes: For example, the Sequence Space method can more conveniently handle a binding ELB relevant for the analysis described in Section 6.2, as one can impose the lower bound on nominal rates via monetary news shocks as in McKay and Wieland

[15] In the context of two-asset HANK models, segmented asset markets are for example used in Kaplan et al. (2018) or Bayer et al. (2024), who assume that government bonds can *only* be held as a liquid asset and capital *only* as an illiquid asset. In contrast, Auclert et al. (2024) assume that government bonds and "shares" (claims on capital returns and monopoly rents) are perfect substitutes for liquidity provision, i.e., they assume an integrated asset market.

My LAF set-up results in equal returns on public debt and capital in steady state, as in in Auclert et al. (2024). In settings with $\Psi > 0$, the return on government bonds B_t might in principle exceed the one on capital. This is, however, a mechanical consequence of how the liquidity cost is set up and does not preclude liquidity from being scarce if Ψ is large. Making the linear liquidity cost φ specific to the LAF's capital holdings instead would result in a direct liquidity premium on public debt without noticeably affecting model dynamics.

(2021). In contrast, the State Space method allows to easily check whether the model admits a unique and stable solution for a given parameterization via the Blanchard-Kahn-conditions and proved conveniently fast for exercises requiring the model to be solved many times. Further details on the numerical implementation are provided in Appendix B.6.

3.7 Calibration

A period is interpreted to be a quarter. I aim for the model to be consistent with the most relevant features of the US economy and the key empirical moments emphasized by the HANK literature, such as a plausible income- and wealth distribution, the presence of poor and wealthy "Hand-to-Mouth" (HtM) households and in turn a fairly high aggregate MPC. To do so, I first set a range of parameters exogenously, relying on the previous literature: In addition to standard preference- and technology parameters, this includes some parameters exclusively affecting the dynamic model response to aggregate shocks, for which I rely on previous papers estimating HANK models. While this part is relegated to Appendix B.3, it is important to note that I parameterize the models' monetary policy rule with inflation coefficient of $\theta_\pi = 1.5$, placing me firmly inside the parameter range associated with active monetary policy. Furthermore, the robustness of the main results with regard to the various external calibration choices is analyzed in Appendix C.

The remaining parameters are chosen so that the model matches various targets in the non-stochastic steady state. To clarify how they come about, I present for each parameter the moment I use to identify it. While in principle any parameter will somewhat affect any of the stationary equilibrium's target moments, it nevertheless turns out that achieving a good fit with the target relies mostly on the stated parameter.

Several parameters are disciplined by moments related to the steady state wealth distribution. I choose the household discount factor β to match a ratio of average steady state capital holdings to output of 11.22 as in Bayer et al. (2024), resulting in $\beta = 0.9838$. The probability ζ determines the amount of "super rich" entrepreneur households and I use it to target a Top 10% wealth share of 70%, approximately the value computed by Krueger et al. (2016) using SCF data. This requires a value of approx. 0.0005.

λ determines the (il-)liquidity of capital and thus how many liquid assets agents wish to additionally hold for self-insurance purposes: I use it to target net liquid asset holdings by households to equal 1.8 times quarterly GDP. Firstly, it is in line with the amount of *domestically* held public debt in the US before the start of the 2020 Covid pandemic, the arguably relevant measure in my closed-economy model. However, the target is also close the average *overall* debt-to-GDP ratio for the US over the period 1970-2019 and can thus also be interpreted in this way.[16] Additionally, it is of a roughly similar magnitude as

[16]The statement regarding *domestically-held debt* is based on subtracting FRED series FDHBFIN (Federal Debt held by foreign and international investors) from FYGFDPUN (Federal Debt Held by the Public), while the overall debt-to-GDP ratio is taken from FYGFGDQ188S.

Parameter	Description	Value	Target
β	Time discounting	0.9838	$K/Y = 11.22$
ζ	prob. entrepreneur state	0.0005	Wealth share top 10
λ	prob. illiquid asset adjustment	0.0363	$B/Y = 1.8$
$\bar{R}$	Borrowing penalty	0.0355	16% borrower share
$\underline{a}$	Borrowing limit	-1.4491	100 % avg. quart. income
G_{ss}	Government consumption	0.5649	Budget clearing (18)
φ	Liquidity Fixed Cost	0.0092	$r^l_{ss} = 0.0$
Ψ	Liquidity Supply		See Section 5.4

Table 1: Internally calibrated parameters

the average net amount of liquid assets held by US households (HHs) over the 2014-2019 period.[17]

Regarding household borrowing, I follow Kaplan et al. (2018) by assuming the borrowing limit to equal the average quarterly (post-tax) labor income and set the borrowing penalty $\bar{R}$ so as end up with 16% of households having $a \leq 0$ in SS. The return wedge φ is chosen so that the real return to liquid savings is 0 in SS as in Bayer et al. (2023b), which requires setting φ equal to the steady state return on capital, equal to 0.0092 in the Baseline model (a return of 3.7% in annual terms). Initially, I entertain the assumptions on asset market segmentation from the previous literature, i.e. $\Psi = 0$ and $\Psi \to \infty$. Section 5.4 below will eventually propose an explicit calibration strategy.

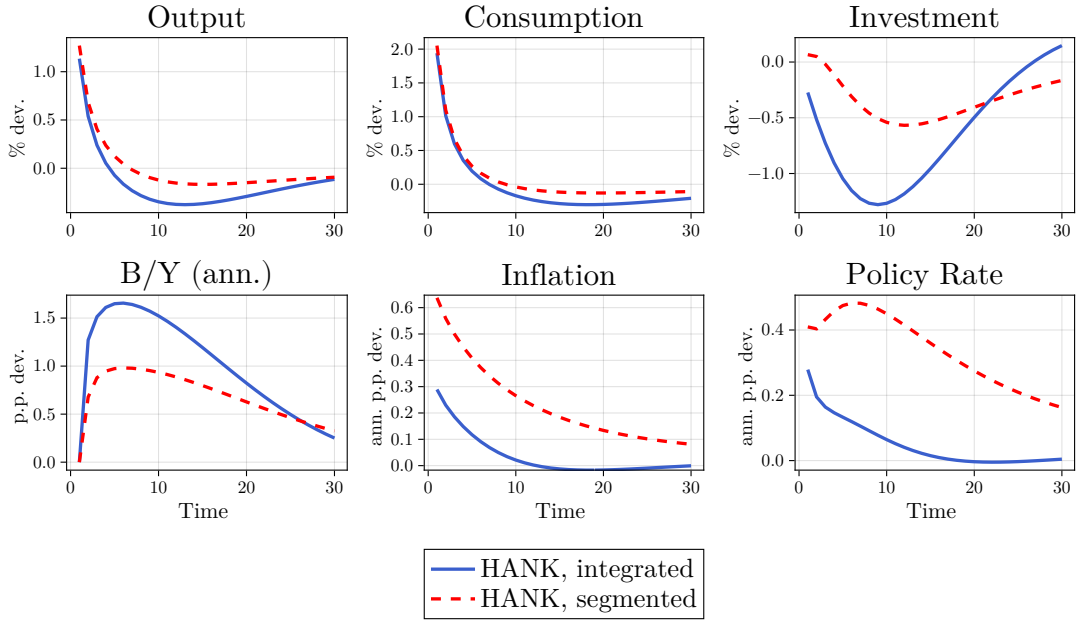
As I show in the additional Appendix B.4, the model generates household micro moments in line with the evidence typically emphasized in the HANK literature. In particular, it achieves a fairly good fit for the distribution of income and wealth, and plausible shares of "poor" and "wealthy" Hand-to-Mouth households (in the sense of Kaplan et al. (2014)). In turn, it also generates an average quarterly MPC of around 15.8%.

4 The asset market and fiscal policy in the 2-asset HANK

Armed with the suitably calibrated 2-asset HANK model, we are now ready to explore how the asset market shapes monetary-fiscal interactions in this model. For this purpose, I first study the aggregate response to expansionary fiscal policy shock before turning to the self-financing result and model determinacy properties. Additional robustness checks on the main insights in this section are provided in Appendix C.

[17] For the purpose of this calculation, I take net liquid asset holdings to be the sum of cash and checkable deposits, money market funds and direct treasury security holdings minus revolving consumer credit and credit card debt. According to the Federal Reserve's Financial Accounts of the United States, on average the holdings of HHs and Non-Profit Organizations (NPOs) equalled 54% of quarterly GDP over that period. Since NPO assets are not necessarily liquid from the point of view of HHs, holdings of the latter should be somewhat lower.

Figure 4: Model IRFs to transfer shock



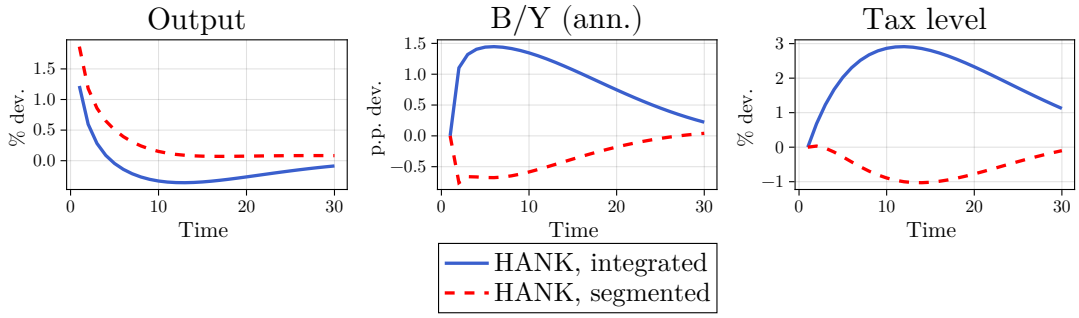
Note: B/Y represents the real market value of public debt B^g over annualized GDP. Figures display relative (in %) or percentage point (p.p.) deviations from Steady State. An expanded figure with more IRFs is provided as Figure G.3 in Appendix G.

4.1 Aggregate effects of fiscal stimulus

To keep the analysis in this subsection transparent, I again consider a simple fiscal policy shock: The only exogenous disturbance will be a one time-shock to government transfers T_t without any persistence, which may be viewed as the government sending out "stimulus checks". To aid this interpretation, I choose the size of the shock to amount to 2% of Steady State GDP. In terms of the USA's 2019 GDP, this would amount to circa USD 1,300 per capita, roughly the size of the one-time payments distributed under the CARES act in 2020.

The response of key aggregate variables to the fiscal stimulus is depicted in Figure 4, both for the cases with integrated and segmented asset markets. Qualitatively, the responses under either model version align: The response of consumption looks as we would expect in a model featuring a high of amount of HtM-households with high MPCs, increasing substantially at impact and fading out after a few quarters. Output and inflation similarly increase at impact, causing the central bank to raise its nominal rate. At the same time, investment decreases, which reflects crowd-out amid higher real interest rates after the shock. This, in combination with slowly increasing taxes to combat the now-higher public debt, causes the output- and consumption-responses to turn negative after a few quarters. Quantitatively, however, we see stark differences: As in the THANK model, inflation and the policy rate rise much more in the segmented $\Psi \to \infty$ scenario, which causes the market value of public debt to increase less due to the devaluation of the nominal long-term

Figure 5: Model IRFs: Self-financing



Note: The figure displays IRFs to a one-time transfer shock under $\theta_\pi = 1.05$ and $\theta_y = 0$. B/Y represents the real market value of public debt B^g over annualized GDP. Figures display relative (in %) or percentage point (p.p.) deviations from Steady State.

debt. Additionally, investment declines much less, which, together with public debt-driven increase in aggregate demand, stabilizes the output responses after a few quarters. This contrasts with the consumption response, which looks very similar in either case. This is again reminiscent of the THANK findings, where the consumption response to the stimulus was rather similar despite very different inflation dynamics. Thus, in my overall conventional 2-asset HANK model, the asset market structure remains a key driver of fiscal policy's impact on inflation and equilibrium interest rates. It does not seem work through the consumption behavior usually emphasized by the HANK literature, but now also through the extent to which investment is crowded out by higher public debt. This feature was absent in the THANK analysis.

4.2 Self-financing

In the previous section, we saw that the HANK model's asset market structure again matters significantly for the real fiscal costs of the policy: unlike in the THANK model without steady state government debt, inflation-driven debt devaluations now play an important role. To make this more obvious, Figure 5 again follows Angeletos et al. (2024a) by considering a scenario with a smaller but still "active" monetary response to inflation, $\theta_\pi = 1.05$. To ease comparability with other work, I shut down the output response as well, so $\theta_y = 0$.

Under segmented markets, the response of output is noticeably stronger compared to the baseline, and we notice self-financing features: The real value of public debt even declines at impact, which the fiscal authority's instrument rule translates into even lower net tax rates. This is, however, accompanied by high and persistent inflation. It also contrasts clearly with the response under integrated asset markets: Output eventually declines below its original level due to the capital crowd-out, and we still need noticeable tax increases to stabilize public debt. Clearly, the remarkable possibility of self-financing fiscal stimulus seems to again depend on macro-level assumptions on liquid asset supply and not just the

(again identical) micro-level patterns of consumer behavior.

4.3 Policy rules and determinacy

We can also do an equivalent to the THANK determinacy analysis in 2.7. The results of that exercise are displayed in Figure 6, where the outcomes for the alternative scenarios are contrasted with the ones of a RA version of the model.[18] The RA model naturally provides for the classical Leeper (1991)-dichotomy discussed above. In contrast to the THANK model, however, the assumption of integrated asset markets doesn't result in full equivalence with the RA case. In the ψ_π-range consistent with active fiscal policy in RANK, macroeconomic stability can be achieved with an inflation reaction slightly above one. Moreover, some values in the RANK's "passive fiscal" region work with a θ_B slightly below one. Overall, though, the model's determinacy patterns are very close to a standard RANK economy when contrasted with the segmented $\Psi \to \infty$ case in Figure 6b.
In the latter, we don't only see a much wider "bridge" between the "active fiscal" and "active monetary" regions, but also see that active monetary policy now requires a significant higher ψ_B: Since there is a positive steady state stock of public debt in the 2-asset HANK, the stronger effects on fiscal expansions on interest rates under segmented asset markets raises the governments refinancing costs and thus require stronger adjustment under active fiscal policy.

5 Liquidity Supply and Fiscal Inflation in HANK

In the previous sections, we found that the HANK model's asset market structure crucially shaped its aggregate response to fiscal shocks as well as its determinacy properties. Why is that? As I will elaborate in this section, the key is that the differing scope for public debt to crowd-out other assets strongly affects the impact of public debt on the "natural" or "neutral" rate of interest.

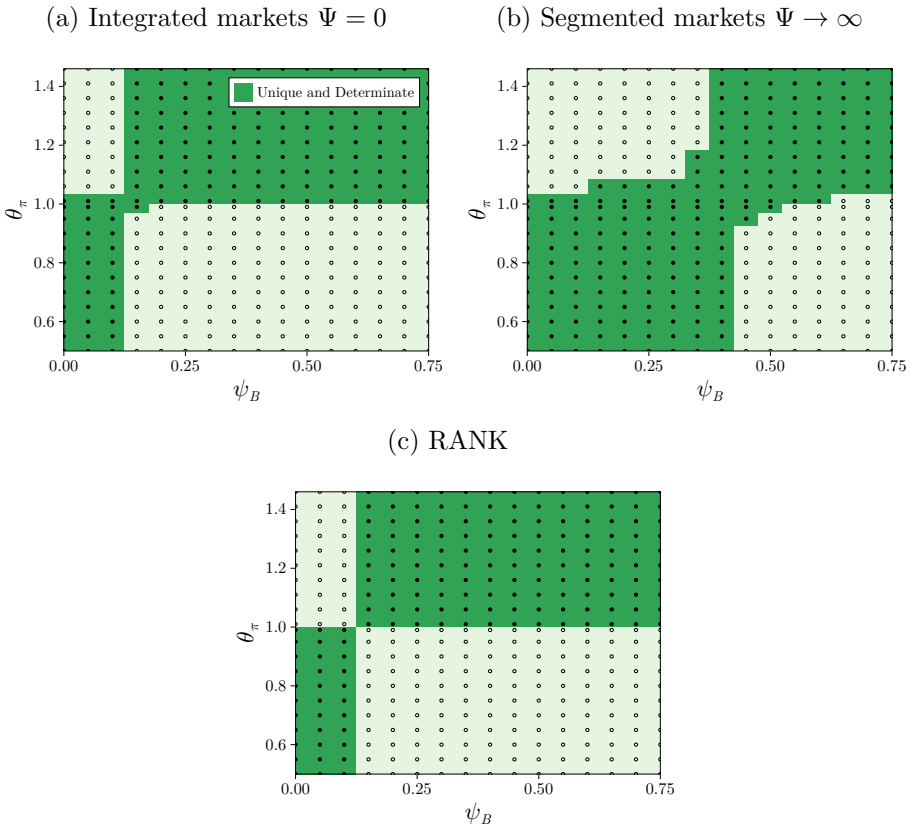
5.1 Public debt and the natural rate

To illustrate the effect of public debt supply on the natural rate in a way abstracting from the model's real and nominal adjustment frictions, I analyze how the return to government bonds changes with public debt in the long run. In either model version, this is equivalent to the change in the long-run natural rate of interest. The exercise involves computing new steady states for higher and lower Debt-to-GDP ratios under the parameterization specified in Section 3.7 and yields Figure 7.[19]

[18] In the RA version, all parameters are unchanged, while the household block is replaced with a representative agent with discount factor $1/(1+r^k_{ss})$. Since a no-arbitrage condition between capital and public debt has to hold in an RA framework, it furthermore assumes integrated asset markets with $\varphi = 0$.

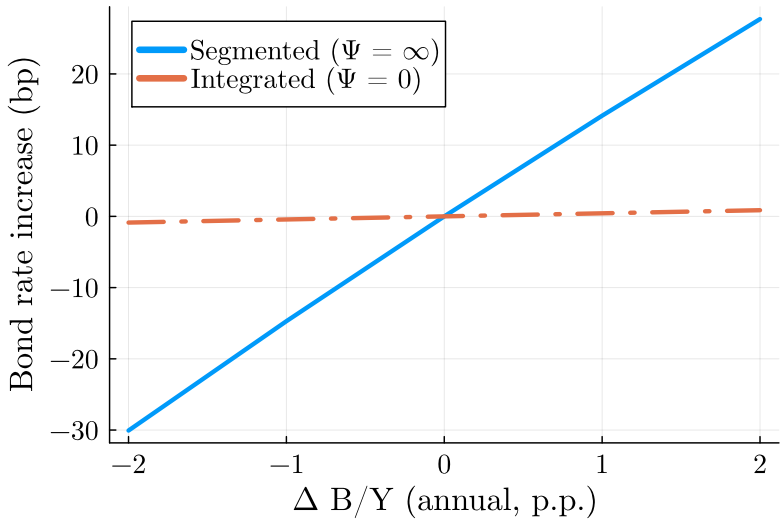
[19] For the exercise, the following assumptions on government policy are made: The central bank adjusts its nominal rate target so that $\pi_{ss} = 1$ is also achieved in the new steady state. At the same time, the fiscal authority keeps G_{ss} at the same value as in the Baseline SS and adapts the tax level τ_t to clear its

Figure 6: Determinacy analyses



Note: Dots indicate the evaluated parameter combinations.

Figure 7: Model: Long-run effects of gov't debt on bond returns



Note: $\Delta B/Y$ denotes the change in the gov't debt-to-GDP ratio compared to the Baseline Steady State.

We clearly see very different impacts of government's debt to supply on the return to its bonds. Under segmented asset markets, a 1 p.p. higher annual Debt-to-GDP ratio causes the annual steady state real treasury return $1/Q^B + (1 - \delta^B)$ to increase strongly by approx. 15 bp. In case of the integrated asset market ($\Psi \to 0$), we have the opposite: The response of the real liquid rate is hardly noticeable.

Considering empirical attempts to estimate the effects of public debt supply, does either of these effects plausible? According to a summary in Rachel and Summers (2019), such estimates indicate medium- to long-term effects of 3 and 6 basis points (bp) per percentage point increase in the Debt-to-GDP ratio. For the purpose of this paper, I take this to be indicative about reasonable steady state effects. Under the segmented market assumption ($\Psi \to \infty$) the effect is much stronger, almost 3 times *more* than the upper end of the empirical estimates. In the integrated asset market part, it is much *smaller*, amounting to not even a third of the empirical estimates' lower range (dashed line).[20]

These results encapsulate insights that should be of interest beyond the immediate focus of this paper on monetary-fiscal interactions: Firstly, it also indicates that assumptions on asset markets are of first-order importance for model-based analyses of secular interest rate changes (such as Platzer and Peruffo, 2022). Secondly, a stronger response of interest rates to public debt supply is often taken to imply a stronger crowd-out of capital (see, e.g., the discussion in Laubach, 2009). The comparison above shows that this does not need to be the case in 2-asset models, as the segmented asset market version provides for less crowd-out than the integrated one.

5.2 The mechanism

Having established that the asset market structure is key for public debt's effect on the long-run natural rate, why should that matter for the differences in aggregate responses and determinacy? The different investment responses in the 2-asset HANK are easy to rationalize, as public debt can freely crowd out capital under integrated but not under segmented markets. But why the differences in inflation? While the previous sections already provided related insights, the analysis below aims to improve understanding with the help of a simple analytical exercise.

In that regard, it is useful to consider a simplified version of the model's central bank reaction function, a textbook Taylor rule of the form

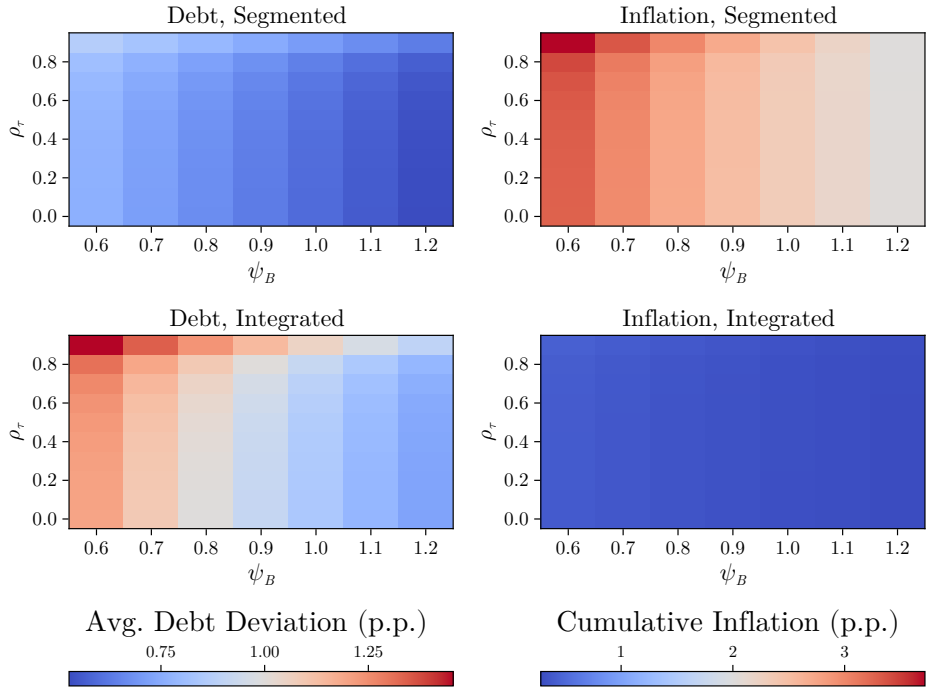
$$1 + i_t = \pi^* R^* + \theta_\pi(\pi_t - \pi^*), \tag{23}$$

allowing for a positive net inflation target π^*. R^* denotes the natural (gross) rate consistent with the steady state level of government debt B^g_{ss}. Now, the amount of government debt in circulation rises temporarily to $B^g_1 > B^g_{ss}$. Notice that we can add and substract a term

budget. For the pure long-run effects, it seems to make little difference whether taxes or G_{ss} are adjusted.

[20] In the THANK model, this is even more extreme: The steady state effects of public debt supply on the steady state interest rates on public debt is even larger under segmented asset markets and exactly 0 in the integrated case.

Figure 8: Debt and Inflation under alternative fiscal policy



Note: Note: The panels on the left-hand size indicate the average percentage-point (p.p.) deviation of public debt (market value) relative to annualized GDP during the first 40 quarters after a one-time transfer shock as in Section 4. The panels on the right-hand side indicate cumulative inflation during the same period.

$\tilde{R}(B_1^g)$ to (23) and re-write it as

$$1 + i_t = \tilde{\pi}_1 \tilde{R}(B_1^g) + \theta_\pi(\pi_t - \tilde{\pi}_1) \quad \text{with} \quad \tilde{\pi}_1 := \pi^* \frac{\theta_\pi - R^*}{\theta_\pi - \tilde{R}(B_1^g)}. \tag{24}$$

If $\tilde{R}(B_1^g) > R^*$, then $\tilde{\pi}_1 > \pi^*$ as long as $\theta_\pi > \tilde{R}(B_1^g)$. So, if public debt rises and the central bank sticks to rule (23) while the current debt-dependent neutral rate $\tilde{R}$ is de facto higher than R^*, the central bank would seem to operate as if having a higher "implicit" inflation target. This effect is the stronger the more equilibrium interest rates depend on public debt supply and active even if the public debt level eventually returns to its original value (and the long-run natural rate doesn't actually change).

To back up that argument, I re-solve the model under various combinations of the parameters ρ_τ and ψ_B that determine the persistence of the tax level and its responsiveness to the value of public debt, respectively.[21] For the same transfer shock as in the previous Section 4, Figure 8 indicates for each of these combinations the induced average deviation of public debt during the first 40 quarters (10 years) as well as cumulative inflation under the that period: The results for the segmented HANK model are displayed in the upper panels and the ones for the integrated $\Psi = 0$ version in the lower ones.

Unsurprisingly, combinations of high ρ_τ and low responsiveness ψ_B result in higher public

[21] All considered combination result in stable and determinate equilibria.

debt. In the segmented asset market HANK, this is systematically associated with significantly stronger increases in the price level. In comparison, in the $\Psi = 0$ case with very small effects of public debt supply on liquid interest rates, we always see lower inflation and a much less pronounced association with public debt, mirroring the THANK case where there was no effect at all. This affirms that the combination of a higher value of public debt and a high responsiveness of the neutral rate to its supply is crucial for the model's inflation response.

Equation (24) is also useful to understand the differences in model determinacy properties. We have

$$\frac{d\tilde{\pi}_1}{d\pi_t} = \frac{\theta_\pi - R^*}{(\theta_\pi - \tilde{R}(B_1^g))^2} \frac{d\tilde{R}(B_1^g)}{dB_1^g} \frac{dB_1^g}{d\pi_t} \tag{25}$$

so if the neutral rate increases in public debt, inflation-induced debt devaluations $\frac{dB_1^g}{d\pi_t}$ increase (decrease) the "implicit" monetary policy stance $\tilde{\pi}_1$ if $\theta_\pi > R^*$ ($\theta_\pi < R^*$). This counteracts the extent to which the central bank induces higher (lower) real interest rates in response to inflation and thus results in a fuzzy separation between "active" and "passive" monetary policy. (25) furthermore suggests this to become more pronounced the stronger the effect of public debt on the neutral rate, i.e. the higher $\frac{d\tilde{R}(B_1^g)}{dB_1^g}$ is, which rationalizes the stronger deviation from RANK under segmented markets. Additionally, consider that if $\frac{d\tilde{R}(B_1^g)}{dB_1^g}$ is high, positive deviatons of public debt raise fiscal authority's real refinancing costs more strongly and a higher ψ_B is necessary to stabilize debt in the absence of a favorable monetary policy stance.

5.3 The role of household heterogeneity

Above, we saw that different asset market structures in HANK models importantly shape their implications for monetary and fiscal interactions. Yet, it is unrelated to household heterogeneity in that various assumptions are consistent with the same steady state micro moments. How do these effects not present in typical RA models come about then?

We already saw in Section 2.5 that in the THANK model, a higher probability of becoming constrained increases the sensitivity of the natural rate of interest with respect to public debt, *conditional* on asset markets being segmented. Indeed, there is a similar link with distributional moments in the two-asset model: As is well known, such frameworks need to feature a sufficiently high gap between the return on liquid and illiquid assets to give rise to relatively high MPCs (c.f. Kaplan and Violante, 2022). With that, the model can generate a substantial number of Wealthy HtM agents as households are incentivized to forego holding large amounts of liquidity in order to reap the illiquid assets' higher returns. In that case, however, it also seems intuitive that if agents are to hold more liquid government bonds, they will have to be compensated with substantially higher returns. This argument, in turn, predicts the interest rate effects of public debt in 2-asset HANK models with *segmented* asset markets to be closely linked to their initial return gap and MPCs.

To analyze the link between the initial return gap and interest rate effects of public debt supply in the segmented $\Psi = \infty$ case more formally, I re-calibrate my baseline framework to provide for lower steady state return gaps. In particular, I aim for the new parameterization to remain consistent with the aggregate moments targeted in 3.7 and just increase the long-run rate of capital depreciation δ_0: Keeping all other externally-set parameters the same and matching the same targets, increasing δ_0 in several steps from 0.0175 to 0.025 (still a common calibration choice) will yield substantially lower capital returns and thus rate gaps in the resulting stationary equilibria.[22] A summary of the respective parameter results is provided in Appendix Table F.5: Overall, if the model is to remain compatible with the same moments under a lower returns gap, it requires a higher λ (i.e., capital to be less illiquid) and households to be more patient (higher β). The former is because the lower rate gap makes capital relatively less attractive, so it needs to be less illiquid for the aggregate household portfolio to remain the same. In turn, the latter is necessary as a higher δ_0 decreases the returns of capital. This obliges households to be more patient if they are to still hold the same amount.

Figure 9 then visualizes the implications of different initial return gaps: In Panel 9a, we see that calibrating the model to be consistent with a lower initial return gap indeed decreases the long-run elasticity of government bond returns with respect to bond supply in the case of segmented asset market (solid line). In fact, it can even generate a response within the 3-6 b.p. range if the return gap is low enough. But as Panel 9b illustrates, this comes at the cost of having substantially lower average MPCs and few HtM households. In line with the THANK model, under *integrated* asset markets, the response of interest rates to public debt supply doesn't change much with the calibration and is always low (dashed line in Panel 9a).

5.4 Disciplining the asset market

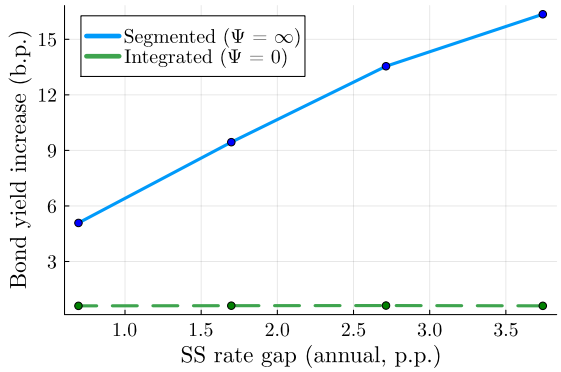
Overall, the above results for the off-the-shelf assumptions on asset market structure are somewhat unsatisfying. This is not only because they fail to generate certain results, but also indicate a drawback of heterogeneous agent business cycle theory: While related frameworks can relate to rich cross-sectional evidence, they may also require subtle modelling choices that matter for aggregate outcomes but cannot be disciplined by micro evidence alone. Instead, further macro-discipline is required as well.

Of course, my set-up casting the model's asset market structure in terms a single parameter Ψ immediately suggests a resolution for the particular issue at hand: If the effects of public debt supply on its returns are overly strong for $\Psi \to \infty$ and overly weak for $\Psi \to 0$, then a value in between will presumably result in a reasonable magnitude. To explore this possibility, Figure 10 displays, for different values of Ψ, how much the steady state return of treasury securities changes after a long-run 1 p.p. increase in the Debt-to-

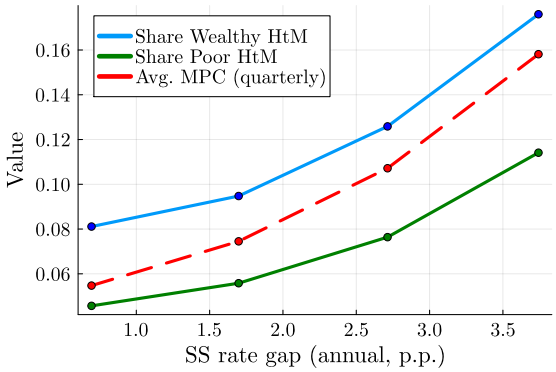
[22] This exploits the close connection between capital returns and the (targeted) K/Y-ratio in Cobb-Douglas production functions: In steady state, (46) requires $r^k_t = \alpha \frac{1}{\mu_{ss}} \frac{Y}{K} - \delta_0$.

Figure 9: Implications of steady state return gaps

(a) Liquid rate elasticity



(b) Micro-moments



Note: Note: "Bond Yield Increase" refers to the difference of the annualized bond yield $\frac{1}{Q^b} + (1 - \delta^B)$ from the calibrated Steady State after solving for a new stationary equilibrium with 1 p.p. higher annual Debt-to-GDP ratio. "SS rate gap" denotes the difference between annualized r^k and r^l in the calibrated steady state.

GDP ratio. The mapping between Ψ and the long-run return effect is clearly monotone, which reassures us that targeting the latter is well-suited to pin down Ψ. We see that for values between 0.003 and 0.0075, the liquid return reaction in the model economy is indeed in line with the range from Rachel and Summers (2019). As baseline calibration, I will adopt $\Psi = 0.005$, which results in a response close to Laubach (2009)'s estimate of 4 basis points.

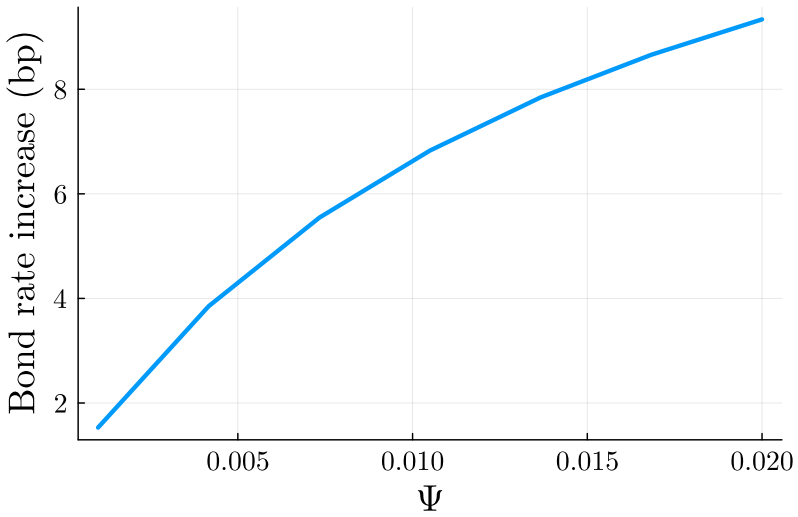
6 How relevant is public debt's liquidity value for monetary policy?

Having proposed a calibration for the HANK's model asset market segmentation in Section 5, we can now examine whether the liquidity margin of Ricardian equivalence still provide for meaningful monetary-fiscal interactions once reasonably disciplined. In that regard, I start with the simple fiscal shock and determinacy exercise familiar from Section 4, before moving on to a richer scenario inspired by the US post-2020 episode.

6.1 Simple fiscal shock and determinacy

Figure 11a provides the model responses already analyzed in Section 4 and contrasts them with the calibrated model version featuring $\Psi = 0.005$. Overall, the responses resemble the model version with integrated $\Psi = 0$ asset market much more than the segmented case. Compared to the former, investment turns out slightly higher while inflation and the policy rate remain low-key elevated following the shock. Naturally, the latter is due to the still-elevated public debt exerting upward pressure on the neutral rate. Overall, while

Figure 10: Treasury return responses by Ψ



Note: Note: "Bond rate increase" refers to the difference of the annualized bond yield $\frac{1}{Q^b} + (1 - \delta^B)$ from the calibrated Steady State after solving for a new stationary equilibrium with 1 p.p. higher annual Debt-to-GDP ratio.

the calibrated version naturally retains the fiscal non-neutrality stemming from the presence of constrained households, the additional relevance of government-provided liquidity seems rather moderate. Of course, this is for a scenario in which the overall increase in debt is moderate and expected to be reined in within a few years.

The similarity between the calibrated and fully integrated asset market setups also carries over to the self-financing exercise: Compare Appendix Figure G.4. Turning to determinacy, the related results are displayed in Figure 11b. As for the fiscal IRFs, the result is "in between" the ones for the segmented and integrated cases. Nevertheless, the parameter region providing for a unique stable equilibrium doesn't closely resemble the four RANK quadrants as in Figure 6c that closely. So, even the disciplined liquidity value of public debt provides for a noticeable deviation from the RA case.

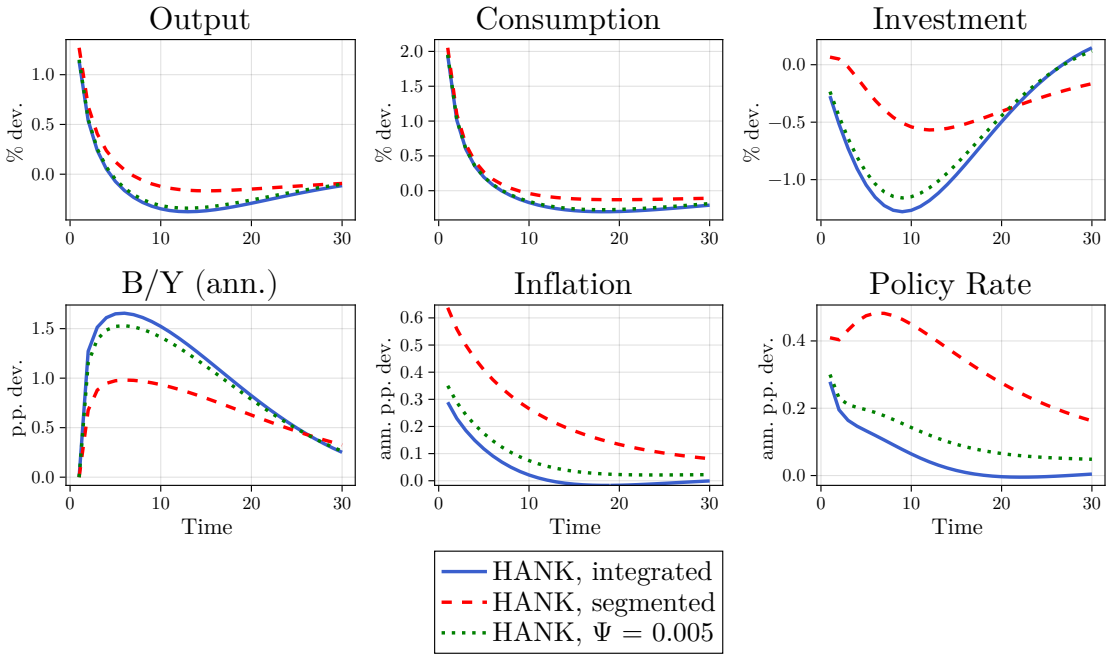
6.2 An application to the post-2020 US

The liquidity effect of public debt supply seemed to be of limited relevance for monetary policy in the simple scenario above. Does that change in a situation with a large and longer-lived fiscal expansion? To provide an answer with real-world relevance, I apply my model to the post-2020 US in a stylized experiment. To analyze and conduct counterfactuals for this episode, we need the model to generate a situation in line with the economic dynamics of that time. Hence, I use a filtering algorithm proposed by McKay and Wieland (2021) to obtain sequences of 5 aggregate shocks that make the framework match the evolution of 5 aggregate variables during the period 2020:Q1-2024:Q2.[23] The various details and caveats

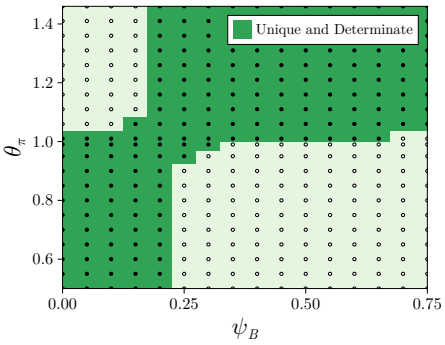
[23]This period was chosen to sidestep the challenge of having to relate the model to the numerous economic governance changes due to the re-election of US President Trump.

Figure 11: Model Results for $\Psi = 0.005$

(a) Model IRFs to transfer shock

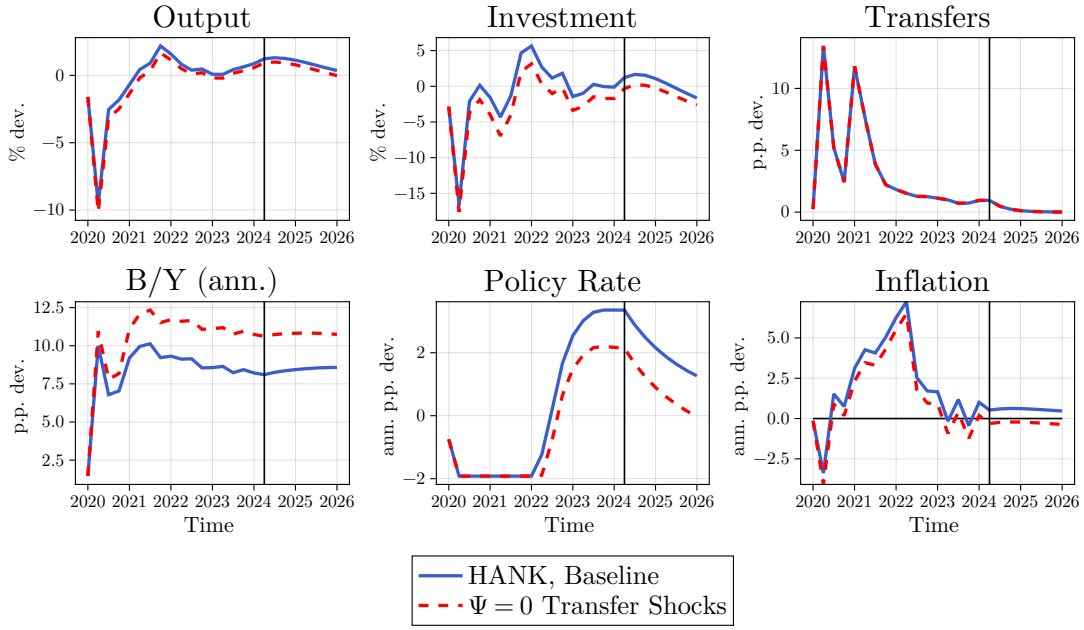


(b) Determinacy analysis



Note: In Subfigure 11a, B/Y represents the real market value of public debt B^g over annualized GDP. All lines display relative (in %) or percentage point (p.p.) deviations from Steady State. In Subfigure 11b, dots indicate the evaluated parameter combinations.

Figure 12: Aggregate dynamics using filtered shocks



Note: B/Y represents the market value of public debt B^g over annualized GDP.

of this exercise are in Appendix D, but note that my model doesn't explicitly provide for Covid-specific features and instead uses standard business cycle shocks.

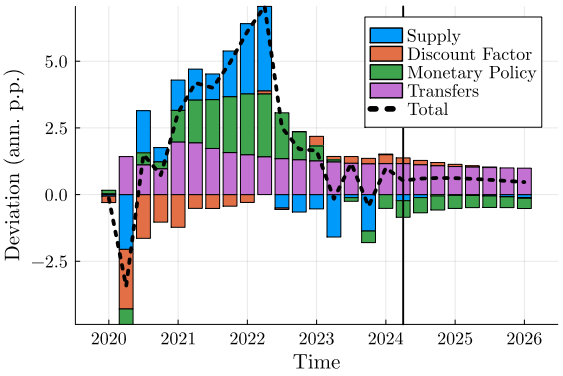
Using the set of aggregate shocks obtained as described, one can simulate the model from 2020:Q1 forward: The dynamics of several key macroeconomics aggregates are displayed as the blue solid line ("Baseline") in Figure 12. Note that by construction, the time paths of all displayed variables except the public debt variable (B/Y) and consumption equal their counterparts in the data until my sample ends in 2024:Q2 (indicated by the black vertical line). Beyond that point, the model is simulated forward without any additional shocks hitting, implying the targeted variables deviate from their empirical counterparts.

In the beginning of 2020, we see real variables such as output and investment take a big hit, accompanied by declining inflation and the central bank's policy rate hitting its ELB. Through the lens of the model, this is due to a combination of households' Covid-related consumption restraints (a discount factor shock) and an unfavorable investment technology disturbance. At the same time, public debt relative to GDP jumps up, both due to the decline in the denominator and a big shock to transfers, the targeted time path of which is displayed in the top-right panel. Of course, as I also illustrate in Appendix D.1, the model increase in debt is smaller than its relevant counterpart in the data, given that I targeted only transfer spending and not other fiscal variables.

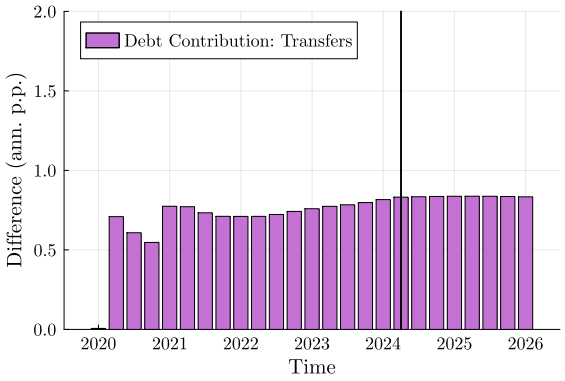
Afterwards, the economy recovered quite quickly: In the HANK model, this is partly due to the initial shocks easing quicker than expected, i.e., expansionary discount factor- and investment technology innovations, and also aided by accommodative monetary policy

Figure 13: Model-implied drivers of inflation

(a) Decomposition of inflation



(b) Inflation Differences



Note: In Subfigure 13a, "Supply" collects the impact of both the "cost-push"- and the investment technology shock. Subfigure 13b displays the difference between inflation in the Baseline model and the scenario with counterfactual propagation of the Transfer shocks, i.e., the difference between the blue and red-dashed line in the "Inflation" panel of Figure 12.

as well as another spike of transfers at the beginning of 2021 (the American Rescue Plan Act). Eventually, inflation started to rise precipitously amid output and consumption above their pre-covid trends, inducing the Federal Reserve (Fed) to start raising its nominal rate in the beginning of 2022. Price pressures eased quickly initially, but inflation remains elevated above target and according to the models' out-of-sample prediction it would be for quite some time into the future, as it subsequently turned out to be. At the same time, the model's value of public debt relative to GDP has not substantially declined since its peak at the beginning of the pandemic.[24] Naturally, by now we expect the final two phenomena to be linked.

Are the implied model dynamics plausible considering non-targeted model moments and subsequent (non-matched) macroeconomic dynamics for the US? A respective analysis is provided in Appendix D.1. To briefly summarize its results, the model has difficulties relating to some labor market moments during the initial Covid-pandemic and -recovery phase. This is arguably not surprising, as its simple labor-market setup is ill-suited to capture the many specifics of the Covid unemployment surge. Nevertheless, the fact that it matches later developments in aggregate labor compensation suggests that it captures important economic drivers of the later inflationary period. Additionally, the model's unconditional forecasts of the time paths of inflation and interest rates beyond 2024:Q2 seem roughly in line with expectations at the time.

6.3 Post-2020 US: Model-implied determinants of Inflation

To better understand to what extent public debt's liquidity effect is related to the persistent last mile inflation in the model, Figure 13a exploits the linearity of the model solution to decompose the inflation response into the contribution of different shocks. The model rationalizes the deflation at the beginning of the Covid pandemic with the said combination of discount factor- and supply shocks, partly counteracted by the strong increase in transfers.[25] Interestingly, while the McKay and Wieland (2021) filtering method assigns the 2022 peak in inflation to adverse supply shocks, it also suggests the combination of government transfers and accommodative monetary policy to be the key drivers of inflation during 2021-2022. My model exercise is thus in line with the findings of Giannone and Primiceri (2024) who argue such "demand side" factors to be the most important determinants of the post-Covid price pressures. Incidentally, the strong decline of inflation in 2022:Q3 is interpreted to be due to an unexpected easing (negative innovations) of "cost push"-shocks, which aligns with a decrease of the oil price and an easing of supply chain bottlenecks at the time.

From the perspective of this paper's topic though, the most interesting observation is the persistent impact of the transfer shocks. Additionally, considering the time path for transfers as on Figure 12, we see that they retain a strong influence on inflation for an extended period of time after their peaks in 2020 and 2021. Indeed, the model suggests them to be the sole reason for inflation staying above target after 2023 and the continuing upward pressure on inflation going forward. To what extent is this due to transfers remaining above trend at the time as compared to the interest rate pressure exerted by the public debt stemming from previous transfers?

To gauge the importance of the transfer-induced debt as compared to current transfer levels, I again make use of the linearity of my model solution, which provides for a $MA(\infty)$-representation in that the time path of a variable model variable x_i can be expressed as

$$x_{it} = \bar{x} + \sum_{e=1}^{n_e} \sum_{i=0}^{\infty} \Theta_x^e(i) \epsilon_{t-i}^e \quad ,$$

where $\Theta_x^e(i)$ denotes the i'th entry of the IRF of variable x with respect to shock e. Specifically, I simulate my model using that representation but propagate the transfer shocks according to the "wrong" IRF from the $\Psi = 0$ economy with integrated asset markets: This attempts to (almost) "shut down" the effect of transfer-related public debt supply on aggregate demand and liquid asset returns. The result of this model exercise is displayed as the red-dashed line in Figure 12. We see that in the absence of that channel, the post-Covid inflation would have practically been over in the beginning of 2023 and remain at or below the Fed's target afterwards. As in Section 6.1 above, this is accompanied by a less pronounced central bank reaction, lower investment as well as a more pronounced increase in the value of government debt. While the differences in

[24] Under the fiscal rule in place, public debt would be expected to start declining in late 2026.

[25] The negative contribution of Monetary Policy reflects the binding nominal interest ELB.

inflation may seem small compared to the very high inflation peaks in 2022, Figure 13b indicates them to be of a relevant size, amounting to more than 0.8 p.p. in annualized terms at the end of 2023.

An alternative way to arrive at a similar conclusion is re-doing the filtering exercise for the $\Psi = 0$ economy: In that case, the corresponding inflation decomposition (relegated to Appendix Figure G.5) assigns much less importance to the transfers but rather attributes the realized inflation to other shocks. It also predicts less inflation persistence going forward. Overall, the model thus suggests that public debt-driven demand pressure may plausibly exert relevant inflationary effects in the aftermath of big fiscal expansions, to the extent that it could quantitatively generate the US's post-2023 last mile inflation persistence.

7 Concluding Remarks

This paper studied monetary-fiscal interactions in a quantitative HANK model. While previous works emphasized the implications of household consumption- and savings behavior of such models, I highlight that several key outcomes depend substantially on the typically less prominent asset market structure. In particular, this is the case for the inflationary effects of fiscal policy, model determinacy properties and the fiscal costs of stimulus policies. Effectively, it does not just matter whether households have high MPCs and hold little liquid assets, but also how fundamentally scarce these liquid assets are. While the potential importance of the latter depends on the micro-moments a model generates, it cannot be determined from them and thus needs to be disciplined separately. In a benchmark 2-asset HANK model, doing so restricts the liquidity supply channel of Ricardian non-equivalence, but not enough to render it irrelevant for policy. In a stylized model experiment on the US post-Covid inflation, it is strong enough to generate the elevated "last mile" inflation in 2023 and afterwards. A central bank can, however, effectively counteract it by reacting directly to the stock of public debt.

Regarding future work, my paper pinpoints a need to thoroughly assess and discipline the asset market structure of rich heterogeneous agent models. While I address this with a simple model extension, more detailed micro-foundations may provide for interesting policy implications. Additionally, it remains an open question how optimal central bank policy should account for the liquidity effects of public debt in settings with rich household heterogeneity.

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Appendix

A Derivations for the Tractable HANK model

A.1 Steady State derivations

With time-invariant C^H and C^S, we can re-arrange the Euler equation (2) to obtain

$$\frac{C^S}{C^H} = \left(\frac{1-\beta s R^A}{\beta(1-s)R^A}\right)^\sigma.$$

Given that in steady state $C^H = ((1-(1-\varphi)R^B\mathcal{B}-\mathcal{G})Y_{ss} - \lambda C_{ss})/(1-\lambda)$ and $C^S = \omega(1-\tau^y)w_{ss}N_{ss} + \bar{\tau} + \frac{(1-\lambda)(1-s)}{\lambda}R^A B_{ss}$, we obtain a non-linear equation that can be solved for R^A. If log-utility $\sigma \to 1$ is assumed, we can simplify it to

$$\frac{(1-(1/\varphi-1)R^A\mathcal{B}-\mathcal{G})/(1-\lambda)}{\frac{\omega(1-\mu\mathcal{T})}{1-\lambda+\lambda\omega} + \mathcal{T} + \frac{(1-\lambda)(1-s)}{\lambda}R^A\mathcal{B}} - \frac{\lambda}{1-\lambda} = \frac{1-\beta s R^A}{\beta(1-s)R^A} \tag{26}$$

which uses that $A_{ss} = B_{ss} = \mathcal{B}Y_{ss}$, $\varphi R^B = R^A$ and $\bar{\tau} = \mathcal{T}Y_{ss}$ by assumption as well as $N_{ss} = \frac{Y_{ss}}{(1-\lambda+\lambda\omega)}$. This can be re-arranged to obtain a quadratic equation in R^A which has a closed-form solution in principle, but the resulting expression is very tedious and in turn not very enlightening. However, analytically convenient expressions can be obtained if $\omega \to 0$ and $\mathcal{T} \to 0$, i.e. if the H household has no labor income. In that case, we can arrange (26) to obtain

$$\begin{aligned}\frac{(1-\mathcal{G})\lambda}{(1-\lambda)\mathcal{B}} - \frac{\lambda}{1-\lambda}(1-s)\left(1+\frac{1/\varphi-1}{1-s}\right)R^A &= \frac{1}{\beta} - sR^A \\ \Leftrightarrow R^A &= \frac{1}{\beta}\frac{1-\lambda}{(s-\lambda/\varphi)} - \frac{\lambda(1-\mathcal{G})}{(s-\lambda/\varphi)\mathcal{B}}\end{aligned}$$

i.e., an expression that cleanly links the steady state liquid return to the debt-to-GDP ratio $\mathcal{B}$. Focussing on the practically relevant case with $s > \lambda/\varphi$, we have

$$\frac{\partial R^A}{\partial \mathcal{B}} = \frac{(1-\mathcal{G})\lambda}{(s-\lambda/\varphi)\mathcal{B}^2} > 0 \quad \text{and} \quad \frac{\partial^2 R^A}{\partial \mathcal{B}^2} = -\frac{2(1-\mathcal{G})\lambda}{(s-\lambda/\varphi)\mathcal{B}^3} < 0,$$

i.e., the interest rate on liquid assets is increasing and concave in the debt-to-GDP ratio. Additionally, note that

$$\frac{\partial \lambda}{\partial s} = \frac{h-1}{(2-s-h)^2} < 0,$$

so

$$\frac{\partial^2 R^A}{\partial s \partial \mathcal{B}} = \frac{1-\mathcal{G}}{\mathcal{B}^2}\frac{\frac{\partial\lambda}{\partial s}(s-\lambda/\varphi) - \lambda(1-\frac{\partial\lambda}{\partial s}\frac{1}{\varphi})}{(s-\lambda/\varphi)^2} = \frac{1-\mathcal{G}}{\mathcal{B}^2}\frac{\frac{\partial\lambda}{\partial s}s - s\lambda/\varphi}{(s-\lambda/\varphi)^2} < 0$$

meaning that the sensitivity of the liquid return to the debt-to-GDP ratio is decreasing in s.

A.2 Log-Linearization

We begin with log-linearizing the equations that are common to all model versions around $B_{ss} = A_{ss} = 0$:

- Aggregate resource constraint:

$$C_t = Y_t - (1/\varphi - 1)R_t^A A_t - G \implies \hat{c}_t = \frac{1}{1-\mathcal{G}}\hat{y}_t - \frac{1-\varphi}{\beta(1-\mathcal{G})}\tilde{a}_t.$$

  Since $A_{ss} = 0$ around the steady state, linearize w.r.t to $\tilde{a}_t = A_t/Y_{ss}$ instead. Recall that $R_{ss}^A = \varphi/\beta$.

- Production:

$$Y_t = L_t = (1 - \lambda + \lambda\omega)N_t \implies \hat{y}_t = \hat{n}_t$$

- Labor supply:

$$C_t^{-\sigma}(1-\tau^y)w_t = \varsigma N_t^{\phi} \implies \hat{w}_t - \sigma\hat{c}_t = \phi\hat{n}_t \implies \hat{w}_t = \underbrace{\left(\phi + \frac{\sigma}{1-\mathcal{G}}\right)}_{:=\Phi}\hat{y}_t - \frac{\sigma\tilde{\varphi}}{(1-\mathcal{G})}\tilde{a}_t$$

  where $\tilde{\varphi} := \frac{1-\varphi}{\beta}$.

- Consumption of H households: Since $A_{ss} = T_{ss} = 0$ in the steady state, linearize w.r.t to $\tilde{a}_t = A_t/Y_{ss}$ and $\tilde{t} = T_t/Y_{ss}$ instead.

$$\begin{aligned} C_t^H &= (1-\tau^y)w_t N_t\omega + \frac{(1-\lambda)(1-s)}{\lambda}R_t^A A_t + \bar{\tau} + T_t \\ \implies \hat{c}_t^H &= \delta(\hat{w}_t + \hat{n}_t) + \underbrace{\frac{(1-\lambda)(1-s)}{\lambda}R_{ss}^A\frac{Y_{ss}}{C_{ss}^H}}_{:=\alpha}\tilde{a}_t + \frac{Y_{ss}}{C_{ss}^H}\tilde{t}_t \\ &= \delta\left[(\Phi+1)\,\hat{y}_t\right] + \underbrace{(\alpha - \delta_a)}_{:=\tilde{\alpha}}\tilde{a}_t + \frac{Y_{ss}}{C_{ss}^H}\tilde{t}_t \end{aligned}$$

$$\delta := \frac{\omega(1-\tau^y)w_{ss}N_{ss}}{C_{ss}^H} = \frac{\omega(1-\tau^y)w_{ss}N_{ss}}{\omega(1-\tau^y)w_{ss}N_{ss} + \bar{\tau}} \in (0,1)$$

  and $\delta_a := \delta\frac{\sigma(1-\varphi)}{\beta(1-\mathcal{G})}$.

- Consumption of S households:

$$\begin{aligned} C_t^S &= (Y_t - (1/\varphi - 1)R_t^A A_t - G - \lambda C_t^H)/(1-\lambda) \\ \implies \hat{c}_t^S &= \underbrace{\frac{1}{1-\lambda}\frac{Y_{ss}}{C_{ss}^S}}_{:=\theta_y}\left[\hat{y}_t - \tilde{\varphi}\tilde{a}_t\right] - \underbrace{\frac{\lambda}{1-\lambda}\frac{C_{ss}^H}{C_{ss}^S}}_{:=\theta_h}\hat{c}_t^H \\ &= \underbrace{(\theta_y - \theta_h\delta(\Phi+1))}_{:=\Theta}\hat{y}_t - \underbrace{[\theta_y\tilde{\varphi} + \theta_h\tilde{\alpha}]}_{:=\Theta_a}\tilde{a}_t - \theta_h\frac{Y_{ss}}{C_{ss}^H}\tilde{t}_t \end{aligned}$$

- Euler equation for liquid assets:

$$(C_t^S)^{-\sigma} = \beta \mathbb{E}_t R_{t+1}^A \left[s(C_{t+1}^S)^{-\sigma} + (1-s)(C_{t+1}^H)^{-\sigma} \right]$$
$$\implies \hat{c}_t^S = -\frac{1}{\sigma} \mathbb{E}_t \hat{r}_{t+1}^A + \chi \mathbb{E}_{\approx} c_{t+1}^S + (1-\chi) \mathbb{E}_{\approx} c_{t+1}^H$$
$$\text{where } \chi := \frac{s(C_{ss}^S)^{-\sigma}}{s(C_{ss}^S)^{-\sigma} + (1-s)(C_{ss}^H)^{-\sigma}} \in (0,1)$$

  Note that since φ is assumed to fulfil (7) so as to have steady state equivalence, we have $\chi = s\varphi$.

- Euler equation for illiquid assets:

$$(C_t^S)^{-\sigma} = \beta \mathbb{E}_t R_{t+1}^I (C_{t+1}^S)^{-\sigma} \implies \hat{c}_t^S = -\frac{1}{\sigma} \mathbb{E}_t \hat{r}_{t+1}^I + \mathbb{E}_t \hat{c}_{t+1}^S$$

  This is the standard log-linear Euler equation.

- Budget constraint of the government: Recall that we are linearizing around a steady state with $B_{ss} = 0$ and $R_{ss}^B = 1/\beta$.

$$\begin{aligned} B_{t+1} &= R_t^B B_t + T_t + \bar{\tau} + G - \tau^y w_t L_t + (1-\lambda)\tau_t \\ \implies \tilde{b}_{t+1} &= \frac{1}{\beta}\tilde{b}_t + \tilde{t}_t - (1-\lambda)\tilde{\tau}_t - \frac{\tau^y w_{ss} L_{ss}}{Y_{ss}}(\hat{w}_t + \hat{n}_t) \\ &= \frac{1}{\beta}\tilde{b}_t + \tilde{t}_t - (1-\lambda)\tilde{\tau}_t - \underbrace{\tau^y w_{ss}}_{:=\phi_\tau}(\hat{w}_t + \hat{n}_t) \\ &= \frac{1}{\beta}\tilde{b}_t + \tilde{t}_t - (1-\lambda)\tilde{\tau}_t - \phi_\tau \left[(\Phi + 1)\, \hat{y}_t - \frac{\sigma\tilde{\varphi}}{(1-\mathcal{G})}\tilde{a}_t \right] \end{aligned} \tag{27}$$

  where the last expression substitues $\hat{w}$ and $\hat{n}$.

- No-profit condition for Liquid Asset Funds:

$$\mathbb{E}_t R_{t+1}^A = \varphi \mathbb{E}_t R_{t+1}^B = \varphi \mathbb{E}_t \frac{1+i_{t+1}}{1+\pi_{t+1}} \implies \mathbb{E}_t \hat{r}_{t+1}^A = \mathbb{E}_t \hat{r}_{t+1}^B = \left(\hat{i}_t - \mathbb{E}_t \hat{\pi}_{t+1} \right)$$

  since φ is assumed to be constructed so that $R^B = 1/\beta$.

To derive the IS condition for the baseline THANK model with segmented asset markets, we can plug the the expression for $\hat{c}_t^H$ and $\hat{c}_t^S$ into the Euler equation for liquid assets to obtain

$$\Theta \hat{y}_t = \underbrace{(\chi\Theta + (1-\chi)\delta(1+\Phi))}_{:=\Gamma} \mathbb{E}_t \hat{y}_{t+1} - \frac{1}{\sigma}\left(\hat{i}_t - \mathbb{E}_{\approx} \hat{\pi}_{t+1} \right) + \underbrace{((1-\chi)\tilde{\alpha} - \chi\Theta_a)}_{:=\Gamma_a} \tilde{a}_{t+1} + \Theta_a \tilde{a}_t$$

where the last terms are zero if fiscal policy implements $\tilde{b}_t = \tilde{a}_t = \tilde{t}_t = 0$. For the alternative model with integrated asset markets, we can make use its additional no-arbitrage condition $\mathbb{E}_t R_{t+1}^I = \mathbb{E}_t R_{t+1}^B = \mathbb{E}_t R_{t+1}^B \implies \mathbb{E}_t \hat{r}_{t+1}^I = \hat{i}_t - \mathbb{E}_t \hat{\pi}_{t+1}$. Using that in the illiquid asset Euler equation, we obtain

$$\hat{c}_t^S = -\frac{1}{\sigma}\left(\hat{i}_t - \mathbb{E}_t \hat{\pi}_{t+1} \right) + \mathbb{E}_t \hat{c}_{t+1}^S$$
$$\implies \Theta \hat{y}_t = \Theta \mathbb{E}_t \hat{y}_{t+1} - \Theta_a(\tilde{a}_{t+1} - \tilde{a}_t) - \frac{1}{\sigma}\left(\hat{i}_t - \mathbb{E}_t \hat{\pi}_{t+1} \right)$$

It is further useful to note that under integrated asset markets, if we substitute c_t^S in the liquid asset Euler equation, we get

$$0 = (\chi - 1)\mathbb{E}_t\hat{c}_{t+1}^S + (1-\chi)\mathbb{E}_t\hat{c}_{t+1}^H - \frac{1}{\sigma}(\hat{i}_t - \mathbb{E}_{\approx}\hat{\pi}_{t+1} - \mathbb{E}_t\hat{r}_{t+1}^I)$$

which, given that the no-arbitrage condition between liquid and illiquid assets requires $\hat{i}_t - \mathbb{E}_{\approx}\hat{\pi}_{t+1} - \mathbb{E}_t\hat{r}_{t+1}^I = 0$, implies $\mathbb{E}_t\hat{c}_{t+1}^S = \mathbb{E}_t\hat{c}_{t+1}^H$. This means the expected deviations (but not the levels) of consumption of S and H households are equalized in this case. Given this result, we can recover the liquid asset from dynamics as

$$\begin{aligned}\mathbb{E}_t\hat{c}_{t+1}^S = \mathbb{E}_t\hat{c}_{t+1}^H \implies \mathbb{E}_t\left(\Theta\hat{y}_{t+1} - \Theta_a\tilde{a}_{t+1}\right) &= \mathbb{E}_t\left(\delta\left[(\Phi+1)\,\hat{y}_{t+1}\right] + \tilde{\alpha}\tilde{a}_{t+1}\right) \\ \implies \tilde{a}_{t+1} = \underbrace{\frac{\Theta - \delta(1+\Phi)}{\Theta_a + \tilde{\alpha}}}_{:=\Lambda}\mathbb{E}_t\hat{y}_{t+1}&\end{aligned}$$

(recall that $\tilde{a}_{t+1}$ is determined at time t). While denominator of Λ is positive under any reasonable parameterization, the nominator must be positive if $\Gamma > \Theta$, as

$$\Gamma > \Theta \Leftrightarrow \frac{\chi\Theta + (1-\chi)\delta(1+\Phi)}{\Theta} > 1 \Leftrightarrow (1-\chi)\frac{\delta(1+\Phi)}{\Theta} > 1-\chi$$

and ≤ 0 if not. If no shock moving $\hat{y}_t$ occurs in period t, we have $(\tilde{a}_{t+1} - \tilde{a}_t) = \Lambda(\mathbb{E}_t\hat{y}_{t+1} - \hat{y}_t)$ and thus

$$\hat{y}_t = \mathbb{E}_t\hat{y}_{t+1} - \frac{1}{\sigma\left(\Theta - \Theta_a\Lambda\right)}\left(\hat{i}_t - \mathbb{E}_t\hat{\pi}_{t+1}\right).$$

Note that

$$\Omega := \Theta - \Theta_a\Lambda = \Theta - \underbrace{\frac{\Theta_a}{\Theta_a + \tilde{\alpha}}}_{\in(0,1)}\left(\Theta - \delta(1+\Phi)\right) > 0.$$

and that $\Omega < \Theta$ if $\Gamma < \Theta$ and $\Omega > \Theta$ if $\Gamma > \Theta$.

Finally, since $\hat{w}_t = \Phi\hat{y}_t - \sigma(1-\varphi)\tilde{a}_t$, the New Keynesian Phillips curve $\pi_t = \kappa_w\hat{w}_t + \beta\mathbb{E}_t\pi_{t+1}$ becomes

$$\pi_t = \kappa\hat{y}_t - \kappa_a\tilde{a}_t + \beta\mathbb{E}_t\pi_{t+1} \tag{28}$$

with $\kappa_a := \kappa_w\sigma\tilde{\varphi}/(1-\mathcal{G})$. The additional term appears since the cost of liquidity provision affects the level of consumption and thus the labor supply condition. While this effect should be very small for reasonable parameterizations, it is not 0 at first order. If $\tilde{b}_t = 0$ in the baseline model version, the conventional NKPC is recovered. For the integrated asset market version, we have $\tilde{a}_t = \Lambda\hat{y}_t$ without any shocks hitting, in which case (28) is isomorphic to the standard case with adjusted slope $\tilde{\kappa} = \kappa - \kappa_a\Lambda$.

A.3 Analysis of the simple fiscal shock

We start by deriving the responses of output and inflation to the baseline model in which necessarily $\tilde{a}_t = \tilde{b}_t$. Since $\tilde{t}_t = 0$ for $t \geq 1$, the IS relationship in these periods is given by

$$\Theta\hat{y}_t = \Gamma\mathbb{E}_t\hat{y}_{t+1} - \frac{1}{\sigma}\left(\hat{i}_t - \mathbb{E}_t\hat{\pi}_{t+1}\right) + \Theta_a\tilde{b}_t + \Gamma_a\tilde{b}_{t+1}$$

Given the exogenous process $\tilde{b}_{t+1} = \rho_b \tilde{b}_t$, we can use the methods of undetermined coefficients to solve for the responses of output and inflation for $t \geq 1$. Conjecture that $\hat{y}_t = \psi_y b_t$ and $\hat{\pi}_t = \psi_\pi b_t$. Plugging this into the above equation and the Phillips curve, we get the relationship

$$\psi_\pi^{BL} = \frac{\kappa \psi_y - \kappa_a}{1 - \rho_b \beta}$$

which we can subsequently use in the IS condition to obtain

$$\psi_y^{BL} = \frac{\Theta_a(1 - \rho_b \chi) + \rho_b(1 - \chi)\tilde{\alpha} + \frac{\kappa_a}{\sigma} \frac{\phi_\pi - \rho_b}{1 - \rho_b \beta}}{\Theta - \Gamma \rho_b + \frac{\kappa}{\sigma} \frac{\phi_\pi - \rho_b}{1 - \rho_b \beta}}. \tag{29}$$

The nominator of this expression is generically positive, while $\Gamma < \Theta$ ensures that the denominator is as well. In that case, if public debt is elevated in the aftermath of a fiscal shock, this will be accompanied by higher output, and, given that κ_a should be small under any reasonable calibration, also higher inflation. What about period $t = 0$? Assuming that the one-time transfer $\tilde{t}_0$ is financed by issuing an equal amount of public debt $\tilde{b}_1 = \tilde{t}_0$, we will have

$$\pi_0 = \kappa \hat{y}_0 + \beta \mathbb{E}_0 \hat{\pi}_1 = \kappa \hat{y}_0 + \beta \psi_\pi \tilde{b}_1 \tag{30}$$

(if the economy starts in steady state, the $\kappa_a \tilde{b}_0$ from (28) is 0). We can now substitute all endogenous terms in the IS condition for $t = 0$

$$\Theta \hat{y}_0 = \Gamma \psi_y^{BL} \tilde{b}_1 + \Gamma_a \tilde{b}_1 + \theta_h \frac{Y_{ss}}{C_{ss}^H} \tilde{t}_0 - \frac{1}{\sigma} \left(\phi_\pi (\kappa y_0 + \beta \psi_\pi^{BL} \tilde{b_1}) - \psi_\pi^{BL} \tilde{b_1} \right) \tag{31}$$

we can obtain

$$\hat{y}_0^{BL} = \frac{\theta_h \frac{Y_{ss}}{C_{ss}^H} \tilde{t}_0 + \left(\Gamma \psi_y^{BL} + \Gamma_a + \frac{(1 - \phi_\pi \beta)}{\sigma} \psi_\pi^{BL} \right) \tilde{b}_1}{\Theta + \frac{\kappa \phi_\pi}{\sigma}}. \tag{32}$$

Now, a slight complication arises in that $\tilde{t}$ is endogenous, in the sense that in period $t = 0$, the real response to fiscal expansion provides the government with extra resources that it can distribute as well. To back out what amount of $\tilde{t}_0$ is consistent with the exogenously given we can turn to (27), which implies under $\tilde{\tau}_t = 0$ and $\tilde{a} = \tilde{b}_0 = 0$ that

$$\tilde{t}_0 = \tilde{b}_1 + \phi_\tau (1 + \Phi) \hat{y}_0.$$

Substituting this into (32), we can solve out $\hat{y}_0$ to obtain

$$\hat{y}_0 = \frac{\theta_h \frac{Y_{ss}}{C_{ss}^H} + \left(\Gamma \psi_y^{BL} + \Gamma_a + \frac{(1 - \phi_\pi \beta)}{\sigma} \psi_\pi^{BL} \right)}{\Theta + \frac{\kappa \phi_\pi}{\sigma} - \theta_h \frac{Y_{ss}}{C_{ss}^H} \phi_\tau (1 + \Phi)} \tilde{b}_1. \tag{33}$$

We note that since $(1 - \phi_\pi \beta) < 0$, $\left(\Gamma \psi_y^{BL} + \Gamma_a + \frac{(1 - \phi_\pi \beta)}{\sigma} \psi_\pi^{BL} \right)$ and in turn $\hat{y}_0$ cannot be guaranteed to be positive for arbitrary calibrations.[26]. However, for typical calibrations without overly strong central bank reaction ϕ_π and a NKPC slope κ of moderate size, it

[26] While Γ_a can be negative, we will typically have $\Gamma \psi_y^{BL} + \Gamma_a > 0$ as I explain below

seems to be the case.

Let us now turn to the model version with integrated asset markets. Abstracting from further shocks in $t \geq 1$, we the inflation coefficent will have to satisfy

$$\pi_t = \tilde{\kappa}\hat{y}_t + \beta \mathbb{E}_t \pi_{t+1} \implies \psi_\pi^{INT} = \frac{\tilde{\kappa}\psi_y^{INT}}{1-\rho_b\beta}$$

in the aftermath of the shock. Turning the IS condition, we note that for $t > 1$, can substitute any instance of $\tilde{a}_t$ by $\Lambda\hat{y}_t$ to obtain, implying we will end up with system (10) which is *independent* of $\tilde{b}$. Hence, output and inflation in $t \geq 1$ must evolve independently of public debt $\tilde{\psi}$ and we have $\hat{y}_t = \pi_t = 0$ for all $t \geq 1$. This makes solving for the initial responses in $t = 0$ straightforward, as we will have $\pi_0 = \kappa\hat{y}_0$ and thus

$$\Theta\hat{y}_0 = (\Theta - \Theta_a\Lambda)\underbrace{\mathbb{E}_{\approx}\hat{y}_1}_{=0} + \theta_h\frac{Y_{ss}}{C_{ss}^H}\tilde{t}_0 - \frac{1}{\sigma}\left(\phi_\pi\kappa\hat{y}_0 - \underbrace{\pi_1}_{=0}\right) \tag{34}$$

$$\implies \hat{y}_0^{INT} = \frac{\theta_h\frac{Y_{ss}}{C_{ss}^H}\tilde{t}_0}{\Theta + \frac{\kappa\phi_\pi}{\sigma}} \implies \hat{y}_0^{INT} = \frac{\theta_h\frac{Y_{ss}}{C_{ss}^H}\tilde{b}_1}{\Theta + \frac{\kappa\phi_\pi}{\sigma} - \theta_h\frac{Y_{ss}}{C_{ss}^H}\phi_\tau(1+\Phi)}. \tag{35}$$

Comparing this to (33), we can see that $y_0^{BL} > y_0^{INT}$ if $\left(\Gamma\psi_y^{BL} + \Gamma_a + \frac{(1-\phi^\pi\beta)}{\sigma}\psi_\pi^{BL}\right)$ is positive. This must not be the case for all reasonable calibrations, but is more likely to be the case if ϕ_π is not too large. Intuitively, since inflation is higher for $t \geq 1$ in the baseline model, it is also in $t = 0$, causing the central bank to react more strongly which can potentially dampen the output response.

Nevertheless, we will typically have initial inflation π_0 being higher in the baseline model. Denoting as $\pi_0^{BL} - \pi_0^{INT} := \Delta\pi_0$ the difference between initial inflation responses, the NK Phillips curve implies

$$\Delta\pi_0 = \kappa\underbrace{(\hat{y}_0^{BL} - \hat{y}_0^{INT})}_{:=\Delta\hat{y}_0} + \beta(\mathbb{E}_0\pi_1^{BL} - \mathbb{E}_0\pi_1^{INT}) = \kappa\Delta\hat{y}_0 + \beta\psi_\pi^{BL}\tilde{b}_1$$

given the previous results. Since $\psi_\pi^{BL} > 0$, clearly $\Delta\pi_0 > 0$ if $\Delta\hat{y}_0 > 0$. However, even if $\Delta\hat{y}_0 \leq 0$, the respective IS relations require that

$$\begin{aligned}
\Delta\hat{y}_0 &\geq \frac{1}{\Theta}\left(\Gamma\psi_y^{BL} + \Gamma_a\right)\tilde{b}_1 - \frac{1}{\sigma\Theta}\left(\phi_\pi(\pi_0^{BL} - \pi_0^{INT}) - \pi_1^{BL}\right) \\
\Leftrightarrow \frac{1}{\kappa}(\Delta\pi_0 - \beta\psi_\pi^{BL}\tilde{b}_1) &\geq \frac{1}{\Theta}\left(\Gamma\psi_y^{BL} + \Gamma_a + \frac{1}{\sigma}\psi_y^{BL}\right)\tilde{b}_1 - \frac{1}{\sigma\Theta}\left(\phi_\pi\Delta\pi_0\right) \\
\Leftrightarrow \Delta\pi_0\left(\frac{1}{\kappa} + \frac{\phi_\pi}{\sigma\Theta}\right) &\geq \frac{1}{\Theta}\left(\Gamma\psi_y^{BL} + \Gamma_a + \psi_\pi^{BL}\left(\frac{1}{\sigma} + \frac{\Theta\beta}{\kappa}\right)\right)\tilde{b}_1,
\end{aligned}$$

i.e., that the inflation difference must be positive whenever

$$\Gamma\psi_y^{BL} + \Gamma_a + \psi_y^{BL}\frac{\kappa + \sigma\Theta\beta}{\sigma(1-\rho_b\beta)} > 0.$$

based on the definition of ψ_π^{BL} above. As I argue below, we usually have $\Gamma\psi_y^{BL} + \Gamma_a > 0$ for common calibrations and the condition adds the additional positive term $(\beta\Theta)/(1-\rho_b\beta)$ which is large particularly when the public debt is reduced only slowly going forward.

Hence, we can expect $\Delta\pi_0 > 0$ for all reasonable calibrations.
Regarding the issue whether we should typically have $(\Gamma\psi_y^{BL} + \Gamma_a) > 0$: Considering (29) as well as the definition of $\Gamma_a := (1-\chi)\tilde{\alpha} - \chi\Theta_\alpha$, this will be the case if

$$\begin{aligned}\frac{\Gamma(\Theta_a(1-\rho_b\chi)+\rho_b(1-\chi)\tilde{\alpha})}{\Theta-\Gamma\rho_b+\tilde{\kappa}} + (1-\chi)\tilde{\alpha} - \chi\Theta_\alpha > 0\\ \Leftrightarrow \Theta_a\left(\Gamma-\chi\Theta-\chi\tilde{\kappa}\right)+(1-\chi)\tilde{\alpha}(\Theta+\bar{\kappa}) > 0,\end{aligned}$$

where $\bar{\kappa} := \frac{\kappa}{\sigma}\frac{\phi_\pi-\rho_b}{1-\rho_b\beta}$. Recall that Θ_a equals $\theta_h\tilde{\alpha}$ plus a small adjustment term depending on the liquidity cost $(1-\varphi)$, where $\theta_h := \frac{\lambda}{1-\lambda}\frac{C_{ss}^H}{C_{ss}^S}$. So, the condition will typically be satsified if

$$\begin{aligned}\theta_h\left(\Gamma-\chi\Theta-\chi\tilde{\kappa}\right)+(1-\chi)(\Theta+\bar{\kappa}) > 0\\ \Leftrightarrow (1-\chi)\Theta+\theta_h(\Gamma-\chi\Theta) > \left[\chi(1+\theta_h)-1\right]\bar{\kappa}\\ (1-\chi)\theta_y > \left[\chi(1+\theta_h)-1\right]\bar{\kappa}\end{aligned}$$

where the last step uses the definitions of Θ and Γ. If $[\chi(1+\theta_h)-1] < 0$, this holds trivially, but for many calibrations $\chi(1+\theta_h) > 1$. Since $\theta_y := \frac{1}{1-\lambda}\frac{Y_{ss}}{C_{ss}^S} > 1$ and $[\chi(1+\theta_h)-1]/(1-\chi)$ should be of moderate size since $\theta_h < 0.5$, $(\Gamma\psi_y^{BL} + \Gamma_a) > 0$ typically holds for moderately-sized $\bar{\kappa}$ (e.g., when the central bank reaction is not very strong or the Phillips curve not very steep).

A.4 Model determinacy properties

Consider the baseline economy: After the inclusion of the feedback rule $(1-\lambda)\tilde{\tau}_t = \phi_b\tilde{b}_t$ and $\hat{i}_t = \phi_\pi\pi_t$, the system of equations characterizing the endogenous dynamics of the economy becomes

$$\begin{aligned}\Theta\hat{y}_t &= \Gamma\mathbb{E}_t\hat{y}_{t+1} - \frac{1}{\sigma}\left(\phi_\pi\pi_t - \mathbb{E}_t\pi_{t+1}\right) + \Theta_a\tilde{b}_t + \Gamma_a\tilde{b}_{t+1}\\ \pi_t &= \kappa\hat{y}_t - \kappa_a\tilde{b}_t + \beta\mathbb{E}_t\pi_{t+1}\\ \tilde{b}_{t+1} &= \frac{1}{\beta}\tilde{b}_t - \phi_b\tilde{b}_t - \phi_\tau\left[\left(\Phi+1\right)\hat{y}_t - \frac{\sigma\tilde{\varphi}}{(1-\mathcal{G})}\tilde{b}_t\right]\end{aligned}$$

This is a system with two "jump" variables $\hat{y}_t$ and π_t and one predetermined variable $\tilde{b}_t$. After substituting the $\mathbb{E}_t\pi_{t+1}$ using the NKPC, we can re-write it in the form $\mathbb{E}_t z_{t+1} = \mathbf{A}z_t$ with

$$\mathbf{A} = \begin{pmatrix} \frac{\Theta^*+\frac{\kappa}{\sigma\beta}}{\Gamma} & -\frac{(1-\beta\phi_\pi)}{\Gamma\sigma\beta} & -\frac{(\Theta_a^*+\frac{\kappa_a}{\sigma\beta})}{\Gamma} \\ -\frac{\kappa}{\beta} & \frac{1}{\beta} & \kappa_a/\beta \\ -(\phi_\tau)(1+\Phi) & 0 & \delta_b \end{pmatrix}.$$

where

$$\begin{aligned}\Theta^* &:= \Theta + \Gamma_a\phi_\tau(1+\Phi)\\ \delta_b &:= \frac{1}{\beta} - \phi_b + \phi_\tau\frac{\sigma\tilde{\varphi}}{(1-\mathcal{G})}\\ \Theta_a^* &:= \Theta_a + \Gamma_a\delta_b.\end{aligned}$$

We note that this system nests the standard RANK model as a special case with $\Theta^* = \Gamma = 1$ and $\Theta = \kappa_a = 0$. For the purpose of studying determinacy, it also nests the model with integrated assets markets if σ and κ are replaced with the appropriate adjusted values $\tilde{\sigma} = \sigma\Omega$ and $\tilde{\kappa} = \kappa - \kappa_a\Lambda$.[27]

To proceed, I build on Proposition C.2 in Woodford (2003), which provides necessary and sufficient conditions for determinacy in a system of the form $\mathbb{E}_t z_{t+1} = \mathbf{A} z_t$ with 2 jump variables and one predetermined variable. Specifically, said Proposition states that determinacy can arise in three mutually exclusive cases, each stated in terms of the characteristic polynomial of $\mathbf{A}$

$$\mathcal{P}(\lambda) = \lambda^3 + A_2\lambda^2 + A_1\lambda + A_0$$

evaluated at $\lambda = 1$ and $\lambda = -1$, as well as additional conditions on the coefficients A_0, A_1 and A_2. For the analysis below, I shall use $\kappa_a \approx 0$, noting that the model's determinacy properties are unlikely to change substantially due to this term given that $\kappa_w\tilde{\varphi}$ should be small under any reasonable calibration.[28] We have

$$\begin{aligned}
A_2 &= -tr(\mathbf{A}) = -\left(\frac{\Theta^* + \frac{\kappa}{\sigma\beta}}{\Gamma} + \frac{1}{\beta} + \delta_b\right) \\
A_1 &= M_{12} + M_{13} + M_{23} = \frac{\Theta^* + \frac{\kappa\phi_\pi}{\sigma}}{\Gamma\beta} + \frac{1}{\Gamma}\left(\left(\Theta^* + \frac{\kappa}{\sigma\beta}\right)\delta_b - \Theta_a^*\phi_\tau(1+\Phi)\right) + \frac{\delta_b}{\beta} \\
A_0 &= -\det(\mathbf{A}) = -\frac{1}{\Gamma\beta}\left[\left(\Theta^* + \frac{\kappa\phi_\pi}{\sigma}\right)\delta_b - \Theta_a^*\phi_\tau(1+\Phi)\right]
\end{aligned}$$

where the M terms denote the principle minors of $\mathbf{A}$.

Evaluating $\mathcal{P}(-1) = -1 + A_2 - A_1 + A_0$, we obtain after some re-arranging

$$\mathcal{P}(-1) = \frac{1}{\Gamma\beta}\left[\Theta_a^*\phi_\tau(1+\Phi)(1+\beta) - (1+\delta_b)\left((\Theta^* + \Gamma)(1+\beta) + \frac{\kappa(1+\phi_\pi)}{\sigma}\right)\right]. \quad (36)$$

In the case of a RANK model or the THANK with integrated asset markets, we have $\Theta_a^* = 0$, so clearly $\mathcal{P}(-1) < 0$. In the baseline model, this must not be the case for arbitrary calibrations, which already highlights the more complex determinacy properties of this model version. However, for reasonable calibrations, we should have $\mathcal{P}(-1) < 0$ as well. In this regard, note that $\mathcal{P}(-1) < 0$ if

$$\begin{aligned}
&(1+\delta_b)\left((\Theta^* + \Gamma)(1+\beta)\right) > \Theta_a^*\phi_\tau(1+\Phi)(1+\beta) \\
\Leftrightarrow\ &(1+\delta_b)\left((\Theta + \Gamma)(1+\beta)\right) > (\Theta_a - \Gamma_a)\phi_\tau(1+\Phi)(1+\beta)
\end{aligned}$$

which uses the definition of Θ^*, Θ_a^* and is already weaker than necessary due to the omission of the $\frac{\kappa(1+\phi_\pi)}{\sigma}$ term. We further note that $\Theta + \Gamma \geq (1+\chi)\Theta$, and $\Theta_a - \Gamma_a \approx$

[27] Due to certainty equivalence, studying the deterministic case providing for $tildea_t = \Lambda\hat{y}_t$ is sufficient for this purpose.

[28] Since the only need for the liquidity cost term $\tilde{\varphi}$ in the baseline model with segmented asset market is to allow for steady state equivalence with the integrated alternative, the determinacy properties of a model version without are arguably the economically interesting object anyway.

$((1+\chi)\theta_h - (1-\chi))\alpha$ if we omit the small adjustment terms stemming from the liquidity cost. Since $\alpha > 0$, we can thus expect $\mathcal{P}(-1) < 0$ under the even weaker condition

$$\begin{aligned} \Theta &> \frac{1}{1+\delta_b}\theta_h\alpha\phi_\tau(1+\Phi) = \frac{1-s}{1+\delta_b}\frac{Y_{ss}}{C^S_{ss}}\phi_\tau(1+\Phi) \\ &\Leftrightarrow 1 > \left(\frac{(1-s)(1-\lambda)}{1+\delta_b}\frac{\tau_y}{\mu} + \lambda\delta\frac{C^H_{ss}}{Y_{ss}}\right)(1+\Phi), \end{aligned} \tag{37}$$

where the second step uses the definitions of the various composite parameters. All calibrations considered by Bilbiie (2025) provide for $s > 0.8$ and since λ determines the quarterly MPC in the model, reasonable values should be 0.4 at most (and arguably lower than 0.3). If $\delta_b > 0$ and $\tau_y < 0.5$, that means $\frac{(1-s)(1-\lambda)}{1+\delta_b}\frac{\tau_y}{\mu} < 0.05$, while even under a relatively high δ (i.e. a low share of transfers in H), $\lambda\delta\frac{C^H_{ss}}{Y_{ss}}$ should be around 0.3 at most. Considering that typical calibrations of $\Phi = (\phi + \sigma/(1-\mathcal{G}))$ are around or below 2 and condition (37) was weaker than necessary, we can expect $\mathcal{P}(-1) < 0$ for all reasonable calibrations.[29]

Now, if $\mathcal{P}(-1) < 0$, Woodford (2003)'s Proposition C.2 implies that a necessary condition for determinacy is $\mathcal{P}(1) > 0$. Evaluating $\mathcal{P}(1) = 1 + A_2 + A_1 + A_0$, we obtain after some re-arranging

$$\begin{aligned} \mathcal{P}(1) &= 1 + A_2 + A_1 + A_0 \\ &= \frac{1}{\Gamma\beta}\left[(1-\delta_b)\left((\Theta-\Gamma)(1-\beta) + \frac{\kappa(\phi_\pi - 1)}{\sigma}\right) + (1-\beta)(\Theta_a + \Gamma_a)\phi_\tau(1+\Phi)\right] \end{aligned} \tag{38}$$

We note that in the case of RANK and the integrated asset market version of the THANK, $\Theta^* = \Gamma = 1$ and $\Theta^*_a = 0$, the condition $\mathcal{P}(1) > 0$ simplifies to

$$(1-\delta_b)(\phi_\pi - 1) > 0$$

which is this models'version of Leeper (1991)'s result that determinacy can only obtain if either a) the monetary authority reacts more than 1-to-1 to inflation $\phi_\pi > 1$ while the fiscal authority stabilises debt $\delta_b < 1$ ("active monetary, passive fiscal") or b) the monetary authority reacts less than 1-to-1 to inflation $\phi_\pi < 1$ while the fiscal authority doesn't stabilise debt $\delta_b > 1$ ("passive monetary, active fiscal"). In contrast, the full condition (38) doesn't factor cleanly so even conditionally on $\phi_\pi > 1$ or $\delta_b > 1$, the possible values of the respective other parameters that can ensure $\mathcal{P} > 0$ will, unlike in Leepers' condition depend generically on the respective other value.

Ultimately, note that given $\mathcal{P}(-1) < 0$, $\mathcal{P}(1) > 0$ is only a necessary but not sufficient condition for determinacy. For sufficiency, Woodford (2003)'s Proposition requires either $|A_2| > 3$ or $A_0^2 - A_0A_2 + A_1 - 1 > 0$. Note that the first condition will typically be satisfied if δ_b is close to 1 or above, i.e., around or beyond the boundary between passive and active fiscal policy in standard models. For lower δ_b, condition $A_0^2 - A_0A_2 + A_1 - 1 > 0$ needs to

[29] Implicitly, $1 > \lambda\delta\frac{C^H_{ss}}{Y_{ss}}(1+\Phi)$ is required for $\Theta > 0$, i.e., a positive interest rate elasticity in aggregate demand relation (10). The condition then simply adds a small correction to this, so effectively requires that the calibration is not too "close" to the case with $\Theta \leq 0$.

be checked. While analyzing the expression directly is very tedious, there are arguments that $\mathcal{P}(1) > 0$ will be typically sufficient (and not only necessary) for determinacy in case $\delta_b \in (0,1)$, at least under Euler equation discounting (above $|A_2|> 3$ can be expected to apply).

Drawing on similar arguments as above, we should have $\Theta^*/\Gamma > \Theta_a\phi_\tau(1+\Phi)$ under reasonable calibrations providing for Euler equation discounting $\Gamma/\Theta < 1$. That means there is a $\delta_{b0} \in (0,1)$ for which $A_0 = 0$ and $A_0 > 0$ for $\delta_b < \delta_{b0}$. Since A_2 is clearly negative for any $\delta_b \in (0,1)$, it follows that all products in $A_0^2 - A_0A_2$ are positive for $\delta_b \in (0, \delta_{b0})$ and given the size of the Θ^*/Γ term in A_1, one can expect that $A_0^2 - A_0A_2 + A_1 - 1 > 0$ will hold for all $\delta_b \in (0, \delta_{b0})$. For the same reason, we should have $A_0^2 - A_0A_2 + A_1 - 1 = A_1 - 1 > 0$ at δ_{b0} itself.

What about the case $\delta_b \in (\delta_{b0}, 1)$? We note that $-\det(\mathbf{A}) = A_0$ is < 0 and monotonously decreasing in δ_b in that case. In turn, as $\det(\mathbf{A}) = \lambda_1\lambda_2\lambda_3$ (where λ's denote the eigenvalues of $\mathbf{A}$), the eigenvalue product must be > 0 and increasing in δ_b. If we have determinacy at δ_{b0} and thus two eigenvalues outside the unit circle, the increase should be driven by the eigenvalue inside the unit circle as long as $\mathcal{P}(1) > 0$ and $\mathcal{P}(-1) < 0$ hold so that there is no unit circle crossing at ± 1. Given that determinacy is again ensured for high δ_b, one would expect determinacy properties to be preserved for $\delta_b \in (\delta_{b0}, 1)$ as well. However, this is a heuristic argument and doesn't strictly rule out crossings by complex conjugate pairs in this range.

B The quantitative 2-asset HANK model

B.1 The household problem in recursive form

Letting Γ_t denote a set containing the economy's *aggregate* state at period t, we are now ready to state the Bellman equation corresponding to the households' dynamic utility maximization problem, which are

$$V^a(a_{it}, k_{it}, s_{it}, \Xi_{it}; \Gamma_t) = \max_{c_{it}, k_{it+1}, a_{it+1}} \left\{ \frac{c_{it}^{1-\xi} - 1}{1-\xi} - \varsigma \frac{N_t^{1+\gamma}}{1+\gamma} + \beta \mathbb{E}_t A_{t+1} V(a_{it+1}, k_{it+1}, s_{it+1}, \Xi_{it+1}; \Gamma_{t+1}) \right\}$$
$$\text{s.t. to (13), (16), } k_{it} \geq 0 \text{ and } a_{it} \geq \underline{a} \tag{39}$$

for an household able to adjust its capital stock and

$$V^{na}(a_{it}, k_{it}, s_{it}, \Xi_{it}; \Gamma_t) = \max_{c_{it}, a_{it+1}} \left\{ \frac{c_{it}^{1-\xi} - 1}{1-\xi} - \varsigma \frac{N_t^{1+\gamma}}{1+\gamma} + \beta \mathbb{E}_t A_{t+1} V(a_{it+1}, k_{it}, s_{it+1}, \Xi_{it+1}; \Gamma_{t+1}) \right\}$$
$$\text{s.t. to (14), (16), } k_{it} \geq 0 \text{ and } a_{it} \geq \underline{a} \tag{40}$$

for a household that is unable to do so. The ex-ante value function $V(\cdot)$ is given by

$$V(a_{it+1}, k_{it}, s_{it+1}, \Xi_{it+1}; \Gamma_{t+1}) = \lambda V^a(a_{it}, k_{it+1}, s_{it+1}, \Xi_{it+1}; \Gamma_{t+1}) + (1-\lambda) V^{na}(a_{it+1}, k_{it+1}, s_{it+1}, \Xi_{it+1}; \Gamma_{t+1}).$$

B.2 Production

As Bayer et al. (2024), I make the simplifying assumption that firms solving forward-looking problems (such as the retailers' price setting problem) discount the future at the households' discount parameter β.[30]

B.2.1 Final goods production

The economy's final good is produced by a representative firm that assembles a set of differentiated inputs $j \in [0,1]$ according to the CES technology

$$Y_t = \int_0^1 y_{jt}^{\frac{\epsilon_t - 1}{\epsilon_t}} dj. \tag{41}$$

Denoting the intermediate prices as p_{jt}, this gives rise to the familiar input demand schedule

$$y_{jt} = \left(\frac{p_{jt}}{P_t}\right)^{-\epsilon_t} Y_t \tag{42}$$

with optimal price index $P_t = (\int_0^1 p_{jt}^{1-\epsilon_t})^{1/(1-\epsilon_t)}$. Note that I allow the elasticity of substitution between different varieties to exogenously vary over time, i.e., I allow for what is commonly referred to as "cost-push" shocks in the literature. For notational convenience, I define $\mu_t := \frac{\epsilon_t}{\epsilon_t - 1}$ to denote the target mark-up of the retailers presented in the next section.

B.2.2 Retailers

There is a unit mass of retailers, each of which produce a given variety of the differentiated input as monopolist, taking into account demand schedule (42). Their only input are intermediate goods, which they purchase at real price mc_t (also referred to as "marginal costs") from the competitive intermediate goods producers. However, they are subject to nominal rigidities à la Calvo (1983), i.e., in any given period their nominal price remains fixed with probability λ_Y.

If receiving a re-set opportunity, a retailer will choose a price to maximize the corresponding expected net present value of real profits

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_Y^t \left(\frac{p_{jt}^*}{P_t} - mc_t\right) \left(\frac{p_{jt}^*}{P_t}\right)^{\frac{-\mu_t}{\mu_t - 1}} Y_t.$$

In equilibrium, log-linearizing the first order conditions of the resulting price setting problem and combining them with the (also linearized) equations governing price dynamics will give rise to the standard log-linear Phillips curve

$$\log(\pi_t) = \kappa_Y \left(mc_t - \frac{1}{\mu_t}\right) + \beta \mathbb{E}_t \log(\pi_{t+1}) \tag{43}$$

[30] Since I will linearize the model with respect to aggregate shocks, only the steady-state value of the discount factor in the firms' dynamic problems will matter for the dynamic model responses. Bayer et al. (2019) and Lee (2021) report that using different specifications does not significantly affect results in their 2-asset HANK models with many similar features.

with $\kappa_Y := \frac{(1-\lambda_Y)(1-\lambda_Y\beta)}{\lambda_Y}$.

B.2.3 Intermediate goods producers

The homogeneous intermediate good is produced by a continuum of firms that use a constant-returns-to-scale technology represented by production function

$$F(u_tK_t, H_t) = F(u_tK_t, H_t) = (u_tK_t)^\alpha H_t^{1-\alpha}. \tag{44}$$

K_t and H_t denote the input of capital and labor services. u_t is the degree of capital utilization that determines capital depreciation according to

$$\delta(u_t) = \delta_0 + \delta_1(u_t - 1) + \frac{\delta_2}{2}(u_t - 1)^2.$$

Taking the price h_t for labor services as well as the capital rental rate r_t and its output price mc_t as given, an intermediate goods producer solves the static profit maximization problem

$$\max_{K_t, H_t, u_t} mc_tF(u_tK_t, H_t) - h_tH_t - (r_t + q_t\delta(u_t))K_t,$$

the solution of which can be characterized using the following first order conditions:

$$h_t = (1-\alpha)mc_t(u_tK_t)^\alpha H_t^{-\alpha} \tag{45}$$

$$r_t + q_t\delta(u_t) = \alpha mc_tu_t(u_tK_t)^{\alpha-1}H_t^{1-\alpha} \tag{46}$$

$$q_t(\delta_1 + \delta_2(u_t - 1)) = \alpha mc_t(u_tK_t)^{\alpha-1}H_t^{1-\alpha}. \tag{47}$$

B.2.4 Capital goods producer

Capital goods producers use the final good as input and operate a technology subject to adjustment costs: Using I_t units of the final good, they can produce

$$Z_t^I \left[1 - \frac{\phi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] I_t$$

units of capital. Investment-specific productivity Z_t^I is exogenous and potentially following a time-varying shock process. Taking the price of capital q_t as given, the producers choose I_t to maximize the net present value of real profits

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(q_tZ_t^I \left[1 - \frac{\phi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] I_t - I_t\right)$$

and their optimal interior solution will fulfill first-order condition

$$1 + q_tZ_t^I \left(\frac{\phi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - 1 + \phi\left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}}\right) = \beta q_{t+1}Z_{t+1}^I\phi\left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2. \tag{48}$$

B.2.5 Labor market

The labor market follows a set-up as in Auclert et al. (2024). Labor services are produced by a representative labor packer that aggregates a range of differentiated labor inputs $u \in (0,1)$ according to

$$N_t = \left(\int_0^1 N_{ut}^{\frac{\epsilon_w - 1}{\epsilon_w}} du \right)^{\frac{\epsilon_w}{\epsilon_w - 1}}$$

and will thus demand

$$N_{ut} = \left(\frac{W_{ut}}{W_t} \right)^{-\epsilon_w} N_t \tag{49}$$

of each labor variety. Each of the differentiated labor types is supplied by a union that sets the nominal wage W_{ut} as a monopolist to maximize the utility of its members. The latter are required to work according to a uniform schedule, i.e., all u workers have to supply the same amount of hours N_{ut}. Unfortunately, every period the leadership of a union u suffers utility costs $\frac{\psi}{2}\left(\frac{W_{ut}}{W_{ut-1}} - \pi_{SS}\right)^2$ for changing the nominal wage, perhaps due the administrative burden of adjusting contracts. In turn, every union solves

$$\max_{\{W_{u\tau}\}_{\tau=t}^{\infty}} \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left(\int \left(u(c_{i\tau}) - \varsigma \frac{N_{i\tau}^{1+\gamma}}{1+\gamma} \right) di - \frac{\psi}{2} \left(\frac{W_{ut}}{W_{ut-1}} - 1 \right)^2 \right), \tag{50}$$

taking demand schedule (49) into account.

Households are exogenously distributed over unions in a uniform manner: Note that the law of large numbers applies thus also *within* unions so that the distribution of agents i overall and within any union u coincides.[31] Due to symmetry, the F.O.C.s of (50) then give rise to an aggregate *Wage Phillips curve* of the form

$$\begin{aligned} \pi_t^w(1-\pi_t^w) = \kappa_w \left(\varsigma N_t^{1+\gamma} - \frac{\epsilon_w - 1}{\epsilon_w}(1-\tau_p)(1-\tau_t^w) \int \left(u'(c_{it}) \left(s_{it} \frac{W_t}{P_t} N_t \right)^{1-\tau_p} \right) di \right) \\ + \beta \mathbb{E}_t \pi_{t+1}^w (1-\pi_{t+1}^w), \end{aligned} \tag{51}$$

with $w_t := W_t/P_t$ and $\pi_t^w := \frac{W_t}{W_{t-1}}$. For convenience, I define $\kappa_w := \frac{\epsilon_w}{\psi}$ to denote the slope of the Wage Phillips curve. Given the uniform hours $N_{it} = N_{ut}$ for all union members and demand schedule (49), we have

$$\frac{\partial}{\partial W_{ut}} N_{ut} = -\epsilon_w \frac{N_{ut}}{W_{ut}}$$

and

$$\frac{\partial}{\partial W_{ut}} u(c_{it}) = u'(c_{it})(1-\tau_p)(1-\tau_w) \left(s_{it} \frac{W_{ut}}{P_t} N_{ut} \right)^{-\tau_p} s_{it} \frac{N_{ut}}{P_t} (1-\epsilon_w) \quad ,$$

[31] Since all labor varieties will be symmetric in equilibrium, her labor type u doesn't matter for an individual's consumption-saving problem.

the latter reflecting that due to the envelope theorem, the marginal utility of additional resources should equal the marginal utility of consumption. In turn, the F.O.C. corresponding to (50) is

$$(1-\tau_p)(1-\tau_w)\frac{1-\epsilon_w}{W_{ut}}\int\left(u'(c_{it})\left(s_{it}\frac{W_{ut}}{P_t}N_{ut}\right)^{1-\tau_p}\right)di+\frac{\epsilon_w}{W_{ut}}\varsigma N_{ut}^{1+\gamma}$$
$$-\psi\left(\frac{W_{ut}}{W_{ut-1}}-1\right)\frac{1}{W_{ut-1}}+\beta\mathbb{E}_t\psi\left(\frac{W_{ut+1}}{W_{ut}}-1\right)\frac{W_{ut+1}}{(W_{ut})^2}=0 \quad .$$

If we now use that unions are symmetric and thus $N_{ut}=N_t$ and $W_{ut}=W_t$, re-arranging yields

$$\pi_t^w(1-\pi_t^w)=\frac{\epsilon_w}{\psi}\left(\varsigma N_t^{1+\gamma}-\frac{\epsilon_w-1}{\epsilon_w}(1-\tau_p)(1-\tau_w)\int\left(u'(c_{it})\left(s_{it}\frac{W_t}{P_t}N_t\right)^{1-\tau_p}\right)di\right)$$
$$+\beta\mathbb{E}_t\pi_{t+1}^w(1-\pi_{t+1}^w) \quad .$$

B.3 External calibration

The model's externally calibrated parameters are displayed in Table B.1: I set the households' risk aversion parameter to $\xi=1.5$, within the range of standard values used in the literature. Regarding technology, I use the conventional value of $\alpha=0.33$ for the Cobb-Douglas parameter for capital and set a quarterly depreciation rate for capital of $\delta=0.0175$, implying approx. 7% annual depreciation. Similar, I set μ_t to a conventional value of 1.1, resulting in a steady state markup of 10%. The elasticity of substitutions between different labor varieties is assumed to be the same as for goods and thus $\epsilon_w=11$.[32] The slope of the price Phillips curve is set to $\kappa_Y=0.06$, in line with the recent evidence by Gagliardone et al. (2023). In the HANK literature, wages are often assumed to be substantially stickier than prices, even though estimated DSGE models do not always support this. I set $\kappa_w=0.015$ to be consistent with the former, a value based on the estimate of Auclert et al. (2020). However, given the empirical controversies surrounding these parameters, related robustness checks will be discussed in Appendix C.
Several other parameters governing the economy are calibrated following Bayer et al. (2024): First, I also set the probability of exiting the $\Xi=1$ state within a given period to be 6.25% and adopt their tax progressivity parameter $\tau_p=0.12$. The investment adjustment cost is chosen to be 3.5 and the ratio δ_2/δ_1 set to be 1, reflecting the results of their model estimation. For a given δ_2/δ_1-ratio, I always set δ_1 and δ_2 to achieve $u_t=1.0$ in steady state. Again, since estimates for the investment- and utilization adjustment parameters also vary in the literature, these values will be subjected to robustness tests as well.

Regarding monetary policy, I parameterize the model's interest rule with standard values also employed by Bayer et al. (2023b) to study post-2020 macroeconomic dynamics in the US. In particular, this includes setting the Central Bank's inflation reaction parameter

[32] Since I set κ_w independently of ϵ_w and calibrate ς to achieve $N_{ss}=1$, the value of this parameter is practically of limited importance.

Parameter	Description	Value	Source
ξ	Risk aversion	1.5	Standard
ι	Exit prob. entrepreneurs	1/16	Bayer et al. (2024)
α	Cobb-Douglas parameter	0.33	Standard
δ_0	Steady State depreciation	0.0175	Standard
μ	SS Goods markup	1.1	Standard
κ_Y	Slope of price Phillips curve	0.06	Gagliardone et al. (2023)
κ_w	Slope of wage Phillips curve	0.015	Auclert et al. (2020)
ϵ_w	EOS labor varieties	11	Standard
ϕ	investment adjustment cost	3.5	Bayer et al. (2024)
δ_2/δ_1	utilization parameters	1.0	Bayer et al. (2024)
γ	Inverse Frisch	1.0	Standard
δ^B	Government debt duration	0.05	5 years avg. maturity
τ	Tax level	0.2	$G/Y \approx 17.5\%$
τ^p	Tax progressivity	0.12	Bayer et al. (2024)
τ^Ξ	Profit Tax	0.24	US Tax Code
$(\rho_R, \theta_\pi, \theta_y)$	Taylor rule parameters	(0.8,1.5,0.2)	Bayer et al. (2023b)
R^{LB}	Effective Lower Bound	$r^R_{SS} - 0.005$	2 p.p. below r^R_{SS}
(ρ_τ, ψ_B)	Tax rule parameters	(0.85, 1.25)	See text

Table B.1: Externally set parameters

to the value $\theta_\pi = 1.5$ first proposed by Taylor (1993), making it clear that monetary policy is "active" in my model. The ELB is set to be 2 percentage points (in annual terms) below the steady state policy rate r^R_{SS}, given that an exercise in Section 6 effectively assumes the model to be in steady state before 2020. In that year, the nominal rate was around 2% and the ELB thus 2 p.p. below it.

On the fiscal side, the steady labor tax level τ is chosen to be consistent with $G/Y \approx 17.5\%$ given the model's other targets, in line with the average ratio of government consumption and investment to GDP in 2014-2019. The tax rate on the "entrepreneurs"'s profit incomes are set to 24%, reflecting the top tax bracket for qualified dividends in the US. Bianchi et al. (2023) report the average maturity of US treasury debt to typically vary between 4.5-5.5 years, so I chose $\delta^B = 0.05$ to be consistent with an average 5-year (20 quarter) duration.

Initially, I set $\rho_\tau = 0.85$ and $\psi_B = 1.25$, ad hoc values that result in a moderately drawn-out public debt responses. In particular, these parameters imply that for a simple transfer shock as studied in Section 4, public debt will start to clearly decline after approx. 2 years. As will become clear, different combinations of parameters yield similar results as long as they provide for public debt responses of comparable magnitude.

	Disposable Income		Net Worth	
	Model	Data	Model	Data
Quint. 1	6.8	4.5	0.0	-0.2
Quint. 2	10.8	9.9	1.2	1.2
Quint. 3	14.8	15.3	4.2	4.6
Quint. 4	20.6	22.8	11.0	11.9
Quint. 5	46.9	47.5	83.8	82.5
Gini	0.40	0.42	0.80	0.78

Note: "Data" refers to moments computed by Krueger et al. (2016) using PSID and SCF.

Table B.2: Distributional moments comparison

B.4 Distributional Moments

In this section, I validate the internal calibration by analyzing various model-generated moments that were not directly targeted.

Table B.2 compares various untargeted moments of the model's Steady State income- and wealth distributions with their empirical counterparts as reported by Krueger et al. (2016). The latter are based on the 2006 Panel Survey of Income Dynamics (PSID) and the 2007 Survey of Consumer Finance (SCF), respectively.[33] Arguably, the model achieves a fairly good fit, in particular for Net Worth.

Since I am employing a two-asset model, it is not only relevant to assess how closely the framework matches data moments related to the distribution of overall net worth, but also the different asset classes held by the households. I do so in Table B.3: First, I am considering moments of the illiquid- and liquid wealth distribution separately. In particular, I compare them with statistics reported by Kaplan et al. (2018), who rely on the 2004 SCF. As in the data, the model generates a more unequal distribution of liquid assets and ownership of both asset classes is concentrated in their respective Top 10%, with the bottom 50% holding hardly any. Also, the model moments of the illiquid asset distribution are close to the data, mildly under-predicting the share of the Top 10%. However, for liquid assets, I generate a comparably more equal asset distributions, with the share held by the Top 10% not as high and the share of the Next 40% substantially larger than in the SCF data. But, as noted by Kaplan et al. (2018), it is "notoriously challenging" to match the extreme right tail of wealth distributions with income risk alone. From that perspective, I view my model's performance as satisfactory.

Finally, I analyze how many households are *Hand-to-Mouth* (HtM) in the sense of Kaplan et al. (2014), i.e., whether their liquid asset holdings are less than 2 weeks ($\approx 1/6$ of a model period) of current household income above of either 0 or the borrowing constraint.

[33] In the data, disposable income is defined as the sum of after-tax earnings, income generated by assets held as well as unemployment benefits. In the model, it only compromises the first two as there is unemployment. In both model and data, Net Worth relates to both liquid and illiquid assets.

Moments	Model	Data (incl. source)
Illiquid asset shares		(from Kaplan et al., 2018)
Top 10%	67.1	70
Next 40%	31.4	27
Bottom 50%	1.5	3
Liquid asset shares		(from Kaplan et al., 2018)
Top 10%	74.7	86
Next 40%	24.6	18
Bottom 50%	0.7	-4
Hand-to-Mouth (HtM) Status		(from Kaplan et al., 2014)
Share HtM	29.0	31.2
Share Wealthy HtM	17.6	19.2
Share Poor HtM	11.4	12.1

Table B.3: Portfolio moments: Model vs. Data

I also classify them as "Wealthy HtM" if they additionally hold illiquid assets and "Poor HtM" if they do not. The model matches the empirical evidence on the size of either group of agents well. As visualized in Figure B.1, these agents with low liquid wealth tend to have particularly high MPCs. In turn, my framework is able to generate an average quarterly MPC of 15.8% and an average annualized MPC of 36.7%.[34] The former is of a similar magnitude as the corresponding value reported by Kaplan et al. (2018).

B.5 Definition of equilibrium

Definition 1. *A **Recursive Equilibrium** of the model consists of*

- *value functions* $V^a(a_{it}, k_{it}, s_{it}, \Psi_{it}; \Gamma_t)$, $V^{na}(a_{it}, k_{it}, s_{it}, \Psi_{it}; \Gamma_t)$
- *household policies* $a^a(a_{it}, k_{it}, s_{it}, \Psi_{it}; \Gamma_t)$, $a^{na}(a_{it}, k_{it}, s_{it}, \Psi_{it}; \Gamma_t)$, $k(a_{it}, k_{it}, s_{it}, \Psi_{it}; \Gamma_t)$ *and* $c^a(a_{it}, k_{it}, s_{it}, \Psi_{it}; \Gamma_t)$, $c^{na}(a_{it}, k_{it}, s_{it}, \Psi_{it}; \Gamma_t)$,
- *firm- and union policies* I_t, K_t, H_t, Y_t, N_t, u_t, B_t^l, Π_t, $y_{jt} \forall j \in [0,1]$, w_t
- *prices* h_t, r_t, q_t, r_t^l, mc_t
- *inflation* π_t
- *government policies* $G_t, B_{t+1}^g, \tau_t, r_{t+1}^R$,

so that

1. *Given prices* r_t^l, r_t, q_t, *wages* w_t *and profits* Π_t, *the value functions* $V^a(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t)$, $V^{na}(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t)$ *solve the households' Bellman equations in* (39) *and* (40)

[34] I compute individuals' annualized MPCs $aMPC$ as $aMPC = 1-(1-qMPC)^4$ following Carroll et al. (2017). Note that these *annualized* MPCs will not exactly equal individuals' *annual* MPCs.

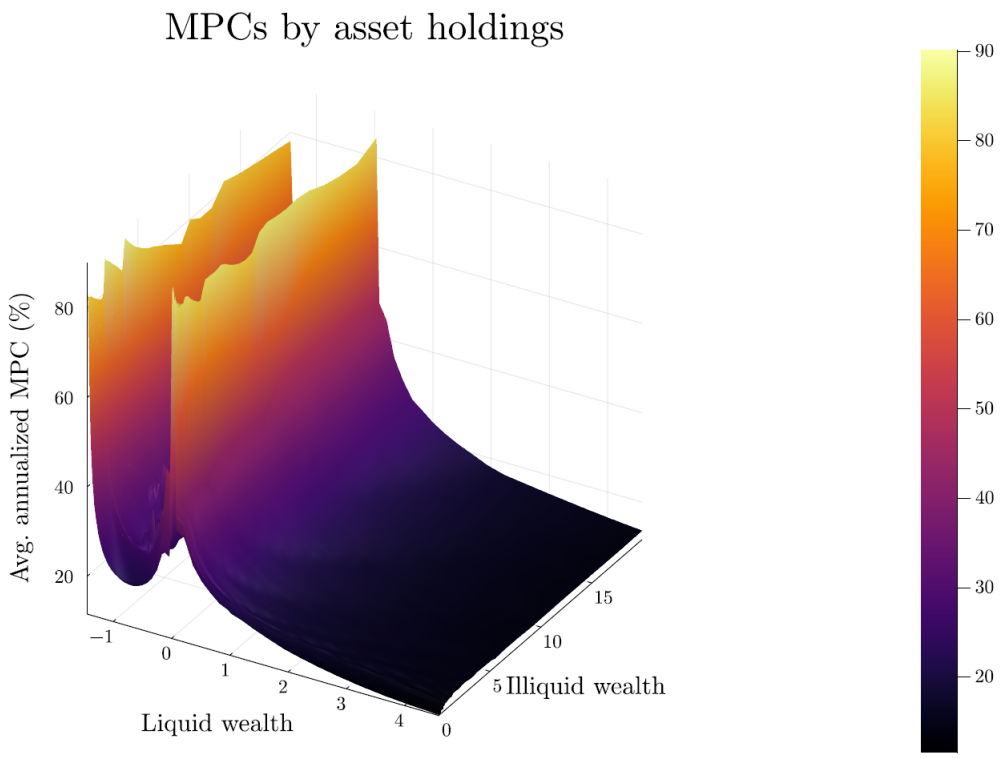


Figure B.1: Model MPC distribution

and $a(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t)$, $k(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t)$, $c(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t)$ *are the resulting optimal policy functions.*

2. *Expectations are model-conistent.*

3. $y_{jt} \in [0, 1]$ *are consistent with demand schedule* (42) *and final output* Y_t *given by* (41).

4. *Inflation* π_t *is consistent with Phillips curve* (43).

5. *Given prices* h_t, r_t, q_t, mc_t, *the intermediate goods producers choices* K_t, H_t, u_t *are consistent with optimality conditions* (45)-(47).

6. *Given price* q_t, *the intermediate goods producers choices* I_t *are consistent with optimality condition* (48).

7. *The labor packer's zero profit condition* $h_t = w_t$ *is fulfilled.*

8. *The dynamics of the wage level* w_t *is consistent with* (51).

9. *The Liquid Asset Funds' portfolio choice is consistent with* (21).

10. *The return of liquid assets is given by* (22).

11. *Given inflation* π_t *and output growth* Y_t/Y_{t-1}, *the monetary authority set* r^R_{t+1} *according to* (17).

12. *Taking the remaining values as given, the government sets taxes according to* (19) *and issues debt* B^g_{t+1} *so that* (18) *holds.*

13. *The market for liquid asset clears, i.e.,*

$$A^l_t = \int_0^1 a_{it} di \quad .$$

14. *The government bond market clears, i.e.,*

$$B^l_t = B^g_t \quad .$$

15. *The capital market clears, i.e.,*

$$K_t = \frac{A^l_t - B^l_t}{q_{t-1}} + \int_0^1 k_{it} di \quad .$$

16. *The market for investment good clears, i.e.,*

$$K_{t+1} = (1 - \delta(u_t))K_t + \left[1 - \frac{\phi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] I_t$$

17. *The market for labor services clears, i.e.,*

$$H_t = N_t \int_{m^\Xi}^1 s_{it} di.$$

18. *The market for intermediate goods clears, i.e.,*

$$\int_0^1 y_t(j) dj = F_t(u_t K_t, H_t)$$

19. *The final good market clears, i.e.,*

$$\begin{aligned} Y_t =& C_t + G_t + I_t + \frac{\phi}{2}\left[\frac{I_t}{I_{t-1}} - 1\right]^2 + \bar{R}\int_0^1 \mathbb{1}(a_{it} \leq 0) a_{it} di \\ &- \left[\phi + \frac{\Psi}{2}\left(1 - \frac{B^l_t}{A^l_t}\right)^2\right] A^l_t \end{aligned}$$

where $\mathbb{1}(\cdot)$ *denotes the indicator function.*

20. *The distributions of income and wealth evolve according to household's policy function and the exogenous transition probabilities* $\pi^s(\cdot|\cdot)$, ζ *and* ι.

B.6 Details on numerical implementation

B.6.1 Details on Steady State Solution

The household problem needs to be solved on a discretization of the state space: I choose 90 grid points for both a and k, either of which are non-linearily spaced as household

decision functions tend to be more non-linear for lower levels of assets. In particular, the grid points for both a for k are spaced according to the "double exponential" rule, i.e.

$$\mathcal{X} = x_{min} + \exp(\exp(\mathbf{u}(\log(1 + \log(1 + x_{max} - x_{min})), n_i)) - 1) - 1$$

where x_{min} is the minimum value on the grid for variable x, x_{max} the maximum value and $\mathbf{u}(0, x_{max})$ a vector of equidistant points on the interval $[0, x_{max}]$. Since household value- and policy functions will feature and additional kink around $a = 0$ when the borrowing penalty kicks in, I add 5 additional grid points in the immediate vicinity of that point. Given that individual labor productivity is discretized to 17 points, this means that the household problem is solved on a tensor grid of $90 \times 90 \times (17 + 1) = 145800$ points (the "entrepreneur" status adds an "income" state to the 17 "skill" states). The discretization of the individual labor productivity process follows an off-the-shelf method à la Tauchen (1986). Whenever interpolation is needed off the grid, I use linear interpolation

For the implementation of the multidimensional EGM algorithm, I follow the replication codes for Bayer et al. (2024) closely.[35] Given the random illiquid asset adjustment, the EGM scheme only needs to iterate over marginal value functions (i.e. the derivatives of V with respect to m and k) and does not compute V directly.

For finding the steady, I iterate over r^l_{ss} and r^k_{ss}: Given these values, the remaining steady variables can be backed out and the household-problem solved. I then use a heuristic updating procedure to search for r^l_{ss} and r^k_{ss} so that the asset markets clear.

B.6.2 Details on State Space Perturbation

As already indicated in the main text, the model's dynamic equilibrium is approximated using First-Order Perturbation around its non-stochastic steady state. For the State Space perturbation à la Bayer et al. (2024), note that when using the discretized representations of the marginal value functions as well as the joint income/asset distribution, the equilibrium can be represented as the solution to a non-linear difference equation of the form

$$\mathbb{E}_t F(\mathbf{y_t}, \mathbf{x_t}, \mathbf{y_{t+1}}, \mathbf{x_{t+1}}) = 0 \tag{52}$$

as, e.g., used by Schmitt-Grohe and Uribe (2004). $\mathbf{y}$ denotes a vector of control variables, which includes the households' marginal value functions on the grid and $\mathbf{x}$ a vector of state variables, which includes the discretized distribution.

In theory, one could find the linearized equilibrium using the standard approach of computing the Jacobians of F as in (52) and then solve the resulting linear difference equation relying on methods such as Klein (2000). In practice, however, such an approach would involve very high computational costs for the 2-asset HANK model, given that the full $\mathbf{y}$ and $\mathbf{x}$ have a combined length exceeding $200,000$.

[35] As of October 2025, these replication codes are available under https://github.com/BASEforHANK/BASEtoolbox.jl.

To overcome this problem, Bayer et al. (2024) propose a procedure which conducts dimension reduction in 2 steps, one before computing the Jacobians and one after. Specifically, it first uses a Discrete Cosine Transform (DCT) to dimension-reduce the marginal value functions: The values resulting from such a DCT are coefficients of a fitted multi-dimensional Chebychev polynomial, of which only a subset are selected to be perturbed: Bayer et al. (2024) propose to use the nodes that are most important for describing the derivatives of the steady state marginal value functions to changes in the set of prices that households directly take into account (e.g., interest rates and the wage). The other coefficients are kept at their steady state values.

For reducing the dimensionality of the joint distribution in the first step, the authors furthermore suggest splitting it into marginals and a copula, where the latter is in effect treated as an interpolator mapping the steady state marginal distributions into the joint distribution. That "interpolator" can also be dimension-reduced through a DCT or just kept fixed, so one only perturbs the marginals as well as selected coefficients of the copula, which have substantially lower dimension. Overall, in my application the procedure manages to shrink the effective dimensionality of the system to a manageable number of approx. 1400, for which an initial perturbation solution is obtained.
The second step further reduces the set of DCT coefficients by using the first step solution to check which ones vary only very little with the aggregate shocks and are thus not important for explaining model dynamics. It is useful if the model has to be repeatedly solved for different parameters, such as for checking model stability for different parameters as e.g., in Section 4. For a more detailed exposition, see Bayer et al. (2024).

B.6.3 Details on Sequence Space Perturbation

As already mentioned in the main text, in addition to the State Space perturbation method described above, I also use a Sequence Space linearization method à la Auclert et al. (2021), as its allows to flexibly expose the economy to various news shocks. This proves useful particular for the analysis in Section 6.2: Firstly, the analysis in that Section requires the model to be able to handle a binding lower bound on the nominal interest rate. As already pointed out by McKay and Wieland (2021), this can be achieved (relatively) easily in a Sequence space setting using news shocks. The idea is that if an aggregate shock would cause the central bank (CB) to violate the ELB in a certain number of periods, one can solve for a sequence of pre-announced monetary policy (news) shocks that would keep the economy at the ELB instead. The CB then enforces the ELB by announcing exactly these shocks. Secondly, the same feature of a sequence space solution makes it easy to consider different interest rate rules. This is because in a linearized model, those can similarly be imposed by announcing a suitable set of news shocks to the policy rule in place (McKay and Wolf, 2023).

I obtain the Sequence Space Jacobians (SSJs) of the model's heterogeneous agent block as described in Auclert et al. (2021), although I rely on automatic differentiation instead

of finite differences to ensure accuracy of the derivatives. For obtaining the general equilibrium SSJ's, I then build on the model representation proposed by Bhandari et al. (2023), which, for given Heterogeneous Agents SSJs, yields the same GE SSJs as Auclert et al. (2021)'s Directed Acyclical Graph (DAG) approach.[36] I use a truncation horizon of $T = 500$ periods, as my 2-asset HANK model features relatively-long lived IRFs due to the presence of investment adjustment costs and shocks with quite high persistence.

C Robustness analyses

This appendix aims to address potential concerns regarding the generality and robustness of the paper's main insights in Section 4. In particular, the respective model exercises were conducted only in the context of a particular fiscal policy scenario and the model features several parameters whose values are subject to empirical controversies.

C.1 Alternative Fiscal Shocks

Firstly, to what extent do the results in Section 4 depend on the used fiscal policy scenario? To answer this question, I firstly considered an alternative scenario with a government consumption shock instead of the transfer shock. In particular, Appendix Figure G.6 displays the macroeconomic response to a persistent increase in government consumption G, assumed to increase by 2.5% on impact and afterwards following an AR(1)-decay with persistence 0.9. While the aggregate responses naturally differ, considering different asset market structures has quantitatively comparable effects.
Secondly, I computed IRFs for the original transfer shock but assuming that the fiscal authority consolidates by reducing government consumption G instead of changing taxes. The respective results are provided in Appendix Figure G.7. For this alternative, the aggregate wealth effect due to less wasteful (in this model) government spending causes household consumption to increases slightly more and investment to decrease less. But as long public debt and hence its liquidity effect evolve similarly, there are no major changes compared to the baseline fiscal rule.

C.2 Alternative model parameterizations

Like every New Keynesian model, the framework used for the above analysis contains several parameters subject to empirical controversies, in particularly the "slopes" of the New Keynesian Price- and Wage Phillips curves. Additionally, since investment demand was found to be important for the transmission of the debt-driven inflation, it is relevant to check to whether the above results are due to specific values for the model's capital utilization- and adjustment costs. To address this, I varied the parameters one-by-one to assert robustness with respect to the Baseline calibration's parameter choices. The

[36] An example application for a simpler HANK model can be found under https://mhaense1.github.io/SSJ_Julia_Notebook/SSJ_notebook_2.html.

resulting IRFs to the transfer shock are displayed in Appendix G and briefly summarized below.

Allowing for higher or lower price stickiness by varying the NKPC slope κ affects the absolute size of the inflation responses to the fiscal shock, but not so much the relative importance of the asset market structure. The same is the case for wage stickiness (c.f. Appendix Figures G.8 and G.9). Results are similarly robust to considering alternatives values for the investment adjustment- and utilization parameters, which affect the responses of inflation and real aggregates only moderately (Appendix Figures G.10 and G.11).

C.3 Sticky Expectations

It is well known that heterogeneous agent (HA) business cycle models struggle to match empirically estimated IRFs of aggregate consumption to some business cycle shocks: In the data, such responses are often found to be very smooth, while HA models generate initial jumps due to household's high MPCs and the absence of "habit formation" assumption. However, several authors argued that HA models extended with "sticky expectations", in that households only infrequently update their information about macroeconomic aggregates, can resolve the tension (see Carroll et al., 2020; Auclert et al., 2020).
Here, I address the potential concern that my baseline model's "debt inflation" dynamics may hinge on its (perhaps less desirable) full information rational expectation assumptions and introduce sticky expectations as in Auclert et al. (2020). I assume that households update their information with a quarterly probability of 10%, close to the estimation result in Auclert et al. (2020) and more sticky than in the calibration of Carroll et al. (2020). The corresponding results for the transfer shock are displayed in Appendix Figure G.12: The responses are quite similar to the baseline in Section 4 and the key insight on the relevance of the asset market structure is essentially unaffected.

D Post-2020 US experiment

As described previously in Appendix B, the HANK model contains 5 shocks, two supply shocks (investment technology, "cost push"/markup), a demand shock (discount factor) and two policy shocks (monetary policy, transfers). Under the assumption that the economy was in steady state in 2019, these exogenous disturbances are used to replicate the subsequent evolution of aggregate output, investment, inflation, the central bank's policy rate as well as government transfer spending. For the real variables subject to trend growth, this refers to the relative deviation from their pre-pandemic trends instead of levels.[37] For further information on the construction of the targeted variables, please refer to Appendix E.

[37] Strictly speaking, I cannot match transfer spending's relative deviation from trend in my model as transfer payments are zero in its stationary equilibrium. Instead, I match the deviation of transfers relative to trend output.

	Z^I	μ	ϵ^R	A	T
AR(1) persistence	0.75	0.9	0.0	0.9	0.5

Table D.4: Assumed persistence of model shocks

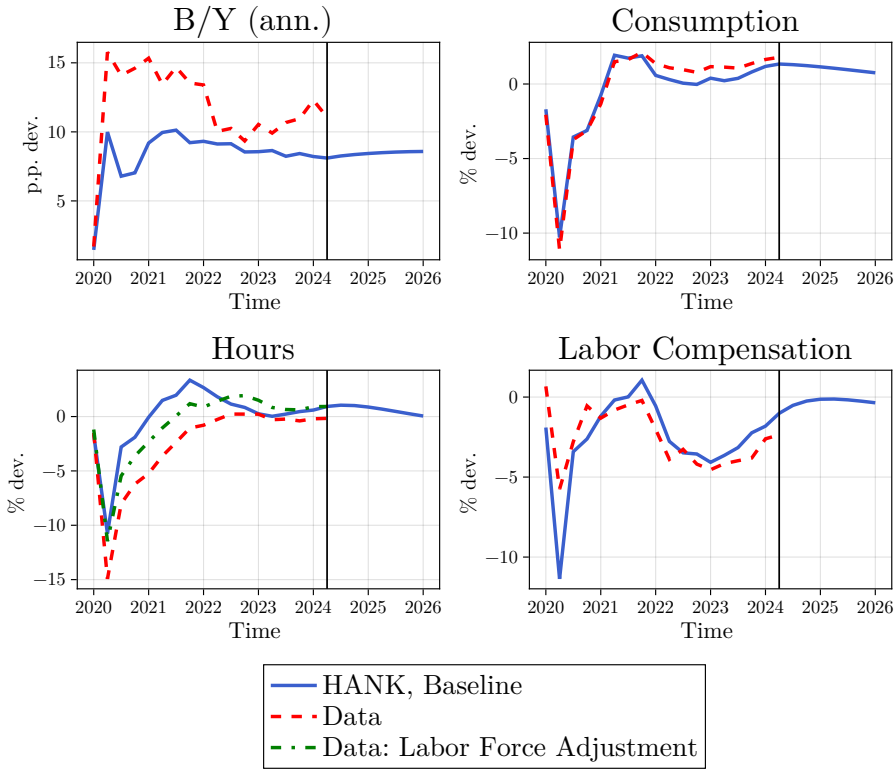
The choice of the 5 business cycle shocks mentioned above is motivated as follows: The discount factor shock is supposed to induce pandemic-related consumption restraints as in Bardóczy et al. (2024), which requires additional investment shocks to not give rise to counterfactually higher investment. The monetary policy- and transfer shocks are needed to replicate the time-paths of the policy rate and transfer payments while the "cost-push" introduces another source of supply side inflation. I intentionally do not model other Covid-related spending programs such as support for corporations as it is less clear to whom these should be assigned in my framework. Given that this will result in my model generating less public debt than in the data, I view this as a conservative choice.

Since the number of shocks equals the number of target variables, the McKay and Wieland (2021) filtering method does not require me to take a stance on the variance of the business cycle shocks. The method can account for an ELB and is described in more detail in Appendix B.6.

However, assuming that all shocks follow $AR(1)$-processes, I still need to make assumptions on their persistence in order to compute the necessary IRFs. My calibration choice is presented in Table D.4: The values for the supply shocks (μ, Z^I) and the discount factor disturbance (A) are set to salient values in the ballpark of Bayer et al. (2024)'s estimates. Since many of the big transfer expansions during the pandemic period were designed to be short-lived, I further assume the autoregressive parameter of the transfer shock to be a low 0.5. As the rate smoothing term of the monetary policy rule (17) already provides for a persistent impact of the rate shock ϵ^R, the latter does not depend on its previous value. To ensure that the short-lived transfer shocks result in a long-lived debt response, I furthermore reduce fiscal responsiveness to for $(\rho_\tau, \psi_B) = (0.94, 0.5)$. These values were selected so that public debt does not noticeable decline before 2026 in the filtered baseline scenario.

Naturally, the resulting analyses have caveats. Firstly, my model doesn't feature any Covid-related features such as lock-downs but rather assigns the observed aggregate dynamics during 2020-2021 to standard business cycle shocks. While in line with other DSGE model-based investigations of the post-pandemic inflation (e.g. Gagliardone and Gertler, 2023; Bianchi et al., 2023), the model does thus only provide a simplistic account of various pandemic-specific phenomena. This includes the nature of transfer payments made by the government, which are assumed to consist solely of uniform lump-sum payments for the purpose of this exercise: Since transfers specifically aimed at poor agents with high MPCs tend to have larger effects in HANK models, this simplification can again be seen as a conservative choice. Secondly, the fact that the analysis is based on a linearized

Figure D.2: Non-targeted variables: Model vs. Data



Note: B/Y represents the market value of public debt B^g over annualized GDP. The construction of the data series is specified in Appendix E.

model means that we will miss out on non-linearities that may be relevant for the large shocks occurring during the period under consideration. Again, my analysis shares this reservation with numerous other studies of the US post-2020 period (including the two cited previously). Finally, all the results obviously depend on the assumption of underlying policy rules: Under different ones, e.g., a partly active fiscal policy regime as in Bianchi et al. (2023) instead of the active Taylor rule, the same aggregate dynamics might be assigned to different shocks.

D.1 Comparison for untargeted variables

In this Appendix, I gauge how well the model relates to some non-targeted moments so as to be able to judge what aspects of the US economy it does or does not capture well for the post-2020 exercise. Again, the construction of the additional data used here is specified in Appendix E. The top-left panel of Figure D.2 compares the relative value of public debt in the model with an approximation of the market value of domestically held US federal debt in the data. As anticipated, the model generates a smaller expansion, implying that if anything, my exercise have under-estimate the amount of "debt inflation" for a given calibration.

While aggregate consumption was not directly targeted in the construction of the

shocks, the resulting fits the data very well: This is not surprising as in the model (and reality), the by far most important components of GDP are private investment and consumption. Having targeted both output and investment, a good fit for consumption is essentially by construction.[38]

A relevant and more interesting set of non-targeted model variables relates to labor supply. Here, the success of my model partly depends on which data moment one would consider the most relevant real-world counter-part for the simple set-up in my HANK model: In the center panel of Figure D.2, we observe that if one follows the common convention of using Hours Worked divided by the aggregate population (red-dashed line), my model substantially over-estimates the labor supply recovery after the pandemic. In contrast, if adjusting by the size of the civilian labor force (green dot-dashed line), it does a better job.

Given that the conventional DSGE labor market set-up in my model is arguably too simplistic to capture details such as time-varying participation and composition-effects important during the pandemic recovery, a perhaps more reasonable demand is it matching well the overall amount of labor compensation paid ($h_t H_t$ in the model), which directly matters for the model households' aggregate consumption- and savings decisions. While my model overstates the initial drop at the beginning of the pandemic, it matches its subsequent dynamics well, exuding confidence that the HANK framework captures the relevant economic forces at work at least after 2020.[39]

Finally, one may be wondering whether the model's forecast of elevated inflation and a decreasing federal funds rate is at odds with the developments after 2024:Q2. On this issue, recall that the forward simulation does not account for subsequent shocks hitting the economy and any further disturbances could of course explain the difference. Indeed, from the perspective of 2024:Q2, inflation expectations in my model do not seem unreasonably out of touch with various measures of inflation expectations at the time: According to the Cleveland Fed's model of inflation expectations, 1- and 2-year expected inflation was approx. 2.7% and 2.6% in June 2024, respectively. The May 2024 Survey of Professional Forecasters suggests an expected inflation of 3.1% for 2024 and 2.5% for the period 2024 - 2028, while FOMC member's inflation expectations ranged between $2.5 - 3.0\%$ for 2024 and $2.2 - 2.5\%$ for 2025 at the time (c.f. Federal Open Market Committee, 2024). For comparison, my model's predicted inflation rate is approx. 2.7% for 2024 and 2.6% for 2025. There is less publicly available data for expectations about the federal funds rate. The model-implied values, approx. 3.2% for the end of 2025 and 2.9% for the end of 2026, fall within the ranges of the June 2024 FOMC Summary of Economic Projections (SOEP), although only at the lower end for 2025 (again, see Federal Open Market Committee, 2024).

[38] The fact that the match is not perfect is due to the variables being de-trended separately and the dynamics of government consumption not being targeted.

[39] The smaller initial drop in labor compensation despite the strong fall in hours at the beginning of the Covid-pandemic is due to composition effects, with much more low-income than high-income workers being laid off in early 2020.

E Data Construction

E.1 Data for model exercise

This Appendix describes the construction of the data used for the model exercises in Section 6.2. The analysis uses the following aggregate variables, the data for which were again obtained from the Federal Reserve Economic Data (FRED) platform:

- **Nominal Rate**: The variable corresponds to the federal funds rate (FRED series FEDFUNDS).
- **Inflation**: (Gross) Inflation corresponds to the growth of the GDP deflator (GDPDEF) compared to the previous quarter.
- **Output**: (Real) Output corresponds to the sum of the following variables divided by the GDP deflator and current population (CNP16OV):
  - Personal Consumption Expenditures: Non-durable Goods (PCND)
  - Personal Consumption Expenditures: Durable Goods (PCDG)
  - Personal Consumption Expenditures: Services (PCESV)
  - Gross Private Domestic Investment (GPDI)
  - Government Consumption Expenditure and Gross Investment (GCE)
- **Investment**: Gross Private Domestic Investment (GPDI) divided by the GDP deflator and current population (CNP16OV).
- **Transfers**: (Real) Transfer payments consist of the sum of the following variables divided by the GDP deflator and current population (CNP16OV).
  - Federal government current transfer payments: Government social benefits to persons (B087RC1Q027SBEA)
  - Federal government current transfer payments: Grants-in-aid to state and local governments (FGSL)

  The definition of this variable follows Bianchi et al. (2023).
- **Hours worked:** Nonfarm Business Sector Hours Worked for All Workers (HOANBS) divided by either the level of the civilian labor force (CNP16OV) or the civilian labor force (CLF16oV).
- **Labor Compensation:** Compensation of Employees (W209RC1) divided by the GDP deflator (GDPDEF) and current population (CNP16OV).

The pre-covid trends for Output, Government Consumption, Investment and Transfers are taken to be linear time trends estimated for the respective variables over the period 2014Q1 to 2019Q4.

Rate gap	δ_0	β	ζ	λ	$\bar{R}$	G_{ss}
3.74% (Baseline model)	0.0175	0.9838	0.0005	0.0363	0.0355	0.5650
2.71%	0.02	0.9866	0.0004	0.067	0.0299	0.5832
1.70%	0.0225	0.9894	0.0003	0.1068	0.0222	0.5986
0.69%	0.025	0.9921	0.0003	0.1760	0.0131	0.6137

Table F.5: Alternative calibrations used in Section 5.3

Finally, for the comparison between model-implied and actual public debt, I use an approximation of the market value of treasury debt held by the domestic debt public: To the best of my knowledge, there is no publicly available breakdown of the market value of US treasury debt into domestic and foreign holdings throughout the entire period 2020Q1-2024Q2. Instead, I calculate a "foreign share" s^f as Federal Debt Held by Foreign and International Investors (FDHBFIN) over Federal Debt held by the Public (FYGFDPUN) and then take the market value of domestically-held public debt to be $(1 - s^f)$ times the Market Value of Marketable Treasury Debt (MVMTD027MNFRBDAL) minus Federal government checkable deposits and currency as reported in Federal Reserve's Financial Accounts of the United States (FL313020005.Q): The latter would reduce the governments net liquid asset supply from the perspective of the model.

Implicitly, the approximation being correct requires the treasury debt portfolios held by domestic and foreign agents to not differ systematically in terms of maturity structure etc. The US Treasury (2024) reports foreign holdings to have weighted average maturity of 6.3 years, a bit but not overwhelmingly higher than the overall average.

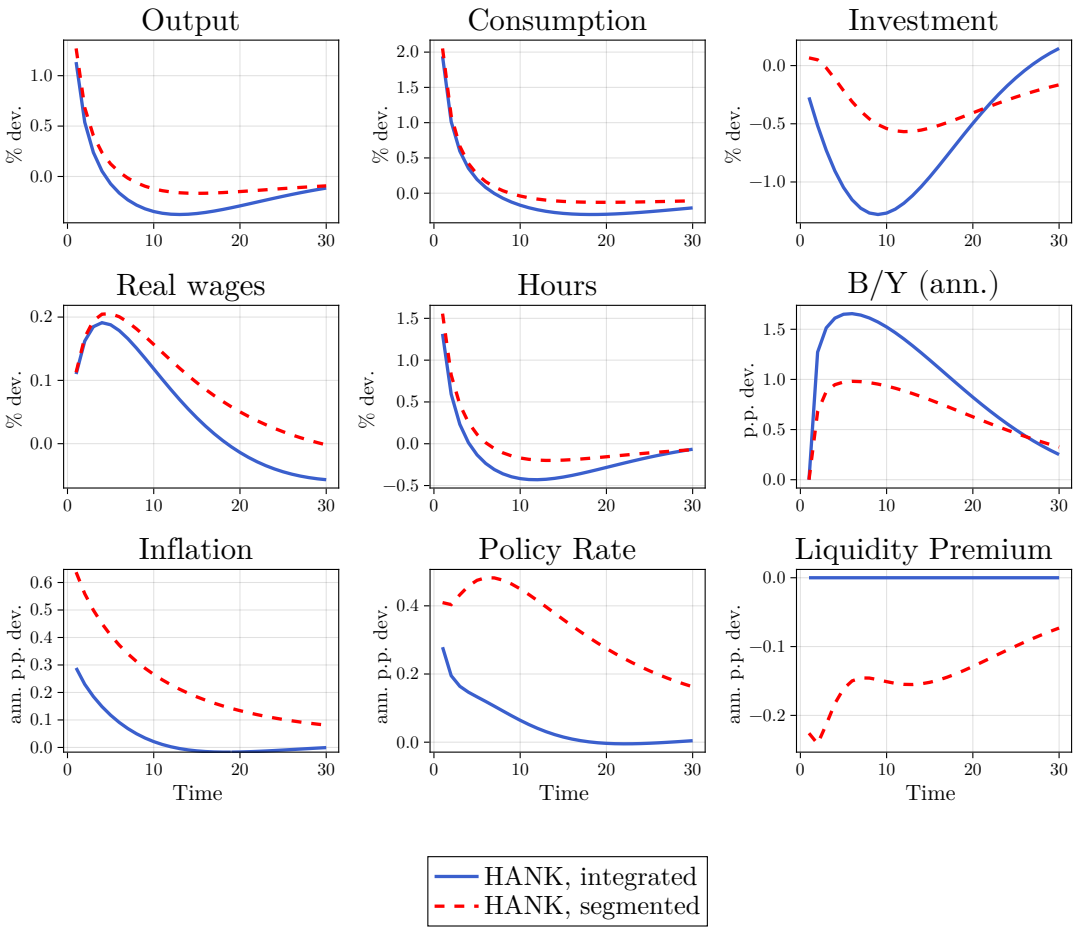
F Additional Tables

This Appendix contains auxiliary Tables referred to in the main text.

G Additional Figures

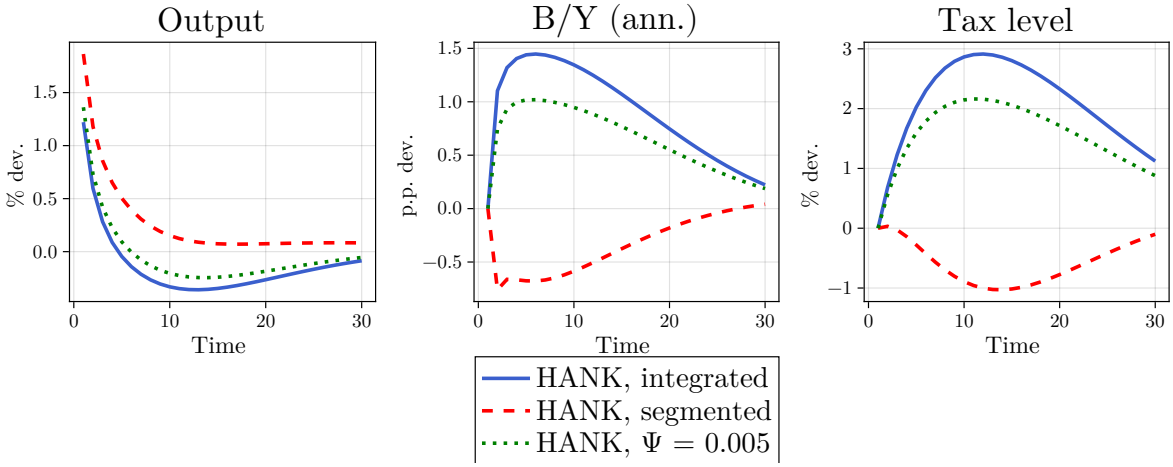
This Appendix contains auxiliary Figures referred to in the main text or previous appendices.

Figure G.3: Model IRFs to fiscal shock



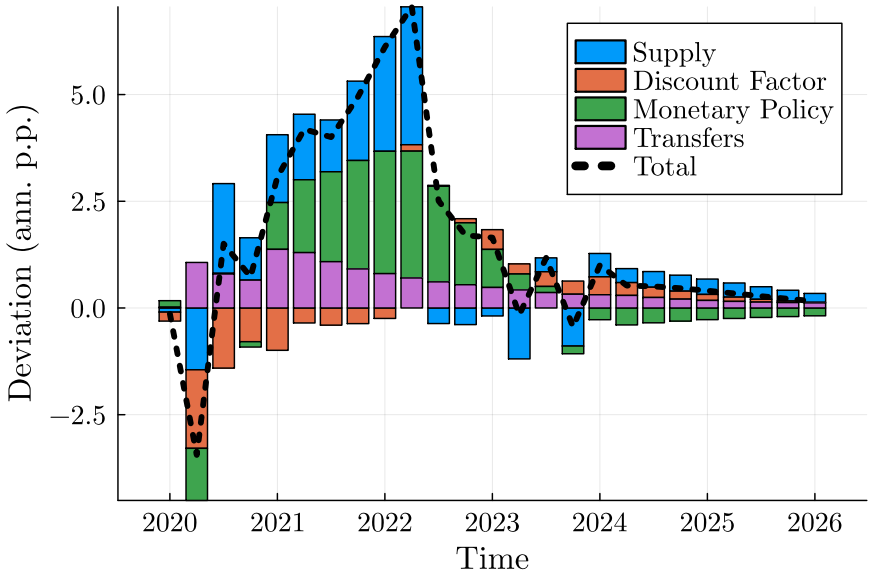
Note: B/Y represents the real market value of public debt B^g over 4 times (=annualized) GDP. The liquidity premium is defined as $\mathbb{E}_t\left(\frac{q_{t+1}+r^k_{t+1}}{q_t} - \frac{R^r_t}{\pi_{t+1}}\right)$.

Figure G.4: Model IRFs: Self-financing



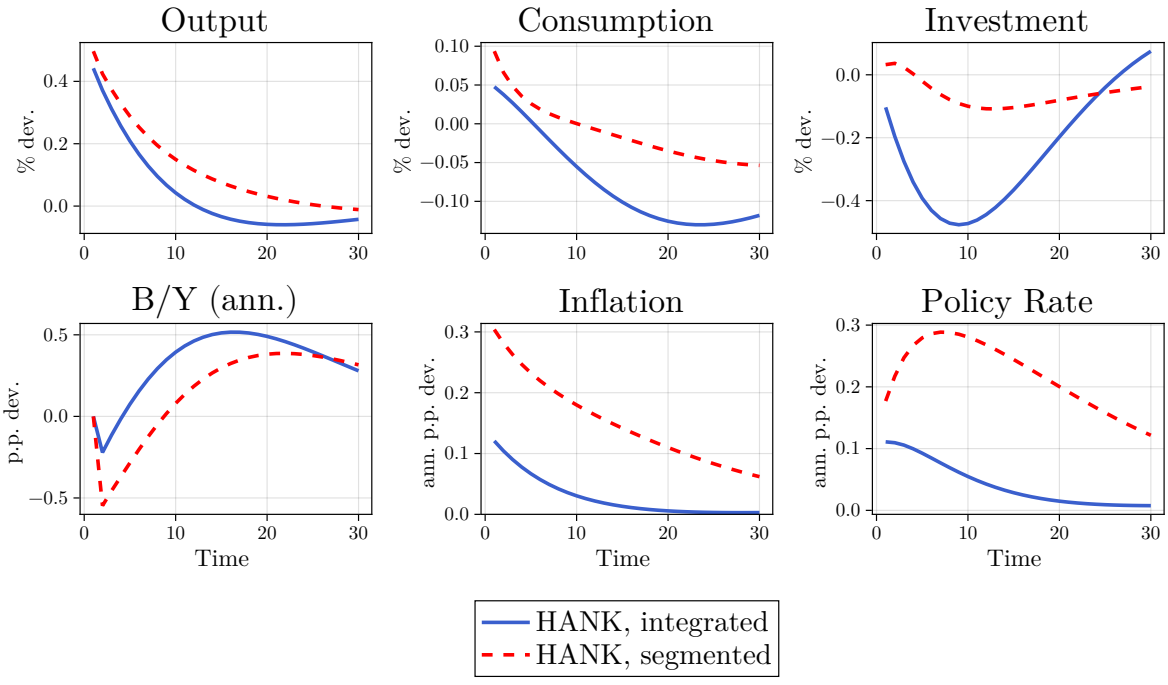
Note: The figure displays IRFs to a one-time transfer shock under $\theta_\pi = 1.05$ and $\theta_y = 0$. B/Y represents the real market value of public debt B^g over annualized GDP. Figures display relative (in %) or percentage point (p.p.) deviations from Steady State.

Figure G.5: Inflation decomposition: $\Psi = 0$ case



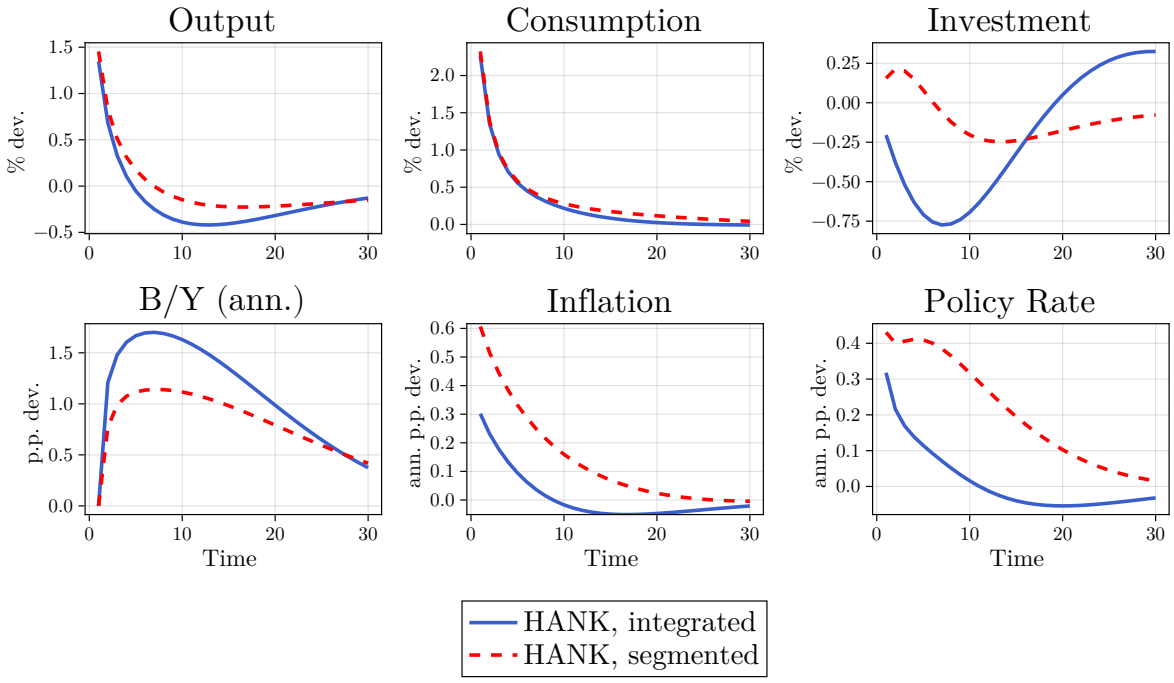
Note: "Supply" collects the impact of both the "cost-push"- and the investment technology shock.

Figure G.6: Model IRFs to Government spending shock



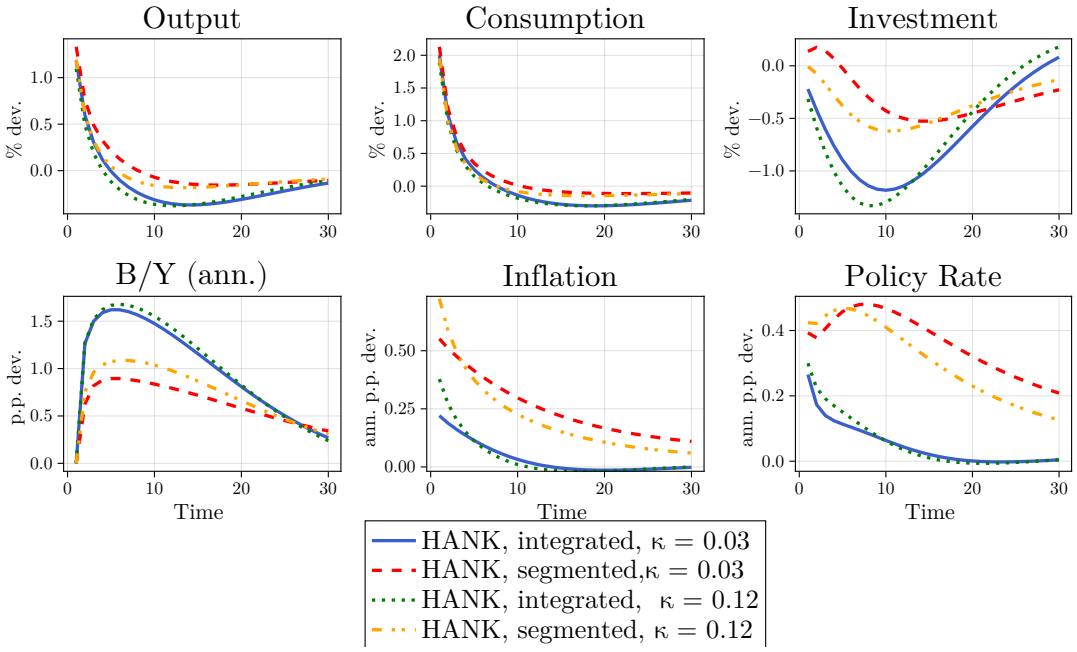
Note: B/Y represents the real market value of public debt B^g over annualized GDP. Figures display relative (in %) or percentage point (p.p.) deviations from Steady State.

Figure G.7: Model IRFs to Transfer shocks: G adjusts



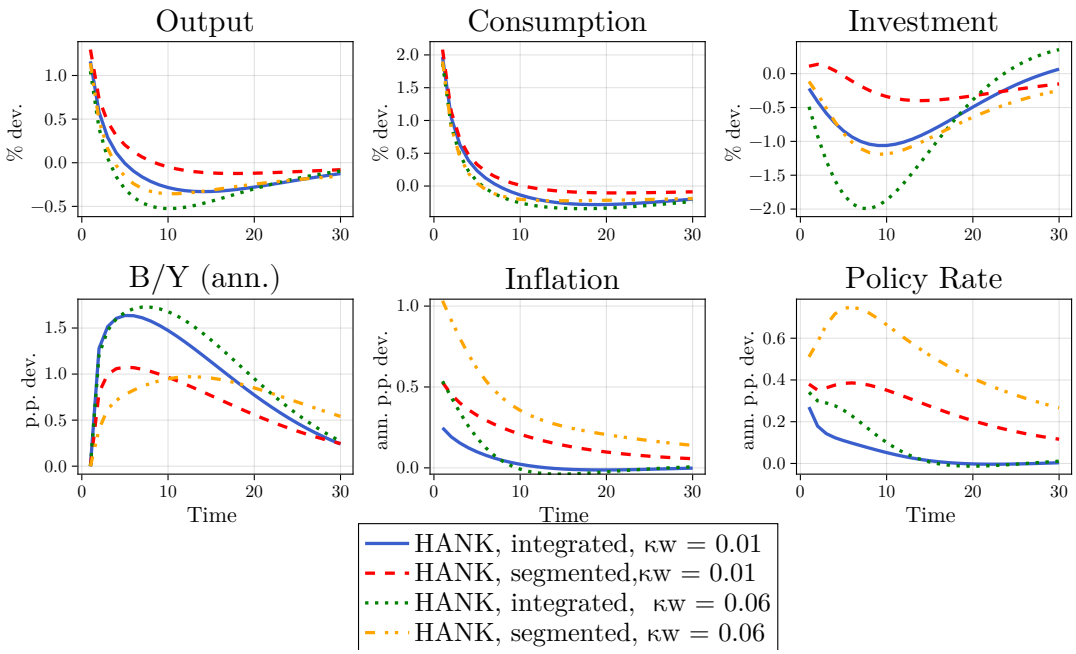
Note: B/Y represents the real market value of public debt B^g over annualized GDP. Figures display relative (in %) or percentage point (p.p.) deviations from Steady State. Instead of adjusting taxes, the government is assumed to consolidate its finance by following the rule $\log G_t = \rho_G \log G_{t-1} + (1-\rho_G)(\log G_{SS} - 0.85 * (\log B^g_t - \log B_{SS}))$ with $\rho_G = 0.9$.

Figure G.8: IRFs to transfer shock: Varying κ



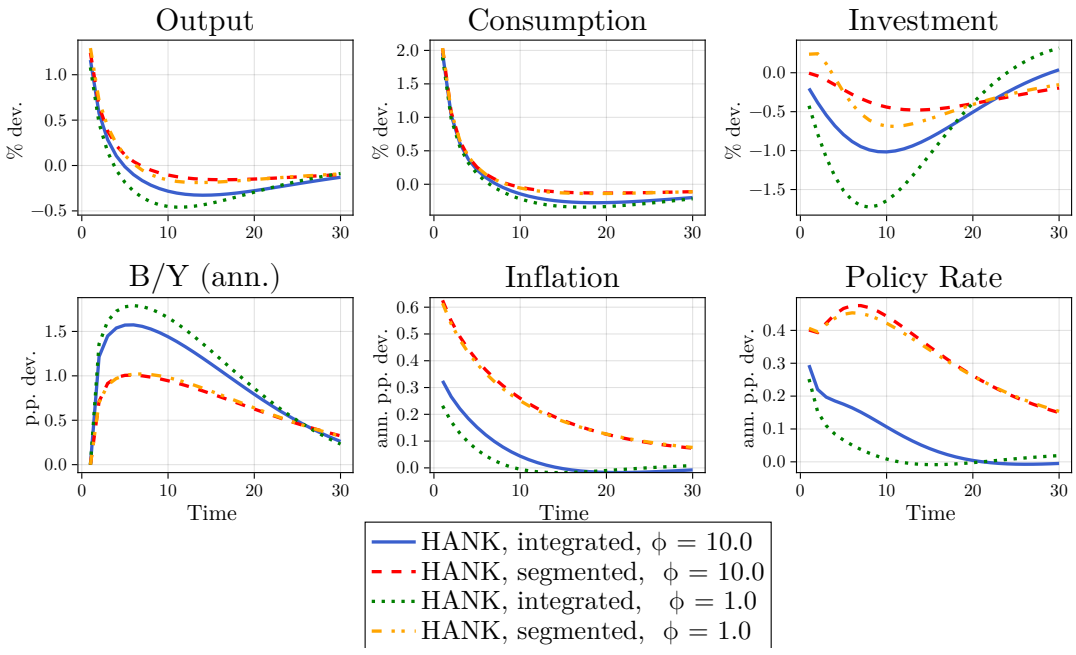
Note: B/Y represents the real market value of public debt B^g over 4 times (=annualized) GDP.

Figure G.9: IRFs to transfer shock: Varying κ_w



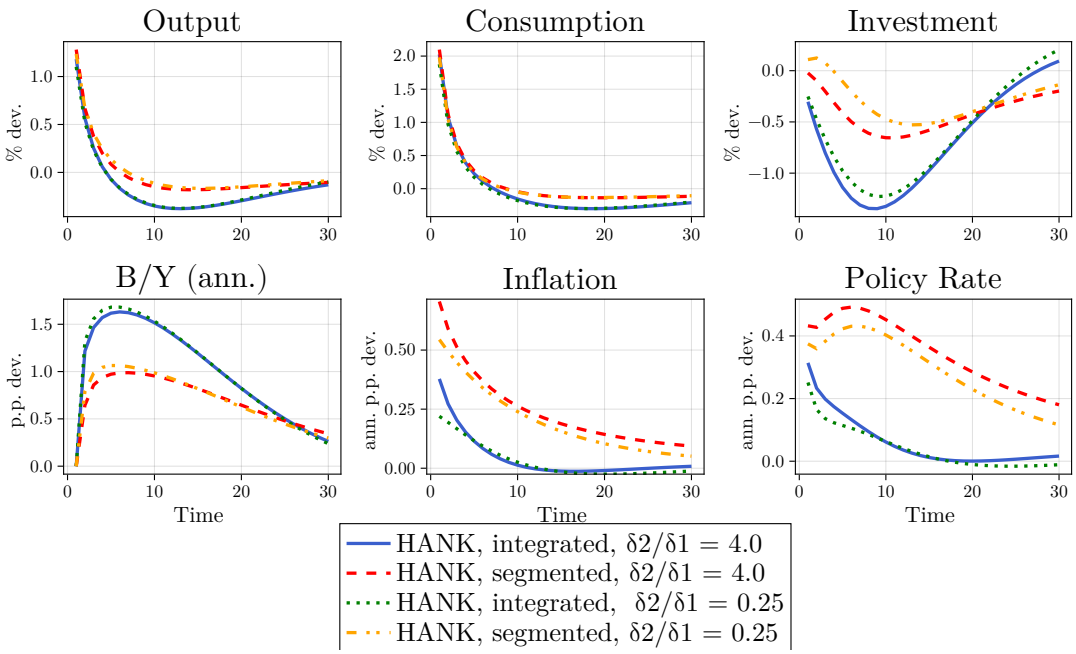
Note: B/Y represents the real market value of public debt B^g over 4 times (=annualized) GDP.

Figure G.10: IRFs to transfer shock: Varying ϕ



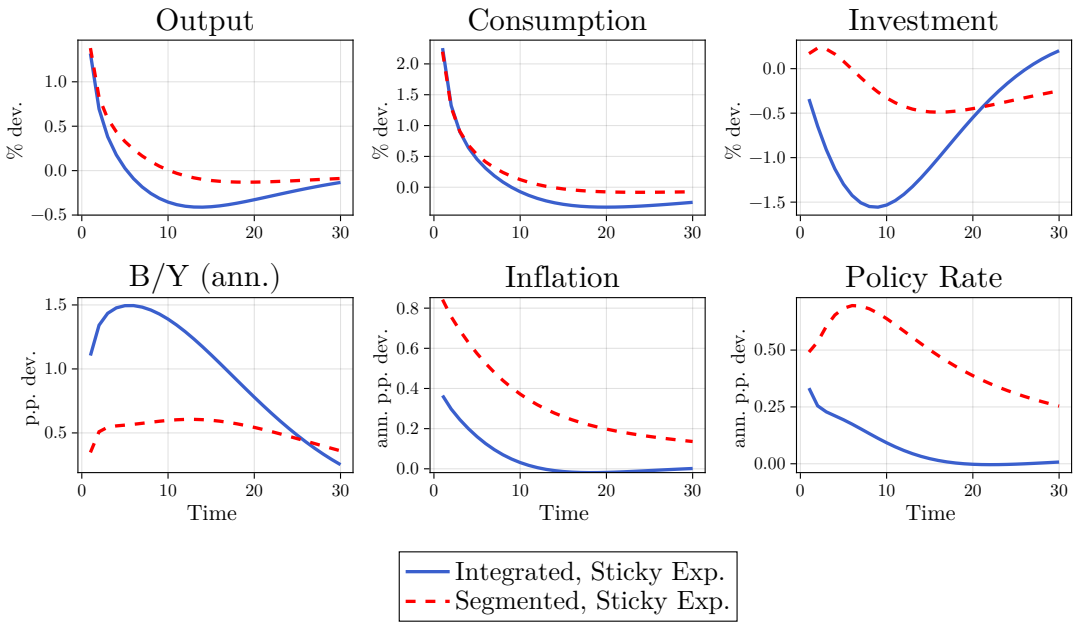
Note: B/Y represents the real market value of public debt B^g over 4 times (=annualized) GDP.

Figure G.11: IRFs to transfer shock: Varying δ_2/δ_1



Note: B/Y represents the real market value of public debt B^g over 4 times (=annualized) GDP.

Figure G.12: IRFs to transfer shock: Sticky Expectations



Note: B/Y represents the real market value of public debt B^g over 4 times (=annualized) GDP.