HANK faces Unemployment*

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Abstract

Since the advent of Heterogeneous Agent New Keynesian (HANK) models, countercyclical unemployment risk has been deemed an important amplification channel for business cycles shocks. We revisit this issue in the context of a rich two-asset HANK framework with search and matching frictions, and we tackle the long-standing challenge of modeling wage bargaining in this class of models. We find the scope for deflationary "unemployment fears" spirals to be noticeable, but hinge on the absence of counteracting savings motives and the structure of the asset market. Additionally, we analyze alternative monetary responses to an adverse supply shock and find that their heterogeneous welfare effects depend importantly on the modeling of labor market heterogeneity. In our baseline, the middle class gains most if the central bank accommodates an employment recovery at the cost of higher inflation.

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1 Introduction

A higher risk and incidence of unemployment is a key channel through which households are affected by business cycle fluctuations. It obviously affects the incomes of those ending up unemployed, but also the savings behavior of those who fear doing so. The latter channel received considerable attention in the recent Heterogeneous Agent New Keynesian (HANK) literature emphasizing incomplete asset markets and nominal rigidities: If higher unemployment risk induces households to hold more precautionary (liquid) savings and consume less, aggregate demand is reduced. The resulting deflationary pressure even further increases unemployment risk, and so on, in a deflationary equilibrium spiral. Hence, unemployment risk-driven precautionary saving behavior - which we shall refer to as *unemployment fears* for brevity - can act as an amplifier of business cycle dynamics in such frameworks.

A range of papers found this mechanism to provide for a substantial amplification of aggregate fluctuations (e.g., Ravn and Sterk, 2021; Broer et al., 2025) and important implications for the design of stabilization policy (e.g., Challe, 2020; McKay and Reis, 2021). Yet, many of them are based on relatively simple models, such as so-called zero-liquidity HANK models with a degenerate wealth distribution. The respective tractability provides useful insights, but to what extent do they generalize? While endogenously varying unemployment is also featured in analyses featuring rich quantitative HANK models (such as Gornemann et al., 2021; Lee, 2021a), their complexity and broader focus tend to make it difficult to assess the actual importance of the *unemployment fears* amplification.[1]

In our work, we embed a rich model of the labor market into a quantitative 2-asset HANK model à la Bayer et al. (2024). Our framework can relate to the microeconomic moments emphasized by the HANK literature while also providing for the many economic forces shaping the business cycle in quantitative DSGE models. Within this complex model, we take particular care to pin down and analyze how the time-varying unemployment risk affects the propagation of aggregate shocks. Additionally, we also consider how unemployment shapes the distributional effects of monetary policy and propose a resolution to a modeling challenge: Having explicit wage bargaining is often seen as difficult in heterogeneous agent environments, given that standard bargaining protocols such as the Nash solution would imply wages to depend on a workers' asset holdings. We demonstrate that an Alternating Offer Bargaining (AOB) protocol in the vein of Christiano et al. (2016) and Ljungqvist and Sargent (2021) can yield wages not depending on

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[1] Even though empirical work such as Juelsrud and Wold (2025) has documented that households indeed precautionary save in the face of higher unemployment risk, the general equilibrium nature of the amplification mechanism makes it very hard to test directly. Consider, for example, that in some zero-liquidity models, it may be crucial even though no household is ever observed to save more.

individual wealth while retaining a micro-founded forward-looking component.

Our results indicate the impact of unemployment risk-driven precautionary saving to be more intricate than suggested by the previous literature. In particular, its effects on inflation and feedback to the real economy differ markedly between different type of shocks. We find this to be due to the presence (or absence) of other important drivers of liquid asset demand typically absent in simpler HANK models, notably time-varying incomes from illiquid assets and profits. Moreover, the propagation of *unemployment fears* to the aggregate economy depends on the structure of the asset markets: In our model, liquid assets can be in potentially ample supply even if households hold little of it. In that case, the unemployment risk has little effect on inflation but may stabilize investment instead.

In our analyses, the way we chose to differentiate the aggregate effects of unemployment risk-driven precautionary saving from the many economic forces at play in our model is the following: We consider an alternative model version which only differs from our baseline model in that households have counterfactual beliefs regarding their idiosyncratic unemployment risk. The difference between this "naive" HANK model and our baseline economy provides a natural measure of the *precautionary* motive independent of the distributional channel one would also capture by studying, e.g., an economy with higher unemployment insurance.[2]

We begin by studying two supply shocks in our model, a TFP shock and a so-called "cost push" (markup) shock. The responses to the TFP shock appear conventional and only moderately affected by unemployment-risk demand amplification. In marked contrast, the latter overturns the conventional inflationary nature of the "cost push" shock and is accompanied by a more pronounced impact on real activity. Such heterogeneity is also present between further supply- and demand disturbances and is not simply tied to the magnitude of the unemployment response itself.

Decomposing the contributions of household's liquid asset demand, we ascribe the often moderate impact of the *unemployment fears* to the mentioned presence or absence of counteracting savings motives. For example, in the aftermath of the "cost-push" shocks, the liquidity demand related to unemployment risk is *relatively* large, while dissaving due to lower capital- and profit incomes render it *relatively* small following the TFP shock. This pattern, that a smaller relative size of unemployment-related liquid savings demand is accompanied by less amplification of the shock, is present also for the various other model shocks under consideration. We conclude that while simpler HANK-SaM models have provided useful conceptual insights, their omission of various (arguably relevant) drivers of liquidity supply can overstate the degree of demand

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[2] While either are potentially interesting, capturing distributional effects requires less obviously models with *endogenously time-varying* unemployment.

amplification.

Given the importance of liquid asset demand, we also turn to liquidity supply. As alluded to above, many previous analyses considered set-ups in which liquid assets are in small supply (often zero). While providing for tractability, using such frameworks for drawing quantitative conclusions seems to be motivated by the empirical regularity that most households hold little liquid wealth. For example, Challe (2020) states that for that reason, "focusing on an equilibrium with zero liquidity may not hugely distort the response of desired savings to aggregate shocks". However, by varying the usefulness of capital for liquidity provision while keeping the household wealth distribution fixed, our two-asset model showcases that the crucial margin for the emergence of risk-driven deflationary spirals is *not* households holding little liquid assets but rather liquidity being *fundamentally scarce*. Although safe and liquid assets are in limited supply (e.g., Caballero et al., 2017), relating to household-side evidence alone seems insufficient to calibrate their relevant degree of scarcity.

Afterwards, we further investigate the importance of profits for inflation and demand amplification by using a simple model tweak. This suggests the savings demand stemming from cyclical profit variation to not only mediate the macroeconomic importance of time-varying unemployment risk specifically, but the economy's nominal and aggregate dynamics more broadly. The distribution of profits has previously been highlighted to importantly shape model responses to aggregate shocks and our results advance this notion by highlighting their potential to shape equilibrium interest rates and inflation. This is even in the absence of wealth effects on labor supply decisions.

In further robustness checks, we also assess how our conclusions are affected if the model households' display higher risk aversion or if wages are sticky in nominal (and not just real) terms. In the former case, the scope for *unemployment fears* to shape the macroeconomic response to shocks unsurprisingly increases, but the economic forces moderating it remain important. Nominal stickiness, in turn, substantially changes the cyclical dynamics of unemployment and households' expectations of their respective risk can become stabilizing.

Regarding monetary policy, we begin by studying the HANK models' determinacy properties and establish that the model features shaping the *unemployment fears* amplification are also crucial for the existence of unique and stable equilibria. Additionally, we ask: Does a detailed modeling of unemployment still matter if said amplification is moderate? As a simple exercise, we study how different monetary policy rules affect households' welfare in the aftermath of an energy price shock for which this is case. Allowing for model features such as skill losses during unemployment or heterogeneous job separation rates does not only affect how much households gain/lose but also changes which groups of households are affected most. In our baseline, the middle class gains most if the central banks acts less to stabilize employment, but with homogeneous job separation rates along the income distribution, it would be high income households. Thus, for studying the distributional effects of monetary policy, unemployment and related labor market heterogeneity appears relevant nevertheless.

In what follows, we provide further information on the relevant literature. We then present the main model specification in Section 2 covering the household sector, the production side and the labor market. In Section 3 we provide the calibration of the model parameters and validate its by comparing untargeted model moments with relevant empirical counterparts. We continue with our results on the contribution of the *unemployment fears* in Section 4. The following Section 5 features the robustness tests and in Section 6, we explore our model's implication for monetary policy. Section 7 concludes.

Literature review Our paper contributes to the sprawling HANK literature, pioneered by McKay and Reis (2016) and Kaplan et al. (2018). Within that area, our work naturally relates most closely to other research analyzing the role of time-varying unemployment risk and related policies. In addition to the various papers already cited above, den Haan et al. (2017) analyzes the discussed *unemployment fears* spirals in a model with portfolio choice between money and stocks, emphasizing the importance of nominal wage rigidity. Further work deducing the precautionary savings demand channel to have substantial policy implications includes Albertini et al. (2021) and Dengler and Gehrke (2022), among others.
Other papers employ quantitatively oriented one-asset HANK-SaM models to study the heterogeneous welfare effects of different monetary policy rules (Gornemann et al., 2021), the stabilization effects of unemployment insurance (Kekre, 2022) or the aggregate effects of deviations from rational expectations (Bardoczy and Guerreiro, 2023). Alves (2022) and Birinci et al. (2022) analyze the implications of job-to-job transitions in HANK models, an aspect many other Hank-SaM papers (including ours) abstract from. Lee (2021b) also constructs a 2-asset HANK model with SaM frictions but only focuses on the transmission of monetary policy shocks.
Naturally, our work also relates to papers incorporating SaM frictions into rich New Keynesian models without household heterogeneity. In addition to the mentioned Christiano et al. (2016), earlier examples are Walsh (2005) or Gertler et al. (2008).

A work particularly close to ours is the paper by Graves (2025), who also studies how cyclical unemployment risk amplifies aggregate shocks in a 2-asset HANK economy. He finds noticeable effects stemming from households' endogenous illiquid asset adjustment, but does not provide our insights on the importance of liquid asset demand- and supply.[3] Cho (2023) provides results related to ours by finding the aggregate effects of precautionary savings to be small in his estimated one-asset HANK-SaM model, but conducts little analysis on how this comes about.[4] Additionally, Jung (2023) previously found that moderate wage rigidity can dampen demand amplification in a zero-liquidity HANK-SaM model, as wage incomes may provide a counteracting savings motive to unemployment risk. Our work provides further insights on the importance of alternative sources of liquidity demand in a richer, quantitatively-oriented model, among others.

Finally, our results on the importance of profits are reminiscent of Broer et al. (2020), who identify their distribution to be an important modeling aspect due to their effects on households' labor supply choices. Alves et al. (2020) also find the profit allocation to matter noticeably for model effects of monetary policy shocks. And even though we focused on time-varying unemployment, we believe that our insights on its propagation should also be of interest for work on the influence of others types of time-varying idiosyncratic risk. While our results do not preclude them to have important aggregate effects, we expect their overall impact to be moderated by similar mechanisms as in our model. As a case in point, our findings on the importance of the asset market structure bear some resemblance to results by Dominguez Diaz (2021), who argues that financial sector constraints can matter substantially for the aggregate effects of (exogenously) higher idiosyncratic risk in a 2-asset HANK economy.

2 The model

This section describes our two-asset HANK model, many aspects of which are similar to the model studied by Bayer et al. (2024), except the way the labor- and asset markets are modeled.

Period timing In every period, there is the following order of events, on which additional details will be provided below:

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[3] While our model can relate to his empirical evidence, we find little amplification through investment in our baseline model, which we take to be due to the presence of investment adjustment costs and our different assumptions on illiquid asset adjustment. Additionally, Graves (2025) study compares a baseline model to another framework featuring no UI benefits and thus answers the related but not identical question "*Does the presence of UI dampens aggregate shocks?*"

[4] Based on our results, we conjecture that his model featuring an always unconstrained "patient" household is important for this outcome, as this introduces a potentially ample liquidity supply for workers that can lend to/from this agent.

1. Aggregate shocks are revealed; job separations take place; government policies are announced
2. The labor market opens: labor agencies post vacancies; Unemployed search for jobs; matches are formed
3. The labor market closes; there is an even number of M subperiods during which production takes place and workers and labor agencies can negotiate over wages
4. Goods and asset markets open: Asset returns are paid out; consumption and investment decisions are made
5. Goods and asset markets close; shocks to idiosyncratic states s_{it} and Ξ_{it} are revealed

2.1 Households

2.1.1 Idiosyncratic states

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

- First of all, households vary in terms of their holdings of liquid and illiquid assets a_{it} and k_{it}. We require that $k_{it} \geq 0$ as well as $a_{it} \geq \underline{a}$, with $\underline{a}$ representing an exogenous borrowing limit. k_{it} is a capital investment which 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), we 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 frictional labor market, while the latter don't supply labor on 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 $\Xi_{it} = 1$ households. Transitions to and out of the "entrepreneur" state are exogenous with probabilities ζ and ι.
- 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. This state also affects job separation- and job finding rates as specified below. We allow for transition probabilities $\Pi^s(s_{it+1}|s_{it}, e_{it})$ to depend on employment status

e_{it} (see next bullet point) in order to parsimoniously allow for skill accumulation (depreciation) while employed (unemployed). Workers who are selected to become entrepreneurs lose their idiosyncratic s_{it} state as well as their job, while exiting entrepreneurs draw a new s_{it} according to exogenous probabilities $p_{s_1}, p_{s_2}, \ldots$ and enter unemployment.

- Finally, workers will either be employed ($e_{it} = 1$) or unemployed ($e_{it} = 0$). We assume there to be no disutility from either work or job search, so that all workers are working or searching full time. Job finding rates and unemployment risk will be *endogenously* determined on the frictional labor market described in Section 2.3. Note that either may depend on individual labor productivity as we allow search effectiveness and job separation rates to vary by s.
  Workers receive a wage $w_t(s_{it})$, while unemployed agents receive an unemployment insurance (UI) benefit $b_t(s_{it})$. As outlined above, wages w_t will be the outcome of an AOB bargaining protocol to be detailed in Section 2.3.3, while $b_t(s_{it})$ is set by the government: its level is assumed to depend on s_{it} to introduce dependence on previous income without adding additional state variables to the household problem.

Below, we will (with some abuse of notation) denote by $m_t(\cdot)$ the mass of households that, at the beginning of a period, are currently in the specified state, e.g., $m_t(k, s, e)$ is the respective measure of households with capital holding k, skill s and employment status e. Additionally, we will use m_t^e, m_t^u and m_t^{Ξ} to denote the masses of agents that feature states $e_{it} = 1$, $e_{it} = 0$ or $\Xi_{it} = 1$ at the beginning of stage 4 of any period t (compare Section 2 above).

2.1.2 The Household problem

Households gain utility from consumption c according to the preference structure

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

The above formulation allows for a time-varying demand shock A_t shifting *all* households' discount factor β, a vehicle to introduce so-called “demand shocks”. An agent who get to adjust its illiquid capital stock will face budget constraint (written in real terms)

$$c_{it} + q_t k_{it+1} + a_{it+1} = y_{it}(e_{it}, s_{it}, \Xi_{it}) + R_t^a(a_{it}) a_{it} + (q_t + r_t^k) k_{it} \tag{2}$$

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

$$c_{it} + a_{it+1} = y_{it}(e_{it}, s_{it}, \Xi_{it}) + R_t^a(a_{it}) a_{it} + r_t^k k_{it} \tag{3}$$

with $k_{it} = k_{it+1}$. Both budget constraint are already written in real terms. q_t denotes the time t price of capital goods, r^k_t the real net return of capital goods and $r^a_t(a_{it})$ 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

$$R^a_t(a_{it}) = \begin{cases} R^l_t & \text{if } \ a_{it} \geq 0; \\ R^l_t + \bar{R} & \text{if } \ a_{it} < 0, \end{cases} \tag{4}$$

where R^l_t is the real gross return on liquid savings, which will depend on the nominal central bank rate r^R_t and inflation $\pi_t = \frac{P_t}{P_{t-1}}$ as specified below. $\bar{R}$ is a real borrowing penalty.[5] Finally, y_{it} represents an household's post-tax labor-, benefit- or profit income so that

$$y_{it}(e_{it}, s_{it}, \Xi_{it}) = \begin{cases} (1-\tau^y_t)(w_t(s_{it}))^{1-\tau_p} & \text{if } \ e_{it} = 1, \ \Xi_{it} = 0 \\ (1-\tau^y_t)(b_t(s_{it}))^{1-\tau_p} & \text{if } \ e_{it} = 0, \ \Xi_{it} = 0 \\ (1-\tau^\Xi_t)\frac{\Pi_t}{m^\Xi_t} & \text{if } \ \Xi_{it} = 1 \end{cases} . \tag{5}$$

As in the US and various European countries, both wage- and UI income is subject to income taxes. These follow an affine tax schedule in the vein of Benabou (2002), for which the parameters τ^y and τ^p determine the level and degree of progressivity, respectively. Profit income, in turn, is taxed at rate τ^Ξ_t.

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

$$\begin{aligned} & V^a(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t) = \\ & \quad \max_{c_{it}, k_{it+1}, a_{it+1}} \left\{ \frac{c_{it}^{1-\xi} - 1}{1-\xi} + \beta \mathbb{E}_t A_{t+1} V(a_{it+1}, k_{it+1}, e_{it+1}, s_{it+1}, \Xi_{it+1}; \Gamma_{t+1}) \right\} \\ & \quad \text{s.t. to } (2), (5), k_{it} \geq 0 \text{ and } a_{it} \geq \underline{\mathrm{a}} \end{aligned} \tag{6}$$

for an household able to adjust its capital stock and

$$\begin{aligned} & V^{na}(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t) = \\ & \quad \max_{c_{it}, a_{it+1}} \left\{ \frac{c_{it}^{1-\xi} - 1}{1-\xi} + \beta \mathbb{E}_t A_{t+1} V(a_{it+1}, k_{it}, e_{it+1}, s_{it+1}, \Xi_{it+1}; \Gamma_{t+1}) \right\} \\ & \quad \text{s.t. to } (3), (5), k_{it} \geq 0 \text{ and } a_{it} \geq \underline{\mathrm{a}} \end{aligned} \tag{7}$$

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[5] Our 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.

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

$$\begin{aligned} V(a_{it+1}, k_{it}, e_{it+1}, s_{it+1}, \Xi_{it+1}; \Gamma_{t+1}) = {} & \lambda V^a(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t) \\ & + (1-\lambda) V^{na}(a_{it}, k_{it}, e_{it}, s_{it}, \Xi_{it}; \Gamma_t) \quad . \end{aligned}$$

2.2 Production

The model's supply side is similar to standard "medium scale" DSGE models, except the way the labor market is modelled: 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 latter set prices in a monopolistic competitive fashion subject to nominal rigidities and require intermediate goods to produce their output. These are produced by a set of competitive intermediate goods producers that require capital, energy and labor services as inputs. However, the provision of the labor input requires hiring on a frictional labor market à la Diamond-Mortensen-Pissarides, which is handled by labor agencies. As Bayer et al. (2024), we make the simplifying assumption that firms solving forward-looking problems discount the future at the household's discount factor β.[6]

2.2.1 Final Goods producer

The representative final good producer combines a continuum of differentiated inputs according to production function

$$Y_t = \left(\int_0^1 y_{jt}^{\frac{1}{\mu_t}} \, dj \right)^{\mu_t} \quad . \tag{8}$$

with $\mu_t > 1$. Given prices p_{jt}, the first order conditions of the producers profit maximization problem give rise to the familiar demand schedule for any given variety as

$$y_{jt} = \left(\frac{p_{jt}}{P_t} \right)^{\frac{-\mu_t}{\mu_t - 1}} Y_t \tag{9}$$

where P_t is the aggregate price level given by

$$P_t = \left(\int_0^1 p_{jt}^{\frac{1}{1-\mu_t}} \, dj \right)^{1-\mu_t} \quad .$$

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

We allow for exogenous time variation in μ_t, so-called "cost-push" (markup) shocks.

2.2.2 Retailers

There is a unit mass of retailers, each of which produce a given variety as monopolist, taking into account demand schedule (9). Their only input are intermediate goods, which they purchase at real price mc_t (also referred to as "marginal cost") from the competitive intermediate goods producers. Additionally, they have to pay a fixed cost ς in terms of the final good and are subject to nominal rigidities à la Calvo with price indexation, i.e. they can only re-set their price if chosen with an exogenous probability λ_Y.
If not receiving the re-set opportunity, a retailer's price is automatically adjusted by the Steady State (SS) inflation rate π_{SS}.[7] If receiving it, the retailer will decide a price to maximize the corresponding expected net present value of real profits

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

Log-linearizing the first order conditions of the resulting price setting problem gives rise to the standard log-linear Phillips curve

$$\log\left(\frac{\pi_t}{\pi_{SS}}\right) = \kappa_Y \left(mc_t - \frac{1}{\mu_t} \right) + \beta \mathbb{E}_t \log\left(\frac{\pi_{t+1}}{\pi_{SS}}\right) \tag{10}$$

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

2.2.3 Intermediate goods producers

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

$$F_t(u_t K_t, H_t, E_t) = Z_t F(u_t K_t, H_t, E_t) = Z_t \left(\varrho^{\frac{1}{\epsilon_e}} E_t^{\frac{\epsilon_e - 1}{\epsilon_e}} + (1-\varrho)^{\frac{1}{\epsilon_e}} \left((u_t K_t)^{\alpha} H_t^{1-\alpha} \right)^{\frac{\epsilon_e - 1}{\epsilon_e}} \right)^{\frac{\varepsilon_e}{\varepsilon_e - 1}} . \tag{11}$$

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

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

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[7] This allows to normalize $\pi_{SS} = 1$.

and Z_t is a shock to Total Factor Productivity (TFP). We chose to include an energy good input in (11) to be able to consider shocks to energy prices, a recently salient macroeconomic issue. The functional form in (11) is inspired by Hassler et al. (2021).

Taking the prices p_t^E and h_t for energy and 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

$$\max_{K_t, E_t, H_t, u_t} mc_t F_t(u_t K_t, H_t, E_t) - p_t^E E_t - h_t H_t - (r_t + q_t \delta(u_t)) K_t,$$

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

$$p_t^E = mc_t Z_t \left(\frac{E_t}{\varrho F(u_t K_t, H_t, E_t)} \right)^{-\frac{1}{\epsilon_e}} \tag{12}$$

$$h_t = (1-\alpha) mc_t Z_t \left(\frac{(u_t K_t)^\alpha H_t^{1-\alpha}}{(1-\varrho) F(u_t K_t, H_t, E_t)} \right)^{-\frac{1}{\epsilon_e}} \left(\frac{u_t K_t}{H_t} \right)^\alpha \tag{13}$$

$$r_t + q_t \delta(u_t) = \alpha mc_t Z_t \left(\frac{(u_t K_t)^\alpha H_t^{1-\alpha}}{(1-\varrho) F(u_t K_t, H_t, E_t)} \right)^{-\frac{1}{\epsilon_e}} \left(\frac{u_t K_t}{H_t} \right)^{\alpha-1} u_t \tag{14}$$

$$q_t(\delta_1 + \delta_2(u_t - 1)) = \alpha mc_t Z_t \left(\frac{(u_t K_t)^\alpha H_t^{1-\alpha}}{(1-\varrho) F(u_t K_t, H_t, E_t)} \right)^{-\frac{1}{\epsilon_e}} \left(\frac{u_t K_t}{H_t} \right)^{\alpha-1}. \tag{15}$$

2.2.4 Energy goods production

For simplicity, the production of energy goods is modeled in a particularly parsimonious fashion: We assume there to be a competitive energy producer that is endowed with a technology to transform Z_t^E units of the final good into one unit of the energy good, with Z_t^E itself being determined by an exogenous shock process. In turn, the real price of energy will effectively be given exogenously as $p_t^E = Z_t^E$. Such a setting is isomorphic to a case in which energy goods need to be purchased on a world market at an exogenously determined (and potentially fluctuating) real price p_t^E.

2.2.5 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

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

and their optimal interior solution will fulfill first-order condition

$$1 + q_t Z_t^I \left(\frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 - 1 + \phi \left(\frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} \right) = \beta \mathbb{E}_t q_{t+1} Z_{t+1}^I \phi \left(\frac{I_{t+1}}{I_t} - 1 \right) \left(\frac{I_{t+1}}{I_t} \right)^2 . \tag{16}$$

2.3 Labor market

2.3.1 Labor agencies

Labor services are produced by a continuum of homogeneous labor agencies, each of which is matched with at most one worker of productivity s_t. Such a match produces s_t units of the labor service output, the price of which are taken as given by an agency.[8] Job separations are exogenous and take place either if (1) the match is subject to a separation shock arriving with probability $\delta(s)$ or if (2) the worker becomes an entrepreneur with probability ζ. We allow for job separation rates $\delta(s)$ to depend on skill, consistent with evidence that low-income workers face higher job separation rates (see e.g. Birinci and See, 2021). Given all the above, the recursive characterization of the value of a matched agency is

$$J(s_t; \Gamma_t) = h_t s_t - w_t(s_t) + (1 - \zeta)(1 - \delta(s_t)) \beta \mathbb{E}_t J(s_{t+1}; \Gamma_{t+1}) \quad . \tag{17}$$

2.3.2 Job matching and vacancy creation

There is a single labor market, on which unmatched labor agencies can meet unemployed workers by posting vacancies. The number of meeting is governed by a Cobb-Douglas matching technology

$$M_t(V_t, U_t) = A_m U_t^{\chi} V_t^{1-\chi} \quad . \tag{18}$$

V_t represents the total number of vacancies posted and

$$U_t = \sum_{s_i \in \mathcal{S}} \varpi(s_i) [\delta(s_i) m_t(e = 1, s = s_i) + m_t(e = 0, s = s_i)]$$

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[8] Due to CRS and the market for labor services being competitive, one could equivalently assume that intermediate goods firms produce labor services "in-house" and handle hiring themselves.

the total mass of workers searching for a job. From (18), it follows that the period-t aggregate job-finding probability p_t^{UE} and vacancy-filling probability p_t^{vf} are

$$p_t^{UE} = \frac{M_t(V_t, U_t)}{U_t} = A_m \theta_t^{1-\chi} \quad \text{and} \quad p_t^{vf} = \frac{M_t(V_t, U_t)}{V_t} = A_m \theta_t^{-\chi} \quad , \tag{19}$$

respectively. $\varpi(s_i)$ is a search effectiveness term so that an s_i worker finds jobs with probability $\varpi(s_i)p_t^{UE}$ and gets unemployed with probability $\delta(s_i)(1-\varpi(s_i)p_t^{UE})$. This allows for an income gradient also along the job finding dimension. $\theta_t := V_t/U_t$ is the aggregate labor market tightness.

Hiring is costly in that a) posting a vacancy incurs a real resource cost of κ_1 per vacancy posted and b) upon meeting a worker a labor agency needs to pay a resource cost of κ_2 before bargaining can begin. The latter may represent resources needed to "screen" the worker. In equilibrium, θ_t is pinned down by a free entry condition of the form

$$\kappa_1 = p_t^{vf} \left(\sum_{s \in \mathcal{S}} \frac{U_t(s)}{U_t} J(s; \Gamma_t) - \kappa_2 \right) \tag{20}$$

with

$$U_t(s_i) = \varpi(s_i)[m_t(e=0, s=s_i) + \delta(s_i) m_t(e=1, s=s_i)]$$

denoting the effective mass of search by $s_i \in \mathcal{S}$ agents. These terms reflect labor agencies taking into account which type of workers they are most likely to meet.

2.3.3 Wage determination

Wages are determined according to an *intra-period* Alternative Offer Bargaining (AOB) protocol in as in Christiano et al. (2016), imposing the restriction of no intra-period bargaining break-downs used by Ljungqvist and Sargent (2021):[9] During the M subperiods of a period's production stage (compare Section 2), the worker and the labor agency take turns extending wage offers: We will be denoting variables on a per-subperiod basis with a Δ, e.g. $h_{\Delta,t} := \frac{h_t}{M}$ is the revenue a labor agency gains by producing during one of the subperiods etc..

We assume that in any given period, the labor agency gets to make the first offer. If the worker rejects it, she can make a counter-offer in the next period that the firm can reject or accept, and so on. Once a wage agreement has been reached, the match starts producing labor services and the worker is paid the agreed wage rate for the remainder of the period. However, before that happens, an agency matched with a skill s-worker incurs a cost of delay $\gamma_\Delta(s)$ per subperiod,

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[9] Ljungqvist and Sargent (2021) find this restrictions to hardly affect model dynamics in the rich representative agent New Keynesian model studied by Christiano et al. (2016).

while the worker will receive an outside income $\tilde{b}_{\Delta,t}(s)$ per subperiod. Both these values will have to depend on the respective's workers productivity s to avoid high (low) productivity workers being able to bargain wages that are disproportionately low (high) comparatively to their skill. If no wage is accepted before the last period M, the worker gets to make a *take-it-or-leave-it* offer during the last subperiod (M is even). If rejected by the firm, the match irreparably dissolves and the worker enters the pool of the unemployed.

Now, to characterize the wage outcome, we first note that independently of worker wealth, a worker (agency) in our model would always like the wage to be as high (low) as possible.[10] In turn, it is optimal for each party to make offers barely acceptable to the other.[11] Hence, slightly abusing notation, if a firm gets to make an wage offer $w^f_{j,\Delta,t}$ to a worker in a subperiod $j < M$, this offer should fulfill

$$\begin{aligned} &V\left((1-\tau^y)[(M-j+1)w^f_{j,\Delta,t} + (j-1)\tilde{b}_{\Delta,t}(s)]^{1-\tau^p}, \cdots\right) \\ =&V\left((1-\tau_y)[(M-j)w^w_{j+1,\Delta,t}(s) + j\tilde{b}_{\Delta,t}(s)]^{1-\tau^p}, \cdots\right) \end{aligned} \tag{21}$$

with V being a value functions as in (6) or (7), having added y_t as additional input. The left-hand side is the value a worker would obtain from accepting the offer, while the right-hand side is the value of not accepting and making the equilibrium counter-offer $w^w_{j+1,\Delta,t}(s)$ in the next subperiod (which will be accepted). Since V as in (6), (7) is strictly increasing in income (additional resources can always be consumed), (21) implies

$$(M-j+1)w^f_{j,\Delta,t}(s) + (j-1)\tilde{b}_{\Delta,t}(s) = (M-j)w^w_{j+1,\Delta,t}(s) + j\tilde{b}_{\Delta,t}(s) \quad . \tag{22}$$

Intuitively, worker wealth does not matter for in indifference condition (21), as any worker prefers higher period income in our setting. Similarly, if a worker gets to make a wage offer $w^f_{j,\Delta,t}$ to a firm in a subperiod $j < M$, this offer should fulfill

$$(M-j+1)(h_{\Delta,t}s - w^w_{j,\Delta,t}(s)) = -\gamma_\Delta(s) + (M-j)(h_{\Delta,t}s - w^f_{j+1,\Delta,t}(s)) \quad . \tag{23}$$

Finally, if no wage is accepted until period $j = M$, the indifference condition for an agency contemplating a worker's offer $w^w_{M,\Delta,t}$ would be

$$h_{\Delta,t}s - w^w_{M,\Delta,t}(s) + (1-\zeta)(1-\delta(s_t))\beta\mathbb{E}_t J(s_{t+1}, \Gamma_t) = 0 \tag{24}$$

as, if rejecting the offer, the firm would have to look for a new worker, the value of which is 0 due to free entry. We note that worker wealth does not enter indifference condition (24) either, as any worker would like to claim the maximum possible amount of income during the final

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[10] This may not generalize to some settings with endogenous separations in which the firm has the opportunity to lay off the worker ex-post.

[11] If indifferent, a party is assumed to accept.

bargaining period.

Since the equilibrium wage outcome can be characterized using equations (22), (23) and (24), it follows that our AOB bargaining scheme delivers wages that are independent of worker wealth:

Proposition 1. *The per-period wage of a matched worker with labor productivity s will be given by*

$$w_t(s) = \frac{1}{2}\left(h_t s + \tilde{b}_t(s)\right) + \frac{M-2}{2M}\gamma(s) + (1-\zeta)(1-\delta(s_t))\beta\mathbb{E}_t J(s_{t+1}, \Gamma_t) \quad . \tag{25}$$

Proof. See Appendix A.1. ☐

We note that in contrast to ad hoc wage rules often used in the literature, (25) features a forward-looking component, i.e., a workers wage today will depend on the expected value of her output in the future.

2.4 Government

2.4.1 Monetary Authority

The monetary authority sets the nominal interest rate on a reserve asset in zero net supply according to a Taylor rule of the form

$$\frac{R^B_{t+1}}{R^B_{SS}} = \left(\frac{R^B_t}{R^B_{SS}}\right)^{\rho^r} \left[\left(\frac{\pi_t}{\pi_{SS}}\right)^{\theta_\pi} \exp(m^u_t - m^u_{SS})^{-\theta_u}\right]^{1-\rho^r} \tag{26}$$

In any equilibrium requiring a no-arbitrage condition between the reserve asset and (short-term) government debt, this will be equivalent to the central bank setting the nominal return on the latter directly. The parameter ρ^r introduces rate smoothing and if $\theta_u \neq 0$, the rule reacts to unemployment in addition to inflation.

2.4.2 Fiscal Authority

The fiscal authority collects taxes, pays out unemployment insurance and engages in government consumption G_t. Its budget constraint (in real terms) is

$$B_{t+1} + \Theta_t = G_t + \frac{R^B_t}{\pi_t} B_t + \underbrace{\sum_{s\in\mathcal{S}} [b_t(s) - (1-\tau^y) b_t(s)^{1-\tau_p}] m^u_t(s)}_{=\text{net UI spending}} . \tag{27}$$

B is the outstanding amount of government debt issued at nominal interest rate R^B. Θ_t collects aggregate tax revenues and equals

$$\Theta_t = \tau_t^{\Xi}\Pi_t + \sum_{s\in\mathcal{S}} m_t^e(s)[w_t(s) - (1-\tau_t^y)w_t(s)^{1-\tau_p}].$$

In our benchmark application, we assume the real value of UI benefits to be constant over time and equal a replacement rate over steady state wages, i.e.

$$b_t(s) = \Upsilon_b(s)w_{SS}(s). \tag{28}$$

This replacement rate may depend on an individual's income state s to mimic caps on UI benefits prevalent in many jurisdictions: Effectively, they mean that replacement rates decline above a certain income threshold. We assume government consumption G_t to be fixed unless affected by exogenous policy shocks. Without any occurring, we have $G_t = G_{SS}$. In case an aggregate shock changes any component of constraint (27), the fiscal authority issues any amount of debt B_{t+1} necessary to make it hold. However, to stabilize public debt, taxes respond to government indebtedness: Specifically, the levels of both $\tau_t^y = \tau_t\tau_{SS}^y$ and $\tau_t^{\Xi} = \tau_t\tau_{SS}^{\Xi}$ evolve according to

$$\tau_t = \tau_{t-1}^{\rho_\tau}\left(\frac{B_t}{B_{SS}}\right)^{(1-\rho_\tau)\psi_B} \tag{29}$$

with $\tau_{SS} = 1$. Intuitively, policy rule (29) means that the government will eventually raise taxes to pay for higher expenditures, but may do so only with delay.

2.5 Asset market

We adopt the same asset market structure as Hänsel (2024a), which allows us to parsimoniously consider different assumptions on liquidity supply. In particular, there is a centralized market for claims to (illiquid) capital but households obtain liquid assets from a set of competitive *liquid asset funds* (LAFs). 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_{t+1}^l they receive from the households in capital, government bonds and reserves. In particular, the LAFs solve

$$\max_{B_{t+1}^l}\left\{\mathbb{E}_t\left[(r_{t+1}^k + q_{t+1})\frac{A_{t+1}^l - B_{t+1}^l}{q_t} + \frac{R_{t+1}^B}{\pi_{t+1}}B_{t+1}^l\right] - A_{t+1}^l\left(\varphi + \frac{\Psi}{2}\left(1 - \frac{B_{t+1}^l}{A_{t+1}^l}\right)^2\right)\right\}, \tag{30}$$

where A_{t+1}^l denotes the total amount of assets intermediated by the LAF and B_t^l the amount of government debt 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 $\frac{\Psi}{2}\left(1 - \frac{B_t^l}{A_t^l}\right)^2$ that increases in the relative amount of the fund's asset positions that are *not* in liquid government assets. The LAFs' aggregate portfolio choice can be determined from the corresponding F.O.C.

$$\mathbb{E}_t\left(\frac{r^k_{t+1}+q_{t+1}}{q_t}\right)-\Psi\left(1-\frac{B^l_{t+1}}{A^l_{t+1}}\right)=\mathbb{E}_t\left(\frac{R^B_{t+1}}{\pi_{t+1}}\right) \tag{31}$$

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

$$R^l_t=\frac{R^B_t}{\pi_t}\frac{B^l_t}{A^l_t}+\frac{q_t+r^k_t}{q_{t-1}}\frac{A^l_t-B^l_t}{A^l_t}-\varphi-\frac{\Psi}{2}\left(1-\frac{B^l_t}{A^l_t}\right)^2. \tag{32}$$

We shall focus particularly on the cases $\Psi \to \infty$ and $\Psi = 0$: The former case implies *segmented* asset market as in Kaplan et al. (2018) or Graves (2025), who assume that capital can only be held in illiquid form. In turn, households' net liquid savings need to equal B_t in equilibrium and liquidity is scarce. However, if $\Psi = 0$, (31) boils down to a no-arbitrage condition between government and capital returns. In this case, there is a large potential supply of liquidity as the LAFs can freely invest in (or short-sell) capital and equilibrium only requires the sum of liquid and illiquid household savings to equal $B_t + K_t$, which is similar to the set-up in Auclert et al. (2024). Note that if the HANK model is calibrated to feature $\int_0^1 a_{it}di = A^l_{SS} = B_{SS}$ and $R^l_{SS}+\varphi = \frac{R^B_{SS}}{\pi_{ss}} = 1 + r^k_{SS}$, its steady state is consistent with any $\Psi \geq 0$. Thus, one can vary the asset market structure while leaving the wealth distribution and other steady state moments unchanged.

2.6 Market clearing conditions and equilibrium

The Definition of Equilibrium is standard, but tedious, given that our model features multiple markets and also requires keeping track of the evolution of measures $m_t(\cdot)$. In turn, we relegate these details to Appendix A.2.

2.7 Numerical Approach

We approximate the dynamic equilibrium of the model using a version of the method used by Bayer et al. (2024), which conducts first-order perturbation around the economy's non-stochastic steady state, following a dimension reduction step.

For obtaining that steady state, we use a multi-dimensional Endogenous Grid Method similar to the algorithm described in Bayer et al. (2019) to solve the households' dynamic programming problem. The joint income- and asset distribution is approximated as a histogram using the "lottery"-method proposed by Young (2010).

However, the representations of the (marginal) value functions as well as the joint distribution

Parameter	Description	Value	Source
ξ	risk aversion	1.0	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}	SS goods markup	1.2	Standard
ϵ_E	Elasticity of substitution energy	0.1	Pieroni (2023)
ϕ	investment adjustment cost	3.5	Bayer et al. (2024)
δ_2/δ_1	utilization parameters	1.0	Bayer et al. (2024)
κ_Y	Slope of NK Phillips curve	0.08	Standard
χ	matching elasticity	0.5	Petrongolo and Pissarides (2001)
M	no. bargaining periods	60	Christiano et al. (2016)
τ_p	Tax progressivity	0.12	Bayer et al. (2024)
$(\tau^y_{SS}, \tau^{\Xi}_{SS})$	SS Tax levels	0.25	See text
(ρ_τ, ψ_B)	Tax rule	(0.85, 0.95)	See text
$(\rho_R, \theta_\pi, \theta_u)$	Taylor rule parameters	(0.5,1.5,0.0)	See text
(R^B_{SS}, π_{SS})	SS nominal rate & inflation	$(1 + r^k_{SS}$, 1.0)	Standard

Table 1: Externally set parameters

on a tensor grid are too large to be practically handled by standard perturbation algorithms. In turn, the dimensionality of the (marginal) value function is reduced by applying a Discrete Cosine Transform (DCT) and perturbing only the coefficients most important for explaining a) how household's marginal value functions are affected by changes in prices and b) their shape in SS. Additionally, the joint distribution is split into a copula and marginals and we only perturb the marginals as well as the largest coefficients resulting from a similar DCT of the copula. Ultimately, to zoom in on the determinants of aggregate consumption and saving, we compute Sequence Space Jacobians (SSJs) for the models' household block. Further details on the numerical implementation are provided in Appendix A.4.

3 Calibration

3.1 Externally calibrated

A model period is interpreted to be a quarter. We aim for our model to be consistent with the most relevant features of the US economy: As part of our calibration strategy, we 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 we rely on previous papers estimating a HANK model. Afterwards, we choose the remaining parameters values to match various steady state (SS) distribution- and labor market moments.

The household's risk aversion parameter is set to 1.0 (log-utility) in our baseline model, a standard value also used by Kaplan et al. (2018). For robustness analyses in Section 5, we will additionally consider a model version with $\xi = 2$. Regarding technology, we use the standard values of $\alpha = 0.33$ for the Cobb-Douglas parameter for capital and set a quarterly depreciation rate for capital of $\delta = 0.0175$. Similar, we set the SS value for μ_t to a conventional value of 1.2, resulting in a markup of 20%. The elasticity of substitution between energy and the capital-labor-bundle is set to 0.1, the benchmark value used by Pieroni (2023). The number of subperiods during which bargaining can take place is set to $M = 60$, the same value as in Christiano et al. (2016): this reflects the typical number of business days within a quarter. We furthermore set $\chi = 0.5$, a standard value for the matching elasticity going back to Petrongolo and Pissarides (2001). The slope of the New Keynesian Phillips curve is 0.08, a standard value also calibrated by Graves (2025).

Several other parameters governing the economy are set according to Bayer et al. (2024): First of all, we also set the probability of exiting the $\Xi = 1$ state within a given period to be 6.25%. The respective agents are assumed to enter unemployment at the median s. 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, we always set δ_1 and δ_2 to achieve $u_t = 1.0$ in steady state. Finally, we also parameterize tax progressivity with $\tau_p = 0.12$.

The remaining government policies are parameterized as follows: We follow Shimer (2005) by targeting an UI replacement rate of 0.4, except for workers whose UI level would exceed an unemployment cap 60% of the average (steady state) wage. For those agents, the replacement rate is reduced to be consistent with the cap. For the Taylor rule, our benchmark calibration features a moderate nominal rate persistence of $\rho_R = 0.5$.[12] The coefficient on inflation has the "textbook" value $\theta_\pi = 1.5$ and we chose $\theta_u = 0.0$, i.e., the central bank only reacts to inflation as in typical "textbook" models. The SS nominal rate equals the return to capital, to be in line with the (normalized) zero net inflation target and enable the setup in Section 2.5 nest different asset market setups. The level of taxes τ^y is set to 25%, a common value that yields a plausible Government consumption-to-GDP ratio of ca. 16%. In the US, the top tax bracket for qualified dividends was ca. 24% until 2017 and 20% afterwards. Given these similar values, we parameterize the profit tax level as $\tau^{\Xi} = \tau_y$ for simplicity. Regarding the dynamics of these tax

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[12] While many authors consider rules with substantially more persistence, e.g. $\rho_R = 0.8$, Consolo and Favero (2009) argue this to be inconsistent with the low predictability of monetary policy rates.

Parameter	Description	Value Baseline	Target
β	Time discounting	0.9901	$K/Y = 11.22$
ζ	prob. entrepreneur state	0.0005	Wealth share top 10
λ	illiquid asset adjustment	0.0713	$B/Y = 1.04$
$\bar{R}$	Borrowing penalty	0.0418	16% borrower share
$\underline{a}$	Borrowing limit	-0.879	100 % avg. quart. income
φ	Liquidity cost	0.0105	-2% p.a. liquid return
ϱ	Energy share parameter	0.0509	SS energy share 5%
ς	Retailer fixed cost	0.1819	50% of rents
A_m	Matching efficiency	0.6543	Unemployment rate 5.5%
$\frac{\kappa_1}{p_{ss}^{vf}} + \kappa_2$	total hiring cost	0.0670	7% of avg. hire wage
κ_2	screening cost	0.0268	40% of hiring cost
s	Ind. labor productivity	See Appendix A.5	See text
$\gamma(s)$	Costs of delay	See Appendix A.5	See text
$\delta(s)$	Separation rates	See Appendix A.5	See text
$\varpi(s)$	Search efficiencies	See Appendix A.5	See text
$\Upsilon_b(s)$	UI replacement rates	See Appendix A.5	40% replacement with cap

Table 2: Internally calibrated parameters

levels, we use $\rho_{\mathcal{T}} = 0.85$ and $\psi_B = 0.95$, which provides for moderately slow fiscal consolidation in the aftermath of business cycle shocks.

Finally, we adapt the $\Psi \to \infty$ setting for the asset as baseline. Not only is this "segmented" case commonly used in 2-asset HANK models (c.f. Kaplan et al., 2018; Bayer et al., 2024), it also corresponds more closely to the "zero liquidity" or one-asset set-ups often employed in HANK-SaM papers. These commonly assume liquid assets to be scarce in that the household sector's net liquid savings are limited to equal 0 or the stock of public debt in equilibrium (see the various references in Section 1).

3.2 Internal calibration

The remaining parameters are chosen so that the model matches various target moments in the non-stochastic steady state. To clarify how they come about, we present for each parameter the moment we use to identify it. While, if taking other *parameters* as given, any parameter will somewhat affect any of the stationary equilibrium's target moments, it is often the case that if one assumes other *target moments* to have been realized, individual parameters can be identified just by the respective moments. For the parameters for which this is not true, it nevertheless turns out that achieving a good fit with the target relies mostly on the stated parameters. Table 2 contains the values for the baseline calibration, while the results for alternative model variants are relegated to Appendix A.5.

We impose the stationary equilibrium return on liquid savings to be -2% per year, consistent with a zero nominal return as in Violante and Kaplan (2022). Since our other calibration targets also pin down the steady state return to capital, our quarterly calibration requires $\varphi = r^k_{SS} + 0.005$ to be consistent with the conditions stated at the end of Section 2.5. Next, several parameter values are used to target moments related to the long-run wealth distribution: We 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 $\beta = 0.9901$. As the probability ζ determines the amount of "super rich" entrepreneur households, we use it to target a Top 10% wealth share of 70%, which requires values of approx. 0.0005. The borrowing penalty $\bar{R}$ determines the share of households with a negative liquid asset position: to get a share of 16%, we set value of 0.0418.[13] λ determines the (il-)liquidity of capital and thus how much liquid bonds wish to additionally hold for consumption smoothing purposes: We use it to target mean liquid asset holdings of 0.26 times annual output as in Kaplan et al. (2018) (this equals government debt in steady state). This requires $\lambda = 0.071$ in our baseline model. We also follow these authors by setting the borrowing limit equal to the average quarterly labor- and transfer income (post-tax).

ϱ, which governs the importance of energy for production, is set to 0.0504, targeting a GDP share of aggregate energy spending of 5%. This value is roughly consistent with recently observed values for the US (e.g., 5.7% in 2019 and 4.8% in 2020). The motivation for including the fixed cost ς is as follows: It is known that lower markups lead to more volatile profits in New Keynesian models (e.g., Andreasen and Dang, 2019). In our model, we do not only follow the previous literature in allocating profits to special groups of agents, but will also find them to be important for the determination of equilibrium interest rates and inflation below. In turn, it seems desirable for profit incomes to be neither overly volatile nor account for an overly large share of aggregate income. Thus, we employ the fix cost to "absorb" 50% of SS monopoly rents.[14]

Regarding the "labor" parameters, we first choose matching productivity $A_m = 0.6543$ to achieve an average unemployment rate of 5.5%. Following Christiano et al. (2016), we next target steady state hiring costs $\kappa_1/p^{vf}_{SS} + \kappa_2$ to be 7% of the average wage of newly hired workers and furthermore assume the screening cost κ_2 to account for 40% of this cost. The relative size of this

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[13] While this value may appear very high (around 17% annually), note that the convention in the 2-asset HANK literature is to treat secured borrowing such as mortgage debt as part of household's net illiquid asset stock. Various forms of unsecured borrowing such as credit card debt or overdraft facilities commonly feature borrowing rates of similar magnitude.

[14] Additionally, including the fixed cost avoids an implausibly low labor share of aggregate income.

fixed cost is an important determinant of the sensitivity of unemployment to aggregate shocks, and we choose this share so that the unemployment peak after a TFP shock is of a similar magnitude as in Broer et al. (2025). Finally, it is necessary to set the parameters connected to the individual labor productivity levels s. To calibrate the values for s and $\gamma(s)$, we build on the literature estimating income processes: In particular, the recent paper by Braxton et al. (2021) estimates a process in which the permanent component $z_{i,t}$ of log individual income has an AR(1) form with labor market status-specific parameters

$$z_{i,t+1} = \mu_z(e_{it}) + \rho_z z_{i,t} + \sigma_z(z_{i,t})\varepsilon_{i,t} \quad ,$$

i.e. the drift and the innovation variance of the process depend on whether an individual works or not. Braxton et al. (2021) argue that such a set-up captures on-the-job skill accumulation as well as human capital depreciation during unemployment. Since we wish to account for such phenomena, we use their annual estimates $\rho_z = 0.94$, $(\mu_z(1), \mu_z(0)) = (0.0038, -0.1472)$ as well as $(\sigma_z(1), \sigma_z(0)) = (0.2261, 0.4171)$, transform them into quarterly values and discretize the process onto a grid of 11 points following the methodology outlined in their paper.[15].

This, however, provides us only with a discretized process for household's *labor earnings*, i.e. the wages $w_t(s_{it})$, while the calibration requires the primitives determining them. Conveniently, the linearity of bargaining outcome (25) provides an easy way of backing them out: To pin down the bargaining costs for every $s \in \mathcal{S}$, we impose that wage levels correspond to a piecerate in the initial steady state, i.e., $w(s)_{ss} = \bar{w} h_{ss} s$. We choose $\bar{w}$ by targeting a steady state vacancy filling rate of 0.71 (den Haan et al., 2000). The s and $\gamma(s)$ levels giving rise to this outcome can subsequently be obtained by using that other target moments provide the steady state level h_{ss} and solving a linear system. The actually realized values for s and $\gamma(s)$ are provided in Appendix A.5.

For the worker outside income, we follow the paper by Christiano et al. (2016) inspiring our bargaining solution by using $\tilde{b}_t = b_t$, i.e. impose that the bargaining outside income is equal to the income received during regular unemployment.

Finally, for the separation rates $\delta(s)$ and search efficiency $\varpi(s)$, we build on Birinci and See (2021). This involves using the functional form $\delta(s) = \bar{\delta}\exp(\eta_\delta(w_{ss}(s) - 1))$ and choosing $\bar{\delta}$ to target an average monthly EU flow rate of $\bar{p}^{EU}_{SS} = 3.5\%$ and η_δ to get an EU flow rate ratio of $p^{EU}(s_{ns})/p^{EU}(s_1) = 0.2$. i.e. the richest workers are 5 times less likely to loose their jobs than the poorest workers.[16] Similarly, we have $\varpi(s) = \exp(\eta_\varpi(w_{ss}(s) - 1))$ to target a job finding

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[15] For the transformation, we follow an approach similar to Krueger et al. (2016): The persistence of the quarterly process is set to $\hat{\rho}_z = \rho_z^{1/4}$ and we replicate the cross-sectional variance of the AR(1) processes by setting $\hat{\sigma}_z(e_{it}) = \sqrt{\frac{1-\hat{\rho}_z^2}{1-\rho_z^2}}\sigma_z(e_{it})$. We adapt the drift so that the quarterly processes have the same mean as the annual one, i.e. $\hat{\mu}_z(e_{it}) = \frac{1-\hat{\rho_z}}{1-\rho_z}\mu_z(e_{it})$

[16] Birinci and See (2021) target $\bar{p}^{EU}_{SS} = 1.2\%$ and $p^{EU}(s_{ns})/p^{EU}(s_1) = 1/5.54 \approx 0.18$ for a monthly calibration.

	Disposable Income		Net Worth	
	Model	Data	Model	Data
Quint. 1	6.1	4.5	0.0	-0.9
Quint. 2	10.3	9.9	0.8	0.8
Quint. 3	14.9	15.3	3.9	4.4
Quint. 4	21.4	22.8	11.1	13.0
Quint. 5	47.3	47.5	84.1	82.5
Gini	0.41	0.42	0.80	0.77

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

Table 3: Distributional moments comparison: Models vs. Data

gradient of $p^{UE}(s_{ns})/p^{UE}(s_1) = 1.25$, consistent with their evidence that the job finding rate of workers in the bottom income quintile is 20% lower than for workers in the top income quintile.

3.3 Distributional Moments

In this section, we validate our internal calibration by analyzing various model-generated moments not directly targeted by the calibration.

Table 3 compares various untargeted moments of the models' Steady State income- and wealth distributions with empirical counterparts as reported by Krueger et al. (2016). The latter are based on the 2006 Panel Survey of Income Dynamics (PSID), with Disposable Income defined as the sum of after-tax earnings plus unemployment benefits plus income generated by assets held. In both model and data, Net Worth relates to both liquid and illiquid assets. While the model can naturally not achieve a perfect fit, they match both the distributions' quintiles as well as their Gini coefficients well.

Since we are employing a two-asset model, it is not only relevant how closely our framework matches data moments related to the distribution of net worth, but also the asset portfolios held by the households. We do so in Table 4: First, we are considering moments of the illiquid- and liquid wealth distribution separately. In particular, we compare them with statistics reported by Kaplan et al. (2018), who use the 2004 Survey of Consumer Finance (SCF). As in the data, we generate 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. However, compared to the reported data moments, we generate a somewhat more equal liquid asset distributions, with the shares held by the Top 10% not as high and the share of the Next

Moments	Model	Data (incl. source)
Illiquid asset shares		(from Kaplan et al., 2018)
Top 10%	71.2	70
Next 40%	26.9	27
Bottom 50%	1.8	3
Liquid asset shares		(from Kaplan et al., 2018)
Top 10%	80.6	86
Next 40%	20.3	18
Bottom 50%	-0.9	-4
Hand-to-Mouth (HtM) Status		(from Kaplan et al., 2014)
Share HtM	30.8	31.2
Share Wealthy HtM	21.8	19.2
Share Poor HtM	9.0	12.1

Table 4: Portfolio moments comparison: Models vs. Data

40% substantially larger than in the SCF data. Finally, we also analyze whether households are *Hand-to-Mouth* (HtM) in the sense of Kaplan et al. (2014), i.e., whether their liquid asset holdings are a) positive but amount to less than 2 weeks (1/6 of a model period) of income or b) negative and amount to less than the borrowing constraint plus the 2 weeks of income. We also classify them as "Wealthy HtM" if they additionally hold illiquid assets and "Poor HtM" if they do not. Our baseline model matches the empirical evidence on the size of either group of agents reasonably well, although we generate somewhat too few poor HtM. As a consequence, the HANK-SaM framework features an average quarterly MPC of 16.4% (implying an average annualized MPC of 41.6%).[17]

Given the issues we analyze in this work, it is also relevant to consider the unemployment-related consumption- and saving behavior generated by our framework. In our baseline model, agents transiting into unemployment initially reduce their consumption by around 14% on average. Moreover, mean SS consumption of unemployed agents amounts to ca. 73% of the number for employed HHs, respectively. This partly reflects a composition effect, as agents with low labor productivity are more likely to be unemployed. Overall, these numbers lie within the range of empirical estimates (cf. Chodorow-Reich and Karabarbounis, 2016; Ganong and Noel, 2019). We additionally find that despite using a simple "random adjustment" setup for illiquid assets, our model seem reasonably consistent with Graves (2025)'s empirical evidence that unemployment

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[17] We annualize individual's quarterly MPCs $qMPC_i$ as $aMPC_i = 1 - (1 - qMPC_i)^4$ following Carroll et al. (2017). Note that these *annualized* MPCs do not exactly equal their *annual* MPCs. Due to Jensen's inequality, averaging the annualized MPCs differs from annualizing the average MPC.

spells predict illiquid asset withdrawal. Approximately 94% of the unemployed HH's who end up receiving the chance to adjust their illiquid holdings reduce them, while this is only the case for roughly 60% of employed households. In our baseline, this translates into less than 4.5% of employed but approx. 7% of unemployed HHs withdrawing illiquid assets every quarter. For longer unemployment spells, the individual withdrawal probability accumulates.

4 Cyclical amplification from *Unemployment Fears*

4.1 Isolating the effects of *unemployment fears*

Measuring the aggregate effects of risk-induced amplification is a non-trivial challenge in rich HANK models. This is because they differ in many aspects from complete markets models, e.g., due to the presence of high MPC households or additional investment frictions related to illiquid asset adjustment. Also, unemployment risk has *redistributive* effects in addition to reducing the risks associated with unemployment.

To overcome this challenge and to single out the impact of unemployment risk, we consider a version of the model in which policy is unchanged and aggregate dynamics unrestricted, but households' expectation deviate from rational expectations in the following way: Households always believe that their idiosyncratic employment transition probabilities are fixed at their steady state levels, i.e., don't realize their unemployment risk has changed. Technically, this only involves not perturbing the p^{UE}_{t+1} and p^{EU}_{t+1} terms entering the Euler equations of the household problem when computing the derivatives for the linearized model solution. The result then provides the first-order solution of a general equilibrium model in which workers are "naive" about their individual unemployment risk.[18] The model with "naive" workers will be based on exactly the same steady state and the distributional impacts of any shock is unrestricted. For example, it will still be the case that low income households transit at relatively higher rates into unemployment, but they will not take into account that their risk has gone up for making their consumption-savings decision. Thus, the precautionary channel is shut to the extent it is present in a certainty-equivalent linearized HANK economy.

In what follows, we will consider the difference between two models, "HANK Baseline" vs "HANK naive", which indicates the general equilibrium precautionary motive from the *unem-*

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[18] For readers familiar with the Sequence Space methodology by Auclert et al. (2021), this is equivalent to specifying the employment transition probabilities entering agents' expectation as an additional input of the "HA Block" (as compared to the one that will actually move the distribution) and then not disturbing it. Indeed, this is how we shall proceed for some partial equilibrium decompositions below.

ployment fear effect.[19] Similar decompositions have previously been used by Harmenberg and Öberg (2021) and Fernandes and Rigato (2022) in partial equilibrium settings and by Cho (2023) in his one-asset HANK model.

We reckon that, in line with our linearized model solution, our insights are quantitatively applicable to moderately-sized shocks in "normal" times (i.e., around the steady state). While this is in line with most previous work in the HANK literature, SaM models can feature significant non-linearities and state-dependence (e.g., Pizzinelli et al., 2020; Hänsel, 2024), which may increase the importance of unemployment-related precautionary motives but are challenging to analyze in the context of HANK models as rich as ours. Nevertheless, we conjecture that the key economic mechanisms shaping our results will remain important beyond the first order.

4.2 *Unemployment fears* and the response to (supply) shocks

We begin by studying the model's aggregate responses to two supply shocks, the TFP shock and the "cost push" shock to the New Keynesian Phillips curve. This is motivated by the prominent finding in the previous literature that *unemployment fears* precautionary savings can overturn the conventional inflation response to such shocks with implications on the conduct of monetary policy (Challe, 2020; Ravn and Sterk, 2021; Broer et al., 2025). However, we will also discuss other sources of cyclical fluctuations below.

Figure 1 displays the models Impulse Response Functions (IRFs) to supply disturbances. The responses to the TFP shock (see Panels 1a) align with conventional New Keynesian models featuring labor market frictions: output, consumption and investment fall upon impact of the shock, the latter with a notable hump-shape due to the presence of investment adjustment costs. The unemployment response peaks after approximately a year somewhat above 0.4 percentage points (p.p.), in line with Broer et al. (2025). This is accompanied by a moderate decrease in real wages induced by the AOB bargaining protocol. Inflation increases substantially upon impact of the shock, in response to which the central bank's policy rule prescribes a higher policy rate. As the downturn reduces tax revenues and increases outlays on unemployment insurance and debt service, the stock of public debt increases but is eventually reigned in by the fiscal authority's tax adjustments.

For the "cost push" shock (see Panel 1b), output, consumption and investment similarly fall, although with somewhat different magnitude. Unemployment and wages react noticeably more:

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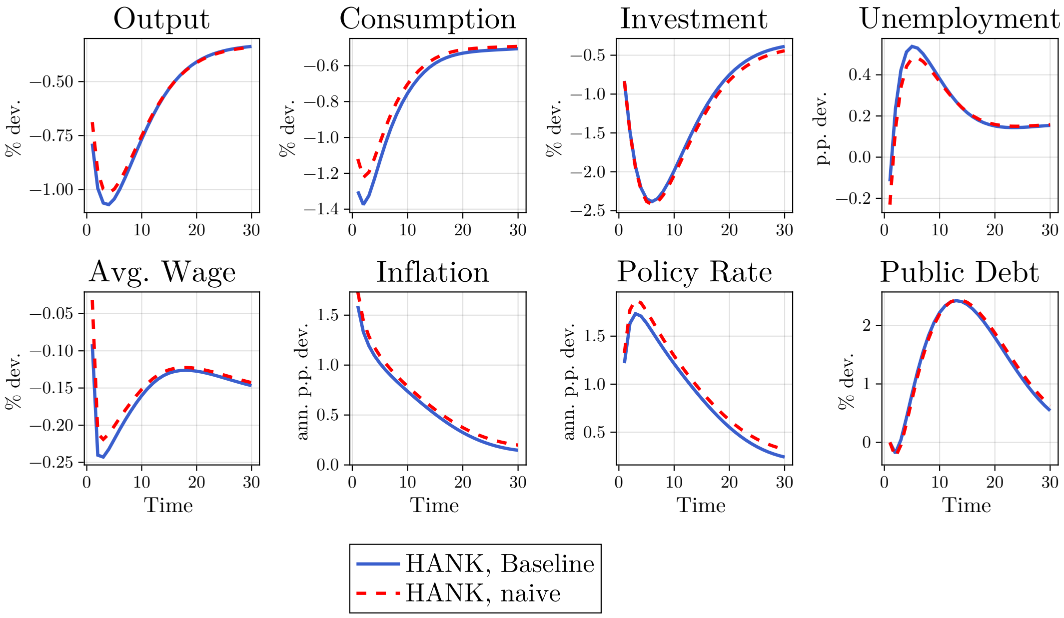
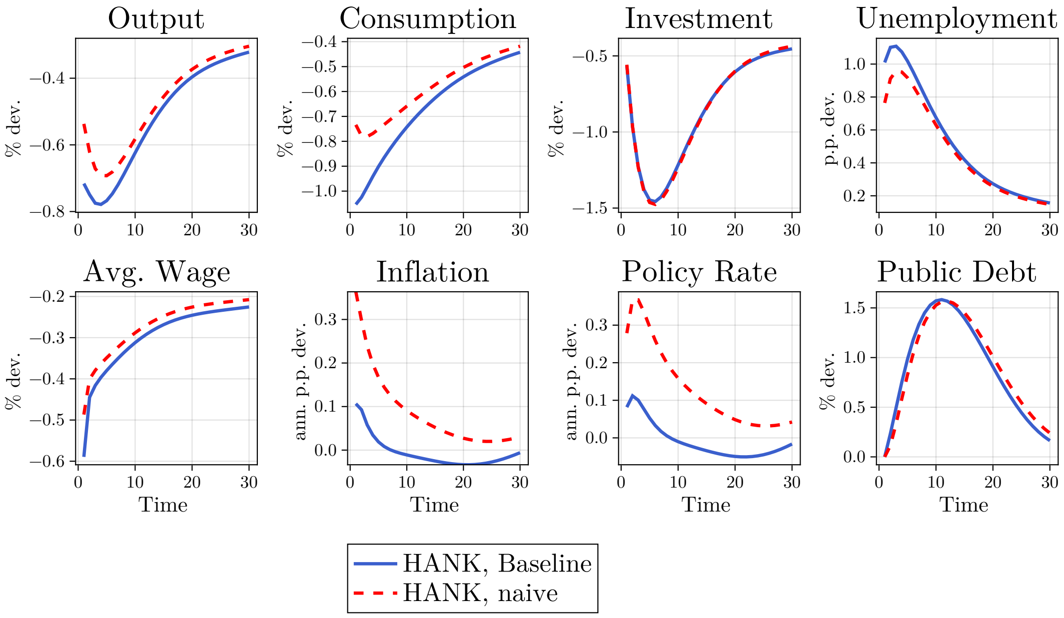
[19] In principle, the comparison also encompasses an intertemporal substitution motive, as unemployment is a downward risk. However, it works in the same direction, as income being lower in the future induces saving today to smooth consumption. In turn, our comparison isolates an *upper bound* for the impact of the purely precautionary motive.

Figure 1: Aggregate response to supply shocks

(a) TFP shock



(b) "Cost push" shock



Note: The red-dashed lines display the model responses of the "naive" model version with fixed employment transition beliefs. Each shock has a size of 1% and subsequently follows an AR(1) process with autoregressive parameter 0.9. The responses of the policy rate and inflation is displayed in annualized percentage point (ann. p.p.) deviations. "Avg. Wage" denotes the economy-wide average real wage.

The higher markups reduce the value of matches without higher marginal costs, which, for the TFP shock, sustain more demand for labor. Most notably, though, we see that in the baseline model (blue solid line), inflation and in turn the interest rate barely changes in response to the "cost push" shock in spite of its usual function as "stagflationary" disturbance.

This connects to what we deem to be a very interesting finding from the IRFs above. The relevance of the *unemployment fears* for inflation and their feedback into real outcomes – measured by the difference between the baseline HANK (blue line) and the "naive" counterfactuals (red-dashed line) – varies considerably between the two supply shocks. Our quantitative HANK model generates a similar unemployment response in line with more tractable frameworks in the literature. However, in response to a productivity (TFP) shock *unemployment fears* generate little downward pressures on inflation and a moderate general equilibrium feedback into real activity. In contrast, *unemployment fears* strongly influence the inflation response after the "cost-push" shock and have more pronounced effects on various other outcomes. While the stronger unemployment response would call for a stronger effect, we still find particularly remarkable the much stronger downward pressure on the policy rate and inflation .[20]

To go beyond the above"eyeball" measure of amplification and also consider further shocks, the first four rows of Table 5 displays the relative sum of the absolute deviations of several key model variables for the respective first 30 periods after the shock,

$$\left(\frac{\sum_{t=1}^{30} \left| x_t^{base} - x_{ss} \right|}{\sum_{t=1}^{30} \left| x_t^{naive} - x_{ss} \right|} \right). \tag{33}$$

x_t denotes the respective variable in period t after the shock.[21] We also include the respective results for the other model shocks, including the demand shock A_t and investment technology shock Z_t^I, the IRF figures to which are relegated to Appendix A.7 for brevity. The more the relative sum differs from one, the more important are the *unemployment fears* for the initial propagation of the respective variables after the shock. We see these values differ most strongly for inflation, but the amplification effects for consumption and unemployment are also sizable.

Overall, while *unemployment fears* can noticeably depress inflation and consumption after some shocks, its propensity to do so differs noticeably for different sources of aggregate fluctuations in

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[20] Our results contrast with Challe (2020), who finds the responses to TFP and "cost-push" shocks to be very similar in his zero liquidity HANK-SaM model. This contrast relates to the model assumptions on profits, which we shall discuss further below in Section 4.5.

[21] Given the linearity of the model solution, this measure is independent of the size of the shock. We truncate the sum, as we found that the "naive" model return can provide for delayed convergence back to steady state at long horizons after the shock. While a potentially interesting phenomenon, we choose to abstract from it in this analysis focused on short-run amplification. The specific truncation horizon was chosen to correspond to our IRF figures and the patterns remain robust to considering shorter or somewhat longer ones.

Table 5: *Unemployment fears* amplification by shock

Variable	Shock				
	Z_t	μ_t	A_t	Z_t^I	p_t^E
Inflation	0.953	0.567	0.988	1.073	0.951
Unemployment	1.016	1.048	1.013	1.033	1.027
Consumption	1.035	1.068	1.005	1.073	1.04
Investment	0.978	0.999	0.964	0.976	0.982
Rel. demand fears	0.053	0.292	0.014	0.194	0.061

Note: In the first four rows, the values display the relative sums of the absolute model IRFs for the first 30 periods of after the respective shocks $\left(\frac{\sum_{t=1}^{30}|x_t^{base}-x_{ss}|}{\sum_{t=1}^{30}|x_t^{naive}-x_{ss}|}\right)$. The final row displays the relative absolute size of the *unemployment fears*-driven liquidity demand - compare Section 4.3. All shocks are assumed to follow an AR(1)-process with autoregessive parameter 0.9.

our quantitative HANK model. Since the demand shock also generates a substantially stronger response of unemployment relative to output than, say, the TFP shock Z_t, these differences cannot easily be rationalized just by the different unemployment responses to the respective shocks itself.

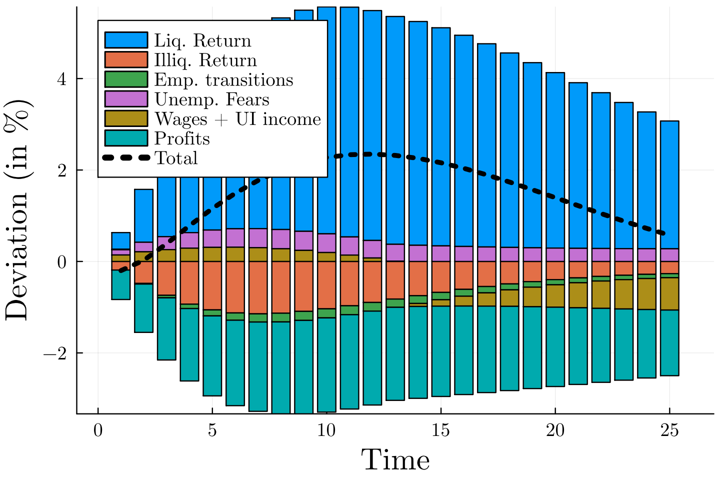
4.3 Drivers of (non-)amplification

What can then explain the markedly different importance of the *unemployment fears* spirals for real outcomes and inflation? Recall the underlying economic idea: Higher unemployment risk increases households' desired savings, which induces downward pressure on real (liquid asset) interest rates. At least under conventional monetary policy rules, lower real liquid returns require lower inflation, and, by the New Keynesian Phillips curve, lower marginal costs. The latter reduce the value of job matches and wages, which depresses economic activity further (giving rise to a second round and so on).
Now, for this channel to be important, the unemployment risk should compromise an important driver of the time-variation in liquid asset demand. To investigate its different components, we compute partial equilibrium Sequence Space Jacobians for its household block, which we use to decompose the sources of households' liquid savings demand under the price- and interest rate paths implied by our model solution. To relate to our above analysis, we compute Jacobians for perceived and realized employment transition probabilities separately, which allows us to discern the influence of the former in line with our "naive" equilibrium counterfactual.

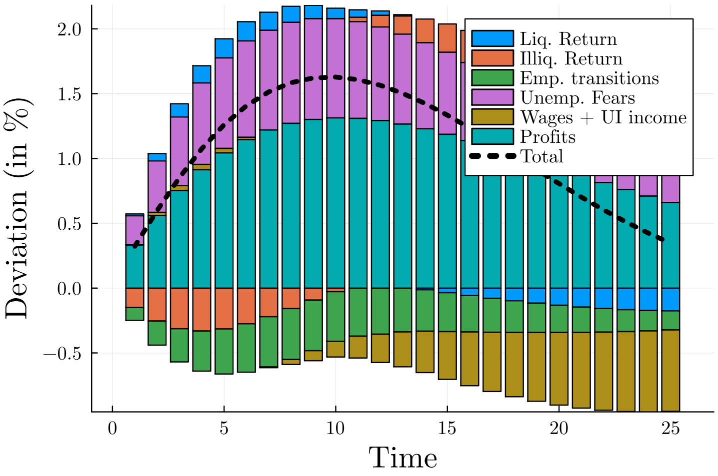
As a start, consider the respective decomposition in response to the TFP shock as displayed

Figure 2: Decomposition of household liquid savings responses

(a) Decomposition: TFP shock



(b) Decomposition: “Cost-push” shock



Note: The contributions “Wages + UI income” combines all inputs relating to after-tax wage- and UI income and thus incorporates the effects of changing tax levels.

in Figure 2a. A negative TFP shock leads to lower firm profitability and lower returns from illiquid asset (capital). As a consequence, both factors negatively contribute to households liquid savings. Liquid assets returns, however, are driven up by the excess bond supply generated by the fiscal automatic stabilisers and their impact on higher public debt (liquid asset). As a result, the large increase in liquid returns diminishes the relative size of the precautionary saving motive stemming from the unemployment-risk precautionary channel.

All in all, Figure 2a provides useful insights into the drivers of precautionary saving and why insights from simple (zero liquidity) models may not necessarily carry over to richer models with a more realistic setup featuring non-zero financial holdings in equilibrium. In our framework, the key drivers of household savings and intertemporal substitutions are related to profits (blue), liquid (turquoise) and illiquid (orange) asset returns. Just compared to the ones from wage and UI income as well as realized employment transitions, the contribution of perceived unemployment risk would be relatively substantial.

But what about the "cost-push" shock? Considering the corresponding decomposition in Figure 2b reveals that a key difference: There are less counteracting savings motives. As the shock increases markups and in turn profits, the rich "entrepreneurs" actually want to save substantially more which offsets almost the entire rise in public debt supply (which is smaller in this case). Realized unemployment and post-tax wages still counteract the unemployment-risk driven savings but retain a relatively moderate magnitude. This leaves the unemployment risk component with relatively more scope to influence equilibrium returns and in turn inflation, marginal costs and real activity.

Overall, the above decompositions provide a rationale for moderated effects of the deflationary unemployment risk spirals in our baseline model: Richer HANK models effectively feature various sources of counteracting liquid asset demand and -supply, for example intertemporal substitution-driven dissaving by richer agents and a higher supply of public debt. However, if these turn out to be weaker for certain shocks, as in response to the "cost-push" shock, the *unemployment fears* can nevertheless provide for important general equilibrium effects.
To further back up this argument, the final row in Table 5 displays average ratio of the *fears*-driven liquidity demand, i.e., the equivalents to the purple bars as in Figure 2, over the sum of the absolute value of all other components shaping households' liquid (i.e., the equivalent to the sum of the absolute size of all other bars). This provides a measure of its relative size, again computed for the first 30 periods after the shocks' impact. For shocks for which it is larger, we observe stronger (absolute) amplification of inflation and unemployment.

Ultimately, we think that two aspects implicit in the above analysis merit further discussion. Firstly, in line with many previous works, our baseline model assumed a scarce availability of liquid assets. While often motivated by the fact that many households hold little liquid assets, as explained above, our two asset model does not require a strong connection between liquid asset holdings and (potential) liquid asset supply. Indeed, not allowing capital to be useful for liquid asset supply may provide for overly strong effects of public debt supply on interest rates: see Hänsel (2024a) for an analysis of this issue in a two-asset HANK model.
Secondly, savings out of profit incomes seem quantitatively important for aggregate outcomes in our economy. Our assumption of assigning profit incomes net of the fixed cost to rich "entrepreneurs" with low MPCs ensures that this stream of income is mostly set aside. Yet, in

zero-liquidity HANK-SaM models (as well as some richer models), profits are often assumed to go to "capitalist" who can not or do not save in equilibrium (Ravn and Sterk, 2021; Broer et al., 2025) and do thus not affect savings demand. We shall investigate the importance of these two assumptions in the following subsections.

4.4 The role of the asset market structure

To highlight how assumptions on the asset market shape the macroeconomic effects of unemployment risk-driven precautionary savings, we contrast our baseline economy with an alternative featuring $\Psi = 0$, i.e., in which the aggregate capital stock is as useful as government debt for the purpose of liquid asset provision. As discussed in Section 2, this is consistent with exactly the same microeconomic moments on household asset holdings.

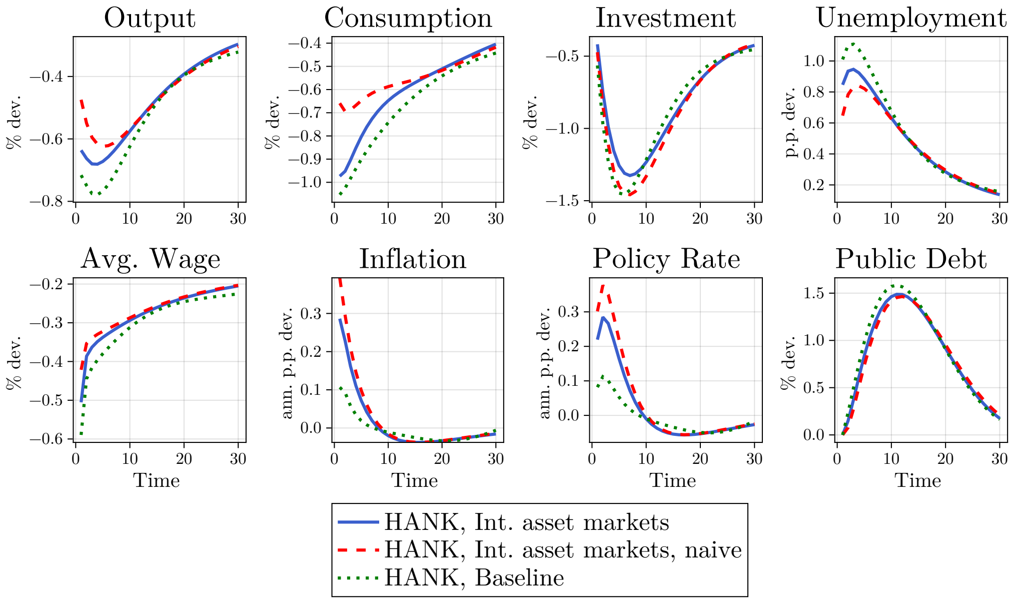
We find that the macroeconomic responses to the "cost push" shock illustrate the importance of the asset market structure well. Consider Figure 3a, which displays the results for the alternative set-up, also contrasting it with the baseline (added as green-dotted line). Compared with the latter, the shock "recovers" its conventional inflationary effect. Additionally, the aggregate response to the shock is noticeably stabilized. While the *unemployment fears* still noticeably decrease consumption, they increase investment instead (which was hardly affected in the baseline setup).

One may wonder why there is still clear demand feedback to interest rates and in turn inflation and unemployment at all, given that integrated asset markets will essentially add households' precautionary saving to the much larger aggregate capital stock? The reason is the capital adjustment cost, which still renders the overall asset supply inelastic in the short run. To confirm this intuition, Appendix Figure A.6 provides responses with the adjustment cost parameter ϕ set to 0. In this case, the perceived unemployment risk mostly increases investment at the cost of lower consumption, while an equilibrium demand feedback to unemployment and inflation is barely noticeable, despite a stronger unemployment response.

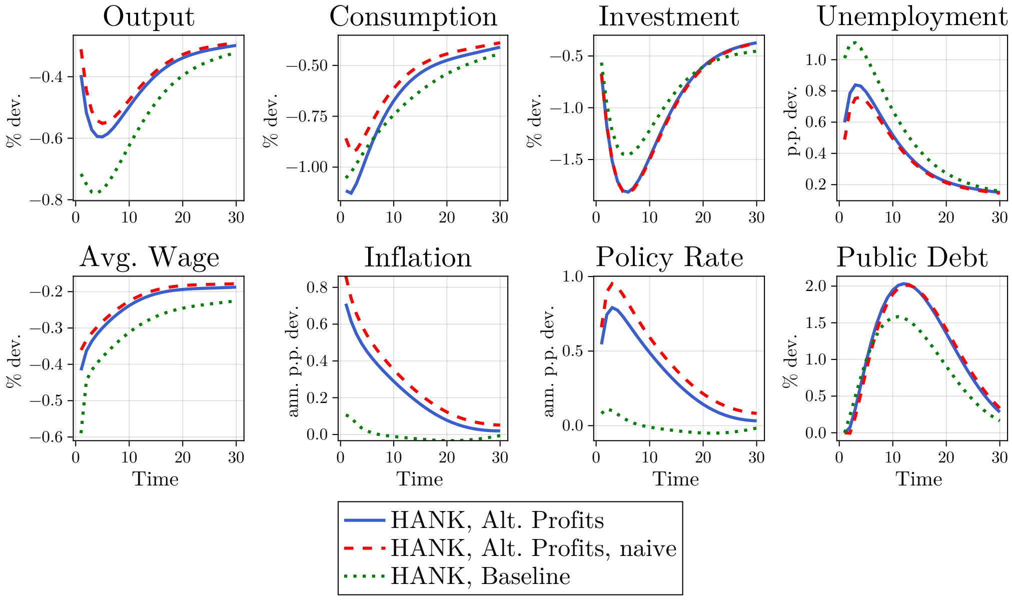
To parsimoniously extend the above analysis to the various alternative shocks, Panel 6a of Table 6 again reports the *unemployment fears* amplification measures for the alternative asset market structure with and without capital adjustment costs. In Table 6a, we still notice that relatively larger *fears* liquidity demand causes the inflation responses to be amplified more, but much less than in the baseline. At the same time, amplification of unemployment is much reduced, while the measures for consumption become more homogeneous. Consistent with the reasoning above, this is accompanied by consistently stronger effects of the *unemployment fears* on investment.

Figure 3: IRFs to “cost push” shock - model variations

(a) Model Response to a cost-push shock: $\Psi = 0$



(b) Model Response to a cost-push shock: Alternative profits



Note: Responses to 1% decrease of μ_t that evolves according to $\log(\mu_t/\mu_{ss}) = 0.9\log(\mu_{t-1}/\mu_{ss})$. “Avg. Wage” denotes the economy-wide average real wage.

We take the results in this subsection to show that the emergence of deflationary unemployment risk spirals depends crucially on liquid assets being in scarce supply. While that seems plausible, our model setup also demonstrates that getting the practical extent of their scarcity right cannot be achieved by just targeting steady state moments relating to household's consumption- or savings behavior (recall that our model's initial steady state is consistent with any $\Psi \geq 0$). While we do not wish to take a strong stance on its "correct" value for the purpose of this paper, Hänsel (2024a) finds that after calibrating Ψ using evidence on the interest rate effects of public debt supply, the model dynamics in his 2-asset HANK model resemble the integrated $\Psi = 0$ benchmark more closely than the segmented $\Psi \to \infty$ one. We also note that even if unemployment risk doesn't provide for much demand feedback in the $\Psi = 0$ case, it doesn't become unimportant but relevant for the economy's investment response.

4.5 The influence of profits

While we deem it plausible that most profits are received by rich households with small MPCs (as implied by our baseline assumptions), their importance for our previous results as well as the differing assumptions in the literature make it interesting to isolate the effects of this margin. To do so, we tweak our baseline economy in the following way: Instead of profits, the $\Xi = 1$ households receive equal shares of a time-invariant endowment $\bar{\Pi}$ equalling the profit income they receive in our baseline steady state. The actual profits are paid out to an additional group of Hand-to-Mouth capitalists, which, as in many zero-liquidity HANK models, do not participate in any markets and consume the profits instantly. This means that the only other change to the model structure is adding the $\bar{\Pi}$ term to the aggregate resource constraint and substracting $C_t^{HC} = \Pi_t$ from it.[22]

We present the IRFs of this model variant to the "cost push" shock in Figure 3b, again accompanied by the baseline one (green-dotted line). As cyclical variations in profits are no longer saved in this model version, the respective downward pressure on real interest rates is eliminated and we see inflation as well as interest rates rise substantially after the shock. This aggregate demand noticeably stabilizes unemployment and inflation. While the distribution of profits has previously been argued to be an important determinant of macroeconomic dynamics in HANK models (Broer et al., 2020; Alves et al., 2020), our results add an additional flavor to this idea by highlighting their potential importance for savings demand and equilibrium interest rates.[23]

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[22] Since Hand-to-Mouth capitalists HC do not participate in any markets, it would be equivalent to assume that actual profits are discarded.

[23] In Appendix Figure A.4, we additionally display the response to the TFP shock under the alternative profits assumption. Comparing it with Figure 3b, we find the model responses to be very similar now, suggesting that Challe (2020)'s finding of TFP- and markup shocks having similar effects in his HANK-SaM model can be ascribed

Table 6: *Unemployment fears* amplification - Model variations

(a) Alternative asset markets only ($\Psi = 0$)

Variable	Shock				
	Z_t	μ_t	A_t	Z_t^I	p_t^E
Inflation	0.961	0.916	0.992	1.021	0.959
Unemployment	0.999	1.018	1.005	1.01	1.002
Consumption	1.041	1.048	0.995	1.051	1.042
Investment	0.963	0.972	0.955	0.96	0.964
Rel. demand fears	0.183	0.297	0.041	0.139	0.216

(b) Alternative profits

Variable	Shock				
	Z_t	μ_t	A_t	Z_t^I	p_t^E
Inflation	0.844	0.884	0.975	1.119	0.881
Unemployment	1.033	1.032	1.007	1.026	1.032
Consumption	1.057	1.056	1.002	1.091	1.056
Investment	0.995	0.994	0.965	0.983	0.994
Rel. demand fears	0.266	0.213	0.017	0.212	0.217

(c) Higher risk aversion $\xi = 2$

Variable	Shock				
	Z_t	μ_t	A_t	Z_t^I	p_t^E
Inflation	0.902	0.879	0.932	1.127	0.899
Unemployment	1.02	1.052	1.005	1.034	1.026
Consumption	1.069	1.097	0.99	1.115	1.073
Investment	0.96	0.979	0.949	0.953	0.965
Rel. demand fears	0.1	0.37	0.025	0.203	0.109

Note: In the Tables' first four rows, the values display the relative sums of the absolute model IRFs for the first 30 periods of after the respective shocks $\left(\frac{\sum_{t=1}^{30}\left|x_t^{base}-x_{ss}\right|}{\sum_{t=1}^{30}\left|x_t^{naive}-x_{ss}\right|}\right)$. The final row displays the relative absolute size of the *unemployment fears*-driven liquidity demand - compare Section 4.3. All shocks are assumed to follow an AR(1)-process with autoregessive parameter 0.9.

More important with respect to the main theme of this paper, though, is that by changing the additional sources of liquidity demand, the relative importance of the *unemployment fears* changes noticeably. Effectively, the responses now display a similar as for the TFP shock, where the unemployment-risk driven precautionary savings demand exerted a noticeable but arguably moderate aggregate effect. Just considering the responses from the "cost push" shock, one might thus conclude that assumption ensuring profits to be consumed/discarded are actually conservative if it comes to the demand effects of time-varying unemployment risk. However, after other supply shocks such as TFP Z_t, profits actually decrease, reducing the counteracting liquidity demand and increasing general equilibrium amplification: As can be seen in Table 6b, it becomes similarly strong as for the "cost push" shock μ_t.

We conclude from this subsection that the distribution of profits income, a controversial issue in the literature, can matter significantly for the aggregate effects of countercyclical income risk in HANK. Thereby, it supports our earlier point on counteracting savings motives and makes it seem very relevant to discipline this model aspect more rigorously in future work by, e.g., drawing on applicable micro-data.

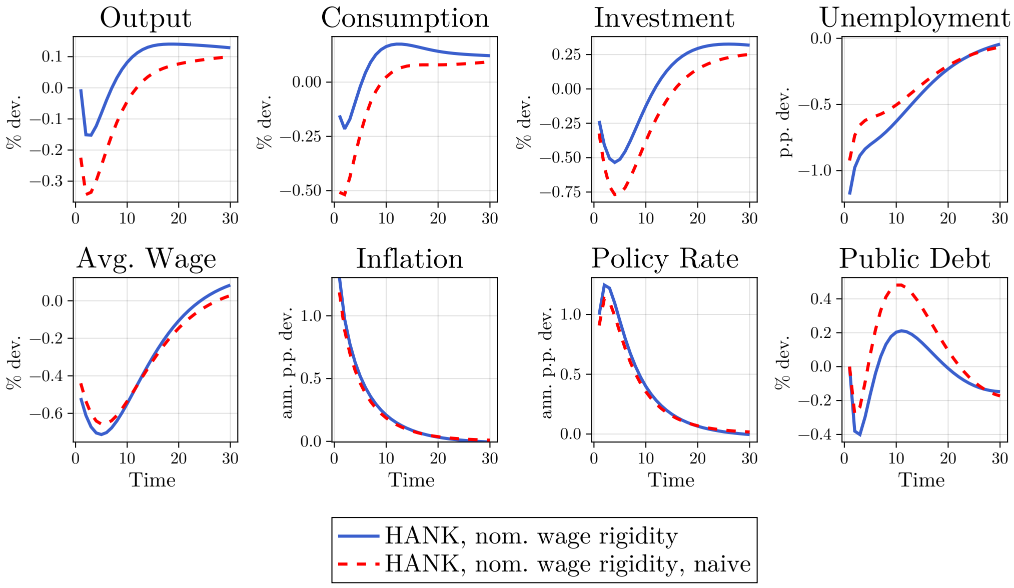
5 Further robustness considerations

Although our two-asset HANK model is set up and calibrated mostly in accordance with prior work, we use this Section to ask whether its implications are likely robust with respect to two related choices: Firstly, our bargaining set up does, in accordance with Christiano et al. (2016) and Ljungqvist and Sargent (2021), only provide for wages being relatively sticky in real terms. However, in practice wages may be subject to nominal rigidities and den Haan et al. (2017) argued this to be key for *unemployment fears* amplification along the lines we are interested in: If its deflationary effects push up real wage costs due to nominal wage stickiness, job creation may go down even more, resulting in unemployment being amplified more. Hence, we briefly consider a simple extension that incorporates additional nominal wage stickiness.

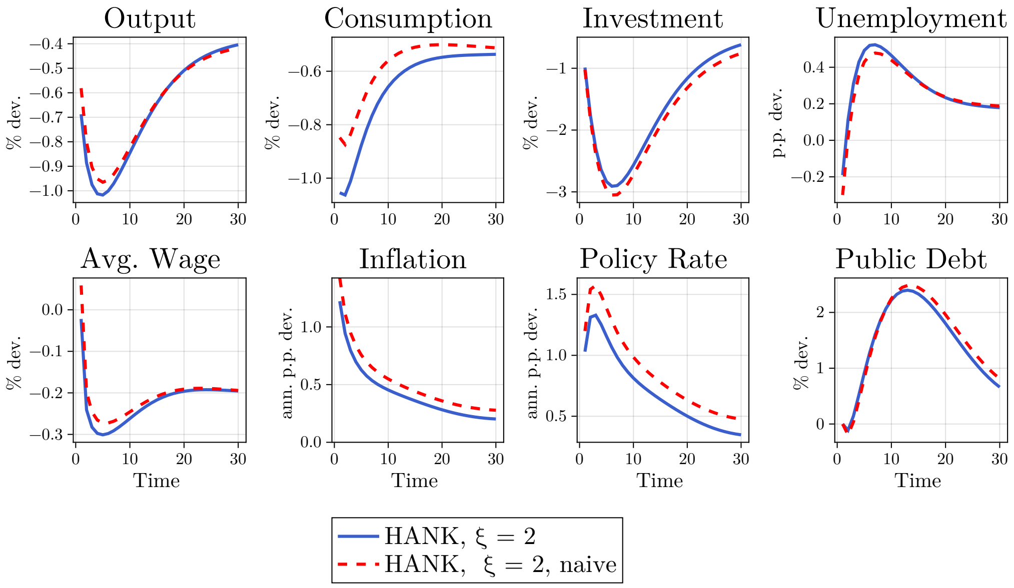
Additionally, our baseline calibration provides a degree of risk aversion at the lower end of commonly used parameterizations. It is thus of interest to check whether our insights are affected by a calibration with higher risk aversion.

Figure 4: IRFs to TFP shock - Robustness exercises

(a) Model Response to TFP shock: Nominal wage rigidity



(b) Model Response to TFP shock: $\xi = 2$



Note: Responses to 1% decrease of μ_t that evolves according to $\log Z_t = 0.9 \log Z_{t-1}$. "Avg. Wage" denotes the economy-wide average real wage.

5.1 Nominal wage rigidity

While our AOB bargaining set-up is appealing due to being both micro-founded and tractable, it can unfortunately not incorporate nominal wage rigidity without losing one of these features. In turn, we pragmatically consider a counterfactual in which real wages evolve according to

$$w_t(s) = \omega \frac{w_{t-1}(s)}{\pi_t} + (1-\omega) w_t(s)^{AOB} \quad \forall s \in \mathcal{S},$$

where w_t^{AOB} is given by bargaining solution (25) and $\omega \in (0,1)$ is a parameter determining the degree of nominal wage stickiness. While admittedly ad hoc, this formulation retains an endogenous forward-looking component through the w_t^{AOB} bargaining outcome that would prevail without the nominal rigidity.

In our setting, such a setup changes the macroeconomic response substantially: In Figure 4a, we display the response to the TFP shock under nominal wage rigidity, The unemployment response turns procyclical as wages are eroded by inflation and the perceived unemployment "risk" actually ends up stabilizing the economy. We find a stabilizing effect of added nominal wage rigidity even for the the originally deflationary "cost push" shock (cf. Appendix Figure A.7). Thus, it seems that we didn't miss out on business cycle amplification by abstracting from nominal wage rigidity for the analysis above.

5.2 Higher risk aversion

Here, we briefly consider whether a calibration with higher risk aversion would substantially change our conclusions above. For this purpose, we calibrate an alternative model version targeting the same moments but featuring the higher risk aversion $\xi = 2$. The internal calibration and corresponding distributional moments are reported in Appendix A.5.[24] We note that while the $\xi = 2$ model version achieves a similarly good fit with many moments of the income- and wealth distribution as our baseline model, the higher risk aversion results in substantially smaller amount of HtM households. In turn, it provides for a quarterly MPC of only 6.9%. This value is substantially lower than the evidence often cited in the HANK literature, which, however, has recently been subject to empirical debates (Borusyak et al., 2024; Orchard et al., 2025).

In Figure 4b, we again present the TFP IRFs for this further model variant. Unsurprisingly, we

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to his assumption of profits being allocated to constrained agents not participating in the asset market.

[24] The macro parameters are unchanged compared to baseline besides the hiring costs and the monetary policy reaction. To ensure determinacy of the respective model versions, we increased the monetary policy parameter θ_π to 1.65. As we find in Section 6.1 below, our Baseline model has a smaller determinacy region than Representative Agent New Keynesian models and higher risk aversion exacerbates this. To prevent this from overly increasing unemployment fluctuations, we further reduced the share of hiring fixed costs to 25%.

see the amplification of inflation and unemployment become somewhat more pronounced, but no big changes compared to the baseline. We noticed this pattern also for the other shocks, for which we here refer to the measures reported in Table 6c: Absolute amplification increases across the board, but the original qualitative patterns and its connection with the presence of counteracting liquidity demand remain. We take this to indicate that while the absolute importance of the *unemployment fears* unsurprisingly increases with risk aversion, the same economic forces shaping their macroeconomic effects remain relevant nevertheless.

6 Implications for Monetary Policy

After our investigation of unemployment risk's relevance for business cycle amplification, we want to explore some of our model's implications for monetary policy. In particular, we begin by briefly analyzing its local determinacy properties, i.e., how strong the central bank needs to systematically react to inflation in order to rule out self-fulfilling fluctuations in our model. Afterwards, we ask whether detailed modeling of unemployment matters for monetary policy's distributional implications.

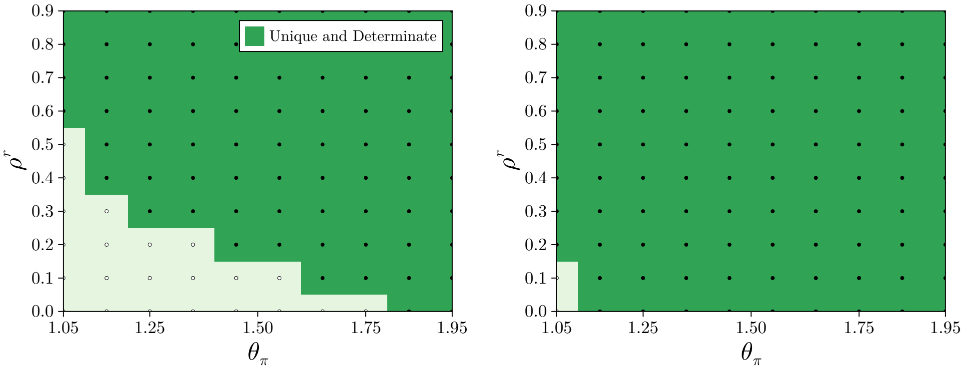
6.1 Determinacy

According to modern business cycle theory, central banks face the crucial challenge of anchoring inflation expectations and avoiding self-fulfilling fluctuations. In turn, we explore the set of monetary policy rules that achieve this outcome in our model. This complements previous analyses finding that household heterogeneity and countercyclical income risk make locally stable equilibria more difficult to achieve (e.g., Ravn and Sterk, 2021).

Figure 5a indicates which combinations of monetary policy rule parameters ρ^r (nominal rate persistence) and θ_π (inflation reaction) generate a locally stable equilibrium in our baseline model (all else equal). Indeed, the baseline model's determinacy region is substantially smaller compared to standard representative agent models. Even the conventional $\theta_\pi = 1.5$ cannot by itself achieve determinacy, although moderate nominal rate persistence cures this. In line with the findings in the previous literature, the comparison with the "naive" model in Figure 5b shows that this can be explained by the presence of the *unemployment fears*

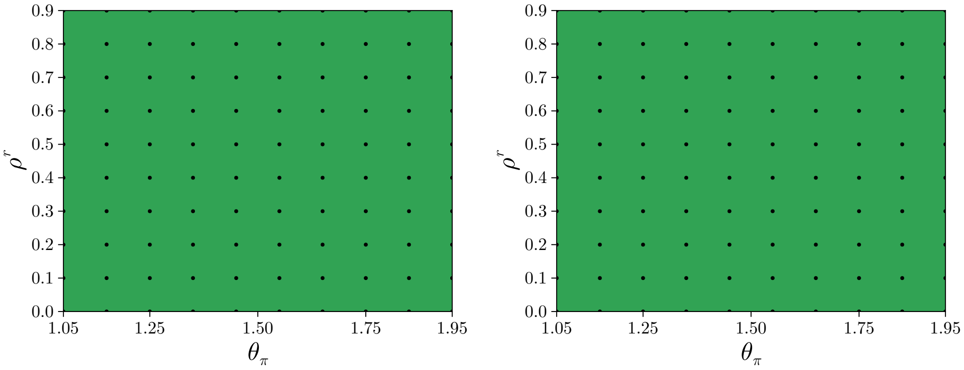
In turn, the model features we identified to be important for the respective demand amplification should also be relevant for determinacy, so we repeat the exercise for the alternative asset market ($\Psi = 0$) and alternative profits assumptions models in Figures 5d and 5c. Clearly, the parameter space in which the central bank successfully anchors inflation in these set-ups is much wider and

Figure 5: Determinacy analyses



(a) Baseline model

(b) “Naive” model



(c) $\Psi = 0$ model

(d) Alternative profit model

Note: The darker region marks the parameter space in which there exists a locally unique equilibrium. Dots indicate the evaluated parameter combinations.

more similar to conventional representative agent models.[25] Hence, our model indicates that taking into account and disciplining the channels that the shape the macroeconomic propagation of time-varying *unemployment fears* should be relevant for designing the systematic conduct of monetary policy. To the best of our knowledge, the insight that the distribution of profits can be important for determinacy in HANK economies has also not been stated explicitly before.

6.2 Unemployment and the heterogeneous impact of monetary policy

An interpretation of our results above may be that unemployment risk-driven precautionary savings are of limited macroeconomic importance for some business cycle shocks. Does that mean that detailed modeling of unemployment and labor market frictions should be of limited concern for HANK modeling? Here, we study how an alternative monetary policy explicitly reacting to unemployment explicitly affects the welfare improving for different types of households. We do so not only using our baseline model but also two alternative calibrations that a) do not provide for skill losses during unemployment or b) have homogeneous job finding and separation rates: The idea is to gauge the relevance of allowing for such features. Otherwise, these counterfactuals match the same steady state targets and thus generate a similar income- and wealth distribution – compare Appendix A.5.

Due to the macroeconomic salience of energy prices in recent years, we conduct an analysis for our model's stylized energy price shock p_t^E. As an illustrative exercise, we ask whether and how much different households would prefer the central bank to follow a monetary policy rule with an explicit unemployment reaction ($\theta_u = 0.2$) following the shock, which moderates the following unemployment increase at the cost of higher inflation[26]. The motivation is that in the presence of equilibrium unemployment and search and matching frictions, simple monetary policy rules that mimic optimal policy are typically found to include a reaction to the unemployment rate (see Blanchard and Galí, 2010; Abbritti and Consolo, 2022).

To assess which types of households gain or lose from the alternative policy option, we compute households' consumption-equivalent utility gains under a perfect foresight assumption. While this abstracts from the possibility of other shocks occurring and thus systematic stabilization, it provides us with an intuitive one-dimensional measure of how much different households' exposure to a specific shock is affected by the alternative policy.

Figure 6 presents the respective results along the income dimension s. Almost all households gain from the alternative policy, but interestingly, we see that in the baseline model, employed "middle class" households seems to benefit more than low-income ones if the central bank sta-

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[25] The $\Psi = 0$ model is even stable under $\theta_\pi = 1$, while the textbook representative agent models requires $\theta_\pi > 1$.

[26] For brevity, we display the respective model IRFs only in Appendix A.7

bilizes unemployment at the cost of higher inflation. This is despite low s households being more likely to become unemployed. A comparison with Figure 6b suggests this to be due to the presence of skill losses during unemployment: Once we abstract from them, it is indeed the income-poor households that gain most. Intuitively, even though low-s households are more likely to be unemployed, the middle of the distribution has more to lose during unemployment. Additionally, we note that the absence of skill losses substantially reduces the welfare gains of more accommodating monetary policy.[27]

Considering the case with homogeneous job-finding and job-loss probabilities (as well as skill losses) in Figure 6c, the accommodative policy has an even more regressive impact than the baseline. Here, it is clearly the households with high (potential) labor income that gain most. They have skills to lose, a lower UI replacement rate due to the modeled benefit and now also a higher unemployment risk.

Our takeaway from this exercise is that various unemployment-related model features can noticeably affect which households are affected how much from alternative monetary policy and who gains most from particularly policies. Thus, if one aims to study distributional outcomes, carefully modeling unemployment seems to be of notable importance.

7 Conclusions

The demand effect of unemployment risk-driven precautionary saving has been argued to be a crucial amplifier of business cycle fluctuations, in particular for supply shocks. Yet, respective analyses have mostly been based on frameworks with limited household heterogeneity, while richer models yielded equivocal conclusions.

To provide a new perspective on the relevance of these channels, we develop a two-asset HANK model with search and matching frictions and address two important issues. Firstly, we provide a micro-founded way of modeling wage setting in rich heterogeneous agents models that is closely connected to the existing literature and provides for wage outcomes independent of worker wealth. Secondly, we use a simple and consistent way to isolate and measure the general equilibrium impact of precautionary *unemployment fears* demand amplification in a complex HANK model.

We find that the precautionary-saving channel stemming from *unemployment fears* has notable aggregate effects, but for many aggregate shocks, its quantitative impact is moderate. We

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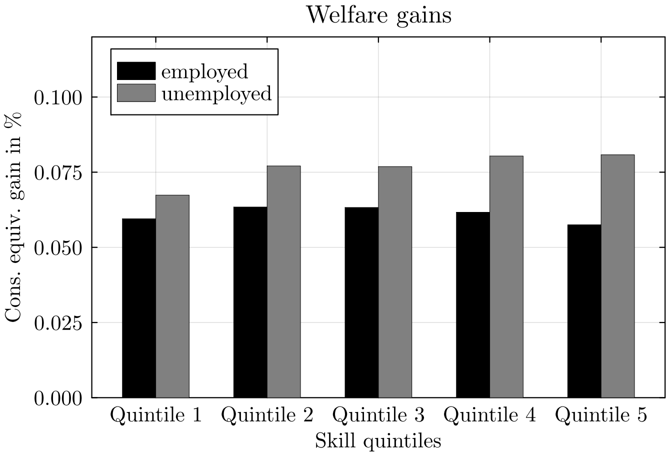
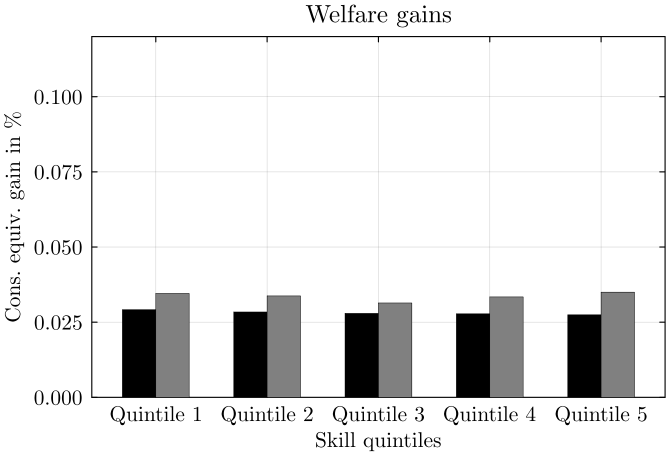
[27] Given that the considered shock is of moderate size, all welfare gains are of small absolute magnitude. The result that allowing for skill losses is important for the welfare effects of business cycle shocks was also found by Walentin and Westermark (2022) previously.

Figure 6: Welfare effects of alternative policy rule

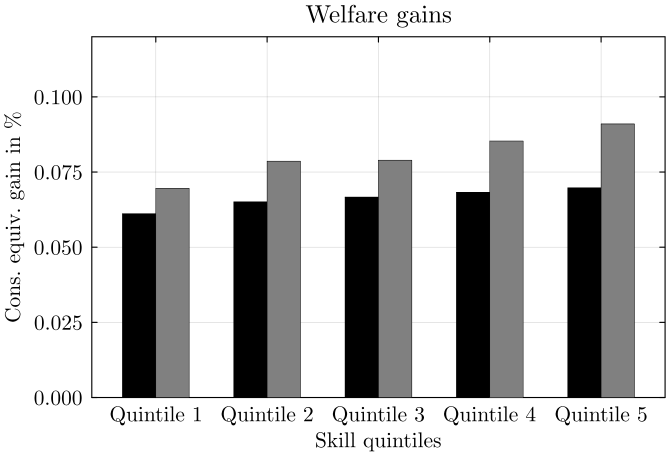
(a) Baseline



(b) No skill losses



(c) Hom. p^{EU} and p^{UE}



Note: The bars show the average consumption-equivalent gains regarding the $\theta_u = 0.2$ central bank rule.

ascribe this result to the presence of various counteracting savings channels not present in many earlier models. Additionally, we highlight that its deflationary effects and feedback to real activity depends importantly on two assumptions the literature has not converged on: Firstly, how restricted the liquid asset supply potentially available to households is (as opposed to their measured liquid asset holdings). Secondly, how the cyclically-varying firm profits are allocated.

Considering our model's implication for monetary policy, we find these modeling choices to be key for its determinacy properties. Therefore, getting their practical relevance right does not only for matter for understanding the transmission of aggregate shocks, but also for the design of systematic monetary policy. A simple welfare exercise furthermore shows that unemployment-related labor market heterogeneity is relevant for evaluating the heterogeneous impact of alternative policy rules.

Ultimately, our work suggests many avenues for future research. As already indicated above, it seems important to better discipline the allocation of profits in HANK models, preferably based on suitable micro-evidence. Given the importance of profits in our model, we also conjecture that entrepreneurial- or business risk may be a relevant but so far less explored margin for demand amplification. While our model provides for rich labor-market heterogeneity, it also abstracts from margins such as endogenous search effort or job heterogeneity with on-the-job search. Although some work in this direction already exists, further studying these aspects in the context of quantitative HANK models could yield additional insights on the amplification of business cycle shocks and effects of stabilization policies. Finally, it may be interesting to use higher-order or global solution methods to explore how our results are affected in non-linear settings with aggregate risk. We hope to address some of these topics in future work.

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A Appendix

A.1 Derivation of the AOB bargaining outcome

Re-arranging indifference conditions (22) and (23) yields

$$w^{f}_{j,\Delta,t}(s) = \frac{\tilde{b}_{\Delta,t}(s)}{(M-j+1)} + \frac{M-j}{M-j+1} w^{w}_{j+1,\Delta,t}(s) \tag{34}$$

and

$$w^{w}_{j,\Delta,t}(s) = \frac{\gamma_{\Delta}(s) + h_{\Delta,t}s}{M-J+1} + \frac{M-j}{M-j+1} w^{f}_{j+1,\Delta,t}(s) \tag{35}$$

which we can combine to obtain

$$w^{w}_{j,\Delta,t}(s) = \frac{\gamma_{\Delta}(s) + h_{\Delta,t}s + \tilde{b}_{\Delta,t}(s)}{M-j+1} + \frac{M-j-1}{M-j+1} w^{w}_{j+2,\Delta,t}(s) \quad . \tag{36}$$

Iterating (36) forward $M/2-1$ times, we obtain

$$w^{w}_{2,\Delta,t}(s) = \frac{M-2}{2} \frac{\gamma_{\Delta}(s) + h_{\Delta,t}s + \tilde{b}_{\Delta,t}(s)}{M-1} + \frac{1}{M-1} w^{w}_{M,\Delta,t}(s)$$

which we can use in (34) for $j=1$ to get

$$w^{f}_{1,\Delta,t}(s) = \tilde{b}_{\Delta,t}(s) + \frac{M-2}{2} \frac{\gamma_{\Delta}(s) + h_{\Delta,t}s + \frac{\tilde{b}_{\Delta,t}(s)}{1-\tau^{w}}}{M} + \frac{1}{M} w^{w}_{M,\Delta,t}(s) \quad . \tag{37}$$

Substituting (24) and re-arranging, we obtain the equilibrium subperiod 1 offer extended by the firm

$$w^{f}_{1,\Delta,t}(s) = \frac{1}{2}\left(h_{\Delta,t}s + \tilde{b}_{\Delta,t}(s)\right) + \frac{M-2}{2M}\gamma_{\Delta}(s) + \frac{1}{M}(1-\zeta)(1-\delta(s_t))\beta\mathbb{E}_t J(s_{t+1},\Gamma_t) \tag{38}$$

which will be accepted. In turn, the period wage is this wage times M, i.e.

$$w_t(s) = \frac{1}{2}\left(h_t s + \tilde{b}_t(s)\right) + \frac{M-2}{2M}\gamma(s) + (1-\zeta)(1-\delta(s_t))\beta\mathbb{E}_t J(s_{t+1},\Gamma_t)$$

A.2 Definition of equilibrium

Below, we define the equilibrium of our baseline model. The definitions for other model version are analogous. For the "naive equilibrium" versions, household value functions and -policies will be consistent with labor market transitions as determined by steady state labor market tightness θ_{SS} instead of the labor market tightness consistent with (20).

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

- *value functions* $V^a(a_{it}, k_{it}, e_{it}, s_{it}, \Psi_{it}; \Gamma_t)$, $V^{na}(a_{it}, k_{it}, e_{it}, s_{it}, \Psi_{it}; \Gamma_t)$ *and* $J(s_{it}, \Gamma_t)$,
- *household policies* $a^a(a_{it}, k_{it}, e_{it}, s_{it}, \Psi_{it}; \Gamma_t)$, $a^{na}(a_{it}, k_{it}, e_{it}, s_{it}, \Psi_{it}; \Gamma_t)$, $k(a_{it}, k_{it}, e_{it}, s_{it}, \Psi_{it}; \Gamma_t)$ *and* $c^a(a_{it}, k_{it}, e_{it}, s_{it}, \Psi_{it}; \Gamma_t)$, $c^{na}(a_{it}, k_{it}, e_{it}, s_{it}, \Psi_{it}; \Gamma_t)$,
- *firm sector policies* I_t, K_t, H_t, B_t^l, Y_t, E_t, u_t, θ_t, Π_t,$y_{jt} \forall j \in [0, 1]$
- *prices* p_t^E, h_t, r_t, q_t, R_t^l, mc_t
- *a wage schedule* $w_t(s) \forall s \in \mathcal{S}$,
- *government policies* $b_t(s), G_t, B_{t+1}, R_{t+1}^B$,
- *measures* $m_t(\cdot)$,

so that

1. *Given prices* R_t^l, r_t^k, q_t, *labor market tightness* θ_t, *wage schedule* $w_t(s)$ *and profits* Π_t *as well as government policies* τ_t *and* $b_t(s)$, *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* (6) *and* (7) *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. $y_{jt} \in [0, 1]$ *are consistent with demand schedule* (9) *and final output* Y_t *given by* (8).
3. *Inflation* π_t *is consistent with Phillips curve* (10).
4. *Given prices* p_t^E, h_t, r_t, q_t, mc_t *and technology shock* Z_t *the intermediate goods producers choices* K_t, E_t, H_t, u_t *are consistent with optimality conditions* (12)-(15).
5. *Given price* q_t *and technology shock* Z_t^I, *the intermediate goods producers choices* I_t *are consistent with optimality condition* (16).
6. *Given prices* h_t *and wage schedule* $w_t(s)$, *labor agency value functions* $J(s_{it}, \Gamma_t)$ *are consistent with* (17).
7. *The wage schedule* $w_t(s)$ *is consistent with bargaining outcome* (25).
8. *Labor market tightness* θ_t *is consistent with free-entry condition* (20).
9. *Aggregate job finding and vacancy filling probabilities* p_t^{UE} *and* p_t^{vf} *are consistent with* (19)
10. *Given inflation* π_t *and unemployment* u_t, *the monetary authority sets* R_{t+1}^B *according to* (26).

11. *Taking the remaining values as given, the government sets taxes according to (29) and issues debt B^g_{t+1} so that (27) holds.*

12. *The LAFs investment choice B^l_t is consistent with optimality condition (31).*

13. *Liquid return R^l_t is consistent with (32)*

14. *Aggregate profits are given by*

$$\begin{aligned}\Pi_t = \int_0^1 y_{jt}\left(\frac{p_j t}{P_t} - mc_t\right) dj - \varsigma + \sum_{s\in\mathcal{S}} \mu^e_t(s)(h_t s - w_t(s)) - V_t(\kappa_1 + p^{vf}_t \kappa_2) \\ + \underbrace{q_t(K_{t+1} - (1-\delta(u_t))K_t) - I_t}_{inv.\ firm\ profits}\end{aligned}$$

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

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

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

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

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

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

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

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

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

$$H_t = \sum_{s\in\mathcal{S}} s m^e_t(s) \quad .$$

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

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

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

$$\begin{aligned}Y_t =& C_t + G_t + I_t + \varsigma + \frac{\phi}{2}\left[\frac{I_t}{I_{t-1}} - 1\right]^2 \\ &+ (\kappa_1 + \kappa_2 p^{vf}_t)V_t + \bar{R}\int_{\underline{a}}^0 a_{it} m_t(a_{it}) da_{it} + \frac{E_t}{Z^E_t} \quad .\end{aligned} \tag{39}$$

22. *The dynamics of measures $m_t(\cdot)$ is consistent as described in Appendix A.3*

A.3 Details on measures m

Formally, m_t describes a probability measure on the measurable space $(\mathcal{X}, \mathcal{A})$, with $\mathcal{X} := [\underline{\mathrm{a}}, \infty] \times \mathbb{R}_+ \times [0,1] \times \mathcal{S} \times [0,1]$ and $\mathcal{A} := \mathbf{B}([\underline{\mathrm{a}}, \infty]) \times \mathbf{B}(\mathbb{R}_+) \times \mathbf{P}([0,1]) \times \mathbf{P}(\mathcal{S}) \times \mathbf{P}([0,1])$, where $\mathbf{P}(\cdot)$ denotes the power set and $\mathbf{B}(\cdot)$ the Borel σ-algebra of a given set.

Practically, with some abuse of notation, we have $m_t(\cdot)$ describe the masses of households in a particular state at the beginning at period t, i.e $m_t(a = a_i, k = k_i, e = e_i, s = s_i, \Xi = \Xi_i)$ is the mass of households with assets a_i, k_i, employment status e_i, skill s_i and "entrepreneur status" Ξ_i. For ease of notation above, we suppress states that are fully integrated over, e.g.

$$m_t(a = a_i, e = e_i) = \sum_{\Xi_i \in \{0,1\}} \sum_{s_i \in \mathcal{S}} \int_0^\infty m_t(a = a_i, k = k_i, e = e_i, s = s_i, \Xi = \Xi_i) dk_i \tag{40}$$

denotes the mass of households with employment status e_i and bond holdings a_i. Additionally, we suppress the annotation of non-suppressed inputs whenever it does not cause any confusion, i.e. we may write $m_t(e_i) = m_t(e = e_i)$.

Naturally, to be consistent with a unit mass of households, we require

$$\sum_{e_i \in \{0,1\}} \sum_{\Xi_i \in \{0,1\}} \sum_{s_i \in \mathcal{S}} \int_0^\infty \int_{\underline{\mathrm{a}}}^\infty m_t(a = a_i, k = k_i, e = e_i, s = s_i, \Xi = \Xi_i) da_i dk_i = 1 \quad .$$

Additionally, the evolution of measures also need to be consistent with household choices. Defining

$$\begin{aligned}
\tilde{X}^{na}(a', k, e, s, \Psi; \Gamma_t) &:= \big\{ a \in [\underline{\mathrm{a}}, \infty) : \ a^{na}(a, k_{it}, e_{it}, s_{it}, \Psi_{it}; \Gamma_t) = a' \big\} \\
\tilde{X}^{a}(\{a', k'\}, e, s, \Psi; \Gamma_t) &:= \big\{ \{a, k\} \in [\underline{\mathrm{a}}, \infty) \times \mathbb{R}_+ : \ a^{a}(a, k, s, \Psi; \Gamma_t) = a' \ \text{ and} \\
&\qquad k(a, k, e, s, \Psi; \Gamma_t) = k' \big\}
\end{aligned}$$

as well as the "middle of period" measure $\tilde{m}_t(a, k, e, s, \Xi)$ fulfilling

$$\begin{aligned}
\tilde{m}_t(a, k, e = 1, s, \Xi = 0) &= \varpi(s) p_t^{UE} m_t(a, k, e = 0, s, \Xi = 0) \\
&\quad + (1 - \delta(s) + \delta(s)\varpi(s) p_t^{UE}) m_t(a, k, e = 1, s, \Xi = 0) \\
\tilde{m}_t(a, k, e = 0, s, \Xi = 0) &= (1 - \varpi(s) p_t^{UE}) m_t(a, k, e = 0, s, \Xi = 0) \\
&\quad + \delta(s)(1 - \varpi(s) p_t^{UE}) m_t(a, k, e = 1, s, \Xi = 0) \\
\tilde{m}_t(a, k, e, s, \Xi = 1) &= m_t(a, k, e, s, \Xi = 1)
\end{aligned}$$

means they must follow

$$
\begin{aligned}
& m_{t+1}(a,k,e,s,\psi=0) = \\
& (1-\zeta)\sum_{s_t\in\mathcal{S}} \Pi^s(s,|s_t,e) \Bigg(\lambda \int_{\tilde{X}^a(\{a,k\},e,s_t,\Xi=0;\Gamma_t)} d\tilde{m}_t(a_{it},k_{it},s_t,\Xi_t=0) \\
& + (1-\lambda) \int_{\tilde{X}^{na}(a,k,e,s_t,\Xi=0;\Gamma_t)} d\tilde{m}_t(a_{it},k,s_t,\Xi_t=0) \Bigg) \\
& + \iota p_s \Bigg(\lambda \int_{\tilde{X}^a(\{a,k\},e,s,\Xi=1;\Gamma_t)} d\tilde{m}_t(a_{it},k_{it},\Xi_t=1) \\
& + (1-\lambda) \int_{\tilde{X}^{na}(a,k,e,s,\Xi=1;\Gamma_t)} d\tilde{m}_t(a_{it},k,\Xi_t=1) \Bigg)
\end{aligned}
$$

and

$$
\begin{aligned}
& m_{t+1}(a,k,e=0,\psi=1) = \\
& \zeta \Bigg(\lambda \int_{\tilde{X}^a(\{a,k\},e,s,\Xi=0;\Gamma_t)} d\tilde{m}_t(a_{it},k_{it},\Xi_t=0) + (1-\lambda) \int_{\tilde{X}^{na}(a,k,e,s,\Xi=0;\Gamma_t)} d\tilde{m}_t(a_{it},k,\Xi_t=0) \Bigg) \\
& +(1-\iota) \Bigg(\lambda \int_{\tilde{X}^a(\{a,k\},e,s,\Xi=1;\Gamma_t)} d\tilde{m}_t(a_{it},k_{it},\Xi_t=1) \\
& + (1-\lambda) \int_{\tilde{X}^{na}(a,k,e,s,\Xi=1;\Gamma_t)} d\tilde{m}_t(a_{it},k,\Xi_t=1) \Bigg)
\end{aligned}
$$

Finally measures m_t^e, m_t^u and m_t^Ψ will fulfill

$$
m_t^e = \sum_{s\in\mathcal{S}} \left[(1-\delta(s)+\delta(s)\varpi(s)p_t^{UE}) m_t(e=1,s) + \varpi(s)p_t^{UE} m_t(e=0,s) \right]
$$

as well as

$$
m_t^u = \sum_{s\in\mathcal{S}} \left[\delta(s)(1-\varpi(s)p_t^{UE}) m_t(e=1,s) + (1-\varpi(s)p_t^{UE}) m_t(e=0,s) \right] \quad .
$$

A.4 Details on numerical implementation

The household problem needs to be solved on a discretization of the state space: We choose 80 grid points for both a and k, either of which are non-linearly 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.

$$
\mathcal{X} = x_{min} + \exp(\exp(\mathbf{u}(0, x_{max}))) - 1
$$

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, we add 5 additional grid points in the immediate vicinity of that point. Given that individual labor productivity is discretized to 13 points, this means that the household problem is solved on a tensor grid of $85 \times 85 \times (2 \times 13 + 1) = 195075$ points (the "entrepreneur" status adds an additional "income" state to the 2×11 for employed and unemployed workers). The discretization of the individual labor productivity process is described in the main text, Section 3. Whenever interpolation is needed off the grid, we use linear interpolation.

For the implementation of the multidimensional EGM algorithm, we follow the replication codes for Bayer et al. (2024) closely.[28] Given the random illiquid asset adjustment, the EGM scheme only iterates over marginal value functions (i.e. the derivatives of V with respect to m and k) and does not compute V directly.

For a given calibration, solving the stationary steady state is relatively easy if we treat the central bank policy targets to effectively fix the steady state return on the liquid asset. In that case, finding the stationary equilibrium can be reduced to a root-finding problem for a single variable, the steady state return on capital.

For the state space perturbation, our setting provides for a complication relative to Bayer et al. (2024) in that households differ in a discrete fashion that does not have straightforward order (employed vs. unemployed). In turn, we adapt two aspects of their algorithm: Firstly, the DCT reduction for the value functions in done separately for employed and unemployed workers. This was inspired by the replication codes for Bayer et al. (2023). Secondly, we also conduct the copula split separately for both the joint distributions of employed and unemployed workers. In turn, the dimension-reduced state space contains the marginals and copula coefficients for either.[29]

Finally, to compute the household block's SSJs, we build on the "Fake news" algorithm proposed in Auclert et al. (2021). In our setting, its baseline version would be computationally quite costly as our "household block" has a potentially large number of inputs (a wage level for every $s \in \mathcal{S}$). In turn, we use an insight outlined in Hänsel (2024b) and combine the labor agencies into the same "Joint" block as the households, which only requires Jacobians w.r.t. the time paths of aggregates influencing barganing outcome (25) instead.

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

[29] For these steps, the "entrepreneurs" are handled to together with the employed workers.

A.5 Additional tables

- The model parameters not explicitly stated in Section 3 are provided in Table A.1.

	s	$\gamma(s)$	$\delta(s)$	$\varpi(z)$	$\Upsilon_b(s)$
s_1	0.143	0.135	0.128	0.954	0.4
s_2	0.179	0.171	0.124	0.958	0.4
s_3	0.223	0.212	0.12	0.963	0.4
s_4	0.278	0.263	0.114	0.97	0.4
s_5	0.347	0.325	0.108	0.977	0.4
s_6	0.433	0.4	0.1	0.987	0.4
s_7	0.54	0.491	0.091	1.0	0.4
s_8	0.673	0.6	0.082	1.016	0.4
s_9	0.839	0.732	0.071	1.036	0.4
s_{10}	1.047	0.987	0.059	1.062	0.352
s_{11}	1.306	1.384	0.048	1.095	0.283
s_{12}	1.628	1.892	0.036	1.137	0.227
s_{13}	2.031	2.57	0.026	1.193	0.182

Table A.1: Skill-specific parameters

A.6 "Unemployment fears" for different shocks

In this Appendix, we display the responses of the baseline and "naive" models to the business cycle shocks not further considered in the main text. All disturbances are assumed to be reverting back to the original values according to $\log x_t = 0.9 \log x_{t-1}$, except for the transfer and- monetary policy shock. These are assumed to have no persistence, although the monetary policy shock is indirectly persistent through the backward-looking component in the policy rule. Recall that due to the linearized model solution, the scale of the shock does not affect the shape and relative magnitudes of the response.

A.7 Additional Figures

Parameter	$\xi = 2$	No skill losses	Hom. p^{EU} & p^{UE}
β	0.9850	0.9906	0.9907
ζ	0.0003	0.0005	0.005
λ	0.1339	0.071	0.071
$\bar{R}$	0.0394	0.042	0.039
$\underline{a}$	-0.854	-0.879	-0.834
φ	0.0105	0.0105	0.0105
ϱ	0.0509	0.0509	0.0509
ς	0.1827	0.1819	0.1766
A_m	0.6551	0.6534	0.6523
$\frac{\kappa_1}{p_{ss}^{vf}} + \kappa_2$	0.0702	0.070	0.081
κ_2	0.0168	0.0281	0.0324

Table A.2: Internally calibrated parameters - alternative model versions

	Disposable Income					Net Worth				
	Baseline	$\xi = 2$	HL1	HL2	Data	Baseline	$\xi = 2$	HL1	HL2	Data
Quint. 1	6.1	6.0	6.3	6.3	4.5	0.0	0.0	0.0	0.0	-0.9
Quint. 2	10.3	10.1	10.6	10.5	9.9	0.8	1.5	0.7	0.8	0.8
Quint. 3	14.9	14.6	15.1	14.9	15.3	3.9	4.8	3.6	3.8	4.4
Quint. 4	21.4	20.9	21.3	21.2	22.8	11.1	11.6	10.7	11.0	13.0
Quint. 5	47.3	48.4	46.6	47.1	47.5	84.1	81.9	84.8	84.5	82.5
Gini	0.41	0.43	0.40	0.41	0.42	0.80	0.80	0.81	0.80	0.77

"Data" refers to moments computed by Krueger et al. (2016) using PSID. "HL1" denotes the model version without skill losses and "HL2" the model version with homogeneous job finding and -separation rates.

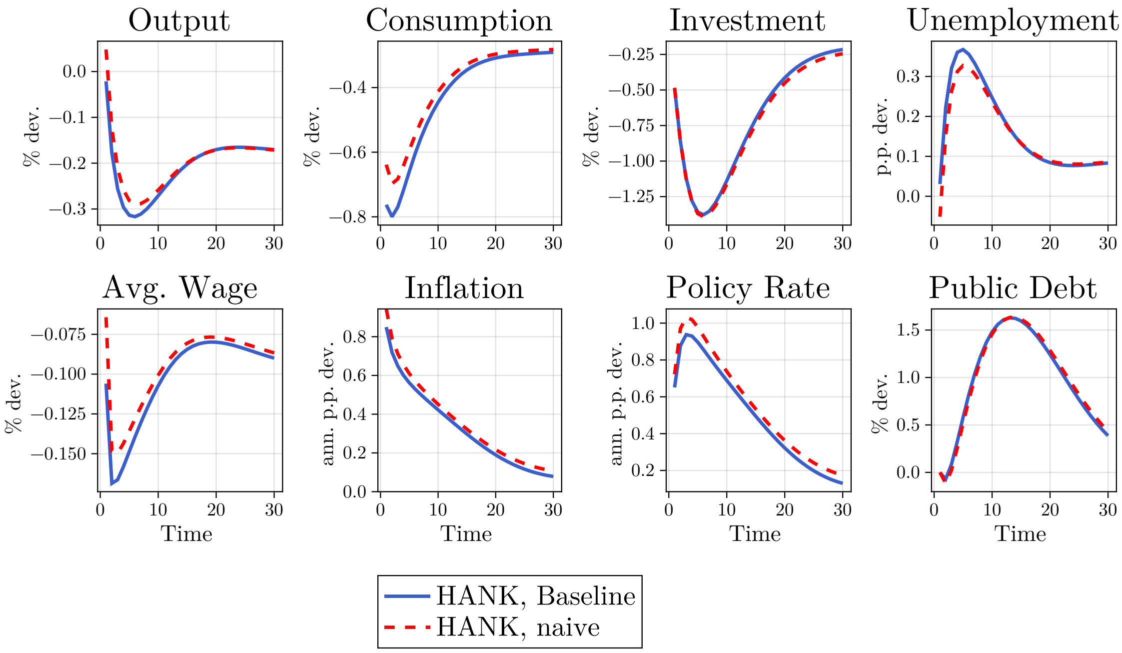
Table A.3: Distributional moments comparison: Alternative model versions

Moments	Baseline	$\xi = 2$	HL1	HL2	Data
Illiquid asset shares					
Top 10%	73.4	71.3	71.4	71.5	70
Next 40%	24.7	25.6	26.9	26.8	27
Bottom 50%	1.8	3.1	1.6	1.7	3
Liquid asset shares					
Top 10%	80.3	74.6	81.7	80.1	86
Next 40%	20.6	24.6	19.5	21.1	18
Bottom 50%	-0.9	0.08	-1.2	-1.2	-4
Hand-to-Mouth (HtM) Status					
Share HtM	29.0	14.6	32.5	31.4	31.2
Share Wealthy HtM	20.3	12.1	22.4	21.1	19.2
Share Poor HtM	8.7	2.5	10.1	10.3	12.1

"HL1" denotes the model version without skill losses and "HL2" the model version with homogeneous job finding and -separation rates.

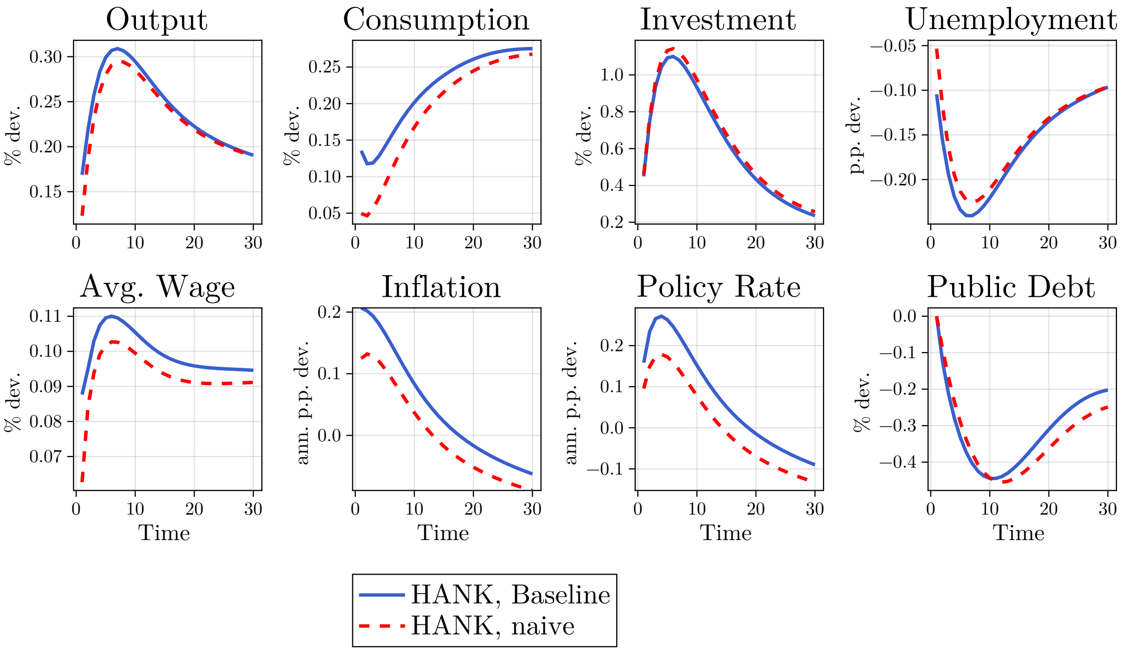
Table A.4: Portfolio moments comparison: Alternative model versions.

Figure A.1: Model Response to an energy price shock shock



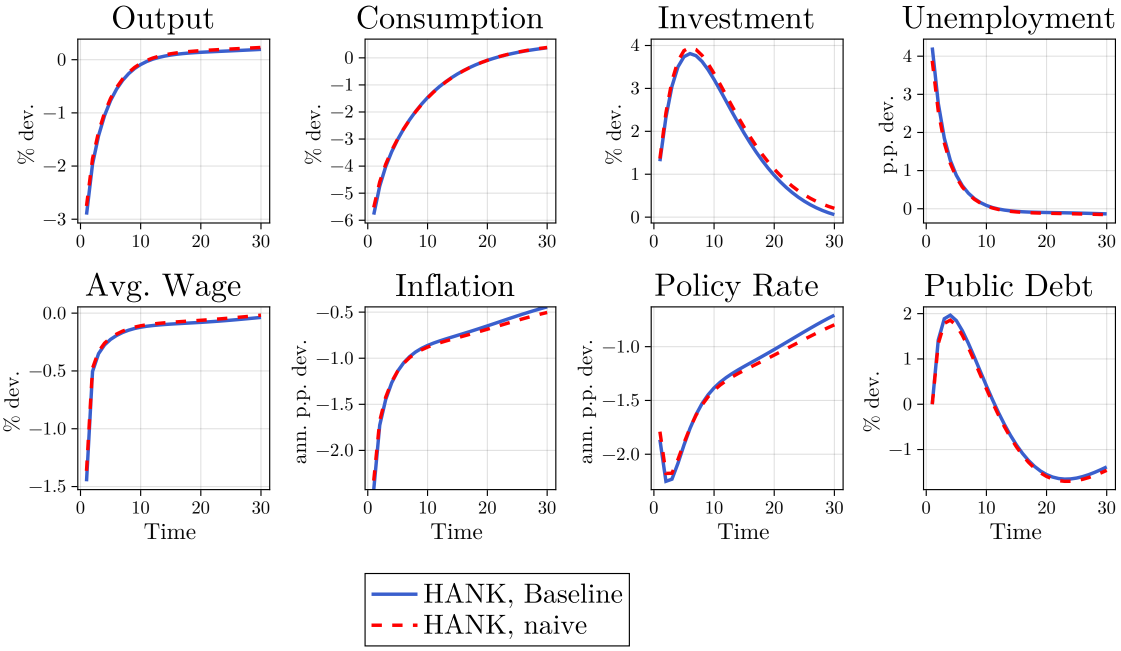
Note: "Avg. Wage" denotes the economy-wide average real wage.

Figure A.2: Model Response to an investment technology shock



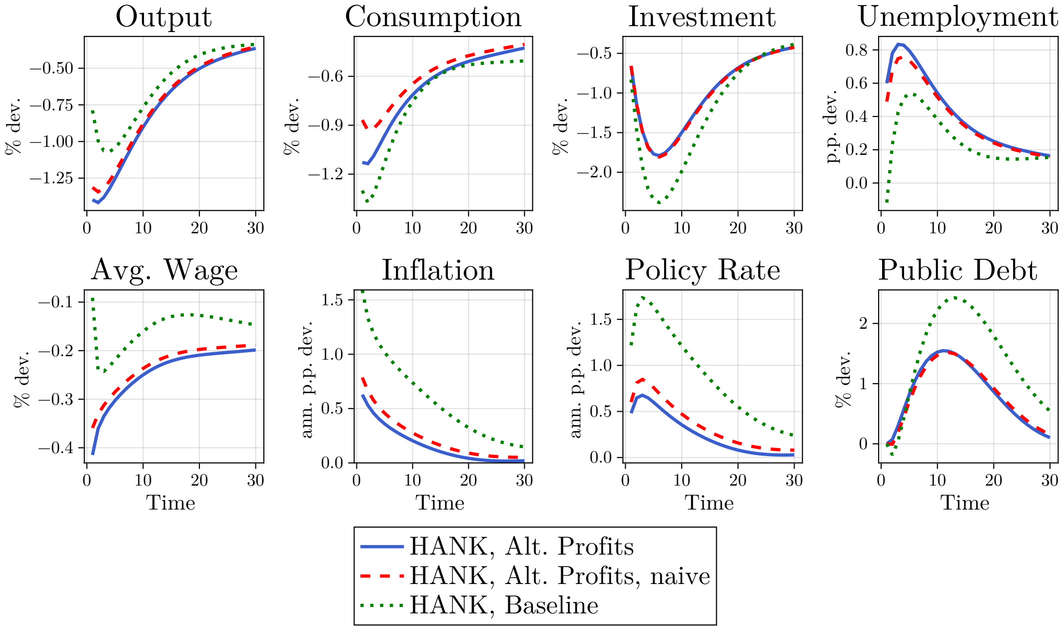
Note: "Avg. Wage" denotes the economy-wide average real wage.

Figure A.3: Model Response to a demand (preference) shock



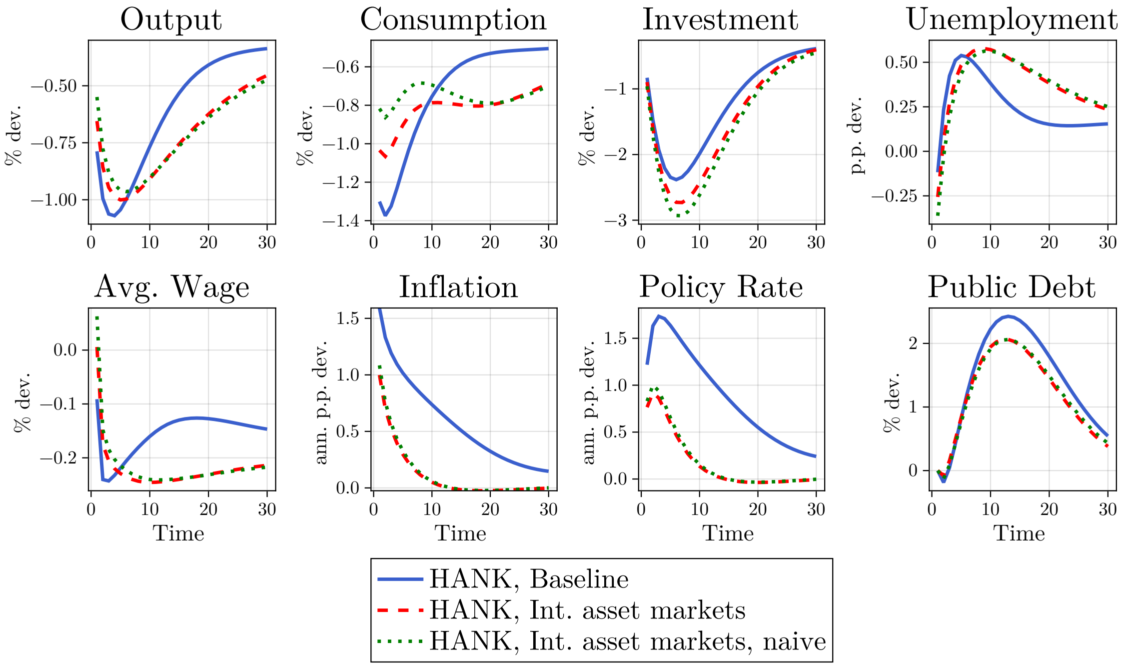
Note: "Avg. Wage" denotes the economy-wide average real wage.

Figure A.4: Model Response to a TFP shock: Alternative Profits



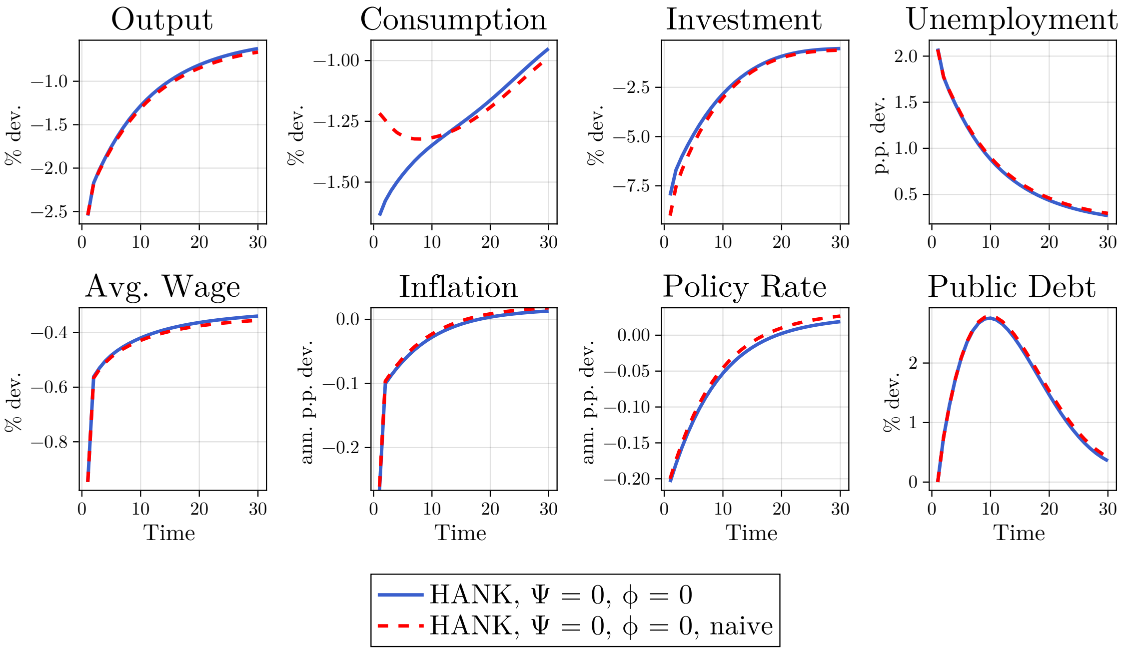
Note: Response to 1% decrease of Z_t that evolves according to $\log Z_t = 0.9 \log Z_{t-1}$. “Avg. Wage” denotes the economy-wide average real wage. For the “Alternative Profits” models, consumption does not include the profits consumed by the Hand-to-Mouth “capitalists”.

Figure A.5: Model Response to a TFP shock: $\Psi = 0$



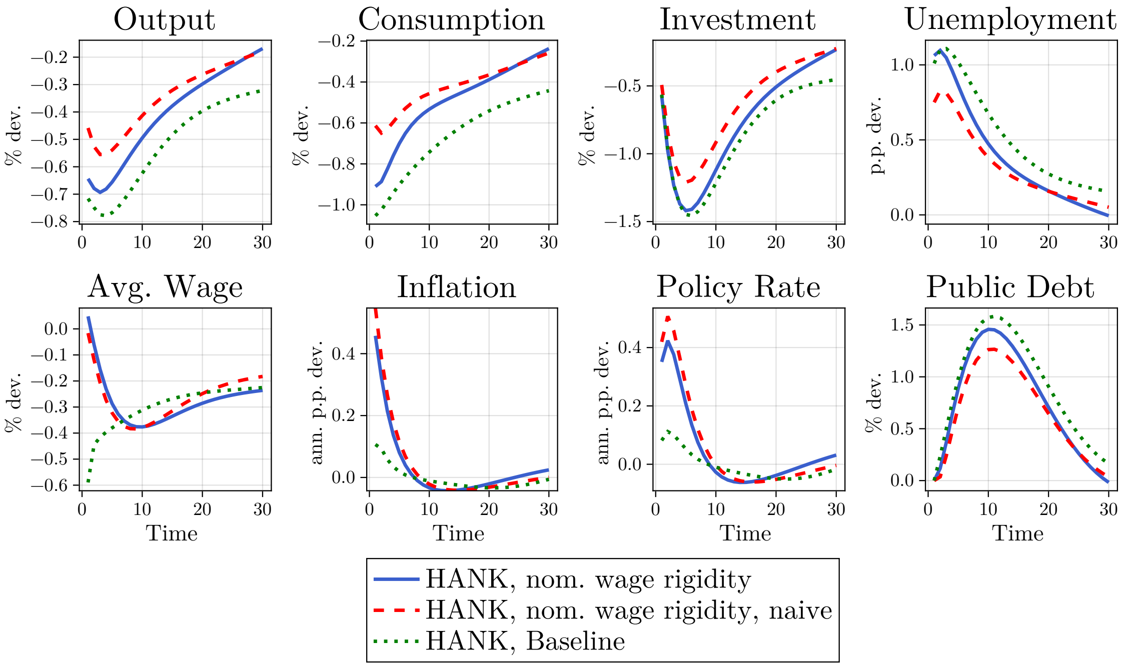
Note: Response to 1% decrease of Z_t that evolves according to $\log Z_t = 0.9 \log Z_{t-1}$. "Avg. Wage" denotes the economy-wide average real wage.

Figure A.6: Model Response to a “cost push” shock: $\Psi = 0$ and $\phi = 0$



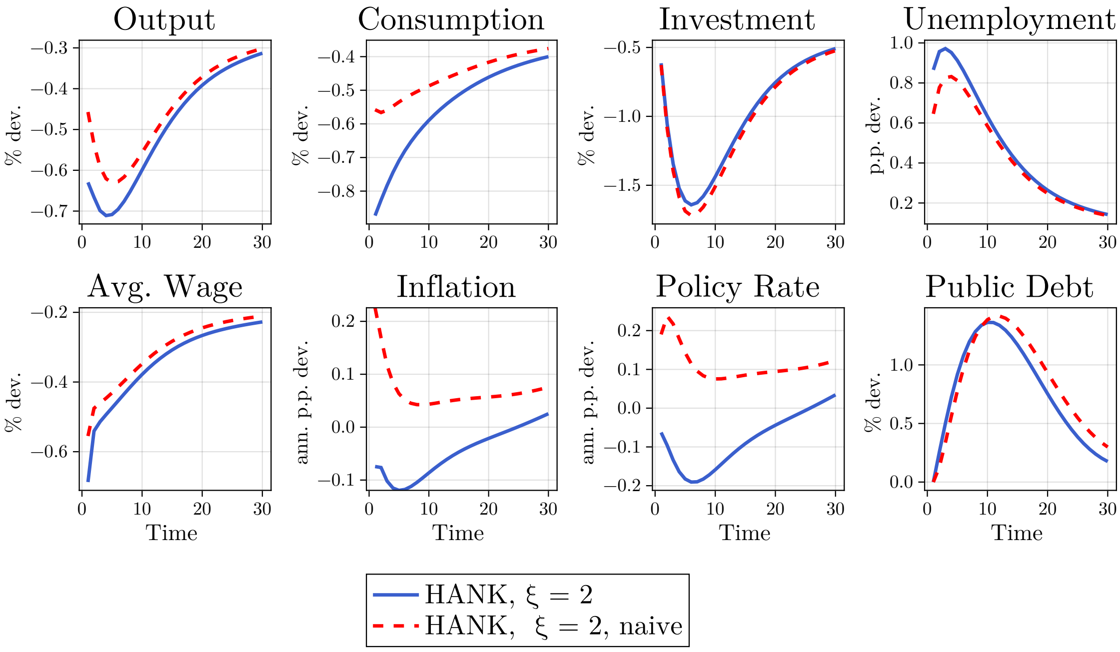
Note: Response to 1% decrease of μ_t that evolves according to $\log(\mu_t/\mu_{ss}) = 0.9\log(\mu_{t-1}/\mu_{ss})$. Model version without capital adjustment cost and integrated asset markets.

Figure A.7: Model Response to a "cost push" shock: Nominal wage rigidity



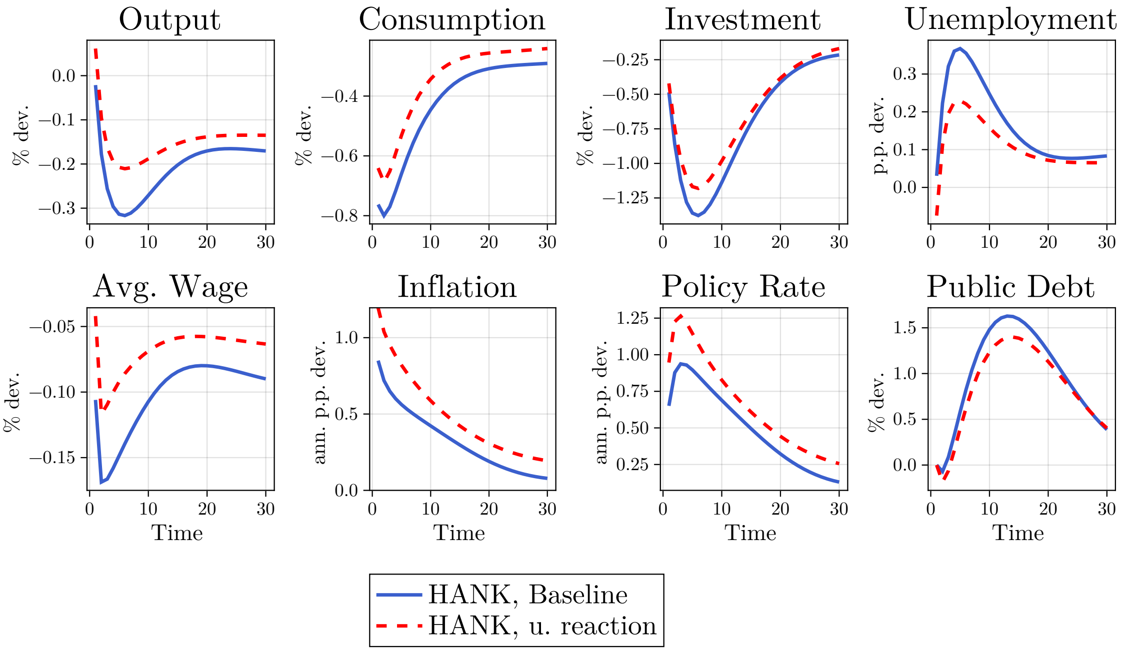
Note: Response to 1% decrease of μ_t that evolves according to $\log(\mu_t/\mu_{ss}) = 0.9 \log(\mu_{t-1}/\mu_{ss})$. "Avg. Wage" denotes the economy-wide average real wage.

Figure A.8: Model Response to a “cost push” shock: Higher Risk aversion



Note: Response to 1% decrease of μ_t that evolves according to $\log(\mu_t/\mu_{ss}) = 0.9\log(\mu_{t-1}/\mu_{ss})$. “Avg. Wage” denotes the economy-wide average real wage.

Figure A.9: Model Response to an energy shock



Note: Response to 10% decrease of p_t^E that evolves according to $\log p_t^E = 0.9 \log p_{t-1}^E$. "Avg. Wage" denotes the economy-wide average real wage.