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Unconventional Fiscal Policy in HANK

Hannah Seidl[*] Fabian Seyrich[†]

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Abstract

We show that in a New Keynesian model with household heterogeneity, fiscal policy can be a perfect substitute for monetary policy: three simple conditions for consumption taxes, labor taxes, and the government debt level are sufficient to induce the same consumption and labor supply of each household and, thus, the same allocation as interest rate policies. When monetary policy is constrained by a binding lower bound, a currency union, or an exchange rate peg, fiscal policy can therefore replicate any allocation that hypothetically unconstrained monetary policy would generate.

Keywords: Unconventional Fiscal Policy, Heterogeneous Agents, Incomplete Markets, Liquidity Trap, Sticky Prices

JEL Codes: E12, E21, E24, E43, E52

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1 Introduction

Monetary policy oftentimes cannot freely adjust the nominal interest rate—be it due to a binding lower bound, a currency union, or an exchange rate peg. In these environments of constrained monetary policy, policymakers need to resort to alternative policy tools.

In this paper, we show that fiscal policy can be a perfect substitute for monetary policy in a state-of-the-art heterogeneous agent New Keynesian model (HANK). We prove that three simple conditions for consumption taxes, labor taxes, and the government debt level are sufficient to generate the same consumption and labor supply of *each* household and, thus, the same allocation as monetary policy. The insight is that this fiscal policy scheme—which we label *HANK unconventional fiscal policy (HANK-UFP)*—affects the optimization problem of each household in the same way as a change in the interest rate: HANK-UFP and interest rate changes induce the same inter- and intratemporal incentives for consumption and labor supply in each household's first-order conditions as well as the same effects on each household's budget constraint. This perfect substitutability result holds when monetary policy is constrained meaning that HANK-UFP circumvents the constraints on monetary policy. In particular, we show at the Effective Lower Bound (ELB) that HANK-UFP can generate any allocation that hypothetically unconstrained monetary policy could achieve by inducing the same cross-sectional consumption and labor supply.

Our perfect substitutability result between monetary policy and fiscal policy in HANK builds on the perfect substitutability result in representative agent New Keynesian (RANK) models (see Correia et al. (2008), Correia et al. (2013)). In RANK, tax policies alone—*unconventional fiscal policy (UFP)*—are sufficient to induce the same optimization problem of the representative household as monetary policy since they induce the same inter- and intratemporal incentives for consumption and labor supply. However, this result relies on the fact that, by construction, policies do not redistribute across households as all of the income accrues to the same household. In contrast, in HANK models, households are heterogeneous in their income compositions—in line with empirical evidence. One of our contributions is to show that, as a consequence, tax policies alone are no longer sufficient to induce the same optimization problem of each household in HANK. The reason is that tax and interest rate policies have different effects on the various income components of households. We show that this implies that tax policies are not able to stabilize the economy while the ELB is binding and, in addition, push the economy to a steady state with lower output after the ELB stops binding. As a result, the welfare of each household is lower than with HANK-UFP.

For our analysis, we extend the textbook New Keynesian model by a standard heterogeneous agent, incomplete markets set-up. We assume that households face uninsurable idiosyncratic income risk and borrowing constraints. Households self-insure against idiosyncratic shocks to their labor productivity by buying risk-free bonds. Monetary policy sets the interest rate and fiscal policy sets proportional taxes on consumption and on labor, issues government debt, and pays lump-sum transfers to households. For simplicity, we abstract from aggregate risk in our analysis.[1] In this model, we analytically characterize our fiscal policy scheme, HANK-UFP, which induces the same optimization problem of each household. This is sufficient to generate the same effects through general equilibrium since monetary policy and fiscal policy do not affect firms' equilibrium conditions directly but only through the household block.

To fix ideas, consider the effects of expansionary monetary policy on the households' optimization problems which are replicated by HANK-UFP as follows. In line with Correia et al. (2013), tax policies generate the same policy wedges as monetary policy in the first-order conditions of households. Pre-announced paths for higher future consumption taxes trigger the same incentives to intertemporally substitute consumption as a decrease in the real interest rate. Yet, higher consumption taxes also incentivize households to reduce their labor supply. Lower labor taxes offset this effect of consumption taxes on the labor-leisure equations.

We prove that when these tax policies are combined with debt policies in the form of higher government debt, each household's income and therefore her budget constraint is identically affected by HANK-UFP and monetary policy. We show that for this to be the case, it is sufficient that monetary policy and HANK-UFP induce the same redistribution through the policy block.[2] Expansionary monetary policy redistributes from asset holders to the government: on the one hand, lower interest rates induce a negative wealth effect which affects households in proportion to their asset holdings. On the other hand, the government issues the assets and, hence, has lower interest rate payments which shifts resources to the government. These additional resources are then redistributed back to the households through a fiscal response. HANK-UFP replicates this redistribution through the policy block as follows. Higher consumption taxes generate the same negative wealth effect on the assets of households as they decrease the purchasing power of assets. This again hurts

[1] Adding aggregate risk would affect the path of interest rates that monetary policy aims to implement. Yet, the effects of these interest rate paths on the households' optimization problems would still be replicated by our fiscal policy scheme as our fiscal policy scheme replicates the allocation of any path of interest rates.

[2] Among others, Bhandari et al. (2021), Bilbiie (2018), and Acharya and Dogra (2020) highlight the effects of households' heterogeneous exposure to a policy change arising indirectly through changes in output. While households are also heterogeneously exposed to changes in output in our model, this does not affect our perfect substitutability result because these effects are the same with HANK-UFP and monetary policy since both identically affect output. Thus, for our analysis, it is sufficient to focus on the heterogeneous exposure of households to policy changes arising directly from changes in monetary and fiscal policy variables, that is, through the policy block.

households in proportion to their asset holdings. As households accumulate these assets for self-insurance purposes, higher consumption taxes increase the precautionary savings demand of households in proportion to their asset holdings. The government accommodates this higher asset demand by increasing the government debt level such that the value of total assets in purchasing power terms is the same as in the monetary policy case. This provides the government with the same additional resources as in the monetary policy case which triggers the same fiscal response and, thus, the same redistribution back to the households.

Our perfect substitutability result between fiscal policy and monetary policy is especially relevant when conventional monetary policy is constrained. We therefore apply our perfect substitutability result at the ELB—a typical case of constrained monetary policy—and show that HANK-UFP circumvents the constraint. By increasing consumption taxes, decreasing labor taxes, and permanently increasing the government debt level, HANK-UFP replicates the allocation associated with hypothetically unconstrained monetary policy—the counterfactual in which monetary policy could freely set nominal interest rates without any lower bound constraints.

In this ELB environment, we quantify the role of debt policies—the novel instrument that is necessary for perfect substitutability in HANK. We first highlight the importance of a permanently higher government debt level. To this end, we analyze a fiscal policy scheme that uses tax policies and increases the debt level only *temporarily* while in the long-run, debt reverts to its old steady state level. With this fiscal policy scheme, the economy converges to a new steady state with lower output after the ELB episode. The reason is that fiscal policy cannot satisfy the higher precautionary savings demand of households in the long-run induced by the permanently higher consumption taxes. Consequently, households are worse insured against their idiosyncratic income risk which permanently increases the inefficiency from incomplete markets. This shows that tax policies which are neutral in RANK in the long-run can induce long-run inefficiencies in HANK.

Next, we highlight the importance of debt policies to achieve the same macroeconomic stabilization in the short-run as unconstrained monetary policy during the ELB episode. To this end, we study the UFP scheme of Correia et al. (2013) through the lens of our HANK-model. Since the government debt level is now constant, the fiscal response that monetary policy induces through reducing the interest rate payments cannot be replicated by this fiscal policy scheme. As a consequence, this fiscal policy scheme cannot fully stabilize the economy in the short-run. Not matching macroeconomic aggregates of unconstrained monetary policy also implies that both alternative fiscal policy schemes fail to achieve cross-sectional equivalence with unconstrained monetary policy. What is more, with these fiscal policy schemes, the welfare of each household is lower.

While our baseline model abstracts from investment, we show that fiscal policy can also be a perfect substitute for monetary policy if we extend our model by investment. In this version of our model, monetary policy affects aggregate output not only through changes in consumption but also through changes in investment as the production function now includes capital. We show analytically that when a condition for temporary investment subsidies is added to HANK-UFP, the allocation of monetary policy can again be replicated. The intuition for this result is that, on the one hand, this additional instrument replicates the incentives of monetary policy to invest since interest rates and subsidies symmetrically enter the firms' first-order conditions as shown by Correia et al. (2013). On the other hand, investment subsidies replicate the redistribution of expansionary monetary policy from asset-holders to firms. The reason is that these subsidies are financed by a permanent increase in the government debt level and, thus, by households in proportion to their asset holdings.[3]

Related literature. Feldstein (2002) and Hall (2011) propose to increase future consumption taxes when monetary policy is constrained by the ELB. Correia et al. (2008) and Correia et al. (2013) show that a combination of consumption taxes and labor taxes is a perfect substitute for monetary policy in RANK by replicating its effects on the policy wedges in the household's first-order conditions. Bianchi-Vimercati et al. (2021) show that in RANK, the effectiveness of these tax policies is not affected by bounded rationality in the form of level-k thinking. We depart from the textbook RANK in a different way and show that Correia et al. (2013)'s seminal result relies on the fact that monetary and fiscal policy do not redistribute among households in RANK. We show that when households are heterogeneous in their income composition, UFP as prescribed by Correia et al. (2013) is no longer a perfect substitute for monetary policy. We further show that in HANK, tax policies alone cannot fully stabilize in the short-run and, in addition, induce a lower output in the long-run.

There is a large literature on the transmission mechanism of monetary policy in HANK (see among many others Werning (2016), McKay et al. (2016), Kaplan et al. (2018), Bilbiie (2018), Auclert (2019), Hagedorn et al. (2019a), Acharya and Dogra (2020), Auclert et al. (2020)), Luetticke (2021).[4] Recently, the HANK literature has also studied fiscal policy. Auclert et al. (2018), Ferriere and Navarro (2018), and Hagedorn et al. (2019b) analyze fiscal

[3]This is for the same reason as above: the savings of households are now split between bonds and capital, but an increase in consumption taxes decreases the purchasing power of all asset holdings of households. Hence, by increasing the debt level to accommodate the resulting increase in precautionary savings and using part of it to finance the investment subsidy, HANK-UFP redistributes from asset-rich households to the government and firms in the same way as monetary policy redistributes from asset-rich households to the government and firms.

[4]There is also a growing literature analyzing the transmission mechanism of monetary policy in models with firm heterogeneity, see among others Reiter et al. (2013), Koby and Wolf (2020), and Ottonello and Winberry (2020).

multipliers in HANK models. Unlike our paper, these papers do not study whether fiscal policy can replicate the allocations of unconstrained monetary policy. Oh and Reis (2012) and Bayer et al. (2020b) show that transfer policies can have large effects in HANK models which is also reflected in our numerical analysis. As in our analysis, Bayer et al. (2020a) show that the government debt level affects the economy in the short- and in the long-run. In particular, they show how the government debt level affects the liquidity spread which, in turn, affects the real economy. In contrast, we provide a specific rule for the government debt level as part of a set of sufficient conditions such that fiscal policy is a perfect substitute for monetary policy. Bhandari et al. (2021) analyze optimal fiscal and monetary policy in a HANK model with aggregate risk. They analyze how idiosyncratic insurance possibilities shape optimal monetary and fiscal policy in the face of aggregate shocks while we focus on the substitutability of monetary policy by fiscal policy. Unlike our analysis, Bhandari et al. (2021) include aggregate risk, but they abstract from borrowing constraints, a binding ELB, and consumption taxes. Le Grand et al. (2021) also study optimal fiscal and monetary policy in a HANK model. Their set of fiscal instruments can replicate the allocations of monetary policy away from the ELB in their HANK model. Unlike our HANK-UFP scheme, they use capital taxes instead of consumption taxes. This is an important distinction from our analysis for two reasons: first, capital taxes face the same limitations as interest rate policies since the nominal after-tax return on savings cannot become negative. Hence, capital taxes cannot be used to circumvent the ELB constraint. Second, capital taxes have different effects on the budget constraints of households compared to consumption taxes.

Wolf (2021) is closest to our paper. He shows that transfer policies can achieve the same aggregate outcomes as interest rate cuts in a linearized HANK model with sticky wages. Unlike our perfect substitutability result, Wolf (2021) derives his aggregate equivalence result by showing that lump-sum transfers can trigger the same *aggregate* consumption response in partial equilibrium as monetary policy. In a linearized environment in which the labor supply of households is not affected by their individual consumption in the short-run, this then generates the same responses of macroeconomic aggregates through general equilibrium. Unlike Wolf (2021), we show that with tax and debt policies, fiscal policy can directly manipulate the optimization problem of each household in the same way as monetary policy. Thus, our result differs from the result in Wolf (2021) in two aspects: first, HANK-UFP does not only achieve equivalence in aggregates but also in the cross-section of households and, thus, the distribution of households evolves in the same way with monetary and fiscal policy. Second, this implies that our result also holds if households' labor supply is affected by their individual consumption in the short-run as the cross-sectional consumption and labor supply is the same as with monetary policy. To the best of our knowledge, we are the first who show how fiscal policy can circumvent constraints of monetary policy, including the ELB constraint, in a HANK model.

Outline. Section 2 presents our HANK model. Section 3 shows analytically that HANK-UFP is a perfect substitute for monetary policy. Section 4 provides a numerical analysis to show how HANK-UFP circumvents the ELB constraint. Section 5 analyzes alternative fiscal policy schemes to highlight the role of debt policies in HANK-UFP. Section 6 concludes.

2 Model

This section outlines our HANK model which is a sticky-price New Keynesian model extended by a standard heterogeneous households, incomplete markets set-up.

2.1 Households

The economy is populated by a continuum of households who are identical in their preferences given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_{h,t}^{1-\gamma}}{1-\gamma} - \frac{l_{h,t}^{1+\psi}}{1+\psi} \right],$$

where β denotes the household's discount factor, $c_{h,t}$ denotes consumption of household h in period t, and $l_{h,t}$ denotes her labor supply. The parameters γ and ψ govern the degree of risk aversion and the inverse Frisch elasticity, respectively.

The budget constraint of household h and her borrowing constraint are given by:

$$(1+\tau_t^C)c_{h,t} + \frac{b_{h,t+1}}{1+r_t} = b_{h,t} + (1-\tau_t^L)w_t z_{h,t} l_{h,t} + D_t + Tr_t$$

$$b_{h,t+1} \geq 0.$$

Household h has expenditures for consumption, $c_{h,t}$, and 1-period risk-free bonds, $b_{h,t}$, which pay the real interest rate, r_t, and are issued by the government. In addition, households pay a proportional tax rate on consumption, τ_t^C, and a proportional tax rate on their individual labor income, τ_t^L. The labor income consists of the wage rate, w_t[5], the individual productivity level, z_t, and the individual labor supply. Since $z_{h,t}$ evolves according to an exogenous finite-state Markov chain, households face idiosyncratic income risk. As in McKay et al. (2016), we

[5]Unless stated otherwise, all variables are denoted in real terms.

assume that all households receive an equal share of firms' dividends, D_t[6], and a lump-sum transfer, Tr_t, from the government. For our analytical analysis in Section 3, it is useful to represent the budget constraint in purchasing power terms:

$$c_{h,t} + \frac{b_{h,t+1}}{(1+\tau_t^C)(1+r_t)} = \frac{b_{h,t}}{(1+\tau_t^C)} + \frac{(1-\tau_t^L)}{(1+\tau_t^C)} w_t z_{h,t} l_{h,t} + \frac{D_t + Tr_t}{(1+\tau_t^C)}. \tag{1}$$

We assume the standard Bewley-Huggett-Aiyagari incomplete markets setup such that there are no state-contingent securities. As households cannot buy perfect insurance, they accumulate government bonds to self-insure their idiosyncratic risk. As a consequence, households differ in their individual state, $h = (b, z)$, which consists of households' asset position, b, and their specific productivity level, z. The decision problem of a household with individual state h is given by:

$$V_t(b_{h,t}, z_{h,t}) = \max_{c_{h,t}, l_{h,t}, b_{h,t+1}} \left\{ \frac{c_{h,t}^{1-\gamma}}{1-\gamma} - \frac{l_{h,t}^{1+\psi}}{1+\psi} + \beta \sum_{z_{h,t+1}} Pr(z_{h,t+1}|z_{h,t}) V_{t+1}(b_{h,t+1}, z_{h,t+1}) \right\},$$

subject to equation (1). The Euler equation is given by:

$$c_{h,t}^{-\gamma} \geq \beta E_t \left\{ \left(\frac{1+i_t}{1+\pi_{t+1}} \frac{1+\tau_t^C}{1+\tau_{t+1}^C} \right) c_{h,t+1}^{-\gamma} \right\}, \tag{2}$$

which governs the intertemporal substitution decision of households. Both lower real interest rates and higher future consumption taxes increase the intertemporal policy wedge, $\frac{1+\pi_{t+1}}{1+i_t} \frac{1+\tau_{t+1}^C}{1+\tau_t^C}$, thereby incentivizing households to consume more today.

The labor-leisure equation is given by:

$$l_{h,t}^{\psi} = c_{h,t}^{-\gamma} z_{h,t} w_t \frac{1-\tau_t^L}{1+\tau_t^C}. \tag{3}$$

Consumption taxes and labor taxes directly influence the labor supply of households through the intratemporal policy wedge, $\frac{1-\tau_t^L}{1+\tau_t^C}$.

Let $c_t(b, z)$, $\ell_t(b, z)$, and $b_{t+1}(b, z)$ denote the policy functions for consumption, labor supply, and savings, respectively, that satisfy equations (1), (2), and (3) given the household's individual state.

[6] Note that our perfect substitutability result also holds if we assume different rules for the distribution of dividends. We will discuss this further in Section 3.

2.2 Firms

Final good firms produce in a perfectly competitive market using intermediate goods as inputs. Their decision problem is:

$$\max_{y_{j,t}} \left\{ P_t Y_t - \int_0^1 p_{j,t} y_{j,t} dj \right\},$$

subject to a CES production technology:

$$Y_t = \left(\int_0^1 y_{j,t}^{1/\mu} dj \right)^{\mu},$$

where $y_{j,t}$ denotes the intermediate good produced by firm j and $p_{j,t}$ is the corresponding price. Y_t denotes the final consumption good, P_t denotes the overall price index, and μ determines the degree of substitution among input factors. The aggregate price index is given by:

$$P_t = \left(\int_0^1 p_{j,t}^{1/(1-\mu)} dj \right)^{1-\mu}.$$

Solving the maximization problem yields the demand function of final good firms for the intermediate good j:

$$y_{j,t} = \left(\frac{p_{j,t}}{P_t} \right)^{\frac{\mu}{1-\mu}} Y_t. \tag{4}$$

Intermediate goods are produced by a continuum of intermediate good firms in monopolistically competitive markets according to:

$$y_{j,t} = n_{j,t}.$$

Following Correia et al. (2013), we assume that price setting takes place before consumption taxes. As in Calvo (1983), we allow an intermediate good firm to reset its price only with a certain probability, θ. If a firm is allowed to reset its prices, it solves the following non-static maximization problem:

$$\max_{p_t^*, \{y_{j,s}, n_{j,s}\}_{s=t}^{\infty}} \sum_{s=t}^{\infty} \beta^{s-t} (1-\theta)^{s-t} \left(\frac{p_t^*}{P_s} y_{j,s} - w_s n_{j,s} \right),$$

subject to the final good firms' demand given in (4). The optimal price ratio p_t^*/P_t that solves this problem is given by:

$$\frac{p_t^*}{P_t} = \frac{\sum_{s=t}^{\infty} \beta^{s-t}(1-\theta)^{s-t} \left(\frac{P_t}{P_s}\right)^{\frac{\mu}{1-\mu}} Y_s \mu w_s}{\sum_{s=t}^{\infty} \beta^{s-t}(1-\theta)^{s-t} \left(\frac{P_t}{P_s}\right)^{\frac{\mu}{1-\mu}} Y_s}. \tag{5}$$

Let $(1+\pi_{t+1}) = \frac{P_{t+1}}{P_t}$ denote the gross inflation rate.

2.3 Policy

We close the model by specifying monetary and fiscal policy.

Monetary policy. To simplify our analytical results in Section 3, we assume for now that monetary policy directly controls the real interest rate, r_t. Importantly, our perfect substitutability result does not depend on this simplification and still holds if we assume that monetary policy controls the nominal interest rate.

Fiscal policy. The government has expenditures for a fixed amount of government consumption, $\bar{G}$, lump-sum transfers, Tr_t, and for repaying debt, B_t. It finances its expenditures by collecting total tax payments, T_t, and by issuing future debt. The government's budget constraint is given by:

$$\bar{G} + Tr_t + B_t = \frac{B_{t+1}}{1+r_t} + T_t. \tag{6}$$

Total tax payments are given by:

$$T_t = \tau_t^C C_t + \tau_t^L w_t L_t, \tag{7}$$

where C_t and L_t denote aggregate consumption and aggregate labor, respectively. For simplicity, we assume for now $\bar{G} = 0$ but relax this assumption in Section 4.

2.4 Aggregation, Market Clearing, and Equilibrium

The aggregate production function of the economy is given by:

$$S_t Y_t = \int_0^1 n_{j,t} dj \equiv N_t, \tag{8}$$

where N_t denotes the aggregate labor demand of the intermediate good firms. S_t measures the efficiency loss that occurs whenever prices differ and is given by:

$$S_t \equiv \int_0^1 \left(\frac{p_{j,t}}{P_t}\right)^{\frac{\mu}{1-\mu}} dj \geq 1.$$

It evolves according to:

$$S_{t+1} = (1-\theta)S_t(1+\pi_{t+1})^{\frac{-\mu}{1-\mu}} + \theta\left(\frac{p^*_{t+1}}{P_{t+1}}\right)^{\frac{\mu}{1-\mu}}. \tag{9}$$

Inflation is a function of the optimal relative price of the updating firms:

$$1+\pi_t = \left(\frac{1-\theta}{1-\theta(\frac{p^*_t}{P_t})^{\frac{1}{1-\mu}}}\right)^{1-\mu}. \tag{10}$$

The distribution of households over their individual states, $\Gamma_{t+1}(\mathcal{B}, z')$, evolves following the exogenous Markov chain for the productivity level and the endogenously derived savings policy functions of the households. Formally:

$$\Gamma_{t+1}(\mathcal{B}, z') = \int_{\{(b,z):b_{t+1}(b,z)\in\mathcal{B}\}} Pr(z'|z)d\Gamma_t(b,z) \tag{11}$$

for all sets $\mathcal{B} \subset \mathbb{R}$. Aggregate labor supply, consumption, and savings are:

$$L_t = \int_0^1 z\ell_t(b,z)d\Gamma_t(b,z), \tag{12}$$

$$C_t = \int_0^1 c_t(b,z)d\Gamma_t(b,z), \tag{13}$$

and

$$B^d_{t+1} = \int_0^1 b_{t+1}(b,z)d\Gamma_t(b,z), \tag{14}$$

respectively.

Labor market clearing requires:

$$L_t = N_t, \tag{15}$$

the bond market clears when:

$$B_t = B_t^d, \tag{16}$$

and the goods market clears when:

$$Y_t = C_t + \bar{G}. \tag{17}$$

Dividend payments are given by:

$$D_t = Y_t - w_t N_t. \tag{18}$$

Equilibrium. We define an equilibrium of the economy to consist of:

1. Policy and value functions $\{b_{t+1}(b,z),\ \ell_t(b,z),\ c_t(b,z),\ V_t(b,z)\}_{t=0}^{\infty}$ that solve the households' problems,
2. distributions $\{\Gamma_t(b,z)\}_{t=0}^{\infty}$ that evolve according to (11),
3. sequences of the aggregate variables

$$X \equiv \left\{C_t, L_t, N_t, Y_t, d_t, i_t, w_t, \pi_t, r_t, p_t^*/P_t, S_t, Tr_t, T_t, \tau_t^C, \tau_t^L, B_t^d, B_t\right\}_{t=0}^{\infty}$$

that satisfy the equilibrium equations (5), (6), (7), (8), (9), (10), (15), (17), (18), the household aggregation equations (12), (13), (14), as well as the paths for the real interest rate, consumption taxes, labor taxes, and the government debt level to be specified below.

3 HANK-UFP

In this section, we prove that HANK-UFP is a perfect substitute for monetary policy in HANK. In particular, we derive a set of sufficient conditions for three *aggregate* fiscal instruments which jointly replicate the consumption and labor supply of *each* household and, thus, the allocation of any given change in interest rates. We subsequently show that this perfect substitutability result is general in the sense that it does not rely on specific modelling assumptions.

3.1 Perfect Substitutability with Monetary Policy

Monetary policy. Assume a standard perfect foresight monetary policy experiment. The economy is in steady state when in period $t = 0$, monetary policy announces a new path of real rates, $\{r_t^{MP}\}_{t=0}^{\infty}$, with $r_t^{MP} = \bar{r}$ for all $t > s$ for some s. We denote variables associated with this monetary policy experiment with a superscript MP. Consumption taxes, labor taxes, and the government debt level are fixed at their steady state values, that is, for all t, $\tau_t^{L,MP} = \bar{\tau}^L$, $\tau_t^{C,MP} = \bar{\tau}^C$, $B_t^{MP} = \bar{B}$, while transfers, Tr_t^{MP}, adjust to keep the government budget balanced. We focus on the equilibrium in which the economy converges back to steady state for $t \to \infty$.

Monetary Policy affects the economy through changing the optimization problem of households. In particular, it changes the households' problem in two ways: first, monetary policy changes the *intertemporal policy wedge*, $\frac{1}{(1+r_t)} \frac{1+\tau_{t+1}^C}{1+\tau_t^C}$, in the Euler equation of households (equation (2)) which incentivizes households to intertemporally reallocate consumption. Second, monetary policy has effects on the budget constraints of households. Importantly, these effects are not the same across households since, on the one hand, households differ in the composition of their income and, on the other hand, monetary policy has different effects on the various income components of households. We come back to this in the next paragraph.

HANK-UFP. We now describe how fiscal policy replicates the allocation associated with the monetary policy experiment. Assume that the real interest rate is kept at its steady state level, $r_t^{UFP} = \bar{r}\ \forall t$, and fiscal policy changes the paths for its aggregate instruments, $\tau_t^{C,UFP}$, $\tau_t^{L,UFP}$, and B_{t+1}^{UFP}. The following proposition states our perfect substitutability result between fiscal policy and monetary policy in HANK.

Proposition 1. *Consider HANK-UFP, a fiscal policy scheme which sets the paths for consumption taxes, $\tau_t^{C,UFP}$, labor taxes, $\tau_t^{L,UFP}$, and the government debt level, B_{t+1}^{UFP}, according to the following conditions*

$$\Big(1+\bar{r}\Big)\frac{1+\tau_t^{C,UFP}}{1+\tau_{t+1}^{C,UFP}} = 1 + r_t^{MP}, \tag{19}$$

$$\frac{1-\tau_t^{L,UFP}}{1+\tau_t^{C,UFP}} = \frac{1-\bar{\tau}^L}{1+\bar{\tau}^C}, \tag{20}$$

$$\frac{B_{t+1}^{UFP}}{\bar{B}} = \frac{1+\tau_{t+1}^{C,UFP}}{1+\bar{\tau}^C}, \tag{21}$$

while lump-sum transfers, Tr_t^{UFP}, adjust to keep the government budget constraint bal-

anced. HANK-UFP yields the same allocation as the monetary policy experiment. That is, consumption and labor supply is the same for each household in every period, i.e., $(c_{h,t}^{UFP}, l_{h,t}^{UFP}) = (c_{h,t}^{MP}, l_{h,t}^{MP})$ *$\forall h$ and $\forall t$. Hence, conditions (19) - (21) are sufficient conditions for HANK-UFP to be a perfect substitute for monetary policy.*

While we relegate the formal proof of Proposition 1 to Appendix A, we now explain the rationale behind our perfect substitutability result. As in Correia et al. (2008) and Correia et al. (2013), HANK-UFP uses consumption taxes and labor taxes to replicate the effects of monetary policy on the policy wedges in the first-order conditions of households. According to condition (19), consumption taxes are set such that the intertemporal policy wedge in the Euler equation of each household is the same as in the monetary policy experiment. Intuitively, by changing the ratio of future over current consumption taxes, fiscal policy changes the relative price of current consumption versus future consumption. This way, fiscal policy triggers the same incentive to intertemporally reallocate consumption as a change in the real interest rate. Unlike a change in the real interest rate, adjusting consumption taxes changes the *intratemporal policy wedge*, $\frac{1-\tau_t^L}{1+\tau_t^C}$, in the labor-leisure equations of households (equation (3)). When labor taxes are set according to condition (20), they offset this effect on the labor supply of households.

Furthermore, HANK-UFP ensures that the effects on the budget constraint of each household are the same as with monetary policy. To this end, HANK-UFP replicates the effects of monetary policy on *each component* of households' incomes. Equivalence in the intratemporal policy wedge (condition (20)) ensures that households' net wage is the same in purchasing power terms (PPT) as in the monetary policy experiment. Condition (19) ensures that the real return on assets in PPT is the same as in the monetary policy experiment. This implies that households want to save the same amount in PPT as in the monetary policy experiment, that is $b_{h,t+1}^{UFP} = \frac{1+\tau_{t+1}^{C,UFP}}{1+\bar{\tau}^C} b_{h,t+1}^{MP}$. Put differently, each household increases her savings demand in proportion to her asset holding. Debt dynamics following condition (21) ensure that the asset supply in PPT is the same as in the monetary policy case such that an increase in savings of each household is feasible in the aggregate. At the same time, these debt policies shift the same resources measured in PPT to the government as monetary policy. Conditions (19)-(21) together with the government budget constraint (6) yield the following transfer path:

$$Tr_t^{UFP} = \frac{1+\tau_t^{C,UFP}}{1+\bar{\tau}^C} Tr_t^{MP} + D_t\left(\frac{1+\tau_t^{C,UFP}}{1+\bar{\tau}^C} - 1\right). \tag{22}$$

Hence, transfers follow the path of transfers associated with the monetary policy experiment adjusted for the change in purchasing power. In addition, transfers compensate for the change in purchasing power of the dividend income.[7] This reflects that tax revenues are higher with HANK-UFP than with monetary policy as the increase in consumption taxes applies to total output, Y_t, whereas the decrease in labor taxes only applies to total labor income, $w_t N_t = Y_t - D_t$. Overall, equation (22) implies that also the lump-sum income component of households is the same in PPT as with monetary policy.

In sum, HANK-UFP replicates the effects of monetary policy both on the policy wedges in the first-order conditions and on the budget constraints of households. Thus, each household faces the same optimization problem with HANK-UFP and monetary policy which implies that both policies induce the same consumption and labor supply of each household. As neither the interest rate nor fiscal policy variables are part of the firms' equilibrium equations, equivalence in each household's behavior generates the same allocation through general equilibrium.

Policy-induced redistribution. A corollary of our perfect-substitutability result is that monetary policy and HANK-UFP induce the same redistribution among households. We now show that HANK-UFP achieves this by replicating the redistribution of monetary policy through the policy block, that is, the partial equilibrium redistribution through changes in monetary and fiscal policy variables. To capture this policy-induced redistribution formally, we define the policy-exposure of each household by $\Xi_{h,t}$. This captures the partial-equilibrium changes of resources for household h which are induced by changes in policy variables assuming fixed households' and firms' behavior, that is, $(c_{h,t}, l_{h,t}, \frac{b_{h,t+1}}{1+\tau^C_{t+1}}, d_t, w_t) = (\bar{c}_h, \bar{l}_h, \frac{\bar{b}'_h}{1+\bar{\tau}}, \bar{d}, \bar{w})$.[8]

Lemma 1. *The policy-exposure of household h towards monetary policy is given by $\Xi^{MP}_{h,t} = \bar{B}(\frac{1}{1+r^{MP}_t} - \frac{1}{1+\bar{r}}) - \bar{b}'_h(\frac{1}{1+r^{MP}_t} - \frac{1}{1+\bar{r}})$. Consider periods of expansionary monetary policy, that is $r^{MP}_t < \bar{r}$. Then $\Xi^{MP}_{h,t} < 0$ for $\bar{b}'_h > \bar{B}$ and $\Xi^{MP}_{h,t} > 0$ for $\bar{b}'_h < \bar{B}$. That is, expansionary monetary policy redistributes from households that have a higher asset position than the average to households that have a lower asset position than the average. The opposite is true for periods with contractionary monetary policy. With HANK-UFP, the households' policy exposure is given by $\Xi^{UFP}_{h,t} = \frac{1+\tau^{C,UFP}_t}{1+\bar{\tau}^C}\Xi^{MP}_{h,t}$. Hence, HANK-UFP replicates the policy exposure of monetary policy for each household in PPT.*

[7]Note that the same compensation for the loss in purchasing power of dividends can be achieved by a lump-sum transfer to firms (or equivalently a reduction in lump-sum taxes on firms). In this case, the aggregate transfer payment to firms would equal the second term in equation (22). Hence, our perfect substitutability result does not depend on the assumption of lump-sum dividends but can also be achieved with any other assumption on how dividends are distributed.

[8]The bar on top of aggregate variables denotes their respective steady state values. The bar on top of choice variables of households denotes household h's behavior in stationary equilibrium. As the savings of a household determine its individual state in the next period, we need to adjust the savings for the purchasing power. Otherwise, this partial equilibrium decomposition would compare different households in the monetary policy experiment and in the HANK-UFP case as discussed above.

Again, we relegate the proof of Lemma 1 to Appendix B and focus here on the intuition. A decrease in interest rates generates a negative wealth effect on assets from which households suffer in proportion to their asset holdings. At the same time, lower interest rates shift resources to the government as the government issues the assets and now has lower interest payments. Hence, lower interest rates imply a redistribution from asset holders to the government. As this implies an increase in lump-sum transfers, expansionary monetary policy redistributes from asset-rich to asset-poor households.[9] HANK-UFP induces the same negative wealth effect on assets from which households suffer in proportion to their asset holdings—exactly as with monetary policy. The reason is that higher consumption taxes decrease the purchasing power of assets thereby inflating away the buffer stock of households. As a consequence, households buy additional government debt in proportion to their asset holdings. Since this expansion in debt increases lump-sum transfers to all households, the redistribution through changes in policy variables is the same as with monetary policy.

Relation to perfect substitutability in RANK. Correia et al. (2013) show that consumption taxes and labor taxes set according to conditions (19) and (20), respectively, are sufficient for perfect substitutability with monetary policy in RANK. Our analysis shows that these two instruments are no longer sufficient in HANK. With only tax policies, fiscal policy replicates the effects of monetary policy on the policy wedges in the first-order conditions of households but not on the budget constraints such that households are differently exposed to these tax policies and monetary policy. In HANK, these heterogeneous effects on households' budget constraints matter. This is because first, the heterogeneous exposure of households prevents cross-sectional equivalence with monetary policy. Second, it also breaks the aggregate equivalence since households are heterogeneous in their marginal propensities to consume (MPCs). In addition, with only tax policies, the value of total assets in PPT changes which has real effects since households hold these assets for self-insurance purposes. In our numerical analyses in Section 5.2, we quantify the shortcomings of this fiscal policy scheme and show them to be substantial.

3.2 Model Extensions

We now show that our perfect substitutability result does not depend on specific assumptions of our model.

[9] In Section 3.2, we show that our perfect substitutability result does not depend on the assumption that transfers adjust after a monetary policy shock but also holds when we assume any other fiscal response.

Alternative fiscal responses to monetary policy. The HANK literature highlights the importance of the fiscal response to monetary policy (see Kaplan et al. (2018) and Auclert et al. (2020)). In particular, Kaplan et al. (2018) distinguish three different fiscal responses: first, transfers adjust to balance the government budget after a change in monetary policy which is our baseline. Second, debt adjusts in the short-run and transfers bring back government debt in the long-run. Third, government spending adjusts. Our perfect substitutability result between fiscal policy and monetary policy does not depend on the fiscal response we assume. If debt adjusts in the short-run and transfers bring back government debt in the long-run in the monetary policy experiment, the conditions in Proposition 1 are still sufficient. In this case, the paths for transfers and debt induced by a change in the interest rate are different compared to our baseline. Note, however, that condition (21) accounts for any debt and transfer paths induced by monetary policy. If fiscal policy adjusts government spending in response to monetary policy, Proposition 1 needs to be extended by the following condition for government spending: $G_t^{UFP} = G_t^{MP}$.

Extension to investment. A natural extension of our model is to add capital to the production technology. We assume that a representative mutual fund collects savings of households, A_t, and allocates them to bonds, B_t, and capital, K_t.[10] In this medium-scaled HANK model, monetary policy affects real outcomes through changing both consumption and investment. Still, fiscal policy is a perfect substitute for monetary policy if we extend HANK-UFP by a condition for temporary investment subsidies. We here focus on the intuition for this result and leave details for Appendix C. Expansionary monetary policy increases the incentive of the mutual fund to invest in capital which reduces the rental rate on capital. Since firms can now cheaper rent capital, this entails a redistribution from asset holders to firms. As shown in Correia et al. (2013), temporary investment subsidies yield the same incentives to invest as expansionary monetary policy since both policies equally affect the policy wedges in the firms' first-order conditions. Moreover, our fiscal policy mix replicates the redistribution from asset holders to firms of monetary policy, since the investment subsidies are financed through a permanent increase in the government debt level. To see this, note that the higher consumption taxes increase the precautionary savings demand in proportion to the total amount of assets as they decrease the purchasing power of all assets in the economy. Hence, the rule for the government debt level is now given by

[10] Assuming a mutual fund is a common way to introduce capital into a HANK model (see Hagedorn et al. (2019b), Gornemann et al. (2016)). Our perfect substitutability result does not depend on the mutual fund assumption but also holds if we introduce capital differently, e.g., by assuming that the capital stock is owned by households.

a modification of equation (21):

$$B_{t+1}^{UFP} = \frac{1+\tau_{t+1}^C}{1+\bar{\tau}^C}\bar{B} + \left(\frac{1+\tau_{t+1}^C}{1+\bar{\tau}^C} - 1\right)K_{t+1}.$$

This way, the expansion in the government debt level is sufficient to finance the investment subsidies. Thus, each household indirectly finances the investment subsidy in proportion to her asset holdings.

4 Circumventing the ELB Constraint

Our perfect substitutability result between fiscal policy and monetary policy is especially relevant when monetary policy is constrained. To illustrate this, we now show how HANK-UFP circumvents the ELB constraint—a natural example of constrained monetary policy. In this section, we demonstrate that HANK-UFP achieves the same allocation as hypothetically unconstrained monetary policy when a discount factor shock pushes the economy to the ELB. To this end, we turn to a numerical exercise of our model in Section 2.

Monetary policy. We now assume that monetary policy controls the nominal interest rate and follows a Taylor rule. The central bank sets the nominal interest rate, i_t, according to:

$$1 + i_t = \max\left\{\underline{I}, (1+\bar{i})\left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi}\right\}. \tag{23}$$

The parameter ϕ_π measures how responsive the central bank reacts to deviations in inflation from steady state. In the case of constrained monetary policy, the Taylor rule is truncated by the ELB. Thus, $\underline{I} = 1$ and nominal interest rates cannot go below zero. In the counterfactual of unconstrained monetary policy, $\underline{I} \longrightarrow -\infty$, and monetary policy follows the Taylor rule without any constraints.

The nominal and the real interest rate are linked via the Fisher equation:

$$1 + r_t = \frac{1+i_t}{1+\pi_{t+1}}. \tag{24}$$

4.1 Calibration

Table 1 summarizes our calibration which are standard values in the literature. We set the households' discount factor, β, such that the annual steady state real interest rate, $\bar{r}$, is 2%.

Table 1: Calibration of the model.

Parameter	Description	Value
β	Discount factor	0.982
γ	Risk aversion	2
ψ	Inverse of Frisch elasticity	2
μ	Markup	1.2
θ	Price reversion rate	0.15
ρ_z	Autocorrelation of idiosyncratic risk	0.966
σ_z	Unconditional variance of idiosyncratic risk	0.501
$\bar{\tau^C}$	Consumption tax rate	5%
$\bar{\tau^L}$	Labor tax rate	28%
$\bar{G}/\bar{Y}$	Government consumption share	0.2
$\bar{Tr}/\bar{Y}$	Transfer share	0.055
$\bar{B}/(4*\bar{Y})$	Government debt share	0.9
ϕ_π	Inflation Taylor weight	$\to\infty$

We set both the coefficient for risk aversion, γ, and for the inverse Frisch elasticity, ψ, to 2. The latter reflects the finding of Chetty (2012) who proposes that the Frisch elasticity should be around 0.5 for plausible income effects. Following Christiano et al. (2011), we set the markup parameter, μ, to 1.2, and the price reversion rate, θ, to 0.15.

The calibration of the idiosyncratic income risk follows McKay et al. (2016). We assume that households cannot borrow. We choose the labor income risk to approximate the findings of Floden and Lindé (2001). We discretize a quarterly AR(1) process with an autoregressive coefficient of 0.966 and an innovation variance of 0.017 into a three-state Markov chain by using Rouwenhorst (1995)'s method.[11] The resulting Markov chain matches the unconditional and the conditional mean, the unconditional and the conditional variance, and the first-order autocorrelation of the underlying quarterly AR(1) process.

Following Correia et al. (2013), we set the consumption tax rate $\bar{\tau^C} = 5\%$ and the labor tax rate $\bar{\tau^L} = 28\%$. As in Christiano et al. (2011), we set government consumption $\bar{G}/\bar{Y} = 0.2$. We follow McKay and Reis (2016) and calibrate government debt such that the interest payments of the government in steady state equal the average net interest payments per GDP by the U.S. government from 1946-2007. This yields an annual government debt share, $\bar{B}/(4*\bar{Y})$, of 0.9 and average MPCs of 0.124. Our calibration results in a steady state transfer share of $\bar{Tr}/\bar{Y} = 0.055$. We assume that monetary policy aims to fully stabilize inflation and, hence, we set the Taylor-coefficient $\phi_\pi \to \infty$.

[11] Floden and Lindé (2001) estimate the annual log wage process assuming that it follows an AR(1) process resulting in an autoregressive coefficient of 0.961 and an innovation variance of 0.426. The annual AR(1) process is simulated by a quarterly AR(1) process with an autoregressive coefficient of 0.966 and an innovation variance of 0.017.

4.2 Solution Method

We solve the model using the perfect foresight method proposed in McKay et al. (2016). We compute the transition paths of the economy in response to a discount factor shock. Initially, the economy is in steady state. Without fiscal policy interventions, we assume that the economy returns to its old steady state after 250 periods. With HANK-UFP, we assume that the economy has transitioned to its new steady state after 250 periods.

We guess the paths of the prices and the quantities of the variables specified in Section 2.4. We then check whether these prices and quantities are consistent with the definition of an equilibrium in Section 2.4 in each period. This implies to solve for the aggregate behavior of households given the guessed prices in each period. We use the endogenous grid point method of Carroll (2006) to solve the individual household problem backwards. We use the non-stochastic simulation algorithm in Young (2010) to simulate the distribution of households forward.

When the aggregate behavior of households is not consistent with the guessed quantities, we update the guess for prices and quantities. For this purpose, we use an auxiliary model. It approximates the aggregate behavior of households with an auxiliary Euler equation and an auxiliary labor-leisure equation which contain time-varying heterogeneity wedges. We solve the auxiliary model with a version of Newton's method and iterate until the aggregate behavior of households is consistent with the guessed quantities and prices.

4.3 HANK-UFP at the ELB

We follow Christiano et al. (2011) and approximate the effects of a binding ELB by engineering an unexpected temporary increase in the discount factor of households. The discount factor increases by 1.75% for 5 quarters before it jumps back to its steady state level. This brings the economy to the ELB which then binds for 5 quarters. The black, dash-dot lines in Figure 1 show the dynamics of macroeconomic aggregates without an additional fiscal stimulus. In this *constrained monetary policy case*, output falls by 2.5%, consumption by 3.1%, and inflation by 3.9 annual percentage points.

How would macroeconomic aggregates react if monetary policy was not constrained by the ELB? The red, solid lines show this *unconstrained monetary policy case*. Without the ELB constraint, the central bank sets negative interest rates for 5 quarters which decrease at most to -4.3 annual percentage points. By construction, this fully stabilizes inflation. As is typical for discount factor shocks, this implies a small boom and, hence, output slightly increases and peaks at 0.1%.[12] The same is true for consumption which peaks at 0.2%.

[12] The reason is that a discount factor shock is not only a demand shock but also has a supply side

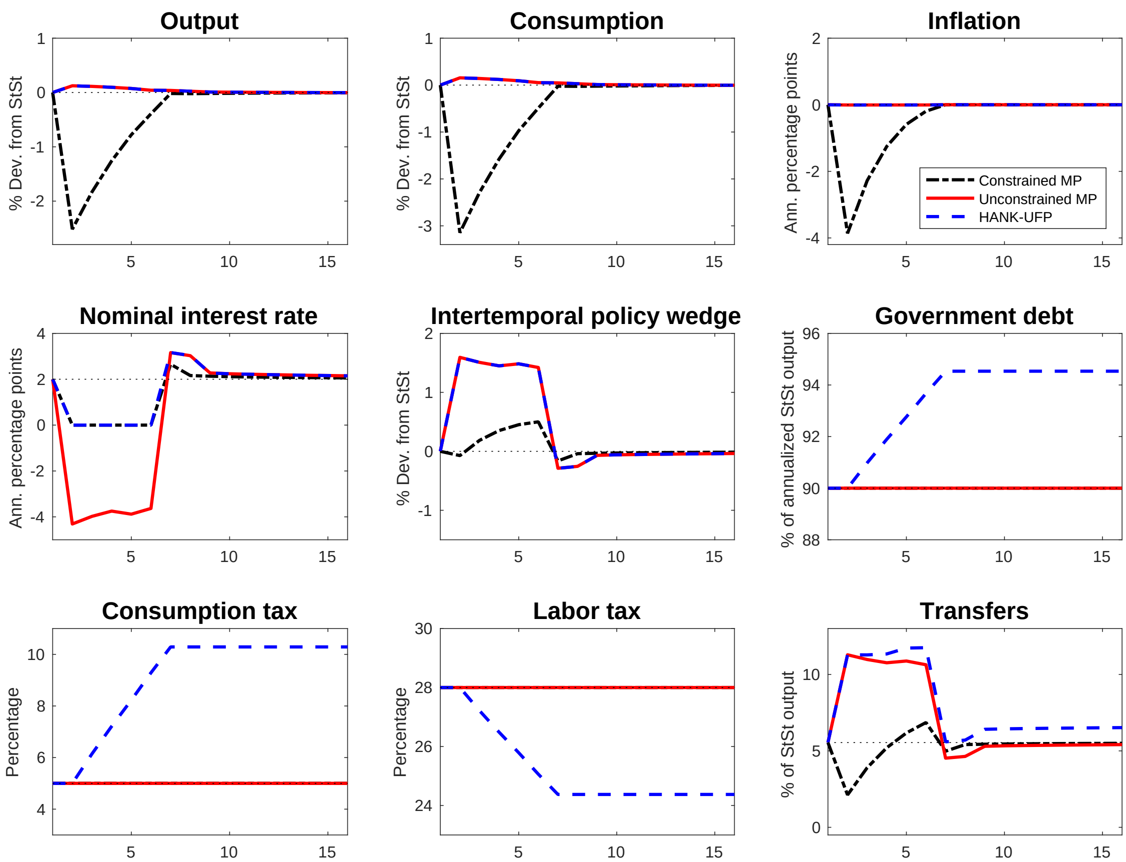

Figure 1: Impulse response functions after a shock to the discount factor with a Taylor rule truncated by the ELB ("Constrained MP"), with a Taylor rule without a lower bound ("Unconstrained MP"), and with a truncated Taylor rule and an additional HANK-UFP stimulus ("HANK-UFP"). Horizontal axes denote quarters.

The blue, dashed lines show the *HANK-UFP case*. The impulse response functions (IRFs) of the macroeconomic aggregates reflect that HANK-UFP achieves the same stabilization as unconstrained monetary policy since both responses lie perfectly on top of each other. Fiscal policy sets the paths for consumption taxes, labor taxes, and the government debt level to replicate the effects of monetary policy on both the first-order conditions and on the budget constraint of each household. According to condition (19), consumption taxes increase while the ELB is binding along a pre-announced path, in total from 5% to 10.3%. This way, consumption taxes replicate the effects through the intertemporal substitution channel of unconstrained monetary policy which is reflected by the IRFs of the intertemporal policy wedge in both cases. Labor taxes, correspondingly, decrease in total from 28.0% to 24.4% (condition (20)). In line with condition (21), government debt increases to a permanently higher level of 94.5% (instead of 90.0%) such that households can hold the same amount of assets in PPT as in the unconstrained monetary policy case. As equation (22) shows, this implies that transfers follow the path of transfers in the unconstrained monetary policy case but overshoot them to compensate for the loss in purchasing power of the lump-sum income component. At most, transfers increase from 5.5% to 11.8% of GDP.

Cross-sectional equivalence. Section 3 shows that HANK-UFP replicates monetary policy by replicating the consumption and labor supply of each household in every period. Obviously, this result also holds in our numerical example. Hence, the welfare of each household and the paths for consumption inequality is the same. The equivalence also holds for the paths of wealth and income inequality when adjusting wealth and income for PPT.

5 Importance of Debt Policies

In this section, we quantify the role of debt policies in the HANK-UFP mix. To this end, we construct two alternative fiscal policy schemes which only differ in their respective debt dynamics from HANK-UFP. We then compare these allocations with the ones associated with unconstrained monetary policy after the same discount factor shock as in Section 4.3.

5.1 Implications for the Long-run

We first stress the importance of keeping government debt at a permanently higher level after the ELB episode. To this end, we conduct an alternative fiscal policy scheme—*debt-reverting-UFP*—in which government debt reverts back to its original steady state level. In particular,

component (see equation (5)) which is, ceteris paribus, deflationary.

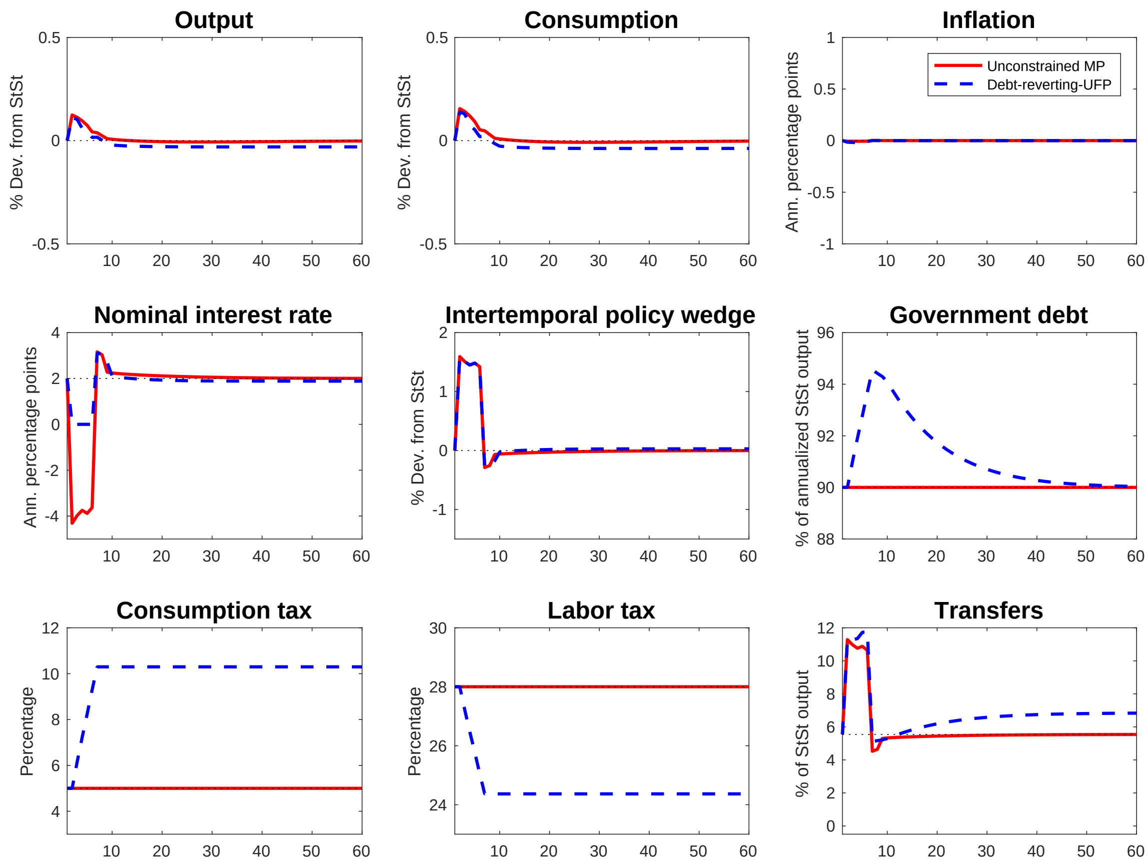

Figure 2: Impulse response functions after a shock to the discount factor with a Taylor rule without a lower bound ("Unconstrained MP") and with a truncated Taylor rule and a debt-reverting-UFP stimulus ("Debt-reverting-UFP"). Horizontal axes denote quarters.

consumption taxes increase and labor taxes decrease. In addition, we allow government debt to increase in the short-run to finance the same transfer path as with HANK-UFP while the ELB is binding. However, after the ELB stops binding, transfers follow a standard debt-feedback rule, $T_t - \bar{T} = \vartheta \frac{B_{t+1} - \bar{B}}{\bar{Y}}$ with $\vartheta = 0.05$, to bring back government debt to its pre-crisis level, $\bar{B}^{UFP} = \bar{B} = 90\%$ of annual GDP.

Figure 2 compares debt-reverting-UFP (blue, dashed lines) with unconstrained monetary policy (red, solid lines) in response to the same discount factor shock as in Section 4.3. Note that the unconstrained monetary policy case as well as the constrained monetary policy case (not shown) are the same as in Figure 1 and that we increase the time horizon from 16 to 60 periods to highlight the long-run effects. It becomes evident that debt-reverting-UFP still nearly replicates macroeconomic aggregates of unconstrained monetary policy in the short-run. Yet, even after the ELB stops binding, output and consumption in the debt-reverting-UFP case remain permanently lower than in the unconstrained monetary policy case. The reason is that as soon as government debt comes back to its original steady state level, the supply of assets in PPT is lower than in the unconstrained monetary policy case. Hence, households cannot hold the same amount of savings in PPT such that they are worse insured against their idiosyncratic income risk. This pushes down the real interest rate and increases the inefficiencies from incomplete markets. In the end, the economy converges to a new steady state in which output is around 0.03% smaller than in the old steady state.[13] Even though this is a small number, given that it is a permanent effect, it has a sizeable impact on households' welfare as we discuss below.

Our analysis shows that debt-reverting-UFP contains a trade-off between short-run stabilization and long-run inefficiencies. This point is more general: in HANK models, tax policies that interact with the precautionary savings motive of households are not neutral but can have a quantitatively significant impact on the economy in the long-run. Accordingly, debt policies play a crucial role in balancing these effects. This is in stark contrast to RANK models, in which there is no precautionary savings motive and the asset demand is perfectly elastic with respect to the real interest rate in the long-run.

Cross-sectional outcomes. As macroeconomic dynamics are not the same, cross-sectional outcomes also differ with debt-reverting-UFP. We summarize the cross-sectional differences by comparing the welfare implications of debt-reverting-UFP and HANK-UFP on each household. Figure 3 shows the consumption compensation of each household in the economy with debt-reverting-UFP and with HANK-UFP (which is the same as with unconstrained monetary policy).[14] The blue (low productivity households), red (middle productivity), and black (high productivity) solid lines depict the consumption compensation in the debt-reverting-UFP case. The respective dashed lines depict the consumption compensation in the HANK-UFP case. Figure 3 shows that each household is worse off with debt-reverting-UFP than with HANK-UFP as the solid lines lie always below the respective dashed lines.[15] This

[13]The negative effect of a lower asset supply on the new steady state output has also been highlighted by Guerrieri and Lorenzoni (2017). With debt-reverting-UFP, this is the same effect because it decreases the asset supply in PPT which is the asset supply that matters for households.

[14]We compute the consumption compensation as the consumption increase that is additionally necessary in the baseline of the constrained monetary policy case such that each household is indifferent between the baseline and the two policy cases (debt-reverting-UFP and HANK-UFP). Given our specification of preferences, we cannot compute lifetime consumption compensation. Thus, we compute the consumption compensation for 4 quarters as in Kekre (2021).

[15]Note that all lines of both debt-reverting-UFP and HANK-UFP cross the x-axis at some point. This indicates that high-asset households are worse off with HANK-UFP stabilization (and, equivalently, with unconstrained monetary policy stabilization). The reason is that the stabilization policy reduces their wealth significantly in PPT terms. This effect outweighs their welfare loss out of a recession caused by the ELB in the baseline case of constrained monetary policy. Yet, the average consumption compensation of HANK-UFP (and equivalently unconstrained monetary policy) is 2.4% reflecting that HANK-UFP would be highly beneficial from a Utilitarian social planner perspective compared to debt-reverting-UFP which only has an

reflects that the welfare costs of the idiosyncratic income risk significantly increase for all households due to worse insurance possibilities. In sum, bringing back government debt to its original steady state level induces inefficiencies in the long-run which, in turn, significantly lowers the welfare of each household.

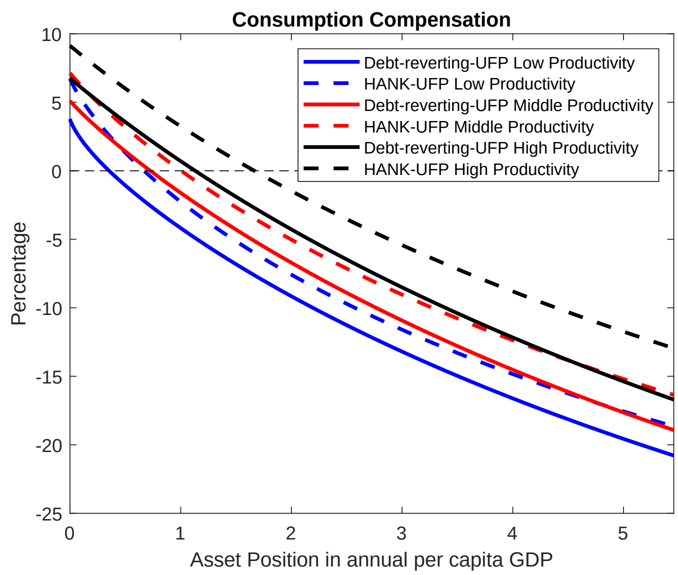

Figure 3: Consumption compensation for 4 quarters for each household such that she is indifferent between the respective policy and constrained monetary policy.

5.2 Implication for the Short-run

We now study a fiscal policy scheme which only uses tax policies to highlight the importance of debt policies for the short-run stabilization. In particular, consumption taxes and labor taxes are set as in Proposition 1 to replicate the effects on the first-order conditions of households while government debt is constant. Note that this is the *RANK-UFP* scheme as proposed in Correia et al. (2013).

Figure 4 compares RANK-UFP (blue, dashed lines) with unconstrained monetary policy (red, solid lines) in response to the same discount factor shock as in Section 4.3. It reflects that on top of the long-run inefficiencies discussed in Section 5.1, RANK-UFP does not achieve the same stabilization as unconstrained monetary policy while the ELB is binding. The reason is that since government debt does not increase while the ELB binds, lump-sum transfers are much lower in these periods than with HANK-UFP. Hence, RANK-UFP does not provide additional resources to high-MPC households while the ELB is binding.[16]

average consumption compensation of 0.1%.

[16]The stimulative effect of transfer policies is a common feature in HANK models as Ricardian equivalence does not hold (Oh and Reis, 2012, Hagedorn et al., 2019b, Bayer et al., 2020b, Wolf, 2021).

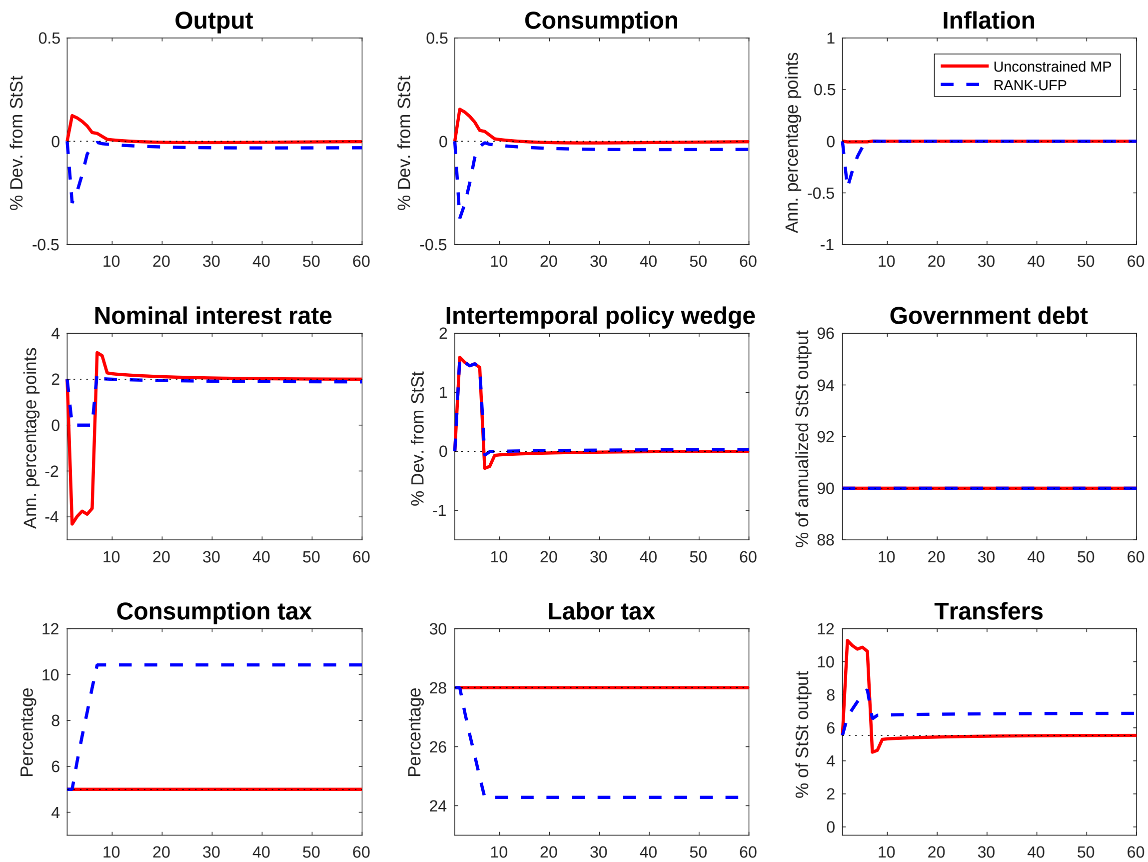

Figure 4: Impulse response functions after a shock to the discount factor with a Taylor rule without a lower bound ("Unconstrained MP") and with a truncated Taylor rule and an additional constant-debt-UFP stimulus ("RANK-UFP"). Horizontal axes denote quarters.

Accordingly, output drops on impact by 0.3%, consumption by 0.4%, and inflation by 0.5 annual percentage points. The large deviations in macroeconomic outcomes with RANK-UFP from the unconstrained monetary policy case show that using debt policies is quantitatively important for macroeconomic stabilization.

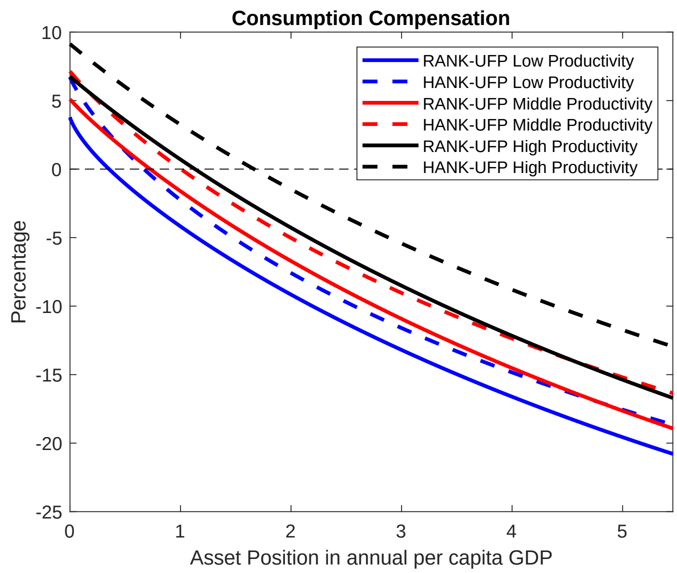

Figure 5: Consumption compensation for 4 quarters for each household such that she is indifferent between the respective policy and constrained monetary policy.

Cross-sectional outcomes. We again summarize the cross-sectional differences by comparing the welfare implications of RANK-UFP and HANK-UFP on each household. Figure 5 shows the consumption compensation (again for 4 quarters) of each household in the economy with RANK-UFP and with HANK-UFP. The blue (low productivity households), red (middle productivity), and black (high productivity) solid lines depict the RANK-UFP case and the respective dashed lines depict the HANK-UFP case. As with debt-reverting-UFP analyzed in Section 5.1, also with RANK-UFP, each household is worse-off than with HANK-UFP. Yet, given the lack of macroeconomic stabilization in the short-run on top of the lower steady state output in the long-run, the average consumption compensation is now -0.3% and, thus, even negative. In other words, on average households would prefer no policy intervention and, hence, the ELB recession in the constrained monetary policy case instead of fiscal policy engaging in RANK-UFP.

Scaling up RANK-UFP. Figure 6 shows an experiment in which RANK-UFP uses a more aggressive stimulation through the intertemporal policy wedge in the Euler equations of households to achieve zero inflation while the ELB is binding. Now, consumption taxes

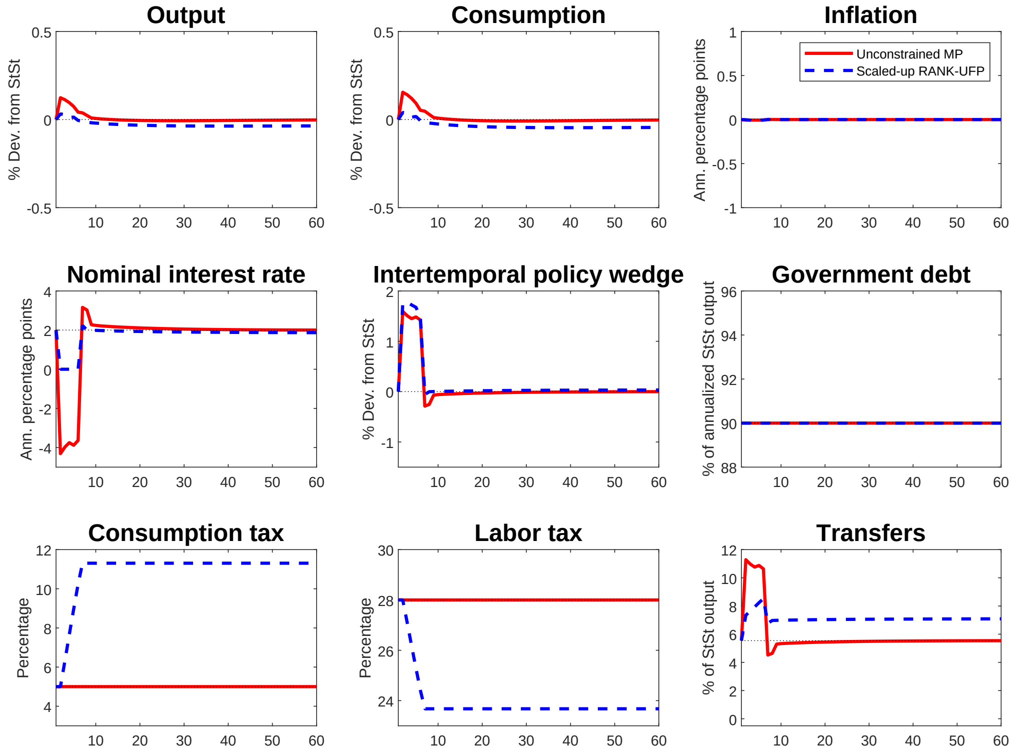

Figure 6: Impulse response functions after a shock to the discount factor with a Taylor rule without a lower bound ("Unconstrained MP") and with a truncated Taylor rule and an additional Scaled-up constant-debt-UFP stimulus ("Scaled-up RANK-UFP"). Horizontal axes denote quarters.

do no longer follow condition (19) but instead, they target zero inflation while the ELB is binding. The path of consumption taxes is now scaled-up and increases in total from 5.0% to 11.3% and, thus, the intertemporal policy wedge increases by more than in the unconstrained monetary policy case as reflected in Figure 6. Correspondingly, labor taxes decrease from 28.0% to 23.7%, still following condition (20).

By construction, inflation is zero with scaled-up RANK UPF. To achieve zero inflation, output increases less than in the unconstrained MP case as Figure 6 shows. The reason is that, given the anticipated permanently lower output, potential output, i.e., the output that fully stabilizes inflation, is already lower during the ELB period. As a matter of fact, scaling up the increase in consumption taxes reduces the purchasing power of households' asset holdings even more. Consequently, the inefficiencies of the incomplete markets and, thus, the long-run costs of tax policies are higher than when not scaling up the consumption responses: the economy now converges to a steady state in which the real interest rate is 1.88% (vs. 2.00%) and steady state output declines by 0.04% compared to the old steady state output. Our welfare analysis shows that the long-run costs outweigh the gains from the short-run stabilization since the average consumption compensation for 4 quarters is 0.4%. Thus, the welfare is again on average lower than with constrained monetary policy.

6 Conclusion

We show that fiscal policy can be a perfect substitute for monetary policy in HANK as it can replicate the allocation of monetary policy. The insight is that with consumption taxes, labor taxes, and adjusting the government debt level, fiscal policy can manipulate the optimization problem of each household in the same way as a change in interest rates: these tax and debt policies jointly replicate the effects of interest rate changes on the policy wedges in the first-order conditions and the budget constraint of each household. Our perfect substitutability result is especially relevant when monetary policy is constrained—be it due to a binding lower bound, a currency union, or an exchange rate peg—since it implies that fiscal policy can circumvent these constraints. Unlike analyses with a representative agent, our analysis shows that including debt policies in the fiscal policy mix is necessary for perfect substitutability with monetary policy in HANK. Moreover, we highlight at the ELB that not using debt policies has quantitatively important consequences for cross-sectional and aggregate outcomes. When the fiscal authority uses only tax policies, it cannot replicate macroeconomic aggregates in the short-run and generates a permanently lower output in the long-run. As a result, aggregate welfare is lower compared to a case in which there is no fiscal stimulus at all.

Due to the long duration of the low interest rate environment, the importance of fiscal policy tools to stimulate the economy has grown. This is reflected by policies that have recently been implemented in response to the COVID-19 pandemic such as stimulus checks or temporary changes in the value-added tax. An avenue for future research would be to analyze how to compose mixes of (un)conventional monetary and fiscal instruments conditional on different business cycle shocks. This would imply to consider monetary and fiscal policy as complements reflecting the insight that monetary and fiscal policy are intertwined when Ricardian equivalence does not hold. Promising steps in this direction include Galí (2020), Bhandari et al. (2021), and Le Grand et al. (2021).

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A Proof of Proposition 1

In this section, we prove Proposition 1 which states that HANK-UFP yields the same allocation as the one induced by the real interest rate path in the monetary policy experiment. Let us assume that the equilibrium path induced by the monetary policy experiment in Section (3) is

$$X^{MP} = \left\{ B_t^{d*}, C_t^*, L_t^*, Y_t^*, D_t^*, w_t^*, \pi_t^*, \tilde{p}_t^*/P_t^*, r_t^{MP}, \bar{\tau}^C, \bar{\tau}^L, Tr_t^{MP}, \bar{B} \right\}_{t=0}^{\infty},$$

with the individual behavior of each household given by

$$x_h^{MP} = \{b_{h,t}^*, c_{h,t}^*, l_{h,t}^*\}_{t=0}^{\infty}.$$

We now show that

$$X^{UFP} = \left\{ \frac{1+\tau_t^{C,UFP}}{1+\bar{\tau}^C} B_t^{d*}, C_t^*, L_t^*, Y_t^*, D_t^*, w_t^*, \pi_t^*, \tilde{p}_t^*/P_t^*, \bar{r}, \tau_t^{C,UFP}, \tau_t^{L,UFP}, Tr_t^{UFP}, B_t^{UFP} \right\}_{t=0}^{\infty}$$
$$\text{with } x_h^{UFP} = \left\{ \frac{1+\tau_t^{C,UFP}}{1+\bar{\tau}^C} b_{h,t}^*, c_{h,t}^*, l_{h,t}^* \right\}_{t=0}^{\infty}$$

is an equilibrium path if $\tau_t^{L,UFP}, \tau_t^{C,UFP}$, and B_t^{UFP} satisfy conditions (19), (20), and (21), respectively.

Since neither the real interest rate nor the fiscal policy variables show up in any equilibrium condition of the firm side, it is sufficient to show that X^{UFP} satisfies the sequences of Euler equations (2), labor-leisure equations (3), and budget constraints (1) of each household as well as the government budget constraint. Without loss of generality, fix a household j. We now prove that if her behavior in the monetary policy experiment, $x_j^{MP} = \{b_{j,t}^*, c_{j,t}^*, l_{j,t}^*\}_{t=0}^{\infty}$, satisfies her sequences of Euler equations, labor leisure equations, and budget constraints in the monetary policy experiment, $x_j^{UFP} = \{\frac{1+\tau_t^{C,UFP}}{1+\bar{\tau}^C} b_{j,t}^*, c_{j,t}^*, l_{j,t}^*\}_{t=0}^{\infty}$ does so in the HANK-UFP case.

Satisfying household's first-order conditions. Any path of consumption, $\{c_{j,t}^*\}_{t=0}^{\infty}$, that satisfies the sequence of Euler equations of household j with $\{r_t^{MP}\}_{t=0}^{\infty}$ and steady state tax rates, also satisfies the sequence of Euler equations of household j with interest rates in steady state and $\{\tau_t^{C,UFP}\}_{t=0}^{\infty}$ which satisfies condition (19). In addition, any paths of consumption and labor, $\{c_{j,t}^*, l_{j,t}^*\}_{t=0}^{\infty}$, that satisfy the sequence of labor-leisure equations of household j with steady state taxes, satisfy the sequence of labor-leisure equations of household j if $\{\tau_t^{L,UFP}, \tau_t^{C,UFP}\}_{t=0}^{\infty}$ satisfy condition (20).

Satisfying household's budget constraint. Next, we show that if x_j^{MP} satisfies the sequence of budget constraints of household j in the monetary policy experiment, x_j^{UFP} does so with HANK-UFP. For that, it is convenient to look at her three income components separately:

$$c_{j,t} = \underbrace{\frac{(1-\tau_t^L)}{(1+\tau_t^C)} w_t l_{j,t} z_{j,t}}_{I} + \underbrace{\frac{D_t + Tr_t}{(1+\tau_t^C)}}_{II} + \underbrace{\frac{b_{j,t}}{(1+\tau_t^C)} - \frac{b_{j,t+1}}{(1+\tau_t^C)(1+r_t)}}_{III}. \tag{25}$$

We now show that each of these components is exactly the same with x_j^{MP} and X^{MP} as well as with x_j^{UFP} and X^{UFP}.

The labor income, term (I) in equation (25), is the same in the monetary policy experiment and in the HANK-UFP case, iff:

$$\frac{(1-\bar{\tau}^L)}{(1+\bar{\tau}^C)} w_t^* l_{j,t}^* z_{j,t} = \frac{(1-\tau_t^{L,UFP})}{(1-\tau_t^{C,UFP})} w_t^* l_{j,t}^* z_{j,t} \tag{26}$$

which holds, given that taxes are set according to condition (20).

The lump-sum income, term (II) in equation (25), is identical in the monetary policy experiment and in the HANK-UFP case, iff:

$$\frac{D_t^* + Tr_t^{MP}}{(1+\bar{\tau}^C)} = \frac{D_t^* + Tr_t^{UFP}}{(1+\tau_t^{C,UFP})} \tag{27}$$

which holds if Tr_t^{UFP} is set according to condition (22). We will show below that this is indeed the transfer path arising in the HANK-UFP case.

Finally, the asset income, term (III) in equation (25), is the same iff:

$$\frac{b_{j,t}^*}{(1+\bar{\tau}^C)} - \frac{b_{j,t+1}^*}{(1+\bar{\tau}^C)(1+r_t^{MP})} = \frac{b_{j,t}^* \frac{1+\tau_t^{C,UFP}}{1+\bar{\tau}^C}}{(1+\tau_t^{C,UFP})} - \frac{b_{j,t+1}^* \frac{1+\tau_{t+1}^{C,UFP}}{1+\bar{\tau}^C}}{(1+\tau_t^{C,UFP})(1+\bar{r})}. \tag{28}$$

Hence, we obtain equivalence iff:

$$\frac{b_{j,t+1}^*}{(1+r_t^{MP})(1+\bar{\tau}^C)} = \frac{b_{j,t+1}^* \frac{1+\tau_{t+1}^{C,UFP}}{1+\bar{\tau}^C}}{(1+\tau_t^{C,UFP})(1+\bar{r})}$$

Using condition (19), we get

$$\frac{b^*_{j,t+1}}{(1+r^{MP}_t)(1+\bar{\tau}^C)} = \frac{b^*_{j,t+1}\frac{1+\tau^{C,UFP}_{t+1}}{1+\bar{\tau}^C}}{(1+\tau^{C,UFP}_t)}\frac{1+\tau^{C,UFP}_t}{(1+r^{MP}_t)(1+\tau^{C,UFP}_{t+1})}$$
$$\iff b^*_{j,t+1} = b^*_{j,t+1}.$$

Thus, equation (28) holds. Hence, x^{UFP}_j satisfies the sequence of budget constraints of household j with HANK-UFP if x^{MP}_j does so in the monetary policy experiment. Furthermore, this also implies that if the individual state of household j is $(b^*_{j,t}, z_{j,t})$ in a given t in the monetary policy experiment, it is $(\frac{1+\tau^C_t}{1+\bar{\tau}^C}b^*_{j,t}, z_{j,t})$ with HANK-UFP.

In sum, $x^{UFP}_{h,t}$ and X^{UFP} are consistent with each household's problem if $x^{MP}_{h,t}$ and X^{MP} are. That is, each household consumes and works the same with HANK-UFP and in the monetary policy experiment and saves the same amount in PPT.

Satisfying government's budget constraint. We now show that if X^{MP} satisfies the government's budget constraint, X^{UFP} does so as well. In the monetary policy experiment, the government's budget constraint is given by:

$$Tr^{MP}_t + \bar{B}\left(1 - \frac{1}{1+r^{MP}_t}\right) = T^{MP}_t. \tag{29}$$

In the HANK-UFP case, the government's budget constraint is given by:

$$Tr^{UFP}_t + B^{UFP}_t = \frac{B^{UFP}_{t+1}}{1+\bar{r}} + T^{UFP}_t.$$

We show that given Proposition 1, this is exactly the same as equation (29). Assuming the transfer path given by condition (22) and rearranging yields:

$$Tr^{MP}_t\left(\frac{1+\tau^{C,UFP}_t}{1+\bar{\tau}^C}\right) + D_t\left(\frac{1+\tau^{C,UFP}_t}{1+\bar{\tau}^C} - 1\right) - T^{UFP}_t = \bar{B}\left(\frac{1+\tau^{C,UFP}_t}{1+\bar{\tau}^C}\right)\left(\frac{1}{1+r^{MP}_t} - 1\right).$$

Multiplying by $\frac{1+\bar{\tau}^C}{1+\tau^{C,UFP}_t}$ yields

$$Tr^{MP}_t + D_t\left(1 - \frac{1+\bar{\tau}^C}{1+\tau^{C,UFP}_t}\right) - T^{UFP}_t\frac{1+\bar{\tau}^C}{1+\tau^{C,UFP}_t} = \bar{B}\left(\frac{1}{1+r^{MP}_t} - 1\right).$$

This is the same as in the monetary policy experiment if

$$D_t\left(1-\frac{1+\bar{\tau^C}}{1+\tau_t^{C,UFP}}\right)-T_t^{UFP}\frac{1+\bar{\tau^C}}{1+\tau_t^{C,UFP}}=-T_t^{MP}. \tag{30}$$

Using the goods market clearing condition, $Y_t^*=C_t^*$, and the profit equation $D_t^*=Y_t^*-w_t^*L_t^*$, it now holds that (dropping the superscript UFP for the sake of readability):

$$\begin{aligned}
D_t^*\left(\frac{1+\tau_t^C}{1+\bar{\tau^C}}-1\right)*\frac{1+\tau_t^C}{1+\bar{\tau^C}}(\bar{\tau^C}C_t^*+\bar{\tau^L}w_t^*L_t^*)&=\tau_t^C C_t^*+\tau_t^L w_t^*L_t^*\\
\iff D_t^*(\tau_t^C-\bar{\tau^C})+C_t^*(\bar{\tau^C}-\tau_t^C)&=(\tau_t^L+\bar{\tau^C}\tau_t^L-\bar{\tau^L}-\tau_t^C\bar{\tau^L})(C_t^*-d_t^*)\\
\iff (\bar{\tau^C}-\tau_t^C-\tau_t^L-\bar{\tau^C}\tau_t^L+\bar{\tau^L}+\tau_t^C\bar{\tau^L})C_t^*&=(\bar{\tau^C}-\tau_t^C-\tau_t^L-\bar{\tau^C}\tau_t^L+\bar{\tau^L}+\tau_t^C\bar{\tau^L})d_t^*
\end{aligned}$$

Thus, the government budget constraint is satisfied if:

$$\begin{aligned}
\bar{\tau^C}-\tau_t^C-\tau_t^L-\bar{\tau^C}\tau_t^L+\bar{\tau^L}+\tau_t^C\bar{\tau^L}&=0\\
\iff \bar{\tau^C}-\tau_t^C-(1+\bar{\tau^C})\tau_t^L+(1+\tau_t^C)\bar{\tau^L}&=0\\
\iff 1+\bar{\tau^C}-(1+\tau_t^C)+(1+\tau_t^C)\bar{\tau^L}&=(1+\bar{\tau^C})\tau_t^L\\
\iff -(1-\bar{\tau^L})(1+\tau_t^C)&=(\tau_t^C-1)(1+\bar{\tau^C})\\
\iff \frac{1-\tau_t^L}{1+\tau_t^C}&=\frac{1-\bar{\tau^L}}{1+\bar{\tau^C}}.
\end{aligned}$$

Which holds given that τ_t^C and τ_t^L are set according to (20).

Consistency with optimal behavior of firms. Given the same households' behavior $\{c_{h,t}^*, l_{h,t}^*\}_{t=0}^{\infty}$ in both policy cases, the firms also face the same demand for goods and the same supply of labor. Hence, if $\{w_t^*, D_t^*, \pi_t^*, \tilde{p}_t{}^*/P_t^*\}_{t=0}^{\infty}$, are equilibrium paths in the monetary policy experiment, they are also equilibrium paths in the UFP case.

Market clearing conditions. From individual behavior x_h^{MP} and x_h^{UFP}, it follows that the sequence of distributions in the HANK-UFP case is $\left\{\Gamma_t^{UFP}(\frac{1+\tau_t^C}{1+\bar{\tau}^C}b,z)\right\}_{t=0}^{\infty}=\left\{\Gamma_t^{MP}(b,z)\right\}_{t=0}^{\infty}$. That is, if the asset position is adjusted by PPT, the distributions are equivalent. Hence, if the asset market clears in the monetary policy experiment, aggregate savings are $B_{t+1}^{d,UFP}=\frac{1+\tau_t^C}{1+\bar{\tau}^C}\bar{B}$ with HANK-UFP which is equal to the supply of government bonds in the HANK-UFP case.

Given the same behavior of firms and the same consumption and labor supply of households, X^{UFP} also clears all other markets if X^{MP} clears all other markets. Thus, we have proven that UFP set according to Proposition 1 yields the same allocation as the monetary policy experiment which implies that UFP and monetary policy are perfect substitutes in HANK.

B Proof of Lemma 1

Policy-exposure to monetary policy. We derive each household's policy-exposure in the monetary policy experiment, $\Xi_{h,t}^{MP}$, which is defined as the net excess in resources for each household given that only policy variables change. To this end, without loss of generality, we fix household j and consider her budget constraint (equation (1)) in some period t where the real interest rate is r_t^{MP} and consumption taxes and labor taxes as well as the government debt level are at their steady state levels $\bar{\tau^C}, \bar{\tau^C}, \bar{B}$, respectively. Consistent with our definition of the policy-induced redistribution, we set $(c_{j,t}, l_{j,t}, \frac{b_{j,t+1}}{1+\tau_{t+1}^C}, d_t, w_t) = (\bar{c}_j, \bar{l}_j, \frac{\bar{b}'_j}{1+\bar{\tau}}, \bar{d}, \bar{w})$. This yields the following expression for her policy-induced redistribution:

$$\Xi_{j,t}^{MP} = -\big(1+\bar{\tau^C}\big)\bar{c}_j - \frac{\bar{b}'_j}{1+r_t^{MP}} + \bar{b}_j + \big(1-\bar{\tau^L}\big)\bar{w}z_{j,t}\bar{l}_j + \bar{D} + \tilde{Tr}_t^{MP}. \tag{31}$$

Solving the government budget constraint with the interest rate at period t (but with constant behavior of the agents) gives $\tilde{Tr}_t^{MP} = (\frac{1}{1+r_t^{MP}} - 1)\bar{B} + \bar{T}$. This can be interpreted as the policy-induced partial equilibrium transfer. Hence, $\Xi_{j,t}^{MP}$ is only affected by the changed return on savings and the direct effect of the real interest rate on transfers. Inserting $\tilde{Tr}_t$ in equation (31) and using the steady state budget constraint of household j yields:

$$\begin{aligned}\Xi_{j,t}^{MP} &= \left(\frac{1}{1+r_t^{MP}} - 1\right)\bar{B} + \bar{T} - \left(\frac{1}{1+\bar{r}} - 1\right)\bar{B} - \bar{T} - \bar{b}'_j\left(\frac{1}{1+r_t^{MP}} - \frac{1}{1+\bar{r}}\right)\\ &= \bar{B}\left(\frac{1}{1+r_t^{MP}} - \frac{1}{1+\bar{r}}\right) - \bar{b}'_j\left(\frac{1}{1+r_t^{MP}} - \frac{1}{1+\bar{r}}\right).\end{aligned}$$

Policy-exposure to HANK-UFP. We now derive the policy-exposure with HANK-UFP, $\Xi_{h,t}^{UFP}$. To this end, without loss of generality, we fix household j and consider her budget constraint (equation (1)) in some period t, where the real interest rate is at its steady state level $\bar{r}$ and consumption taxes and labor taxes as well as the government debt level are set according to Proposition 1. Consistent with our definition of the policy-induced redistribution, we set $(c_{j,t}, l_{j,t}, \frac{b_{j,t+1}}{1+\tau_{t+1}^C}, d_t, w_t) = (\bar{c}_j, \bar{l}_j, \frac{\bar{b}'_j}{1+\bar{\tau}}, \bar{d}, \bar{w})$. This gives the following expression for her policy-induced redistribution:

$$\Xi_{j,t}^{UFP} = -\big(1+\tau_t^{C,UFP}\big)\bar{c}_j - \frac{\frac{1+\tau_{t+1}^{C,UFP}}{1+\bar{\tau}^{C,UFP}}\bar{b}'_j}{1+\bar{r}} + \frac{1+\tau_t^C}{1+\bar{\tau}^C}\bar{b}_j + \big(1-\tau_t^{L,UFP}\big)\bar{w}z_{j,t}\bar{l}_j + \bar{D} + \tilde{Tr}_t^{UFP}.$$

Dividing by gross consumption taxes, inserting the budget constraint in the original steady state, and using condition (20) yields:

$$\frac{\Xi_{j,t}^{UFP}}{1+\tau_t^{C,UFP}} = \frac{\bar{b}_j'}{(1+\bar{r})(1+\bar{\tau}^C)} - \frac{\frac{1+\tau_{t+1}^{C,UFP}}{1+\bar{\tau}^C}\bar{b}_j'}{(1+\bar{r})(1+\tau_t^{C,UFP})} + \frac{\bar{D}}{1+\tau_t^{C,UFP}} - \frac{\bar{D}}{1+\bar{\tau}^C} + \frac{\tilde{Tr}_t^{UFP}}{1+\tau_t^{C,UFP}} - \frac{\bar{Tr}}{1+\bar{\tau}^C}.$$

Rearranging and using condition (19) yields:

$$\frac{\Xi_{j,t}^{UFP}}{1+\tau_t^{C,UFP}} = \frac{\bar{b}_j'}{(1+\bar{\tau}^C)}\left(\frac{1}{(1+\bar{r})} - \frac{1}{(1+r_t^{MP})}\right) + D\left(\frac{\bar{1}}{1+\tau_t^{C,UFP}} - \frac{\bar{1}}{1+\bar{\tau}^C}\right) + \frac{\tilde{Tr}_t^{UFP}}{1+\tau_t^{C,UFP}} - \frac{\bar{Tr}}{1+\bar{\tau}^C}.$$

Solving the government budget constraint and using condition (21) gives the policy-induced transfer in the HANK-UFP case, $\tilde{Tr}_t^{UFP} = \frac{\bar{B}}{1+\bar{r}}\frac{1+\tau_{t+1}^{C,UFP}}{1+\bar{\tau}^C} - \frac{1+\tau_t^{C,UFP}}{1+\bar{\tau}^C}\bar{B} + \tilde{T}_t^{UFP}$, where $\tilde{T}_t^{UFP}$ is the policy-induced partial equilibrium tax income, i.e., the tax income with steady state consumption and labor supply but with HANK-UFP tax rates. Inserting this and the steady state transfer as well as rearranging yields:

$$\begin{aligned}\frac{\Xi_{j,t}^{UFP}}{1+\tau_t^{C,UFP}} = &\frac{\bar{b}_j'}{(1+\bar{\tau}^C)}\left(\frac{1}{(1+\bar{r})} - \frac{1}{(1+r_t^{MP})}\right) + D\left(\frac{1}{1+\tau_t^{C,UFP}} - \frac{1}{1+\bar{\tau}^C}\right) \\ &- \frac{\bar{B}}{(1+\bar{\tau}^C)}\left(\frac{1}{(1+\bar{r})} - \frac{1}{(1+r_t^{MP})}\right) + \frac{\tilde{T}_t^{UFP}}{1+\tau_t^{C,UFP}} - \frac{\bar{T}}{1+\bar{\tau}^C}.\end{aligned}$$

Multiplying with $1+\bar{\tau}^C$ and further rearranging yields:

$$\begin{aligned}\Xi_{j,t}^{UFP}\frac{1+\bar{\tau}^C}{1+\tau_t^{C,UFP}} = &\bar{B}\left(\frac{1}{(1+r_t^{MP})} - \frac{1}{(1+\bar{r})}\right) - \bar{b}_j'\left(\frac{1}{(1+r_t^{MP})} - \frac{1}{(1+\bar{r})}\right) \\ &+ D\left(\frac{1+\bar{\tau}^C}{1+\tau_t^{C,UFP}} - 1\right) + \frac{1+\bar{\tau}^C}{1+\tau_t^{C,UFP}}\tilde{T}_t^{UFP} - \bar{T}.\end{aligned}$$

Given condition (20), the last three terms add up to zero as shown in Appendix A starting from equation (30).[17] Hence,

$$\Xi_{j,t}^{UFP} = \frac{1+\tau_t^{C,UFP}}{1+\bar{\tau}^C}\Xi_{j,t}^{MP}.$$

C Extension to Investment

In this section, we present our extension to investment.

[17] Too see this, replace $C_t^*, L_t^*, w_t^*, D_t^*$ in the equations following equation (30) with their steady state values.

C.1 Households

The household problem is the same as the one described in Section (2.1). Interpret now $b_{h,t+1}$ as her savings collected by a representative mutual fund which allocates households' savings to government bonds and capital. We describe the problem of the mutual fund below.

C.2 Intermediate Good Firms

Intermediate goods are produced by a continuum of intermediate good firms in monopolistically competitive markets. They now produce according to the following Cobb-Douglas production function:

$$y_{j,t} = n_{j,t}^{1-\alpha} k_{j,t}^{\alpha},$$

where $0 < \alpha < 1$, $n_{j,t}$ is labor services, and $k_{j,t}$ is capital services rented in perfectly competitive factor markets. Firms' first-order conditions yield the following term for real marginal cost:

$$mc_t = \left(\frac{1}{\alpha}\right)^{\alpha} \left(\frac{1}{1-\alpha}\right)^{1-\alpha} (r_t^k)^{\alpha} (w_t)^{1-\alpha}.$$

We assume that the intermediate good firms are subject to the same Calvo-pricing as in our benchmark model.

C.3 Mutual Fund

The mutual fund collects households' savings, A_t, pays the return, r_t to households, and invests them in bonds, B_t, and capital, K_t. It maximizes

$$V^{MF}(K_t) \equiv \max_{K_{t+1}, B_{t+1}} (1 + r_{t+1}^k - \delta) K_{t+1} + \tau_t^I \underbrace{(K_{t+1} - (1-\delta)K_t)}_{\equiv I_t} + (1 + r_{t+1}^b) B_{t+1} \\ - (1 + r_{t+1}) A_{t+1} + \frac{V^{MF}(K_{t+1})}{1 + \tilde{r}_{t+2}^a}$$

s.t.

$$A_{t+1} = K_{t+1} + B_{t+1}.$$

Note that we drop the expectation operator as we only consider perfect foresight experiments. The first-order conditions are given by:

$$r^b_{t+1} = r_{t+1}$$

$$1 + r^k_{t+1} - \delta + \tau^I_t = 1 + r_{t+1}.$$

C.4 Fiscal Policy

The government has expenditures for a fixed amount of government consumption, $\bar{G}$, for lump-sum transfers, Tr_t, for repaying debt, B_t, and for the linear investment subsidy, τ^I_t. It finances its expenditures by collecting total tax payments, T_t, and by issuing future debt. The government's budget constraint is given by:

$$\bar{G} + Tr_t + B_t + \tau^I_t I_t = \frac{B_{t+1}}{1 + r_t} + T_t. \tag{32}$$

Total tax payments are given by:

$$T_t = \tau^C_t C_t + \tau^L_t w_t L_t, \tag{33}$$

where C_t and L_t denote aggregate consumption and aggregate labor, respectively. For simplicity, we here assume $\bar{G} = 0$ and $\bar{\tau}^I = 0$.

C.5 Equilibrium

Our definition of an equilibrium of this extended economy is analogous to Section 2.4.