# *Replicating Fiscal Policy Shocks In A Canonical HANK Model à la Auclert, Rognlie, et al. (2025)*

**Seminar Paper**
**Model & Calibration Appendix**

*by*

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**Abstract**

This paper presents our reasoning for model and calibration documentation in full, which can be found in the notebook to comment along on block building of the canonical HANK model by Auclert, Rognlie, et al. (2025). We take criticism on the models calibration values and propose them to be closely matched to more empirica data, while still beeing able to match empirical facts.

# Canonical HANK Model

The authors decided for a standard incomplete markets model with underlying Bewley Huggett-Aiyagari characteristics - meaning incomplete insurance markets and heterogeneous households, describing ex-ante similiar households, which change ex-post, because they are exposed to different idyiosyncratic shocks, which they can only insure againts through riskless bonds or capital as financial markets are incomplete (Kirkby, 2019). Merged with the New Keynesian Paradigm of forward-looking households and firms with market imperfections like sticky prices and wages, the model is underlying for calibration of marginal propensities for consumption, aggregate values of income and wealth as well respectively their distributions.

## The Household Problem

The economies household decision making is ruled by the following consumption maximisation problem:

$$max_{\{c_{it}\}} \quad E_0\left[\sum_{t=0}^{\infty}\left(\prod_{s\leq t-1}\beta_{is}\right)\{log(c_{it})-v(n_{it})\}\right]$$

$$\text{s.t.} \quad c_{it}+a_{it}\leq(1+r_t^p)a_{it-1}+(1-\tau_i)w_te_{it}n_{it} \tag{1}$$

$$a_{it}\geq 0$$

This comprises as a model with unit mass of agents $i\in[0,1]$ that are identical ex-ante but become heterogeneous ex-post because each individual is hit by private shocks $e_{it}$ to labor productivity and to their discount factor $\beta_{it}$, which follow an exogenous Markov process expressing the transitions from one state of shocks and discount factor $(e, \beta)$ to another $(e', \beta')$ ((expressed by the matrix $\prod(e', \beta'|e, \beta)$; the cross-sectional distribution over these states is kept at its stationary value, and average efficiency units of labor are normalized to one.

To study dynamics, the authors consider small, one-time, unexpected disturbances at date 0 (MIT shocks to aggregates like $r_t, w_t$ and $\tau_t$) that move the economy away from its stationary equilibrium. This corresponds to computing first-order IRF's in a fully stochastic counterpart. Each household $i$ has time-separable preferences with $log(u(c_{it}))$ utility in consumption and a separable disutility of labor $v(n_{it})$, supplies efficient units of labor $(e_{it}n_{it})$ according to an exogenously set hours choice nit (e.g., by working unions), pays labor income taxes at rate $\tau_t$, and saves in a mutual fund with assets ait subject to a zero-borrowing constraint $a_{it} \geq 0$, earning the realized return on the fund $r_t^p$.

This poses an individual problem as with given idiosyncratic income risk ($e_{it}$ shocks) and the inability to borrow or fully insure, agents choose consumption $c_{it}$ and next-period assets $a_{it+1}$ to smooth consumption over time while self-insuring against income fluctuations. The combination of income risk $(e_{it})$, discount factor heterogeneity $(\beta_{it})$, and borrowing constraints $(a_{it} \geq 0)$ generates realistic risk-averse saving behavior.

## The Supply Side Set-Up

The authors assume that firm output equals the aggregate of effective labour, acting as price setters including a mark-up attached to the nominal wage over their nominal marginal resulting in a price as of $P = \mu W_t$, implying that real wage $w = \frac{1}{\mu}$.

$$Y_t = N_t, \qquad N_t = \mathrm{E}[e_{it}n_{it}]$$

Introducing a *dividend tax* equal to *labour income tax* $\tau_i$, the post-ex dividends are $d_t = (1-\tau)(Y_t - w_t N_t) = (1-\tau)(1-\frac{1}{\mu})Y_t$. With the New Keynesian paradigm comes price stickyness and the authors use the following assumptions from the literature towards price stickyness:

As of subject to maximise agents utility under constraint of adjustment cost, wages are set by workers union (Erceg et al., 2000). Unions know how to allocate all labour hours over workforce and do so uniformly (Auclert, 2019). The union sets wages to maximize the expected utility of a worker with average consumption (Hagedorn et al., 2019; Auclert, 2019). This yields a linear wage first-order **Phillips curve** for wage inflation under Calvo-Pricing in the form of

$$\pi_t^w = \kappa \left( v'(N_t) - \frac{1-\tau_t}{\mu C_t} \right) + \bar{\beta}\pi_{t+1}^w \tag{2}$$

Wage inflation arises whenever the marginal disutility of working an extra hour, $v'(N_t)$, is higher than the marginal gain to a worker with average consumption. That gain is given by the after-tax real wage $\frac{1-\tau_t}{\mu}$ times the marginal utility of average consumption, $\frac{1}{C_t}$, evaluated over current and future periods. Hence, the Philipps Curve describes the behaviour of price inflation, keeping in mind that prices where set as with a constant markup above the nominal wage, which equalises the terms of price and wage inflation $\pi_t^w = \pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$. Finally, dividends before taxes are defined as the residual of output after paying total labor income: $\text{div}_t = Y_t - w_t N_t$

## Government Endowments

The model's governments budget consists of it's spending $G_t$ and debt in the current state $B_t$ which equals it's collection of labor and corporate taxes as a sum of tax revenue $Y_t$ added by the returns from government bonds it possesses from a period before the constraint is

$$G_t + B_t = (1 + r_{t+1})B_{t-1} + \tau_t Y_t \tag{3}$$

According to a given intertemporal budget constraint, the defined government set-up is supposed to have a strategy in setting $G_t$ and $\tau_t$ accordingly as well as for bonds $B_t$ and spending $G_t$, however, with a still budget constraint respected tax rate.

### Asset Markets and Market Clearing Conditions

Further assumptions are made on asset markets. They assume are a simple asset market and policy environment. As it includes mutual fund collection of household savings $a_it$ and thus two-folded investment either in government bonds or the stock market for which the No-Arbitrage condition must hold

$$1 + r_t = \frac{p_{t+1} + d_{t+1}}{p_t} \tag{4}$$

while total household assets exactly equal the value of equity plus public debt

$$A_t = p_t + B_t \tag{5}$$

Because mutual funds are perfectly competitive, the fund just passes through the bond return to households, and its initial return is the portfolio-weighted average of the stock and bond returns:

$$(1 + r_0^p)A = p_0 + d_0 + (1 + r)B \tag{6}$$

Monetary policy sets the real interest rate on government bonds via a standard interest-rate rule with $1 + i_t = (1 + r_t)(1 + \pi_{t+1})$ and a competitive equilibrium is then defined as prices, quantities, and household decisions such that households optimize and both asset and goods markets clear such that consumption and government spending equal the economies output

$$C_t + G_t = Y_t \tag{7}$$

Once two of equations (5) to (7) hold, the third one will be satisfied automatically - by Walras's law, if all markets but one clear, the last one must clear too.

## Agent Steady State Calculation

### Representative-agent model

The model imposes that a representative agent solves the consumption maximisation problem in (1) with no risk on idiosyncratic income or the discount factor, while they are further able to borrow without constraints, making it a special case as mentioned by the authors. Thus, household consumption for this agent follows a textbook-like **Euler Equation** $C_t^{-1} = \beta(1 + r_t)C_{t+1}^{-1}$ in this special case.

### Two Agent Model

The Bilbiie (2008) and Bilbiie (2019) and Ascari et al. (2016) based two-agent model define a share $(1 - \lambda)$ of agents whose behaviour is described by the prelemenary defined Euler equation, indexed for an unconstrained agent and a share $\lambda$ of agents who do not have access to capital markets, constraining them in that their net-income labor income will always equal their consumption. Overall it is assumed that both all agents have the same productivity $e_{it}$ and join the labour force ($n_{it} = N_t$). For constrained agents it means that consumption equals the after tax labor income and the economies aggregate consumption is the sum of unconstrained and constrained agents' consumption $C_t = (1 - \lambda)C_t^u + \lambda C_t^c$.

## Calibration

The following section defines the author's calibration for the steady state of the economy. In a further static analysis, we will change parameters to check for different outcomes under our assumptions.

Under quarterly frequency, the authors calibration approximates time by values at quarterly points so that it fits the model's quarterly timing, modifying the original continuous-time income process $e_{it}$ based on Kaplan et al., 2018. Their main goal is to find a good approximation of the wealth level and distribtion for most recent U.S. economy data. We comment on the authors calibration in the following paragraph.

| Variable | Description | Value | Variable | Description | Value |
|---|---|---|---|---|---|
| $r$ | Real interest rate (annual) | 2% | $\mu$ | Markups | 1.11 |
| $A$ | Assets to GDP (annual) | 500% | $(\beta^L, \beta^H)$ | Discount factors (quarterly) | (0.91, 1.00) |
| $B$ | Bonds to GDP (annual) | 100% | $\omega$ | Share of patient | 49% |
| $M_{00}$ | Income-weighted MPC (quarterly) | 0.2 | $q$ | Prob of new $\beta$ draw (quarterly) | 1% |
| $G$ | Government spending to GDP | 20% | $T$ | Taxes to GDP | 22% |

Table 1: Calibration of the baseline HA model (Auclert, Rognlie, et al. (2025))

The authors build their calibration using U.S. macro aggregates (wealth-, debt-, spending- and tax-to-GDP ratios, and a long-run real interest rate) from national accounts and fiscal statistics. Their assets-to-GDP calibration $A$ is supported by U.S. Bureau of Economic Analysis (2025) data. However, their bonds-to-GDP $B$ value is lower than what U.S. Office of Management and Budget and FRED St. Louis (2025) data from 2020 on would suggest, while their value for government spending to GDP value $G$ rather matches the U.S. level from 1950's, being constantly within a range of 30% - 40% according to IMF (2025) Public Finance data. With their beforehand mentioned calibrations, they compute a a tax-to-GDP ratio $T/Y$ of 22% ($\frac{G}{Y} + r\frac{B}{Y}$) which would not quite match IMF (2025) having been on it's highest level (13%) in 2000 lowest level in 2009 (7.9%) within a 1973 - 2023 period. They then select preference heterogeneity parameters ($\beta^L = 0.91, \beta^H = 1$ and $\omega$) to match the Board of Governors of the Federal Reserve System (2019) distribution after assuming that the discount factor $\beta$ follows a two-state Markov chain, so that agents switch between 'patient' and 'impatient' types. These parameters are disciplined by matching the Board of Governors of the Federal Reserve System (2019) wealth distribution and a target for the income-weighted MPC. The markup is inferred residually to produce a plausible equity-to-GDP ratio within the model.

**The Phillips-curve** is treated secondary by the authors as they mainly care about real quantities, which they can compute without pinning down inflation in detail. They only specify Phillips-curve parameters to be able to solve for inflation paths when needed, not because these parameters drive their core calibration. Thus simple and conventional values for the nominal block (Frisch elasticity v = 1, a small Phillips-curve slope with normalization to $Y = 1$) are chosen, because we identify their research question to be about heterogeneity and real allocations, not about fine-tuning inflation dynamics.

### Intertemporal MPC's

Household behavior in general equilibrium is summarized by intertemporal marginal propensities to consume (iMPCs), which describe how aggregate consumption responds over time to shocks to labor income, capital gains, and interest rates. In our replication, we follow Auclert, Rognlie, et al. (2025) and use these iMPCs, which the authors computed from the underlying incomplete markets structure as sufficient statistics to build the sequence-space solution and construct the impulse responses in Figure 2. As we are not further interested in the computation and construction reasoning of the Intertemporal MPCs and it's Lorenz curve, we do not focus further on this subsection.

### From IMPC's to General Equilibrium

The authors show how partial-equilibrium iMPCs can be used as sufficient statistics in general equilibrium. They first express post-tax labor income as $Z_t = (1 - \tau_t)w_t N_t = \frac{1}{\mu}(Y_t - T_t)$, so that changes in $Z_t$ are proportional to changes in output net of taxes, $dZ = \frac{1}{\mu}(dY - dT)$. Next, they write the value of aggregate assets $p_0 + d_0$ as the discounted value of dividends $d_t$, which themselves depend on $(Y_t - T_t)$. Differentiating the asset-pricing equation yields how asset values react to interest-rate changes and to $dY - dT$.

In a final step, the authors 'close' the model by expressing the general-equilibrium response of aggregate consumption as a function of policy-relevant objects. According to that, consumption changes $\mathbf{d}C$ reacts toward to channels. First, changes in the interest rate $\mathbf{d}r$ come from ***monetary policy chanel***, while changes in post tax income $dY - dT$ result from a ***fiscal policy chanel***. Using equilibrium relationships for wages, dividends, and asset prices, they derive

$$\mathbf{d}C = \bar{M}^r \, \mathbf{d}r + \bar{M} \, (\mathbf{d}Y - \mathbf{d}T),$$

where $\bar{M}$ is our main matrix of interest as it averages labor-income and capital-gains iMPCs (using wage vs. dividend income shares), and $M_r$ summarizes the direct and asset-price-mediated effects of interest-rate changes on consumption. This means that once iMPCs and income shares are known, one can characterize the general-equilibrium response of consumption to fiscal policy and interest-rate paths.

# Fiscal Policy

The authors consider two types of fiscal policy shocks, while imposing a taylor rule of constant inflation with an interest rate being at it's steady state, and therefore holding monetary policy constant. In the model, a fiscal policy shock either results from holding deficits constant while observing a shock on government spending $G_t$ or viceversa, keeping government spending constant, while observing a shock to it's deficits.

Thus, as Figure 2(a) and (b) only focus on responses to deficit-financed tax cuts in in RA, TA, HA and respectively other alternative HA models, it is the latter aforementioned that we will focus on in our analysis. Once the interest rate is kept at it's steady state, Equation (8) can be rewritten toward resulting the Auclert, Rognlie, et al. (2024) defined "Intertemporal Keynesian cross" as

$$\mathbf{d}C = \bar{M}^r\,\mathbf{d}r + \bar{M}\,(\mathbf{d}Y - \mathbf{d}T), \quad \text{with} \quad r_t = 0, \quad \mathbf{d}C + \mathbf{d}G = \mathbf{d}Y \Rightarrow$$

$$\mathbf{d}Y = \bar{M}(\mathbf{d}Y - \mathbf{d}T) + \mathbf{dG} \tag{10}$$

This expression links the sequence of post-tax income changes and government spending to the sequence of output responses. For a balanced-budget spending shock ($dG = dT, dB = 0$) the solution is $dY = dG$, so the fiscal multiplier equals one, exactly as in a representative-agent model. We implement this condition numerically by solving, for each experiment, for the path of $Y_t$ that clears the asset market, given an exogenous path for government debt generated by the specified fiscal rule, and we then compare the resulting output impulse responses across the RA, TA, and HA specifications.

The deficit-financed shock follows a fiscal rule in equation (11) which assumes that the economy has a possibility to follow its path back towards a steady state.

$$\mathbf{d}B_t = \rho_B \mathbf{d}B_{t-1} - \mathbf{d}T_t^{shock} \tag{11}$$

with $\mathbf{d}T_t^{shock}$ beeing the shock component and $\rho_B$ as the persistence term of debt which has been already accumulated in periods before the shock. It's calibration implies that debt will be paid of after ten years.

## Alternative Heterogenous Agent Models and Policy Rules Experiments

This section addresses alternative tax and policy rule experiments that are computed in Figure 2(b) and are discussed in the notebook.

### ***Taxes On The Richest*** Experiment

The authors next study how the distribution of tax changes affects the deficit-financed multiplier. In the baseline, a given change in taxes or labor income is distributed proportionally across all households, so only the aggregate size matters. They then consider a progressive experiment in which households in the top income state both receive the deficit-financed tax cut and later face the tax increases required to stabilize debt.

### Taylor-Rule Monetary Policy Experiment

The baseline simulations assume a neutral monetary policy, in which the real interest rate does not react to fiscal shocks, so changes in output are driven purely by the fiscal side of the model. To illustrate how monetary tightening alters these results, the authors also consider an active Taylor rule of the form $i_t = r + \phi\pi_t$ with $\phi = 1.5$, so the nominal rate increases whenever inflation rises.

**Angeletos-Lian-Wolf Tax Rate Rule Experiment**

In the Angeletos–Lian–Wolf tax-rate rule, the government starts from a baseline tax rate $\tau$ and implements an unfunded tax cut by lowering the rate to $\tau_t = \tau - \tau_t^X$. To first order, this implies that total tax revenue responds as $dT_t = \tau dY_t - dX_t$, where $dX_t = -Y\, d\tau_t^X$ captures the direct increase in the deficit coming from the lower tax rate. Substituting this fiscal rule into the intertemporal Keynesian cross yields

$$dY = [I - (1 - \tau)M]^{-1} M dX,$$

so the initial deficit-financed tax cut raises output, which in turn raises tax revenue. As long as the matrix inverse (Neumann Series) exists the extra tax revenue generated by the boom can in principle fully pay for the initial deficit, making the tax cut self-financing.

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