

# AdvMacroHet-2024: Grading

## Assignment I: The Aiygari Model

Ad a) Show understanding of the concept stationary equilibrium both in text and in math.

Ad b) Correct implementation of the root finding for the stationary equilibrium. The answer should highlight that wealth inequality comes from idiosyncratic productivity, but is also shaped by labor and capital income taxes.

Ad c) Correct implementation and understanding of the concept of partial equilibrium. The answer should highlight that the labor and capital income tax distort the labor supply and saving decisions of households, and that households are affected differently according to their wealth and productivity. The answer should mention income and substitution effects.

Ad d) Correct computation of the new stationary equilibrium. Correct implementation of the computation of expected welfare across states. Discussion of the efficiency and distributional effects of the change in taxes.

Ad e) Correct implementation of transition path from the old to the new steady state (permanent shock). Same discussion as under d).

## Assignment II: The HANK Model

Ad a) Correct calculation and interpretation of the degree of self-financing. The degree of self-financing expresses how much of the initial government deficit is covered by automatic increases in taxes from a wider tax base. If  $\nu = 1$  the government will never have to raise taxes in order to fund the shock. The answer should also contain a description of how the fiscal transfer affects the economy in the short run, and highlight the role of high MPCs and constrained agents. The answer should explain why the degree of self-financing increases with the timing of the taxation,  $H$ . The degree of self-financing increases with  $H$  because the HANK model features forward looking agents, who increases their consumption more if they observe that the taxation period is further away. This increases the size of the initial boom, thus raising tax revenue, implying that the tax raise needed to occur at  $H$  is smaller, which further reinforces the boom.

Ad b) Correct calibration and implementation of the TANK model in blocks.py. Explain that the DSF is 0 in TANK for all horizons  $H$  since the TANK model features no intertemporal MPCs.

Ad c) Correct computation of the DSF with a lower tax rate. Explain that the DSF is lower due to a mechanical effect (lower tax revenue with a lower tax rate), but that the tax base effect drags in the opposite direction as the boom in the economy is larger when resources are taxed less.

Ad d) Correct computation of the DSF with active monetary policy. Explain that the DSF is smaller since monetary policy actively works against boom caused by the transfer, thus limiting the increase in automatic tax revenue. Explain the model is »real« (monetary policy reacts only to output, government debt is real etc.) so inflation does not affect real variables, and the slope of the NKPC  $\kappa$  does not affect the DSF. Adding nominal government debt would imply that surprise inflation redistributes between the household and the government. Then  $\kappa$  affects the DSF.

# Exam

## Question 1) Solution method and calibration

- a) What is the purpose of discount factor heterogeneity in the model?
- **Answer:** Discount factor heterogeneity allows the HANK model to simultaneously match a high MPC and a high level of liquidity in the economy.
- b) Say we compute the Jacobians  $H_U, H_G$  and solve for the linearized response to a fiscal spending shock  $dG$ .<sup>1</sup> Do we need to recompute the Jacobians  $H_U, H_G$  of the model if we change the parameter  $\phi_\pi$  in the Taylor rule? Do we need to recompute the Jacobians of the household block?
- **Answer:** The parameter  $\phi_\pi$  in the Taylor rule affects the general transition path (in `blocks.py`) so therefore we have to recompute the Jacobians  $H_U, H_G$ . We do not need to recompute the Jacobian of the household block as the parameter  $\phi_\pi$  does not affect the steady state or the household block directly.
- c) Do we need to recompute the Jacobians  $H_U, H_G$  of the model if we change the persistence or the size of the fiscal policy shock? Explain.
- **Answer:** We do not need to recompute the Jacobians when we change the persistence or the size of the shock due to linearity ( $dU = -H_U^{-1}H_G dG$ ).

*Note: You don't have to actually solve for the IRFs in your answers to b) and c) in the code.*

## Question 2) Monetary policy

In this question we study a monetary policy shock  $\epsilon_t^i$  of size  $d\epsilon_0^i = -0.001$  and a quarterly persistence of 0.80. We focus on *linearized* IRFs.

- a) Consider first the model where investment is completely inelastic ( $\phi_K \rightarrow \infty$ ).<sup>2</sup> Compute linear IRFs to a monetary policy shock. Compare the effects in HANK and RANK, and discuss.

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<sup>1</sup> Here  $H$  denotes the residuals (or »targets«) of the model, and  $U$  denotes the unknowns.

<sup>2</sup> You may think of this as the standard HANK model without capital. In the code you can set  $\phi_K = 100$  as an approximation of  $\phi_K \rightarrow \infty$ .

- **Answer:** In the standard model without investment the IRFs to a monetary policy shock are typically very similar in HANK and RANK, and in the present model they are nearly identical. The answer should briefly explain the transmission channel of monetary policy: A reduction in the nominal interest rate reduces the real interest rate when prices or wages are rigid, which stimulates demand through intertemporal substitution.
- b) Decompose the response of aggregate consumption  $C$  in HANK from a) into direct and indirect effects. What would the decomposition look like in RANK?
- **Answer:** In the HANK model the transmission is split roughly equally between the direct effect (intertemporal substitution) and the indirect effect (income effect operating through labor income and MPCs), whereas in the RANK model the entire transmission goes through the direct effect. Still, the overall effect in HANK is roughly the same as in RANK because the direct effect in HANK is weaker since constrained households do not respond to the direct effect of interest rate changes.
- c) Consider a model with elastic capital and investment ( $\phi_K = 3$ ), and compare the effects of a monetary policy shock in HANK and RANK. Decompose the response of consumption in HANK into direct and indirect effects. Does your results differ compared to the results in a) and b)? Explain.
- **Answer:** In the model with investment the consumption response in HANK is larger, since the lower interest rate stimulates investment directly, thus increasing demand and income in the economy. This implies that the indirect effect becomes more important in HANK, whereas in RANK the consumption response is not affected much. The output responses are similar in HANK and RANK because the HANK model features a small degree of crowding out of investment due to the endogenous response of monetary policy.
- d) Compute IRFs in the model with investment under *sticky expectations*. Assume that the probability that a given household does not update their information set in a given period is  $\theta = 0.95$ . Compare and discuss the effectiveness of monetary policy in HANK and RANK.
- **Answer:** In RANK monetary policy barely affects consumption since sticky expectations dampen intertemporal substitution. In HANK the indirect effect now account for nearly all the transmission to consumption, which is still sizable since the (static) indirect effect is still effective even with sticky expectations. The overall response of output is similar in HANK and RANK for the reason discussed in c).

### Question 3) Fiscal policy

We now consider the effects of a fiscal spending shock of 1% of steady state GDP,  $dG_0 = 0.01 \times Y_{ss}$ . Assume that the quarterly persistence is 0.8. We still focus only on *linearized* IRFs.

- a) Solve for a deficit-financed ( $\omega = 0.03$ ) fiscal spending shock. How does the presence of investment affect the fiscal multiplier in HANK relative to RANK? Explain the role of endogenous monetary policy for your results.

- **Answer:** Without investment the fiscal multiplier to a deficit financed shock is larger in HANK due to the multiplier effect coming from high MPCs. With investment the fiscal multipliers in HANK and RANK become closer since the positive consumption response in HANK implies a larger increase in inflation, which causes the central bank to raise the interest rate. This reduces investment. Because consumption does not increase in RANK this does not occur, and the investment response is less negative.

- b) Vary the degree of tax financing  $\omega$  between  $[0.03, 1]$  in the HANK model with investment. When is the cumulative government spending multiplier highest?<sup>3</sup>

- **Answer:** The cumulative government spending multiplier is highest with maximum deficit-financing ( $\omega = 0.03$ ) even with investment. This is the standard result in the HANK literature.

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<sup>3</sup> We define the cumulative multiplier as  $\frac{\sum_{t=0}^{\infty} (1+r_{ss})^{-t} dY_t}{\sum_{t=0}^{\infty} (1+r_{ss})^{-t} dG_t}$ .