The exam consists of three parts: A, B, and C. In the grading, part A is given 25 % weight, part B is given 25 % weight, and part C is given 50 % weight.

Part A (25 %)

a) Suppose you are an advisor at the central bank. The output gap is negative and inflation is below target. At the same time, the interest rate is zero and the central bank is unwilling to lower the interest rate further (negative interest rates should not be considered). Describe which policies are available to the central bank and argue for what the central bank should do using theory and empirical results.

b) In the standard New Keynesian model presented on lecture 2, 3, and 4, there is a representative household that has a very small marginal propensity to consume (around 0.05). Suppose instead that the average marginal propensity to consume among households is 0.50 rather than 0.05. Discuss how such a change in the average marginal propensity to consume affects how monetary policy transmits to aggregate consumption.

Part B (25 %)

We assume that households choose to purchases various goods. The households maximizes the aggregate consumption good subject to a given expenditure level. The problem can be formulated as

$$\max_{C_t(i)} \left(\int_0^1 C_t(i)^{1-\eta} di \right)^{\frac{1}{1-\eta}}$$

subject to

$$X_t = \int_0^1 P_t(i) C_t(i) di$$

a) Show that the demand for good i is

$$C_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-1/\eta} C_t$$

where $P_t = \left(\int_0^1 P_t(i)^{1-1/\eta} di \right)^{\frac{1}{1-1/\eta}}$.

b) Interpret η as an elasticity. What happens when $\eta \to 0$ and $\eta \to \infty$?

c) We assume that firms maximize profits. The firm problem can then be expressed as

$$\max_{P_t(i)} P_t(i)Y_t(i) - W_t N_t(i)$$
$$\text{subject to}$$
$$Y_t(i) = N_t(i)$$
$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-1/\eta} Y_t.$$

Solve for the optimal price and interpret.

Part C (50 %)

We are going to use the New Keynesian model to see how the economy responds to a cost-push shock under an interest rate rule. We assume that the model is

$$\pi_t = E_t\{\pi_{t+1}\} + \kappa x_t + u_t \tag{1}$$
$$x_t = E_t\{x_{t+1}\} - (i_t - E_t\{\pi_{t+1}\}) \tag{2}$$
$$i_t = \phi_\pi \pi_t \tag{3}$$
$$u_t = \rho u_{t-1} + \varepsilon_t^u \tag{4}$$
$$\varepsilon_t^u \sim N(0, \sigma_u) \tag{5}$$
$$\kappa = \left(1 + \frac{\phi + \alpha}{1-\alpha}\right)\left(\frac{1-\theta}{\theta}\right)(1-\theta)\left(\frac{1-\alpha}{1-\alpha+\alpha\varepsilon}\right) \tag{6}$$

where x is the output gap, π is inflation, i is the nominal interest rate, and u is cost-push shock. κ, ϕ_π, ρ, σ_u, ϕ, α, θ, and ε are known parameters.

a) Insert (3) into (2) and guess that

$$x_t = \psi_{xu} u_t$$
$$\pi_t = \psi_{\pi u} u_t$$
$$E_t\{x_{t+1}\} = \rho \psi_{xu} u_t$$
$$E_t\{\pi_{t+1}\} = \rho \psi_{\pi u} u_t.$$

Find the solutions for ψ_{xu} and $\psi_{\pi u}$.

b) Figure 1 shows the impulse responses of the output gap, inflation, the real interest rate, the nominal interest rate, and the cost push shock to an initial shock to ϵ_0^u of 0.25. We have used the following calibration: $\phi = 5$, $\alpha = 0.25$, $\epsilon = 9$, $\theta = 0.75$, $\phi_\pi = 1.5$, and $\rho = 0.5$. Explain why the cost push shock affects the economy the way it does in Figure 1.

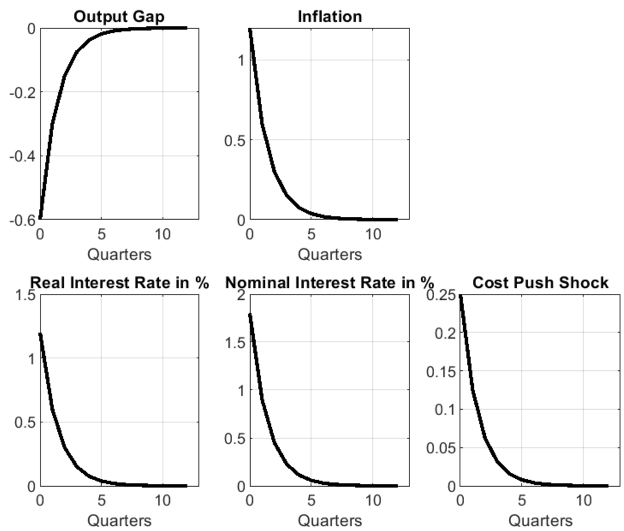

Figure 1: Impulse responses to a cost push shock

c) We now change the calibration by decreasing θ from 0.75 to 0.50. All other parameters are the same as in problem b. Figure 2 presents the impulse responses in the benchmark scenario and in the new calibration. Explain what θ is, how it changes the economic environment, and how agents alter their behavior. Next, explain why the aggregate responses of the economy change in the way presented in Figure 2.

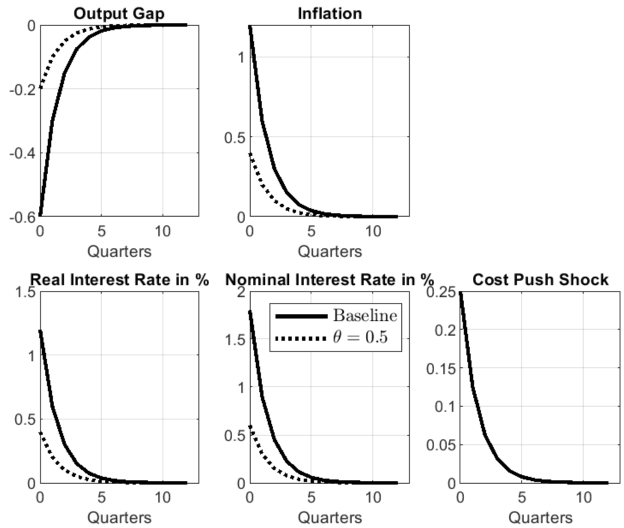

Figure 2: Impulse responses to a cost push shock: variation in θ.

d) Assume now that the central bank follows optimal monetary policy instead of a Taylor rule (3) where the central bank cares about inflation and having an interest rate close to the natural interest rate (which is zero here). The loss function is

$$L_t = \frac{1}{2} \sum_{k=0}^{\infty} \left(\pi_{t+k}^2 + \gamma i_{t+k}^2 \right)$$

where $\gamma > 0$ is a parameter. Show that the solution for optimal monetary policy under discretion is

$$\gamma i_t = \kappa \pi_t. \tag{7}$$

e) Interpret equation (7). What trade-off does the central bank face?

Solution proposal

PART A

a) A good answer here should discuss quantitative easing / credit easing and forward guidance. Liquidity support and macroprudential policies can also be mentioned although these are not required. For each proposed policy, theory and empirical results should be discussed. A good answer should also include a policy recommendation supported by theory and empirical results.

b) A good answer should discuss the following points:

1. High MPC implies stronger indirect income effect through wages or transfers. Labor market responses to monetary policy are now more important for monetary transmission.
2. High MPC implies stronger cash-flow effects, i.e., debtors reduce consumption in response to higher interest rates while those with deposits increase consumption. The distribution of debt and deposits is therefore important for monetary transmission.
3. Intertemporal substitution effects are less important.

PART B

a) Solve by standard method. It is possible to note that $\eta = 1/\epsilon$ and copy from solution to problem set.

b) Note that $\eta = 1/\epsilon$. The interpretation is therefore the opposite of ϵ. In particular, η is a measure of the elasticity of substitution between goods. When $\eta \to 0$, demand is infinitely elastic such that no price deviation is possible without having zero demand. When $\eta \to \infty$, demand is completely inelastic such that demand is independent of the price firms set.

c) The optimal price setting equation is

$$P_t = \frac{1}{1-\eta} W_t.$$

Prices are set as a markup over marginal costs (W_t in this model). If η is low, competition is strong (demand is elastic) and the markup is small; conversely, if η is high, competition is weak (demand is inelastic) and the markup is high.

PART C

a) Solve by the method of undetermined coefficients. The solution is

$$\psi_{xu} = -(\phi_\pi - \rho)\Lambda_u \tag{8}$$

$$\psi_{\pi u} = (1-\rho)\Lambda_u \tag{9}$$

$$\Lambda_u = \frac{1}{(1-\rho)^2 + \kappa(\phi_\pi - \rho)}. \tag{10}$$

b) A cost-push shock is an increase in inflation that is initially not due to a change in output. The central bank responds to this increase in inflation by increasing the interest rate by more than one-for-one with inflation. Hence, the real interest rate also increases and households cut back on consumption, resulting in a reduction in output. This reduction in aggregate demand next results in lower prices, dampening the initial impact on prices, and so on. The total effects are lower output, higher prices, and higher nominal and real interest rates.

c) θ is the parameter for the probability of being stuck with the price in the next period. A lower θ has two effects on this economy. First, prices are more flexible because more firms will respond to any change in current aggregate demand (the output gap). Second, prices are also more responsive to changes in current demand because with a relatively lower θ, the firms care more about the current period relative to future period. For both reasons, κ is higher. Since the central bank initially responds to the cost-push shock by increasing the real interest rate, this reduces the output gap. With a higher κ, this change in the output gap has a greater effect on inflation than before. Inflation therefore increases by less than in the baseline calibration. Further, since inflation increases by less, the nominal interest rate also has to increase by less, dampening the effect also on output. The total effect of a lower θ and therefore higher κ is that all responses are dampened.

d) Use (2) to replace for output in (1). In the current period, the Phillips curve is then $\pi_t = -\kappa i_t + f_t$ where f_t contains all future terms and the shock. The problem can now be solved in any of the standard ways.

e) The trade-off when the central bank faces a positive cost-push shock is that the central bank has to increase the interest rate in order to get inflation down. Equation (7) is the combination of first order conditions illustrating this trade-off. At the optimum, the marginal loss from a higher interest rate (γi_t) is equal to the marginal gain from lower inflation ($\kappa \pi_t$).