The exam consists of two parts, A and B, with equal weight in the grading (50% each). Remember to allocate your time accordingly.

Part A (50 %)

This part contains five problems. You need to answer all to get full score. Your answers to each problem should not exceed one page.

a) **Norges Bank case.**

Figure 1 shows Norges Bank's decomposition of changes in the rate path in the Monetary Policy Report 1/2022. Choose three of the six factors and explain what has happened since the last meeting and the channels through which the channels have contributed to change the interest rate path.

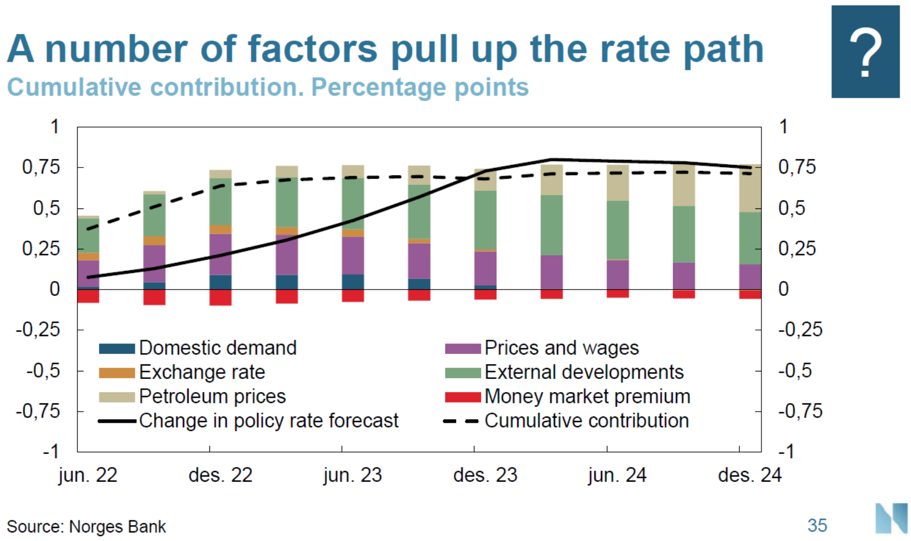

Figure 1: Norges Bank's decomposition of changes in the rate path

b) **Log-linearization.**

Log-linearize $Y_t = A_t L_t^{1-\alpha}$ and $Y_t = C_t + I_t$.

c) **Liquidity trap.**

Briefly explain what characterizes a liquidity trap.

d) **Balance sheet policies.**

Explain how the central bank can use its balance sheet as a monetary policy tool, why these tools should provide monetary stimulus, and what we know about its effectiveness.

e) **Negative interest rates.**

Suppose the central bank policy rate is zero, but the economy still has a negative output gap and inflation below the target. The Governor of the central bank now asks you whether you think the policy rate should be set below zero. Discuss the existing empirical evidence on how effective policy rate cuts below zero can be in terms of stimulating the economy through the banking system, i.e., in terms of lowering deposit and lending rates.

Part B (50 %)

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

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa \tilde{y}_t + u_t \tag{1}$$

$$y_t = E_t\{y_{t+1}\} - (i_t - E_t\{\pi_{t+1}\}) + z_t \tag{2}$$

$$i_t = \phi_\pi \pi_t \tag{3}$$

$$z_t = \rho_z z_{t-1} + \nu_t^z, \qquad \nu_t^z \sim N(0, \sigma_z) \tag{4}$$

$$u_t = \rho_u u_{t-1} + \nu_t^u, \qquad \nu_t^u \sim N(0, \sigma_u) \tag{5}$$

$$\kappa = \left(1 + \frac{\phi + \alpha}{1 - \alpha}\right)\left(\frac{1 - \theta}{\theta}\right)(1 - \beta\theta)\left(\frac{1 - \alpha}{1 - \alpha + \alpha\varepsilon}\right) \tag{6}$$

where π is inflation, y is the output gap, u is a cost-push shock, and z is a discount rate shock. β, κ, σ, ϕ_π, ρ_z, σ_z, ρ_u, σ_u, ϕ, α, θ, and ε are parameters of the model.

a) **Guess and verify.**

Find the model solution for the discount rate shock. Guess that

$$y_t = \psi_{yz} z_t, \quad E_t\{y_{t+1}\} = \rho_z \psi_{yz} z_t,$$
$$\pi_t = \psi_{\pi z} z_t, \quad E_t\{\pi_{t+1}\} = \rho_z \psi_{\pi z} z_t,$$

and show that

$$\psi_{yz} = (1 - \beta\rho_z)\Lambda_z,$$
$$\psi_{\pi z} = \kappa\Lambda_z,$$
$$\Lambda_z = \frac{1}{(1 - \beta\rho_z)(1 - \rho_z) + \kappa(\phi_\pi - \rho_z)}.$$

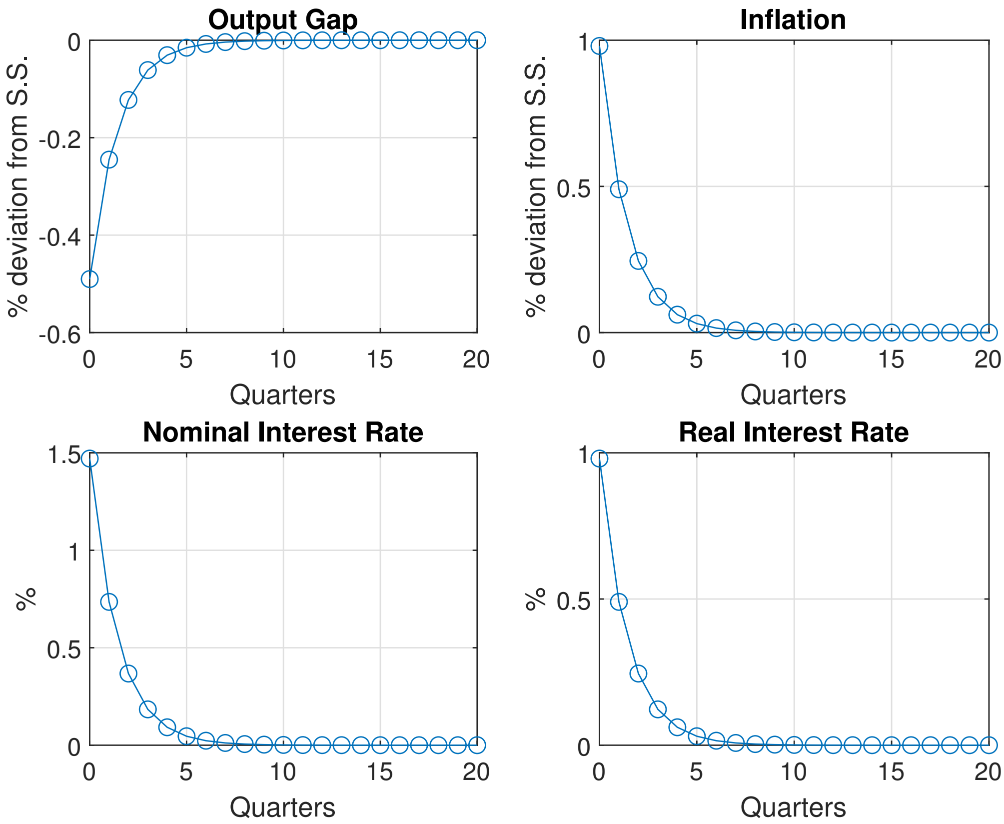

Figure 2: Impulse Responses

b) **Interpretation of impulse responses.**

Figure 2 shows the impulse responses of the output gap, inflation, the nominal interest rate, and the real interest rate to an initial shock to either ν_0^z or ν_0^u (only one of them). The calibration is as follows: $\beta = 0.99$, $\phi = 5$, $\alpha = 0.25$, $\varepsilon = 9$, $\theta = 0.75$, $\phi_\pi = 1.5$, and $\rho_z = \rho_u = 0.5$. Does Figure 2 show the responses from a discount rate or cost-push shock? Explain how one can distinguish between the two shocks. And explain how the shock feeds into the economy.

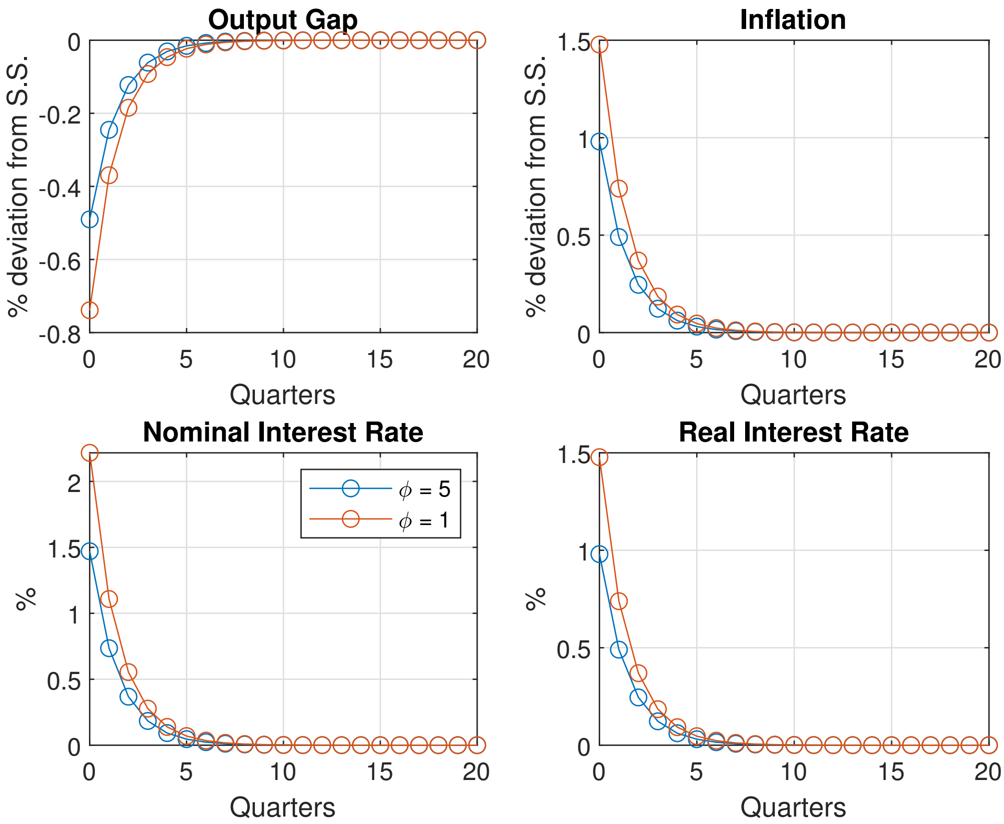

Figure 3: Impulse Responses

c) **Parameter changes.**

We now reduce ϕ from 5 to 1. All other parameters are the same as in problem b. Figure 3 presents the impulse responses in the benchmark scenario and in the new calibration. Explain what ϕ is, how it changes the economic environment, and explain how agents alter their behavior. Next, explain why the aggregate responses of the economy change in the way presented in Figure 3.

d) **Optimal monetary policy.**

We are now going to solve for optimal monetary policy under discretion. Assume that the central bank minimizes the following loss function

$$\mathcal{L} = \frac{1}{2}\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k (\lambda y_{t+k}^2 + \pi_{t+k}^2) \tag{7}$$

where $\lambda > 0$. Minimize the loss function (7) subject to the Phillips curve (1) under discretion. What is the trade-off the central bank faces? How does the central bank optimally respond to a discount rate shock?

Solution Proposal

Part A

a) A good answer should be able to concisely outline the reasoning behind three factors and how they contribute to the change in the interest rate path.

b) The solutions are $y_t = a_t + (1-\alpha)l_t$ and $y_t = \frac{C}{Y}c_t + \frac{I}{Y}i_t$ where lower-case letters denote log-deviations. The students can use any method to solve the problems as long as it is correct.

c) A good answer describes how a liquidity trap is a situation where the policy rate is at zero but there is need for additional monetary stimulus.

d) A good answer describes

- Distinction between pure quantitative easing (QE) and credit easing (CE).
- Gives example of central banks which have implemented QE and CE
- Outlines how QE and CE should provide stimulus (no need for equations, but the the intuition behind the various channels should be explained)
  - QE: Money multiplier and velocity of money
  - CE: Portfolio rebalancing and bank lending channel

e) No need for a model, but a good answer should mention that

- Existing evidence suggests ZLB on household/retail deposits, less so on corporate deposits.
- On average, the pass-through of policy rate cuts diminish below zero.
- If deposit rates are at the ZLB: Banks react differently to policy rate cuts once deposit rates are at the ZLB: banks with large amounts of deposits expand lending less.
- If deposit rates are not at the ZLB: Empirical evidence (from Portugal) suggests that policy rate cuts below zero can be effective.

Part B

a) Solve by method of undetermined coefficients.

b) Figure 2 shows the response to a positive cost-push shock. It is a cost-push shock because inflation and output move in the opposite direction. It is positive because inflation goes up. Initially, the cost push shock raises prices. The central bank responds to this price rise by increasing the interest rate more than one-for-one. Hence, the real interest rate increases and output contracts. As output contracts, the initial impact on inflation is somewhat dampened. The total effect is that inflation goes up, output declines, the nominal interest rate goes up, and the real interest rate goes up.

c) ϕ is the inverse of the Frisch elasticity. When ϕ declines, households become more responsive to wage changes. Hence, a given reduction in output affects wages and thus prices less, resulting in a lower κ and a flatter Phillips curve. In Figure 3, this implies that when the central bank responds to the initial inflation increases by raising the interest rate, it affects output to the same extent, but the output decline has less effect on inflation. Hence, the dampening effect of monetary policy is weaker and the central bank has to respond even stronger. The total effect is thus that inflation is higher, output is lower, the nominal interest rate is higher, and the real interest rate is higher.

d) The solution under discretion is $\lambda y_t = -\kappa \pi_t$. The student should be able to explain the trade-off the central bank faces when the economy is hit by a cost-push shock. When the economy faces cost-push shocks, the central bank has to engineer a recession to reduce inflation. The optimal policy is to set equate the marginal benefit from engineering a recession ($-\kappa \pi_t$) equal to the marginal costs of the recession (λy_t). The optimal response to a discount rate shock is always to fully cancel it out since it entails no trade-off. The student can either compute this directly or write out the argument with words.