The exam consists of three parts, A, B, and C, with weights 50%, 25%, and 25%, respectively. Allocate your time accordingly.

Part A (50 %)

This part contains four problems. You need to answer all to get full score.

a) **Monetary policy and financial stability.** Section 3 in "Regulation of Monetary policy" states: "The operational target of monetary policy shall be annual consumer price inflation of close to 2 percent over time. Inflation targeting shall be forward-looking and flexible so that it can contribute to high and stable output and employment and to counteracting the build-up of financial imbalances".

   i) What is the rationale for including the phrase "counteracting the build-up of financial imbalances" in a monetary policy guideline?

   ii) What is macroprudential policy?

b) **Unconventional monetary policy.**

   i) Discuss how liquidity support from the central bank will affect private banks' balance sheet.

   ii) Why did many central banks provide liquidity support to the banking sector in the aftermath of the global financial crisis?

c) **Kappa.** In the standard New-Keynesian model, the slope of the Phillips curve (κ) is

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

   Explain what σ is and why $\frac{\partial \kappa}{\partial \sigma} > 0$.

d) **CES Demand.** The demand for an individual good in a CES-system is

$$C_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} C_t \tag{2}$$

   where $C_t(i)$ is good i, $P_t(i)$ is the price of good i, P_t is an aggregate price index, and C_t is aggregate demand. Interpret equation (2) and explain the role of ϵ.

Part B (25 %)

In this problem, we are going to solve for optimal monetary policy under various assumptions. The underlying model is from Clarida-Gali-Gertler (1999):

$$L_t = \frac{1}{2}\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k [\lambda y_{t+k}^2 + \pi_{t+k}^2] \tag{3}$$

$$\pi_t = \kappa y_t + \beta \mathbb{E}_t \pi_{t+1} + u_t \tag{4}$$

$$x_t = -\eta[i_t - \mathbb{E}_t \pi_{t+1}] + \mathbb{E}_t y_{t+1} \tag{5}$$

$$u_t = \rho u_{t-1} + \epsilon_t \tag{6}$$

$$\epsilon_t \sim N(0, \sigma_\epsilon) \tag{7}$$

where y_t is the output gap, π_t is the inflation rate, u_t is the cost-push shock, ϵ_t is an i.i.d. innovation to the cost-push shock, and $\lambda > 0$, $\beta \in [0, 1)$, $\kappa > 0$, $\eta > 0$ and $\rho \in [0, 1)$ are parameters. We find optimal monetary policy by minimizing the loss function (3) subject to the model equations.

a) **Optimal monetary policy under commitment.** Solve the problem above for optimal monetary policy under commitment and show that the first order conditions can be combined to the following equation:

$$-\kappa \pi_{t+k} = \begin{cases} \lambda y_{t+k} & \text{if } k = 0 \\ \lambda (y_{t+k} - y_{t+k-1}) & \text{if } k > 0 \end{cases} \tag{8}$$

b) **Interpretation.** Equation (8) can be rewritten to

$$\lambda y_{t+k} = -\kappa \sum_{j=0}^{k} \pi_{t+j} \tag{9}$$

Interpret equation (9).

c) **No persistence in the Phillips curve.** Assume now that equation (4) is given by

$$\pi_t = \kappa y_t + u_t.$$

Explain why the optimal solution under commitment and discretion are the same in this case.

Part C (25 %)

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. The model is

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa y_t \tag{10}$$

$$y_t = E_t\{y_{t+1}\} - (i_t - E_t\{\pi_{t+1}\}) + d_t \tag{11}$$

$$i_t = \phi_\pi \mathbb{E}_t\{\pi_{t+1}\} \tag{12}$$

$$r_t = i_t - \mathbb{E}_t\{\pi_{t+1}\} \tag{13}$$

$$d_t = \rho_d d_{t-1} + v_t^d, \qquad v_t^d \sim N(0, \sigma_d) \tag{14}$$

$$\kappa = \left(1 + \frac{\phi + \alpha}{1 - \alpha}\right)\left(\frac{1 - \theta}{\theta}\right)(1 - \beta\theta)\left(\frac{1 - \alpha}{1 - \alpha + \alpha\varepsilon}\right) \tag{15}$$

where π is inflation, y is the output gap, i is the interest rate, r is the real interest rate, and d is a discount rate shock. β, κ, ϕ_π,ρ_d, σ_d, 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

$$y_t = \psi_y d_t, \quad E_t\{y_{t+1}\} = \rho_d \psi_y d_t,$$
$$\pi_t = \psi_\pi d_t, \quad E_t\{\pi_{t+1}\} = \rho_d \psi_\pi d_t,$$

and show that

$$\psi_y = (1 - \beta\rho_d)\Lambda,$$
$$\psi_\pi = \kappa\Lambda,$$
$$\Lambda = \frac{1}{(1 - \rho_d)(1 - \beta\rho_d) + \kappa\rho_d(\phi_\pi - 1)}.$$

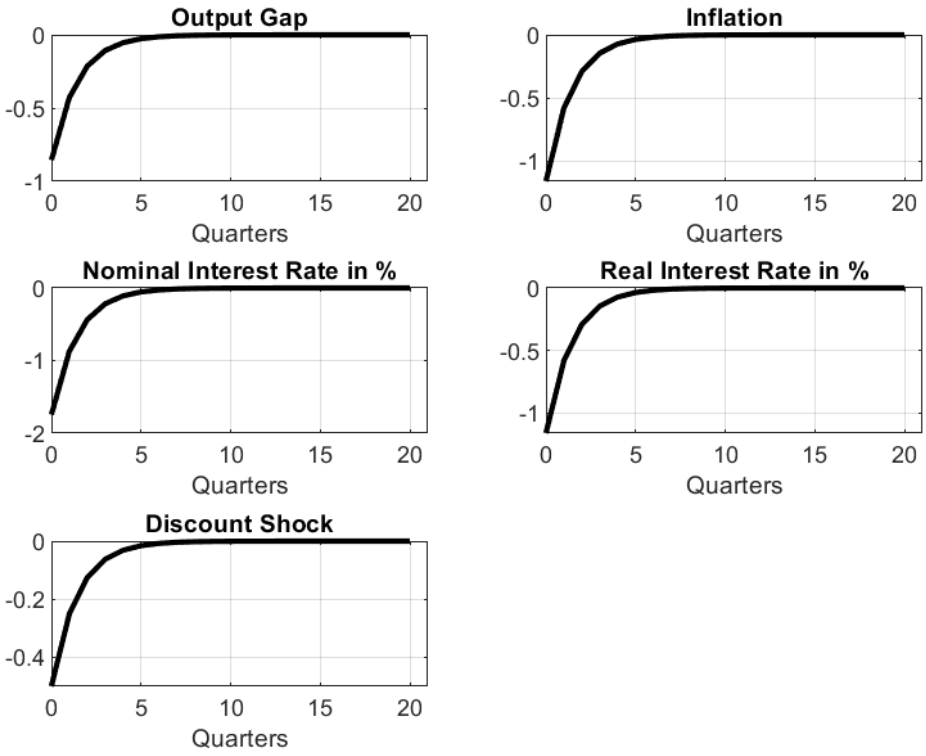


Figure 1: Impulse Responses to a Discount Shock under a Taylor Rule.

b) **Interpretation of impulse responses.**

Figure 1 shows the impulse responses of the output gap, inflation, the nominal interest rate, the real interest rate, and the discount shock to a discount shock of size -0.5. The calibration is as follows: $\beta = 0.99$, $\phi = 5$, $\alpha = 0.25$, $\varepsilon = 9$, $\theta = 0.75$, $\phi_\pi = 1.5$, and $\rho_d = 0.5$. Explain how and why the shock affects the economy in the way displayed in Figure 1.

c) **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

$$\mathcal{L} = \frac{1}{2}\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k (\lambda y_{t+k}^2 + \pi_{t+k}^2) \tag{16}$$

where $\lambda \geq 0$ is the relative weight on output in the loss function. Minimize the loss function (16) subject to the Phillips curve (10) under discretion. What is the trade-off the central bank faces? What is the optimal interest rate response to a discount shock?

Solution Proposal

Part A

a) **Monetary policy and financial stability.**

   i) The arguments behind mandating the central bank to counteract the build-up of financial imbalances are that the costs of financial crises are enormous. Theoretically, the costs of financial crises could be captured by the projections of future inflation and output gaps, but this is very hard in practice (asset pricing, non-linearities, ...). Introducing the extra mandate ensures an additional focus on the build-up of financial imbalances. However, the financial supervision authorities typically have the primary responsibility for reducing the likelihood of financial crises and monetary policy only plays a secondary role here.

   ii) The starting point of macroprudential policies is that there are mechanisms in which bank behavior is procyclical and may amplify business cycle fluctuations (financial accelerator mechanisms). Macroprudential regulation was introduced after the global financial crisis to reduce this behavior. The students should mention an example of a financial accelerator mechanism (for example how an increase in equity in expansions affect banks' lending capacity) and how a specific policy addresses this (the countercyclical capital buffer).

b) **Unconventional monetary policy.**

   i) Here, it is important to state that the central bank finances liquidity support by increasing central bank reserves. In the aggregate, the private banks' deposits at the central bank have to increase with the same amount as the loans they get from the central bank. But the individual bank may use the liquidity support in different ways. Hence, this liquidity support may reduce the liquidity risk of individual banks and make them more willing to lend out money.

   ii) When there is no more room to conduct conventional monetary policy (because the zero lower bound or variants of it binds), and there is still a need to stimulate, there may be a need to conduct unconventional monetary policy. Liquidity support may enable banks to continue to extend loans at reasonable interest rates (without large premiums).

c) **Kappa.** σ is relative risk aversion or the inverse of the elasticity of intertemporal substitution. σ enters κ because it affects the income effect for labor supply. When

output increases, real wages also increase. This effect is stronger the higher σ. The reason is that with a higher σ, the more the household's marginal utility decreases with higher output/consumption. Hence, with higher σ, the household will require more wage compensation to work more, raising κ.

d) **CES Demand.** The CES demand equation states that the demand for an individual good is proportional to the relative price of that good and aggregate demand. The sensitivity of the individual good's demand to the relative price is described by ε, the elasticity of substitution between goods. If ε is high, demand is more price sensitive. When $\varepsilon \to \infty$, we are in a perfectly competitive situation in which all prices must be the same and demand for each good is proportional to aggregate demand.

Part B

a/b) See Lecture Note 6.

c) When the Phillips curve is $\pi_t = \kappa y_t + u_t$, there is no channel through which future inflation affects current inflation. All gains from commitment disappears and the commitment solution collapses to the discretion solution.

Part C

a) Solve by method of undetermined coefficients.

b) Initially, the discount rate shock reduces output, which also leads to a reduction in inflation. The central bank responds to lower (expected) inflation by reducing the interest rate. Since $\phi_\pi > 1$, the reduction in the interest rate is so large that the real interest rate also declines. The reduction in the real interest rate then stimulates output, dampening the initial effect of the discount rate shock. The total effect is lower output, lower inflation, a lower interest rate, and a lower real interest rate.

c) The solution under discretion is $\lambda y_t = -\kappa \pi_t$. 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). With a discount rate shock, output and inflation move in the same direction and there is no trade-off between output and inflation. The optimal response is then to set the output gap to zero, that is, respond with the interest rate in such a way that the discount rate shock does not affect output. In the model, that is the same as saying that $i_t = d_t$.