The exam consists of four parts: A, B, C, and D. In the grading, part A has 10% weight, part B has 30% weight, part C has 30% weight, and part D has 30% weight. Allocate your time accordingly.

Part A: Short questions on macroprudential policy (10%)

a) Explain why banks' behavior could be procyclical.

b) What is macroprudential policy?

Part B: The firm problem (30%)

In this problem set, we are going to solve for the optimal price-setting behavior of a firm that faces Rotemberg adjustment costs. Consider the following firm problem:

$$\max_{P_{i,t}} \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \frac{U_{C,t+k}}{U_{C,t}} \left\{ \frac{P_{i,t+k}}{P_{t+k}} Y_{i,t+k} - \frac{W_{t+k}}{P_{t+k}} N_{i,t+k} - \frac{\Theta(\varepsilon-1)}{2} \left(\frac{P_{i,t+k}}{P_{i,t+k-1}} - 1 \right)^2 Y_{t+k} \right\} \tag{1}$$

subject to

$$Y_{i,t+k} = N_{i,t+k}^{1-\alpha}, \qquad \text{and} \qquad Y_{i,t+k} = \left(\frac{P_{i,t+k}}{P_{t+k}} \right)^{-\varepsilon} Y_{t+k},$$

where P is the price, W is the nominal wage, Y is output, N is hours, U_c is the marginal utility of consumption, and $\beta \in (0,1]$, $\alpha \in (0,1)$, $\varepsilon > 0$, and $\Theta > 0$ are parameters.

When solving the problem, use the following Lagrangian:

$$\begin{aligned} \mathcal{L}_t = & E_t \sum_{k=0}^{\infty} \beta^k \frac{U_{c,t+k}}{U_{c,t}} \Big[\frac{P_{i,t+k}}{P_{t+k}} Y_{i,t+k} - \frac{W_{t+k}}{P_{t+k}} N_{i,t+k} - \frac{\Theta(\varepsilon-1)}{2} \left(\frac{P_{i,t+k}}{P_{i,t+k-1}} - 1 \right)^2 Y_{t+k} \\ & - \zeta_{i,t+k} \left(Y_{i,t+k} - \left(\frac{P_{i,t+k}}{P_{t+k}} \right)^{-\varepsilon} Y_{t+k} \right) - \Psi_{i,t+k} \left(Y_{i,t+k} - N_{i,t+k}^{1-\alpha} \right) \Big] \end{aligned}$$

a) Solve the first-order conditions with respect to hours and output, and show that they can be written as:

$$\Psi_{t+k} = \frac{W_{t+k}/P_{t+k}}{MPN_{t+k}} \qquad \text{and} \qquad \zeta_{t+k} = 1 - \Psi_{t+k}$$

b) Explain what the variables Ψ_{t+k} and ζ_{t+k} represent in the economy?

c) Show that the optimal price setting equation is:

$$1 - \Theta(\varepsilon-1)(\Pi_t - 1)\Pi_t + \Theta(\varepsilon-1)\beta \frac{U_{c,t+1}}{U_{c,t}} (\Pi_{t+1} - 1)\Pi_{t+1} \frac{C_{t+1}}{C_t} - (1 - \Psi_t)\varepsilon = 0. \tag{2}$$

d) Show that the log-linearized version of equation around $\Pi = 1$, $\Psi = \frac{\varepsilon-1}{\varepsilon}$, and $C_t = C$ can be written as:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \frac{1}{\Theta} \widetilde{mc}_t. \tag{3}$$

where $\pi = (\Pi - 1)$ and $\widetilde{mc}_t = \frac{\Psi_t - \Psi}{\Psi}$.

e) Interpret equation (13).

Part C: Monetary policy under a Taylor rule (30%)

We will use the New Keynesian model to see how the economy responds to a cost-push shock when the central bank follows a Taylor rule. The model is

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

$$y_t = \mathbb{E}_t\{y_{t+1}\} - (i_t - \mathbb{E}_t\{\pi_{t+1}\}) \tag{5}$$

$$i_t = \phi_\pi \pi_t \tag{6}$$

$$u_t = \rho u_{t-1} + \varepsilon_t^u \tag{7}$$

$$\varepsilon_t^u \sim N(0, \sigma_u) \tag{8}$$

$$\kappa = \left(1 + \frac{\phi}{1-\alpha} + \frac{\alpha}{1-\alpha}\right)\frac{1}{\Theta} \tag{9}$$

where y is the output gap, π is inflation, i is the nominal interest rate, and u is a cost-push shock. $\beta \in [0,1)$, $\phi_\pi > 0$, $\rho \in [0,1)$, $\sigma_u > 0$, $\phi > 0$, $\alpha \in (0,1)$, and $\Theta > 0$ are parameters. Assume further ϕ_π is set such that the Taylor principle is satisfied.

a) Assume that

$$y_t = \psi_{yu} u_t, \quad \pi_t = \psi_{\pi u} u_t, \quad E_t\{y_{t+1}\} = \rho \psi_{yu} u_t, \quad E_t\{\pi_{t+1}\} = \rho \psi_{\pi u} u_t,$$

and show that

$$\psi_{yu} = -(\phi_\pi - \rho)\Lambda_u, \quad \psi_{\pi u} = (1-\rho)\Lambda_u, \quad \Lambda_u = \frac{1}{(1-\beta\rho)(1-\rho) + \kappa(\phi_\pi - \rho)}.$$

We use the following calibration: $\beta = 0.99$, $\phi = 5$, $\alpha = 0.25$, $\Theta = 46.6$, $\phi_\pi = 1.5$, and $\rho = 0.5$.

b) Figure 1 displays how the economy responds to the cost-push shock. Explain the economic interpretation.

c) Suppose now that $\phi = 1$, but all other parameters are the same. This is the dashed line in Figure 2. Explain the economic interpretation behind the change in impulse responses from the case with $\phi = 5$.

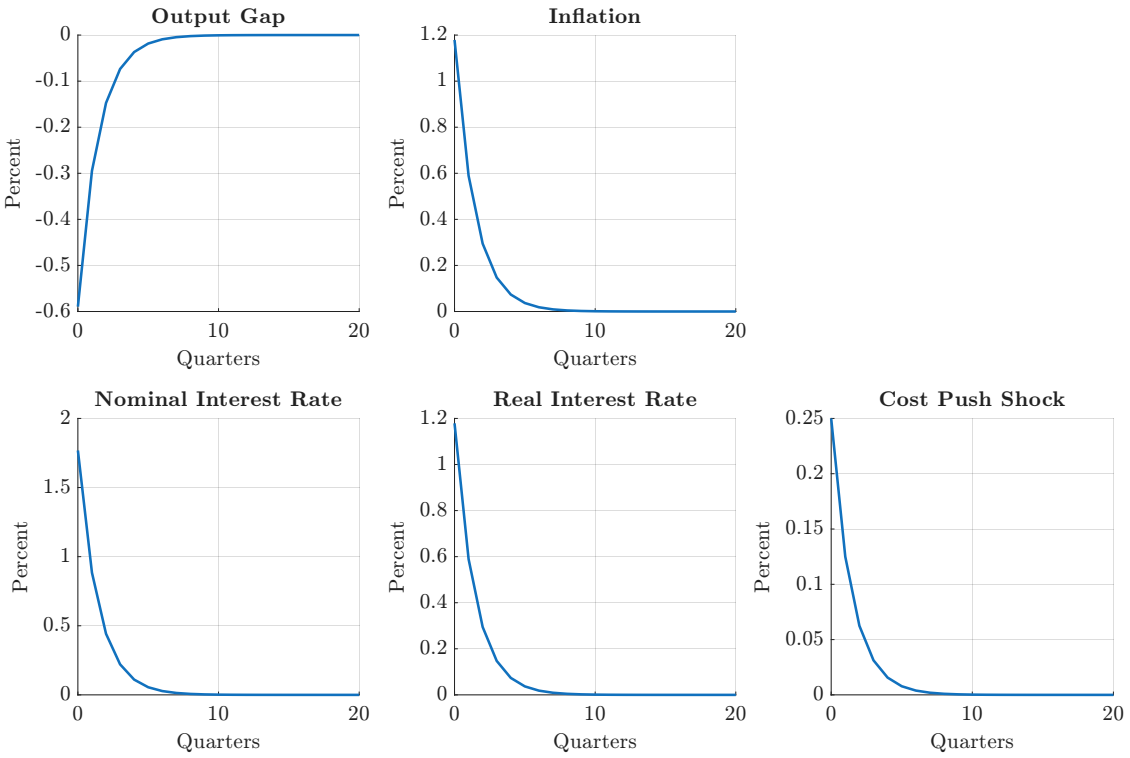


Figure 1: The responses to a cost-push shock

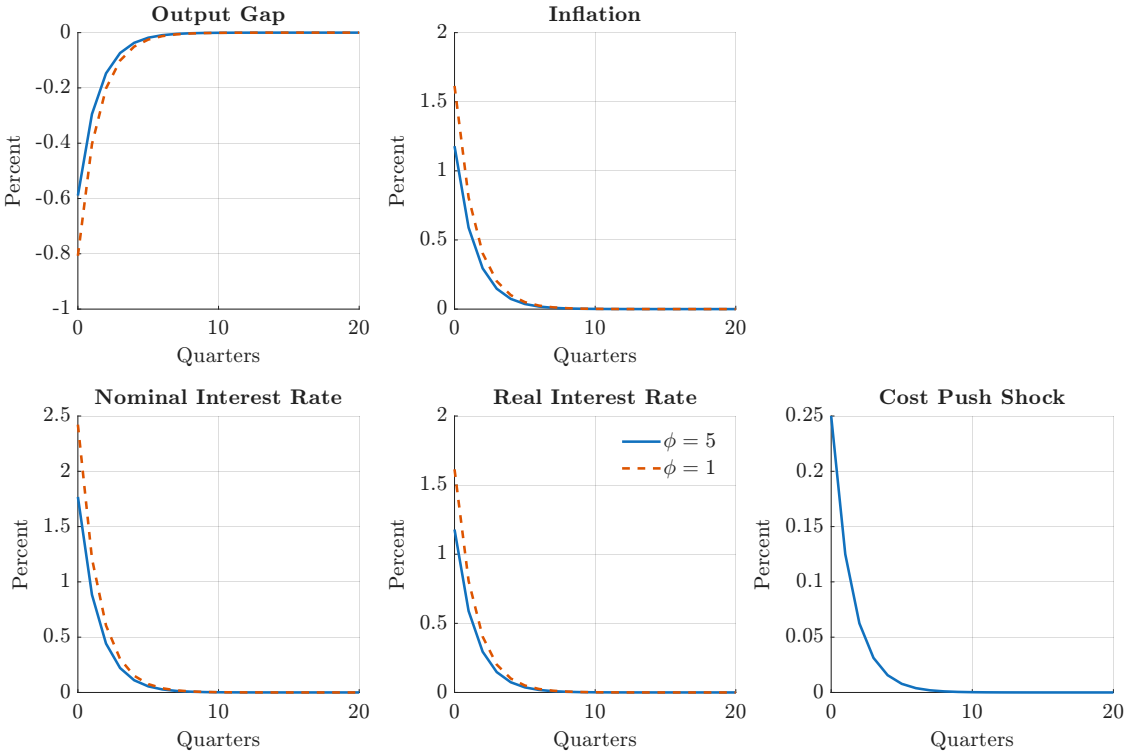


Figure 2: The responses to a cost-push shock with different ϕ

Part D: Monetary policy in closed and open economies (30%)

In a model for a small, closed economy, the following three equations can be derived:

$$\pi = \pi^e + \gamma y + u \tag{10}$$

$$\pi - \pi^* = -\frac{\lambda}{\gamma} y, \tag{11}$$

$$y = -\alpha(i - \pi^e - \rho) + v, \tag{12}$$

where i is the nominal interest rate, π is the inflation rate, π is the inflation expectation, π^* is the inflation target, y is the output gap, ρ is the lon-run equilibrium real rate, v is a demand shock, and u is an inflation shock. All parameters (λ, γ, α) are positive.

a) Discuss and derive the condition for optimal monetary policy (11) based on the closed economy model used in class.

b) How should a central bank react to the following shocks:

i. A negative inflation shock?

ii. A negative demand shock?

c) How should equations (10) and (12) be changed when we consider an open economy?

d) Explain how and why the responses to a demand shock will be different in an open economy compared to a closed economy.

Solution Proposal

Part A: Short questions on macroprudential policy (10%)

a) The financial sector may behave procyclically because the risk premia tend to decrease and bank credit standards loosen in upturns.

b) Macroprudential policy are polices aimed at reducing the risk of financial turbulence. These include capital buffer requirements that make banks more resilient, for example the countercyclical and systemic capital buffers, and lending regulations that reduce borrowing (and thus the vulnerability to shocks) among households, for example the downpayment requirements, the loan-to-income constraints, and the amortization requirements in the lending regulation in Norway.

Part B: The firm problem (30%)

a) Hours:

$$\frac{\partial \mathcal{L}_t}{\partial N_{i,t+k}} = -\frac{W_{t+k}}{P_{t+k}} + \Psi_{i,t+k} MPN_{i,t+k} = 0 \Rightarrow \Psi_{t+k} = \frac{W_{t+k}/P_{t+k}}{MPN_{t+k}}$$

and output:

$$\frac{\partial \mathcal{L}_t}{\partial Y_{i,t+k}} = \frac{P_{i,t+k}}{P_{t+k}} - \zeta_{i,t+k} - \Psi_{i,t+k} = 0 \Rightarrow \zeta_{t+k} = 1 - \Psi_{t+k}.$$

b) Ψ_{t+k} is the real marginal cost, ζ_{t+k} is the real marginal profits.

c) The first-order condition with respect to the price $P_{i,t}$ is:

$$\frac{\partial \mathcal{L}_t}{\partial P_{i,t}} = \frac{Y_{i,t}}{P_t} - \Theta(\varepsilon - 1)\left(\frac{P_{i,t}}{P_{i,t-1}} - 1\right)\frac{Y_t}{P_{i,t-1}} + \Theta(\varepsilon - 1)\beta \frac{U_{c,t+1}}{U_{c,t}}\left(\frac{P_{i,t+1}}{P_{i,t}} - 1\right)\frac{P_{i,t+1}}{P_{i,t}^2} Y_{t+1} - \zeta_{i,t}\varepsilon \underbrace{\left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon-1}\frac{Y_t}{P_t}}_{Y_{i,t}/P_{i,t}} = 0$$

which becomes

$$\frac{\partial \mathcal{L}_t}{\partial P_{i,t}} = 1 - \Theta(\varepsilon - 1)(\Pi_t - 1)\Pi_t + \Theta(\varepsilon - 1)\beta \frac{U_{c,t+1}}{U_{c,t}}(\Pi_{t+1} - 1)\Pi_{t+1}\frac{Y_{t+1}}{Y_t} - (1 - \Psi_t)\varepsilon = 0$$

when we note that $P_{i,t} = P_t$, $Y_{i,t} = Y_t$, and define $\Pi_t = P_t/P_{t-1}$.

d) The first-order Taylor approximation is (use that $\Pi = 1$ such that all the other terms in the Π_{t+1}-expression disappear)

$$-\Theta(\varepsilon-1)(2\Pi-\Pi)(\Pi_t-1)+\Theta(\varepsilon-1)\beta(2\Pi-\Pi)(\Pi_{t+1}-1)+\varepsilon(\Psi_t-\Psi)=0$$

which can be cleaned up to be

$$-\Theta(\varepsilon-1)(\Pi_t-1)+\Theta(\varepsilon-1)\beta(\Pi_{t+1}-1)+\varepsilon(\Psi_t-\Psi)=0.$$

Divide the first two terms by $\Pi = 1$ and multiply and divide the last term by Ψ to get

$$-\Theta(\varepsilon-1)\pi_t+\Theta(\varepsilon-1)\beta\pi_{t+1}+\varepsilon\Psi\widetilde{mc}_t=0$$

where $\widetilde{mc}_t = \frac{\Psi_t-\Psi}{\Psi}$. Use the definition of $\Psi = \frac{W/P}{MPN} = \frac{\varepsilon-1}{\varepsilon}$ to replace in the expression and get:

$$\pi_t = \beta\mathbb{E}_t\pi_{t+1}+\frac{1}{\Theta}\widetilde{mc}_t. \tag{13}$$

e) Inflation today is equal to the discounted sum of all future deviations of real marginal costs from their steady state. The sticky price version thus implies that the price setting of firms is forward-looking and depends on firms' expectations about future real marginal costs.

Part C: Monetary policy under a Taylor rule (30%)

b) Cost-push shock → higher inflation → CB responds by increasing the interest rate (sufficiently to increase the real rate) → lower output gap → reduced inflationary pressure

c) A lower ϕ means that labor supply is more elastic, such that labor supply moves more in response to changes in wages. In the Phillips curve, this logic is inverted: wages (and thus prices) move less to justify the change in output (labor supply). A lower ϕ thus reduces the slope in the Phillips curve, such that any reduction in output through the increase in the real interest rate has less effect on inflation. The total effect is that the central bank responds to the initial inflation shock by raising the interest rate (and the real interest rate), thereby lowering the output gap, which reduces the initial impact of inflation. Because the dampening effect on inflation is weaker, both the nominal and real interest rates will be higher, the output gap will be lower, and inflation will be higher.

Part D: Monetary policy in an open economy (30%)

a) Students should start with the loss function and derive the equation for optimal monetary policy. Then the student should discuss the implications of this rule. For example, the inflation and output gap should have opposite signs (or both be zero), and the trade-off should reflect that the marginal benefit of reducing inflation equals the marginal loss from reducing the output gap.

b) i. In response to a negative inflation shock, the central bank should lower the interest rate, such that the output gap becomes positive, reducing the fall in inflation. The size of this response depends on the central bank's relative weight on output in the loss function and how effective output is in reducing inflation.

ii. In response to a negative demand shock, the central bank should lower the interest rate enough to "cancel" out the demand impulse. For demand shocks in a closed economy, there are no trade-offs, so the central bank manages to ensure that both inflation and the output gap are at their targets.

c) The students must explain the intuition for how the exchange rate enters the Phillips curve (via import prices) and demand curve (via higher exports and lower imports).

d) In an open economy, it is no longer possible to fulle stabilize the economy when it is affected by a demand shock. The reason is that the interest rate also affects the exchange rate.