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 $\Psi_{t+k}$ and $\zeta_{t+k}$ 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 (3).

## 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, $\pi$ 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 $\phi_\pi$ 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 $\phi = 5$.

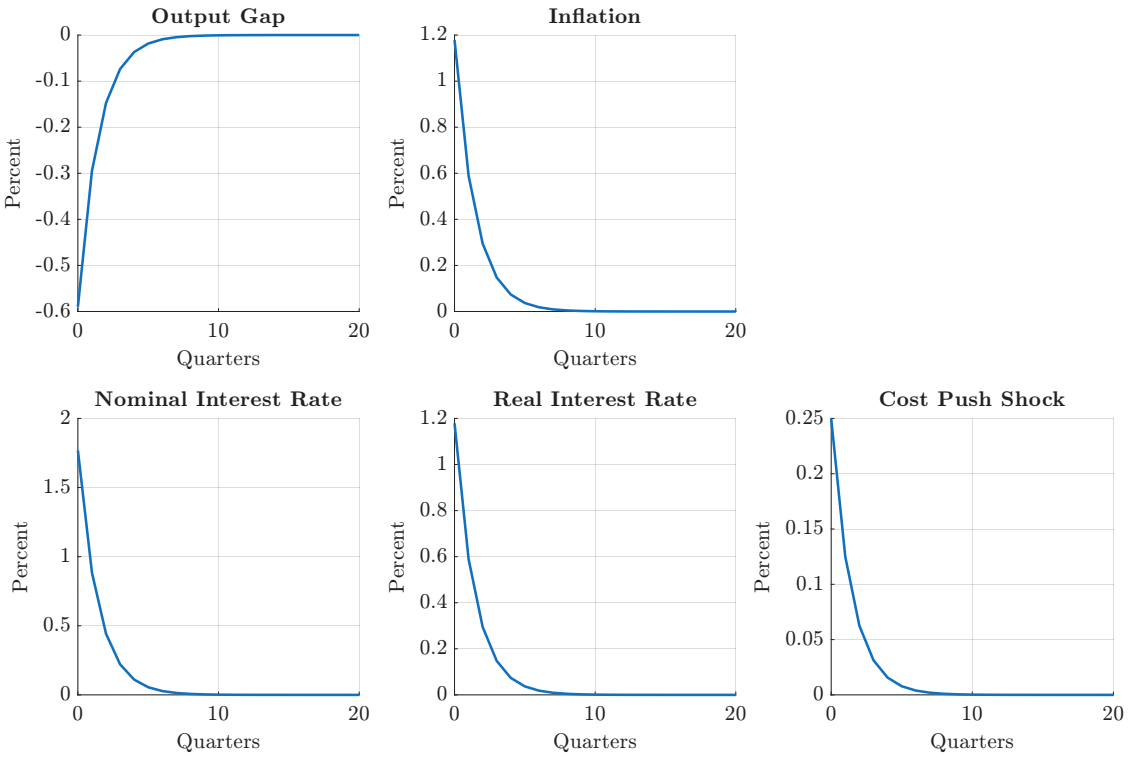



**Figure 1:** The responses to a cost-push shock

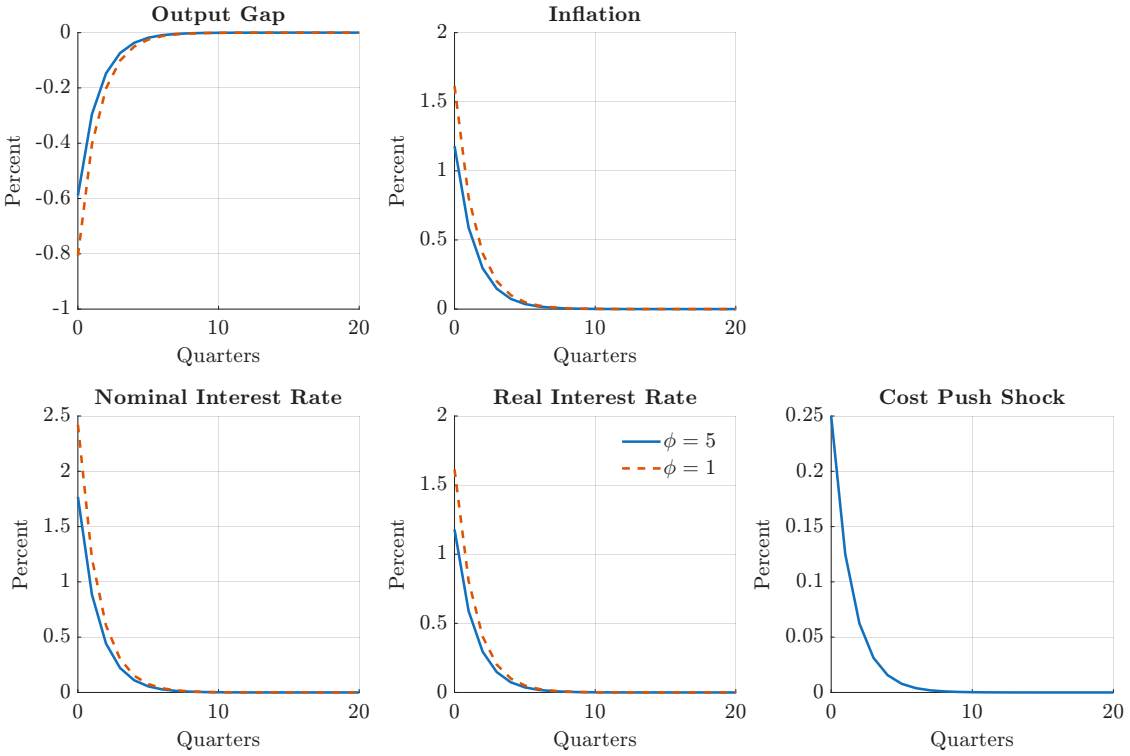



**Figure 2:** The responses to a cost-push shock with different $\phi$

## 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, $\pi$ is the inflation rate, $\pi$ is the inflation expectation, $\pi^*$ is the inflation target, $y$ is the output gap, $\rho$ is the lon-run equilibrium real rate, $v$ is a demand shock, and $u$ is an inflation shock. All parameters ($\lambda$, $\gamma$, $\alpha$) 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.