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%)

Section 3 in the "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.*

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

# Part B: The firm problem (30%)

The firm problem with sticky prices is:

$$\max_{P_t^*,\{N_{t+k|t},Y_{t+k|t}\}_{k=0}^{\infty}} \mathbb{E}_t \sum_{k=0}^{\infty} (\beta\theta)^k \left\{ \frac{U_{c,t+k}}{U_{c,t}} \frac{P_t}{P_{t+k}} \left(P_t^* Y_{t+k|t} - W_{t+k} N_{t+k|t}\right) \right\} \tag{1}$$

subject to

$$Y_{t+k|t} = N_{t+k|t}^{1-\alpha} \tag{2}$$

$$Y_{t+k|t} = \left(\frac{P_t^*}{P_{t+k}}\right)^{-\varepsilon} Y_{t+k} \tag{3}$$

where $P_t^*$ is the optimal price in period $t$, $U_{c,t+k}$ is the marginal utility of consumption in period $t+k$, $W$ is the aggregate nominal wage, $N$ is hours, $Y$ is aggregate output, $P$ is the aggregate price, $\alpha$ is the curvature of the production function, and the notation $\cdot_{t+k|t}$ denotes the value of that variable in period $t+k$ for a firm that last reset its price in period $t$.

**a)** Interpret equation (3). Where does it come from? What is $\varepsilon$?

**b)** Log-linearize equation (3).

**c)** The Lagrangian for the firm problem is

$$\begin{aligned} L_t =& \mathbb{E}_t \sum_{k=0}^{\infty} (\beta\theta)^k \frac{U_{c,t+k}}{U_{c,t}} \frac{P_t}{P_{t+k}} \Big[ P_t^* Y_{t+k|t} - W_{t+k} N_{t+k|t} \\ & - \zeta_{t+k|t} \left( Y_{t+k|t} - \left( \frac{P_t^*}{P_{t+k|t}} \right)^{-\varepsilon} Y_{t+k} \right) - \Psi_{t+k|t} \left( Y_{t+k|t} - N_{t+k|t}^{1-\alpha} \right) \Big]. \end{aligned}$$

Find the first order conditions with respect to hours $N_{t+k|t}$ and output $Y_{t+k|t}$ and solve for $\Psi_{t+k|t}$ and $\zeta_{t+k|t}$, respectively. What is $\Psi_{t+k|t}$ and what is $\zeta_{t+k|t}$?

**d)** One can combine the first order condition with respect to $P_t^*$ with the two first order conditions we have found in (c) to get the price setting equation

$$\sum_{k=0}^{\infty} \underbrace{\theta^k}_{(1)} \mathbb{E}_t \left\{ \underbrace{\beta^k \frac{U_{c,t+k}}{U_{c,t}} \frac{P_t}{P_{t+k}} Y_{t+k|t}}_{(2)} \underbrace{\left[ P_t^* - \frac{\varepsilon}{\varepsilon - 1} \Psi_{t+k|t} \right]}_{(3)} \right\} = 0. \tag{4}$$

Interpret the price-setting equation (4). The answer should explain the terms (1), (2), and (3) in the optimal price setting equation.

# Part C: Optimal monetary policy (30%)

We will use the New Keynesian model to see how the economy responds to a cost-push shock under optimal monetary policy. The model is

$$\pi_t = \beta \mathbb{E}_t\{\pi_{t+1}\} + \kappa x_t + u_t \tag{5}$$

$$x_t = \mathbf{E}_t\{x_{t+1}\} - \eta\left(i_t - \mathbf{E}_t\{\pi_{t+1}\}\right) \tag{6}$$

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

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

where $x$ is the output gap, $\pi$ is inflation, $i$ is the nominal interest rate, and $u$ is a cost-push shock. $\kappa > 0$, $\eta > 0$, $\beta \in [0, 1)$, $\rho \in [0, 1)$, and $\sigma_u > 0$ are parameters. Assume further that the central bank minimizes this loss function:

$$L_t = \frac{1}{2}\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k [\lambda x_{t+k}^2 + \pi_{t+k}^2] \tag{9}$$

with $\lambda \geq 0$.

**a)** Solve for optimal monetary policy under discretion and show that the first-order conditions can be combined to

$$x_{t+k} = -\frac{\kappa}{\lambda}\pi_{t+k} \quad \text{for} \quad k \geq 0. \tag{10}$$

**b)** Show that $\pi_t$ and $x_t$ can be written as functions of the cost-push shocks:

$$\pi_t = \frac{\lambda}{\kappa^2 + \lambda(1 - \beta\rho)} u_t,$$

$$x_t = -\frac{\kappa}{\kappa^2 + \lambda(1 - \beta\rho)} u_t.$$

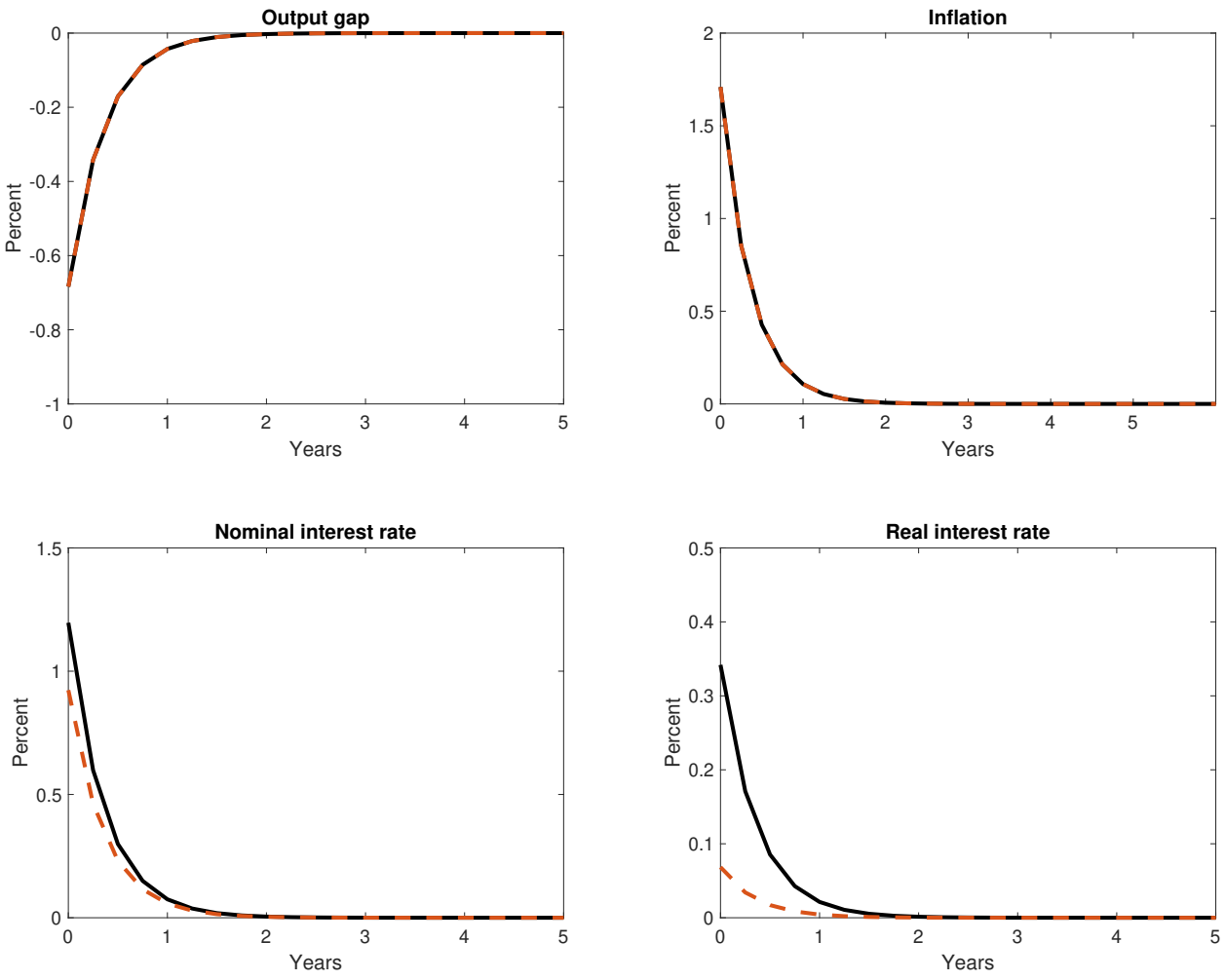



**Figure 1:** Impulse responses to a cost-push shock under two calibrations.

**c)** Figure 1 displays the response of the output gap, inflation, the nominal interest rate, and the real interest rate to a positive cost-push shock under discretion for two calibrations: one where $\eta = 1$ and one where $\eta = 5$. All other parameters are the same ($\kappa$, $\rho$, $\beta$, $\sigma_u$, $\lambda$). Why are the responses of output and inflation the same irrespective of the value of $\eta$? Which interest rate response (solid or dashed) corresponds to which calibration? Explain your answer.

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

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

$$\pi = \pi^e + \left(\gamma_1 + \frac{\gamma_2}{\alpha_1 + \alpha_2}\right) y + u^{\text{open}} \tag{11}$$

$$\pi - \pi^* = -\frac{\lambda}{\gamma_1 + \frac{\gamma_2}{\alpha_1 + \alpha_2}} y, \tag{12}$$

$$y = -(\alpha_1 + \alpha_2)(r - \bar{r}), \tag{13}$$

where

$$u^{\text{open}} = u + \frac{\gamma_2}{\alpha_1 + \alpha_2}[\alpha_1((r^* - \rho) + e^e + z) - v], \tag{14}$$

$$\bar{r} = \rho + \frac{1}{\alpha_1 + \alpha_2} v + \frac{\alpha_2}{\alpha_1 + \alpha_2}((r^* - \rho) + e^e + z), \tag{15}$$

$\pi$ is inflation, $y$ is the output gap, $\pi^e$ is expected inflation, $\pi^*$ is the inflation target, $v$ is a demand shock, $u$ is an inflation shock, $z$ is a risk-premium shock, and $\rho$, $r^*$, $e^e$, $\gamma_1$, $\gamma_2$, $\alpha_1$, and $\alpha_2$ are parameters.

**a)** Discuss the characteristics of a Central Bank's loss function in this model, and the condition for optimal monetary policy (12).

**b)** What determines the exchange rate in this model?

**c)** How should a central bank respond to the following shocks:

i. A negative demand shock?

ii. A negative risk premium shock?

**d)** What would be the optimal policy response to a negative demand shock if the authorities could use both fiscal and monetary policy?