The exam consists of four parts: A, B, C, and D. In the grading, part A has 10% weight, part B has 20% weight, part C has 45% weight, and part D has 25% weight. Allocate your time accordingly.

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

Write short answers to these questions (1-2 paragraphs).

a) Explain why banks' behavior could be pro-cyclical?

b) What is macroprudential policy?

Solutions:

a) *In upturns: risk premia decreases and bank credit standards loosen; in downturns: risk premia increases and credit standards tighten. Hence, bank lending tends to be pro-cyclical.*

In addition: because asset prices are higher in upturns, banks' assets tend to increase in value, increasing their capital ratio and thus allowing them to lend more. In downturns, the asset prices tend to fall, thus leading to lower capital ratio and further contraction of lending from banks.

To get a full score, the student should mention both these channels.

b) *Macroprudential policies consist of policies to dampen the severity of future fianncial crises. Examples include capital buffer requirements for banks (countercyclical and systemic) and lending regulation (e.g., loan-to-value or loan-to-income constraints on household borrowing or amortization requirements on debt).*

To get a full score, the student should explain what macroprudential policies are and include some real-world examples.

Part B: The household problem (20%)

The household problem is

$$\max_{\{C_t,N_t,B_t\}_{t=0}^{\infty}} \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \left(\frac{C_t^{1-\sigma}-1}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi} \right) \tag{1}$$

subject to

$$P_t C_t + \frac{B_t}{1+i_t} \leq B_{t-1} + W_t N_t + D_t \tag{2}$$

$$\lim_{T\to\infty} \mathbb{E}_t \left\{ \beta^{T-t} \frac{U_{C,T}}{U_{C,t}} \frac{B_T}{P_T} \right\} \geq 0 \tag{3}$$

where C_t is consumption, N_t is hours worked, B_t is nominal bonds, P_t is the price of consumption goods, i_t is the nominal interest rate, W_t is the nominal wage, D_t is nominal dividends from firms, $\beta \in [0,1]$ is the discount rate, $\sigma > 0$ is a parameter, and $\phi > 0$ is a parameter.

a) Solve the problem and show that the first-order conditions can be written as

$$C_t^{-\sigma} \frac{W_t}{P_t} = N_t^{\phi} \tag{4}$$

$$C_t^{-\sigma} = \beta(1+i_t)\mathbb{E}_t \left\{ C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} \right\} \tag{5}$$

b) Interpret equation (4) and (5). What are the trade-offs involved for the household?

c) Log-linearize equation (4).

Solutions:

a) *Form Lagrangian*

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi} - \lambda_t \left(P_t C_t + \frac{B_t}{1+i_t} - B_{t-1} - W_t N_t - D_t \right) \right).$$

The first-order conditions are

$$\frac{\partial \mathcal{L}}{\partial C_t} = \mathbb{E}_0 \beta^t \left(C_t^{-\sigma} - \lambda P_t \right) = 0, \tag{6}$$

$$\frac{\partial \mathcal{L}}{\partial N_t} = \mathbb{E}_0 \beta^t \left(-N_t^{\phi} + \lambda W_t \right) = 0, \tag{7}$$

$$\frac{\partial \mathcal{L}}{\partial B_t} = -\mathbb{E}_0 \beta^t \lambda_t \frac{1}{1+i_t} + \mathbb{E}_0 \beta^{t+1} \lambda_{t+1} = 0. \tag{8}$$

Combine (6) and (7) to get:

$$\frac{W_t}{P_t} = N_t^{\phi} C_t^{\sigma}.$$

And combine (6) and (8) to get:

$$C_t^{-\sigma} = \beta(1+i_t) \mathbb{E}_t \left(C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} \right).$$

b) *Equation (4):*

$$\frac{W_t}{P_t} C_t^{-\sigma} = N_t^{\phi}$$

Intuition: Working one more hour makes me $\frac{W_t}{P_t} C_t^{-\sigma}$ better off because I can consume more, but also makes me N_t^{ϕ} worse off because I dislike working. At the optimum, these two are equal.

Equation (5):

$$C_t^{-\sigma} = \beta(1+i_t) C_{t+1}^{-\sigma} \left(\frac{P_t}{P_{t+1}} \right)$$

Intuition: trade-off between consuming today or tomorrow. LHS: marginal utility from consuming one more unit today. RHS: discounted marginal utility from saving one more unit today and consuming it tomorrow. At the optimum, these two are equal.

c) *The student can use any method to get $-\sigma c_t + w_t - p_t = \phi n_t$.*

Part C: Optimal monetary policy (45%)

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

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa x_t + u_t \tag{9}$$
$$x_t = E_t\{x_{t+1}\} - (i_t - E_t\{\pi_{t+1}\}) \tag{10}$$
$$u_t = \rho u_{t-1} + \varepsilon_t^u \tag{11}$$
$$\varepsilon_t^u \sim N(0, \sigma_u) \tag{12}$$

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

$$L_t = \frac{1}{2}\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k [\lambda x_{t+k}^2 + \pi_{t+k}^2] \tag{13}$$

with $\lambda \geq 0$.

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

$$x_{t+k} = -\frac{\kappa}{\lambda}\pi_{t+k} \quad \text{for} \quad k \geq 0. \tag{14}$$

b) Interpret (14). Which trade-off does the central bank face?

c) Show that π_t and x_t can be written as functions of the cost-push shocks:

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

d) Assume that the central bank commits to a response function of the following form

$$x_t = -\omega u_t. \tag{15}$$

Show that the Phillips curve in this case can be written as

$$(1-\beta\rho)\pi_t = \kappa x_t + u_t.$$

e) Solve for optimal monetary policy under commitment to the simple rule (15) and show that the condition is

$$x_{t+k} = -\frac{\kappa}{\lambda(1-\beta\rho)}\pi_{t+k} \quad \text{for} \quad k \geq 0. \tag{16}$$

f) Interpret (16). Compare the solution under an optimal simple rule (16) with the solution under discretion (14). Why do the two solutions differ? What are the gains from commitment?

g) Figure 1 shows how output gap, inflation, the nominal interest rate, and the real interest rate respond to a positive cost-push shock under discretion and under commitment to a simple rule. Explain which line (solid or dashed) corresponds to which type of monetary policy (discretion or commitment). Justify your answer.

Hint: The calibration is $\beta = 0.99$, $\kappa = 0.2$, $\lambda = 0.3$, and $\rho = 0.75$ (this is not strictly necessary to answer this problem but might help to interpret what is going on).

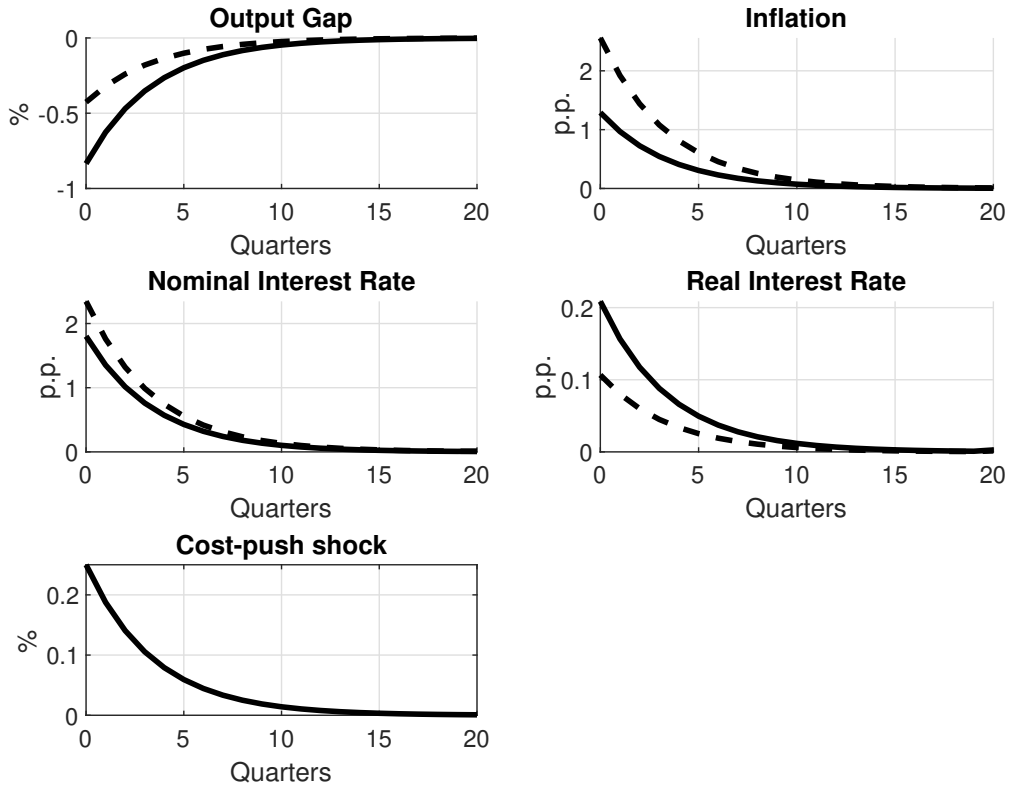


Figure 1: Discretion vs. Optimal Simple Rule: Impulse Responses to a Cost-Push Shock.

Solutions:

a) *Minimize the loss function subject to the Phillips curve, ignoring all future components. The problem is then*

$$\min_{x_t,\pi_t} \frac{1}{2}(\lambda x_t^2 + \pi_t^2 + F_t) - \gamma(\pi_t - \kappa x_t - f_t)$$

with the first-order conditions

$$\begin{aligned} \lambda x_t + \gamma\kappa &= 0 \\ \pi_t - \gamma &= 0. \end{aligned}$$

Combine these two to get (14).

b) *Equation* (14) *can be written as*

$$\lambda x_t = -\kappa\pi_t.$$

The left-hand side is the marginal cost of one more unit of recession, while the right-hand side is the marginal benefit of one more unit of recession in terms of lower inflation. The central bank chooses a policy in which the marginal benefit equals the marginal loss.

c) *Use equation* (14) *to replace for* x_t *in the Phillips curve*

$$\pi_t = \frac{\lambda}{\lambda + \kappa^2}\left(\beta\mathbb{E}_t\pi_{t+1} + u_t\right).$$

Guess that

$$\pi_t = \psi u_t, \quad \pi_{t+1} = \rho\psi u_t$$

and replace

$$\psi u_t = \frac{\lambda}{\lambda + \kappa^2}\left(\beta\rho\psi u_t + u_t\right).$$

Divide through by u_t *and solve*

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

which implies that

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

d) *Assume that the central bank commits to $x_t = -\omega u_t$. Insert into the Phillips curve to get*

$$\begin{aligned}
\pi_t &= \beta \mathbb{E}_t \pi_{t+1} + (1 - \kappa\omega) u_t \\
\pi_t &= \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k (1 - \kappa\omega) u_{t+k} \\
\pi_t &= \sum_{k=0}^{\infty} \beta^k \rho^k (1 - \kappa\omega) u_t \\
\pi_t &= \left(\frac{1 - \kappa\omega}{1 - \beta\rho} \right) u_t
\end{aligned}$$

which is the same as

$$\pi_t (1 - \beta\rho) = \kappa x_t + u_t.$$

e) *The problem is then*

$$\min_{x_t, \pi_t} \frac{1}{2} \sum_{k=0}^{\infty} \left((\lambda x_{t+k}^2 + \pi_{t+k}^2) - \gamma_t (\pi_{t+k}(1 - \beta\rho) - \kappa x_{t+k}) \right)$$

with the first-order conditions

$$\begin{aligned}
\lambda x_t + \gamma\kappa &= 0 \\
\pi_t - \gamma(1 - \beta\rho) &= 0.
\end{aligned}$$

Combine these two to get (16).

f) *Compared with the solution under discretion, it is now optimal for the central bank to engineer a greater contraction in output per inflationary pressure. Why? Because price-setting depends on expectations of future economic conditions, a central bank that can credibly commit to a rule faces an improved trade-off between inflation and output. The improved trade-off comes because future output changes affect inflation also in periods before such that the benefit of reducing inflation per unit of recession is greater.*

g) *The dashed line is the discretion solution while the solid line is the commitment solution. The student can argue via the optimality conditions in which the commitment solution should have more output gap per unit of inflation (the solid line). Another alternative is to compute the actual solution as in (c) and compare but it is not necessary.*

Part D: Monetary and fiscal policy in an open economy (25%)

Assume we are in a small open economy that takes global market prices (π^*) and interest rates (r^*) as given. The macroeconomic policy consists of setting the interest rate (r, monetary policy) and determining the size of public expenditures (g, fiscal policy). The optimal response of monetary and fiscal policy to shocks (u, z, v) are

$$r = \frac{1}{\gamma_2}[(\pi^e - \pi^*) + u] + (e^e + r^* + z), \tag{17}$$

$$g = -\frac{1}{\alpha_3}v + \frac{\alpha_1 + \alpha_2}{\alpha_3\gamma_2}[(\pi^e - \pi^*) + u] + \frac{\alpha_1}{\alpha_3}(e^e + r^* + z) \tag{18}$$

where π^e is inflation expectation, π^* is the inflation target, y is the output gap, e^e is the expected exchange rate, v is a demand shock, u is an inflation shock, and z is a risk premium shock. All parameters (γ_2, α_1, α_2, and α_3) are positive.

a) Discuss how monetary and fiscal policy should react to

(i) a negative demand shock (v)

(ii) a negative inflation shock (u)

(iii) an increase in foreign interest rates (r^*)

b) What does the analysis in (a) tell you about the interaction between monetary and fiscal policy?

c) What is the Tinbergen rule?

Solutions:

a) (i) A negative demand shock (v): *If the central bank lowers interest rates in response to a negative demand shock to prevent a reduction in y, inflation will become too high because the exchange rate weakens as a result of the lower interest rates. Therefore, in an open economy, monetary policy cannot simultaneously shield both the real economy and inflation from the effects of a demand shock (see slide 5 – left-hand chart)). On the other hand, expansionary fiscal policy can shield both the real economy and inflation from the effects of a demand shock because it does not directly affect the exchange rate. The mechanism is to replace lower private demand (negative shock) with higher government demand.*

(ii) A negative inflation shock (u): *If the interest rate is decreased and fiscal policy is contractionary, the output gap can still remain unchanged, but inflation will be higher because the exchange rate depreciates as a result of the lower interest rate. With an optimal combination of expansionary monetary policy and contractionary fiscal policy, the decrease in inflation can be completely offset by a weaker exchange rate without the need for the output gap to become positive. The divergent policy composition allows the exchange rate channel to be more effectively utilized, enabling the simultaneous achievement of price and output stability.*

(iii) An increase in foreign interest rates (r^*): *We can see from the equations that the optimal policy mix implies that the central bank should increase policy rates by the same amount as the increase in the foreign policy rates. The exchange rate equation implies that the policy rate is set high enough for the exchange rate to return to its initial level before the shock occurred. However, the increased policy rate, in isolation, would reduce the level of activity. Fiscal policy can counteract this with an expansionary policy. Thus, with the combination of higher interest rates, which counteracts the depreciation of the exchange rate, and expansionary fiscal policy, which neutralizes the effect of increased interest rates on the real economy, both inflation and output stability can be achieved.*

b) *We can see from the equations that monetary and fiscal policy should respond divergently to all shocks except demand shocks (where only fiscal policy should respond). Therefore, the policy instruments should generally pull in opposite directions. Fiscal policy should be expansionary (high g) when monetary policy is contractionary (high r), and vice versa. It follows from this that monetary policy has a stronger impact on inflation relative to output compared with fiscal policy. In other words, compared with monetary policy, fiscal policy has a relatively stronger effect on output than it has on inflation. The comparative advantage of*

monetary policy lies in its ability to influence inflation, while the comparative advantage of fiscal policy lies in its ability to influence output.

c) *Tinbergen rule: governments must use multiple policy instruments if they want to achieve multiple policy targets. In the case of the model above: fiscal & monetary policy allow full stabilization of inflation and output because we have two goals and two instruments (and the two instruments do not affect the economy in exactly the same way).*