The exam consists of three parts: A, B, and C. In the grading, part A is given 30 % weight, part B is given 20 % weight, and part C is given 50 % weight. The max page limit should be respected, but is not required (a shorter answer may be just as good).

Part A (30 %)

This part contains three short problems. You need to answer all three of them to get full score.

a)

In the standard New-Keynesian model, the slope of the Phillips curve (κ), is defined as:

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

- Explain what θ is and why $\frac{\partial \kappa}{\partial \theta} < 0$.
- Explain what ϵ is and why $\frac{\partial \kappa}{\partial \epsilon} < 0$.

Sketch of answer.

θ is the probability that firm i is not allowed to change prices in any period and/or the share of firms that do not change prices in any period. θ has two effects on κ.

Effect 1: $\theta \uparrow$, then fewer firms change prices and so changes in optimal price have less effect on aggregate inflation.

Effect 2: if $\theta \uparrow$, then firms expect to be stuck with the price for a longer period and is more reluctant to change prices in response to short-run fluctuations in demand.

ϵ is the elasticity of substitution between goods. If ϵ is higher, a deviation from optimal prices results in a bigger change in demand. A higher ϵ therefore makes firms more reluctant to change prices because the cost of having the wrong price in the future is greater. Thus $\frac{\partial \kappa}{\partial \epsilon} < 0$.

b)

Imagine that you are a senior advisor at a central bank. The central bank follows a flexible inflation targeting regime. The output and inflation gaps are negative, and the nominal

Central Bank		Banks		Households/Firms	
Assets	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**
Bonds	Reserves	Reserves Bonds Loans	Deposits Equity	Capital/housing Deposits Bonds	Loans Equity

Figure 1: Simplified balance sheets

interest rate is 0 %. The governor wants to evaluate whether quantitative easing or credit easing might help the central bank in achieving the monetary policy targets. Write a note where you

i) Describe what quantitative easing and credit easing is.

ii) Describe the theory underpinning each of the two balance sheet policies.

iii) Provide a recommendation on future action.

Your written answer should be no more than three pages long.

Sketch of answer. *There is no right answer. A good response should:*

- *Show that the student understands the difference between quantitative easing (QE) and credit easing (CE).*
- *Describe the bank lending channel and link it to QE.*
- *Provide theory/intuition for why QE and CE affect banks differently.*
- *Argue with support from empirical evidence and/or theory for why the central bank should pursue either or none of the balance sheet options available.*
- *Be well-structured, coherent, and easy to read and understand.*
- *Other moments that can be discussed, but are not necessary parts of the curriculum: helicopter drop (sidestepping the bank system), distributional effects of balance sheet policies, costs of balance sheet policies, ...*

c)

The definition of GDP in a closed economy is

$$Y_t = C_t + I_t + G_t \tag{1}$$

where Y_t is GDP, C_t is consumption, I_t is investment, and G_t is government spending. Log-linearize equation (1).

Sketch of answer.

$$\tilde{y}_t = \frac{C}{Y}\tilde{c}_t + \frac{I}{Y}\tilde{i}_t + \frac{G}{Y}\tilde{g}_t$$

Part B (20 %)

In this problem, we are going to solve the household problem under various assumptions. The household problem is:

$$\max_{C_t, N_t, B_t} \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k U(C_{t+k}, N_{t+k}) \tag{2}$$

subject to

$$P_t C_t + \frac{B_t}{1+i_t} \leq B_{t-1} + W_t N_t + D_t \tag{3}$$

$$\lim_{T\to\infty} \mathbb{E}_t \left\{ \beta^{T-t} \frac{U_{C,T}}{U_{C,t}} \frac{B_T}{P_T} \right\} \geq 0 \tag{4}$$

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 dividends from firms, $\beta \in [0, 1)$ is the discount rate, and U is the utility function.

a)

Assume that $U(C_t, N_t) = \frac{C_t^{1-\sigma}-1}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi}$ and show that the first order conditions can be combined to

$$C_t^{-\sigma} \frac{W_t}{P_t} = N_t^{\phi} \tag{5}$$

$$C_t^{-\sigma} = \beta(1+i_t)\mathbb{E}_t \left\{ C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} \right\} \tag{6}$$

Sketch of answer. *Since the student is given the answer, it is important that the steps are* *correct. In particular, the first order condition with respect to bonds tends to be wrong.*

b)

Interpret equation (5) and (6). What are the trade-offs involved for the household?

Sketch of answer. *Equation* (5)*: intratemporal consumption-leisure choice. The marginal utility of working one more hour and consuming the income is equal to marginal dis-utility from working one more hour.*
Equation (6)*: intertemporal consumption choice. The marginal utility of one more unit of consumption today should equal the discounted marginal utility of saving today, earn interest, and consume tomorrow.*

c)

Assume now that $U(C_t, N_t) = \frac{1}{1-\sigma}\left(C_t - \frac{N_t^{1+\phi}}{1+\phi}\right)^{1-\sigma}$ (Greenwood-Hercowitz-Huffman preferences) and show that the intratemporal consumption-labor choice is

$$\frac{W_t}{P_t} = N_t^{\phi} \tag{7}$$

d)

Consider now an economy with a distribution of households. How would you approach data to distinguish between the two models of labor supply (equation (5) and (7))? Which model do you think is most reasonable?

Hint: What does the two models imply for the labor supply of rich (consume much) and poor households? Who should work most (rich or poor, high or low wages)?

Sketch of answer.

- *The two solutions differ in how the marginal utility of consumption enters the problem.*
- *The student should explain why/why not marginal utility of consumption should affect optimal labor supply (the wealth effect).*
- *The GHH-model implies that (i) every person with the same wage works equally much, and (ii) people with higher wages work more, while those with low wages work less.*
- *The separable formulation implies that (i) for the same wage: rich people work less than poor; but (ii) if rich people work more, they have to earn more as well.*

- *The student should show that he/she is able to connect model and data in a meaningful way.*

Part C (50 %)

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

$$L_t = \frac{1}{2}\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k [\lambda x_{t+k}^2 + \pi_{t+k}^2] \tag{8}$$

$$\pi_t = \kappa x_t + \beta \mathbb{E}_t \pi_{t+1} + u_t \tag{9}$$

$$x_t = -\eta[i_t - \mathbb{E}_t \pi_{t+1}] + \mathbb{E}_t x_{t+1} \tag{10}$$

$$u_t = \rho u_{t-1} + \epsilon_t \tag{11}$$

$$\epsilon_t \sim N(0, \sigma_\epsilon) \tag{12}$$

where x_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 (8) subject to the model equations.

a)

Solve the problem above for **optimal monetary policy under discretion** and show that the first order conditions can be combined to yield the "leaning against the wind" condition:

$$\lambda x_t = -\kappa \pi_t \tag{13}$$

b)

Interpret the "leaning against the wind" condition (13). When is it optimal to fully stabilize output and when is it optimal to fully stabilize inflation?

Sketch of answer. *The central bank has to move output to affect inflation. The marginal cost from changing output (λx_t) should equal the marginal benefit from affecting inflation ($-\kappa x_t$). If $\kappa = 0$, output should be fully stabilized, while if $\lambda = 0$, inflation should be fully stabilized. The student should show an appreciation of what λ and κ governs and why they enter the first-order condition.*

c)

Solve the model under discretion such that π_t, x_t, and i_t are functions only of the cost-push shock (u_t).

Sketch of answer. *Note that the exam reveals the solution to π and x_t implicitly in the next problem such that it is not enough to get the right answer, but the student must also get all the calculations are correct.*

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

d)

Assume now that the central bank for some reasons wants the output gap to be positive by b units:

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

and that the Phillips curve has no discounting:

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

The model solution is now:

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

Explain the intuition for why b only enters optimal solution for inflation, but not output.

Sketch of answer. *b is how much more output the central bank wants to have relative to potential output. It enters in the path of optimal inflation, but not for output - the inflationary bias. The intuition is that as the central bank systematically wants output above target, the agents perceive this and expect higher inflation. In the specific setting in this problem, the central bank does not affect output because higher expected inflation induces it to reduce output - and this effect exactly cancels the initial bias. The result is that a preference for higher output only affects inflation and not output.*

e)

Under optimal monetary policy under (unconstrained) commitment, the first order conditions can be rewritten to yield:

$$\lambda x_{t+k} = -\kappa \sum_{j=0}^{k} \pi_{t+j} \tag{14}$$

Interpret equation (14). Explain why it is different from the "leaning against the wind" condition under discretion (13).

Sketch of answer. *Under commitment, the central bank can now commit to a response pattern in the future. In the specific setting of the current model (with a strong forward guidance puzzle), any change in future output affects inflation in all prior periods. The new first order condition is then (14) where the marginal loss from changing output in period $t+k$ (LHS) is weighted against the gains from affecting inflation in all prior periods (RHS).*

Under discretion, there is no sum on the RHS since the central bank cannot commit and thus the change in output in any future period will not affect inflation in any other period than in that same future period, equation (13).