# Problem Set 10

ECON 30020: Intermediate Macroeconomics
Professor Sims
University of Notre Dame, Spring 2018

**Instructions:** You may work on this problem set in groups of up to four people. Should you choose to do so, please make sure to legibly write each group member's name on the first page of your solutions. This problem set is due in class on Thursday April 26.

1. **The Paradox of Toil:** Consider the macroeconomic models with which we have been working. There are in essence three versions of the model – the neoclassical model, the New Keynesian model, and the New Keynesian model with a binding ZLB. The New Keynesian model differs from the neoclassical model in that we replace the labor demand function with the $AS$ curve. The New Keynesian model with a binding ZLB in turn assumes that the real interest rate is fixed at the negative of the rate of expected inflation, i.e. $r_t = -\pi^e_{t+1}$.

   Suppose that there is a shock which makes the household want to work more; i.e. there is a reduction in the exogenous variable $\theta_t$.

   (a) Use the IS-LM-AD-AS diagrams to graphically analyze what happens to $Y_t$, $N_t$, and $w_t$ in the neoclassical model when there is a reduction in $\theta_t$.

   (b) Repeat this analysis but in the partial sticky price model where $P_t = \bar{P}_t + \gamma(Y_t - Y_t^f)$. Ignore the ZLB. Do output, labor input, and the real wage react more or less to the reduction in $\theta_t$ in comparison to the neoclassical model?

   (c) Now consider a reduction in $\theta_t$ in the New Keynesian model in which the ZLB is binding. Compare your answers to the previous parts and provide some intuition for why they differ. Why is the result here sometimes called a "paradox"?

2. **The Fiscal Multiplier at the ZLB:** Consider a simple sticky price model. To make life easy, let us dispense with Ricardian Equivalence and make the consumption function not forward-looking. There is no capital or investment. Production is linear in labor input. The equations characterizing the equilibrium of the model ignoring the ZLB are:

$$C_t = a(Y_t - T_t) - br_t$$

$$N_t = \frac{1}{\theta_t} w_t$$

$$Y_t = N_t$$

$$Y_t = C_t + G_t$$

$$P_t = \bar{P}_t$$
$$\frac{M_t}{P_t} = cY_t - di_t$$
$$r_t = i_t - \pi^e_{t+1}$$

$T_t$, $G_t$, $\theta_t$, $\bar{P}_t$, $M_t$, and $\pi^e_{t+1}$ are all taken to be exogenous. The endogenous variables are $C_t$, $Y_t$, $r_t$, $N_t$, $w_t$, $P_t$, and $i_t$. Because we are dispensing with Ricardian Equivalence, we can treat $T_t$ and $G_t$ as both being exogenous without specifying anything about the government needing to balance its budget in an intertemporal sense. $a$, $b$, $c$, and $d$ are parameters that are assumed to be non-negative; we assume further that $0 < a < 1$ since $a$ here corresponds to the MPC.

(a) Combine these equations to derive an algebraic expression for the $IS$ curve.

(b) Combine the relevant equations to derive an algebraic expression for the $LM$ curve.

(c) Use previous answers to derive an expression for the $AD$ curve.

(d) Combine the $AD$ curve with the $AS$ curve ($P_t = \bar{P}_t$) to express output, $Y_t$, as a function of exogenous variables.

(e) Derive an expression for the *balanced budget* fiscal multiplier; i.e. $\frac{dY_t}{dG_t}$ when it is assumed that $G_t = T_t$. Argue that the balanced budget fiscal multiplier is positive but less than one. Provide some intuition for your answer.

(f) Now derive an expression for the *deficit financed* fiscal multiplier; i.e. $\frac{dY_t}{dG_t}$ when $T_t$ is held fixed when $G_t$ changes. Argue that the deficit financed fiscal multiplier must be non-negative but could be greater than one. How does the value of the parameter $b$ influence whether the multiplier can be greater than one?

(g) Now suppose that the ZLB binds and $i_t = 0$. This means that $r_t = -\pi^e_{t+1}$ is the effective of LM curve (which is different than what you should have found above). Now derive an expression for the deficit financed fiscal multiplier and compare it to your previous answers. Does the value of the parameter $b$ influence the value of the multiplier? Why or why not?