

**PROBLEM SET 4**  
**14.02 Macroeconomics**  
**April 5, 2006**  
**Due April 12, 2006**

I. Answer each as True, False, or Uncertain, and explain your choice.

1. Even in the absence of technological progress, growth could go on forever if capital never depreciated.
2. The more you save the more your country will keep growing in the long run.
3. The U.S. capital stock is far below the golden rule level, therefore, individuals should increase their saving.
4. The convergence hypothesis states that, everything else being equal, the absolute increase of output per capita in small countries will be larger than in large countries.
5. Output per capita in the United States is roughly equal to 60% of output per worker.

II. Short Questions

1. The Effects of a Permanent Decrease in the Rate of Nominal Money Growth  
 Suppose that the economy can be described by the following three equations:

$$\begin{array}{ll}
 u_t - u_{t-1} = -0.4(g_{yt} - 3\%) & \text{Okun's law} \\
 \pi_t - \pi_{t-1} = -(u_t - 5\%) & \text{Phillips curve} \\
 g_{yt} = g_{mt} - \pi_t & \text{Aggregate demand}
 \end{array}$$

- a. Reduce the three equations to two by substituting  $g_{yt}$  from the aggregate demand equation into Okun's law. Write down the dynamic system of two equations, one of which shows  $u_t$  as a function of  $u_{t-1}$ ,  $\pi_{t-1}$ ,  $g_{mt}$  and a constant, and the other shows  $\pi_t$  as a function of  $u_{t-1}$ ,  $\pi_{t-1}$ ,  $g_{mt}$  and a constant. The current inflation and unemployment rate ( $\pi_t, u_t$ ) are determined by the past ( $\pi_{t-1}, u_{t-1}$ ) and the exogenously given monetary policy ( $g_{mt}$ ).

Assume initially that  $u_t = u_{t-1} = 5\%$ ,  $g_{mt} = 13\%$ , and  $\pi_t = 10\%$ . Now suppose that money growth is permanently reduced from 13 to 3%, starting in year  $t$ .

- b. Calculate the final values of the unemployment rate and the inflation rate in the medium-run equilibrium, i.e.,  $(\pi_T, u_T)$  where  $T$  denotes the time when the economy has reached the medium-run equilibrium with  $g_{mt} = 3\%$ . Compare your results with the initial  $(\pi, u)$ .
- c. Now focus on the dynamics. Based on the system of equations you obtained in part (a), compute (using a software of your choice, e.g. Excel<sup>®</sup>) the unemployment and the inflation rate in year  $t, t + 1, \dots, t + 10$ .

Instructions:

- i. In a spreadsheet, label the first row as follows:

$s$	$u_t$	$\pi_t$	$g_{mt}$	$\bar{g}_y$	$u_n$
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- ii. Fill up row 2 by the given values for time  $s = t$ .
- iii. Fill up the next 10 rows of the columns corresponding to  $g_{mt}$ ,  $\bar{g}_y$ ,  $u_n$ . Note:  $g_{mt} = 3\%$  for all  $s \geq t$ ,  $\bar{g}_y = 3\%$ ,  $u_n = 5\%$ .
- iv. Fill up  $B3$  and  $C3$  (corresponding to  $u_t$  and  $\pi_t$ ) by using the equations you derived in part (a). Type ‘=’ in an empty cell to start entering an equation. Excel will calculate the numerical value automatically after you finish typing your equation and hit the ‘enter’ key. Note: while typing an equation, you should refer to the cell that contains the value instead of writing down the value directly. For example, if your equation says  $u_{t+1} = g_{mt+1} + (u_t - u_n)$ , type “=  $D3 + (B2 - F3)$ ” instead of “=  $3\% + (5\% - 5\%)$ ” in cell  $B3$  (the cell representing for  $u_{t+1}$ ).
- v. “Copy”  $B3$  and  $C3$  simultaneously, then “paste” them to  $B4$  and  $C4$ , and all the way to row 12 (for  $s = t + 10$ ). Label the time column  $s$ .
- vi. Print your spreadsheet in one page and include it in your answer key.
- d. Does inflation decline smoothly from 10% to 3%? Why or why not?

## 2. The Facts of Growth

In this problem, we compare Russian and U.S. GDP per capita using current exchange rates and the PPP method.

- a. According to the International Financial Statistics (IFS), in 2000, Russian GDP was 7,305.65 billion rubles, and the Russian population was 146.56 million. Compute Russian GDP per capita in rubles. The IFS gives the average exchange rate for 2000 as 28.129 rubles per dollar. Divide Russian GDP per capita by the exchange rate to convert the number to dollars.
- b. The IFS gives U.S. GDP as \$9,816.97 billion in 2000 and the U.S. population as 284.15 million. Compute U.S. GDP per capita in dollars.
- c. Using the exchange rate method, what was Russian GDP per capita in 2000 as a percentage of U.S. GDP per capita. [Divide your answer in part (a) by your answer in part (b).]
- d. In the Penn World tables ([pwt.econ.upenn.edu](http://pwt.econ.upenn.edu)), retrieve Russian GDP per capita in 2000 as a percentage of U.S. GDP per capita in PPP terms. This data item is “CGDP Relative to the United States.”
- e. Why do the numbers in part (c) and (d) differ?

## 3. Saving, Capital Accumulation, and Output

(This problem is based on the material in the appendix.) Suppose that the economy’s production is given by

$$Y = K^\alpha N^{1-\alpha}.$$

- a. Is this production function characterized by constant returns to scale? Explain.
- b. Are there decreasing returns to capital?

- c. Are there decreasing returns to labor?
- d. Transform the production function into a relation between output per worker and capital per worker.
- e. For a given saving rate ( $s$ ) and a depreciation rate ( $\delta$ ), give an expression for capital per worker in the steady state.
- f. Give an expression for output per worker in the steady state.

Assume that  $\alpha = \frac{1}{3}$ .

- g. Solve for the steady-state level of output per worker when  $\delta = 0.08$  and  $s = 0.32$ .
- h. Suppose that the depreciation rate remains constant at  $\delta = 0.08$  while the saving rate is reduced by half to  $s = 0.16$ . What is the new steady-state output per worker?