

NAME: FU MANCHU

ID :

ECO2143 Macroeconomic Theory II  
First mid-term examination: March 5th, 2012  
University of Ottawa  
Professor: Louis Hotte  
Time allotted: 1h 20min

*Attention: Not all questionnaires are the same. This is questionnaire C. On the answer sheet, you must indicate the letter of your questionnaire with the course's number as follows: ECO2143C. You must answer according to the material seen in this course. Read all answer choices before choosing your answer. GOOD LUCK!*

### QUESTIONNAIRE C

#### I. MULTIPLE CHOICE QUESTIONS (4 points each)

- 1) Suppose that in a country one-third of all females born die at age 25, one-third die at age 32, and one-third live to age 60. Women bear one child at age 20, one child at age 28, and one child at age 35. One-half of children are girls. The net rate of reproduction for this country is:  
 (a) 1.000  
 (b) 1.125  
 (c) 1.200  
 (d) 1.525  
 (e) 2.500
- 2) Using the numbers provided in question 1), calculate the total fertility rate:  
 (a) 0.500  
 (b) 0.750  
 (c) 1.500  
 (d) 2.525  
 (e) 3.000
- 3) Suppose that the returns to education are 13.4% per year for the first four years of schooling (grades 1-4), 10.1% per year for the next four years (grades 5-8), and 6.8% per year for education beyond eight years. What fraction of her wages is due to raw labor for a worker who has 10 years of education?  
 (a) 36.1%  
 (b) 52.6%  
 (c) 68.4%  
 (d) 77.4%  
 (e) 92.3%
- 4) Suppose that function  $y = k^\alpha h^{1-\alpha}$ ,  $\alpha = 1/3$ , denotes the output per worker in the economy, where each variable is defined as done in class. Assume that all workers in the country

have 8 years of education. Using the data from question 3), calculate what proportion of the total national income can be attributed to human capital?

- (a) 39.2%  
 (b) 58.9%  
 (c) 66.6%  
 (d) 75.0%  
 (e) None of the above.
- 5) The relative (total factor) productivity levels of countries can be estimated
- (a) directly by observing worker productivity levels.  
 (b) indirectly by comparing relative output levels with relative factor input levels.  
 (c) by simply comparing relative education levels.  
 (d) by simply comparing the relative health of workers.  
 (e) It is impossible to compare productivity levels between countries.
- 6) According to historical observations,
- (a) better nutrition plays an important role in explaining income levels because not only can workers work better, but it also allows the previously worst fed people to work when they were too weak to work before.  
 (b) the impact of better nutrition is mostly due to the fact that it allows the previously worst fed people to work when they were too weak to work before, but it does not have an important impact on those who already work.  
 (c) nutrition cannot be an important factor in explaining income differences between countries because even though there exists large differences in nutrition levels, nutrition does not have a significant impact on people's capacity to produce.  
 (d) nutrition cannot be an important factor in explaining income differences between countries because nutrition levels are roughly the same across the world.  
 (e) the role of nutrition in explaining economic growth in the UK since 1780 does not appear to be significant.
- 7) In the very long run, economic growth is primarily determined by
- (a) the demographic transition.  
 (b) investment in physical capital.  
 (c) investment in human capital.  
 (d) the level of efficiency.  
 (e) technological progress.
- 8) Consider the following data, which apply to countries X and Z in the years 1960 and 2010. In both countries, the production function is  $y = Ak^\alpha h^{1-\alpha}$ ,  $\alpha = 1/3$ .

Country	Year	$y$	$k$	$h$
X	1960	100	2	3
	2010	1200	5	9
Z	1960	50	4	1
	2010	600	10	3

Which country had higher productivity growth between 1960 and 2010?

- (a) Country X
- (b) Country Z
- (c) Productivity growths were the same in both countries.
- (d) We do not have enough information to answer.
- (e) Productivity is not something that can be estimated.

9) Which of the following statement is clearly FALSE?

- (a) One reason why governments subsidize education is because it is suspected to generate positive externalities.
- (b) Between countries of the world today, there is a negative correlation between GDP per capita and average years of schooling.
- (c) Using “number of years of education” as a measure of human capital differences between countries tends to understate the true differences between poor and rich countries when one considers that quality of education differs also.
- (d) According to one study, improved nutrition appears to be an important determinant of economic growth in the UK over the past 200 years.
- (e) Introducing human capital into the Solow model significantly improves the model’s ability to predict income-level differences between countries of the world today.

10) Which of the following statement is clearly FALSE?

- (a) The patent system has been created in order to solve the problem of exclusion in the use of new ideas.
- (b) Physical capital is considered a rival factor of production.
- (c) Human capital is considered a rival factor of production.
- (d) Generally, a patent has a life of about 7 to 10 years.
- (e) Because of investment portfolio diversification possibilities, financial markets play an important role in promoting technological progress through R&D.

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## II. PROBLEM (QUESTIONNAIRE C)

You must answer the following questions strictly within the space provided. Your answers must be accompanied with clear explanations. Graphs and equations without explanations will not get you far.

**Technological progress and economic growth (60 points)**

Suppose that the national output of an economy is given by the following function:

$$Y = AK^\alpha L^{1-\alpha} = K^\alpha (eL)^{1-\alpha}, \quad \alpha = 1/3$$

where the variables are as defined in class and  $e = A^{\frac{1}{1-\alpha}}$ . (The time subscripts have been removed for clarity.) The total investment and depreciation levels are given by  $I = \gamma Y$  and  $D = \delta K$  respectively. Population ( $L$ ) and total factor productivity ( $A$ ) grow at constant rates  $n$  and  $\hat{A}$  respectively. Let  $eL$  denote the total quantity of "effective workers" available in this economy.

- (1) (30 points) Assume that  $\gamma = 10\%$ ,  $\delta = 5\%$ ,  $n = 3\%$  and  $\hat{e} = 4\%$  per year. Derive an expression for each the following variables and then use it to calculate its steady-state value:

(REMARK: No graphic is required)

- (a) Capital stock per effective worker

$$\text{let } y_e \equiv \frac{Y}{eL}, \quad i_e = \frac{\delta Y}{eL} = \delta y_e, \quad d_e = \frac{\delta K}{eL} = \delta k_e$$

$$k_e = \frac{K}{eL}$$

$$\Rightarrow \Delta k_e = \delta y_e - (\delta + n + \hat{e}) k_e$$

$$\text{where } y_e = (k_e)^\alpha$$

$$\text{In S.S, we have } \Delta k_e = 0,$$

$$\Rightarrow \delta k_e^\alpha = (\delta + n + \hat{e}) k_e \Rightarrow k_e^{SS} = \left( \frac{\delta}{\delta + n + \hat{e}} \right)^{\frac{1}{1-\alpha}}$$

$$\Rightarrow k_e^{SS} = \left( \frac{0.1}{0.05 + 0.03 + 0.04} \right)^{\frac{3}{2}} = 0.76$$

(b) Output per effective worker

$$y_e^{ss} = (re)^{\frac{1}{3}} = (0.76)^{\frac{1}{3}} = 0.91$$

(c) Growth rate of output per effective worker

In S.S.,  $y_e$  is constant over time.  
Hence  $\hat{y}_e^{ss} = 0$ , where  $\hat{y}_e \equiv \frac{\Delta y_e}{y_e}$ .

(d) Growth rate of output per worker

Since  $y_e = \frac{y}{e}$ , we have  
 $\hat{y}_e = \hat{y} - \hat{e} \Rightarrow \hat{y}_e^{ss} = \hat{y}^{ss} - \hat{e} = 0$ .  
 $\Rightarrow \hat{y}^{ss} = \hat{e} = 4\%$ : Output per worker is growing at the same rate as technology in S.S.

(e) Steady-state output level per worker  $y_t^{ss}$  as a function of  $e_t$ .

Since  $y_e = \frac{y}{e}$ , then  $y_t^{ss} = y_e^{ss} e_t$   
 $\Rightarrow y_t^{ss} = 0.91 e_t$

(2) (30 points) Suppose that two countries, denoted 1 and 2, have the same characteristics as those given in part (1) above. The only difference between the two countries is in their technology levels: Country 1's technology level at  $t$  is double that of Country 2, i.e.  $e_{1t} = 2e_{2t}$ , where  $e_{it}$  denotes the technology level of country  $i$  at time  $t$ .

(a) In the long run, how will the growth rates of income per capita differ between the two countries? Justify.

In part (1), we established that income per capita was growing at the same rate as technology parameter  $\hat{e}$ . Both countries' output per capita will thus grow at rate  $\hat{e} = 4\%$  in the long run S-S.

(b) In the long run, how will the levels of income per capita differ between the two countries? Justify.

In part (e), we found that  $y_t^{SS} = 0.91e_t$ . If  $e_{1t} = 2e_{2t}$ , then  $y_{1t}^{SS} = 0.91 \cdot 2e_{2t} = 2y_{2t}^{SS}$ . In S-S, income per capita in country 1 is double that of country 2.

(c) Suppose that you are hired by the World Bank in order to propose a way to make country 2 as well off as country 1. There are two proposals on the table:

- Plan A: A one-shot transfer of capital from country 1 to country 2.

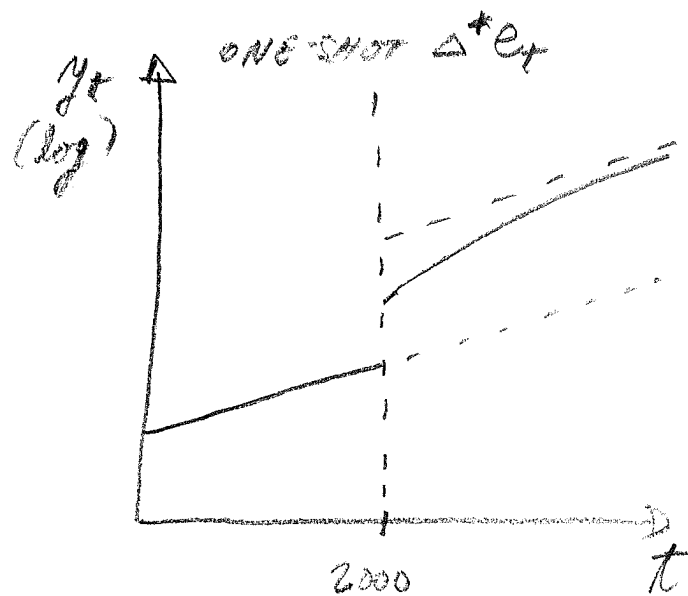
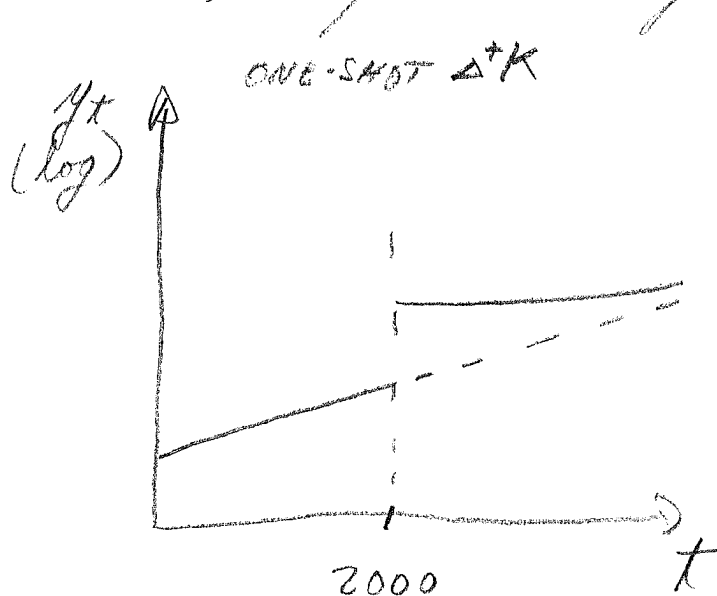
- Plan B: A one-shot transfer of technology from country 1 to country 2.

Which of the two plans would you propose? Justify.

A one-shot transfer of capital will increase per-capita income in country 2 in the short run but will have no effect in the long run. Indeed, in S-S, we have  $y_{2t}^{SS} = 0.91e_{2t}$ , regard less of initial conditions. A one-shot transfer of technology will however have a permanent effect. Suppose for instance that  $e_{2t}$  is raised to the same level as  $e_{1t}$ , say at  $t = 2000$ . We then have  $e_{2t} = e_{1t}$  for  $t \geq 2000$ , such that  $y_{2t}^{SS} = y_{1t}^{SS} = 0.91e_{1t}$  in the long run. Note that the transfer of technology does not affect output of country 1, i.e. it is costless for country 1. This is because ideas are non-rival in their use. This is not true of capital transfers, which are costly for country 1 in terms of reduced output in the short run.

REMARK: The above answer includes what I consider to be the most important elements. See next page for a list of other, related aspects discussed in class that are also relevant.

- Long-run and short-run effects of capital vs technology transfers.
- Non-rivalry of technology vs rivalry of capital.
- Costs of capital transfers vs free technology transfers.
- Problem of appropriateness of technology.
- Problem of tacit knowledge.
- Graphical representations:



-  $k_t^{SS} = e_t k_e^{SS} = 0.76 e_t \Rightarrow$  An increase in the technology level causes an increase in the S-S capital per worker.