ECO2143 Macroeconomic Theory II
Third mid-term examination: March 16 2018
University of Ottawa
Professor: Louis Hotte
Time allotted: 1h 20min

Attention: *Not all questionnaires are the same. This is questionnaire* ***A****. On the answer sheet, you must indicate the letter of your questionnaire with the course's number as follows:* ***ECO2143A****. You must answer according to* ***the material seen in this course****. Read all answer choices before choosing your answer. Calculator permitted.* GOOD LUCK!

QUESTIONNAIRE A

I. MULTIPLE CHOICE QUESTIONS (2 points each)

1. According to the calculations based on the returns to education, it appears that
   (a) In LDCs, human capital accounts for a much lower share of total national income than physical capital.
   (b) In LDCs, human capital accounts for almost twice the share of total national income compared to physical capital.
   (c) In rich countries, human capital accounts for about half the share of total national income compared to physical capital.
   (d) In rich countries, human capital accounts for a larger share of total national income than physical capital.✓

2. Suppose that the yearly returns to education are the following: 13.4% for grades 1 to 4, 10.1% for grades 5 to 8, and 6.8% beyond 8 years. What fraction of wages is due to human capital for a worker who has nine years of education?
   (a) 25.5%
   (b) 40.5%
   (c) 50.5%
   (d) 61.5% ✓
   (e) None of the above is anywhere close to the real value.

3. Suppose that in a country, one quarter of the population has 9 years of schooling and three quarters has 14 years. What is the share of the country's total income - i.e., its GDP - can be attributed to education? Answer this question using the data on returns to education provided in question 2. Assume that the share of physical capital in total income is 1/3.
   (a) 26.3%
   (b) 33.3%
   (c) 46.7% ✓
   (d) 66.6%
   (e) 70.0%

4. According to the numbers seen in class concerning the USA, relative to its GDP,
   (a) investment efforts in physical capital represent much more than those of education.
   (b) investment efforts in physical capital represent much less than those of education.
   (c) investment efforts in education represent roughly the same as those of physical capital. ✓
   (d) the value of investment attributed to salaries forgone by students represents less than 1% of GDP.
   (e) investment in physical capital represents roughly 3% of GDP.

5. Assume that the economy can be represented by the Solow model with the following aggregate output function $Y = K^{\alpha}(eL)^{1-\alpha}$, where each variable is defined as seen in class. Suppose the investment rate is $\gamma = 10\%$, the depreciation rate is $\delta = 5\%$, the growth of the labor force size is $n = 3\%$ per year and the rate of technological progress is $\hat{e} = 2\%$ per year. What will be the long-run, steady-state growth rate of *output per worker*?
   (a) 0%
   (b) 10%
   (c) 5%
   (d) 3%
   (e) 2%✓

6. Using the information from question (5), what will be the long-run, steady-state growth rate of *aggregate output*?
   (a) 0%
   (b) 10%
   (c) 5%✓
   (d) 3%
   (e) 2%

7. 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.

8. According to observations, which of the following assertions is TRUE?
   (a) Productivity differences between the countries of the world are not very important. We should thus look elsewhere to target development aid.
   (b) Differences in the quantities of accumulated factors of production between the countries of the world are not very important. We should thus look elsewhere to target development aid.
   (c) For most of the countries of the world, differences in the quantities of accumulated factors of production are the most important to explain differences in wealth levels. Development should thus target solely factor accumulation in the form of physical and human capital.
   (d) For most of the countries of the world, differences in productivity are the most important to explain differences in wealth levels. Development should thus solely target increases in productivity.
   (e) All of the above are false. ✓

9. Which of the following assertions is clearly FALSE.

(a) A coppersmith's apprentice's knowledge of different styles and techniques is an example of *tacit knowledge*.
(b) It is always better for a country to try to be the *technological leader*.✓
(c) The finding of a new medical drug that eliminates the need for older, less effective drugs, is an example of *creative destruction*.
(d) The *size of the market* is likely to be an important factor influencing the level of R&D efforts.

10. The relative productivity levels of countries can be estimated
(a) directly by observing worker productivity levels.
(b) indirectly by comparing relative output levels to relative factor input levels.✓
(c) by comparing relative education levels.
(d) by comparing the relative health of workers.
(e) It is impossible to compare productivity levels between countries.

11. Regarding growth over the past 35 years or so, which of the following statement most closely corresponds to observations?
(a) Compared to factor accumulation, productivity growth explains a larger share of income growth differences between countries. ✓
(b) Compared to productivity growth, factor accumulation explains a larger share of income growth differences between countries.
(c) Factor accumulation does not explain a very important part of income growth differences between countries.
(d) Productivity growth does not explain a very important part of income growth differences between countries.
(e) Factor accumulation and productivity growth explain roughly equally growth differences between countries.

12. Sustained, long run economic growth is primarily determined by
(a) the demographic transition.
(b) investment in physical capital.
(c) investment in human capital.
(d) technological progress. ✓
(e) the workers' health.

NAME AND ID:

II. PROBLEM

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

1. Growth accounting (30 points) Suppose that output per worker is given by the following expression: $y_t = A_t k_t^{\alpha} h_t^{1-\alpha}$, where $\alpha = 1/3$ and subscript t denotes the year. We have the following data for the 25 years between 1975 and 2000: $y_{1975} = 1000$, $y_{2000} = 5000$, $k_{1975} = 5000$, $k_{2000} = 15000$, $h_{1975} = 1000$, $h_{2000} = 2000$.

(1a) (20 points) Calculate the share of per capita income growth that can be attributed to productivity growth. Begin by explicitly writing down the equation that links per capita income growth to productivity growth and factor growth. Briefly explain your steps and interpret the results.

(1b) (10 points) In 1957, Robert Solow was ignoring the role of human capital accumulation in explaining output growth. Discuss how this omission would have affected your result in (a).

2. Technological progress and economic growth (30 points)
Suppose that the national output of an economy is given by the following function:

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

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, with $\gamma \in (0, 1)$ and $\delta \in (0, 1)$. 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.

a) (15 points) Derive an expression for the steady-state output per effective worker. At what rate is the output per worker growing in this steady-state?

b) (5 points) Explain briefly (in words only) how it is possible that output per worker be growing at a faster rate than $\hat{A}$.

c) (10 points) Suppose that in 1950, productivity growth jumps from $\hat{e}_1$ to $\hat{e}_2$, with $\hat{e}_1 < \hat{e}_2$. Assuming that the economy was in steady-state before 1950, show and explain graphically how the output per worker will change over time after 1950.

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NAME AND ID: BARTOLOMÉ DE LAS CASAS

II. PROBLEM

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

Growth accounting (30 points) As seen in class, suppose that output per worker is given by the following expression: $y_t = A_t k_t^{\alpha} h_t^{1-\alpha}$, where $\alpha = 1/3$ and subscript t denotes the year. We have the following data for the 25 years between 1975 and 2000: $y_{1975} = 1000$, $y_{2000} = 5000$, $k_{1975} = 5000$, $k_{2000} = 15000$, $h_{1975} = 1000$, $h_{2000} = 2000$.

(1a) (20 points) Calculate the share of total per capita income growth which can be attributed to productivity growth. Begin by writing down the equation which links total per capita income growth to productivity growth and factor growth. (No need to derive it. Just write it down.)

$\hat{y} = \hat{A} + \alpha \hat{k} + (1-\alpha)\hat{h}$

In order to estimate $\hat{A}$, we need to calculate $\hat{y}$, $\hat{k}$ and $\hat{h}$. We have:

$y_{2000} = (1+\hat{y})^{25} y_{1975}$

$\Rightarrow \hat{y} = \left(\frac{y_{2000}}{y_{1975}}\right)^{1/25} - 1 = 5^{1/25} - 1 = 6.65\%$

And similarly: $\hat{k} = 3^{1/25} - 1 = 4.49\%$

$\hat{h} = 2^{1/25} - 1 = 2.81\%$

$\Rightarrow 6.65\% = \hat{A} + \frac{1}{3}(4.49\%) + \frac{2}{3}(2.81\%)$

$\boxed{\hat{A} = 3.28\%}$

$\Rightarrow \frac{3.28}{6.65} = 49.3\%$ is the share of total growth attributed to TFP growth.

(1b) (10 points) In 1957, Robert Solow was ignoring the role of human capital accumulation in explaining output growth. Discuss how this omission would have affected your result in (a).

If we ignore the role of $\hat{h}$, then we have

$$\hat{A} = 6.65\% - \frac{1}{3}(4.49\%) = 5.15\%$$

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$\Rightarrow \frac{5.15}{6.65} = 77.5\%$ is the share of total growth now attributed to TFP growth.

We therefore obtain that ignoring the role of human capital leads us to <u>over-estimate</u> the role of TFP growth in explaining economic growth.

II. PROBLEM

Answer 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:

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

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, with $\gamma \in (0,1)$ and $\delta \in (0,1)$. 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.

a) (25 points) Derive an expression for the steady-state output per effective worker. At what rate is the output per worker growing in this steady-state?

We first define the following variables in terms of "effective workers":
$y_e = \frac{Y}{eL}$, $k_e \equiv \frac{K}{eL}$, $i_e = \frac{I}{eL}$, $d_e = \frac{D}{eL}$
Since $\Delta K = I - D$, we have $\Delta k_e = i_e - d_e$
$\Rightarrow \Delta k_e = \gamma k_e^{\alpha} - (\delta + n + \hat{e}) k_e$
In steady-state: $\Delta k_e = 0 \Rightarrow \gamma k_e^{\alpha} = (\delta + n + \hat{e}) k_e$
$\Rightarrow k_e^{SS} = \left(\frac{\gamma}{\delta + n + \hat{e}}\right)^{\frac{1}{1-\alpha}} \Rightarrow \boxed{y_e^{SS} = \left(\frac{\gamma}{\delta + n + \hat{e}}\right)^{\frac{\alpha}{1-\alpha}}}$ ← This is the SS output per effective worker.
$\left(NB\ y_e = \frac{Y}{eL} = k_e^{\alpha}\right)$
Since output per worker $= y = \frac{Y}{L}$,
we have $y_e = y/e \Rightarrow \hat{y}_e = \hat{y} - \hat{e}$. In steady-state, $\hat{y}_e = 0 \Rightarrow \hat{y} = \hat{e}$. Output per worker is growing at rate $\hat{e} = \frac{1}{1-\alpha}\hat{A}$.

b) (10 points) Explain briefly (in words only) how it is possible that output per worker be growing at a faster rate than $\hat{A}$.

We found above that output per worker is growing at rate

$\frac{1}{1-\alpha}\hat{A} > \hat{A}$. This growth rate is larger than the total factor productivity growth rate because as TFP increases, so does the accumulation of capital per worker (k).

c) (25 points) Suppose that in 1950, productivity growth jumps from $\hat{e}_1$ to $\hat{e}_2$, with $\hat{e}_1 < \hat{e}_2$. Assuming that the economy was in steady-state before 1950, show and explain graphically how the output per worker will change over time after 1950.

An increase in $\hat{e}$ moves the economy towards a new steady-state, i.e. from $y_{e_1}^{ss}$ to $y_{e_2}^{ss}$.

In the long run, $y_{e_2}^{ss}$ being constant, we have $\hat{y}_2 = \hat{e}_2$.

Output per worker will be growing at a faster rate than before 1950.