

**EE312 Macroeconomic Theory**  
**Semester 1/2017**  
**Mid-Term Examination**

Date: Wednesday 4 October 2017

Time: 11:00 – 13:00 hr.

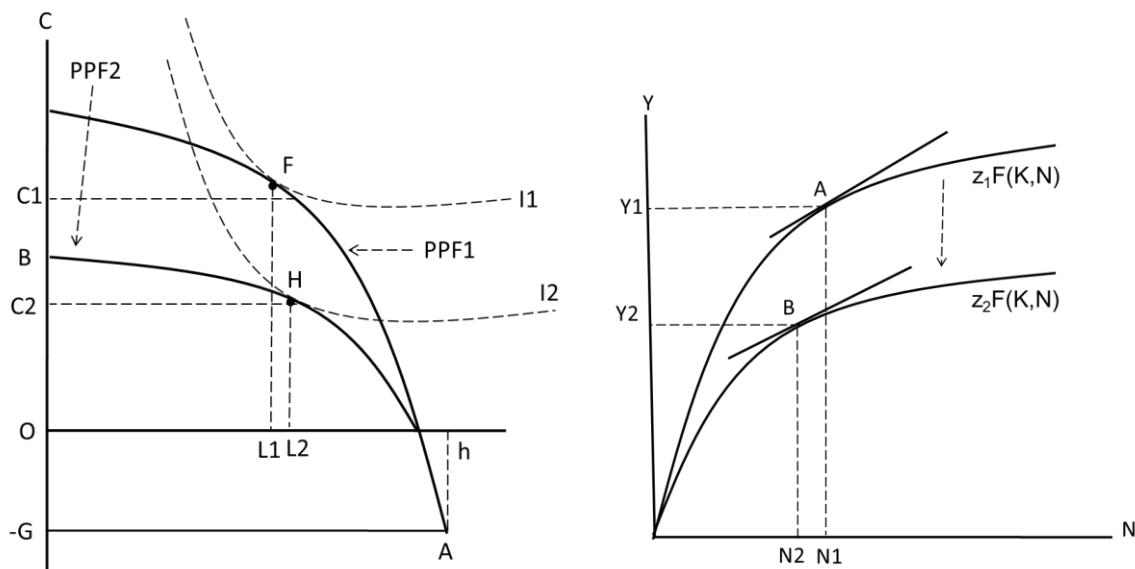
**Instructions**

1. There are three essay questions with a total of 30 points.
2. Write your answers in the provided booklets.
3. Books, notes, calculators and electronic devices are not allowed.
4. Explain the chain of effects among variables correctly. Describe your analysis in words and use diagrams accordingly.
5. Use pens to write your answers; pencils are allowed for drawings only.

**Questions**

1. Assume that total factor productivity decreases (or a negative productivity shock) in **the Closed-Economy, One-Period Macroeconomic Model**. Analyze the effects of the decrease in total factor productivity on aggregate output, consumption, employment and the real wage. (10 points)

**Answer:**



The initial competitive equilibrium is at point F where the firm's Production Possibility Frontier, PPF1, touches the consumer's highest indifference curve I1. At F, the firm maximizes profit and the consumer maximizes utility at the real wage rate equal to the slope

of the PPF. The optimal consumption bundle for the consumer is consumption goods equal to  $C_1$  and leisure equal to  $L_1$ . So the consumer's working time (and labor supply) is  $h - L_1$ .

The decrease in total factor productivity ( $z$ ) from  $z_1$  to  $z_2$  causes the production function to rotate downwards from  $Y_1 = z_1F(K, N^d)$  to  $Y_2 = z_2F(K, N^d)$ , given the capital input ( $K$ ). The slope of the production function decreases at the initial level of labor input ( $N_1$ ). The marginal product of labor ( $MP_N$ ) is lower, inducing the firm to reduce its demand for labor and to offer a lower real wage ( $MP_N = w$ ).

The downward rotation of the production function causes the PPF1 to shift downwards to PPF2. The competitive equilibrium changes from  $F$  to  $H$ . The real wage decreases as the slope of PPF2 at  $H$  is less steep than the slope at  $F$ .

The decrease in the real wage has the substitution effect and income effect. **The substitution effect** causes the consumer to decrease consumption goods and increase leisure (because the cost of leisure has become cheaper). **The income effect** causes the consumer to reduce both consumption goods and leisure (both are normal goods). In short, consumption goods will decrease from  $C_1$  on PPF1 to  $C_2$  on PPF2, but the change in leisure (and labor supply) is unclear.

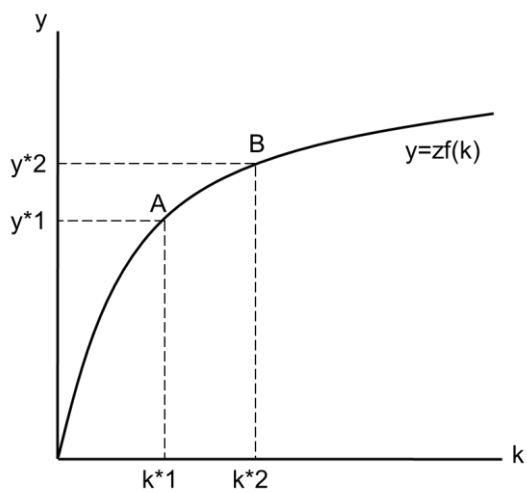
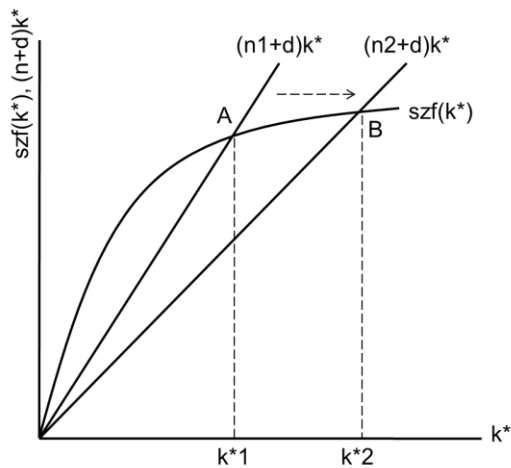
Here we assume a **stronger substitution effect**. So leisure increases from  $L_1$  to  $L_2$  and labor supply decreases from  $(h - L_1)$  to  $(h - L_2)$ . Employment decreases from  $N_1$  to  $N_2$  and, through the production function, output decreases from  $Y_1$  to  $Y_2$ . The real wage is still lower at the new competitive equilibrium as the slope of the production function at  $B$  is still less steep than at  $A$ .

In conclusion, the decrease in total factor productivity results in lower consumption, higher leisure, lower employment, lower output and income and a lower real wage (assuming the stronger substitution effect).

**Note:** students may assume a stronger income effect or equal substitution and income effects.

2. In **the Solow growth model**, suppose the population growth rate ( $n$ ) in the economy decreases. Analyze the effects of the decrease in the population growth rate on the quantity of capital per worker, output per worker and consumption per worker at the steady state. How does the Solow model explain one of the growth facts that poor countries tend to have higher population growth than rich countries? (10 point)

**Answer:**



The economy starts at point A where steady-state saving  $[szf(k^*)]$  equals steady-state investment  $[(n1+d)k^*]$ . Steady-state capital per worker is equal to  $k^*1$  and steady-state output per worker equal to  $y^*1$ . As the population growth rate is  $n1$ , steady-state aggregate output (Y) and steady-state aggregate capital (K) are also growing at the rate of  $n1$ .

Now assume the population growth rate decreases from  $n1$  to  $n2$ . As the slope of the steady-state investment line is  $(n+d)$ , the decrease in  $n$  causes the steady-state investment line to rotate downwards to  $(n2+d)k^*$ . The new steady-state investment line is equal to the saving curve,  $szf(k^*)$  at point B. So steady-state capital per worker increases from  $k^*1$  to  $k^*2$ . And through the per worker production function  $y = zf(k)$ , steady-state output per worker also increases from  $y^*1$  to  $y^*2$ . At the new steady state, the economy will have higher capital per worker and output per worker while aggregate capital and aggregate output are growing at the new rate of  $n2$ .

Consumption per worker also increases according to the equation, given the savings rate:  $c = y - sy = (1 - s) y$ .

One of the growth facts is the negative correlation between income per capita and population growth. Poor countries tend to have higher population growth than rich countries. Even if poor and rich countries have the same savings rate ( $s$ ), depreciation rate ( $d$ ) and total factor productivity ( $z$ ), poor countries with a higher population growth rate at  $n1$  will have a lower level of steady-state capital per worker at  $k^*1$  and a lower steady-state output per worker at  $y^*1$  as against rich countries at  $n2$ ,  $k^*2$  and  $y^*2$ , respectively.

### 3. In the endogenous growth model, assume the following variables:

$Y$  = output

$C$  = consumption

$z$  = marginal product of the efficiency units of labor

$H^s$  and  $H^{s'}$  = supply of current and future human capital by the consumer, respectively

$H^d$  = demand for human capital by the firm

$b$  = the efficiency of human capital accumulation technology

$u$  = time allocated to producing output.

Derive the competitive equilibrium condition for the consumer and the firm. What are the equilibrium growth rates of human capital, consumption and output? Explain why economic growth is unbounded in the model in contrast to limited growth in the Solow model. And how does the endogenous growth model explain the lack of absolute convergence between rich and poor countries? (10 points)

**Answer: The consumer's budget constraint** is total labor earnings from supplying efficiency units of labor ( $uH^s$ ) :

$$C = wuH^s$$

And the accumulation of human capital is expressed by:

$$H^{s'} = b(1-u)H^s$$

The firm's production function is given by:

$$Y = zuH^d$$

So the firm's profit function is total output (or total revenue minus labor cost):

$$\pi = Y - wuH^d$$

$$\pi = zuH^d - wuH^d$$

$$\pi = (z - w)uH^d$$

The firm maximizes profits at  $z = w$  which is also the firm's demand for efficiency units of labor ( $uH^d$ ). The market clears when the demand and supply of efficiency units of labor are equal ( $uH^d = uH^s$ ). Current output (Y) produced by the firm is equal to current consumption (C) by the consumer:

$$Y = C = zuH$$

$$H' = b(1-u)H$$

The growth rate of human capital is determined by:

$$\frac{H'}{H} - 1 = b(1-u) - 1$$

Current consumption is equal to  $C = zuH$  and future consumption is  $C' = zuH'$ . Therefore,

$$\frac{C'}{C} - 1 = \frac{zuH'}{zuH} - 1 = \frac{H'}{H} - 1 = b(1-u) - 1$$

Output is also growing at the same rate as consumption as  $Y = C$ . So both output and

consumption grow at the rate of  $b(1-u) - 1$ .

Economic growth in the model is unbounded because the accumulation of human capital is not subject to diminishing returns to scale. The reason is that knowledge is '**non-rivalry**'. One's acquisition of knowledge does not reduce others' ability to acquire the same knowledge. No limit on how productive a person can be, given increasing knowledge and skills. Human capital also has **positive externalities**. One individual's high level of human capital has positive effects on other individuals' human capital and their productivity. So there is no limit on human capital accumulation and economic growth. In contrast, growth in the Solow model has a limit at the steady state because growth relies on physical capital which has rivalry in use. The accumulation of physical capital, given population growth, is therefore subject to diminishing marginal returns.

There is no absolute convergence between rich and poor countries because rich countries have higher levels of human capital than poor countries. Even if rich and poor countries have the same human capital accumulation technologies ( $b$ ) and the same time allocated to current production ( $u$ ) so that they have the same long-run growth rates of human capital, consumption and output at  $b(1-u)-1$ , poor countries will never catch up with rich countries.

Poor countries also have lower levels of human capital. They have less contact with rich countries. So they receive little positive externalities from human capital in rich countries. Poor countries also lose their existing human capital through brain drain problems.