

Written Exam at the Department of Economics summer 2018-R

Economic Growth

Final Exam

15th August

(3-hour closed book exam)

Answers only in English.

This exam question consists of 4 pages in total

NB: If you fall ill during an examination at Peter Bangsvej, you must contact an invigilator in order to be registered as having fallen ill. In this connection, you must complete a form. Then you submit a blank exam paper and leave the examination. When you arrive home, you must contact your GP and submit a medical report to the Faculty of Social Sciences no later than seven (7) days from the date of the exam.

Be careful not to cheat at exams!

- You cheat at an exam, if during the exam, you:
- Make use of exam aids that are not allowed
- Communicate with or otherwise receive help from other people
- Copy other people's texts without making use of quotation marks and source referencing, so that it may appear to be your own text
- Use the ideas or thoughts of others without making use of source referencing, so it may appear to be your own idea or your thoughts
- Or if you otherwise violate the rules that apply to the exam

## Part 1: Essay questions

**Question 1.a:** In the task based model, suppose that capital is replacing labor in some tasks previously undertaken by medium skill labor. What happens to the allocation of labor to tasks, and to relative wages? Explain the intuition for your answer.

**Question 1.b:** How are a) measured real GDP, b) true real GDP, and c) real consumption including home production affected by each of the following three internet services: Wikipedia, Spotify and AirBnB?

**Question 1.c:** Based on the paper *Spatial Misallocation* by Hsieh and Moretti (2017), discuss the following proposition: "building codes and zoning laws should be set my the central government, not by municipalities".

**Question 1.d.** (i) Please, explain what the difference is between "internal" and "external" learning, and how this distinction is important in the context of endogenizing "A" in the presence of competitive markets. (ii) What is mean by the term "knowledge spillovers"? Provide an example of such spillovers.

**Question 1.e.** Suppose a group of countries establish "a common market", which ensures a fully integrated labor market and more competition over-all. Imagine these are the *only* effects of the common market. Will the common market initiative necessarily increase growth in the member state countries according to the Aghion-Howitt model? Please, explain why/why not.

**Question 1.f.** Consider an economy where aggregate output depends on productive government services, such as infrastructure. Is it necessarily optimal to supply such services by way of lump sum taxation? Please, explain why/why not.

## Part 2A: Beyond GDP

Let  $C$  denote an individual's annual consumption,  $l$  denote leisure plus time spent in home production. Expected lifetime utility in country  $i$  is:

$$U_i = E \sum_{a=1}^{100} \beta^a u(C_{ai}, l_{ai}) S_i(a),$$

where  $E$  is the expectations operator and  $S(a)$  is the probability of surviving to age  $a$ . Define the function  $U_i(\lambda)$  as:

$$U_i(\lambda) = E_i \sum_{a=1}^{100} \beta^a u(\lambda C_{ai}, l_{ai}) S_i(a),$$

**Question 2a:** Explain how  $\lambda_i$  in the expression  $U_{us}(\lambda_i) = U_i(1)$  can be used to assess the welfare level in country  $i$  relative to that in the United States.

Suppose now that period flow-utility is:

$$u(C, l) = \bar{u} + \log C + v(l)$$

where  $C$  in country  $i$  is lognormally distributed with mean  $c_i$  and variance  $\sigma_i^2$ . Abstract from consumption growth.

**Question 2b:** Show that lifetime utility in this simple case is:

$$U_i^{simple} = e_i \left( \bar{u} + \log c_i + v(l_i) - \frac{1}{2} \sigma_i^2 \right)$$

where  $e_i$  is life expectancy.

**Question 2c:** Derive an expression for  $\lambda_i$  using  $U_i^{simple}$  and United States as benchmark. Explain how it can be used to evaluate welfare across countries empirically.

**Question 2d:** Based on the framework developed in this question, and the empirical results in Jones and Klenow (2016), discuss whether GDP/capita is a good proxy for welfare. Is global inequality better or worse when measured in terms of welfare than when measured in terms of GDP/capita?

### Part 3: R&D driven growth

Consider a Romer (1990) model. Time is continuous. A final output is produced using skilled labor ( $H_Y$ ), “raw” labor ( $L$ ), and a variety of intermediate goods. The markets for skilled - and unskilled labor, as well as the market for final goods, are competitive. The final goods producer demand each intermediate goods and acts as a price taker.

In the intermediate good sector one unit of each intermediate good is produced using one unit of capital,  $K$ . Hence the marginal cost of producing an intermediate good is the interest rate,  $r$ . Each intermediate good producer holds a monopoly over the production of the intermediate good of infinite duration. Based on the profits from production of intermediate goods potential entrants are willing to pay for new ideas that allows them to attain a monopoly via the production of a new intermediate good. In equilibrium the cost of producing a new idea equals the discounted value of the stream of profits it produces.

New ideas are produced deterministically using the technology

$$\dot{A}(t) = \bar{\delta} H_A A(t), \quad \bar{\delta} > 0, \tag{1}$$

where  $H_A$  is skilled labor input in R&D. Along a balanced growth path, where  $\gamma_C = \gamma_Y = \gamma_K = \gamma_A = \gamma$ , it can be shown that the supply of skilled labor in R&D is given by:

$$H_A = H - \frac{1}{\bar{\delta}} \frac{\alpha}{(\alpha + \beta)(1 - \alpha - \beta)} r, \quad (2)$$

where  $H$  is the supply of skilled labor, which is in constant supply. Finally, consumption evolves in accordance with the consumption euler

$$\frac{\dot{C}}{C} = \gamma = \frac{1}{\theta} (r - \rho), \quad (3)$$

where  $\theta$  is the elasticity of marginal utility from consumption,  $C$ . Along a balanced growth path the real rate of interest and the growth rate are determined by equation (1) - (3). We assume parameters are such that an equilibrium exists.

**Question 3.a.** (i) Show that the model reduces to two equations in two unknowns:  $\gamma$  and  $r$ . (ii) Draw the two equations in a  $(\gamma, r)$  diagram and explain the economic rationale behind the slope of each schedule. (ii) What is the impact on the growth rate and the real rate of interest, if  $H$  increases? Please, explain the economic reason for this result to arise, and remark on whether the prediction seems consistent with the evidence.

Suppose now that equation (1) is replaced by one proposed by Charles Jones (1995):

$$\dot{A}(t) = \delta(t) H_A, \quad (4)$$

where

$$\delta(t) = \bar{\delta} A(t)^\phi, \quad 0 < \phi < 1, \bar{\delta} > 0. \quad (5)$$

Finally, assume

$$\frac{\dot{H}(t)}{H(t)} = n > 0.$$

Otherwise the model is as above.

**Question 3.b.** Along a balanced growth path the share of the skilled labor force in R&D is constant. Show that the balanced growth rate of  $A$  is

$$\gamma_A = \gamma = \frac{n}{1 - \phi}$$

**Question 3.c.** What is an interpretation of the assumption  $0 < \phi < 1$ ? Is the assumption supported by evidence?

**Question 3.d.** Suppose  $n$  declines. What does the Jones model predict will happen to the balanced growth real rate of interest and the allocation of skilled labor into R&D? Explain your results.