

Problem Set VI

VI.1 In innovation-based growth models there is a tendency for scale effects to arise.

- a) Define two different kinds of scale effects.
- b) Why is it that scale effect tends to arise in innovation-based growth models?
- c) Give examples of different innovation-based growth models with different kinds of scale effects.
- d) Briefly discuss scale effects in relation to empirical evidence.
- e) Briefly describe the main idea in quality ladder models.
- f) Can scale effects on growth arise in quality ladder models? Why or why not?

VI.2 The bulk of empirical evidence suggests that market economies do too little R&D investment compared to the “optimal level” (as usually defined from the perspective of a representative infinitely-lived household).

- a) Is the “lab-equipment” version of the increasing variety model (that is, the version presented in B & S) consistent with this evidence? Why or why not?
- b) Paul Romer’s (1990) version of the increasing variety model is different from the “lab-equipment” version. How?
- c) Is Paul Romer’s (1990) version of the increasing variety model consistent with the mentioned evidence? Why or why not?
- d) Is the quality ladder model consistent with the mentioned evidence? Why or why not?

- e) What would the answers to a), c), and d), respectively, be if the empirical evidence suggested that market economies do too much R&D investment compared to the “optimal level”? Discuss.
- f) We have in this course studied models with non-durable intermediates or durable specialized capital goods of increasing variety or increasing quality. There exists another class of models, namely increasing-consumption-goods-variety models and increasing-consumption-goods-quality models. Suppose the labor force is constant. Then there is in these models typically no growth in the physical output per unit of labor. Do you think they might be considered growth models anyway? In both cases, say why or why not?

VI.3 In 1992 the British economist Peter Sinclair published an article which he entitled “High does nothing and rising is worse: carbon taxes should keep declining to cut harmful emissions.” What do you think the logic behind this claim is?

VI.4 *Growth accounting and sources of growth.* We consider a closed economy in continuous time. The aggregate capital stock, measured in constant efficiency units, grows according to

$$\dot{K}_t = T_t I_t - \delta K_t, \quad \delta > 0, \quad (1)$$

where I_t is aggregate gross investment at time t and T_t measures the “quality” (productivity) of newly produced investment goods. We assume T_t is determined by

$$T_t = \tilde{\xi} \left(\int_{-\infty}^t I_\tau d\tau \right)^\lambda, \quad \tilde{\xi} > 0, \quad 0 < \lambda < \frac{1-\alpha}{\alpha}. \quad (2)$$

The aggregate production function is

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha}, \quad 0 < \alpha < 1, \quad (3)$$

where Y_t is output, L_t is labor input, growing at a given constant rate $n \geq 0$, and A_t is TFP, growing at a given constant rate $\gamma \geq 0$. Finally, by national income accounting,

$$Y_t = I_t + C_t, \quad (4)$$

where C_t is aggregate consumption.

- a) Briefly interpret (1) and (2).

- b) What might the empirical motivation for a model like this be?
- c) Derive from (2) a differential equation for T_t .

The growth rate of a variable x is denoted g_x .

- d) Use the result in c) to find a formula for g_T and on the basis of this express \dot{g}_T/g_T in terms of g_T and g_I .

We now consider a balanced growth path (BGP) with $s \equiv I/Y$ constant and $0 < s < 1$. With the aim of finding g_I along BGP we go through a series of steps.

- e) Why must g_I and TI/K be constant along BGP?
- f) Why must g_T then be constant along BGP?
- g) Express g_T in terms of g_I and then g_K in terms of g_I . *Hint:* first, combine f) and d), then implicate e).
- h) Determine g_I and g_Y . *Hint:* use e) and constancy of s ; take growth rates on both sides of (3).
- i) Determine g_y , where $y \equiv Y/L$. Write down the contributions to g_y from disembodied and embodied technical progress, respectively.
- j) Imagine we have data for the economy described by this model and that the capital stock is measured in constant efficiency units. Applying the standard growth accounting method, what value for the TFP growth rate (Solow residual) would we find?
- k) Suppose $\gamma = 0$. What value for the TFP growth rate would we then find? Compare with the true contribution from technical progress in this case. Comment.

VI.5 *Short questions*

- a) “A relatively homogeneous group of countries such as for example the EU countries tend to experience income convergence in the sense that the standard deviation of income per capita across the countries diminishes over time.” True or not true as an empirical statement? Explain.

- b) “Growth accounting pinpoints the sources of growth.” True or false? Explain.
- c) “If technical change is partly embodied, there is a risk that total factor productivity growth as calculated by the growth accounting method understates the role of technical change.” True or false? Explain.

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