Chapter 8

The Role of Technology in Growth

Solutions to Problems

1. (a) Nonrival. Nonexcludable. One's consumption of National Defense does not diminish another's consumption of National Defense, and within a given country's borders, it is difficult to selectively exclude others from consuming National Defense.

(b) Rival. Excludable. Once a cookie is consumed, no one can consume that cookie. Furthermore, one can easily prevent another from consuming the cookie.

(c) Non-Rival. Excludable. My authorized use of a website does not, to a certain extent because of web traffic, diminish another's use of the same website. However, this good is excludable because a password is required, and so only those selected can access the website.

(d) Rival. Nonexcludable. The consumption of a piece of fruit insures that no other person can consume that same piece of fruit. However, because the fruit grows in a public square, anyone is able to consume the fruit.

3. There are many correct examples in economics where the issue of appropriateness is a barrier to technology transfer from developed to developing countries. Examples include agricultural technologies (certain climates and terrains are incompatible with agricultural technologies in many developed countries), certain electronics (for instance, wireless networking electronics require wireless networks), resource-specific technologies (as water turbines would not be very effective in the Sahara Desert), and so forth.

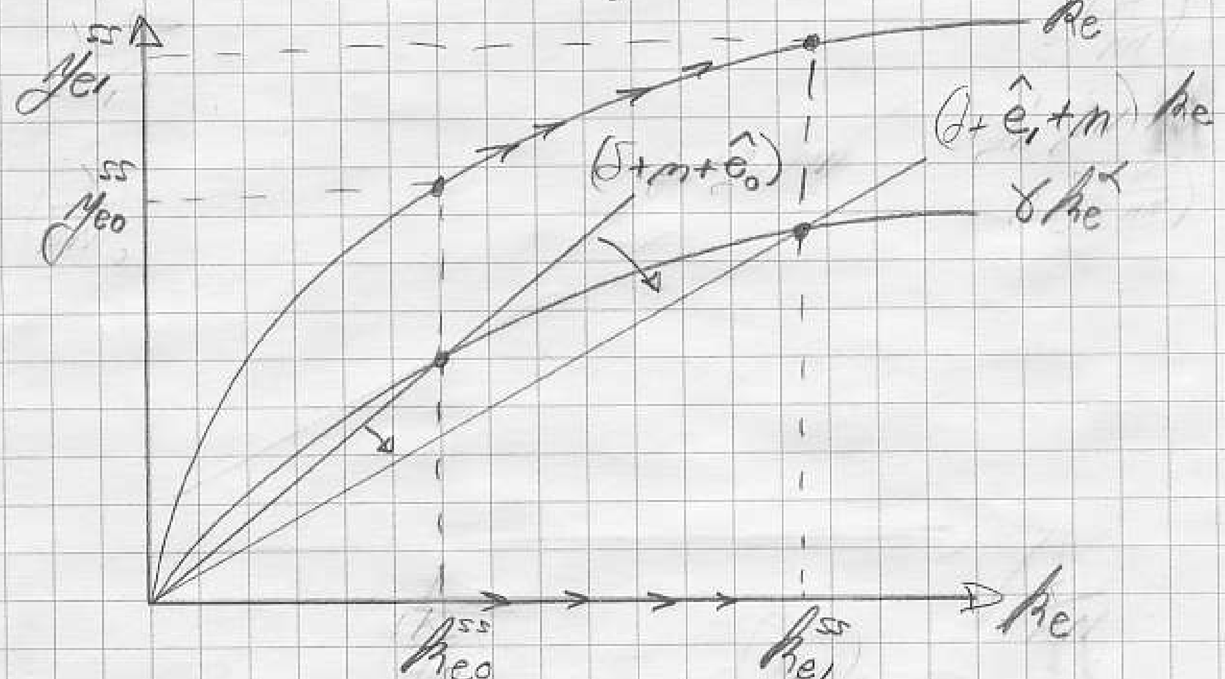
2) SLOWDOWN IN PRODUCTIVITY GROWTH

i) Slowdown in productivity growth

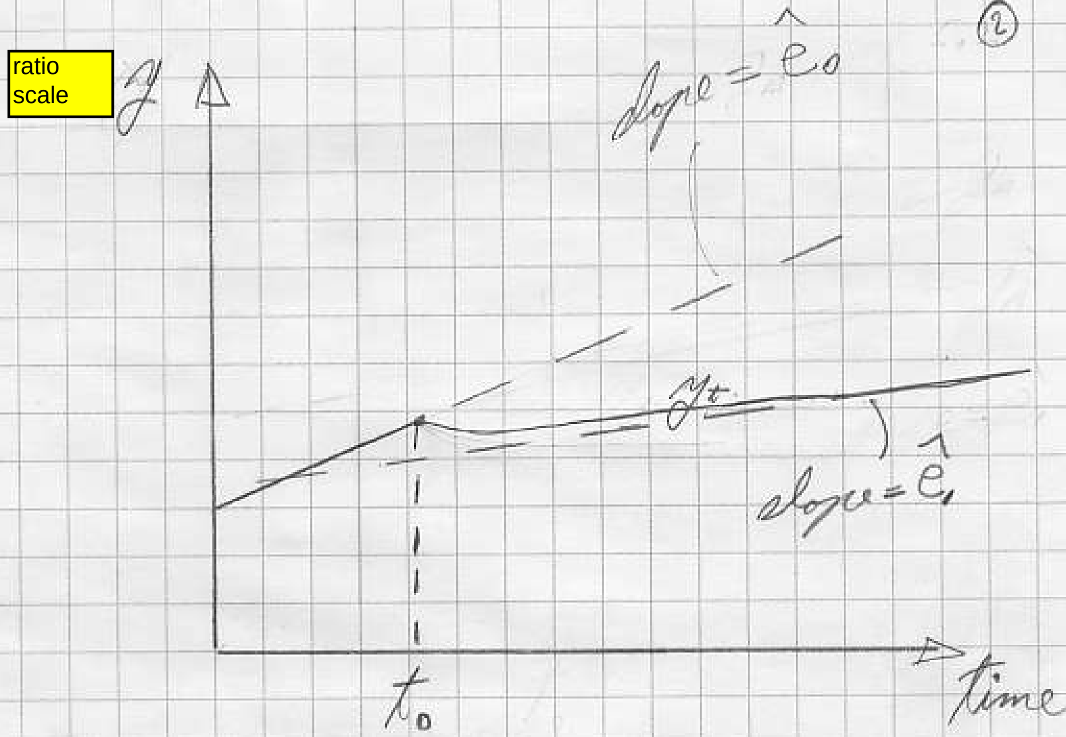
→ Slowdown in technological progress at time t_0 and permanent.

$\hat{e}_1 < \hat{e}_0$

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



A permanent drop in T.P. from $\hat{e}_0$ to $\hat{e}_1$ leads to a gradual increase in capital per effective worker from k_{e0}^{ss} to k_{e1}^{ss}. This is because future values of e will be lower. Output per effective worker will also go up. This may look like an improvement, but it is not. Lower growth of e means that its future values are smaller than in the initial trajectory.

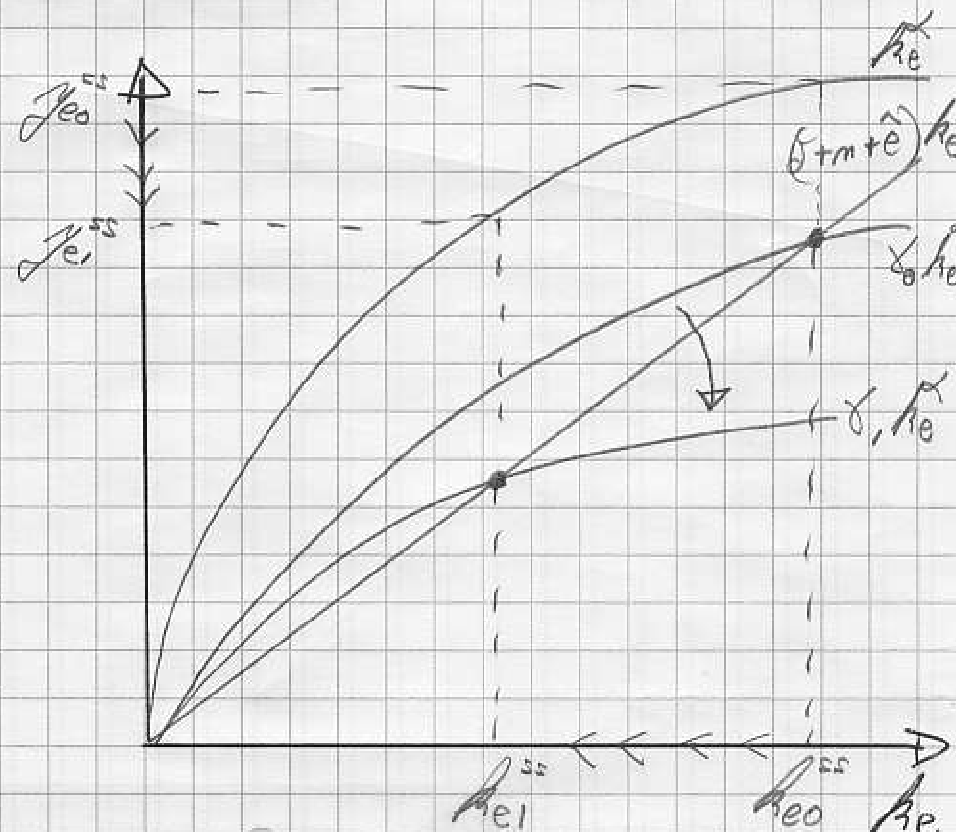


Assume that the economy is initially in a steady-state growth path and that T.P. drops from $\hat{e}_0$ to $\hat{e}_1$ at time t_0. The growth rate of income per capita will slow down and converge towards $\hat{e}_1$ in the long-run.

Over 5 years, both output level and output growth are lower. The same is true over 5 decades.

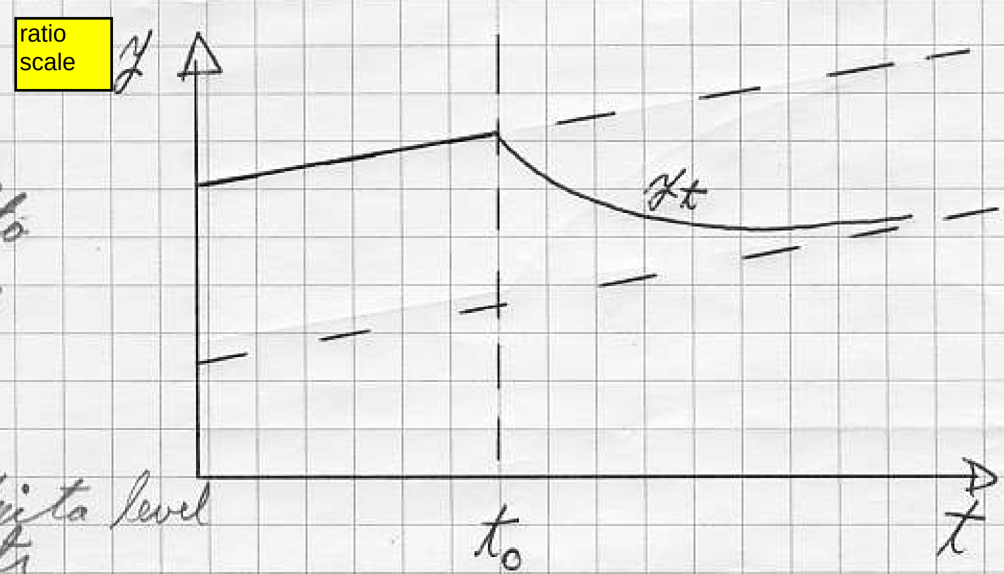
ii) Permanent decline in the savings rate

At t_0, γ drops from γ_0 to γ_1, with $\gamma_1 < \gamma_0$.



In the short run, compared to the initial trajectory, income per capita drops in both level and growth rate.

In the long-run, income per-capita level is lower, but its growth rate is the same.



N.B. $y_t^{ss} = e_t\, y_{et}^{ss} = e_t \left(\frac{\gamma}{\delta+n+\hat{e}}\right)^{\frac{\alpha}{1-\alpha}} \Rightarrow \Delta^{-}\gamma \Rightarrow \Delta^{-} y_t^{ss}$

3) SS OUTPUT AND TECH. PROGRESS

a) In SS, we must have $\Delta k_e = 0$ where $k_e = \frac{K}{eL}$.

$$\Delta k_e = \gamma k_e^{1/2} - (\delta + n + \hat{e}) k_e = 0$$

$$\Rightarrow k_e^{ss} = \left(\frac{\gamma}{\delta + n + \hat{e}}\right)^2 = \left(\frac{0.16}{0.1 + 0.02 + 0.04}\right)^2$$

i) $\Rightarrow \boxed{k_e^{ss} = 1}$

ii) $\Rightarrow y_e^{ss} = \left(k_e^{ss}\right)^{1/2} = 1$

iii) $\hat{y}_e^{ss} = 0$ by definition of the SS since $\hat{k}_e^{ss} = 0$.

iv) $y_e = \frac{y}{e} \Rightarrow \hat{y}_e = \hat{y} - \hat{e}$

Since $\hat{y}_e^{ss} = 0$, we have $\hat{y}^{ss} = \hat{e} = 4\%$.
Per capita income grows at a rate of 4% per year.

v) $y_e = \frac{Y}{eL} \Rightarrow \hat{y}_e = \hat{Y} - \hat{e} - n$

In SS: $\hat{Y}^{ss} = \hat{e} + n = 4\% + 2\% = 6\%$

Aggregate output grows at a rate of 6% per year in the long run

vi) $y_{et} = \frac{y_t}{e_t} \Rightarrow y_t = e_t \, y_{et}$

$\Rightarrow y_t^{ss} = e_t \, y_e^{ss} = e_t \cdot 1$

$\Rightarrow \boxed{y_t^{ss} = e_t}$

b) $\underline{\hat{e} = 8\%}$

$$\Rightarrow k_e^{ss} = \left(\frac{0.16}{0.1 + 0.02 + 0.08}\right)^2 = 0.64$$

$$\Rightarrow y_e^{ss} = (0.64)^{1/2} = 0.8$$

$$\Rightarrow \hat{y}_e^{ss} = 0$$

$$\Rightarrow \hat{y}^{ss} = 8\%$$

$$\hat{Y}^{ss} = 8\% + 2\% = 10\%, \quad \boxed{y_t^{ss} = 0.8 e_t}$$

The increase in growth of TP actually reduces capital stock and income level per <u>effective</u> worker in the long run. But this does not mean that income per capita is reduced. In fact, in the long run, it now grows at a higher rate of 8% per year, while aggregate output growth increases to 10%.

c) $\hat{e} = 4\%$, $n = 6\%$.

$\Rightarrow k_e^{ss} = \left(\frac{0.16}{0.1 + 0.06 + 0.04}\right)^2 = 0.64$

$\Rightarrow y_e^{ss} = (0.64)^{\frac{1}{2}} = 0.8$

$\hat{y}_e^{ss} = 0$ by def.

$\Rightarrow \hat{y}^{ss} = 4\%$

$\hat{Y}^{ss} = 4\% + 6\% = 10\%$.

$$\boxed{y_t^{ss} = 0.8 e_t}$$

d) In the long run, levels of income per capita are:

$y_{at} = e_{at}$ (for a))

$y_{bt} = 0.8 e_{bt}$ (for b))

$y_{ct} = 0.8 e_{ct}$ (for c))

where $e_{at} = e_{ct} < e_{bt}$.

Hence: $y_{at} > y_{ct}$

People are clearly worse off, all else equal, with a higher population growth even though aggregate output grows faster.

Also: $Y_{bt} > Y_{ct}$

Even though the SS output per effective worker are the same in (b) and c), per capita income levels will be higher with higher TP growth than population growth, as would be expected.

Note, however, how the aggregate output growth is the same for both b) and c), though for different reasons.

Finally, we need more mathematical derivation to compare the magnitudes of y_t^a and y_t^b. It can be shown that $y_t^b > y_t^a$, as would be expected by intuition, i.e. a higher TP growth rate increases per capita income, all else equal.