

Foundations of Modern Macroeconomics Second Edition

Chapter 14: Endogenous economic growth (sections 14.4 – 14.5)

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Outline

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 - The EIV model
 - Economic growth / efficiency
 - Scale effect

R & D as the engine of growth

- *Key idea:* Purposeful conduct of R&D activities is the source of growth.
 - In the absence of human and physical capital, households can nevertheless save by accumulating *patents*.
 - Patents are blueprints for the production of “slightly unique” products.
 - The patent holder has a little bit of monopoly power which can be exploited.
 - Hence, in this literature we leave the competitive framework and enter the realm of monopolistic competition.
(Schumpeterian models of “creative destruction” can be built along the lines of the present model. Example: RIQ model.)

Overview of the expanding input variety (EIV) model

- Three productive sectors.
- *Final goods sector* (CRTS, perfectly competitive, external effect “returns to specialization”): Produces a homogenous good using differentiated inputs in the production process.
- *Intermediate goods sector* (many small monopolistically competitive firms): Each firm (patent holder) uses labour to produce its own slightly unique variety of the intermediate input.
- *R&D sector* (CRTS, perfectly competitive, external effect “standing on the shoulder of giants”): Produces blueprints for new intermediate inputs, using labour as an input.
- Production factors perfectly mobile.

Final goods sector (1)

- *Final goods sector* (CRTS, perfectly competitive, external effect “returns to specialization”): Produces a homogenous good using differentiated inputs in the production process.
- Technology:

$$Y(t) \equiv N(t)^\eta \cdot \left[\frac{1}{N(t)} \sum_{i=1}^{N(t)} X_i(t)^{1/\mu} \right]^\mu \quad (S1)$$

where X_i is intermediate input i , N is the existing number of varieties, and μ and η are parameters ($\mu > 1$ and $\eta \geq 1$).

- If $\eta > 1$ there are returns to specialization as in Adam Smith's pin factory. If intermediate inputs are more finely differentiated then firms can use a more roundabout production process.
- μ measures the ease with which inputs can be substituted. This is the source of market power later on.

Final goods sector (2)

- Pricing decision:

$$P_Y(t) \equiv N(t)^{-\eta} \cdot \left[N(t)^{\mu/(1-\mu)} \sum_{i=1}^{N(t)} P_i(t)^{1/(1-\mu)} \right]^{1-\mu}$$

- Derived demand for input i (for $(i = 1, 2, \dots, N(t))$):

$$\frac{X_i(t)}{Y(t)} = N(t)^{(\eta-\mu)/(\mu-1)} \cdot \left(\frac{P_i(t)}{P_Y(t)} \right)^{\mu/(1-\mu)}$$

So $\mu/(1 - \mu)$ is the demand elasticity.

Intermediate goods sector

- *Intermediate goods sector* (many small monopolistically competitive firms): Each firm (patent holder) uses labour to produce its own slightly unique variety of the intermediate input.
- Technology:

$$X_i(t) = Z_X \cdot L_i(t)$$

constant marginal production costs.

- Pricing decision:

$$P_i(t) = \mu \cdot \frac{W(t)}{Z_X}$$

where μ is the gross monopoly markup.

R & D sector

- *R&D sector* (CRTS, perfectly competitive, external effect “standing on the shoulder of giants”): Produces blueprints for new intermediate inputs, using labour as an input.
- Technology:

$$\dot{N}(t) = Z_R \cdot N(t) \cdot L_R(t)$$

Labour engaged in the R&D sector becomes more productive as more patents already exist. Today’s engineers “stand on the shoulders of giants.”

- Pricing decision:

$$P_N(t) = \frac{(1 - s_R) \cdot W(t)}{Z_R \cdot N(t)}$$

Household behaviour

- Representative infinitely-lived households.
- Lifetime utility function:

$$\Lambda(0) = \int_0^{\infty} \frac{C(t)^{1-1/\sigma} - 1}{1 - 1/\sigma} \cdot e^{-\rho t} dt$$

- Household budget identity:

$$P_Y(t)C(t) + P_N(t)\dot{N}(t) = W(t)L_0 - T(t) + N(t)\bar{\Pi}(t)$$

- Optimality conditions:

$$\frac{\dot{C}(t)}{C(t)} = \sigma \cdot [r(t) - \rho]$$

$$r(t) = \frac{\bar{\Pi}(t) + \dot{P}_N(t)}{P_N(t)}$$

where $r(t)$ is the rate of return on blueprints.

Economic growth

- There is no transitional dynamics (no capital).
- The growth rates are:

$$\gamma_N^* = \frac{\frac{\mu - 1}{1 - s_R} Z_R L_0 - \rho}{\frac{\mu - 1}{1 - s_R} + \frac{\eta - 1}{\sigma} + (2 - \eta)} > 0$$
$$\gamma_C^* = \gamma_Y^* = (\eta - 1)\gamma_N^*$$

- The innovation rate, γ_N^* :
 - increases with the monopoly markup (μ) and the subsidy (s_R)
 - increases with the size of the labour force (L_0)
 - (provided $\eta > 1$) increases with the intertemporal substitution elasticity (σ)
 - decreases with the rate of time preference (ρ).
- Consumption and aggregate output grow only if the returns to specialization are operative (so that $\eta > 1$).

Efficiency (1)

- Not obvious that the decentralized market equilibrium is efficient as there are both external effects and non-competitive behaviour.
- “Quick-and-dirty” intuition would seem to suggest that there is too little innovation (under-investment in R&D) because the innovator does not capture all the beneficial effects of his act.
- Formal approach in economic theory:
 - Compute what kind of allocation a (benevolent) social planner would choose
 - Such a planner takes into account (“internalizes”) all external effects/economies of scale
 - Compare socially optimal allocation with decentralized market allocation
 - How can social optimum be replicated in the market?

Efficiency (2)

- (For simple case, $\sigma = 1$) we find:

$$\begin{aligned}\gamma_N^*(s_R) &\equiv \frac{(\mu - 1)Z_R L_0 - \rho(1 - s_R)}{\mu - s_R} \\ \gamma_N^{SO} &= \frac{(\eta - 1)Z_R L_0 - \rho}{\eta - 1}\end{aligned}$$

- Point of view #1: Suppose $s_R = 0$.

$$\mu \cdot [\gamma_N^{SO} - \gamma_N^*(0)] = Z_R L_0 - \rho \cdot \frac{\mu - (\eta - 1)}{\eta - 1}$$

- no general conclusion. $\gamma_N^{SO} > \gamma_N^*(0)$ or $\gamma_N^{SO} < \gamma_N^*(0)$?
- if $\eta = \mu$ (knife-edge case): Q&D intuition is OK! We find that $\gamma_N^{SO} > \gamma_N^*(0)$
- if $\eta \approx 1$ (weak specialization effect): there may be too much innovation!

Efficiency (3)

- Point of view #2: For which subsidy value do we find $\gamma_N^{SO} = \gamma_N^*(s_P)$?

$$\begin{aligned}\frac{s_R^*}{1 - s_R^*} &= \frac{(\eta - 1) Z_R L_0 - \rho [\mu - (\eta - 1)]}{\rho (\mu - 1)} \\ &= \frac{\mu (\eta - 1)}{\rho (\mu - 1)} \cdot [\gamma_N^{SO} - \gamma_N^*(0)]\end{aligned}$$

- it is optimal to subsidize (tax) R&D labour if the *laissez-faire* economy innovates too slowly (quickly) relative to the social optimum.

Counterfactual prediction (1)

- *Problematic aspect:* The growth rate depends on the scale of the economy (L_0 in this case). Hence, large countries should grow faster than small countries. This is not observed in reality. Jones removes the scale effect by replacing the R&D technology by:

$$\dot{N}(t) = Z_R \cdot L_R(t) \cdot N(t)^{\phi_1} \cdot [\bar{L}_R(t)]^{\phi_2 - 1}$$

where \bar{L}_R is average R&D labour per R&D firm.

- We had $\phi_1 = 1$ but now assume $0 < \phi_1 < 1$ (the giants don't grow forever).
- We had $\phi_2 = 1$ but now assume $0 < \phi_2 \leq 1$ (duplication externality: individual R&D firms think the production function is linear, but in actuality it features diminishing returns to labour).

Counterfactual prediction (2)

- Assuming that the population grows at an exponential rate, n_L , the growth rates are now (see book for details):

$$\begin{aligned}\gamma_N^* &= \frac{\phi_2 n_L}{1 - \phi_1} \\ \gamma_y^* &= \gamma_Y^* - n_L = (\mu - 1)\gamma_N^* \\ \gamma_c^* &= \gamma_C^* - n_L = \gamma_y^*\end{aligned}$$

- We reach the striking conclusion that by eliminating the scale effect we are back in the realm of exogenous growth and the Solow model!