6. Creative Destruction

Reference: Philippe Aghion and Peter Howitt, 2006, Growth with Quality-Improving Innovations: An Integrated Framework, Handbook of Economic Growth, Chapter 2.1.

So far:

- Growth through increasing varieties (Horizontal Innovation)
- New varieties have not replaced existing varieties.
- New varieties have indirectly raised productivity of existing ones.
- Deterministic R&D.

Now: a toy version of Aghion and Howitt's (1992) model:

- A rigorous modelling of Joseph Schumpeter's ideas.
- Creative destruction.
- Economic growth results from a succession of product improvements
- Vertical Innovation (better quality of existing goods)
- New innovations make older ones obsolete.
- Success of R&D is uncertain.

Final goods production:

$$Y_t = A_t x_t^{\alpha} \tag{1}$$

Observe:

- only one intermediate good x (in the toy model)
- A measures now the quality of the intermediate good currently in use.
- discrete time

Intermediate goods production

$$x_t = L_{x\,t} \tag{2}$$

L_x: workers in x production.

Employment constraint:

$$L = L_{x\,t} + L_{A\,t} \tag{3}$$

L_A workers in R&D.

The R&D sector:

- R&D is stochastic.
- probability of successful research in period t with L_A researchers: λL_A
- λ: General R&D productivity. Note:
  - no externalities, linearity
  - expect: growth is fully endogenous (not semi-endogenous).
- A successful innovation improves the quality of the intermediate good by factor $\gamma > 1$ (Quality Ladders Model)

If R&D was successful

$$A_{t+1} = \gamma A_t \tag{4}$$

γ measures the size of the innovation.

Generally:

- A successfully innovating firm drives the incumbent firm out of the market (it can deliver higher quality at same price)
- Yet with probability λL_A it is itself replaced in the next period by the next firm.

Here: simplification: patent for 1 period. After that all firms can produce goods of same quality.

Case differentiation:

1. Unconstrained monopoly (as in last lecture):
Profits in the intermediate sector (if R&D was successful):

$$\pi_t = p(x_t) \cdot x_t - w_t x_t$$

p price of the intermediate, w wage .

FOC:

$$p'(x_t) \cdot x_t + p(x_t) - w_t = 0 \qquad \Rightarrow \qquad p' \frac{x_t}{p_t} + 1 = \frac{w_t}{p_t}.$$

Final good producers. FOC for maximimum profits.

$$\alpha A_t x_t^{\alpha-1} - p_t = 0$$

and thus indirect demand:

$$p_t = \alpha A_t x_t^{\alpha-1} \qquad \Rightarrow \qquad p' = (\alpha - 1)\alpha A x_t^{\alpha-2} \qquad \Rightarrow \qquad p' \frac{x_t}{p_t} = \alpha - 1.$$

Implying the equilibrium price

$$\alpha = \frac{w_t}{p_t} \qquad \Rightarrow \qquad p_t = \frac{1}{\alpha} w_t.$$

2. Alternatively, competitive imitators can produce the same quality at a higher marginal cost of χw_t. Maximum monopoly price:

$$p = \chi w_t \qquad \chi \in (1, 1/\alpha).$$

Implied profits:

$$\pi_t = (\chi - 1) w_t x_t \tag{5}$$

Now note that

- expected profits: $\lambda L_{At} \pi_{t+1}$
- if R&D is successful it raises A by factor γ. Thus
  - it raises p by factor γ
  - it raises π by factor γ

Thus expected profits:

$$\lambda L_{At} \gamma \pi_t$$

Free entry into R&D $\rightarrow$ expected profits = costs, i.e.

$$\lambda L_{At} \gamma \pi_t = w_t L_{At}. \tag{6}$$

Insert (5) into (6):

$$w_t = \lambda\gamma(\chi - 1)w_t x_t$$

i.e.

$$1 = \lambda\gamma(\chi - 1)L_{x\,t}$$

since $x_t = L_{x\,t}$.

And since $L_A = L - L_x$:

$$L_{A\,t} = L - \frac{1}{\lambda\gamma(\chi - 1)}. \tag{7}$$

The deterministic growth rate would be

$$\hat{y} \equiv g \equiv \frac{A_{t+1} - A_t}{A_t} = \gamma - 1.$$

Yet, growth occurs only in periods when R&D was successful. Expected growth rate:

$$g = \lambda L_A(\gamma - 1) \tag{8}$$

insert (7) into (8)...

Equilibrium growth rate:

$$g = \lambda(\gamma - 1)\left(L - \frac{1}{\lambda\gamma(\chi - 1)}\right) \tag{9}$$

Comparative statics:

- observe the scale effect of first order
- scope for R&D policy
  - larger size of innovation (γ) increases growth
  - larger productivity (λ) increases growth
  - more market power (χ) increases growth
- fully endogenous growth.

Generalizations (Strulik, 2005, 2006): Suppose

- continuous expansion of varieties through variety R&D
- quality ladders in all sector of already existing varieties
- all kinds of spillovers between within and between sectors
- researchers expand along numbers (population growth) and quality (human capital accumulation).

Any general conclusions possible?

Some conclusions from generalizations:

- It is extremely likely that growth is semi-endogenous (double knife-edge condition).
- Growth is probably in the long-run not controllable by fiscal policy (driven by fundamentals).
- Wether long-run growth is possible depends on whether
  - there can be human capital accumulation forever
  - or human capital accumulation (tied to bodies, brains) can successfully be substituted by knowledge accumulation (CES production function needed).
- Nevertheless policy can have important permanent effects on income levels and long (but not forever) lasting effects on growth.

In order to assess the implications better we need a numerical specification (calibration) of the theoretical model...

Some results from calibration studies:

- Population growth is probably (but not necessarily) harmful for growth.
- The capital dilution effect (from the neoclassical model) is more important than the 2nd order scale effect (from the semi-endogenous growth model).
- Which effect dominates depends on altruism between generations.
- Productivity of education matters a lot.
- On the aggregate level the effort spend on R&D is probably close to the optimal effort.
- Nevertheless there can be huge sectoral misallocations and thus scope for fiscal policy.
- Problem: we don't know much about the responsible external effects between sectors.