Creative Desctruction

The Romer model thought of innovation as adding new intermediate goods to the market (cars, robots, iPhones), but once invented, each good was fixed in quality.

The Schumpeterian model conceives of innovation as improving existing products (iPhone 6 vs. iPhone 5 vs. iPhone 4), with newer versions replacing old versions. Hence the "creative destruction".

Schumpeterian growth changes the mechanical details of growth, but not the general conclusions

- The long-run trend growth rate depends on population growth
- The allocation of workers to research may not be optimal

One advantage of the Schumpeterian model is that it explicitly allows us to think about firm dynamics, or the creation and destruction of firms over time.

Mechanics of Growth

Final goods are produced using

$$Y = K^{\alpha}(A_i L_Y)^{1-\alpha} \tag{1}$$

where A_i is the productivity of the latest version of technology. So $A_2 > A_1$, and $A_{100} > A_{99}$.

A_i moves up in discrete jumps, so

$$A_{i+1} = (1+\gamma)A_i \tag{2}$$

where γ is the "step size", or how much productivity rises each time we innovate.

Growth occurs when we innovate, but that doesn't always happen. The growth rate of A_i from *innovation* to *innovation* is

$$\frac{A_{i+1} - A_i}{A_i} = \gamma \tag{3}$$

but this is not how fast A_i grows over *time*.

The Speed of Innovation

The chance that any given researcher will produce an innovation at any given moment is

$$\overline{\mu} = \theta \frac{L_A^{\lambda-1}}{A_i^{1-\phi}} \tag{4}$$

or the probability of innovating depends on the same forces as before: duplication due to other researchers and the spillovers of A_i on research.

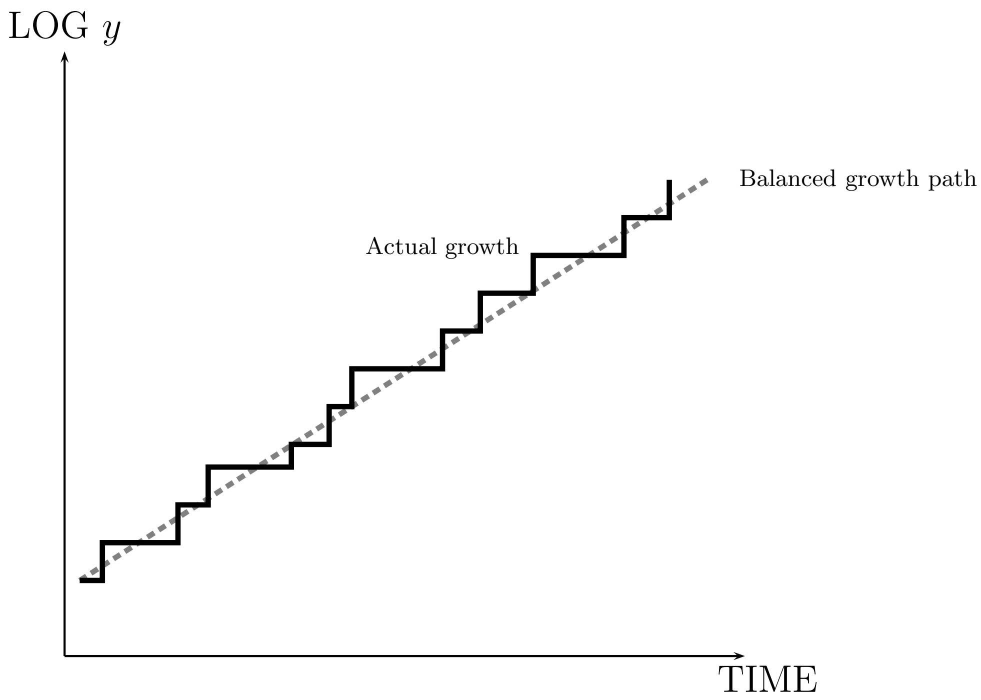
For the economy as a whole, the probability of making an innovation depends on how many researchers are working, so

$$P(Innovation) = \overline{\mu} L_A = \theta \frac{L_A^{\lambda}}{A_i^{1-\phi}}. \tag{5}$$

Long-run Growth Rate

The growth rate of this economy is not immediately obvious.

- At any given point in time, no one may have innovated, so growth is zero.
- When someone does innovate, A_i jumps by γ, so growth is very rapid in that moment
- Look at average growth over long period, smoothing this out



Expected Growth Rate

So the expected growth rate along the BGP (the smoothed line) is

$$E\left[\frac{\dot{A}}{A}\right] = \gamma\overline{\mu}L_A = \gamma\theta\frac{L_A^\lambda}{A_i^{1-\phi}}. \tag{6}$$

- γ tells us how much A jumps when an innovation occurs
- $\overline{\mu}L_A$ tells us the expected value of the number of jumps

Using this, what is the expected growth rate of A along the BGP? Along the BGP the expected growth rate of A will be constant. Using the above and taking logs and derivatives

$$0 = \lambda\frac{\dot{L_A}}{L_A} - (1-\phi)E\left[\frac{\dot{A}}{A}\right] \tag{7}$$

which given that $\dot{L_A}/L_A = n$ along the BGP, means that

$$E\left[\frac{\dot{A}}{A}\right] = g = \frac{\lambda}{1-\phi}n \tag{8}$$

which is identical to what we got in the Romer model.

Comparison

The Schumpeterian model doesn't change our conclusion about the long-run trend growth rate.

- Due to assumption that technological change depends on L_A^λ and $A^{1-\phi}$
- Not relevant whether A is more goods or better goods

Note that γ does not feature in the long-run growth rate

- Larger γ boosts the size of jumps in A, which would be good for growth
- Larger γ, though, raises A, making it harder to find the next innovation
- These effects cancel out

Schumpeterian model differs in the underlying economics, and will differ in the equilibrium value of s_R

Final Goods Production

Final goods produced using

$$Y = L_Y^{1-\alpha} A_i^{1-\alpha} x_i^{\alpha} \tag{9}$$

where x_i is a single intermediate (or capital) good used in the final goods sector. It is indexed by i because each intermediate good has a specific productivity level, A_i associated with it.

Similar to before, final good firms will maximize profits,

- Choose how many units of x_i to use
- Choose which version of x_i to use (latest, or older less productive version)
- Will turn out that all versions cost the same, so they will pick best one

Final Good Sector Profits

They will

$$max_{L_Y,x_i} L_Y^{1-\alpha} A_i^{1-\alpha} x_i^{\alpha} - wL_Y - p_i x_i \tag{10}$$

giving first-order conditions of

$$\begin{aligned} w &= (1-\alpha)\frac{Y}{L_Y} && (11) \\ p_i &= \alpha L_Y^{1-\alpha} A_i^{1-\alpha} x_i^{\alpha-1} && (12) \end{aligned}$$

which again is just that the firm sets marginal cost equal to marginal product.

As in the Romer model, the elasticity of demand for the intermediate good is $\alpha - 1$

Intermediate Good Firms

Int. good firms are monopolists at producing their version of the int. good. As before, they transform one unit of capital into one unit of the int. good. Their profits are

$$\pi_i = p_i(x_i)x_i - rx_i \tag{13}$$

The first-order condition is

$$p_i'(x_i)x_i + p_i(x_i) = r \tag{14}$$

or set marginal revenue to marginal cost.

As before, we can transform this FOC into

$$p_i = \frac{1}{1 + \frac{p_i'(x_i)x_i}{p_i}} r \tag{15}$$

which given the elasticity we found for final goods firm demand gives

$$p_i = \frac{r}{\alpha} \tag{16}$$

Markup Pricing

Similar to the Romer model, int. good firms charge a markup over marginal cost.

- This generates the profits that will motivate innovation
- The price they charge does *not* depend on the version of the int. good they produce
- So all versions of x_i sell for the same price, final good firms only buy the best one (highest A_i)

This set-up ensures the creative desctruction in the economy. Once a new innovation occurs (a new x_{i+1}) with a higher productivity, the old intermediate good (x_i) firm goes out of business and the new firm takes over completely.

Aggregate Output

Given that only one int. good firm operates at a time, it must be that

$$x_i = K \tag{17}$$

meaning that aggregate output is

$$Y = K^{\alpha}(A_i L_Y)^{1-\alpha} \tag{18}$$

which is the same as the standard production function we always use.

We can solve for the distribution of income as we did in the Romer model, yielding

$$\begin{aligned} wL &= (1-\alpha)Y && (19) \\ rK &= \alpha^2 Y && (20) \\ \pi_i &= \alpha(1-\alpha)Y && (21) \end{aligned}$$

with the only difference being that all profits accrue to the one operating int. good firm.

Research Sector

Again, we want to understand the incentive to do research. Inventing a new version x_{i+1} gives you a patent on that good you can sell (or use to be the monopolist). Use arbitrage to value the patent

$$rP_A = \pi + \dot{P}_A - (\overline{\mu}L_A)P_A \tag{22}$$

- rP_A is again the value of putting your money in the bank instead
- $\pi + \dot{P}_A$ is the value of the patent: profits plus capital gains
- $(\overline{\mu}L_A)P_A$ captures the fact that with probability $\overline{\mu}L_A$, you will be replaced as the monopolist by the next innovator, so it is a negative.

Re-arrange to

$$r = \frac{\pi}{P_A} + \frac{\dot{P}_A}{P_A} - \overline{\mu}L_A \tag{23}$$

and for convenience let $\mu = \overline{\mu}L_A$ so

$$r = \frac{\pi}{P_A} + \frac{\dot{P}_A}{P_A} - \mu \tag{24}$$

Patents Along BGP

As in the Romer model, we want to consider the value of a patent along the BGP, where r is constant. This implies π and P_A must grow at the same rate.

- We know that profits are $\pi = \alpha(1-\alpha)Y$, so profits grow at the rate $g+n$
- We know that $g = \gamma\bar{\mu}L_A = \gamma\mu$ along the BGP

so we have that

$$r = \frac{\pi}{P_A} + \gamma\mu + n - \mu \tag{25}$$

which solves to

$$P_A = \frac{\pi}{r - n + \mu(1-\gamma)}. \tag{26}$$

Again, patents are the present discounted value of profits. Now the discount rate is higher because of μ, which captures the chance of being replaced.

Note that no existing monopolist would ever buy the new patent. Why? Because they have to sacrifice their existing profits, meaning they will not pay as much for the new patent. So always new firms coming into existence. “Arrow Replacement Effect”.

Equilibrium for Labor

Again, individuals can either do research to get the next idea, or work in the final goods sector. They move back and forth until the returns to these two activities are identical, or

$$(1-\alpha)\frac{Y}{L_Y} = \overline{\mu}P_A \tag{27}$$

where $\overline{\mu}$ is the chance that an individual will innovate, and P_A is the value of that innvotion to them.

$$(1-\alpha)\frac{Y}{L_Y} = \overline{\mu}\frac{\pi}{r-n+\mu(1-\gamma)} \tag{28}$$

$$(1-\alpha)\frac{Y}{L_Y} = \overline{\mu}\frac{\alpha(1-\alpha)Y}{r-n+\mu(1-\gamma)} \tag{29}$$

$$\frac{1}{L_Y} = \frac{\mu}{L_A}\frac{\alpha}{r-n+\mu(1-\gamma)} \tag{30}$$

$$\frac{L_A}{L_Y} = \mu\frac{\alpha}{r-n+\mu(1-\gamma)} \tag{31}$$

$$\frac{s_R}{1-s_R} = \mu\frac{\alpha}{r-n+\mu(1-\gamma)} \tag{32}$$

which solves to

$$s_R = \frac{1}{1+\frac{r-n+\mu(1-\gamma)}{\alpha\mu}}. \tag{33}$$

Equilibrium s_R

Found

$$s_R = \frac{1}{1 + \frac{r-n+\mu(1-\gamma)}{\alpha\mu}} \tag{34}$$

- Same discount factor $r - n$. If that goes up, value of patents goes down, lower s_R
- First effect of μ: from $\mu(1-\gamma)$ captures the fact that as the probability of innovation goes up, the value of patents declines due to replacement effects
- Second effect of μ: from $\alpha\mu$ captures the fact that as the probability of innovation goes up, you are more likely to get a patent in th first place
- On net, the second effect "wins". You get a patent now, and will only be replace later, so if μ goes up, s_R goes up

Comparing Schumpeter and Romer

The long-run growth rate is identical at $g = \lambda n/(1-\phi)$. The difference is in the *level* of income along the BGP implied by the value of s_R.

- Schumpeterian model has higher s_R if $g < r - n$. In this case the discount rate is very large, and so I care most about profits in the immediate future and little about the fact that I might be replaced some day. So more people do research than in Romer.
- Schumpeterian model has lower s_R if $g > r - n$. In this case the discount rate is low, so people do care about the future replacement a lot. Hence s_R is low compared to Romer.

Remember that higher s_R is not necessarily optimal. $y(t)$ along the BGP depends both positively and negatively on s_R. There is no sense in which Romer or Schumpeter is "better". They are different ways of conceiving of the growth process.