LECTURE 3.4

Schumpeterian Growth

ECON42550 Macroeconomics

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Where We Are

1. Short-Run Fluctuations

1.1 The Keynesian Multiplier

1.2 Introducing IS-MP-PC

1.3 Analysing IS-MP-PC

1.4 The Zero Lower Bound

1.5 Banks, Runs, the Cycle

2. NK Building Blocks

2.1 Expectations, Investment

2.2 Consumption, Fiscal Policy

2.3 Sticky Prices and the NKPC

3. Long-Run Growth

3.1 Growth Facts, Solow

3.2 The Fundamental Causes

3.3 Endogenous Growth

3.4 Schumpeterian Growth

> **This Is the Last Lecture**
> Four blocks today; after them, revision built from your muddiest points.

Last Week's Lecture

Last week ideas became the engine of growth, and the model's sharpest prediction failed.

1. **Ideas Are Different.**
   Why technology cannot be left outside the model, and what kind of economic good an idea is.

2. **The Romer Model.**
   Growth built out of a research sector.

3. **Semi-Endogenous Growth.**
   The model's sharpest prediction fails in the data. Repair it, and the policy conclusion changes.

4. **Gordon and the Future of Growth.**
   The case that the great century of innovation was a one-off, and where AI enters it.

Lecture Plan

1 **Creative Destruction.**
Replace the idea of ideas accumulating with the idea of firms replacing each other.

2 **Competition and Innovation.**
Derive the model's most testable prediction, and test it.

3 **Firm Dynamics.**
Test the model again, against what happens to firms as they age and grow.

4 **Growth Policy.**
Turn the theory into advice, and say where it stops.

> **Aghion's Nobel Lecture**
> Reading: Aghion's Nobel lecture, *The Economics of Creative Destruction*, on Brightspace. Background: Whelan (2023, ch. 12) — last week's chapter, because this lecture has no chapter of its own.

SECTION 1

Creative Destruction

Growth as Replacement

This section replaces the accumulation of ideas with firms replacing each other, and it yields three testable predictions we check today. Growth here is not a stock of knowledge getting larger; it is a sequence of firms taking each other's place, and each step forward has a loser attached to it:

- **One Event, Not Two:** The productivity gain is the incumbent's loss.
- **Contested Growth:** The incumbents who lose have every reason to block entry.

> **Productivity Rises Because the Incumbent Loses**
> A cheaper entrant takes the market and the incumbent's mark-up disappears. Schumpeter's name for that event is **creative destruction**.

Innovation and Growth, Across the United States

The model must fit this correlation. So does Romer's, and so does reverse causation.

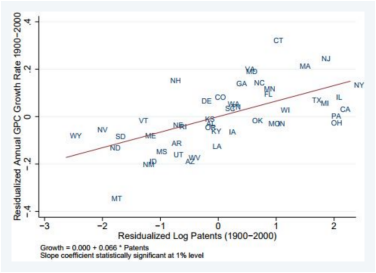

Figure 1: Long-run growth against patenting across US states, 1900–2000, both residualized.

> **States That Innovate More Grow Faster**
> One point per state, and one or two outliers are not driving the slope.

The Aghion–Howitt Economy

Each sector's output comes from whoever holds its best technology. Aggregate output (Y_t) adds the sectors up:

$$Y_{it} = A_{it}^{1-\alpha} K_{it}^{\alpha}, \qquad Y_t = \int_0^1 Y_{it}\, di \tag{1}$$

- i: a sector, one of a continuum
- Y_{it}: output of sector i
- A_{it}: the quality of the leading technology in sector i
- K_{it}: capital used in sector i

> **α Is the Capital Share**
> The same α, and the same one-third, as in 3.1 and 3.3 — **not** the IS-curve slope from Part 1, which shared the letter and nothing else.

Every Sector Is a Small Monopoly with a Queue Behind It

- The firm with the **best current technology** supplies its whole sector at a mark-up.
- That leader keeps the sector until **out-innovated**: entry alone does not end the position.
- The economy is a continuum of small monopolies, each with a queue of challengers.

> **The Mark-Up Is the Prize**
> The mark-up is not a distortion tolerated for tractability; it is what research is paid out of — Romer's point, now with a named loser.

The Quality Ladder

Sectors do not drift upward through a continuum of tiny improvements. They **jump** by a factor γ when somebody innovates, and sit still otherwise:

$$A_{it} \longrightarrow \gamma A_{it}, \qquad \gamma > 1 \tag{2}$$

- γ: the size of one step up the ladder

> **γ Is a Step, Not a Slope**
> In Part 1, γ was the Phillips-curve slope, a small positive number. Here it is a multiplicative step **greater than one**.

Research Buys a Probability

Effort over one period buys a **probability**, not an outcome — which is what makes this a model of turnover rather than accumulation:

$$\Pr(\text{innovation in } i) = \lambda z_{it} \tag{3}$$

- z_{it}: research effort in sector i
- λ: the productivity of research

> **λ Is Not 3.1's λ**
> In 3.1, λ was the crowding-out fraction in $C = (s - \lambda\sigma)Y$. Here it scales research effort into a probability.

The Rent, and Who Destroys It

The prize is worth what it earns for as long as the firm keeps it:

$$V = \frac{\pi}{\rho + \underbrace{\lambda z}_{\text{the rate of creative destruction}}} \tag{4}$$

- V: the value of holding the leading technology
- π: the flow of monopoly profit the leader earns

> **The Denominator Is the Whole Idea**
> A firm discounts its rents twice: the future is worth less, **and somebody else is coming**. More research effort (z) shortens tenure and cuts V.

How Fast the Economy Grows

In one period a sector's A rises by a factor γ with probability λz, and is unchanged otherwise. Adding the sectors up gives the long-run growth rate of output per worker (g):

$$g = \lambda z \times \underbrace{(\gamma - 1)}_{\text{one step, as a fraction}} \tag{5}$$

Policy can pull either lever: raise λz for more frequent innovations, raise γ for larger ones. Which lever is available depends on a country's closeness to the frontier.

> **Growth Is a Rate Times a Size**
> There is no stock of ideas in this expression at all.

What Makes This Different

Two models of the same phenomenon, with opposite internal politics.

Research Only Adds, Nobody Loses

Researchers **add** to a stock of non-rival ideas. The stock never shrinks and nobody's existing income is threatened by a new idea. More research is unambiguously more growth.

Every Step Ends Somebody's Monopoly

Innovators **replace** the incumbent and destroy its rents. Every step up the ladder ends somebody's monopoly. More research is more growth *and* shorter tenure for everyone.

Private and Social Return Diverge

A firm may innovate too little, because it cannot hold the rent for long, or too much, because the rent it destroys is somebody else's.

Why Is Creative Destruction in the Denominator?

The value function has two terms below the line.

> **Question**
> What sits in the denominator of V, and why is each of the two terms there?

Write your answer down without looking, then compare with the person beside you and fix whichever of you is wrong.

SECTION 2

Competition and Innovation

Two Opposing Forces

This section derives the model's most testable prediction and tests it. The obvious argument about competition runs one way: competition erodes the prize, so it must discourage innovation. The model runs both ways:

- **Competition Cuts the Rents from Innovating:** Less to win, so innovate less.
- **Competition Also Cuts the Rents from Standing Still:** Less to keep, so innovate more.

> **Competition Is Scaled from 0 to 1**
> Write product-market competition as c: 0 is no competitive pressure at all, 1 is as competitive as a market gets. Nothing turns on the scaling.

Which Force Wins?

A regulator makes a concentrated industry more competitive — easier entry, tighter merger rules, no exclusive contracts.

> **Question**
> What happens to the amount of innovation in that industry? **More**, **less**, or **it depends**?
> If you pick the third, name what it depends on.

Have a think on your own first, then take ninety seconds with the person beside you.

Rents From Innovating: The Schumpeterian Effect

The classic argument, and the one Schumpeter himself pressed:

- An innovation is worth having only because it buys a **temporary monopoly**.
- Competition erodes the prize: where nobody can hold a mark-up, an innovation earns nothing.
- In V the effect runs through π: lower profit, lower V, lower research effort z.

> **The Comparison to Standing Still Is Missing**
> The argument never asks what the same firm would have earned had it not innovated. That comparison is the missing half.

A Monopolist Has Nothing to Escape From

Section 1 gave each sector one leader and a queue of challengers, so a firm that does not innovate supplies nothing and earns nothing. To ask the missing question, section 2 puts **two firms** in every sector:

- **Level Sectors:** Both firms share the technology, so neither earns a leader's mark-up.
- **Unlevelled Sectors:** One firm leads and one lags — the Schumpeterian case just described.
- **The Gain Is a Difference:** A leader's profit minus what that firm earns standing still.

> **Standing Still Must Also Be Worth Less**
> Under leapfrogging the firm that stands still earns zero whatever competition does, so competition can only shrink the gain from innovating.

Rents From Standing Still: The Escape-Competition Effect

In a level sector competition eats both firms, and innovating is how one of them escapes it:

- Competition cuts both profits and cuts the level firm's harder — more comfort to lose.
- So the gap between leading and being level **widens** as competition rises.

> **The Curve Bends Because the Mix Shifts**
> Escape-competition strengthens in c throughout; the Schumpeterian effect weakens. The **mix** shifts to unlevelled sectors, and the curve bends down.

The Two Forces in One Function

With both forces acting, the toy model writes aggregate innovation as

$$I(c) = \frac{4\kappa c(1-c)}{1+c} \tag{6}$$

- κ: a scale constant
- $I(c)$: aggregate innovation at that level of competition

> **Innovation Vanishes at Both Extremes**
> $I(0) = 0$: a comfortable level pair has nothing to escape. $I(1) = 0$: full competition leaves no prize. In between $I(c) > 0$, so **the peak is interior**.

Where the Closed Form Comes From

$I(c)$ is the toy model's own expression, not a line from the paper:

- **In the Paper:** Aghion and co-authors derive innovation from a Bellman system of value functions.
- **In the App:** $I(c)$ is a static approximation built from current-period profit differences.

> **$I(c)$ Is Not in the Paper**
> Do not quote $I(c)$ as the paper's result. What transfers is the shape and the mechanism behind it, not this algebra.

The Inverted U

Neither *more* nor *less* was right on its own. Competition raises innovation, until it lowers it.

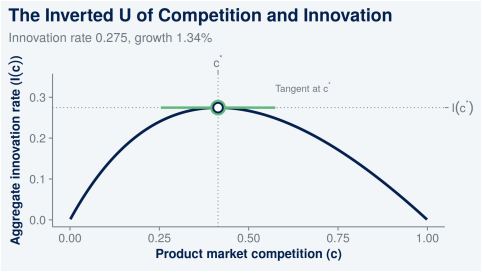

Figure 2: Aggregate innovation against product-market competition: a hump, with the peak marked, a short horizontal tangent drawn through it and labelled $I'(c^*) = 0$, and the peak's level marked off on the right-hand axis.

Escape-Competition Wins Low, Schumpeter Wins High
The tangent is flat exactly where the two forces balance.

Where the Peak Sits

Differentiate $I(c)$ and set the derivative to zero. The numerator gives $1 - 2c - c^2 = 0$, so

$$c^\star = \sqrt{2} - 1 \approx 0.414 \tag{7}$$

- c^*: the level of competition that maximises $I(c)$

> **Two Stars, Two Different Animals**
> x^* is a **resting point**, as r^* and $\tilde{k}^*$ were. $c^\star$ is a **maximiser**: if a country sits there, a regulator put it there.

The Shape Is the Result; the Number Is an Illustration

$\sqrt{2} - 1$ is a property of the **reduced form on the last slide**, not of Schumpeterian growth theory:

- It falls out only when the exogenous catch-up rate is set to zero.
- Allow catch-up, as the original model does, and at a rate of 0.05 the peak sits nearer 0.435.
- The **shape** does not move: innovation rises, peaks and falls regardless.

> **Quote the Shape, Not the Number**
> A student who quotes 0.414 as a property of the model has been mistaught. Quote the shape; quote the number only with the assumption attached.

Aghion and Co-Authors Find the Shape in UK Data

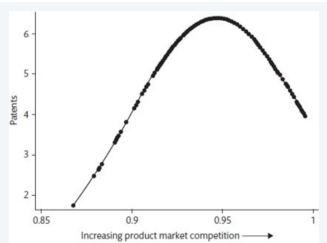

Figure 8.21 The relationship between innovation and competition: UK firms.

Figure 3: Patenting against product-market competition, UK firms: the estimated relationship.

> **The Peak Sits Inside the Observed Range**
> Competition rises left to right. Innovation peaks near 0.95, not at either end.

Competition Is Not Handed to You

The shape is only as good as the variation behind it, and the variation is the hard part:

- Firms that innovate successfully **raise the competitiveness of their own industry**, so a raw correlation runs both ways at once.
- The paper instruments competition with **policy reforms** that shifted it for reasons unrelated to any one firm's research.
- Believing the inverted U therefore means believing that exclusion restriction.

> **Identification Here Copies the Colonial-Origins Instrument**
> The outcome partly chooses the regressor, and an unrelated reform breaks that loop — settler mortality in 3.2, competition reforms here.

Which Force Is Winning on Each Arm?

The curve has two arms, and a different force governs each one.

> **Question**
> Sketch the inverted U, label both axes, and name the force that is winning on each arm.

Draw it from memory, then compare with the person beside you.

SECTION 3

Firm Dynamics

Entry, Exit and Turnover

This section tests the model against how firms enter, grow and exit. Creative destruction is a statement about **firms**, not only about the aggregate growth rate:

- **Entry:** New firms arrive holding new technology and take share from incumbents.
- **Exit:** Incumbents that stop innovating are displaced. That is the model working.
- **Turnover:** The leading firm changes at rate λz, the rate that also sets growth.

> **Growth Is Turnover Times Step Size**
> An economy with very little firm turnover is not a stable one. It is a slow-growing one.

Entry Threat Helps Firms Near the Frontier and Hurts Those Behind

The escape logic again, with entrants doing the work that rivals did:

- A credible **threat of entry** raises innovation in incumbents close to the frontier.
- The same threat **lowers** innovation far behind, where escape is not credible.
- Aghion and co-authors find exactly this split in the firm-level data.

> **Proximity to the Frontier Replaces Competition**
> Whether pressure helps depends on the gain from escaping. Here that gain is **closeness to the frontier** — for a firm now, for a country in section 4.

Two Predictions, Before Any Data

Write both down now. We look at the charts afterwards.

1. **Prediction 1, the size distribution.**
   Firm size should be highly skewed, with a small number of very large firms and a long upper tail, because firms grow through a random sequence of successful innovations rather than towards any target size.

2. **Prediction 2, growth and age.**
   Conditional on surviving, both firm growth and the exit rate should **fall with firm age**, because an older surviving firm is one that has already climbed several rungs and is harder to displace.

Prediction 1 Survives: The Firm Size Distribution

Random innovation produces this shape; an efficient scale would give a mode instead.

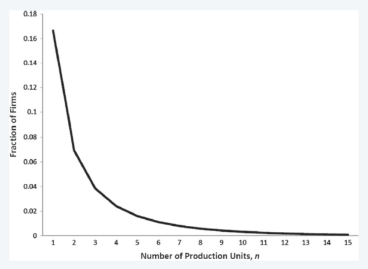

Figure 4: The fraction of firms by number of production units.

> **The Mode Is the Smallest Size**
> Most firms hold one production unit, and the count falls away from there.

Prediction 2 Survives: Three Tests, Three Passes

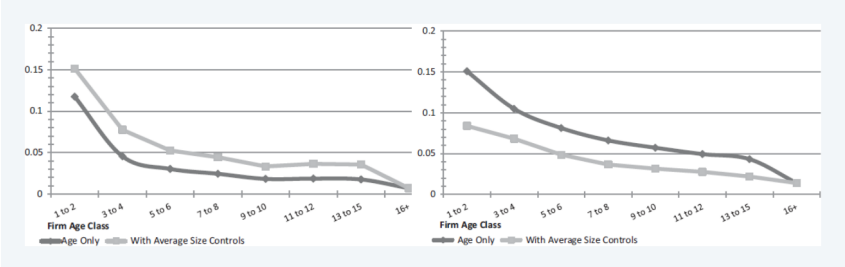

Figure 5: Net employment growth by firm age, left, and job destruction through firm exit, right.

> **Growth and Exit Both Fall, Then Flatten**
> The average hides enormous variance among the young.

SECTION 4

Growth Policy

Appropriate Growth Policies

This section turns the theory into advice that depends on closeness to the frontier:

$$a_{jt} = \frac{A_{jt}}{\bar{A}_t} \tag{8}$$

- A_{jt}: the technology in use in country j
- $\bar{A}_t$: the world frontier technology
- a_{jt}: proximity to the frontier, between 0 and 1

> **Far Countries Imitate, Frontier Countries Innovate**
> **Imitating** a technology that exists elsewhere is cheaper and surer than **innovating** one that exists nowhere. At the frontier only innovation is left.

What Suits a Country Behind Is Not What Suits One at the Frontier

The two ways of growing want different institutions, and a country can only really run one set at a time.

Imitation Rewards Scale and Continuity

Imitation rewards **scale and continuity**: long-term relationships between firms and banks, subsidised investment, incumbents large enough to absorb foreign technology. Selecting the best firms matters less than getting investment done.

Innovation Rewards Selection

Innovation rewards **selection**: entry, competition, exit, flexible labour and product markets, and higher education rather than more years of schooling. Who does the investing now matters more than how much is done.

The Policy That Delivered Catch-Up Blocks What Comes Next

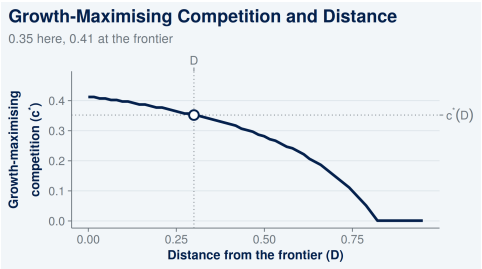

Figure 6: Growth against proximity to the frontier, a_{jt}, under each of the two regimes.

> **The Two Regimes Cross Once**
> Proximity a_{jt} runs left to right: the imitation regime is higher on the left, the innovation regime at the frontier, and the crossing is the switch.

Openness, Entry and Institutions

In lecture 3.2 institutions were the best-identified **fundamental** cause of growth. Creative destruction is the **mechanism** they work through:

- **Openness:** Frontier technology to imitate, and competition at home worth escaping.
- **Property Rights:** An innovator's rent must be collectable, an incumbent's losable.
- **Constraints on the Executive:** An incumbent that cannot out-innovate buys protection.

> **Institutions Make Creative Destruction Possible**
> Good institutions are not a separate cause beside innovation: they let the entrant in and stop the incumbent from shutting entry down.

Growth as Creative Destruction

The last model of the course, and the one closest to policy:

1. **Creative Destruction.**
   Growth comes from firms replacing each other, not only from adding to ideas.

2. **Competition and Innovation.**
   Innovation peaks at intermediate competition, and the UK firm data agree.

3. **Firm Dynamics.**
   Size distribution and falling growth with age: the other two predictions, both passed.

4. **Growth Policy.**
   What works at the frontier is not what works behind it.

What the Course Argued

Twelve lectures, three parts, one argument.

1. **Part 1, the short run.**
   Prices and wages stick; demand, supply and a policy rule set how far output strays.

2. **Part 2, the micro-foundations.**
   Part 1's equations are derived, not assumed: households, firms and sticky prices.

3. **Part 3, the long run.**
   The trend is produced: by capital, then ideas, then firms replacing each other.

> **Cycle and Trend, One Economy**
> The short run is prices that cannot adjust. The long run is technology that improves. The same firms set the prices and make the improvements.

Before the Final

1. **Play:** The Schumpeter toy model. Raise competition across its whole range and watch the winning force change.
2. **Apply:** No problem set. Set 6 was collected before Lecture 3.3, so the work now is revision for the final.
3. **Review:** Aghion's Nobel lecture, and the innovation-and-inequality material now on Brightspace rather than in these slides.

> **Revision Starts from Your Muddiest Points**
> Write one line before you go: your muddiest point in the whole module. The revision session is built from those answers.

Thank you

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BACKUP

Appendix

Notes and Tools

- **Aghion's Nobel lecture** — *The Economics of Creative Destruction*, on Brightspace. Today's reading, and the best single source for this material.
- **Aghion, Bloom, Blundell, Griffith and Howitt (2005)** — *Competition and Innovation: An Inverted-U Relationship*, *Quarterly Journal of Economics* 120(2), the paper behind section 2.
- **Whelan's lecture notes** — the notes for this module. Chapter 12 is the nearest chapter to today.
- **The toy models** — the Schumpeter app draws the inverted U and the frontier figure, in your browser, nothing to install.

References

Whelan, K. (2023). *Lecture notes on macroeconomics*. University College Dublin. https://www.karlwhelan.com/Macro2/Whelan-Lecture-Notes.pdf