

Accounting For Growth

Next Two Classes... Two Questions...

- ▶ Today: Mechanically, **Where does economic growth come from?** Appendix of Chapter 9.
- ▶ Wednesday: **What processes leads to economic growth?** Slide pack, builds off of parts of Chapter 9.

Return to Chapter 3

- ▶ Our production function...

$$\begin{aligned} Y &= A \times F(K, L) \\ &= AK^\alpha L^{1-\alpha} \end{aligned}$$

- ▶ Only three ways output can grow...
 - More capital (K), aka “capital deepening”
 - More labor inputs (L), may be from more workers, better educated workers, etc. aka “labor deepening”
 - Better TFP (A), aka “technological progress”

Growth from Capital

- ▶ The change in output attributed to an increase in capital is

$$\Delta Y = \text{MPK} \times \Delta K$$

- ▶ The MPK is how much extra output we get from adding capital.
- ▶ ΔK is how much capital has been added.

Growth from Labor

- ▶ The change in output attributed to an increase in labor is

$$\Delta Y = \text{MPL} \times \Delta L$$

- ▶ The MPL is how much extra output we get from adding capital.
- ▶ ΔL is how much capital has been added.

Growth from Total Factor Productivity (TFP) I

- ▶ The change in output attributed to an increase in TFP

$$\Delta Y = \Delta A \times F(K, L)$$

- ▶ Very simple. Just how much TFP (A) changed.
- ▶ This is the key property of TFP.
 - A one unit increase in TFP increases output by exactly one unit.
 - It increases the productivity of all inputs. Hence the name “Total Factor” productivity.

Growth from Total Factor Productivity (TFP) II

- ▶ The change in output attributed to an increase in TFP

$$\Delta Y = \Delta A \times F(K, L)$$

- ▶ Very simple. Just how much TFP (A) changed.
- ▶ How to think about this... lots of ways:
 - 2000: 361 million Internet users, 740 million cell phone users
2011: 2.4 billion Internet users, 5.9 billion cell phone users
 - 2001: iPod capacity = 5gb, 1000 songs.
2012: iPod touch capacity = 64gb, 16,000 songs.
 - We also think of institutions as embedded here too... see blog discussion and book

Growth of Output I

- ▶ Put everything together

$$\Delta Y = \Delta A \times F(K, L) + \text{MPK} \times \Delta K + \text{MPL} \times \Delta L$$

- ▶ Then express in percent terms by dividing through by Y .

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \frac{\text{MPK} \times K}{Y} \frac{\Delta K}{K} + \frac{\text{MPL} \times L}{Y} \frac{\Delta L}{L}$$

- ▶ Then notice, with Cobb-Douglas this simplifies to

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha \frac{\Delta K}{K} + (1 - \alpha) \frac{\Delta L}{L}$$

Growth of Output II

- Growth in output is now decomposed into...

$$\frac{\Delta Y}{Y} = \underbrace{\frac{\Delta A}{A}}_{\text{Change in Tehcnology}} \dots + \underbrace{\alpha \frac{\Delta K}{K}}_{\text{Change in Capital}} \dots + \underbrace{(1 - \alpha) \frac{\Delta L}{L}}_{\text{Change in Labor}} \dots$$

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How to Measure TFP?

- No direct way to measure TFP.
- Solution: Infer growth in TFP as a residual. All the growth in output NOT accounted for by growth in inputs...

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha \frac{\Delta K}{K} - (1 - \alpha) \frac{\Delta L}{L}$$

- Often called the "Solow residual" after Robert Solow who first showed how to measure it.

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Accounting for Growth in the US

SOURCES OF GROWTH							
Years	Output Growth $\Delta Y/Y$	=	Capital $\alpha \Delta K/K$	+	Labor $(1 - \alpha) \Delta L/L$	+	Total Factor Productivity $\Delta A/A$
(average percentage increase per year)							
1948-2013	3.5		1.3		1.0		1.2
1948-1972	4.1		1.3		0.9		1.8
1972-1995	3.3		1.4		1.4		0.5
1995-2013	2.9		1.1		0.6		1.1

Data from: U.S. Department of Labor. Data are for the non-farm business sector. Parts may not add to total due to rounding.

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Growth in Living Standards

- Prior results were all about growth in total GDP. Can do the same thing on per worker or per capita basis...

$$\underbrace{\frac{\Delta Y/L}{Y/L}}_{\text{Change in Output per Worker}} = \underbrace{\frac{\Delta A}{A}}_{\text{Change in Tehcnology}} \dots + \underbrace{\alpha \frac{\Delta K/L}{K/L}}_{\text{Change in Capital per Worker}} \dots$$

- Ok, how would you connect this with standard of living?

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Problem Set #2: Growth in China and India

- ▶ Problem Set #2. You do this for China and India.

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Growth in Living Standards in the US...

- ▶ Since the recession, real wages (W/P) have grown very little? Why? How would you use these tools to answer this question.
- ▶ Prof. Robert Gordon's new book "The Rise and Fall of American Growth: The U.S. Standard of Living Since the Civil War"
 - Argues that technology will not advance as it has in the past.
 - This implies slower growth in living standards. Why?
 - What do you think?

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An Important Questions to Think About...

- ▶ If most of growth is projected to come from capital, is this good or worrying? Why or why not?
- ▶ What does this imply about how returns (i.e. rental rate) to capital will evolve in the future?

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