

# EF3441: Intermediate Macroeconomics

Prepared by Dr. Tam  
Lecture 5

# The Main Goal of this Lecture

- ▶ Understand the data facts in economic growth and know how to interpret the data.
- ▶ Understand the Malthusian growth model by understanding
  - ▶ the assumptions and the background stories about these assumptions
  - ▶ steady-state equilibrium
  - ▶ policy analysis and transitional path
- ▶ The successes and failures of the Malthusian model
- ▶ Understand the Solow growth model (Part I) by
  - ▶ knowing the assumptions and facts that motivate this model

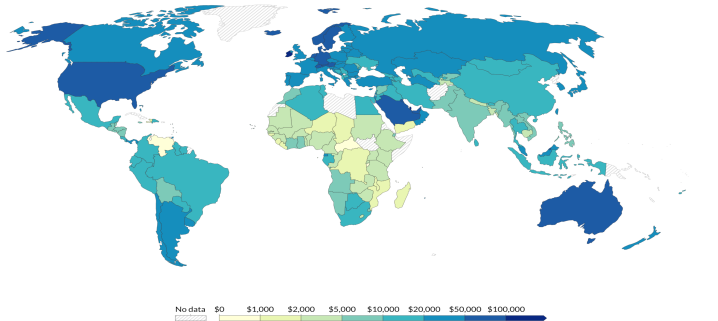
# Income Per Capita Across Countries

## Real GDP per capita, 2019

This data is adjusted for inflation and for differences in the cost of living between countries.

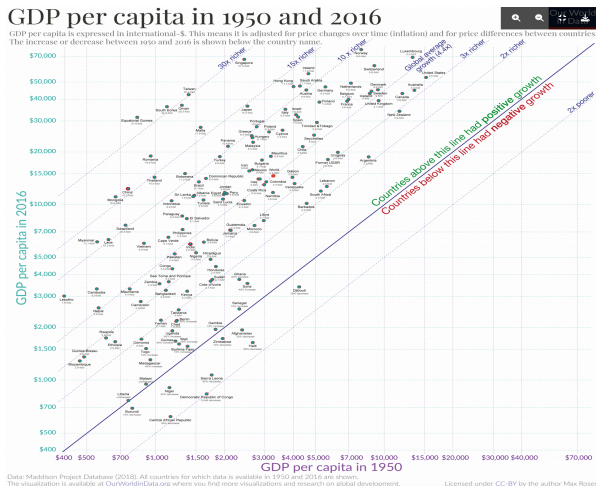
Our World  
In Data

World



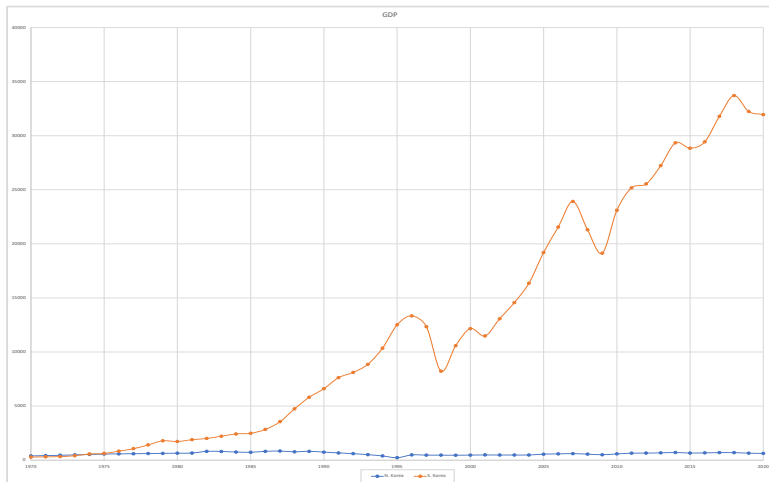
World maps of GDP per capita

# Income Per Capita Across Countries, Con't



World maps of GDP per capita

# Income Per Capita Across Countries, Con't



The United Nations Statistics Division

# Income Per Capita Across Countries, Con't

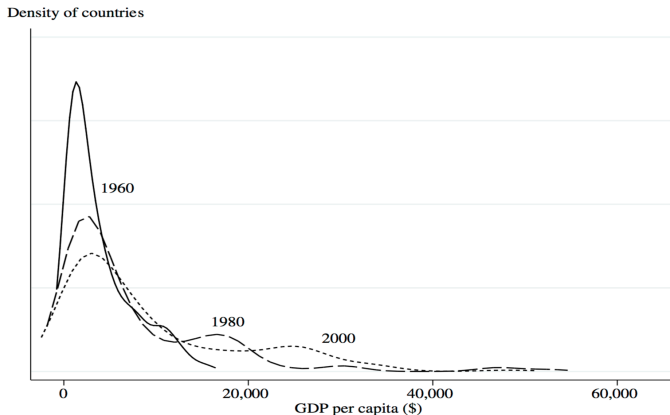


**FIGURE 1.1** Estimates of the distribution of countries according to PPP-adjusted GDP per capita in 1960, 1980, and 2000.

Acemoglu (2008)

# Income Per Capita Across Countries, Con't

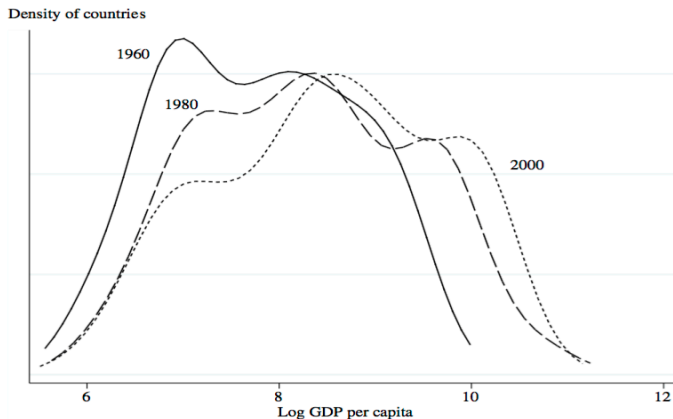


**FIGURE 1.2** Estimates of the distribution of countries according to log GDP per capita (PPP adjusted) in 1960, 1980, and 2000.

Acemoglu (2008)

## Growth In the Last 35 Years

- ▶ Existence of large and sustained growth: (recall the 2% per year for the US)
- ▶ Existence of growth miracles: (Hong Kong, South Korea, Singapore, Japan)
- ▶ Existence of growth disasters: (Venezuela, North Korea, Most of South Saharan Africa)

# Modern Growth Rates: The Distribution of Growth Rates

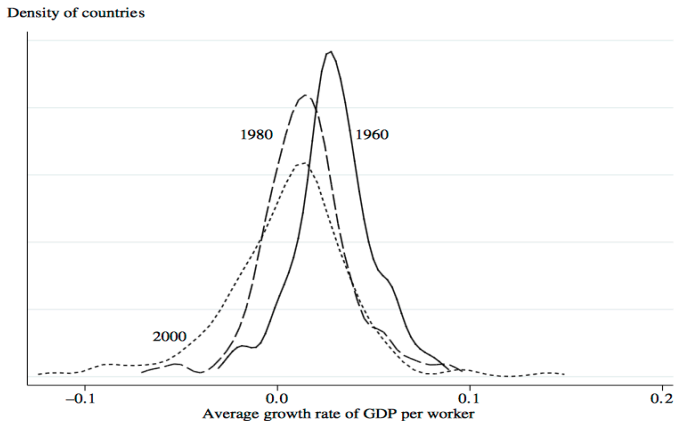
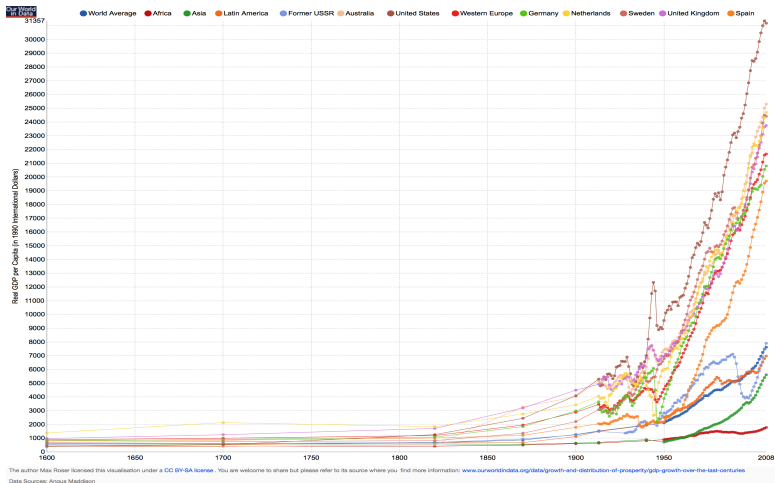


**FIGURE 1.7** Estimates of the distribution of countries according to the growth rate of GDP per worker (PPP adjusted) in 1960, 1980, and 2000.

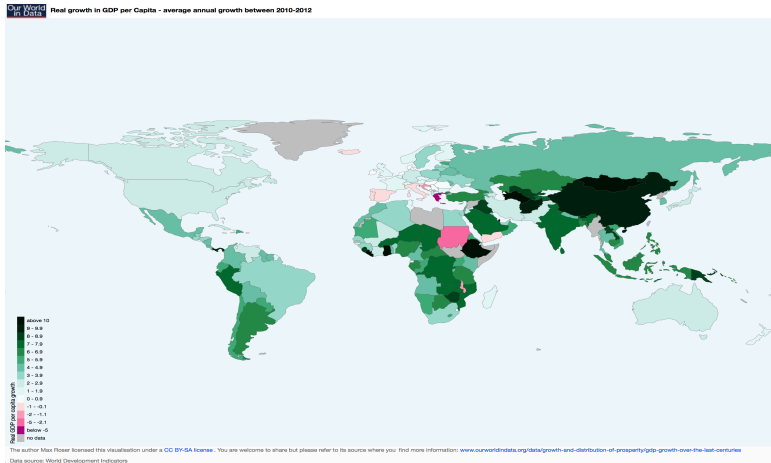
Acemoglu (2008)

# Historical Growth



## Growth Since 1600

# Modern Growth



## Modern Growth Rate

# Taking Stock

So far, the following questions have emerged:

- ▶ How can some countries sustain stable growth?
- ▶ Why do some countries go much faster than others?
- ▶ Why are some countries not growing?
- ▶ Why was the world not growing before the 19th century?

# What Determines Growth?

- ▶ First step: find the data!
- ▶ Great sources:
  - ▶ [Penn World Tables](#)
  - ▶ [IMF World Economic Outlook Database](#)

## What Determines Growth?, Con't

We need a model, but what matters? What should we model?

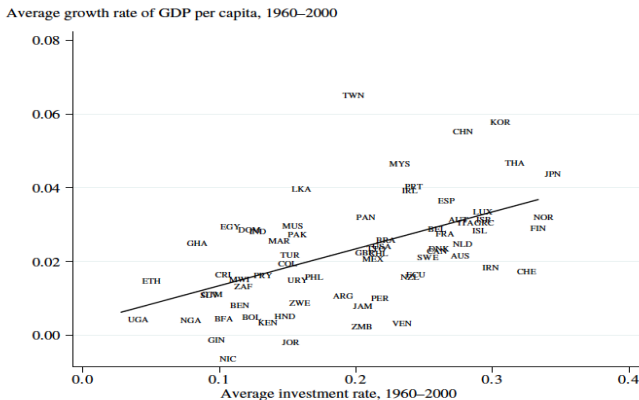
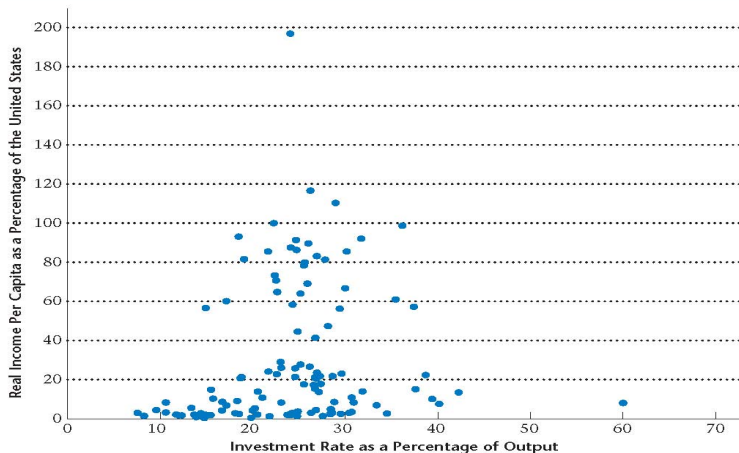


**FIGURE 1.15** The relationship between average growth of GDP per capita and average growth of investments to GDP ratio, 1960–2000.

Acemoglu (2008)

# What Determines Growth?, Con't

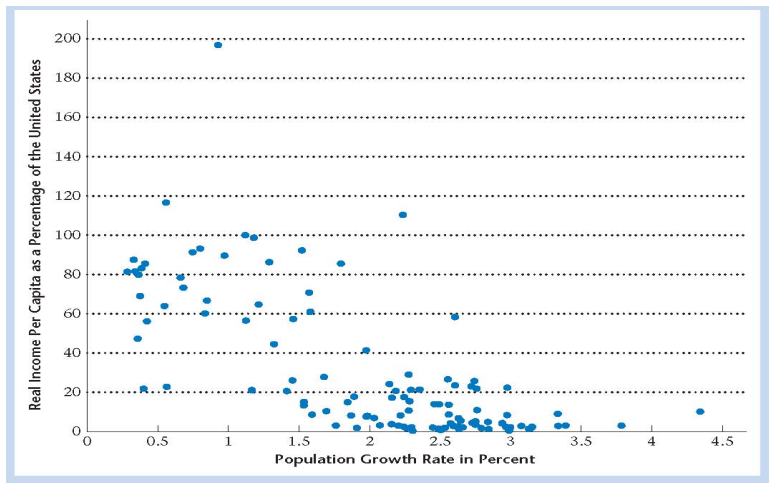
## Investment and GDP growth



Investment is *positively* correlative with GDP levels.

# What Determines Growth?, Con't

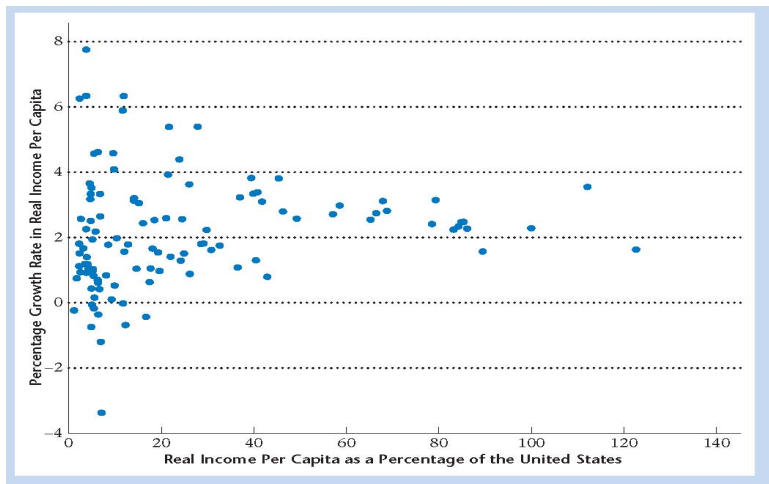
## Population and GDP growth



Population is *negatively* correlative with GDP levels.

# What Determines Growth?, Con't

## Levels of GDP and GDP growth



Levels of GDP are *not* correlative with GDP growth rates.

# Welfare: Consumption

## Log GDP per capita and log consumption per capita

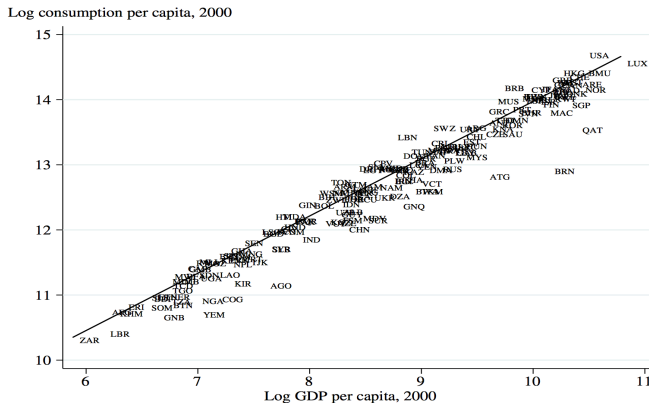


**FIGURE 1.5** The association between income per capita and consumption per capita in 2000. For a definition of the abbreviations used in this and similar figures in the book, see <http://unstats.un.org/unsd/methods/m49/m49alpha.htm>.

## Welfare: Life Expectancy

## Log GDP per capita and life expectancy

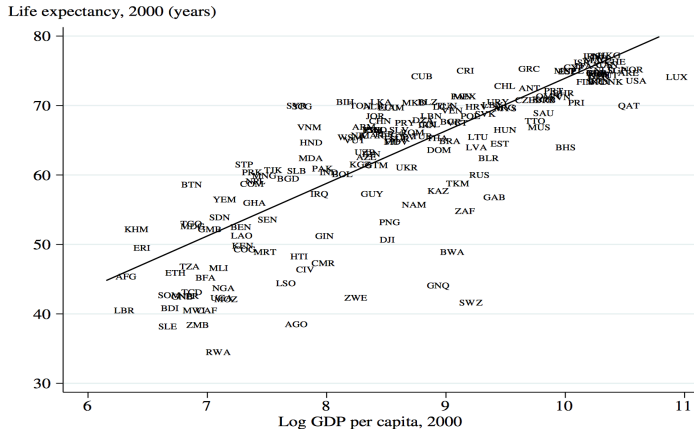


**FIGURE 1.6** The association between income per capita and life expectancy at birth in 2000.

# The Malthusian Model

- ▶ Preferences: fixed labor supply (we normalize to 1 unit)
- ▶ Population = number of workers  $N$
- ▶  $L$  denotes for land
- ▶ The technology:  $Y = zF(L, N)$ . Assume constant return to scale.
  - ▶ Use  $N$  to denote the number of workers today;
  - ▶ Use  $N'$  to denote number of workers tomorrow;
- ▶ **Question:** what determines population growth?

## The Malthusian Model: Population Growth

- ▶ **Key assumption:** *Growth rate of population depends on living standards.*
- ▶ Living standard is related to consumption per capita:

$$\text{Living Standards} = \frac{C}{N}$$

- ▶ We have:

$$\frac{N'}{N} = g\left(\frac{C}{N}\right)$$

$g\left(\frac{C}{N}\right)$  is an increasing and concave function;

## The Malthusian Model: Equilibrium

Equilibrium is standard: Agents and firms optimize, market clearing...

plus: *steady state in the population*  $N' = N = N^*$

Equilibrium is determined by:

- ▶ Market Clearing for goods market:  $C = Y = zF(L, N)$
- ▶ Steady State condition:

$$N' = N$$

- ▶ Population growth equation:

$$\frac{N'}{N} = g\left(\frac{C}{N}\right)$$

## The Malthusian Model: Equilibrium, Con't

- ▶ Substitute  $C$  in population growth equation:

$$\frac{N'}{N} = g \left( \frac{zF(L, N)}{N} \right)$$

- ▶ Using our constant return to scale assumption:

$$\frac{N'}{N} = g \left( zF \left( \frac{L}{N}, 1 \right) \right)$$

where  $\frac{L}{N} = \text{land per capita}$

## The Malthusian Model: Equilibrium, Con't

- ▶ We now have two equilibrium conditions:

$$N' = N$$

$$\frac{N'}{N} = g \left( zF \left( \frac{L}{N}, 1 \right) \right)$$

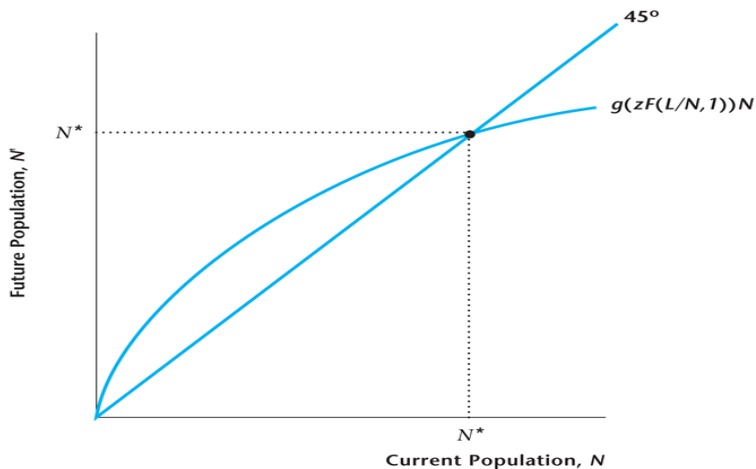
- ▶ Combining these two equilibrium conditions:

$$g \left( zF \left( \frac{L}{N}, 1 \right) \right) = 1$$

## The Malthusian Model: Equilibrium, Con't

Equilibrium exist:  $N^*$

(intersection of 45-degree line and concave curve)



Notes: is there another equilibrium?

## The Malthusian Model: Policy

- ▶ We had large technological developments before the Industrial Revolution
- ▶ If  $z$  has constantly been increasing, why has the standard of living stagnated for centuries?

## The Malthusian Model: Policy Analysis

What happens if  $z$  increases at a time  $T = 1$ ?

Recall that in steady state :

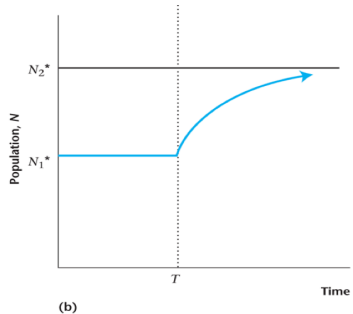
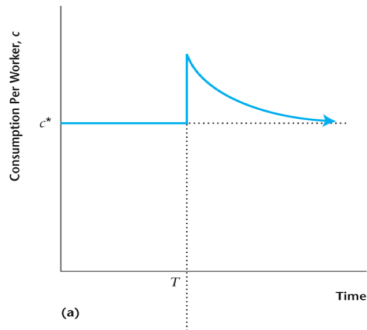
$$g\left(\frac{C_1^*}{N_1^*}\right) = 1$$

$$C_1^* = z_1 F(L, N_1^*)$$

If  $z_1 < z_2$ , then:

- ▶  $C_1^* < z_2 F(L, N_1^*)$ , so  $C_1^*$  must increase to  $C_2^*$
- ▶ From population growth equation:  $g\left(\frac{C_2^*}{N_1^*}\right) > 1$  so  $N_1^*$  must increase to  $N_2^*$
- ▶ Converge to new steady state with  $C_2^* = z_2 F(L, N_2^*)$

# The Malthusian Model: Policy Analysis, Con't



# The Malthusian Model

## How Useful is the Malthusian Model?

- ▶ Model provides a reasonable explanation for pre-1800 growth facts in the world.
- ▶ Malthus did not predict the effects of technological advances on fertility.
- ▶ Malthus did not understand the role of capital accumulation in growth.

## Example

Consider the Malthusian model of growth. Analyze the long-run effects on the steady state of the following changes to the environment:

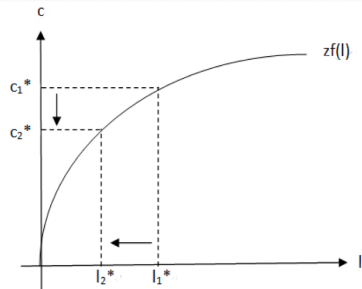
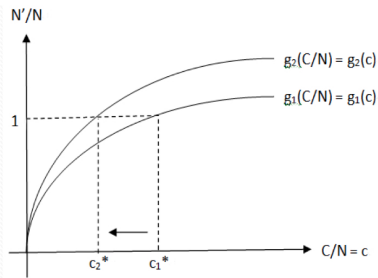
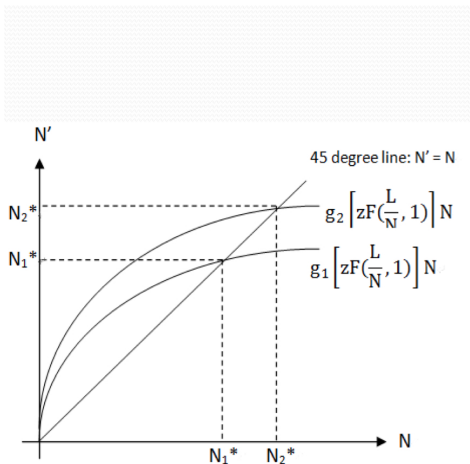
1. Increase in hygiene in medical practice increases the survival rates of newborns.
2. Increase the quality of the land.

## Example, Con't

An increase in hygiene in medical practice increases the survival rates of newborns:

- ▶ higher population growth rate
- ▶ shifts the  $g$  function upward
- ▶ in the long run,  $N_1^* \rightarrow N_2^*$ , where  $N_2^* > N_1^*$
- ▶ lower living standard in the long run

## Example, Con't

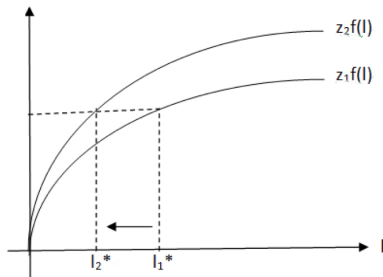
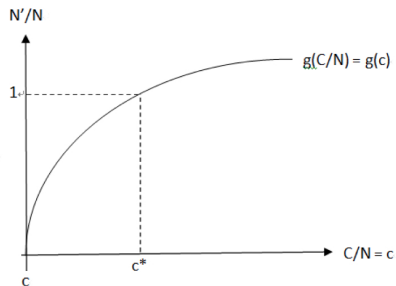
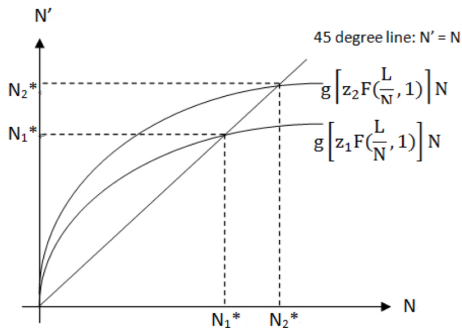


## Example, Con't

Increase the quality of land:

- ▶ total factor productivity increases
- ▶  $z$  increases
- ▶ in the long run,  $N_1^* \rightarrow N_2^*$ , where  $N_2^* > N_1^*$
- ▶ the long-run living standard is unchanged

## Example, Con't



# The Solow Growth Model: Introduction

New Ingredients:

- ▶ Exogenous population growth rate ( $n$ ). Assume  $n > -1$ .
- ▶ Saving ( $s$ ). The fraction of income that is saved ( $s$  is an exogenous parameter)

## The Household

- ▶ Exogenous population growth:

$$N' = (1 + n)N,$$

- ▶ Households care about consumption and the future the budget constraint is:

$$C + S = Y$$

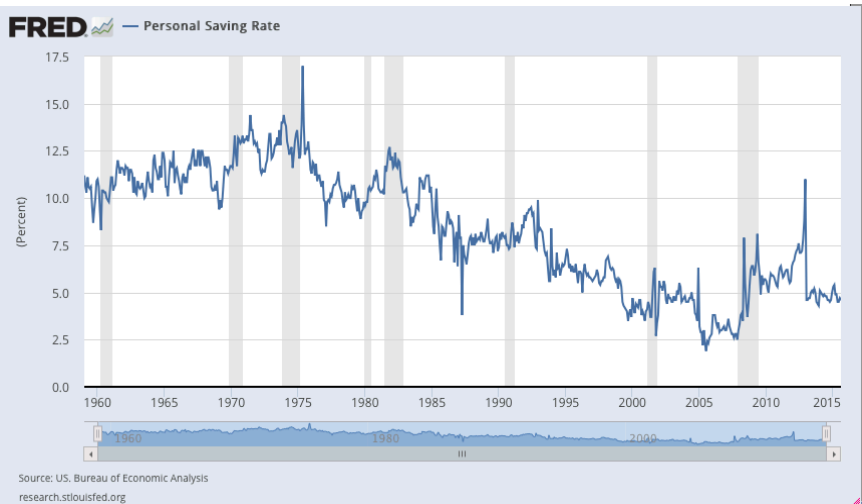
Recall:  $C$  is consumption,  $S$  is saving, and  $Y$  is income.  
There is no government for now.

- ▶ For now: “rule of thumb” for saving

$$S = sY \rightarrow C = (1 - s)Y$$

Households save a constant fraction of their income.

# Saving Rate in the US



## Capital and the Firm

- ▶ Production function:  $Y = zF(K, N)$ . Recall:  $z$  is exogenous for now.
- ▶ Capital accumulation:

$$K' = (1 - \delta)K + I$$

Recall:  $I$  is an investment and  $\delta$  is the depreciation rate:  
 $0 < \delta < 1$ .

## The Firm

Take the dynamic firm's problem. *i.e.* firm chooses labor and investment to maximize its present-value profits.

$$\pi(K) = \max_{I, N} \left\{ Y - wn - I + \frac{\pi(K')}{1+r} \right\}$$

Subject to:

$$Y = zF(K, N)$$

and

$$K' = (1 - \delta)K + I$$