Economic Growth Models

Prof. Goldstein

Economic Demography

Econ/Demog c175

Week 3: Lecture A

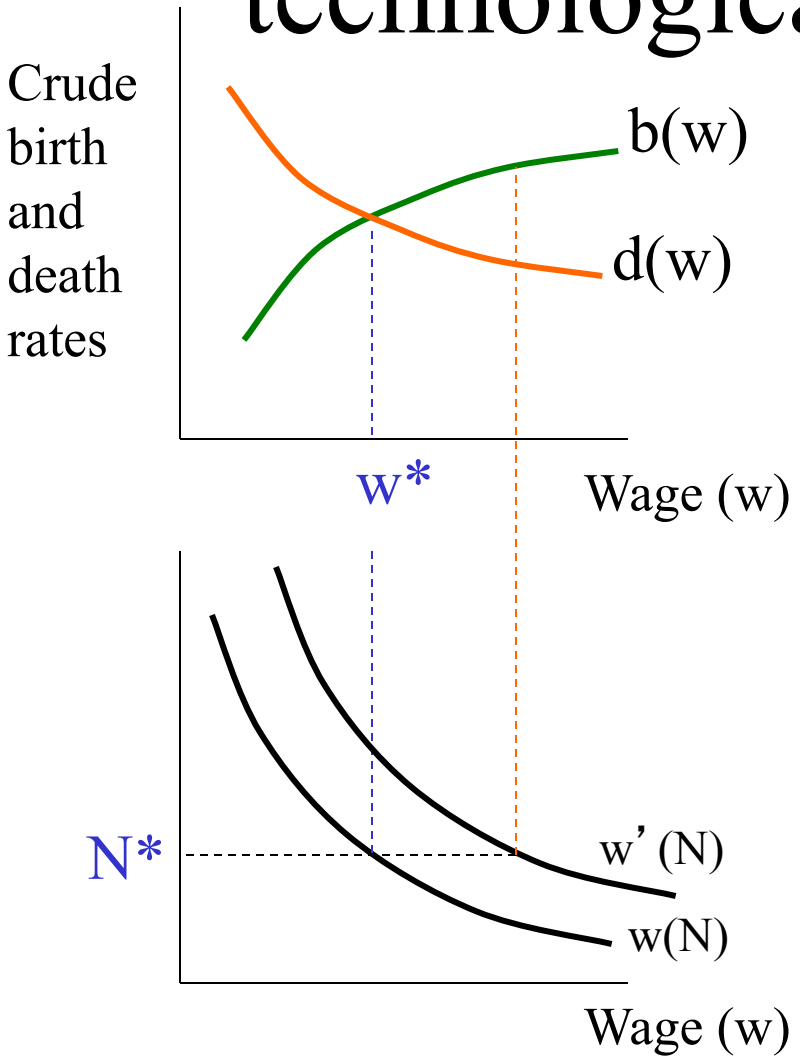
Spring 2017

UC Berkeley

Today's agenda

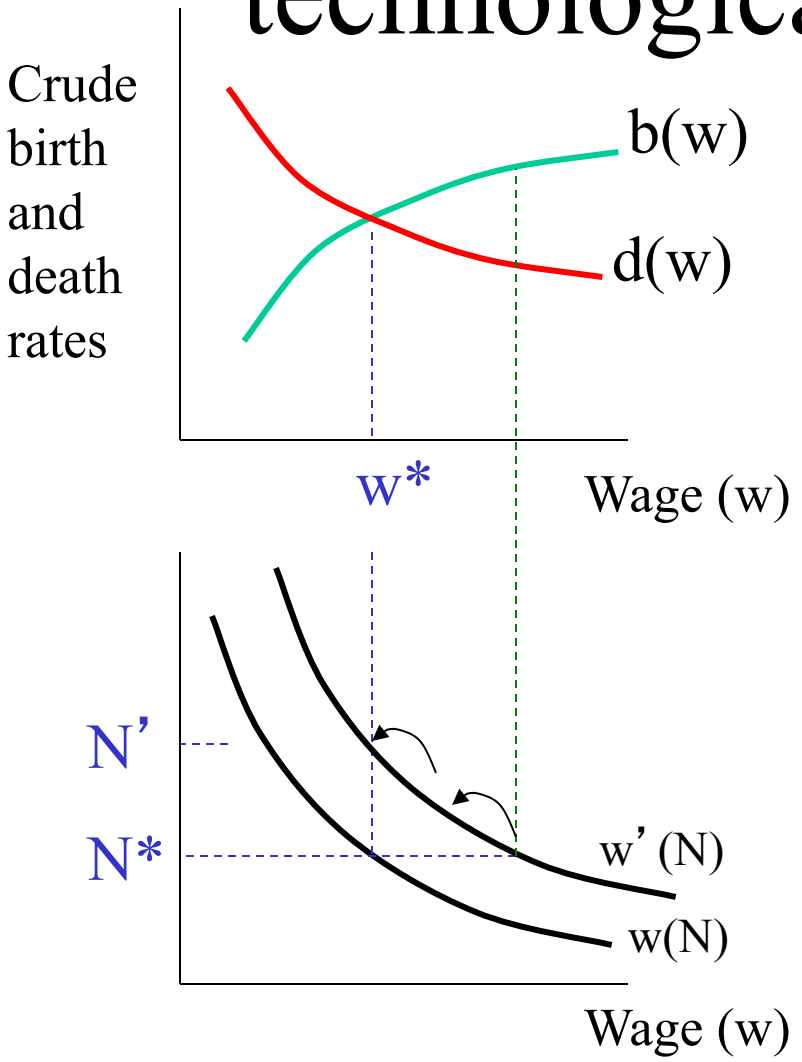
- Malthus cont.
  - Technology
  - Other perturbations (with simulation)
  - Was he wrong?
- Neo-classical growth (with savings) ("Solow" model)
  - Production functions
  - Steady state
  - Role of population growth

Effect of exogenous technological improvement



- Exogenous technology increasing wages
- Do wages stay higher, or revert to old level?

Effect of exogenous technological improvement



- Exogenous technology increasing wages
- But -- increased wages increase population growth
- Which reduces wages
- End result: bigger pop, same living conditions

iClicker Quiz

In our Malthusian model, improving technology

A. Shifts the w(N) curve and permanently raises income
B. Shifts the w(N) curve and temporarily raises income
C. Changes the b(w) and d(w) curves
D. Changes w*

iClicker quiz

In our Malthus model,

A. Land is a variable factor, and labor a fixed factor
B. Labor is variable, and land fixed
C. They are both fixed
D. They are both variable

Economic Growth Models

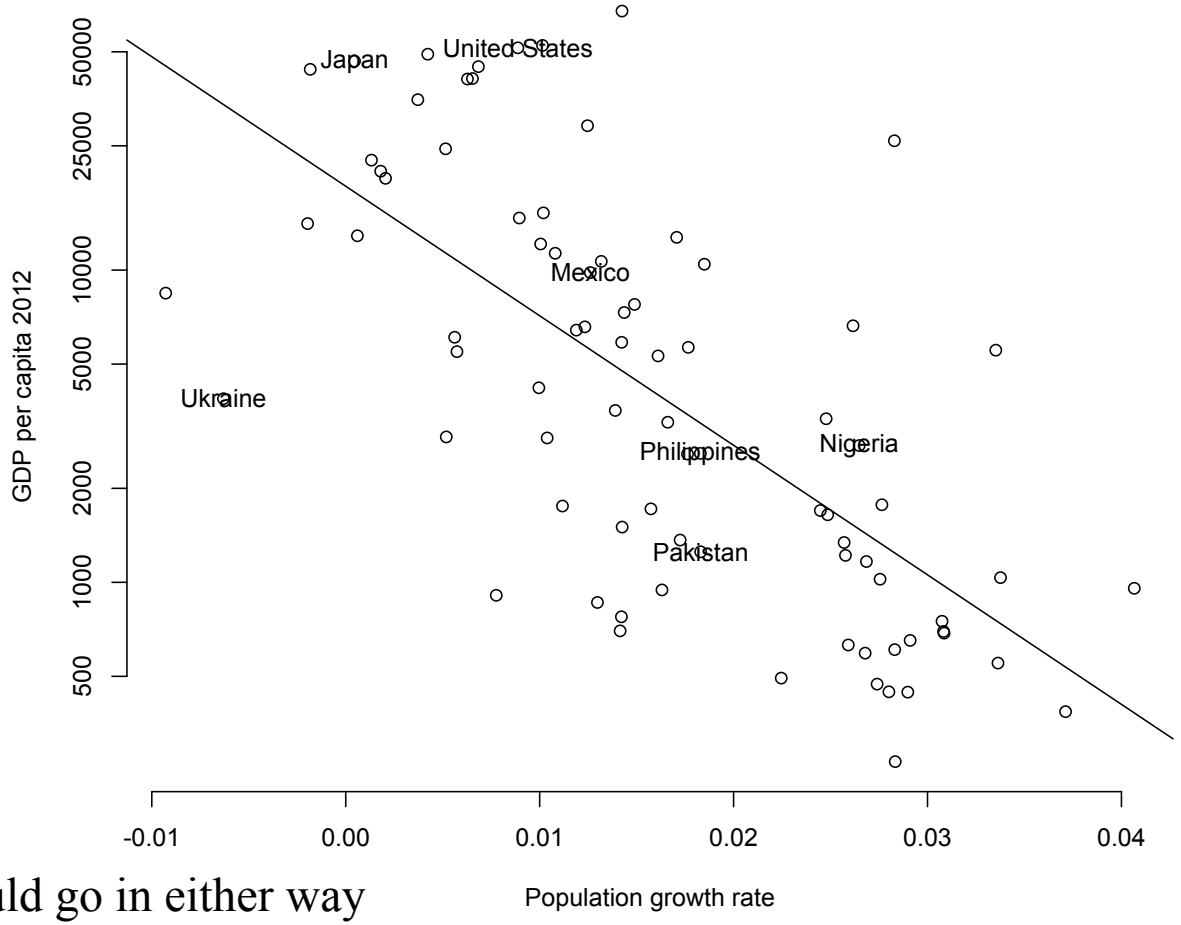
- Question usually framed very generally:
  - "What determines long-run economic growth rate?"
- Our specific interest:
  - "What effect does population change have on economic growth and on individual welfare?"

Is pop growth good? The answers we already have

- Malthus ("dynamic population, dismal result")
  - Pop growth hurts welfare in short-run because of decreasing returns from resources
  - Feedback to population meant that in the long-run no steady growth in output or population size
  - Even technological change didn't help

Do high population growth rates hurt the economy?

GDP Per capita



Source: World Bank

- Causality could go in either way
- But today we'll see a theory of how population growth could hurt

In coming lectures,

- Boserup
  - pop growth will induce tech change and thus increase per capita income
- Ehrlich (environmentalists)
  - pop growth will deplete natural resources and will reduce per cap income, perhaps catastrophically

Under Malthus, we had no capital accumulation, just land and people. What happens if we add savings and productive capital?

	Population	Income (per capita)
A	Steady growth	Steady growth
B	Constant	Steady growth
C	Steady growth	Constant
D	Constant	Constant

Return to this, when you review

Malthus vs. Solow

- With Malthus, 1 fixed factor (land) and 1 variable factor (labor)
- With Solow, no fixed factor, but 2 variable factors (capital K & labor L)
- Technology still exogenous
- With Solow, population is exogenous

Solow's "Neo-Classical" Growth Model

- Our assumptions (* means difficult to relax)
  - *Full employment of labor and capital
  - *All savings gets invested
  - *Labor = constant proportion of population
  - Output depends only on capital / labor ratio (i.e., no natural resources, absolute amount of capital or pop doesn't matter)
  - Savings rate constant over time, pop growth too
  - No technological change

Other assumptions that could be made

- Savings rate increases with pop growth rate because fewer old dissavers (Modigliani)
- Technological progress is constant (easy)
- Technological progress depends on pop size (harder) (Boserup)
- Natural resource constraints (harder) (environmentalists, Samuelson)
- Demography depends on economy (harder)

Notation

- Capital per person = $k = K/L$
- Output per person = $y = Y/L = f(k)$
- s = savings rate; Savings per person = $s \times y$
- d = depreciation rate
- n = population growth rate (a.k.a. “R”)

Our production function

1. Total output is a function of capital and labor

$$Y = f(K, L)$$

2. Diminishing returns in K or L if other is held constant

3. Constant returns to scale

(e.g., if we double K & L, we double Y).

Size doesn't matter since we don't have any fixed resources

For example

Cobb-Douglas production function is often taken

$$Y = f(K, L)$$

$$= K^a L^{1-a}, \; 0 < a < 1$$

Per capita, divide both sides by L

$$Y/L = y = (K/L)^a = k^a$$

More generally,

$$y = f(K/L) = f(K, 1) = f(k)$$

Our picture

Notation

K = capital, k = per worker

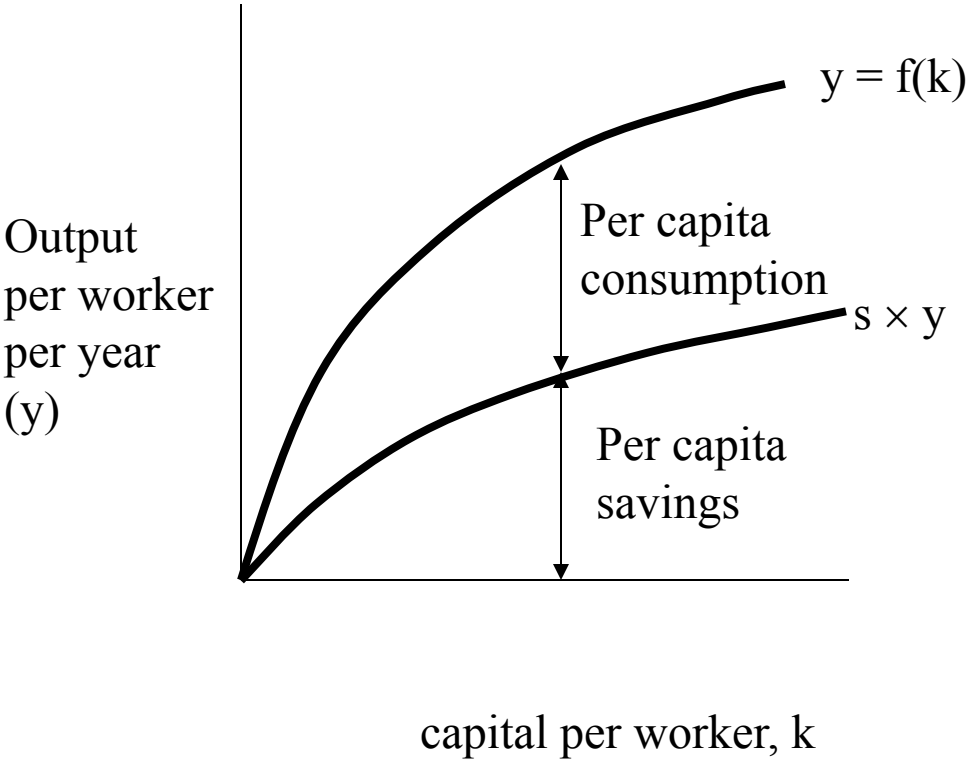
n = pop growth rate (our "R")

Y = output; per worker: y = f(k)

s = proportion of output saved

Assumptions:

1. decreasing returns to capital
2. savings is proportional to output



What happens to capital per person over time?

Without new capital investment,

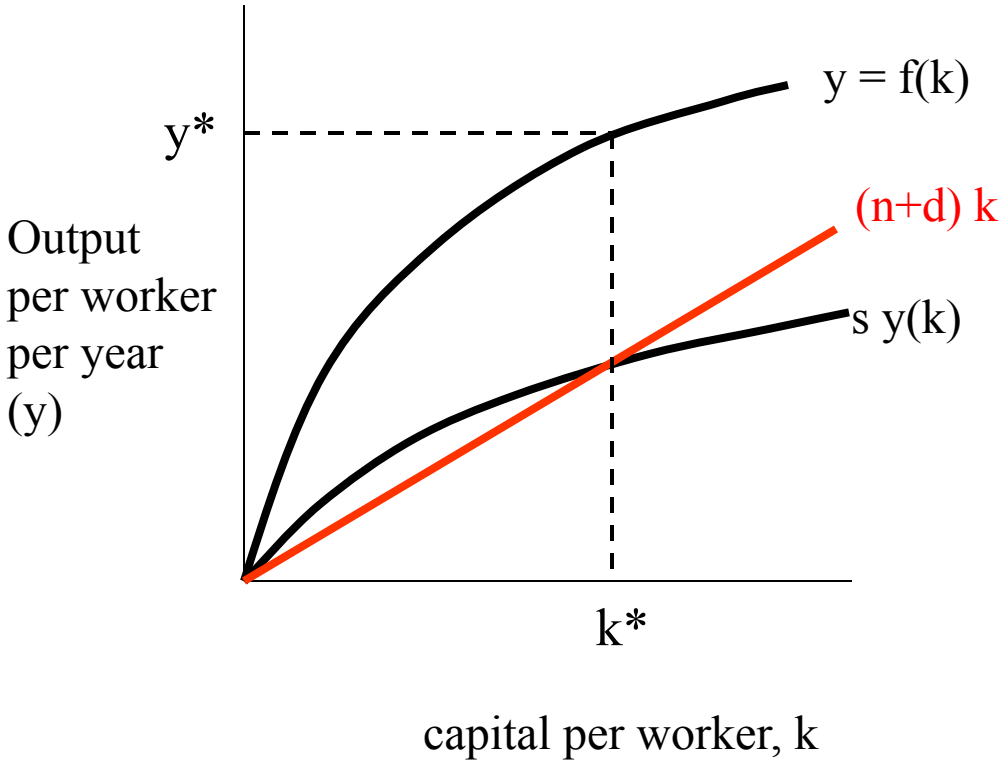
- Population growth dilutes the capital per person at a rate of n per year
- Depreciation will reduce capital stock by a rate d per year

In order to keep K/L ratio constant, we need to invest $(n + d) \times K$ total, or $(n + d) \times k$ per person

The steady-state: equilibrium

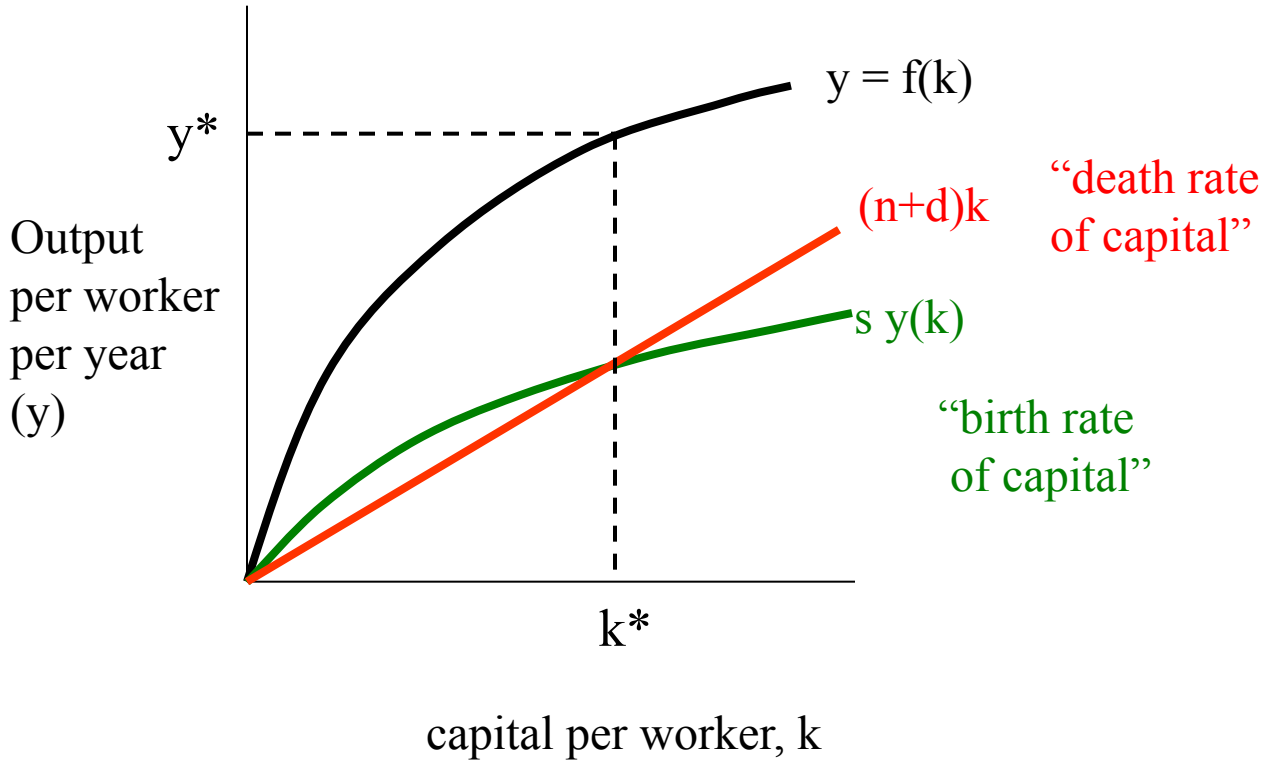
k* is the steady-state amount of capital per worker

y* is the steady-state output per worker



- (n+d) k = loss of capital per person per unit of time
- s y(k) = new investment per person
- *Is this equilibrium stable?*
- What is the per capita income growth rate in the steady state?

Malthus-like dynamics, except we can do everything on one picture



Standard implications

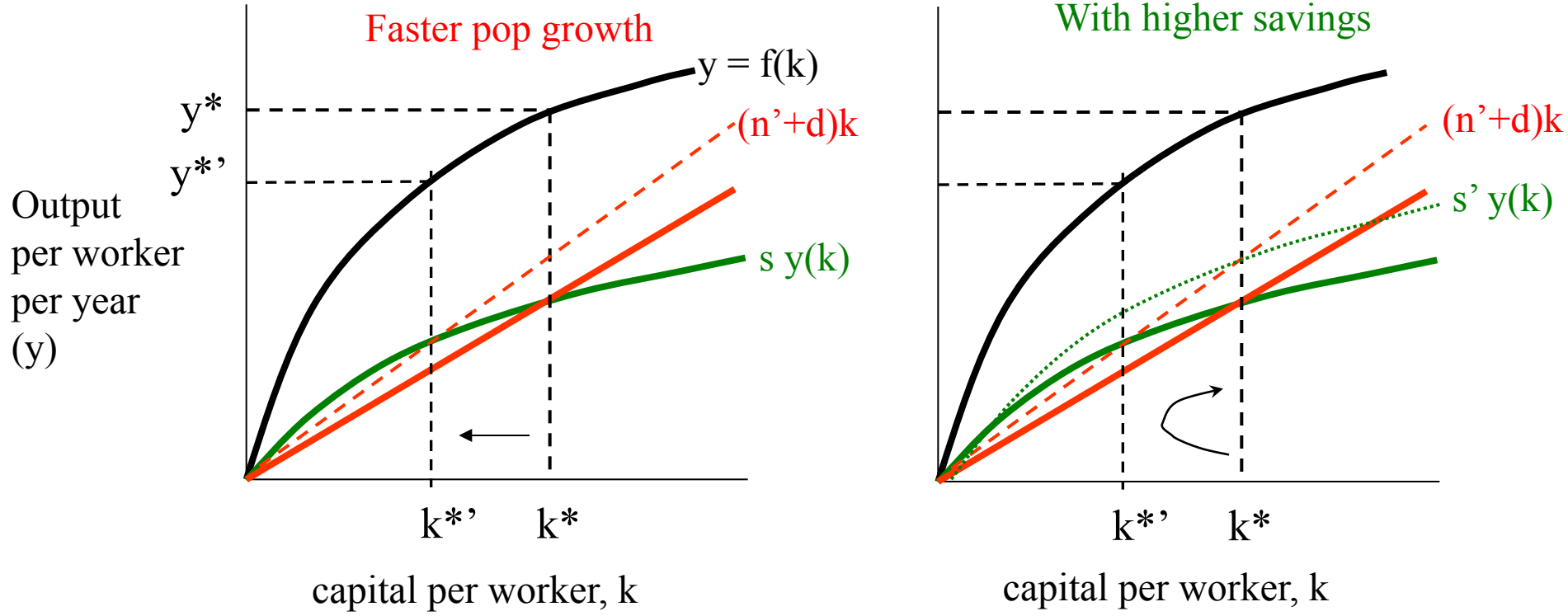
- In the steady state, there is no change in output per worker, so what happens to size of economy?
- What happens if we increase savings rate?
  - to level of output?
  - to level of consumption?
  - to long run growth rate?

What happens if we increase population growth?

- Let's find new steady state k*' and new output y*'.
- Is there anything we could do to keep old level of per capital output?

Consequences of faster pop growth

- To keep per capita income *y* constant, could save more and consume less



How much more would we have to save?

- In steady state, $sy = (n+d)k$, so $s = (n+d)\, k / y$
- savings rate = (pop growth rate + depreciation) × capital / output ratio
- Empirically, capital-output ratio about 3
- So, increasing n by 1% requires savings to increase by 3% if income is to stay the same.

Conclusions (1)

- Neo-classical growth retells the Malthusian story of an equilibrium around a constant standard of living.
- Good news :
  - Steady population growth without worsening wages (not possible in Malthus)
  - Technological change creates permanent improvement (not transitory like Malthus)

Conclusions (2)

- Bad news :
  - More capital (e.g., “foreign aid”) won’t change steady state output
  - Faster population growth implies lower income (unless forego consumption and keep savings up)
  - Key to growth is technology, not savings.

- Next time :
  - Using Solow model to study inequality (Piketty reading)
  - Lab will be posted on Thursday