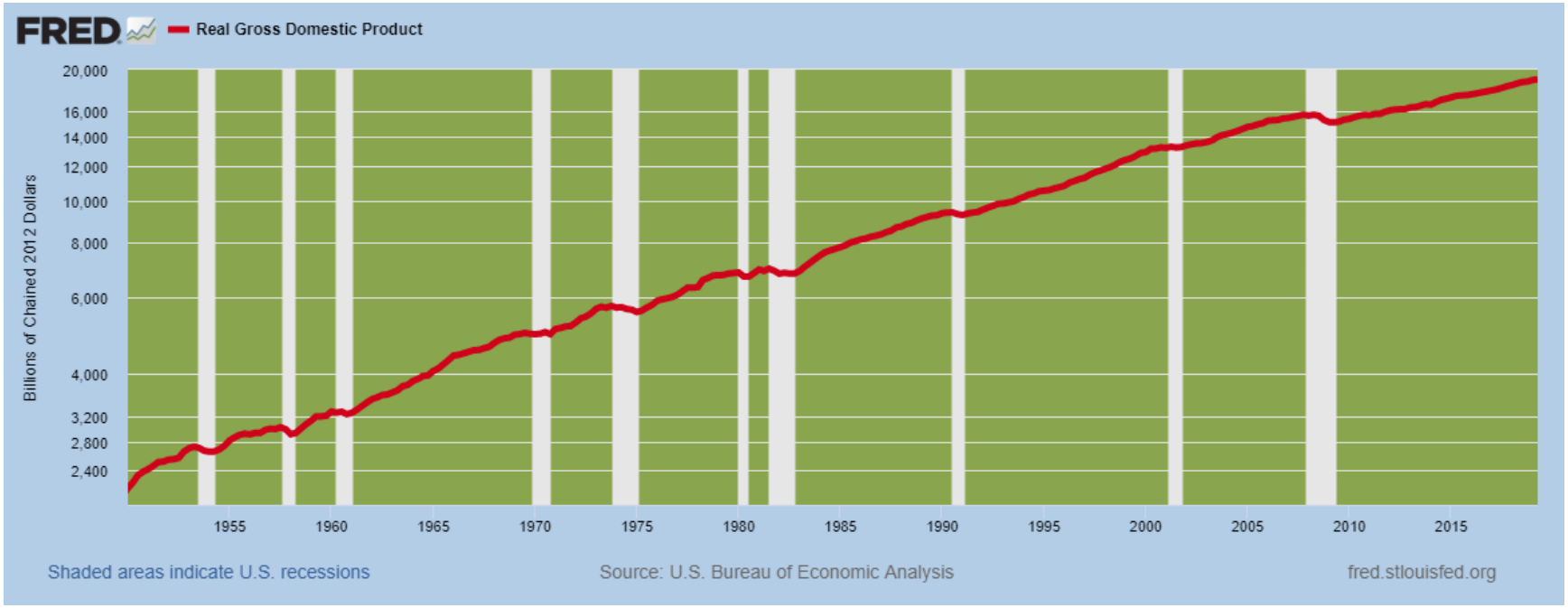
Long Run Economic Growth

Technological Change

Battles Resource Scarcity

October 9th, 2019

Growing Output: the Reality
Since the Industrial Revolution,
(with USA real GDP growth of **3.1%** per year, 1950-2018)

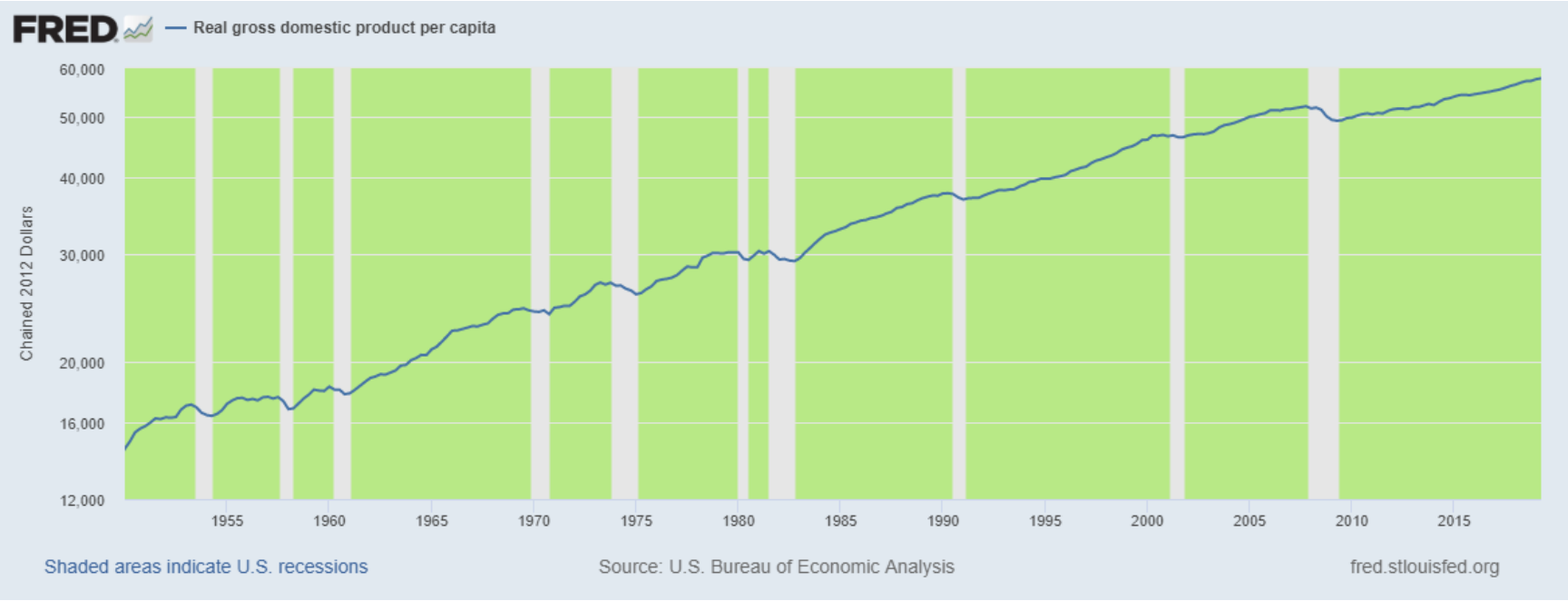


Growth in GDP per capita = 1.9%

Growth in Y = Growth in labor input plus growth in labor productivity

%Δ Y = 3.1% %Δ L = 1.1% %Δ LP = 1.9%

(1.0308 = 1.0113 × 1.0193)



Technology and the Entrepreneur
The antidote to the Malthusian Dilemma

- Thomas Malthus, 1826:

  "when all the fertile land is occupied,

  the yearly increase in food must depend upon the land already in possession."

  "this is a fund which must be gradually diminishing."

The Malthusian dilemma?

- Soon enough, the world will be engulfed in a **dismal** reality:
  - No more new land to cultivate
  - Population growth pushing for more food
  - Starvation will be what curtails population in this **world of diminishing returns**

Let us consider farming in the U.S.A.

	1948	2004
output (Y)	100	270
labor input (L)	20	5
output per hour (Y/L)	5	54

Farming Trends

U.S. farm output grew 1.8% per year

U.S. farm labor contracted 2.5% per year

Thus U.S. farm output is 2.7 times higher

U.S. labor input is 75% lower

Calculating growth in farming labor productivity

			annualized
	1948	2004	growth rate
output	100	270	1.7%
labor input	20	5	-2.0%
output per hour	5	54	4.4%

Output Growth:
Evaluating the Drivers

- Domestic demographics + net immigration drives changes in the working age population.
- LF ≡ The labor force. LF = LFPR × working age pop.
- L ≡ Employed labor. $L = LF - U_{(level)}$
- As L, labor's input rises, output rises.
- Growth in output/capita—growth in Y for a given labor input—is driven by the quality of the labor input.

Labor Productivity

- How can we make laborers' input more productive?

  We can give them tools.

  We can invent and deploy better tools.

  We can train and educate laborers.

Deconstructing Labor Productivity And Climbing Output Growth

- The Lawn Mowing Business

- Company Formed: Grass Cutters LLC.

- Four Employees, one mower, one truck

1 Team

2 hours/lawn/team

5 lawns/team/10 hour day

4 employees mow 5 lawns in total, per day

Capital Deepening
Round 1

- Company Wants to be More Productive:

  Company Buys:

  One more Truck, One more Mower

  Four Employees, Two mowers, two trucks

  2 Teams:

  2.5 hours per lawn per two person team

  4 lawns per two person team per 10 hour day

  4 employees mow 8 lawns in total, per day

Capital Deepening
Round 2

- Company Productivity Push Continues:

  Company Buys:

  Two more Trucks, Two more Mowers

  Four Employees, Four mowers, Four trucks:

  4 Teams (1 person per team)
  4 hours/lawn/team
  2.5 lawns/team/10 hour day
  4 employees mow 10 lawns in total, per day

Capital Deepening
Round 3

- Company Productivity Push Goes Crazy:

  Company Buys:

  One more Truck, One more Mower

  Four Employees, Five mowers, Five trucks:

  (spare truck and mower prevent idle workers, during machine breakdowns)

  4 Teams

  4 hours/lawn/team

  2.512 lawns/team/10 hour day

  4 employees mow 10.04 lawns in total, per day

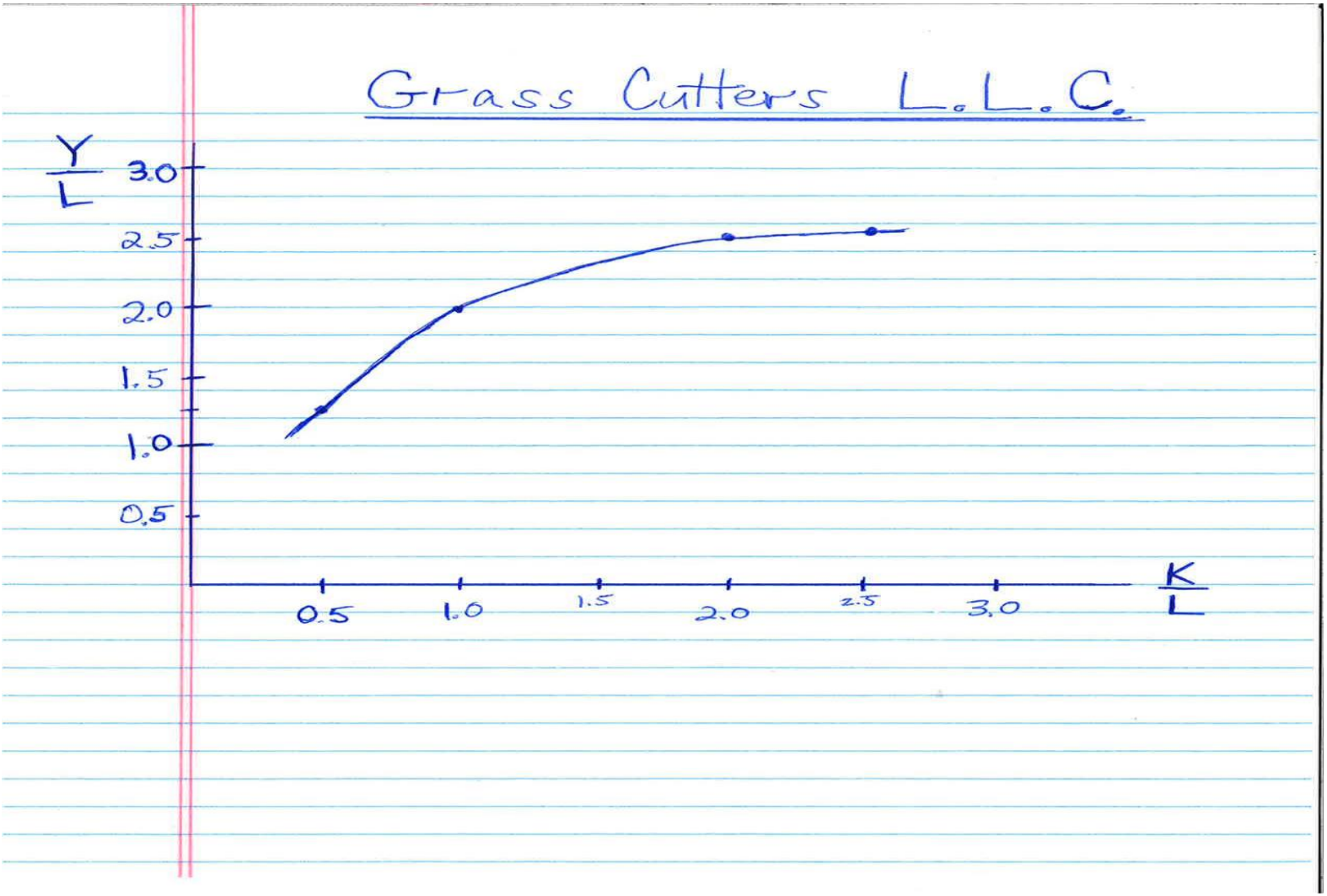
Capital Deepening:
Diminishing Returns

	original company	investment round # 1	investment round # 2	investment round # 3
Number of workers	4	4	4	4
Number of machines	2	4	8	10
Number of lawns mowed	5	8	10	10.05
capital/worker	0.5	1.0	2.0	2.5
output/worker	1.25	2.00	2.50	2.51

Optimal K/L Ratio?
Look at labor vs machine costs

emerging economy					developed economy			
	original company		round 2 investment			original company		round 2 investment
# of workers	4		4		# of workers	4		4
# of machines	2		8		# of machines	2		8
# of lawns/day	5		10		# of lawns/day	5		10
output per worker/day	1.25		2.5		output per worker/day	1.25		2.5
cost/worker/year	$5,000		$5,000		cost/worker/year	$35,000		$35,000
cost/machine/year	$20,000		$20,000		cost/machine/year	$20,000		$20,000
total labor cost/year	$20,000		$20,000		total labor cost/year	$140,000		$140,000
total capital cost /year	$40,000		$160,000		total capital cost /year	$40,000		$160,000
total cost/year	$60,000		$180,000			$180,000		$300,000
200 days per year	1000		2000		200 days per year	1000		2000
cost per lawn	$60		$90		cost per lawn	$180		$150

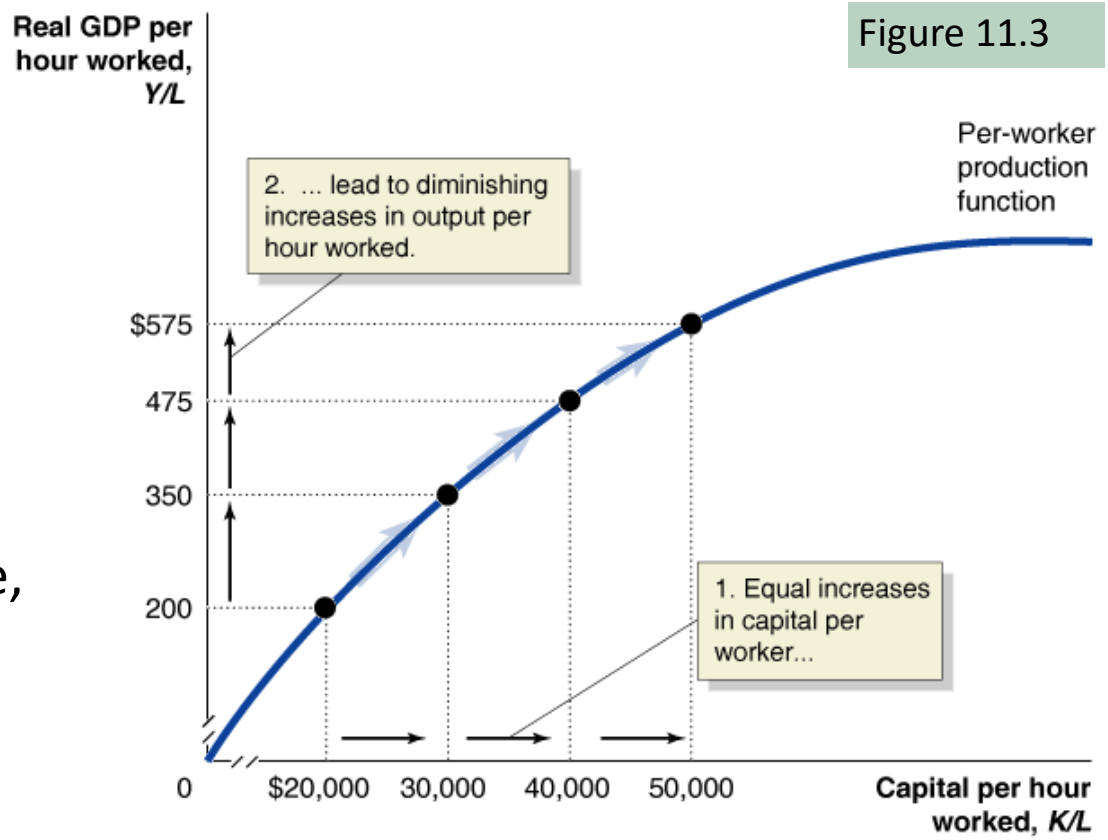
Capital Deepening: A Great source of Developing World Growth.



Production per worker: We see diminishing returns

A *per-worker production function*: relate real GDP/hour worked, and capital per hour worked, holding the level of technology constant.

The first units of capital would be the most effective, allowing output per hour to increase most.

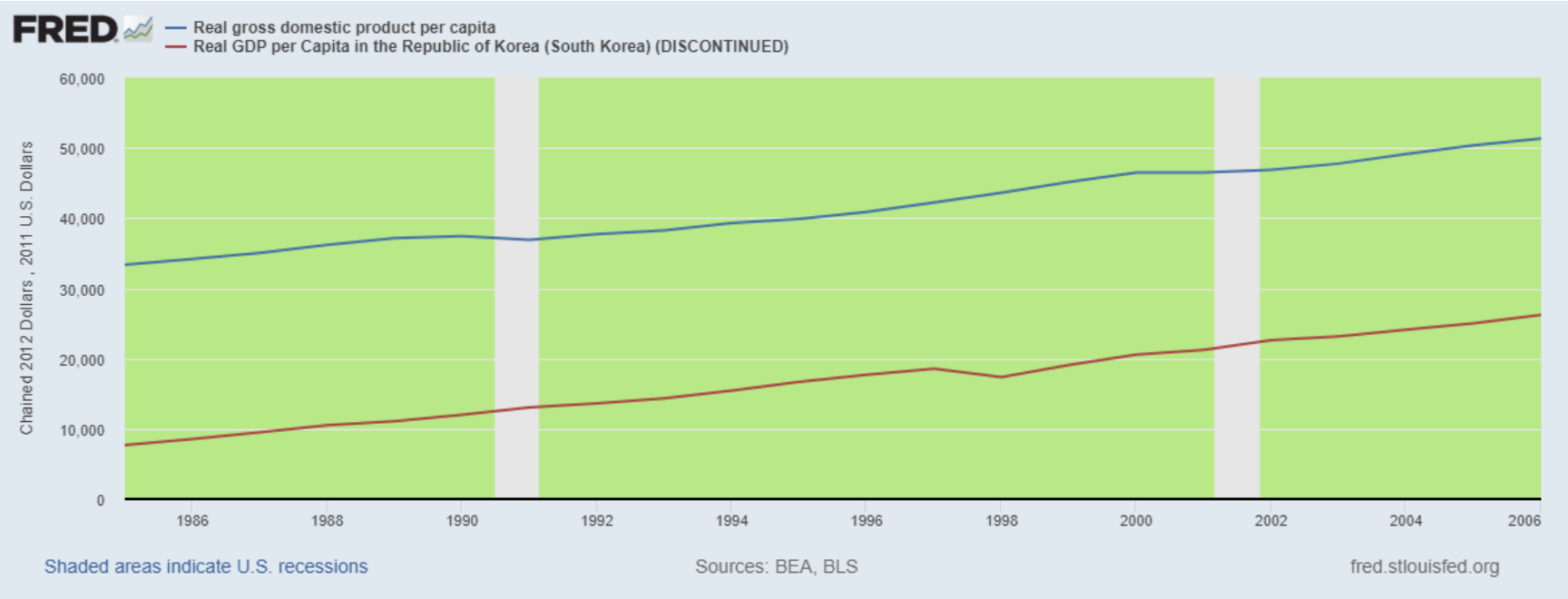


Subsequent increases? *diminishing returns*: smaller increases in output resulting from increasing one factor of production progressively higher while keeping the other factors of production constant.

Paul Krugman and the Asian Miracle

- The 1990s fascination with booming Asian Tigers
  (Korea, Taiwan, Hong Kong, Singapore, Thailand)
- The Asian Tigers were growing at 5% to 6% per year, and Wall Street Gurus Declared they had a 'New Model' for Growth
- 'No!' said Krugman. They are simply capital deepening
- Once they catch up to Western K/Y ratios (once they have the same machines per worker that the Western laborers have) their growth rates will slow sharply and they will look like the West.
- What happened? The Tigers caught up and
- The Tigers Slowed!

	Real GDP	Per Capita
	(annualized	growth)
	1990-1997	1997-2007
USA	1.7%	2.1%
S.Korea	6.4%	3.9%



Efficiency of Capital: Not More Machines—Smarter Machines

- Company Productivity Push: A New Approach

- Gasoline Push Mowers Replaced

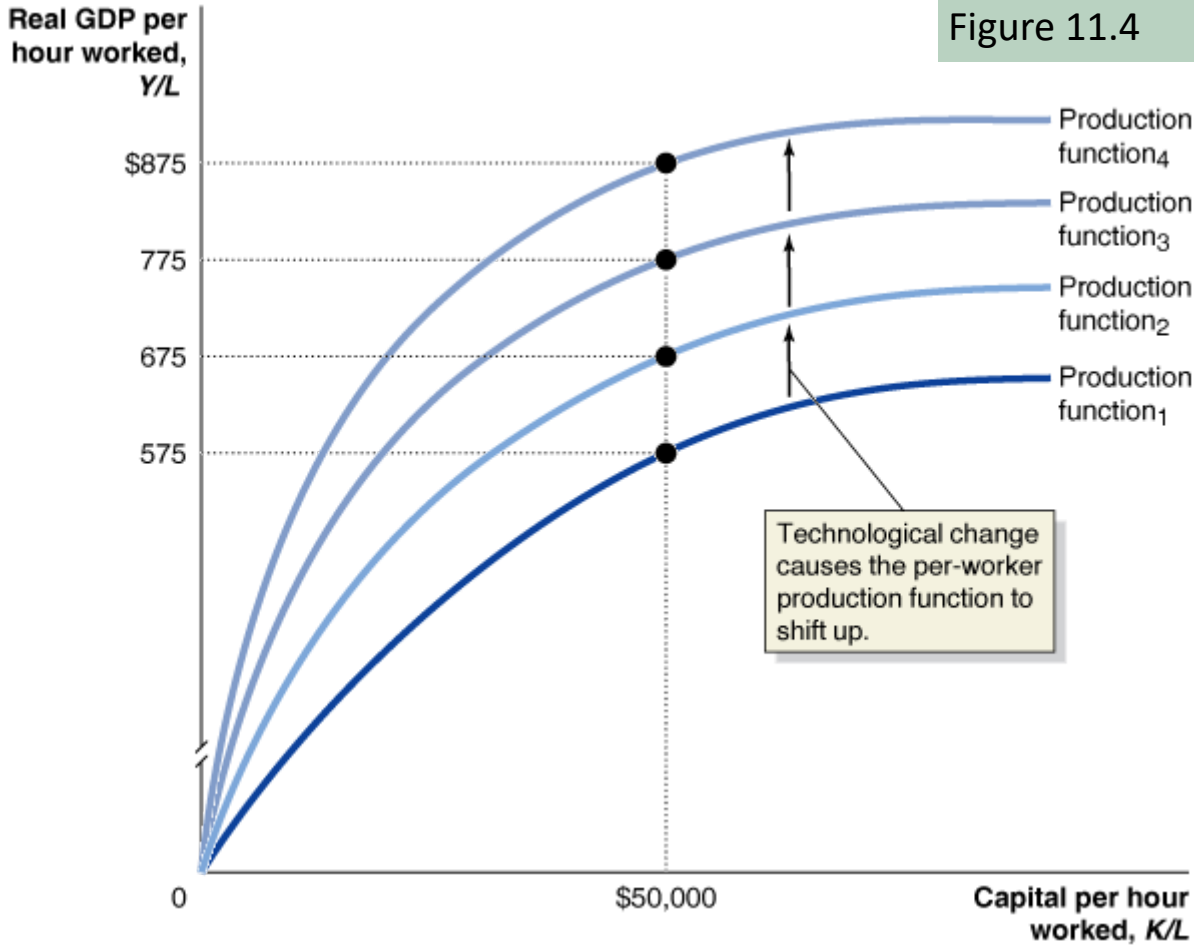
- Sit-down mowers provided
- K/L remains the same—10 machines/worker
- Y/L rises—improved machines drives the increase in output/hour

More capital or technological change?

If a country is relatively lacking in capital—like many of the developing countries—increase in capital will be very effective at increasing real GDP per capita.

In countries where the amount of capital is already relatively high, technological change becomes a more effective way to increase output per hour.

Figure 11.4



The Solow Growth Model

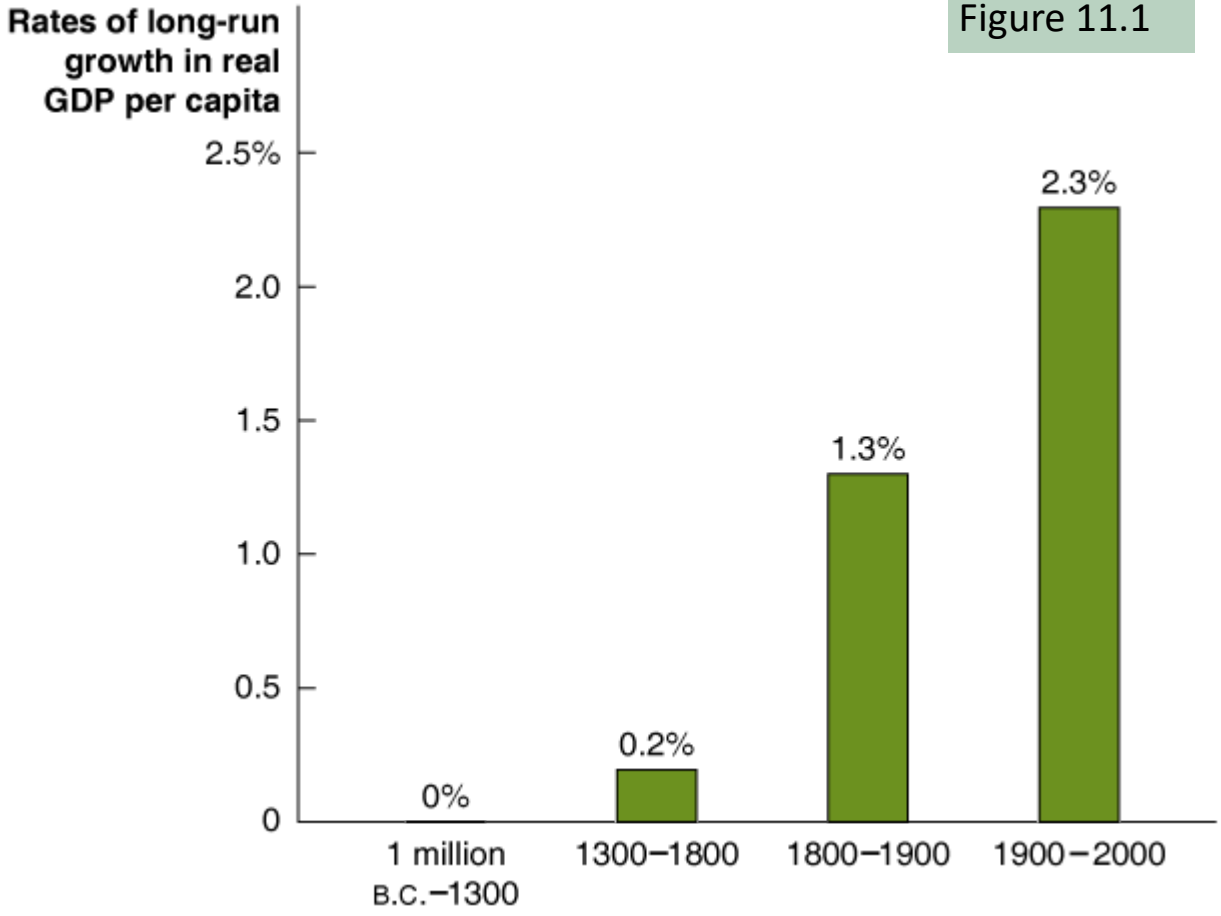
- Robert Solow: M.I.T.
- 1950s develops his theory of growth.
- Once capital deepening is done, technological innovation drives productivity and economic growth.
- Innovation is the ‘Solow’ residual

Average annual growth rates for the world economy

The graph shows Brad DeLong's estimated average annual growth rates for the world economy.

The Industrial Revolution, and its subsequent spread throughout the world, resulted in sustained increases in real GDP per capita.

Figure 11.1



DECONSTRUCTING RECENT U.S. PRODUCTIVITY PERFORMANCE

	1987-2018	1995-2000	2000-2007	2007-2018
OUTPUT PER HOUR	2.0%	2.9%	2.8%	1.3%
CAPITAL DEEPENING	0.9%	1.2%	1.1%	0.7%
LABOR COMPOSITION	0.3%	0.2%	0.3%	0.2%
MULTI-FACTOR PRODUCTIVITY	0.8%	1.4%	1.4%	0.4%

Paul Romer's Nobel Prize:
Ideas Drive Progress and Are Embraced Everywhere.
Idea Creation, therefore, benefits from Government Assistance

- **Solow's Residual** appears as ideas lead to new inventions. Solow just assumed that they arrive.

- A BIG invention, by definition benefits the world in a BIG way.

- Because millions can copy your invention, you will not be paid anything close to the value of the benefits you bestow upon the world.

- Universities and Government funding can support idea creation, leading to more inventions and stronger growth.

Romer's Key Insight?
Ideas are *Nonrival*

- Why do economists talk about scarcity? Because most goods are ***rivalrous***, *that is, if I use the good, you cannot use the good.*

  I eat the apple, you cannot eat the apple.

  I occupy the airline seat, you cannot.

- Ideas are ***Nonrival***!!!

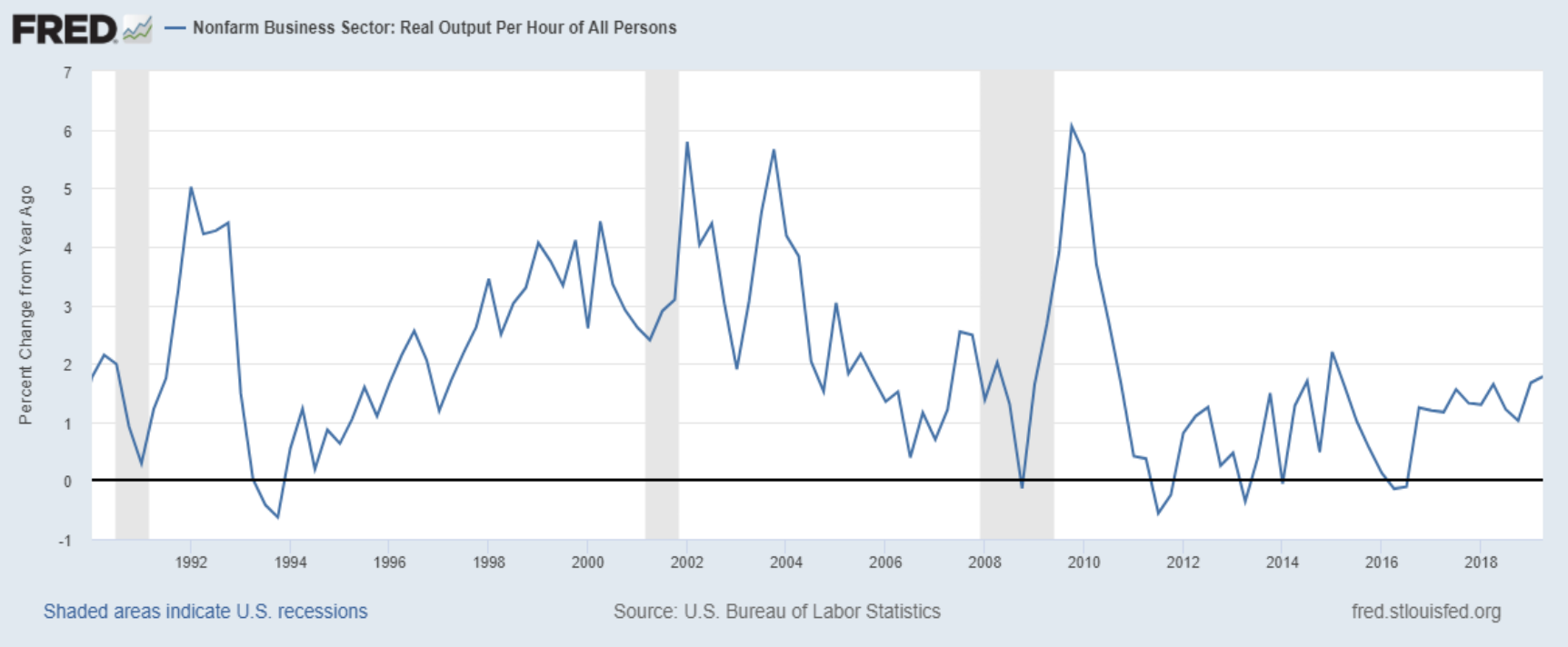
  Pythagoras gave us the 3/4/5 right triangle. Carpenters use it today.

From Chad Jones, 10/21/2015

As an example, consider oral rehydration therapy, one of Romer's favorite examples. Until recently, millions of children died of diarrhea in developing countries. Part of the problem is that parents, seeing a child with diarrhea, would withdraw fluids. Dehydration would set in, and the child would die. Oral rehydration therapy is an idea: dissolving a few minerals, salts, and a little sugar in water in just the right proportions produces a life-saving solution that rehydrates children and saves their lives. Once this idea was discovered, it could be used to save any number of children every year — the idea (the chemical formula) does not become increasingly scarce as more people use it.

ROMER: IDEA CREATION, IF WE SUPPORT IT CORRECTLY, WILL FOSTER CONTINUED IMPRESSIVE GROWTH

Robert Gordon, Northwestern, Sees Little Hope for a Rebound. He asserts the dismal last decade, a 1.3% average gain, 2010:Q2-2019:Q2, is the new normal.



CBO FORECASTS 1.8%

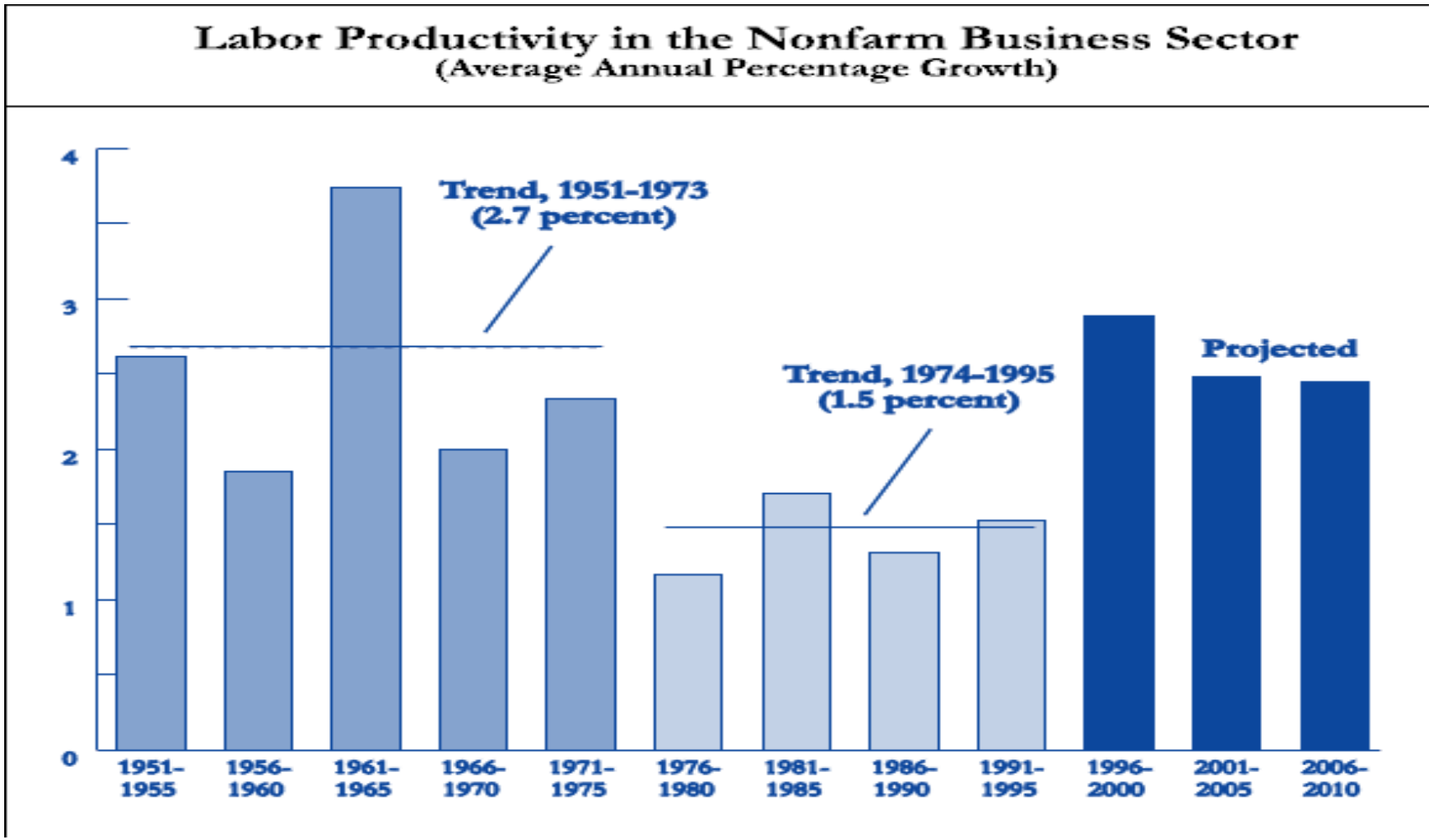
IT WAS 1.8% or less: 31% of the time

1.9% or better: 69% of the time

(The distribution of 25-year average labor productivity performances: 1952-2013)

						X			
						X			
						X			
						X			
					X	X			
		X			X	X			
	X	X			X	X			
X	X	X	X		X	X			
X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X
1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5

CBO on Labor Productivity in 2001:
A dream of 2.6%, following 5 years of 2.8%



Policy Implications of Productivity Labor Force Projections

- For the Fed to set a speed limit, they need an opinion on LTSG
- We need to forecast:
  - Labor productivity growth rate
  - Labor force growth rate

If labor productivity is 2.2% and LF grows 1.0%

- What will real GDP equal In 2040?
- Original Expectations:

  LTSG = 1.5% + 0.5% = 2.0%

  $(1.02)^{25}$ X $19.0 trillion = $ 31.2 trillion

  Alternative Expectations:

  LTSG = 2.2% + 1.0% = 3.2%

  $(1.032)^{25}$ X $19.0 trillion = $ 41.8 trillion

Is Productivity Always Good?

- The automobile arrives and wagon wheel manufacturers go bankrupt.
- They invented Expedia.Com and 1000s of Travel agents Lost their Job.
- Innovation kills jobs, in the short run, that is UNDENIABLE

Joseph Schumpeter and 'Creative Destruction'

- Schumpeter saw the economy as very volatile

- The economy does not 'carefully adjust' like our AE model, to find new equilibrium

- Entrepreneurs revolutionize businesses and carnage, periodically ensues.
- To Schumpeter, large scale bankruptcies are the PRICE OF PROGRESS

Let's Combine Schumpeter and Romer's insights.

- Romer: A new idea revolutionizes the way we do things:

  We use a Zinc/air battery, recharged by the sun.

  It takes 10 workers.

  Drilling for oil, sent gas stations took 15 workers.

  Fossil fuel industry collapses, many jobs, net, are lost.

  All of modern history suggests we will find other useful things for people to do

Schumpeter vs. Keynes
(What Professor Hubbard skipped)

- Schumpeter linked 'creative destruction' to periods of economic decline.
- Bankruptcies, job losses, recessions, were inescapable as new technologies rendered existing companies obsolete.
- Recessions, reflecting 'creative destruction' are the PRICE OF PROGRESS.
- Austrians (like Schumpeter) argue against government intervention to thwart recessions

Keynes: financial system flaws and the need for intervention

- Keynes looked at major economic declines differently.
- Mistakes in financial markets, dashed expectations, can throw the economy into DEEP recessions
- COLLAPSING BANKS ≠ COLLAPSING CANDY STORES
- Governments can and should help minimize/reverse such declines.