
Macroeconomic Models

From Macro Statistics to Macro Models

From Macro Statistics to Macro Models

- Macro variables **quantify** the performance of the economy
- Decision makers use them to **monitor** changes in the economy and formulate **policies**
- Economists use them to develop and test **theories** about how the economy works
 - **Models** that explain how the variables are determined and how policy affects them

Macroeconomics in a Nutshell

- Macro variables fluctuate around their ideal values (the stars)
 - **Potential** output (Y^*)
 - **Natural** rate of unemployment (U^*)
 - Inflation **target** (π^*)
 - **Neutral** interest rate (i^*)
- Stars are related
- Star values may change over time

Long-Run Economic Growth

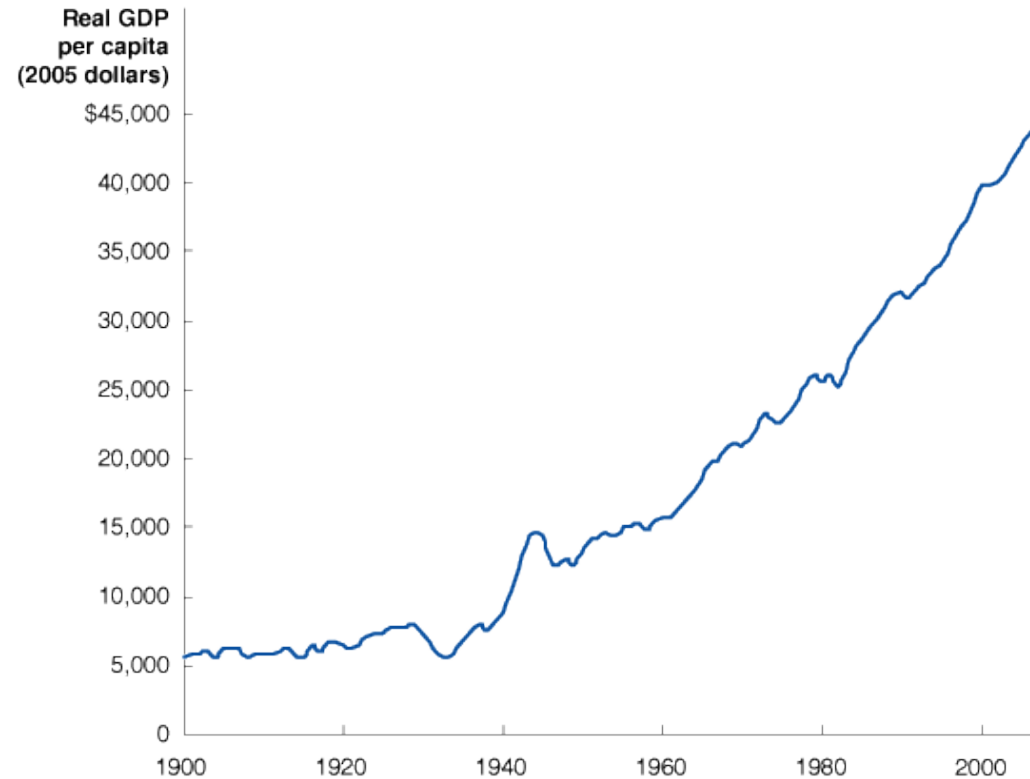
Technological Change Battles Resource Scarcity

Outline

1. Productivity
2. Technological Change
3. Potential GDP

- Textbook Readings: Ch. 10 pp. 318-328, Ch. 11

Output Growth: The Reality Since Industrial Revolution



- **Income/capita**

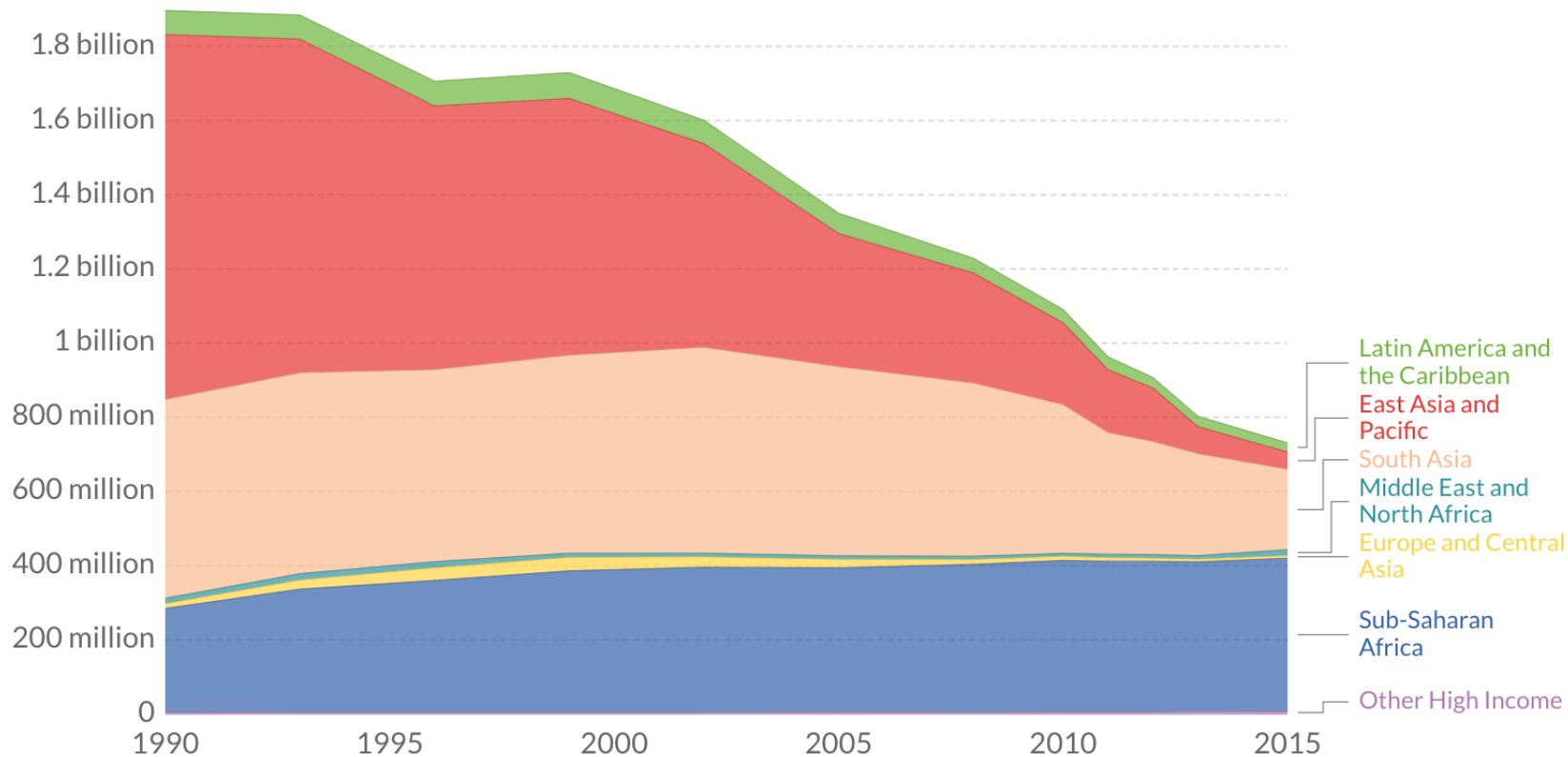
- has been rising over most of modern history
- vary significantly across countries and over time

People Living in Extreme Poverty

Total population living in extreme poverty, by world region

Numbers are in millions of people. Extreme poverty is defined as living with per capita household consumption below 1.90 international dollars per day (in 2011 PPP prices). International dollars are adjusted for inflation and for price differences across countries.

Our World
in Data



Source: PovcalNet (World Bank)

Note: Consumption per capita is the preferred welfare indicator for the World Bank's analysis of global poverty. However, for about 25% of the countries, estimates correspond to income, rather than consumption.

CC BY

What Does Growth Mean?

Index	Percentage Change	Index	Percentage Change	Index	Percentage Change
100		100		100	
110		110		110	
120		121		105	
130		133.1		115	
140		146.41		110	

The Malthusian Dilemma

- Thomas Malthus (1826) suggested that **population growth will deplete the natural resources** necessary to produce food
 - No more new land to cultivate, population growth pushing for more food
 - Starvation will curtail population in this world of diminishing returns
- **Technology and the entrepreneur**: The antidote to the Malthusian dilemma

Example: Farming Trends in the U.S.

			Annualized
	1948	2004	Growth Rate
Output (Y)	100	270	1.8%
Labor input (L)	20	5	-2.4%
Output per hour (Y/L)	5	54	4.3%

- U.S. farm output **grew 1.8%** per year
 - U.S. farm **output** is 2.7 times **higher**
- U.S. farm labor **contracted 2.4%** per year
 - U.S. **labor input** is 75% **lower**

Labor Productivity

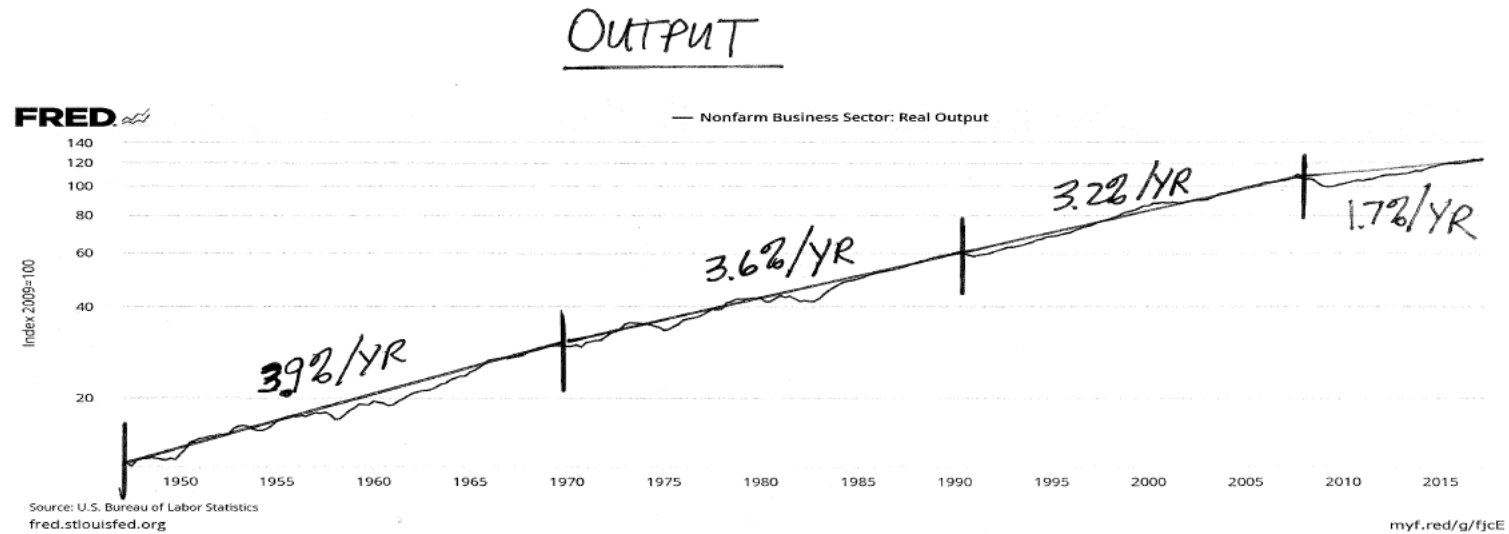
- Labor productivity: Quantity of G&S produced in one hour of work
 - How much stuff you make per hour of work effort
- Labor productivity = Output/Hour
- If everyone can produce 25% more per hour, then we will have 25% more stuff

U.S. Output Growth: Evaluating the Drivers

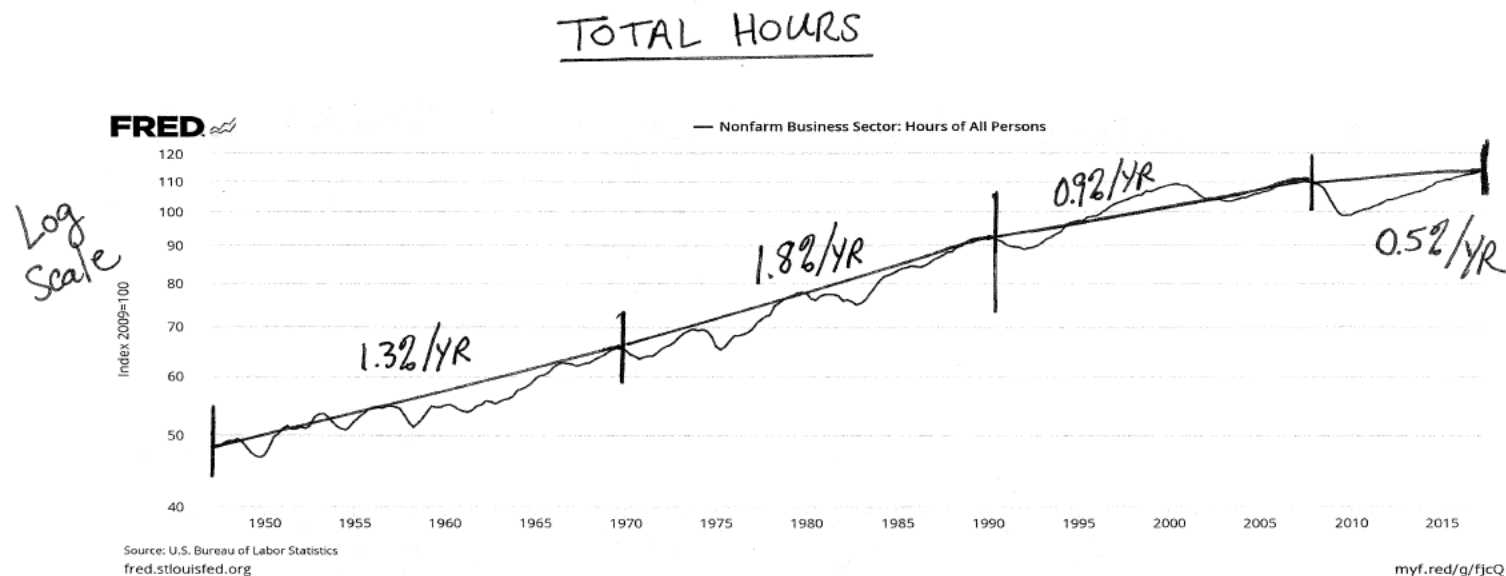
- Deconstructing recent U.S. productivity performance

	1987-	1995-	2000-	2007-	2014-
	2015	2000	2007	2015	2015
OUTPUT PER HOUR	2.0	2.9	2.6	1.2	0.6
CAPITAL DEEPENING	0.8	1.2	1.0	0.5	0.1
LABOR COMPOSITION	0.3	0.2	0.2	0.3	0.3
MULTI-FACTOR PRODUCTIVITY	0.9	1.5	1.4	0.4	0.2

US Post-WWII Output



US Post-WWII Total Hours



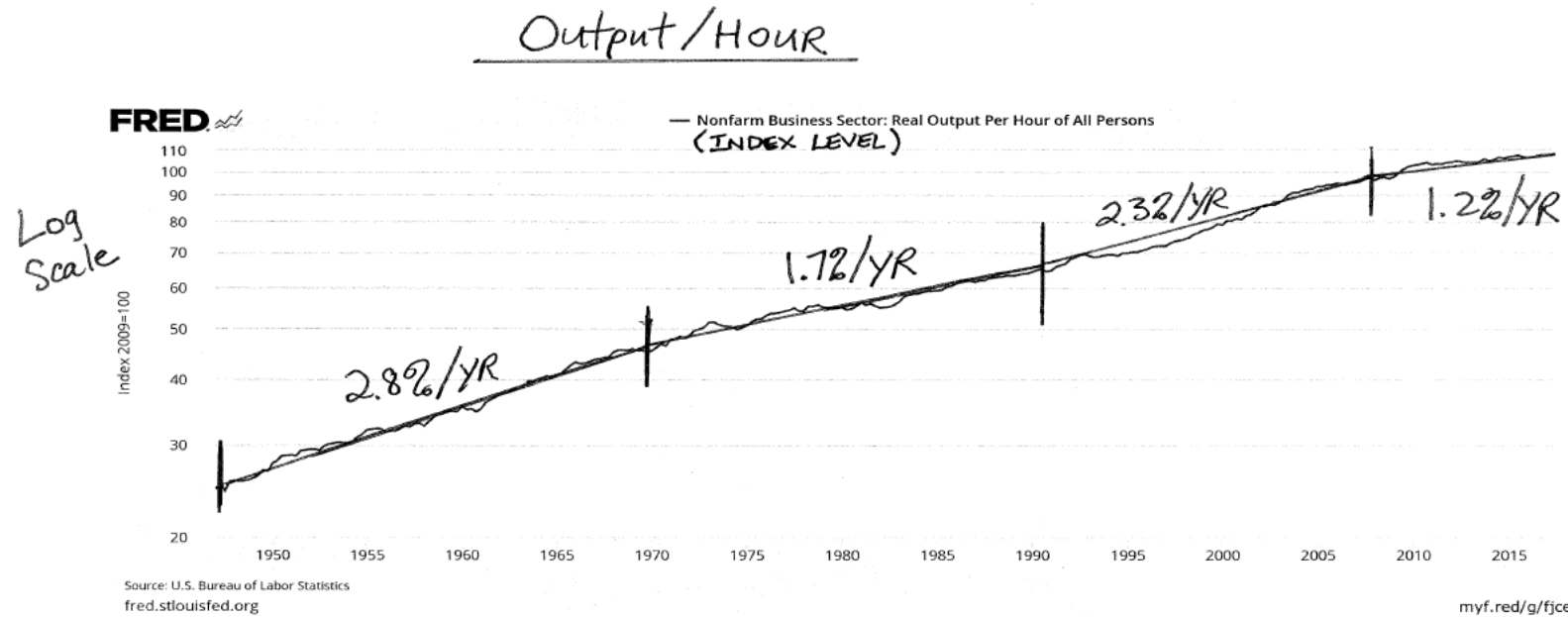
Average Workweek $\equiv$ # of hours, on average, workers were on the job

Number of workers $\rightarrow$ Non-farm payroll level

$(\text{Average workweek}) \times (\text{Number of workers}) = \text{TOTAL HOURS WORKED}$

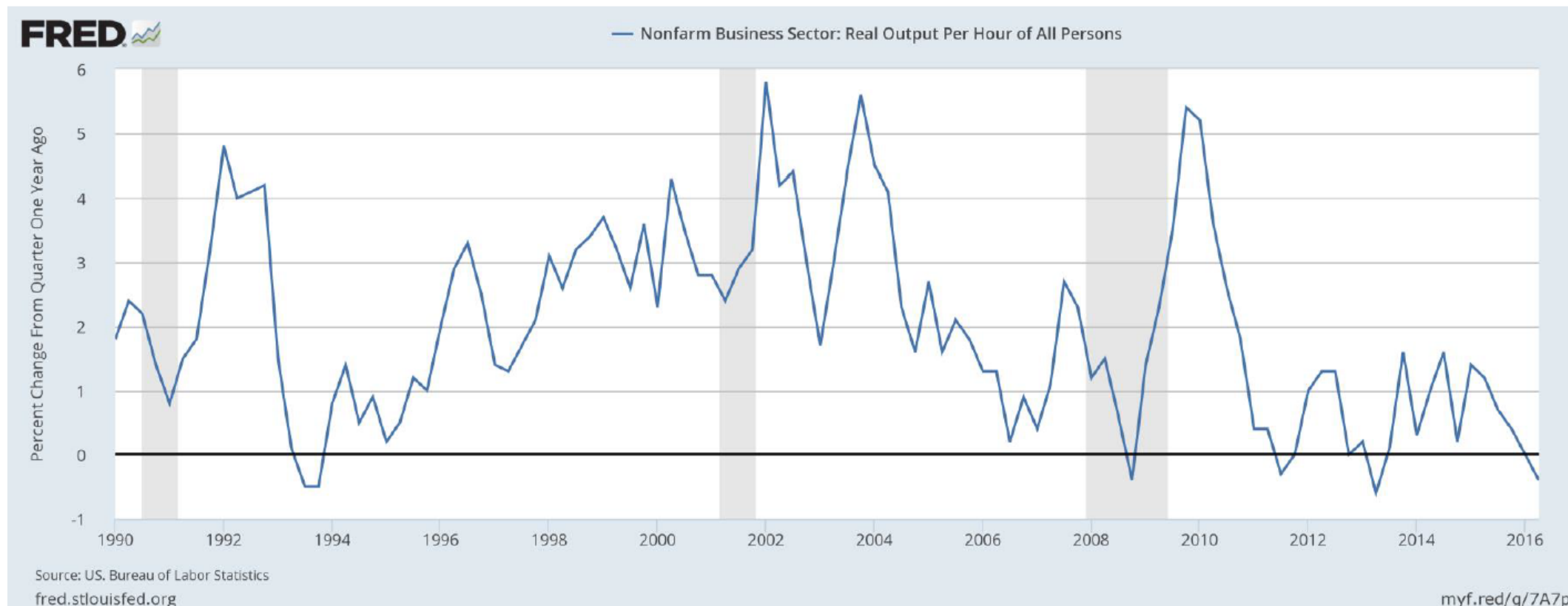
[INDEXED: 2009 value is set equal to 100]

US Post-WWII Labor Productivity



$$\frac{Q2: 2017}{108.1} \quad \frac{Q2: 2008}{97.2} \quad \left(\frac{108.1}{97.2} \right)^{\left(\frac{1}{4} \right)}$$

Labor Productivity Growth



What Determines the Rate of Long-Run Growth?

- A country's standard of living depends on its ability to **produce** G&S
- Increases in real GDP/capita depend on increases in **productivity**!
 - Why the standard of living in Denmark is higher than in Nigeria?
 - Why the standard of living in Japan has grown faster than in Argentina?
- **Economic growth**: The process by which rising productivity increases the average standard of living
 - What causes labor productivity to increase?

How Can We Make Laborers' Input More Productive?

- We can **train and educate** laborers (human capital)
 - Knowledge and skills that workers acquire (high school vs college)
- We can give them **more tools** (physical capital)
 - Increase the capital stock (computers, trucks, factory buildings)
- We can invent **better tools** (technological change)
 - Technology: Process a firm uses to turn inputs into outputs
 - Technological change: Increase in quantity of output produced using a given quantity of inputs



Economic Growth Model

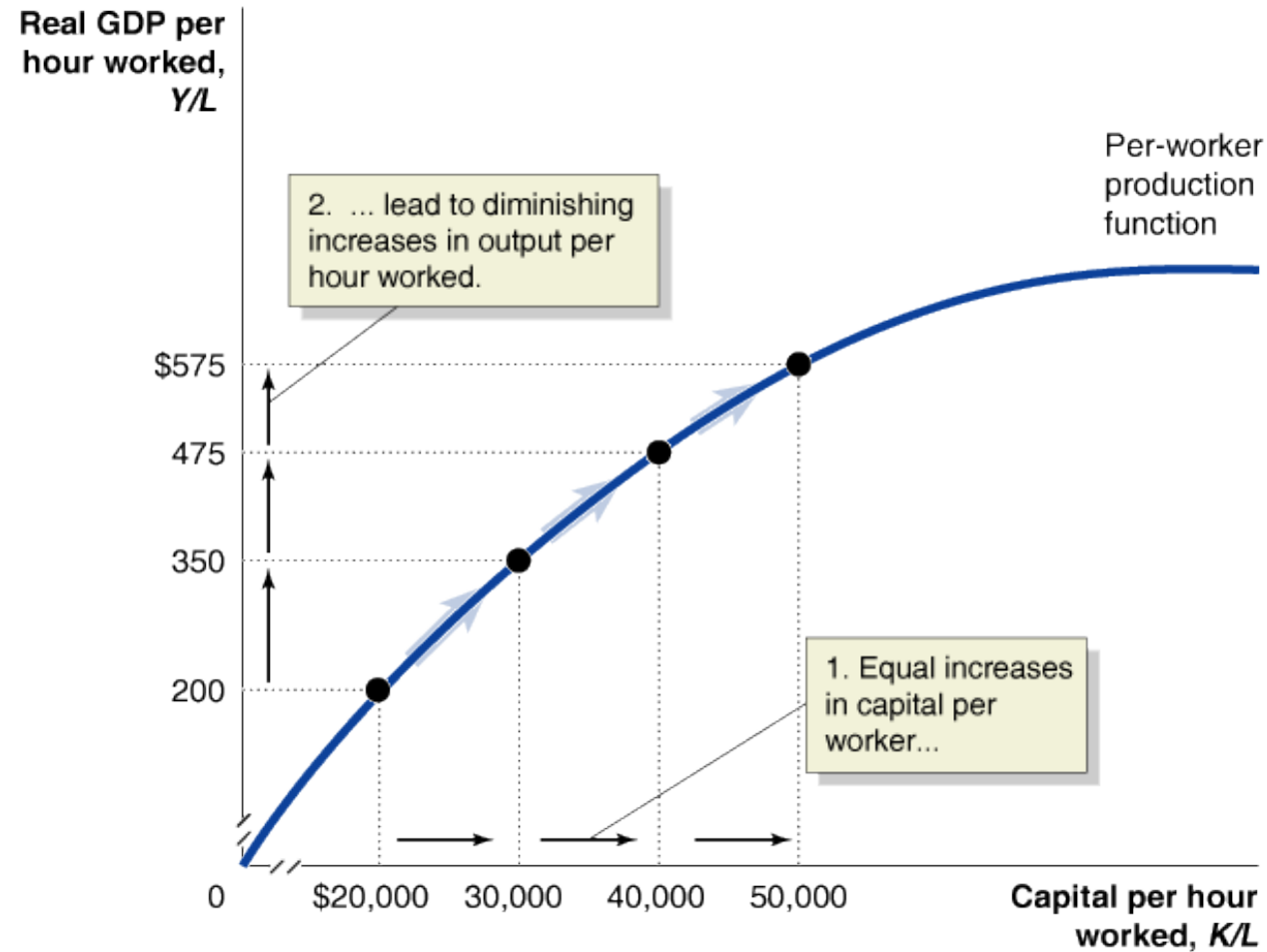
- Model **explains** growth rates in real GDP/capita over the long run
- We looked at increases in real GDP *per hour worked* (Y/L) and increases in capital *per hour worked* (K/L)
- The economic growth model is illustrated using the **per-worker production function**
 - Relationship between K/L and Y/L , holding the level of technology constant

Capital Deepening: Diminishing Returns

	original	investment	investment	investment
	<u>company</u>	<u>round # 1</u>	<u>round # 2</u>	<u>round # 3</u>
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

Capital Deepening: Great Source of Developing World Growth

The Per-Worker Production Function



Why Are There Diminishing Returns to Capital?

- When workers already have a large amount of capital to produce G&S, if they are given an additional unit of capital, their productivity increases only a little
- **Implications** of diminishing returns to capital:
 - Increasing the saving rate (and so K) increases growth **temporarily**
 - **Catch-up**: Income per capita in **poor countries will grow faster** than in rich countries



Is Table Consistent with the Economic Growth Model?

	Real GDP per capita 1960	Annual Growth in real GDP per capita, 1960 -2011
Taiwan	\$1,861	5.81%
Panama	2,120	3.50
Brazil	2,483	2.73
Costa Rica	4,920	1.42
Venezuela	7,015	0.91

Paul Krugman and the Asian Miracle

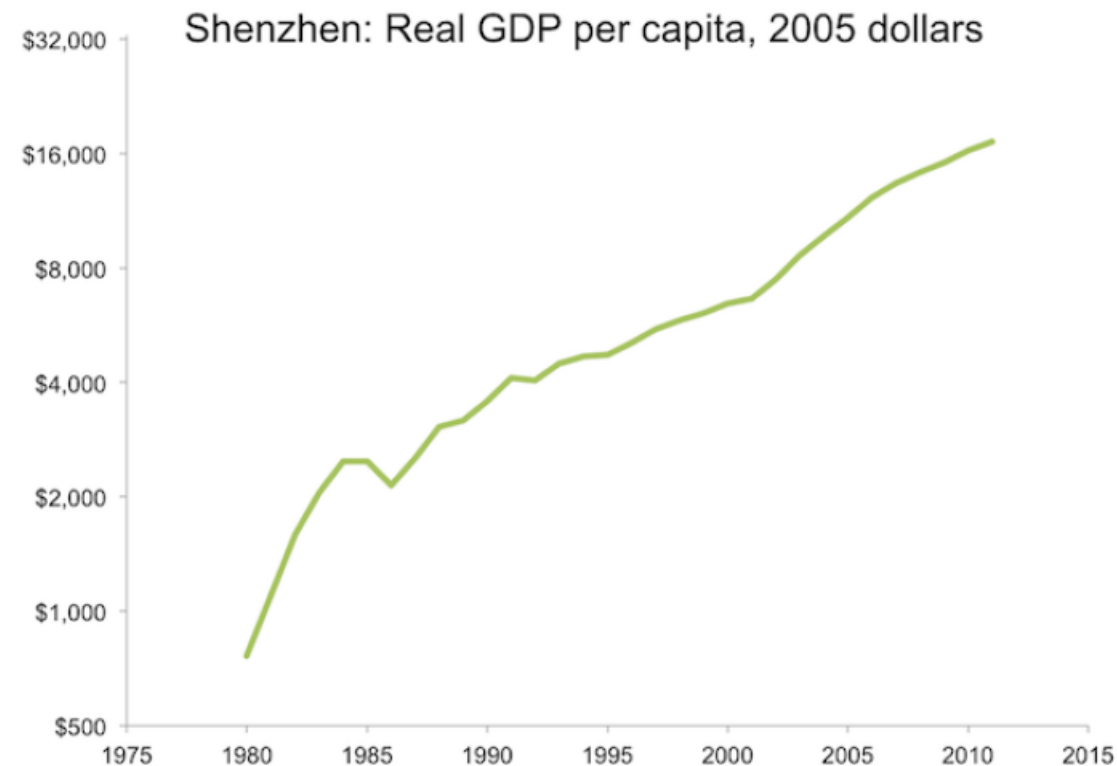
- In 1990s, fascination with booming **Asian Tigers**: Korea, Taiwan, Hong Kong, Singapore, Thailand
- The Asian Tigers were **growing at 5% to 6%** per year, and Wall Street gurus declared they had a 'new model' for growth
- 'No!' said Krugman. It is simply **capital deepening**
- Once they **catch-up** 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!**

Capital Deepening in China

- It offered opportunities for catch-up growth

1980-1985 → 23%/year,

1985-2011 → 7%/year

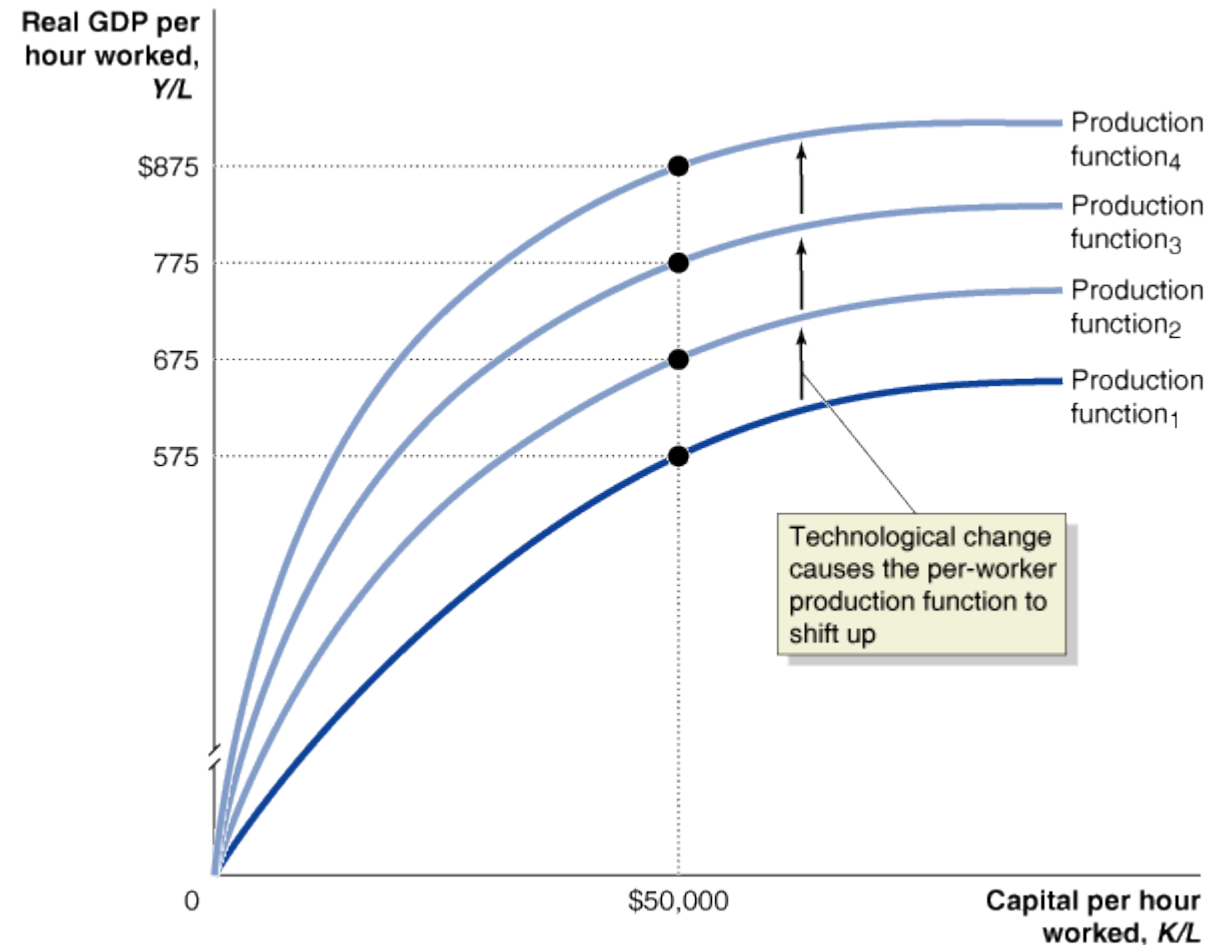


Is Capital Deepening Only Way to Sustain Growth?

- Capital deepening works for developing countries
 - If a country is relatively **lacking in capital**, increase in capital will be very effective at increasing real GDP per capita
- What about advanced countries?
 - **Just accumulating** more inputs **does not** ensure more production
- In countries where the amount of capital is already high, **technological change** becomes a more effective way to increase output per hour

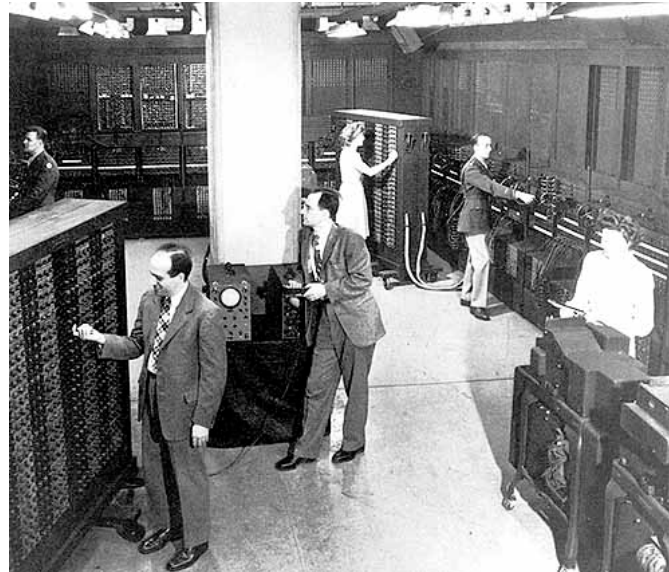
The Key to Sustaining Economic Growth

Technological Change



Technological Change

- It helps economies **avoid** diminishing returns to capital
 - Efficiency of Capital: Not more machines—smarter machines



- **Solow growth model** (1954): Once capital deepening is done, **technological innovation drives productivity** and growth

But What Are the Sources of Technological Change?

- Paul Romer (1980): **Accumulation of knowledge** is key to growth
 - Knowledge capital has **decreasing** returns *at the firm level* but **increasing** returns *at the economy level*
 - Example: Chemical formula for a drug that cures X



Policies to Increase Accumulation of Knowledge Capital

- Protect intellectual property → Patents, copyright
- Support R&D → Directly, subsidies, tax benefits
- Subsidizing education → K-12, public colleges



Why Did the Industrial Revolution Begin in England?

- For economic growth, government needs to provide the necessary type of **institutional framework**
- The British government's guarantee of **property rights** set the stage for the Industrial Revolution



ROW GDP/Capita 1960-2011: Success Stories Closed Gap

	U.S.A.	KOREA	IRELAND	FRANCE	AUSTRALIA
Real GDP Per capita In 1960	\$15,000	\$2,000	\$6,000	\$10,000	\$15,000
Annualized Real growth 1960 to 2011	1.8%	5.5%	3.1%	2.2%	1.9%

ROW GDP/Capita 1960-2011: Success Stories Closed Gap

	U.S.A.	KOREA	IRELAND	FRANCE	AUSTRALIA
Real GDP Per capita In 1960	\$15,000	\$2,000	\$6,000	\$10,000	\$15,000
Real GDP Per capita In 2011	\$37,250	\$30,650	\$28,500	\$30,300	\$39,200

Post-WWII ROW Stagnation Stories

	Niger	Venezuela	Columbia	Argentina
Real GDP Per capita In 1960	\$1,000	\$7,000	\$4,000	\$6,000
Annualized Real growth 1960 to 2011	-1.1%	1.1%	2.1%	1.8%

Why Doesn't Capital Flow from Rich to Poor Countries?

- May be the **return on capital is not higher** in poor countries, why?
 - Misallocation and bad composition of investment (e.g. **lack of physical infrastructure**)
 - Misappropriation of investment (e.g. **corruption**)
 - Lack of “human capital” in the workforce (**education/skills/health**)
 - Deficiency in contractual environment (**property rights, rule of law**, etc.)

Why So Much Worry About Growth Rates?

- How long does it take to double the flow of output?

- A rough rule for growth rates

Divide the growth rate into 70

- | | | |
|----------------------|-----------------------------|-----------------------|
| • 2% growth | $70/2 = 35 \text{ years}$ | $(1.02)^{35} = 2$ |
| • 3.5% growth | $70/3.5 = 20 \text{ years}$ | $(1.035)^{20} = 1.99$ |
| • 5% growth | $70/5 = 14 \text{ years}$ | $(1.05)^{14} = 1.98$ |

Paul Romer on the Magic of Compounding

- How many squares on a chessboard?
 - 64
- How many white squares?
 - 32
- Place a penny on the first white square, 2 pennies on second, 4 pennies on the third, ...
- How many dollars on the 32 white square?

\$21,474,836

64 Squares Like 64 Years of Adult Life

- A penny doubled each white square is a world in which output doubles every two years
- How does that compare to a world in which output doubles every year?
- Year 33, we double **\$21,474,836**
- We continue to double squares 34, 35, ..., 64
- How many dollars on the 64th square?

\$92,233,720,368,547,800

(\$92 quadrillion)

Two Views on Future Productivity

- Robert Gordon: **Great inventions** (electricity, urban sanitation, combustion engine, modern communication) **belong to the past**
 - Demographics
 - Education
 - Inequality
 - Government debt
- Brynjolfsson and McAfee:
 - “First machine age” (Ind. Rev.) → physical power (i.e. internal combustion)
 - **Second machine age** (now!) characterized by “**mental power**” (i.e. big data, AI, etc.)

Did per Person Growth Over History Speed Up or Down?

PRODUCTIVITY GROWTH RATES FOR LEADING COUNTRIES

Lead Country	Interval	Annual Average Compound Growth Rate of GDP per Man-Hour (%)
Netherlands	1700–1785	–.07
United Kingdom	1785–1820	.5
United Kingdom	1820–90	1.4
United States	1890–1979	2.3

SOURCE.—Maddison (1982).

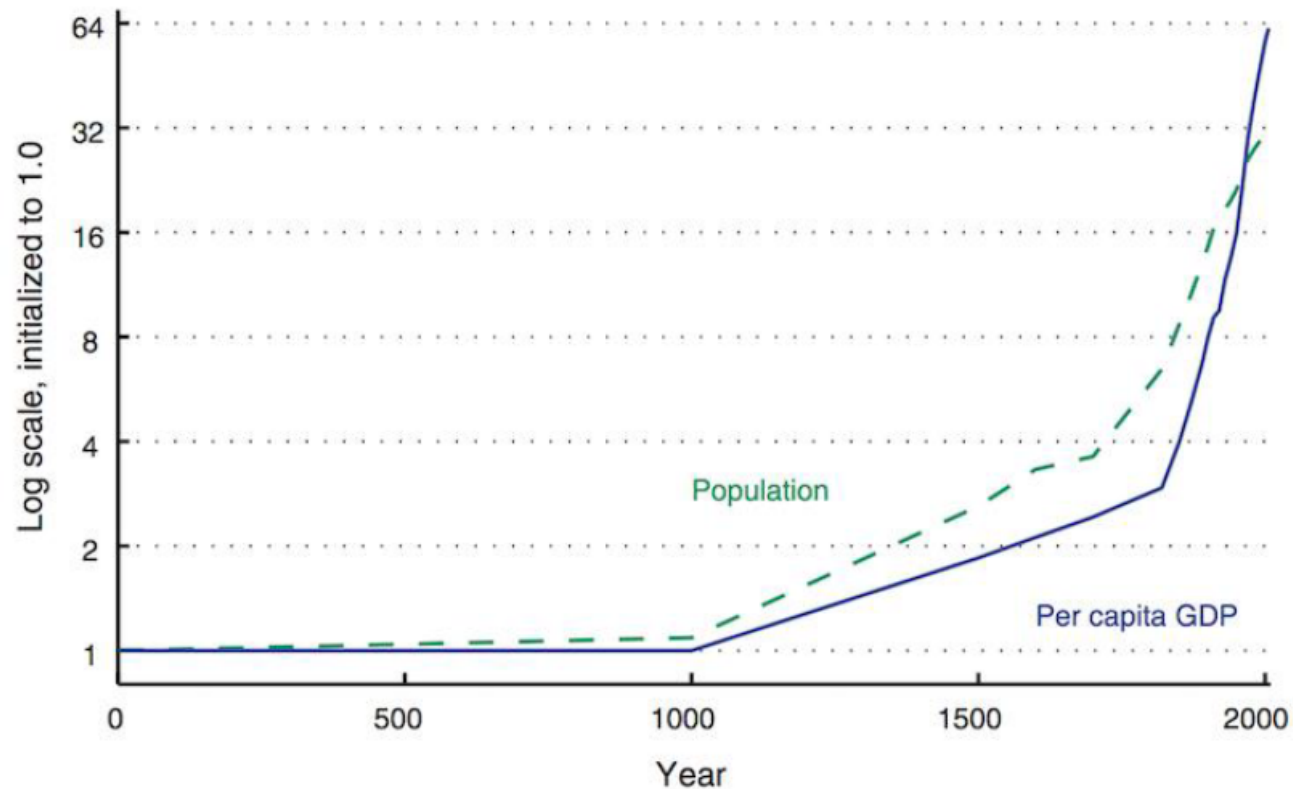
Romer's Thought Experiment

- Throughout history, growth rates must have been accelerating
 - GDP per capita growth rate today = 2%
 - Income per capita in 2015 = \$40,000
 - Income per capita in 1015 = \$??
- If growth had been steady at 2%
$$(1.02)^{1,000} \times \$?? = \$40,000$$
$$\$?? = \$40,000 / 398,264,652 = \$0.0001$$
- Annual income per capita in 1015 would be 0.01 cents
 - Impossible, everyone starves

History Lesson

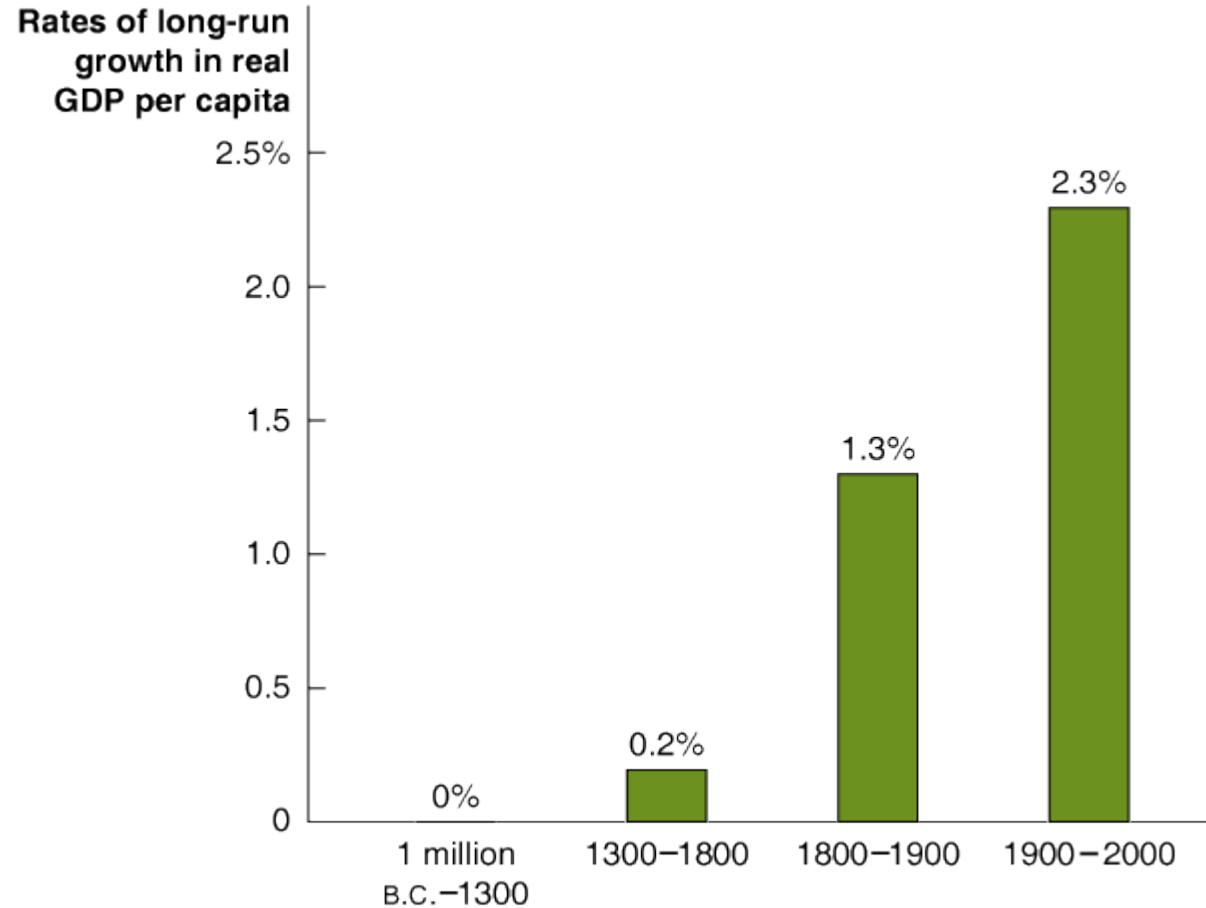
- History suggests that the growth rate continues to accelerate

(source for chart: Paul Romer blog, *Economic Growth*, October 12th, 2015)



Economic Growth from 1,000,000 B.C. to the Present

Average Annual Growth Rates for the World Economy



A Positive Prospect for Productivity

“Every generation has perceived the limits to growth that finite resources and undesirable side effects would pose if no new recipes or ideas were discovered”

“The difficulty is the same one we have with compounding: possibilities do not merely add up: they multiply” (Romer’s blog)

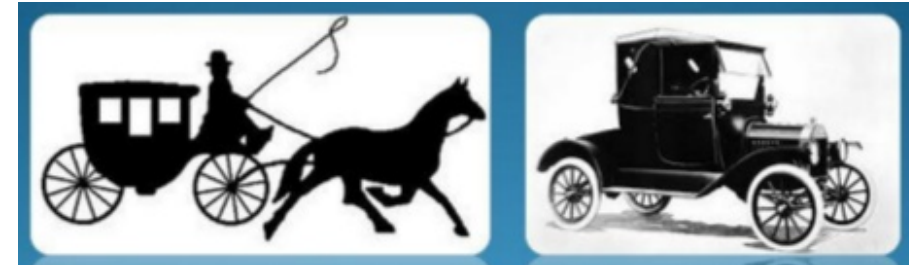
- Example: Periodic table has 100 different types of atoms
- Mix tin + copper together, you get bronze
- How many two-element combinations? 100×99 possibilities
- Betting on future growth is a bet on ever more ingenious recipes
 - It has been the correct bet for 1,000 years

Is Productivity Always Good?

- Innovation kills jobs in the short run
 - ATM and bank clerks
 - Expedia.com and travel agents
- Question is how and whether workers can successfully shift toward other jobs
- In this sense, there is a role for government in ensuring a smooth transition
 - Training programs

Joseph Schumpeter and 'Creative Destruction'

- Schumpeter saw the **economy as very volatile**
 - The economy does not 'carefully adjust' to find a new equilibrium
- **Entrepreneurs** periodically revolutionize businesses
 - Bankruptcies, job losses, recessions are inescapable as new technologies rendered existing companies obsolete
- To Schumpeter, **recessions** and **large scale bankruptcies**, reflecting '**creative destruction**', are the **price of progress**
 - Austrians argue against government intervention to thwart recessions



Keynes: Financial System Flaws and Need of Intervention

- John M. Keynes looked at major economic declines differently
- **Mistakes in financial markets** and dashed expectations can throw the economy into **deep recessions**
- Collapsing banks $\neq$ collapsing candy stores
- Governments can and should help **minimize/reverse** such declines

Secular Stagnation: A Fear that Grips the World

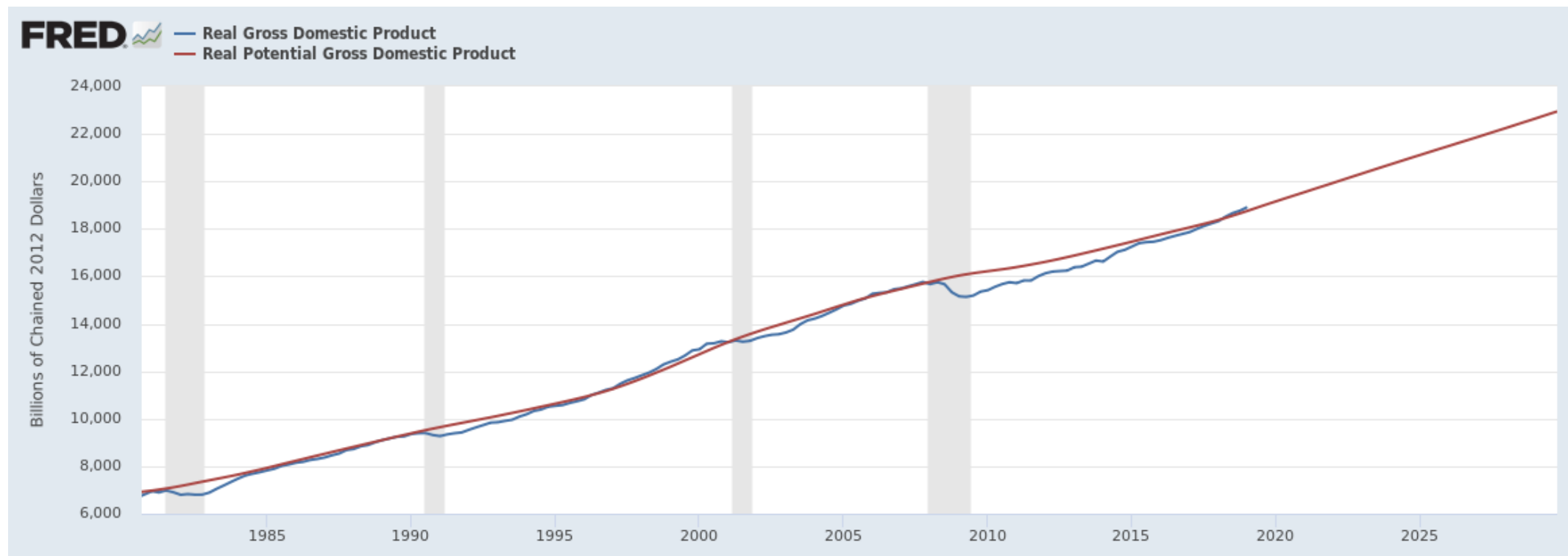
- Global growth has been very weak following the 2008-2009 Great Recession
 - U.S. real GDP growth has been weak
 - Japan, after its financial market crisis 1989-1990, has been locked in slow growth
- Are the U.S. and the ROW trapped in a long term slow growth zone?
- Or are there policies that can return higher growth rates?

If Stagnation Persists, Is It Supply or Demand?

- Many Keynesians say it is **Demand**
 - The world is saving too much: households, firms, governments
 - We face a global paradox of thrift: consumer spending, corporate investment and government investment are all weak
- Many Conservatives say it is from curtailed **Supply**
 - Regulatory excesses stifle risk taking
 - High corporate tax rates stifle investment
 - Productivity is weak due to these government interventions

Potential GDP

- Level of real GDP when firms produce **at capacity** (not 24/7)
- **Increases over time** as LF grows, capital stock grows, tech. change



Estimating Long-Run Growth

- Suppose we want to forecast the value of real GDP in 25 years from now
- We need to forecast:
 - Labor productivity growth (LPG) rate
 - Labor force growth (LFG) rate
- **Long-term sustainable growth** (LTSG) rate:

$$\text{LTSG} = \text{Labor Productivity Growth} + \text{Labor Force Growth}$$

Policy Implications: What Will Real GDP Equal in 2044?

- Scenario 1

- Expectations: LPG = 1.7%, LFG = 0.5%
- LTSG = 1.7% + 0.5% = 2.2%
- $(1.022)^{25} \times \$18.8 \text{ trillion} = \text{\$32.4 trillion}$

- Scenario 2

- Expectations: LPG = 2.2%, LFG = 1.0%
- LTSG = 2.2% + 1.0% = 3.2%
- $(1.032)^{25} \times \$18.8 \text{ trillion} = \text{\$41.3 trillion}$

- Critical for assessment of **public budget sustainability** (Debt/GDP)

Budget Deficit and Long-Run Projections

- Congressional Budget Office's baseline forecast

$$\text{LTSG} = 1.5\% + 0.5\% = 2\%$$

- Debt as a share of GDP in 2040? **104%**

- If, instead

$$\text{LTSG} = 2.0\% + 0.7\% = 2.7\%$$

- Debt as a share of GDP in 2040? **68%**