

# The Future of Fiscal Policy: American Economic Policy Debates in the 21<sup>st</sup> Century

Owen Zidar  
Woodrow Wilson School  
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Week 1

## 1 Overview

- Introductions
- Course outline, schedule, logistics, goals of course
- Brief Overview of Fiscal Policy in the US

## 2 Government Intervention in the Economy

- Quantitative economic framework/ Inequality example
- Equity consequences of taxation
- Efficiency consequences of taxation

## 3 Recent Economic Developments

- Growth, Technological Change, and Inequality
- Who benefits from *TFP* growth?

## 4 Discussion: Should we tax robots?

## ① My background

- Ph.D. from UC Berkeley, BA from Dartmouth
- Staff Economist at Council of Economic Advisers
- Formerly an Assistant Professor at Chicago Booth, now at Princeton
- Co-chair NBER business tax group

## ② Research fiscal policy topics

- Incidence and efficiency costs of corporate taxation
- Economic impacts of taxing high-income earners
- Effect of state tax system on U.S. economy
- The structure of state corporate taxation
- Business taxation and ownership in the U.S.
- Who profits from patents? Rent sharing at innovative firms
- Business Income and U.S. income inequality

## ① Efficiency, Equity, and Fiscal Policy

- ① Efficiency, Growth, and Technological Change
- ② Equity and the distribution of income
- ③ Policy Discussion: Should we tax Robots?

## ② Place-Based Policies and Local Economic Development

## ③ K: Business Tax Reform

## ④ L: Taxing top earners

## ⑤ A: Innovation Policy

## ⑥ The EITC and the safety net

## Logistics:

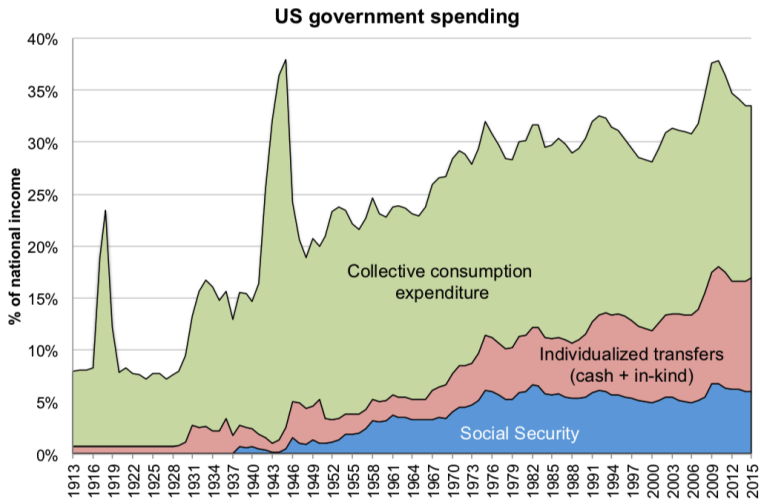
- 1 Class schedule
- 2 Four one-page policy memos
- 3 One in class policy presentation (signups)
- 4 Active participation
- 5 Four-page policy proposal memo

## Goal:

- 1 Have engaging, informative, and policy relevant discussions of central fiscal policy issues
- 2 Incorporate applied economic models and evidence on policies in question

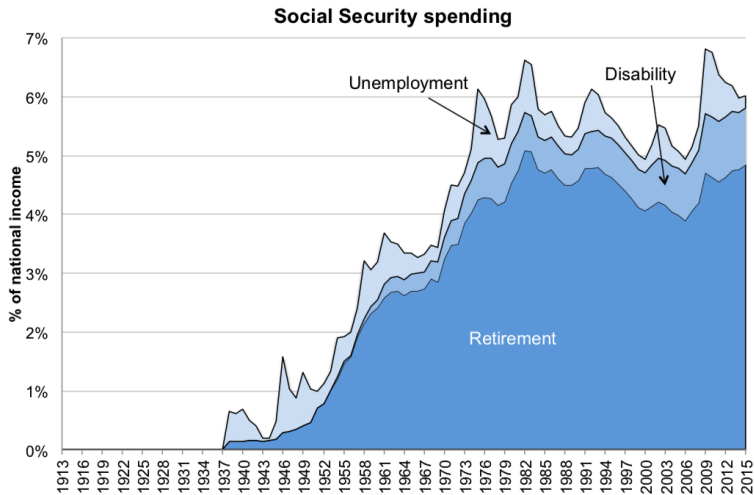
# Brief Overview of Fiscal Policy in the US

# Federal+State+Local Government Spending



Source: G. Zucman (2018)

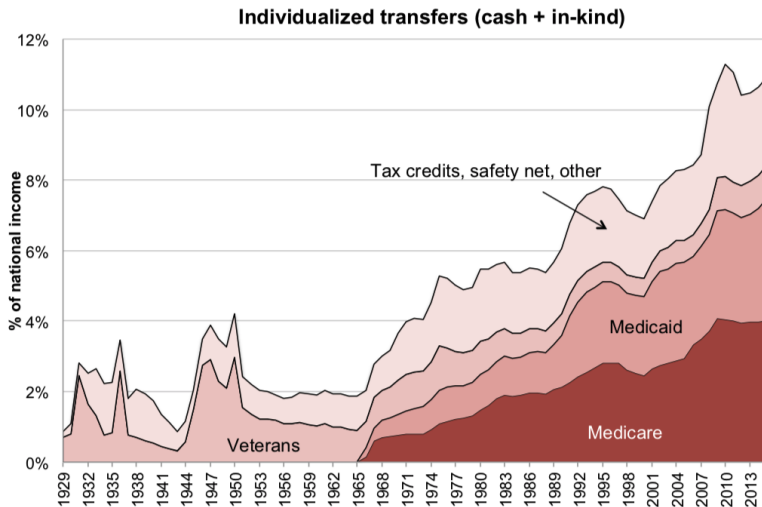
# Federal+State+Local Social Security Spending



Source: G. Zucman (2018)

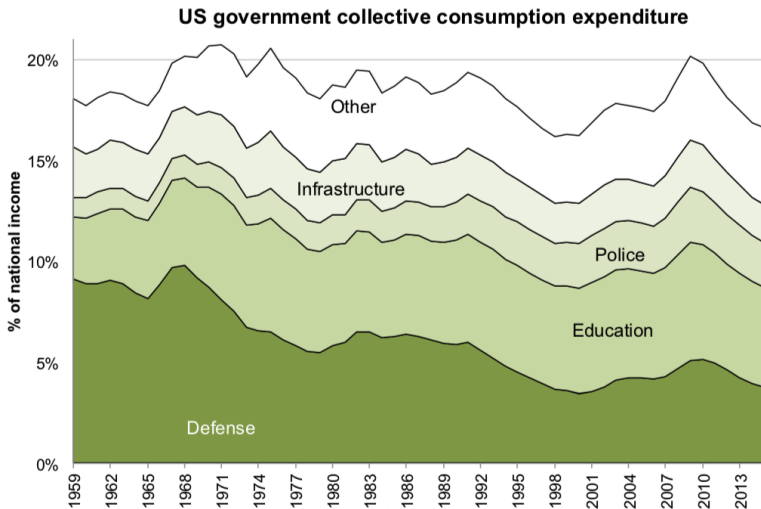


# Federal+State+Local Individualized Transfer Spending



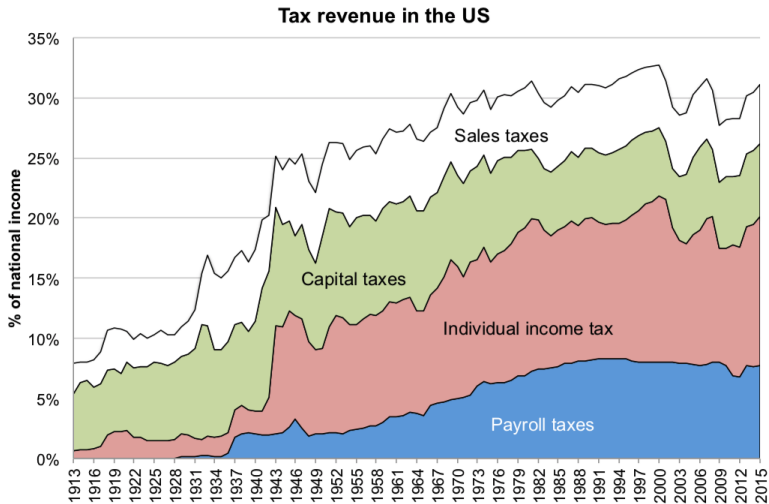
Source: G. Zucman (2018)

# Federal+State+Local Collective Consumption Spending



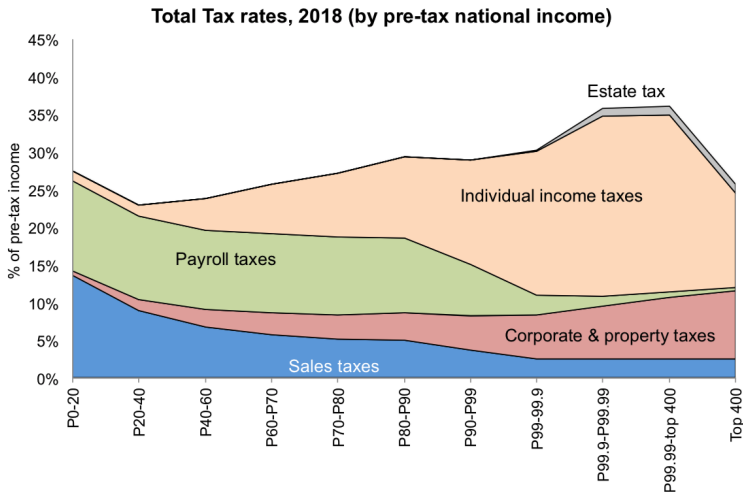
Source: G. Zucman (2018)

# Federal+State+Local Tax Revenue



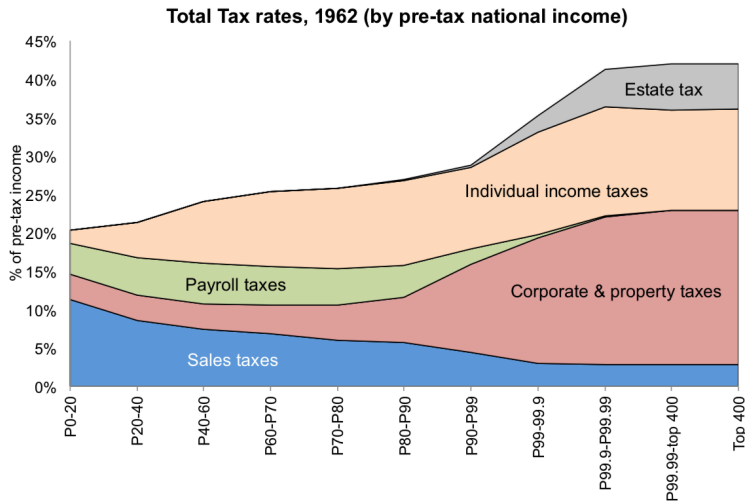
Source: G. Zucman (2018)

# Federal+State+Local Tax Rates by Income Group in 2018



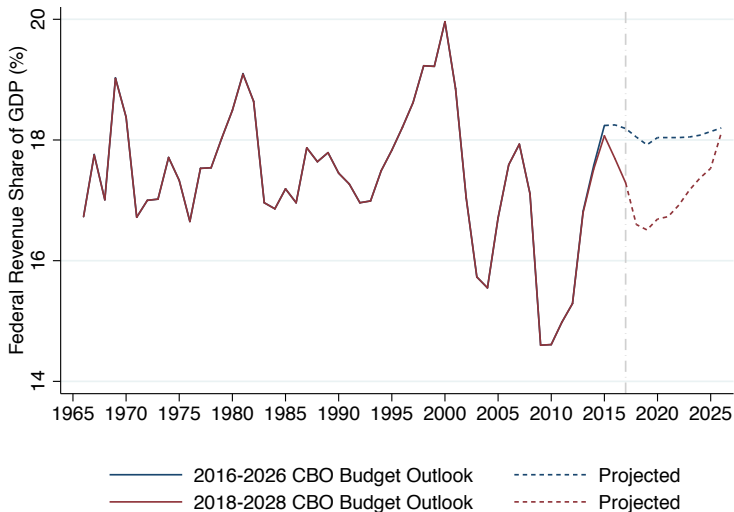
Source: E. Saez (2018). N.B.: assumptions are required to distribute tax burdens across groups.

# Federal+State+Local Tax Rates by Income Group in 1962



Source: E. Saez (2018). N.B.: assumptions are required to distribute tax burdens across groups.

# Federal Revenue Projections: Pre and Post TCJA



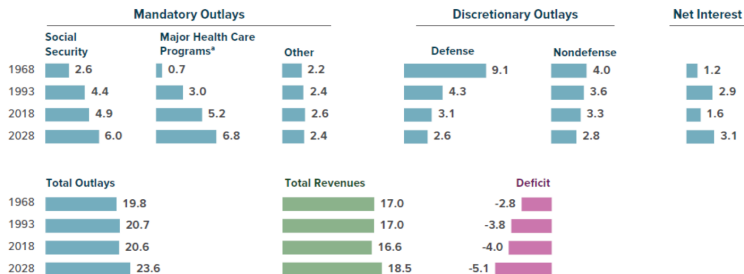
Source: CBO Budget and Economic Outlook

# Federal Outlays, Revenues, and Deficits

Figure 4-3.

## Outlays and Revenues Projected in CBO's Baseline, Compared With Actual Values 25 and 50 Years Ago

Percentage of Gross Domestic Product



Source: Congressional Budget Office.

a. Consists of spending on Medicare (net of premiums and other offsetting receipts), Medicaid, and the Children's Health Insurance Program as well as outlays to subsidize health insurance purchased through the marketplaces established under the Affordable Care Act and related spending.

Source: CBO Budget and Economic Outlook 2018 - 2028

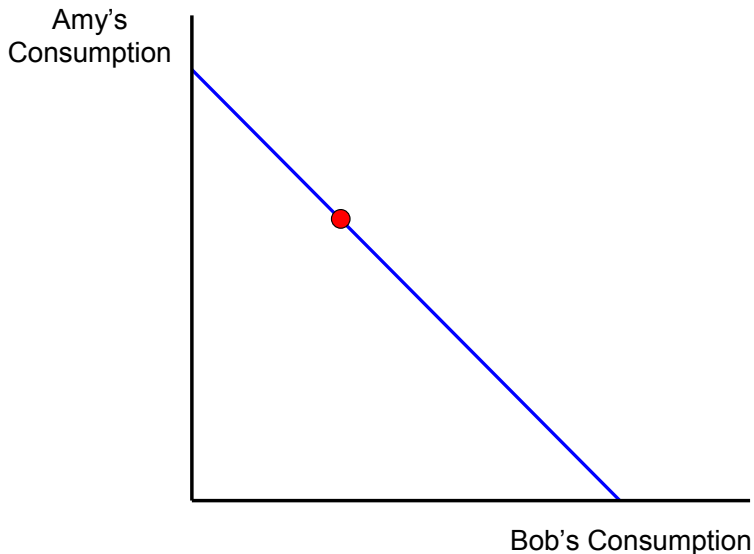
# Government Intervention



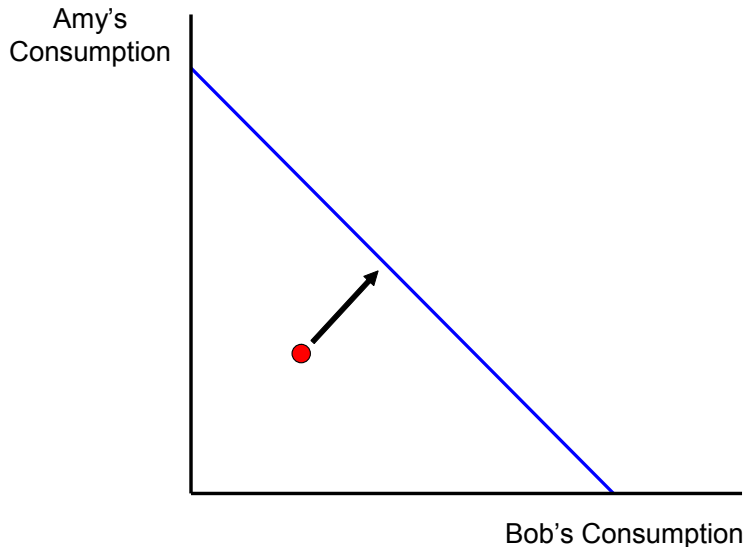
# Government Intervention in the Economy

- Organizing framework: “When is government intervention necessary in a market economy?”
  - Market first, government second approach
  - Why? Private market outcome is efficient under a broad set of conditions (1st welfare theorem)
- This section can be split into two parts
  - How can govt. improve efficiency when private market is inefficient?
  - What can govt. do if private market outcome is undesirable due to distributional concerns?

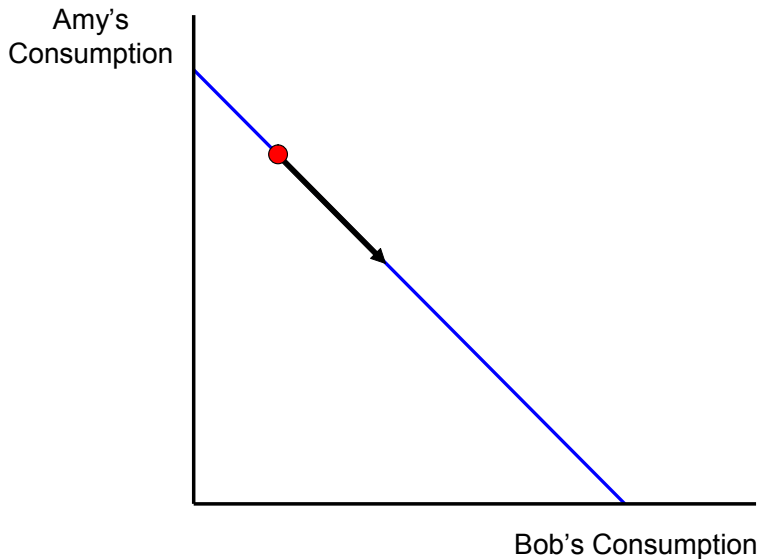
# Efficient Private Market Allocation of Goods



# First Role for Government: Improve Efficiency



## Second Role for Government: Improve Distribution



# First Welfare Theorem

Private market provides Pareto efficient outcome under three conditions

- 1 No externalities
- 2 Perfect information
- 3 Perfect competition

This theorem tells us when government should intervene

# Failure 1: Externalities

- Markets may be incomplete due to lack of prices (e.g. pollution)
  - Achieving an efficient solution requires an organization to coordinate individuals – that is, a government
- This is why govt. funds public goods (highways, education, defense)
- Questions: What public goods to provide and how to correct externalities?

# Failure 2: Asymmetric Information and Incomplete Markets

When some agents have more information than others, markets fail

- ① Adverse selection in health insurance
  - Healthy people drop out of private market → unraveling
  - Mandated coverage could make everyone better off
- ② Capital markets (credit constraints) and subsidies for education
- ③ Markets for intergenerational goods
  - Future generation's interests may not be fully reflected in market outcomes

## Failure 3: Imperfect Competition

- When markets are not competitive, there is role for govt. regulation
  - Ex: natural monopolies such as electricity and telephones
- We will discuss monopolies later in the course (in the innovation policy discussion)



# Individual Failures

- If agents do not optimize, government intervention (e.g. by forcing saving via social security) may be desirable
  - This is an “individual” failure rather than a market failure
- Conceptual challenge: how to avoid paternalism
  - Why does government know what is desirable for you (e.g. wearing a seatbelt, not smoking, saving more)
- Difficult but central issues for optimal policy design

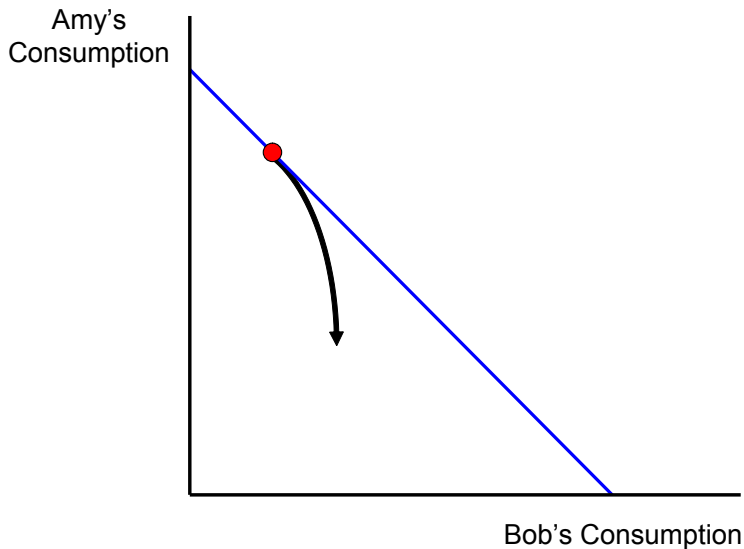
# Redistribution Concerns

- Even when the private market outcome is efficient, may not have good distributional properties
- Efficient markets generally seem to deliver very large rewards to a small set of people (top incomes)
- Government can redistribute income through tax and transfer system

# Why Limit Government Intervention?

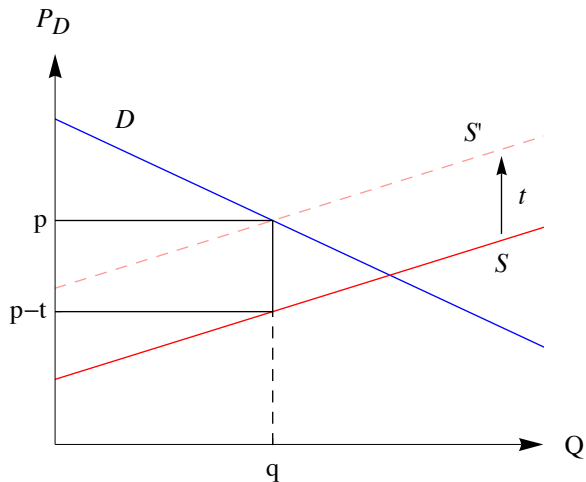
- One solution to these issues would be for the government to oversee all production and allocation in the economy (socialism).
- Serious problems with this solution
  - 1 Information: how does government aggregate preferences and technology to choose optimal production and allocation?
  - 2 Government policies distort incentives (behavioral responses in private sector)
- In practice, there are sharp tradeoffs between the costs and benefits of government intervention

# Equity-Efficiency Tradeoff

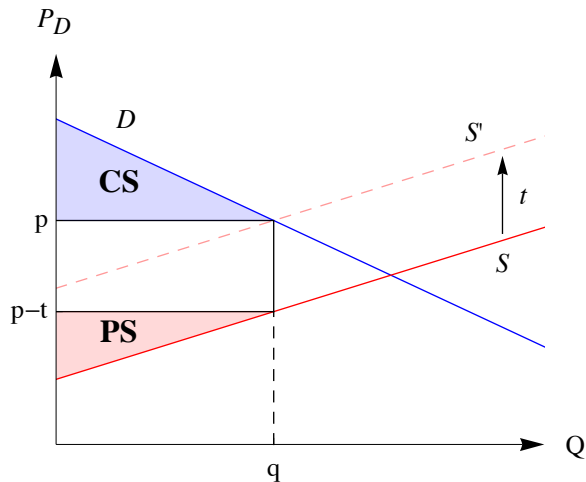


# Efficiency and equity consequences of taxation

# Efficiency and equity consequences of taxation

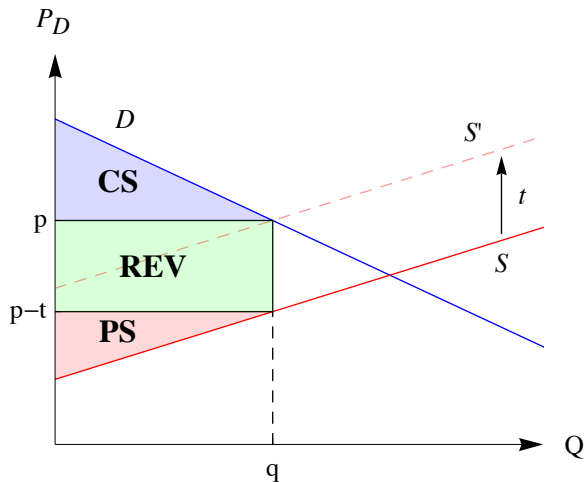


Market Equilibrium with Taxes



- Consumer Surplus
- Producer Surplus

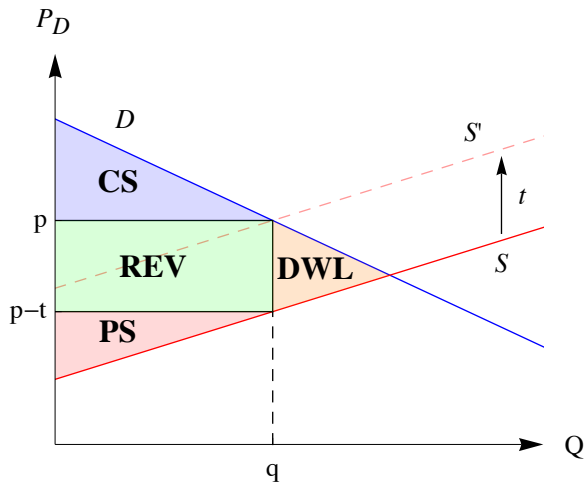
Market Equilibrium with Taxes



Market Equilibrium with Taxes

- Consumer Surplus
- Producer Surplus
- Government Revenue





Market Equilibrium with Taxes

- Consumer Surplus
- Producer Surplus
- Government Revenue
- Deadweight Loss

## Definition

- Efficiency costs: effect of policies on **size** of the pie
- Focus in efficiency analysis is on quantities, not prices
- Incidence: effect of policies on **distribution** of economic pie

To evaluate the efficiency and equity consequences of taxes, having a simple quantitative analytical framework is useful

# Quantitative Economic Framework (and Inequality Example)

# Recall the two ways the quantity demanded can change

1. Moves *along* demand curve vs. 2. Shifts *of* demand curve

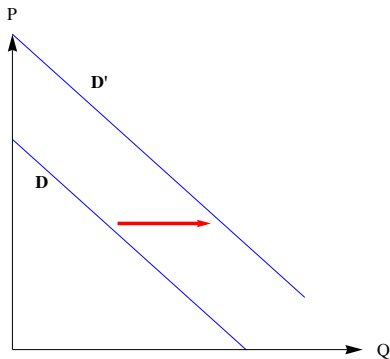
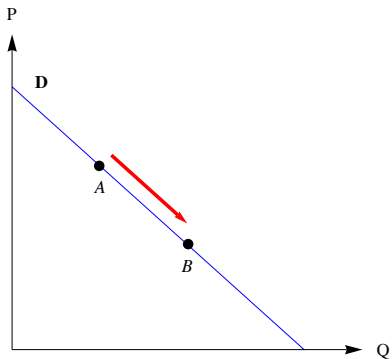
“Demand goes up” can mean one of two things.

Move along a demand curve:

Price falls, so quantity goes up

Shift of a demand curve:

Any  $P$  gives a higher  $Q$



# Two ways the quantity demanded can change (Math)

The quantity demanded can change in two ways:

$$\% \Delta Q^D = \underbrace{\% \Delta D}_{\text{Shift}} + \underbrace{\varepsilon^D \% \Delta P}_{\text{Movement Along}}$$

- $\% \Delta Q^D$  is the percentage change in the quantity demanded
- $\% \Delta D$  is the shift in demand in percentage terms
- $\% \Delta P$  is the percentage change in price
- $\varepsilon^D$  is the elasticity of demand

Note that the shift and movement along are in terms of percent changes in **quantities**

## Two ways the quantity supplied can change (Math)

Similarly, the quantity supplied can change in two ways:

$$\% \Delta Q^S = \underbrace{\% \Delta S}_{\text{Shift}} + \underbrace{\epsilon^S \% \Delta P}_{\text{Movement Along}}$$

- $\% \Delta Q^S$  is the percentage change in the quantity supplied
- $\% \Delta S$  is the shift in supply in percentage terms
- $\% \Delta P$  is the percentage change in price
- $\epsilon^S$  is the elasticity of supply

Note that the shift and movement along are in terms of percent changes in **quantities**

What do we know?

$$\textcircled{1} \quad \% \Delta Q^D = \% \Delta D + \varepsilon^D \% \Delta P$$

$$\textcircled{2} \quad \% \Delta Q^S = \% \Delta S + \varepsilon^S \% \Delta P$$

In equilibrium, the change in quantity demanded and supplied have to be the same:

$$\begin{aligned} \% \Delta Q^D &= \% \Delta Q^S \\ \% \Delta D + \varepsilon^D \% \Delta P &= \% \Delta S + \varepsilon^S \% \Delta P \end{aligned}$$

# Implications for Prices and Quantities

The magnitude of price changes reflect four forces:

$$\% \Delta P = \frac{\% \Delta D - \% \Delta S}{\epsilon^S - \epsilon^D}$$

We can use this price change to determine the quantity change:

$$\% \Delta Q = \% \Delta S + \epsilon^S \left( \frac{\% \Delta D - \% \Delta S}{\epsilon^S - \epsilon^D} \right)$$

$$\% \Delta Q = \frac{-\epsilon^D \% \Delta S + \epsilon^S \% \Delta D}{\epsilon^S - \epsilon^D}$$

**Bottom line:** the quantity change is a an elasticity-weighted average of shifts in supply and demand

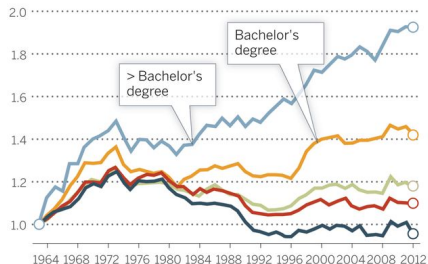


# Application: Rise in Wage Inequality (from D. Autor)

## Changes in real wage levels of full-time U.S. workers by sex and education, 1963–2012

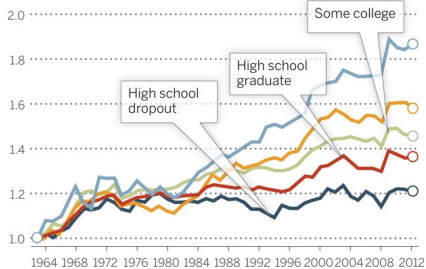
Real weekly earnings relative to 1963 (men)

**A**



Real weekly earnings relative to 1963 (women)

**B**

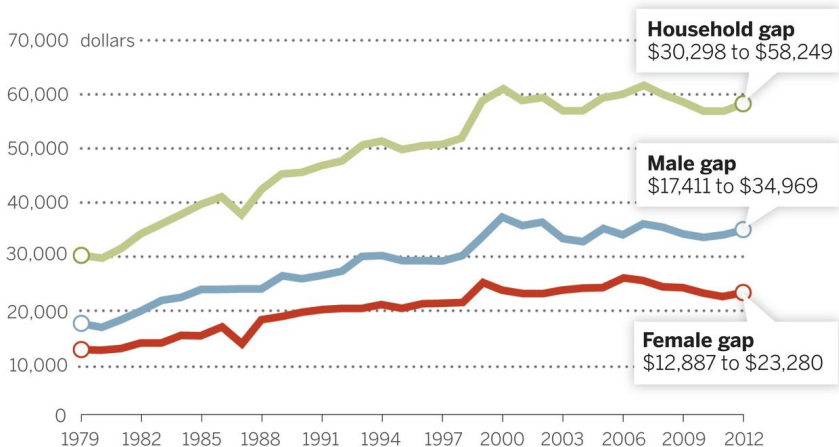


From David Autor. *Science* 23 May 2014: Vol. 344 no. 6186 pp. 843-851

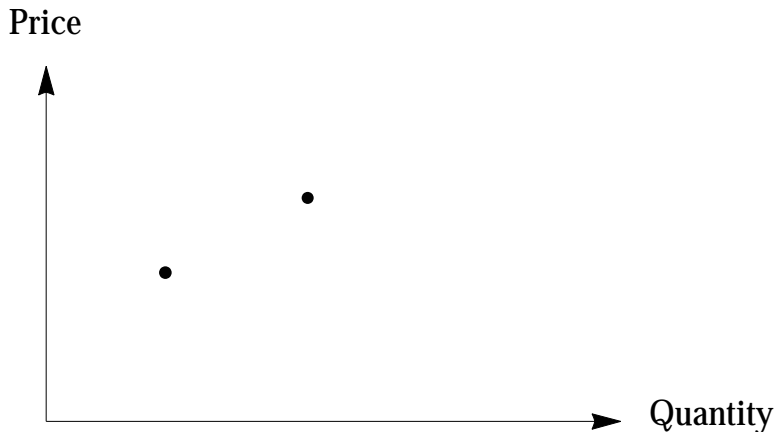
# College vs. High-school Gap in Median Earnings (D. Autor)

## College/high school median annual earnings gap, 1979–2012

In constant 2012 dollars



# What do we actually observe (Katz-Murphy Example)



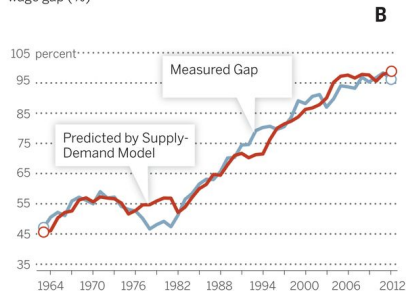
# Supply has increased, but outpaced by demand

There's a “race between education and technology” (Goldin and Katz)

## The supply of college graduates and the U.S. college/high school premium, 1963–2012

College share of hours worked (%), 1963–2012:  
All working-age adults

College versus high school  
wage gap (%)



## Using Framework: $\% \Delta D > \% \Delta S$

To fix ideas, suppose the extreme case of  $\Delta S = 0$ . Then we have:

$$\% \Delta P = \frac{\% \Delta D}{\varepsilon^S - \varepsilon^D}$$

$$\% \Delta Q = \frac{\varepsilon^S \% \Delta D}{\varepsilon^S - \varepsilon^D}$$

### Takeaways:

- 1 When demand increases, price and quantity increase (if supply is upward sloping)
- 2 If supply is not very elastic, then price responses will be large
- 3 Rise in wage inequality partially reflects higher demand for skill<sup>1</sup>

# Equity Consequences of Taxation

## Definition

Tax incidence is the study of the effects of tax policies on prices and the distribution of utilities

- Ideally, we would characterize the effect of a tax change on utility levels of all agents in the economy
- Useful simplification in practice: aggregate economic agents into a few groups
- Incidence analyzed at a number of levels:
  - ① Producer vs. consumer (tax on cigarettes)
  - ② Source of income (labor vs. capital)
  - ③ Income level (rich vs. poor)
  - ④ Region or country (local property taxes)
  - ⑤ Across generations (social security reform)



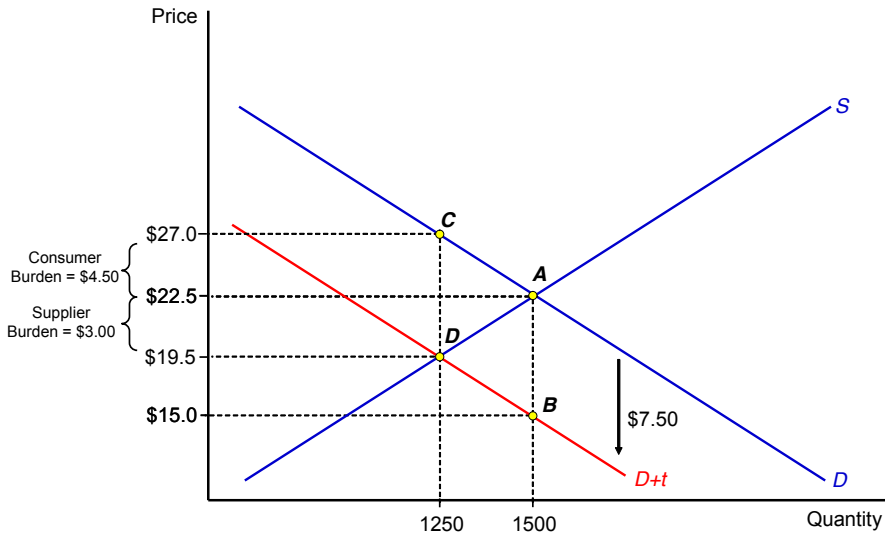
# Key Lessons about Tax Incidence

- ① Economic tax incidence separate from “legal incidence”

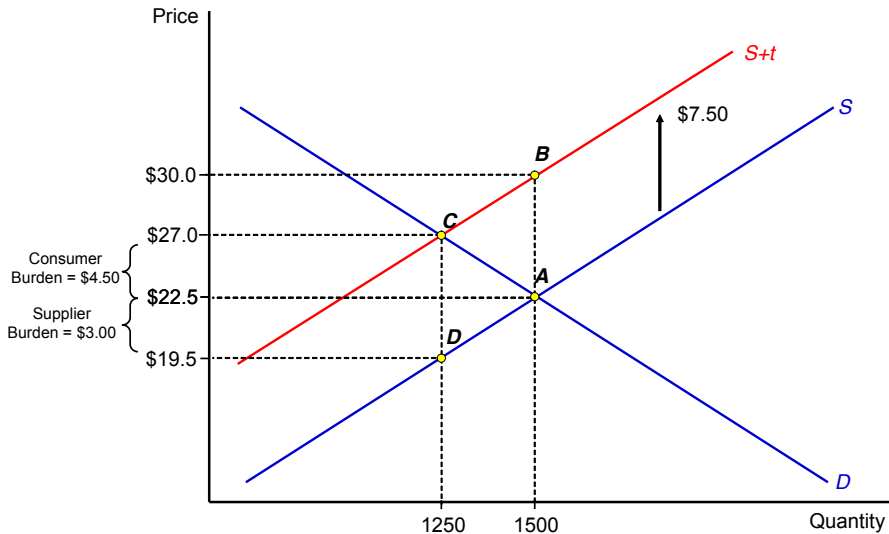
# Key Lessons about Tax Incidence

- ① Economic tax incidence separate from “legal incidence”
- ② Taxing consumers and producers results in same economic impact<sup>2</sup>

## Tax Levied on Consumers



### Tax Levied on Producers



# Analytical Framework

We know a three things:<sup>3</sup>

$$\% \Delta P_D = \% \Delta P_S + \tau$$

$$\% \Delta Q^D = \varepsilon^D \% \Delta P_D$$

$$\% \Delta Q^S = \varepsilon^S \% \Delta P_S$$

We also have market clearing:

$$\% \Delta Q^D = \% \Delta Q^S$$

$$\varepsilon^D \% \Delta P_D = \varepsilon^S (\% \Delta P_D - \tau)$$

# Analytical Framework: Implications

$$\% \Delta P_D = \tau \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D}$$

$$\% \Delta P_S = \tau \frac{\varepsilon^D}{\varepsilon^S - \varepsilon^D}$$

$$\% \Delta Q = \tau \frac{1}{\frac{1}{\varepsilon^D} - \frac{1}{\varepsilon^S}}$$

## 3 Key Lessons about Tax Incidence

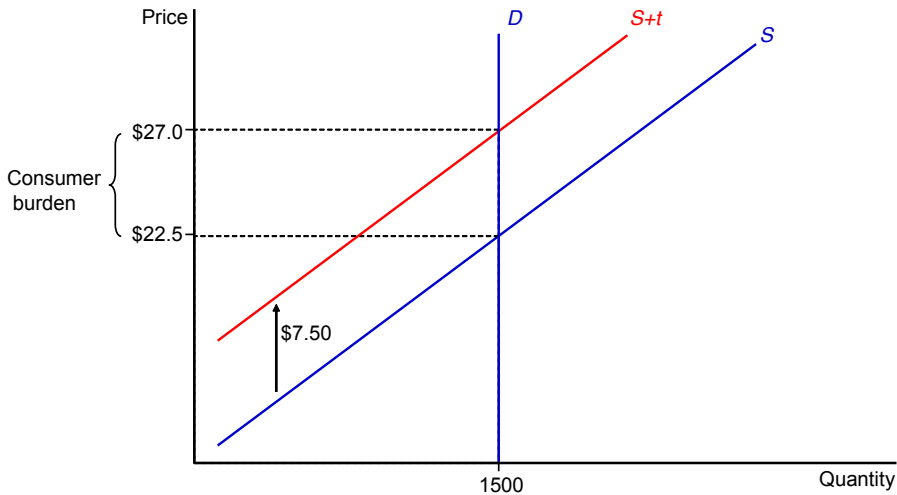
- 1 Economic tax incidence separate from “legal incidence”
- 2 Taxing consumers and producers results in same economic impact<sup>4</sup>
- 3 Incidence depends on *relative elasticities*
  - The more elastic agent is more able to avoid burden of the tax

$$\% \Delta P_D = \tau \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D}$$

$$\% \Delta P_S = \tau \frac{\varepsilon^D}{\varepsilon^S - \varepsilon^D}$$

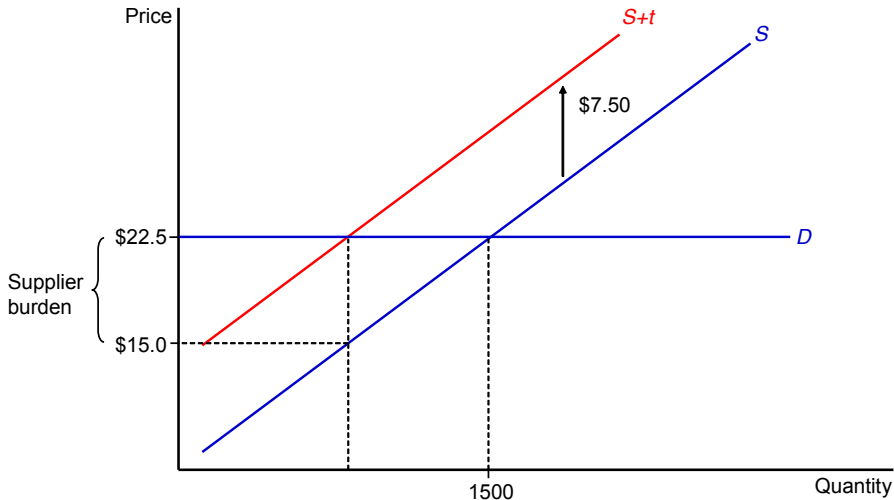
- The ratio  $\frac{\% \Delta P_D}{\% \Delta P_S} = \frac{\varepsilon^S}{\varepsilon^D}$  is the inverse of the elasticities
- If the demand elasticity is twice as large as the supply elasticity, then sellers pay two-thirds of the tax and buyers pay only one-third

## Perfectly Inelastic Demand





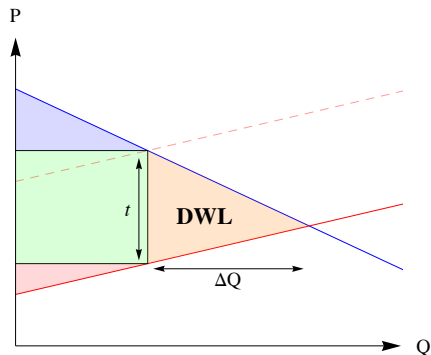
## Perfectly Elastic Demand



# Efficiency Consequences of Taxation

# Deadweight Loss

Marginal cost of taxation increasing in the tax rate

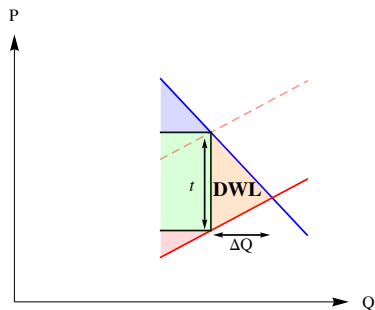
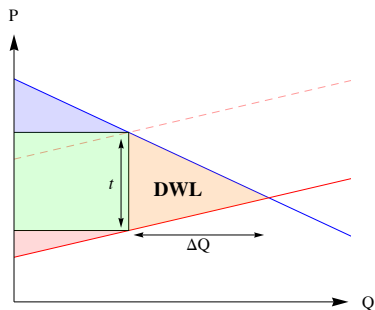


- Deadweight loss is approximately *quadratic* in the tax amount
  - $DWL = \frac{1}{2}t \cdot \Delta Q$
  - $\Delta Q$  proportional to  $t$  (for linear supply & demand)
  - So DWL goes as  $t^2$

# Deadweight Loss

More elastic supply & demand  $\Rightarrow$  More DWL

Two markets with same  $P$  &  $Q$ , but different supply and demand curves:



- For a given tax  $t$ , DWL is bigger if supply & demand are more elastic
  - $DWL = \frac{1}{2}t \cdot \Delta Q$
  - More elastic supply and demand mean larger  $\Delta Q$  for a given  $t$
  - Intuition: DWL is caused by loss of transactions  
More elastic S&D means more transactions destroyed

# Quantitatively, DWL is a triangle (starting from tax=0)

- Base of the triangle (measured vertically) is the change in prices:  $\tau P$
- The height of the triangle (measured horizontally) is the change in quantities:  $Q\% \Delta Q$

Social Cost is:

$$\begin{aligned} &= \frac{1}{2} \tau P Q (\% \Delta Q) \\ &= \frac{1}{2} \underbrace{\tau P Q}_{\text{Tax Revenue}} \left( \tau \frac{1}{\frac{1}{\epsilon^D} - \frac{1}{\epsilon^S}} \right) \\ &= \frac{1}{2} \tau^2 P Q \left( \frac{1}{\frac{1}{\epsilon^D} - \frac{1}{\epsilon^S}} \right) \end{aligned}$$

Social Cost from increasing taxes is:  $\frac{d(\text{Social Cost})}{d\tau} = \tau TR \left( \frac{1}{\frac{1}{\epsilon^D} - \frac{1}{\epsilon^S}} \right)$ .

Tax	Elasticity of Demand	Elasticity of Supply	Change in Buyer's Price	Change in Seller's price	Change in Output	Social Cost (% of TR)
10%	0.0	0.5	10.0%	0.0%	0.0%	0.0%
10%	0.0	1.0	10.0%	0.0%	0.0%	0.0%
10%	0.0	2.0	10.0%	0.0%	0.0%	0.0%
10%	-0.5	0.0	0.0%	-10.0%	0.0%	0.0%
10%	-1.0	0.0	0.0%	-10.0%	0.0%	0.0%
10%	-2.0	0.0	0.0%	-10.0%	0.0%	0.0%
10%	-0.5	0.5	5.0%	-5.0%	-2.5%	-0.1%
10%	-0.5	1.0	6.7%	-3.3%	-3.3%	-0.2%
10%	-0.5	2.0	8.0%	-2.0%	-4.0%	-0.2%
10%	-1.0	0.5	3.3%	-6.7%	-3.3%	-0.2%
10%	-1.0	1.0	5.0%	-5.0%	-5.0%	-0.3%
10%	-1.0	2.0	6.7%	-3.3%	-6.7%	-0.3%
10%	-2.0	0.5	2.0%	-8.0%	-4.0%	-0.2%
10%	-2.0	1.0	3.3%	-6.7%	-6.7%	-0.3%
10%	-2.0	2.0	5.0%	-5.0%	-10.0%	-0.5%
20%	-1.0	1.0	10.0%	-10.0%	-10.0%	-1.0%
30%	-1.0	1.0	15.0%	-15.0%	-15.0%	-2.3%
40%	-1.0	1.0	20.0%	-20.0%	-20.0%	-4.0%
50%	-1.0	1.0	25.0%	-25.0%	-25.0%	-6.3%

With many goods, most efficient way to raise revenue is:

- ① Tax inelastic goods more (e.g. medical drugs, food)
- ② Spread taxes across all goods to keep rates relatively low on all goods (broad tax base)

These are two countervailing forces; balancing them requires quantitative measure meant of deadweight loss

# Recent Economic Developments



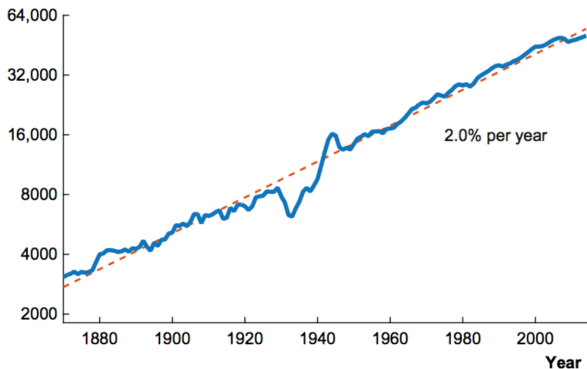
## Outline:

- ① Growth, Technological Change, and Inequality
- ② Who benefits from *TFP* growth?
- ③ Geography: the location and scale of US economic activity (wait until place-based policy class)

# Growth, Technological Change, and Inequality

# Per capita growth in $\frac{Y}{L}$

Log scale, chained 2009 dollars



NOTES: This figure shows log GDP per capita in the US from 1870 to 2014. The blue full line plots GDP per capita, in 2009 log-dollars. The red dashed line plots the average growth rate of GDP in the time period.

SOURCE: Jones (2016).

# Q: Where does economic progress come from?

What forces that lead to growth in  $\frac{Y}{L}$ ?

- 1  $A$ : new technology and improvements in technology (new knowledge)
  - E.g., electricity, transportation/cars, computer revolution/internet, etc
  - Also growth in markets/more integrated markets that create new opportunities
- 2  $K$ : new physical capital
  - E.g., new power plants, infrastructure, etc.
- 3  $H$ : investments in human capital

These three sources work together. Need  $H$  and  $K$  to produce and implement new technologies (e.g., robots replacing workers)

- Need technology  $A$  to develop robots
- Need to invest  $K$  to improve plant
- Need  $H$  to design, build, and maintain the robots

$$Y_t = \underbrace{A_t M_t}_{TFP} K_t^\alpha H_t^{1-\alpha}$$

where

- $Y_t$ : final output in year  $t$
- $A_t$ : economy's stock of knowledge
- $M_t$ : residual component of TFP
- $K_t$ : stock of physical capital
- $H_t$ : human capital stock
- $0 < \alpha < 1$  is factor elasticity of capital

# Rewriting Production Fct with Labor-Augmenting TFP

$$\frac{Y_t}{L_t} = \underbrace{\left( \frac{K_t}{Y_t} \right)^{\frac{\alpha}{1-\alpha}}}_{\text{Capital deepening}} \frac{H_t}{L_t} Z_t$$

where

- $L_t$ : total hours worked
- $Y_t/L_t$ : output per hour
- $Z_t: (A_t M_t)^{\frac{1}{1-\alpha}}$
- $H_t/L_t$ : aggregate human capital per hour worked (also measure labor composition)
  - If one type of labor:  $H_t = h_t L_t$ , where  $h_t$  is human capital per worker
  - If multiple types of labor that are perfect substitutes in terms of efficiency units:  $H_t/L_t$  captures composition effects

# Growth Accounting for the US

Period	Output per hour	Contributions from		
		<i>K/Y</i>	Labor composition	Labor-Aug. TFP
<b>1948–2013</b>	<b>2.5</b>	<b>0.1</b>	<b>0.3</b>	<b>2.0</b>
1948–1973	3.3	−0.2	0.3	3.2
1973–1990	1.6	0.5	0.3	0.8
1990–1995	1.6	0.2	0.7	0.7
1995–2000	3.0	0.3	0.3	2.3
2000–2007	2.7	0.2	0.3	2.2
2007–2013	1.7	0.1	0.5	1.1

*Note:* Average annual growth rates (in percent) for output per hour and its components for the private business sector, following Eq. (3).

*Source:* Authors calculations using Bureau of Labor Statistics, *Multifactor Productivity Trends*, August 21, 2014.

SOURCE: Jones (2016).

# Growth and inequality are closely linked

Technology and  $K$  tend to be complementary with skill

Q: What forces govern wage inequality?

- 1  $+A$ : new technology and improvements in technology (new knowledge)
- 2  $+K$ : new physical capital
- 3  $-H$ : supply of human capital

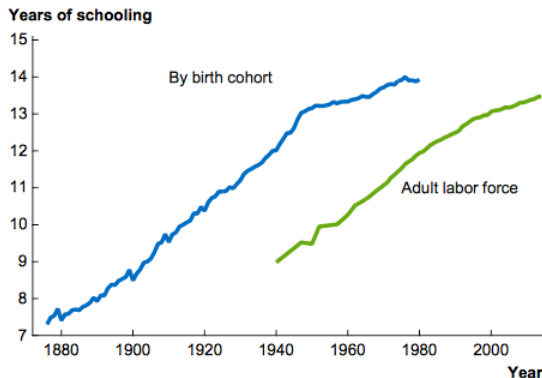
**Key point for understanding both growth and inequality:**

- Forces driving economic growth also cause wage inequality
- One that works in opposite direction is the supply of human capital  $H$



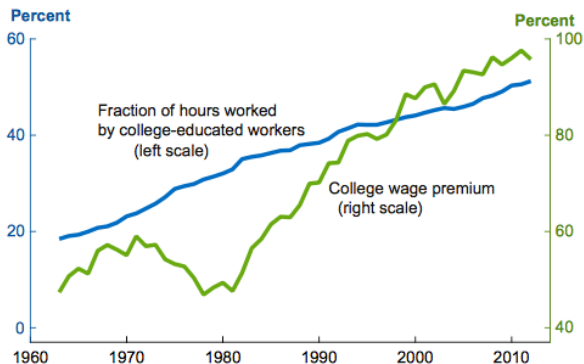
# What happens when supply of $H$ falls short?

THE FACTS OF ECONOMIC GROWTH



**Fig. 7** Educational attainment, United States. Source: The blue (dark gray in the print version) line shows educational attainment by birth cohort from Goldin, C., Katz, L.F. 2007. Long-run changes in the wage structure: narrowing, widening, polarizing. *Brook. Pap. Econ. Act.* 2, 135–165. The green (gray in the print version) line shows average educational attainment for the labor force aged 25 and over from the Current Population Survey.

# What happens when supply falls short? $\% \Delta P = \frac{\% \Delta D - \% \Delta S}{\epsilon^S - \epsilon^D}$



**Fig. 8** The supply of college graduates and the college wage premium, 1963–2012. *Note:* The supply of US college graduates, measured by their share of total hours worked, has risen from below 20% to more than 50% by 2012. The US college wage premium is calculated as the average excess amount earned by college graduates relative to nongraduates, controlling for experience and gender composition within each educational group. Source: Autor, D.H. 2014. *Skills, education, and the rise of earnings inequality among the “other 99 percent”*. *Science* 344 (6186), 843–851, fig. 3.

# Who benefits from *TFP* growth?

## Definition

**Productivity** is the amount of output that can be produced from a given set of inputs

## Definition

**Technological change** refers to changes in the production process that increase (or decrease) the amount of output that can be produced from a given quantity of inputs and/or alter the optimal mix of inputs used to produce a given level of output

# Average Labor Productivity

- Labor productivity is output  $Y$  per worker-hour  $L$
- The **average product of labor**  $APL = \frac{Y}{L}$

$$\% \Delta APL = \% \Delta Y - \% \Delta L$$

- For instance, if output is growing at 4% per year while labor input is growing at only 3% per year, then labor productivity must be growing at 1% = 4% - 3% per year

# Marginal Labor Productivity

- We can also examine productivity growth for a competitive industry using the VMP theory of demand
- Recall  $W = P \times MPL$ , which gives us:

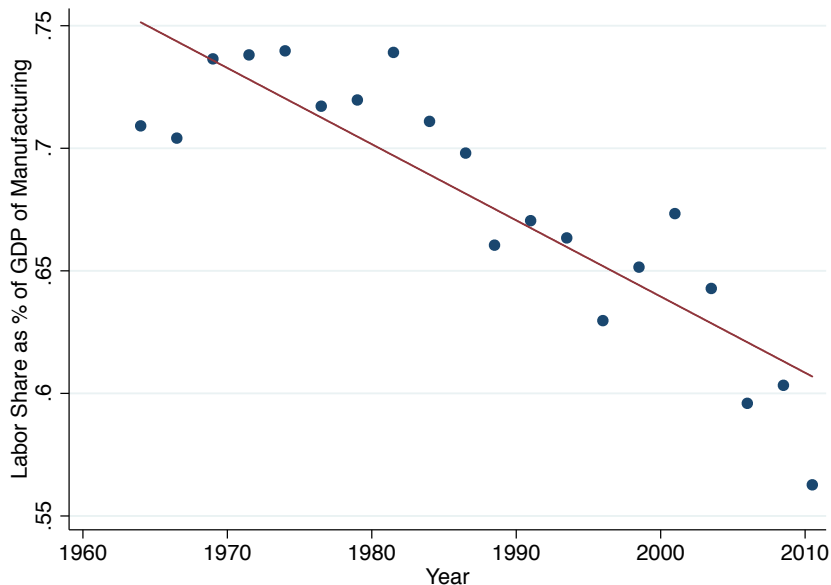
$$\% \Delta MPL = \% \Delta w - \% \Delta P$$

- Since  $\% \Delta w - \% \Delta P$  is growth in the real wage rate (where real is defined relative to the price of output), this equation tells us that we can measure growth in **marginal productivity** by growth in the real wage
- For instance, if the price of output for a competitive industry is growing at 5% per year while the wage rate is growing at 6% per year, then the marginal productivity must be growing at 1% per year

# Relating Average and Marginal Labor Productivity

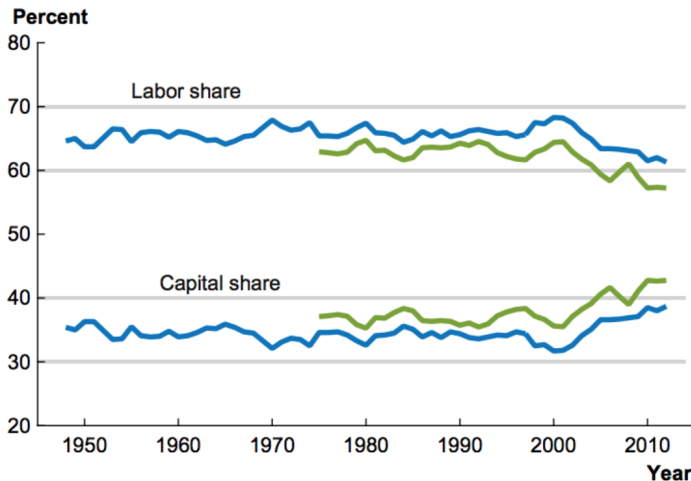
- The average product of labor is  $\frac{Y}{L}$
- The marginal product of labor is  $\frac{w}{p}$
- The ratio is  $\frac{Y/L}{w/p} = \frac{PY}{WL} = \frac{1}{s_L}$  where  $s_L$  is the share of income that goes to labor, i.e., **labor's share**

# Declining Labor Share in US Manufacturing





Historically, labor's share had been pretty stable at  $\approx 66\%$



SOURCE: The series starting in 1975 are from Karabarbounis and Neiman (2014) and measure the factor shares for the corporate sector, which the authors argue is helpful in eliminating issues related to self-employment. The series starting in 1948 is from the Bureau of Labor Statistics Multifactor Productivity Trends for the private business sector. The factor shares add to 100%.

# Changes in the Labor Share

- The ratio expression, i.e.  $\frac{w/p}{Y/L} = s_L$ , implies:

$$\% \Delta MPL - \% \Delta APL = \% \Delta s_L$$

- Hence, labor's share falls when average productivity grows faster than marginal productivity
- Growth in  $\frac{Y}{L}$  reflects growth in other inputs besides labor

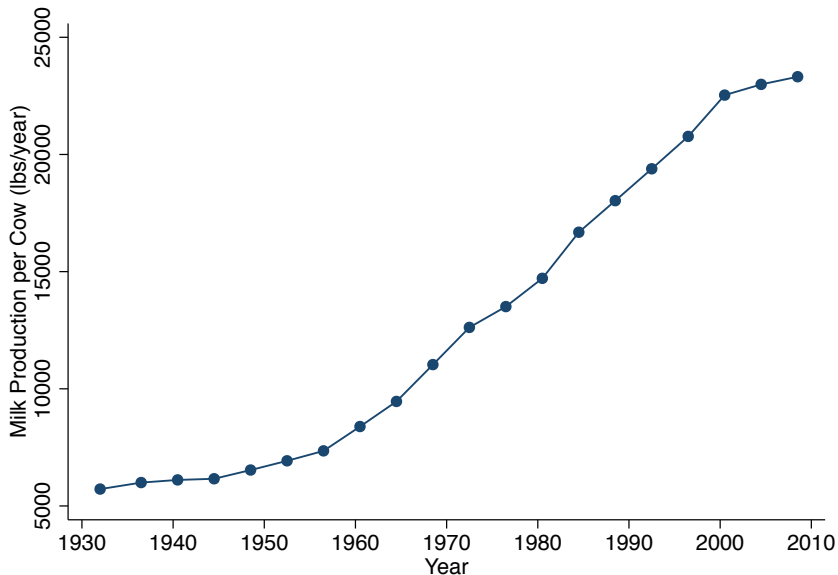
# Total Factor Productivity

- **Total Factor Productivity (TFP)** takes account of the growth in all inputs. TFP growth measures how much output actually goes up relative to how much we expect it to go up based on changes in inputs
- With two inputs, labor and capital, TFP growth is:

$$\% \Delta TFP = \% \Delta Y - (s_L \% \Delta L + s_K \% \Delta K)$$

- where  $(s_L \% \Delta L + s_K \% \Delta K)$  is referred to as the growth in total inputs since it combines the growth in labor and capital to get a measure of the inputs overall (note that the weights are the cost shares of the two inputs)

# Striking Productivity Growth: Milk Production per Cow



Source: [http://nass.usda.gov/Statistics\\_by\\_State/Washington/Historic\\_Data/dairy/milkper.pdf](http://nass.usda.gov/Statistics_by_State/Washington/Historic_Data/dairy/milkper.pdf)

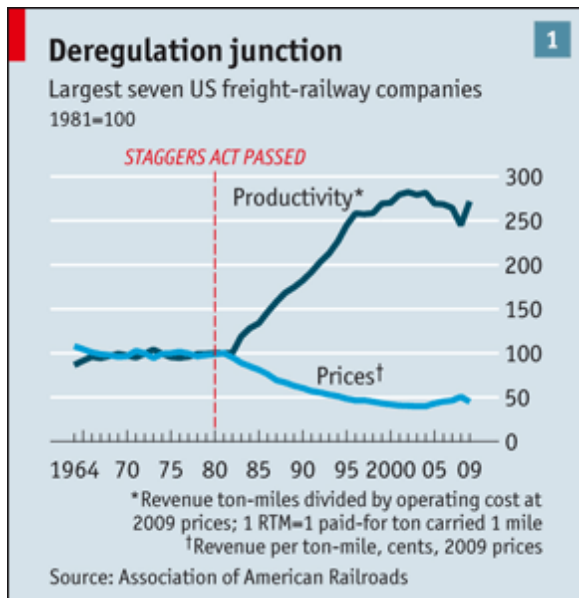
# Total Factor Productivity based on Prices

- We can also measure TFP growth using prices

$$\% \Delta TFP = \underbrace{(s_L \% \Delta w + s_K \% \Delta r)}_{\text{Predicted cost}} - \underbrace{\% \Delta P}_{\text{Actual "cost"}}$$

- Note that this approach is analogous to how we measured labor productivity using the real wage

# Productivity Growth after deregulation of rail industry



# Average Labor Productivity

- We can use what we have done so far to revisit why  $\frac{Y}{L}$  is growing

$$\% \Delta Y = \% \Delta TFP + s_L \% \Delta L + s_K \% \Delta K$$

$$\% \Delta Y - \% \Delta L = \% \Delta TFP + s_L \% \Delta L + s_K \% \Delta K - \% \Delta L$$

$$\% \Delta Y - \% \Delta L = \% \Delta TFP + s_K (\% \Delta K - \% \Delta L)$$

$$\% \Delta Y / L = \% \Delta TFP + s_K (\% \Delta K / L)$$

- Note we used  $s_L = 1 - s_K$  in the third line

**Takeaway:**  $\frac{Y}{L}$  increases with TFP growth and capital deepening (i.e., growth in the capital to labor ratio)

# Who benefits from unbiased $TFP$ growth?

- ① **Production:**  $Y = AF(K, L)$

$$dY = F(K, L)dA + AF_K dK + AF_L dL \quad (1)$$

$$\% \Delta Y = \% \Delta A + s_K \% \Delta K + s_L \% \Delta L \quad (2)$$

where  $A$  is total factor productivity,  $\% \Delta X$  denotes a percentage change in  $X$ ,  $s_K \equiv \frac{F_K K}{Y}$ , and  $s_L \equiv \frac{F_L L}{Y}$ .

- ② **Income:**  $PY = RK + WL$

$$\% \Delta P + \% \Delta Y = s_K (\% \Delta R + \% \Delta K) + s_L (\% \Delta W + \% \Delta L) \quad (3)$$

- ③ **Incidence:**

Rearranging equation (3) and substituting the expression for  $\% \Delta Y$  from equation (2) yields:

$$\% \Delta A = s_K \underbrace{(\% \Delta R - \% \Delta P)}_{=0 \text{ if capital adjusts}} + s_L \underbrace{(\% \Delta W - \% \Delta P)}_{\text{Real wages}} \Rightarrow \% \Delta W / P = \frac{\% \Delta A}{s_L} \quad (4)$$



# Who benefits from unbiased $TFP$ growth (adding skill)?

① **Production:**  $Y = AF(K, S, U)$

$$\% \Delta Y = \% \Delta A + s_K \% \Delta K + \underbrace{s_S \% \Delta S + s_U \% \Delta U}_{=s_L \% \Delta L} \quad (5)$$

where  $S$  is high-skilled labor and  $U$  is low skilled labor.

② **Income:**  $PY = RK + \underbrace{W_S S + W_U U}_{=WL}$

$$\% \Delta P + \% \Delta Y = s_K (\% \Delta R + \% \Delta K) + s_S (\% \Delta W_S + \% \Delta S) \quad (6)$$

$$+ s_U (\% \Delta W_U + \% \Delta U) \quad (7)$$

③ **Incidence:**

$$\% \Delta A = s_K \underbrace{(\% \Delta R/P)}_{=0 \text{ if capital adjusts}} + s_S \underbrace{(\% \Delta W_S/P)}_{\text{Skilled real wages}} + s_U \underbrace{(\% \Delta W_U/P)}_{\text{Unskilled real wages}}$$

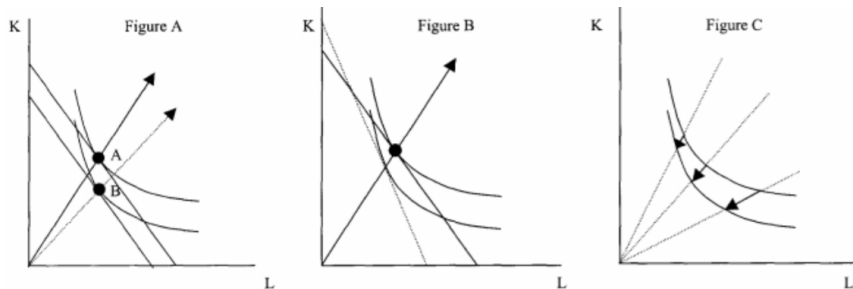
$$\Rightarrow \frac{\% \Delta A}{s_L} = \frac{s_S}{s_L} (\% \Delta W_S/P) + \frac{s_U}{s_L} (\% \Delta W_U/P) \quad (8)$$

# Biased Technological Change

- Technological progress can also change the relative demands for capital and labor (or skilled and unskilled labor)
- We refer to this type of change as biased technological change

# The Impact of Biased Technological Change

These figures illustrate the impact of biased change in favor of labor



# Biased Technological Change

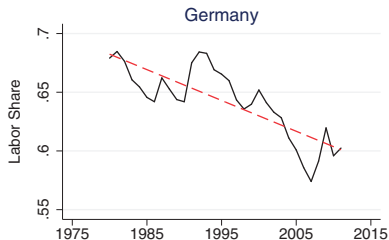
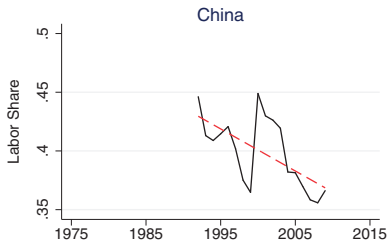
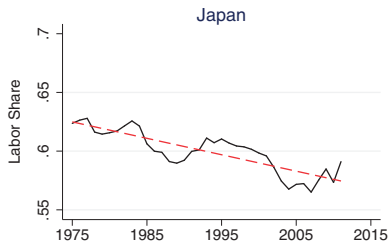
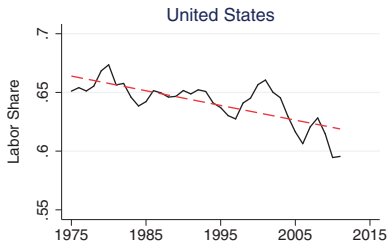
- All three figures show the same shift in the unit isoquant
- Figure A shows that at the same relative price of capital and labor (i.e.,  $w/r$  fixed) the firm would switch to using relatively more labor (i.e.,  $K/L$  would fall)
- Figure B shows that at the same factor ratio (i.e., along the same ray from the origin), the relative price of labor would have to go up (i.e.,  $w/r$  would have to rise)
- Figure C shows that with technological change biased in favor of labor, the rate of technological improvement is greatest at higher  $L/K$  (i.e., lower  $K/L$  ratios)

# Measuring Biased Technological Change

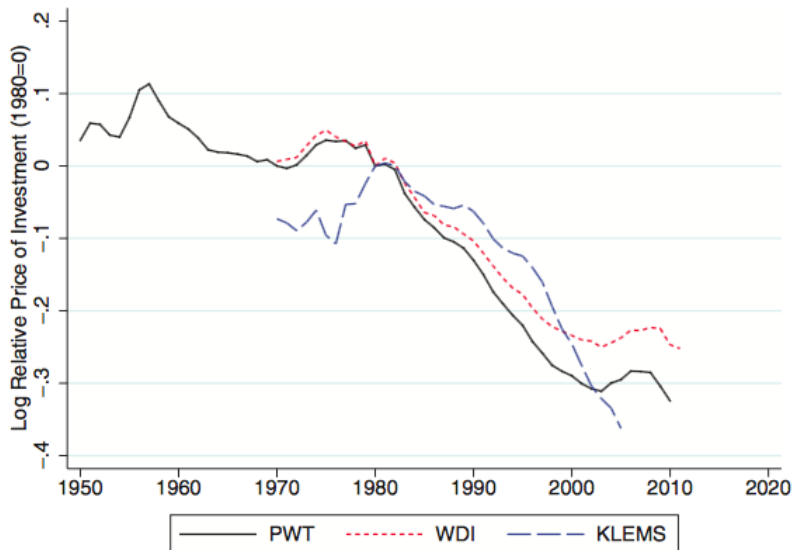
$$\% \Delta L/K - \sigma \% \Delta r/w \equiv \text{Technological bias}$$

- This is the actual change in the labor to capital ratio less the predicted change given the change in prices
- This idea is analogous to shifts in the intercept and then movement along the demand curve from consumer theory
- Need  $\sigma$ , which is the elasticity of substitution between labor and capital, (think the slope of demand) to measure technological bias
- However, we can sign the direction of bias by seeing if  $L/K$  shifts at every price (analogous to a demand shift  $\% \Delta D$ )

# Q: What caused the global decline of the labor share?



# A: A decline in cost of capital



## Q: What caused the global decline of the labor share?

According to an important new paper<sup>5</sup> by Karabarbounis and Neiman

- A: Decline in cost of capital (i.e., lower price of computers, lower corporate income taxes, lower interest rates) induced firms to substitute sufficiently from labor toward capital, causing  $s_L$  to go down



## Q: What caused the global decline of the labor share?

According to an important new paper<sup>5</sup> by Karabarbounis and Neiman

- A: Decline in cost of capital (i.e., lower price of computers, lower corporate income taxes, lower interest rates) induced firms to substitute sufficiently from labor toward capital, causing  $s_L$  to go down
- **Bottom Line:** Implies decline in cost of capital explains **roughly half** of the decline in the labor share

# Policy Discussion: Should we tax robots?



## THREE ENGINEERS, HUNDREDS OF ROBOTS, ONE WAREHOUSE

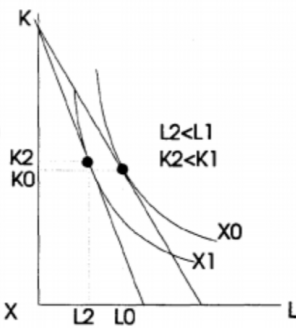
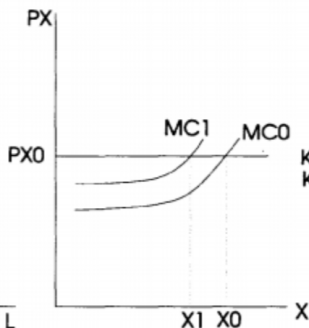
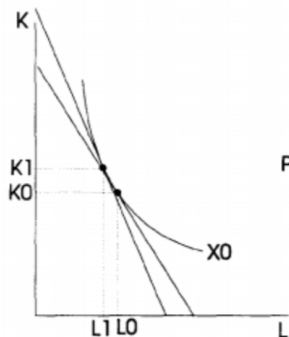
Kiva Systems wants to revolutionize distribution centers by setting swarms of robots loose on the inventory BY ERICO GUIZZO

**NO HANDS:** Machines do the heavy lifting at a Staples Denver facility.

# Robots and the price of capital

- What happens when capital (robots) gets cheaper?
- Will firms hire fewer workers?

# Impact of a change in a factor price



# Impact of a change in a factor price

- An increase in the wage causes the isocost curve to be steeper and leads to a substitution of capital for labor, holding the level of output fixed as shown in the prior figure
- The reduction in labor from  $L_0$  to  $L_1$  is called the **substitution effect** and always leads to less labor employed as the wage increases
- The rise in the wage will change the marginal cost and lead to a change in output which is called the **scale effect**

# Impact of a change in a factor price

- Marginal cost at a level of output  $X$  is simply the change in total cost for an increase in output to  $X + 1$  (approx).

$$MC(X) = L(X + 1)w + K(X + 1)r - (L(X)w + K(X)r)$$

$$MC(X) = w(L(X + 1) - L(X)) + r(K(X + 1) - K(X))$$

- Hence, an increase in the wage will increase  $MC$  as long as  $L(X + 1) > L(X)$ , i.e., as long as labor is a normal factor of production. Same for  $K$ .
- This increase in  $MC$  will reduce output and lead to a further reduction in the use of labor.

# Impact of a change in a factor price on other factor

- The effect on capital is ambiguous because the substitution and scale effects go in opposite directions
- Higher wages cause firms to substitute towards capital at any given level of output (thus increasing capital usage)
- But the higher wage also raises marginal cost of output (assuming labor is a normal factor of production) which will reduce the use of capital (assuming capital is a normal factor)

**So are cheaper robots reducing employment?**



# Impact of a change in a factor price on other factor

- The effect on capital is ambiguous because the substitution and scale effects go in opposite directions
- Higher wages cause firms to substitute towards capital at any given level of output (thus increasing capital usage)
- But the higher wage also raises marginal cost of output (assuming labor is a normal factor of production) which will reduce the use of capital (assuming capital is a normal factor)

## **So are cheaper robots reducing employment?**

Unclear. It depends on magnitude of substitution and scale effects.

A separate channel is through technological change.

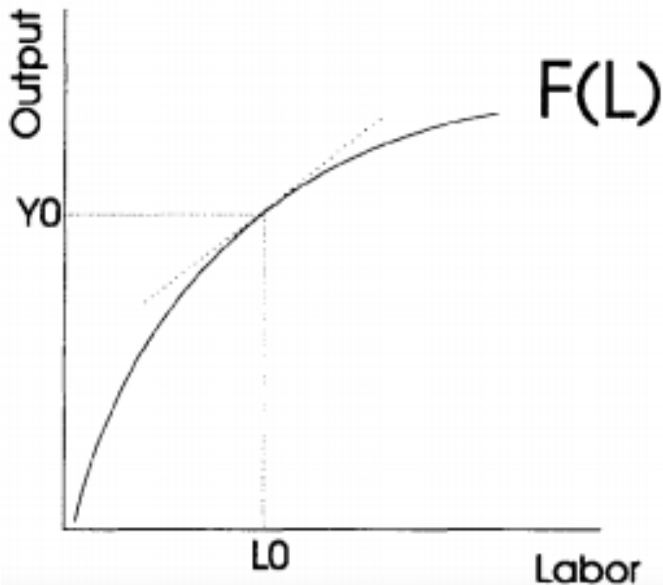
# APPENDIX

Background material:  
Factor demand,  $W = VMPL$ , and cost

# A Production Function

- To understand the nature of derived demand for factors, let's introduce the production function
- Consider a firm that produces good  $Y$  using only labor
- A **production function**  $F(L)$  gives the amount of the good produced as a function of labor employed

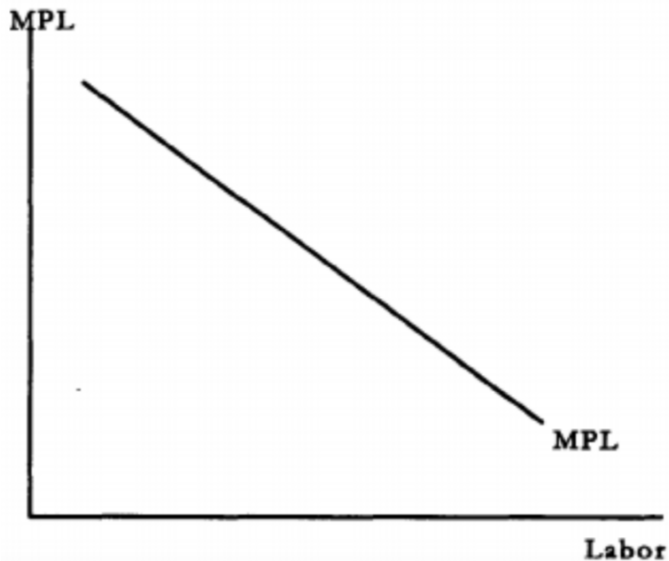
# Production Function: $Y = F(L)$



# Marginal Product of Labor

- The marginal product of labor  $MPL = \frac{\partial F}{\partial L}$  gives the rate of change of output with respect to the quantity of labor
- $MPL$ , i.e. the slope of  $F(L)$ , decreases with the quantity of labor. Since other factors such as capital (i.e., the size of the plant) are being held constant, output increases at a decreasing rate as the quantity of labor is increased
- Note that unlike utility, output is a thing we can actually measure
- For instance, we can reasonably ask how many hours of work does it take to make a TV or a haircut

# Marginal Product of Labor



# Marginal Product of Labor

- Firms will employ labor to the point where the marginal gain to adding additional labor is exactly equal to the cost of an additional unit of labor
- The return to additional labor is the amount of output that labor can produce times the price of output  
 $MPL \times P \equiv$  Value marginal product of labor or  $VMP$
- The cost of labor is the the wage  $w$ .
- Hence the optimal choice of labor by the firm will be where  
 $P \times MPL = w$
- When goods prices  $P$  are high, it pays for the firm to use more labor



# Marginal Product of Labor

- If we denote non-labor costs as  $C$ , then the firm's profits are:

$$\underbrace{P \times F(L)}_{\text{Revenues}} - C - wL$$

FOC:

$$P \times \frac{\partial F}{\partial L} - w = 0$$
$$P \times MPL = w$$

## Example: Marginal Product of Labor

- Suppose  $p = 10$ ,  $F(L) = L^{.5}$ , and non-labor costs are zero
- How many people should we hire if wages are \$1? \$5?

$$\underbrace{10L^{.5}}_{\text{Revenues}} - wL$$

$$P \times \frac{\partial F}{\partial L} - w = 0$$

$$10 \times .5L^{-.5} - w = 0$$

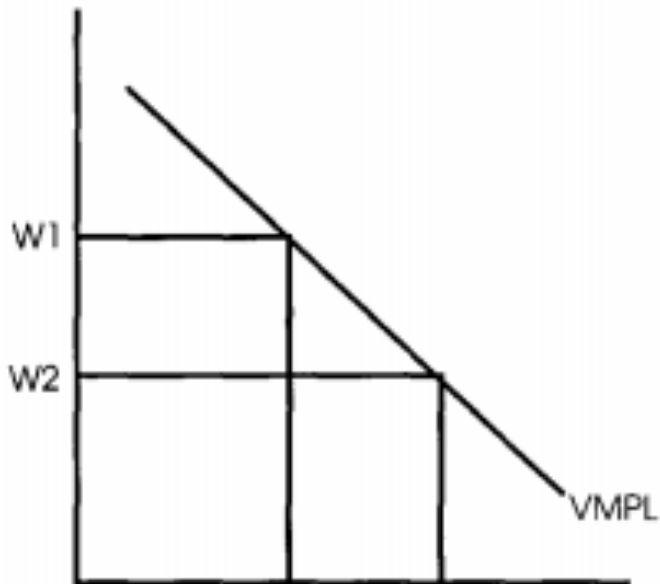
$$L^{-.5} = \frac{w}{5}$$

$$L = \left(\frac{5}{w}\right)^2$$

$$\Rightarrow L(1) = \left(\frac{5}{1}\right)^2 = 25$$

$$\Rightarrow L(5) = \left(\frac{5}{5}\right)^2 = 1$$

# Marginal Product of Labor



# Long-Run Factor demand (two-inputs)

- Firms generally use multiple inputs to produce output (e.g., a manufacturing firm may use labor together with plant and equipment to produce its output).
- Our discussion thus far is “short-run” because the size of the plant and the amount of equipment can be regarded as fixed
- The *VMP* schedule can be thought of as the marginal product of labor holding the level of these other inputs (which we collectively call capital) fixed at the current level
- The level of capital strongly influences the demand for labor as a given worker can produce more with capital
- In the long-run, firms decide on the optimal level of labor and capital jointly

# Long-Run Factor demand (two-inputs)

Firms make their choice of capital and labor in two stages:

- 1 The firm decides the mix of labor and capital that can produce a given level output at the least cost
- 2 The firm makes calculates this cost for different amounts of output and then determines the optimal level of output by producing where price equals the marginal cost of production

The optimal levels of labor and capital are then the cost-minimizing levels for this chosen level of output

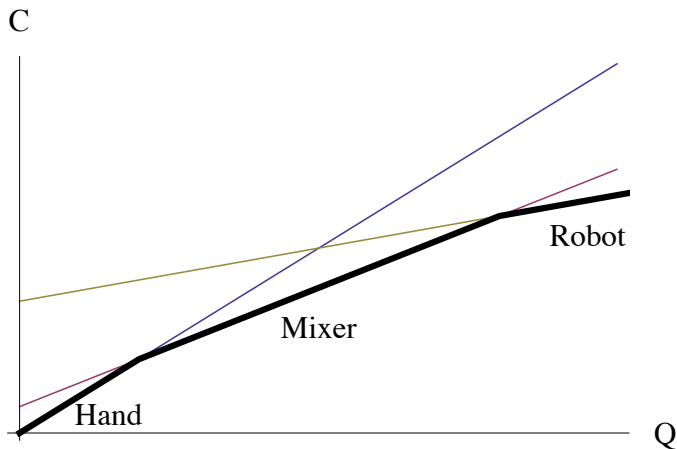
# Cost Functions - Cake Example, 3 levels of capital

For any desired quantity, find lowest cost mix of inputs to produce it

- Example: How much does it cost to bake 100 cakes?
  - Option 1: 100×Ingredients (\$2 each), spoon and bowl (free), 50 hours of labor (\$10/hr)
    - Cost:  $200 + 500 = \$700$
  - Option 2: 100×Ingredients (\$2 each), electric mixer (\$100), 25 hours of labor (\$10/hr)
    - Cost:  $200 + 100 + 250 = \$550$
  - Option 3: 100×Ingredients (\$2 each), cake robot (\$10000), 1 hour of labor (\$10/hr)
    - Cost:  $200 + 10000 + 10 = \$10,210$
- Lowest Cost: Option 2
- $C(100) = 550$
- $C(100) = 550$
- Now repeat for every  $Q$

# Cost Functions - Cake Example, 3 levels of capital

Cost function for cake production:



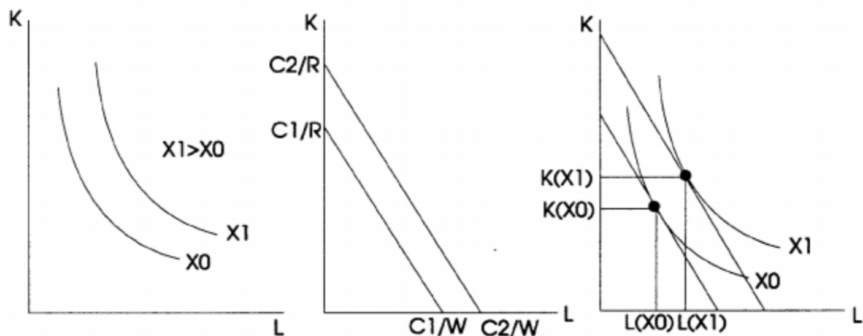
For higher quantities: use more intensive capital and less labor per unit

# Isoquants and the Marginal Rate of Substitution

- If we graph all of the combinations of  $L$  and  $K$  that can be used to produce a given level of output, we get a curve that resembles an indifference curve
- In this case, the curve is called an isoquant (for equal quantity)
- Isoquants slope downward due to the fact that in order to keep the level of output constant a decrease in  $K$  must be accompanied by an increase in  $L$
- As  $K$  becomes more scarce, the amount of  $L$  we need to substitute for a unit of  $K$  will increase
- The amount of labor needed to substitute for a unit of capital (i.e., the amount labor must increase to maintain the current level of output) is called the **marginal rate of substitution** of labor for capital.
- Similarly, the MRS of capital for labor is just the slope of the following isoquant



# Isoquants and Isocost curves



# Isoquants and Isocost curves

- Isoquants determine the ability of the firm to substitute  $K$  and  $L$  in production
- The rate at which  $K$  and  $L$  can be substituted in the market is determined by the prices of capital and labor
- With the price of capital of  $r$  and a price of labor of  $w$ , one unit of labor can be substituted for  $w/r$  units of capital
- This ability to substitute was depicted by the isocost curve, which is the combinations of  $K$  and  $L$  that have equal costs
- The cost-minimizing solution is to find the lowest possible isocost curve
- At this point, the isoquant and isocost curves will be tangent
- The cost to produce  $X_0$  is  $C(X_0) = L(X_0)w + K(X_0)r$