# Econ 39: International Trade

## Week #6: The Heckscher-Ohlin Model

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Winter 2018

# Plan for the day

- Today, we begin discussing the Heckscher-Ohlin trade model.
- It will take (at least) two days.
- Reminders:
    - Problem Set 3 due today.
    - Problem Set 4 (currently) due next Thursday.

# Today's Teams

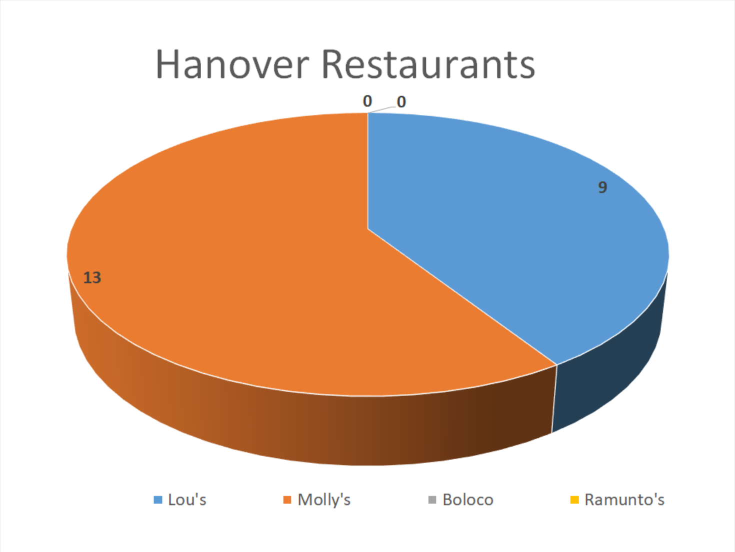
Lou's

Molly's restaurant & bar

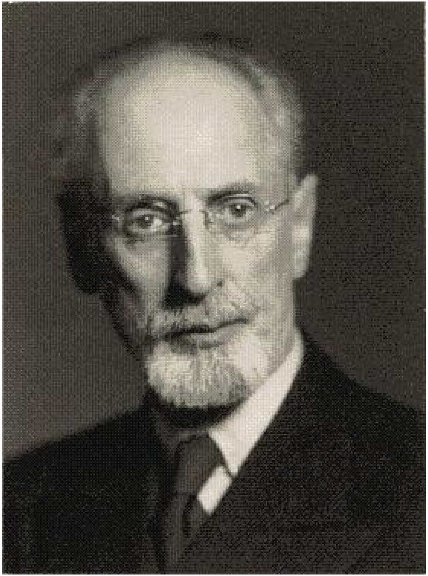
Ramunto's Brick n Brew Pizzeria HANOVER, NH

boloco globally inspired burritos

# Today's Teams



# Eli Heckscher

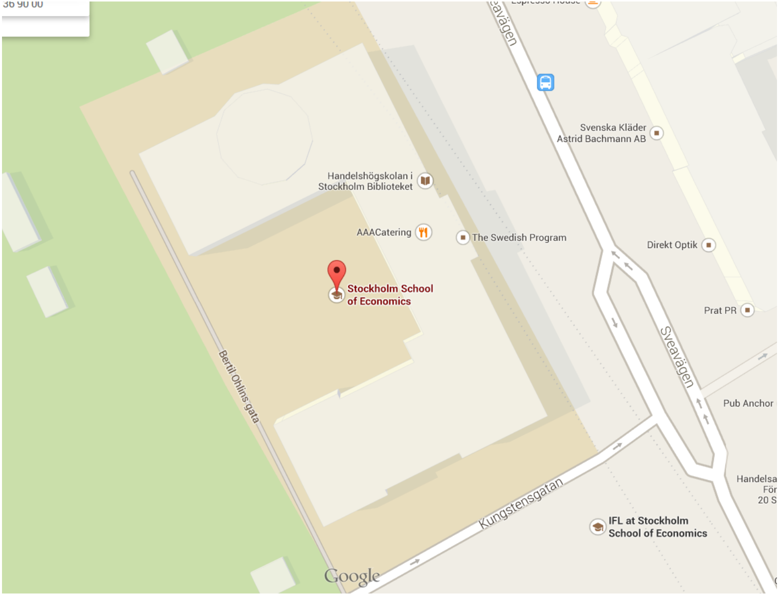


- Swedish economist, 1879-1952
- By his death, he had published 1148 books and articles: ˜16 for every year he was alive!
- In comparison, thus far I have averaged 0.12 articles / year....

# Bertil Ohlin

- Swedish economist, 1899-1979
- His advisor was Eli Heckscher.
- Won the Nobel Prize in 1977.
- Has a road named after him in Sweden.

# Bertil Ohlin



# A nearby road

# The Heckscher-Ohlin Theory

- In the Ricardian model, countries could gain from trade because they had different productivities.
- But why do countries differ in their productivities?
- The basic idea of the H-O theory is that countries vary in their endowments.
- Even if the production technologies are the same, differences in endowments will result in countries using different factor proportions in the production of goods.

# Model Setup

- For now, consider a single country (the U.S.).
- As before, two goods: soccer balls and footballs.
- Now, there are two factors of production:
  - Labor: let total labor in the U.S. be denoted $L_{US}$.
  - Capital: let total capital in the U.S. be denoted $K_{US}$.
- Both labor and capital assumed to be perfectly mobile between the production of both goods.
  - The H-O theory can be interpreted as the long-run version of the specific factor model.

# Production

- As in the specific factors model, production of footballs and soccer balls depends on the amount of factors used in their production.
- Let the production function for footballs be:

$$Q_{US}^{FB} = Q^{FB}\left(L_{US}^{FB}, K_{US}^{FB}\right).$$

- Let the production function for soccer balls be:

$$Q_{US}^{SB} = Q^{SB}\left(L_{US}^{SB}, K_{US}^{SB}\right).$$

- Standard assumptions:
  - For $i \in \{FB, SB\}$:

$$\frac{\partial Q^i}{\partial L} > 0,\ \frac{\partial Q^i}{\partial K} > 0,\ \frac{\partial^2 Q^i}{(\partial L)^2} < 0,\ \frac{\partial^2 Q^i}{(\partial K)^2} < 0$$

  - For $\alpha > 0$ and $i \in \{FB, SB\}$:

$$\alpha Q^i\left(L, K\right) = Q^i\left(\alpha L, \alpha K\right).$$

# Preferences

- As in the previous models, we assume that there is a representative agent with preferences over the consumption of both soccer balls and footballs:

$$U_{US} = U\left(C_{US}^{SB}, C_{US}^{FB}\right).$$

- Standard assumptions:

$$\frac{\partial U}{\partial C^{SB}} > 0,\ \frac{\partial U}{\partial C^{FB}} > 0$$

# Equilibrium condition #1a

- Equilibrium condition #1(a): Given prices (of both final goods and factors), both workers and capital owners choose what to produce to maximize their incomes.
  - Note: unlike the Specific Factors model, we have to keep track of the capital owners' decisions. [Class question: why?]
- Let the income of each worker be called the **wage** and denoted by $w_{US}^i$ for $i \in \{SB, FB\}$.
- Let the income of each owner of capital be called the **rental rate** and denoted by $r_{US}^i$ for $i \in \{SB, FB\}$.

# Equilibrium condition #1a

- The wage and rental rate are both **factor prices** (i.e. they reflect the cost of hiring a factor of production).
- Workers will choose to produce only footballs if $w_{US}^{FB} > w_{US}^{SB}$, only soccer balls if $w_{US}^{SB} > w_{US}^{SB}$, and will be indifferent if $w_{US}^{SB} = w_{US}^{FB}$.
- [Class question: when will capital owners produce only footballs? only soccer balls? be indifferent?]

# Equilibrium condition #1b

- Equilibrium condition #1(b): Given prices (of both final goods and factors), producers of both soccer balls and footballs will maximize their profits.

- Producers of footballs choose $L_{US}^{FB}$ and $K_{US}^{FB}$ in order to maximize profits $\pi_{US}^{FB}$:

$$\pi_{US}^{FB} = \max_{L,K} p^{FB} Q^{FB}(L, K) - w_{US}^{FB} L - r_{US}^{FB} K$$

- Note: We are now introducing the basic building blocks of firms into the model.

# Equilibrium condition #1b

- At the optimum the partial derivative with respect to both $L_{US}^{FB}$ and $K_{US}^{FB}$ must equal zero (these are known as the **first order conditions**):

$$p^{FB}\frac{\partial Q^{FB}\left(L_{US}^{FB},K_{US}^{FB}\right)}{\partial L_{US}^{FB}}=w_{US}^{FB}$$

$$p^{FB}\frac{\partial Q^{FB}\left(L_{US}^{FB},K_{US}^{FB}\right)}{\partial K_{US}^{FB}}=r_{US}^{FB}$$

- Dividing one equation by the other yields:

$$\frac{MPL_{US}^{FB}}{MPK_{US}^{FB}}=\frac{w_{US}^{FB}}{r_{US}^{FB}},$$

where $MPL_{US}^{FB}\equiv\frac{\partial Q^{FB}\left(L_{US}^{FB},K_{US}^{FB}\right)}{\partial L_{US}^{FB}}$ is the **marginal product of labor** and $MPK_{US}^{FB}\equiv\frac{\partial Q^{FB}\left(L_{US}^{FB},K_{US}^{FB}\right)}{\partial K_{US}^{FB}}$ is the **marginal product of capital**.

# Equilibrium condition #1b

- From previous slide:

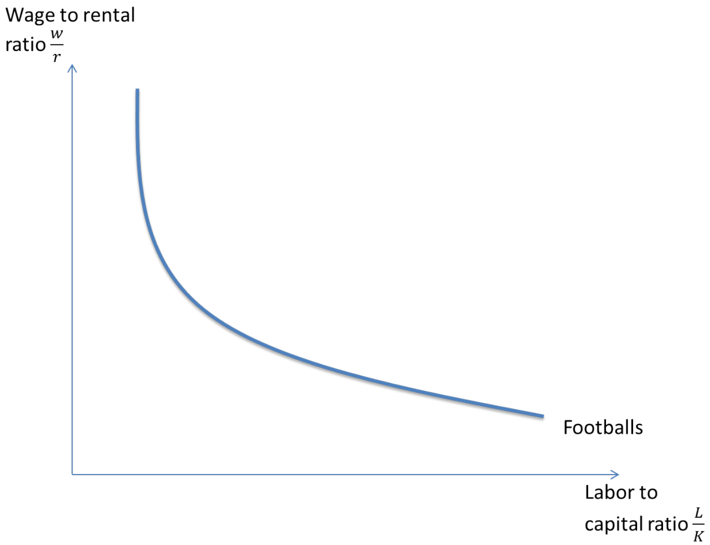
$$\frac{MPL_{US}^{FB}}{MPK_{US}^{FB}} = \frac{w_{US}^{FB}}{r_{US}^{FB}}$$

- Recall that the marginal product of labor $MPL_{US}^{FB}$ is decreasing as you add $L_{US}^{FB}$. [Class question: why?]

- Similarly, the marginal product of capital $MPK_{US}^{FB}$ is decreasing as you add $K_{US}^{FB}$.

- [Class question: suppose that $\frac{w_{US}^{FB}}{r_{US}^{FB}}$ increased. How would the labor to capital ratio have to change to ensure profits are maximized?]

# Factor prices and factor use



# Example

- Suppose that the production function was:

$$Q_{US}^{FB} = \left(L_{US}^{FB}\right)^{\phi} \left(K_{US}^{FB}\right)^{1-\phi}$$

for some $\phi \in (0, 1)$. [Note: $\phi$ for **f**ootball].

- Then the marginal product of labor is:

$$MPL_{US}^{FB} = \phi \left(\frac{L_{US}^{FB}}{K_{US}^{FB}}\right)^{\phi-1}$$

- And the marginal product of capital is:

$$MPK_{US}^{FB} = (1-\phi) \left(\frac{L_{US}^{FB}}{K_{US}^{FB}}\right)^{\phi}$$

# Example (ctd.)

- Hence, profit maximization implies:

$$\frac{MPL_{US}^{FB}}{MPK_{US}^{FB}} = \frac{w_{US}^{FB}}{r_{US}^{FB}} \iff$$
$$\frac{\phi}{1-\phi}\left(\frac{L_{US}^{FB}}{K_{US}^{FB}}\right)^{-1} = \frac{w_{US}^{FB}}{r_{US}^{FB}}.$$

- Hence, $\frac{L_{US}^{FB}}{K_{US}^{FB}}$ is decreasing with $\frac{w_{US}^{FB}}{r_{US}^{FB}}$.

- [Class question: what is the intuition?]

# Factor intensity

- Thus far, we have only considered footballs. What about soccer balls?
- Suppose that, like footballs, soccer balls have a Cobb-Douglass production function:

$$Q_{US}^{SB} = \left(L_{US}^{SB}\right)^{\sigma} \left(K_{US}^{SB}\right)^{1-\sigma}$$

  where $\sigma \in (0,1)$. [Note $\sigma$ for **s**occer ball].
- Suppose too that $\sigma > \phi$. [Class question: what does this mean?].
- From same math as above, we have:

$$\frac{\sigma}{1-\sigma}\left(\frac{L_{US}^{SB}}{K_{US}^{SB}}\right)^{-1} = \frac{w_{US}^{SB}}{r_{US}^{SB}}.$$

# Factor intensity

- From equilibrium condition 1(a), if both soccer balls and footballs are being produced, then the wages and rental rates must be equalized across sectors, i.e.:

$$w_{US}^{SB} = w_{US}^{FB} \text{ and } r_{US}^{SB} = r_{US}^{FB}$$

- Combining this with equilibrium condition 1(b), we can relate the labor to capital ratio in both sectors:

$$\frac{w_{US}^{FB}}{r_{US}^{FB}} = \frac{w_{US}^{SB}}{r_{US}^{SB}} \implies$$

$$\frac{\phi}{1-\phi}\left(\frac{L_{US}^{FB}}{K_{US}^{FB}}\right)^{-1} = \frac{\sigma}{1-\sigma}\left(\frac{L_{US}^{SB}}{K_{US}^{SB}}\right)^{-1} \iff$$

$$\left(\frac{L_{US}^{SB}}{K_{US}^{SB}}\right) / \left(\frac{L_{US}^{FB}}{K_{US}^{FB}}\right) = \frac{\sigma}{1-\sigma} / \frac{\phi}{1-\phi}$$

# Factor intensity

- From previous slide:

$$\left(\frac{L_{US}^{SB}}{K_{US}^{SB}}\right) / \left(\frac{L_{US}^{FB}}{K_{US}^{FB}}\right) = \frac{\sigma}{1-\sigma} / \frac{\phi}{1-\phi}$$

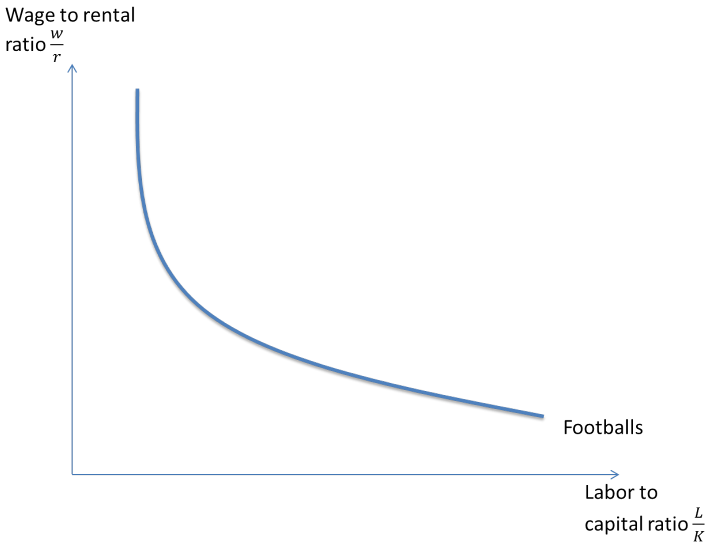
- Since $\sigma > \phi$, this implies that the labor to capital ratio in soccer balls is higher than the labor to capital ratio in footballs:

$$\frac{L_{US}^{SB}}{K_{US}^{SB}} > \frac{L_{US}^{FB}}{K_{US}^{FB}} \tag{1}$$

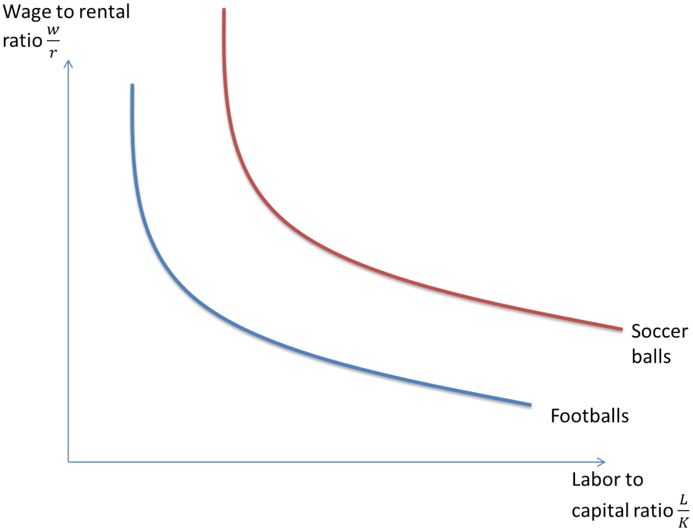
- If equation (1) holds, we say that the production of soccer balls is **labor intensive** while the production of footballs is **capital intensive**.

- [Class question: what does equation (1) mean?]

# Factor intensity



# Factor intensity



# Equilibrium factor prices

- Equilibrium condition 3(a): the total amount of labor in an economy is equal to the amount of labor used in the production of footballs and soccer balls:

$$L_{US} = L_{US}^{SB} + L_{US}^{FB}$$

- Similarly, the total amount of capital in an economy is equal to the amount of capital used in the production of footballs and soccer balls:

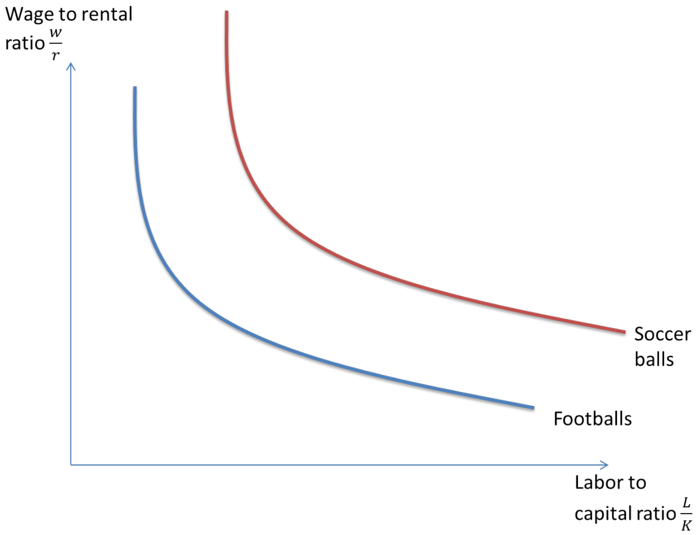
$$K_{US} = K_{US}^{SB} + K_{US}^{FB}$$

- This means that the relative supply of labor and capital in the U.S. can be written as:

$$\frac{L_{US}}{K_{US}} = \frac{L_{US}^{FB}}{K_{US}} + \frac{L_{US}^{SB}}{K_{US}} = \frac{L_{US}^{FB}}{K_{US}^{FB}}\left(\frac{K_{US}^{FB}}{K_{US}}\right) + \frac{L_{US}^{SB}}{K_{US}^{SB}}\left(\frac{K_{US}^{SB}}{K_{US}}\right)$$

- This equation says that the overall labor demand is a weighted average of the labor to capital ratio in both sectors.

# Equilibrium factor prices



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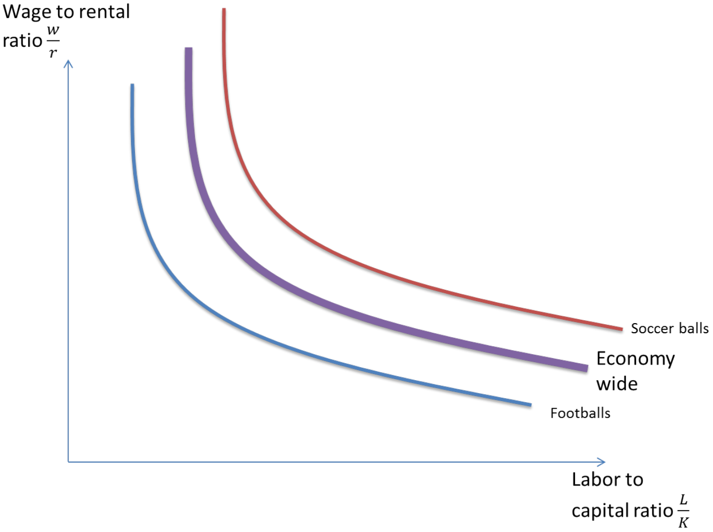

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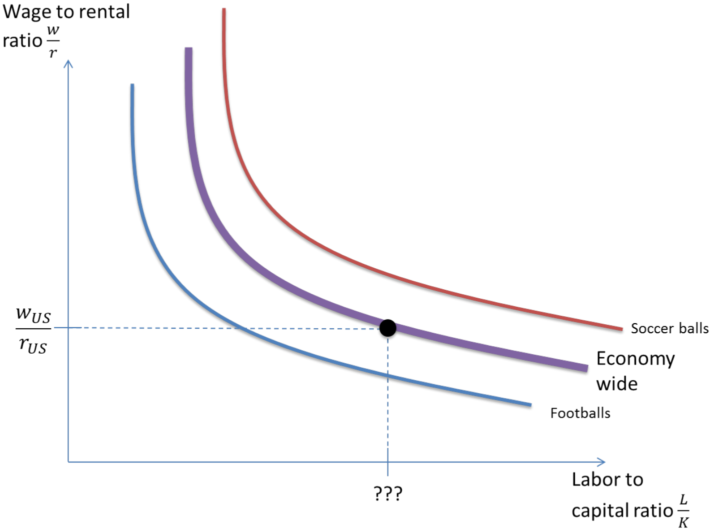

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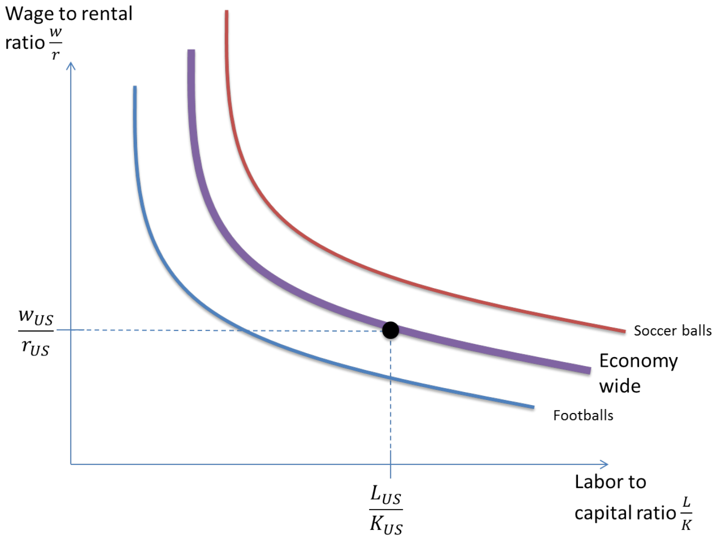

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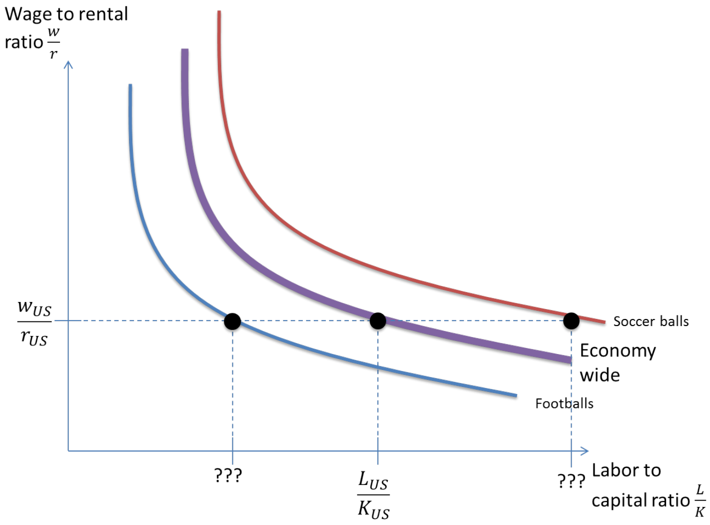
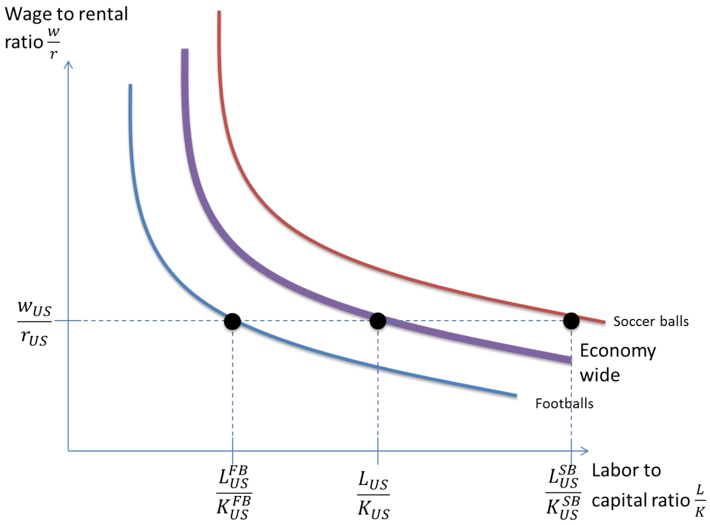


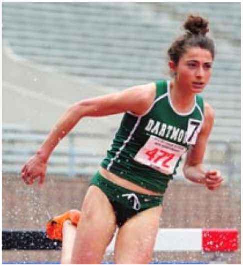
# Equilibrium factor prices



# Plan for the day

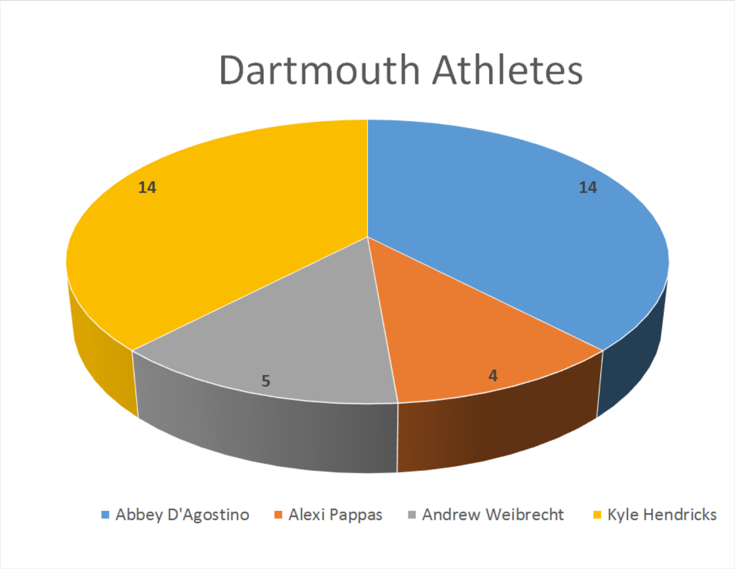
- "Big 3" Theorem #1 (Stolper-Samuelson)
- "Big 3" Theorem #2 (Rybczynski Theorem)
- In class example
- If time:
  - "Big 3" Theorem #3 (the original)
  - Factor price equalization
- Problem Set #4 Due Thursday (for now..)

# Today's Teams



# Today's Teams



# Factor prices and good prices

- Suppose that both soccer balls and footballs are produced.
- Then it must be the case that the wage in both sectors is equalized:

$$
\begin{aligned}
w_{US}^{FB} = w_{US}^{SB} &\implies \\
p_{US}^{FB} MPL_{US}^{FB} = p_{US}^{SB} MPL_{US}^{SB} &\iff \\
\frac{p_{US}^{FB}}{p_{US}^{SB}} = \frac{MPL_{US}^{SB}}{MPL_{US}^{FB}}
\end{aligned}
$$

- Similarly, it must be the case that the rental rate in both sectors is equalized:

$$
\begin{aligned}
r_{US}^{FB} = r_{US}^{SB} &\implies \\
p_{US}^{FB} MPK_{US}^{FB} = p_{US}^{SB} MPK_{US}^{SB} &\iff \\
\frac{p_{US}^{FB}}{p_{US}^{SB}} = \frac{MPK_{US}^{SB}}{MPK_{US}^{FB}}
\end{aligned}
$$

# Effect of an increase in $\frac{p_{US}^{FB}}{p_{US}^{SB}}$

- Suppose that the relative price of footballs $\frac{p_{US}^{FB}}{p_{US}^{SB}}$ increases.
- What happens to the allocation of labor across sectors?
  - Since $\frac{p_{US}^{FB}}{p_{US}^{SB}} = \frac{MPL_{US}^{SB}}{MPL_{US}^{FB}}$, it must be that $\frac{MPL_{US}^{SB}}{MPL_{US}^{FB}}$ increases.
  - Because of the diminishing marginal product of labor, this means that some labor moves from the production of soccer balls to the production of footballs, i.e. $L_{US}^{SB}$ declines and $L_{US}^{FB}$ increases.
- What happens to the allocation of capital across sectors?
  - Identical reasoning as with labor: since $\frac{p_{US}^{FB}}{p_{US}^{SB}} = \frac{MPK_{US}^{SB}}{MPK_{US}^{FB}}$, it must be that $\frac{MPK_{US}^{SB}}{MPK_{US}^{FB}}$ increases.
  - Because of the diminishing marginal product of capital, this means that some capital moves from the production of soccer balls to the production of footballs, i.e. $K_{US}^{SB}$ declines and $K_{US}^{FB}$ increases.

# Effect of an increase in $\frac{p_{US}^{FB}}{p_{US}^{SB}}$

- Hence, an increase in $\frac{p_{US}^{FB}}{p_{US}^{SB}}$ causes both labor and capital to move from the production of soccer balls to the production of footballs.
- *How does this affect the factor prices (i.e. wages and rental rates)?*
- Recall that the relative supply of labor and capital in the U.S. can be written as:

$$\frac{L_{US}}{K_{US}} = \frac{L_{US}^{FB}}{K_{US}^{FB}} \left( \frac{K_{US}^{FB}}{K_{US}} \right) + \frac{L_{US}^{SB}}{K_{US}^{SB}} \left( \frac{K_{US}^{SB}}{K_{US}} \right)$$

- Since an increase in $\frac{p_{US}^{FB}}{p_{US}^{SB}}$ moves capital to the football sector, this increases the weight of the football sector in the labor demand.

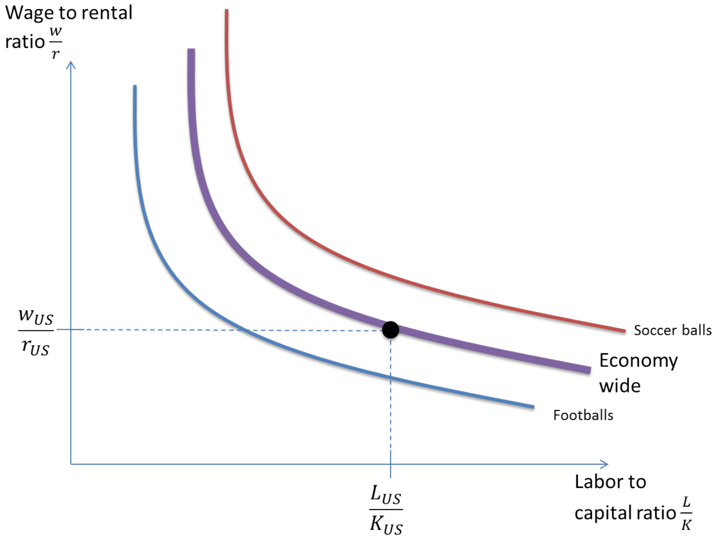
# Effect of an increase in $\frac{p_{US}^{FB}}{p_{US}^{SB}}$

- Recall that the production of footballs is capital intensive, i.e. for any wage to rental ratio, we have:

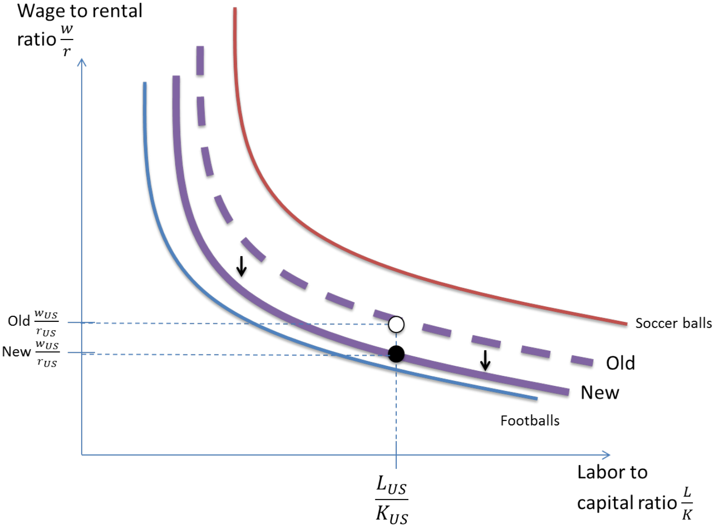
$$\frac{L_{US}^{SB}}{K_{US}^{SB}} > \frac{L_{US}^{FB}}{K_{US}^{FB}}.$$

- Hence, the labor demand (relative to capital) is less in the football sector than the soccer ball sector.
- Because the weight of the football sector has increased, this means that total labor demand has fallen.
- Hence, the equilibrium wage to rental ratio falls as well.
- *Result: an increase in the relative price of a good will increase the relative factor price of the factor that it uses intensively.*

# Effect of an increase in $\frac{p_{US}^{FB}}{p_{US}^{SB}}$



# Effect of an increase in $\frac{p_{US}^{FB}}{p_{US}^{SB}}$




[Class question: how does the labor to capital ratio change in both industries?]

# Winners and losers from a price change

- Who benefits from the increase in the relative price of footballs?
- We saw that the relative wage to rental ratio falls as the relative price of footballs increased since footballs were capital intensive.
- Hence, the labor to capital ratio in both sectors increases.
- Recall that equilibrium condition 1(b) said that the wage to rental ratio is equal to the ratio of the marginal product of labor to the marginal product of capital in both sectors, i.e. for $i \in \{FB, SB\}$:

$$\frac{w_{US}}{r_{US}} = \frac{MPL^i_{US}}{MPK^i_{US}}.$$

- Since the wage to rental ratio has fallen, this implies that the marginal product of labor in both sectors has fallen.
- Similarly, the marginal product of capital in both sectors has risen.

# Winners and losers from a price change

- What can a worker purchase with income $w_{US}$?
  - If she only buys footballs, can buy $w_{US}/p_{US}^{FB}$ footballs. Note that from first order condition 1(b) that: $w_{US}/p_{US}^{FB} = MPL_{US}^{FB}$.
  - If she only buys soccer balls, can buy $w_{US}/p_{US}^{SB}$ soccer balls. Note that $w_{US}/p_{US}^{SB} = MPL_{US}^{SB}$
  - Since the marginal product of labor has fallen in both sectors, a worker in unambiguously worse off!
- What can a capital owner purchase with income $r_{US}$?
  - If she only buys footballs, can buy $r_{US}/p_{US}^{FB}$ footballs. Note that from first order condition 1(b) that: $r_{US}/p_{US}^{FB} = MPK_{US}^{FB}$.
  - If she only buys soccer balls, can buy $r_{US}/p_{US}^{SB}$ soccer balls. Note that $r_{US}/p_{US}^{SB} = MPK_{US}^{SB}$
  - Since the marginal product of capital has risen in both sectors, a capital owner in unambiguously better off!

# Winners and losers from a price change

- **Stolper-Samuelson Theorem**: *a rise in the relative price of a good will make the owner of the factor that the good uses intensively better off and make the owner of the factor of that the good does not use intensively worse off.*

# From last time: Winners and losers from a price change

- **Stolper-Samuelson Theorem***: a rise in the relative price of a good will make the owner of the factor that the good uses intensively better off and make the owner of the factor of that the good does not use intensively worse off.*

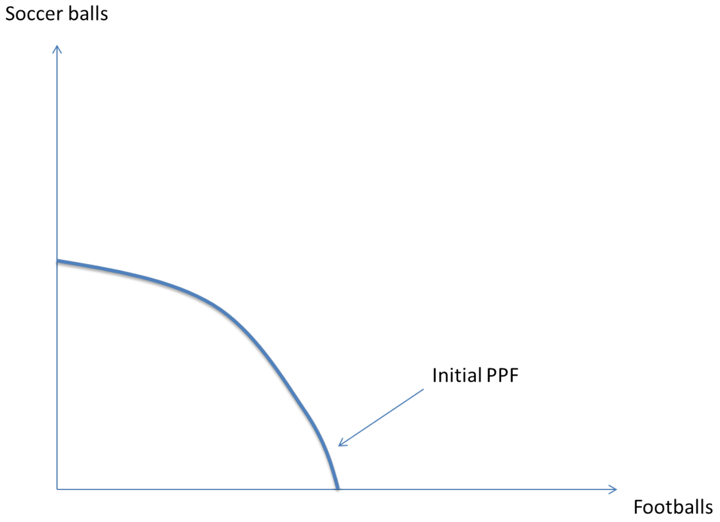
# Increase in the U.S. population

- Suppose the U.S. increases its population from $L^0_{US}$ to $L^1_{US}$, where $L^1_{US} > L^0_{US}$.

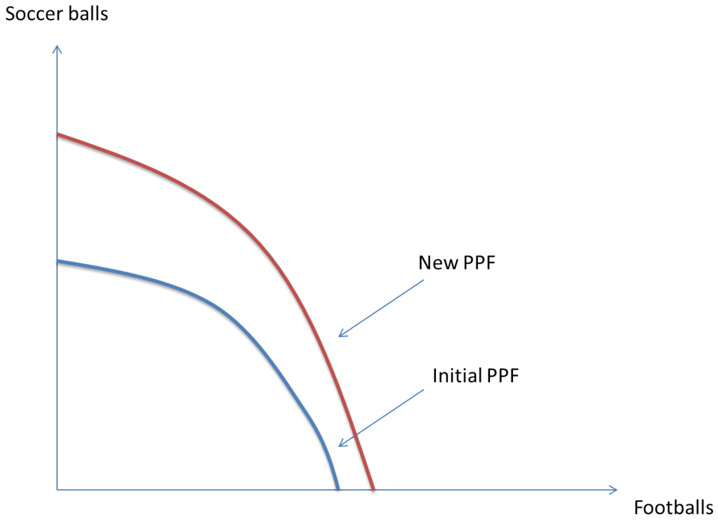
- If the relative price of footballs $\frac{p^{FB}}{p^{SB}}$ remains unchanged, how does what the U.S. produce change?

- Let us answer the question with a figure first and then see how to see it with the math.

# Increase in the U.S. population

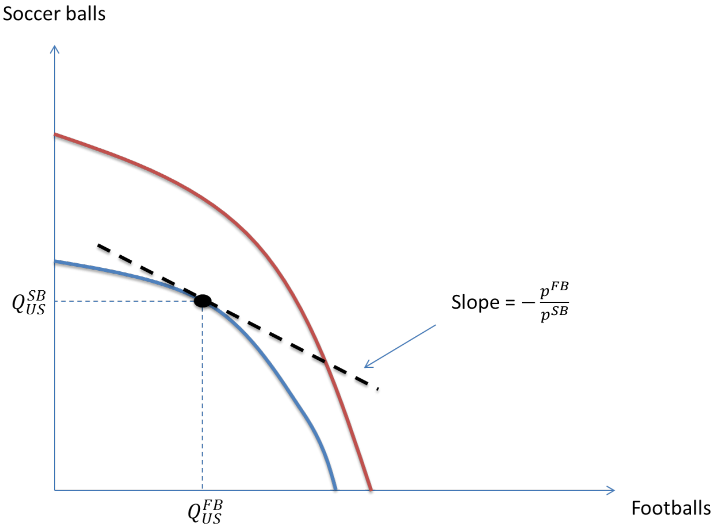


# Increase in the U.S. population

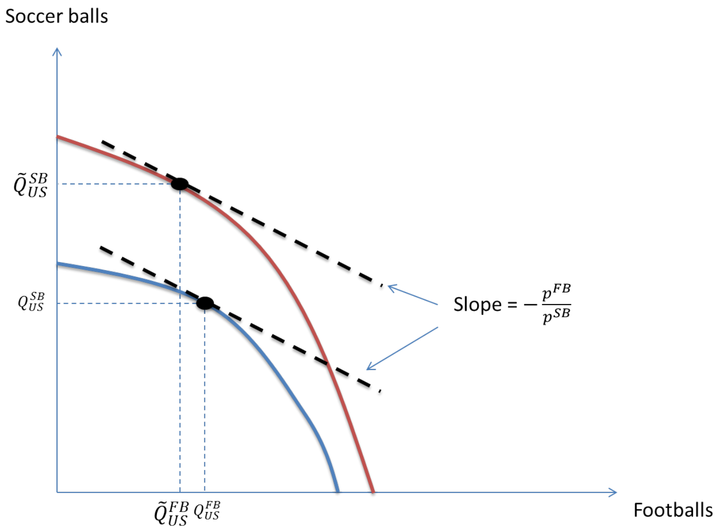



[Class question: Why does an increase in the population cause the PPF to become skewed?]

# Increase in the U.S. population



# Increase in the U.S. population



# Increase in the U.S. population

- Hence:
  - Increasing the labor supply in the United States increased the production of soccer balls (the labor-intensive good) and decreased the production of footballs (the capital-intensive good).
- This is an example of the more general **Rybczynski Theorem**:

  *Given prices and technologies an increase in the endowment of a factor will cause a country to produce more of the good that is intensive in that factor and less of the good that is not intensive in that factor as long as a country produces both goods.*

# Increase in the U.S. population (using math)

- Recall that the equilibrium condition #3 implies:

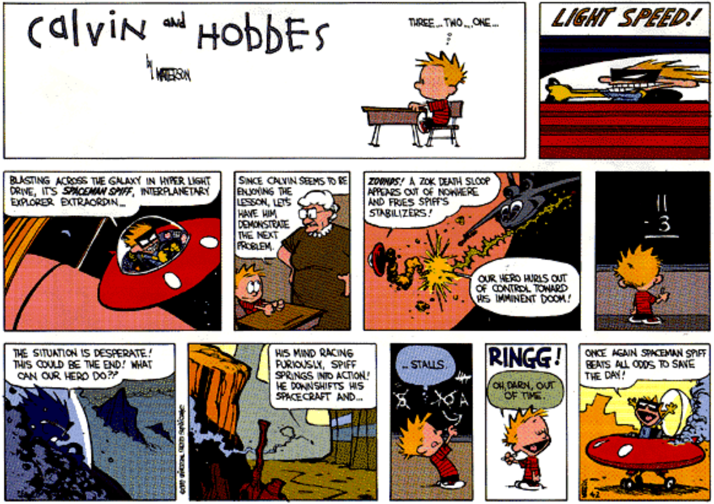
$$\frac{L_{US}}{K_{US}} = \frac{L_{US}^{FB}}{K_{US}^{FB}} \left( \frac{K_{US}^{FB}}{K_{US}} \right) + \frac{L_{US}^{SB}}{K_{US}^{SB}} \left( \frac{K_{US}^{SB}}{K_{US}} \right) \tag{2}$$

- An increase in the U.S. population increases the left hand side of equation (2).
- Recall that:

$$\frac{L_{US}^{SB}}{K_{US}^{SB}} > \frac{L_{US}^{FB}}{K_{US}^{FB}}$$

- Hence, to make the right hand side of equation (2) increase, we need to increase $\frac{K_{US}^{SB}}{K_{US}}$ (and hence decrease $\frac{K_{US}^{FB}}{K_{US}}$).
- Moving capital into the soccer ball sector increases the production of soccer balls and decreases the production of footballs.

# In class example

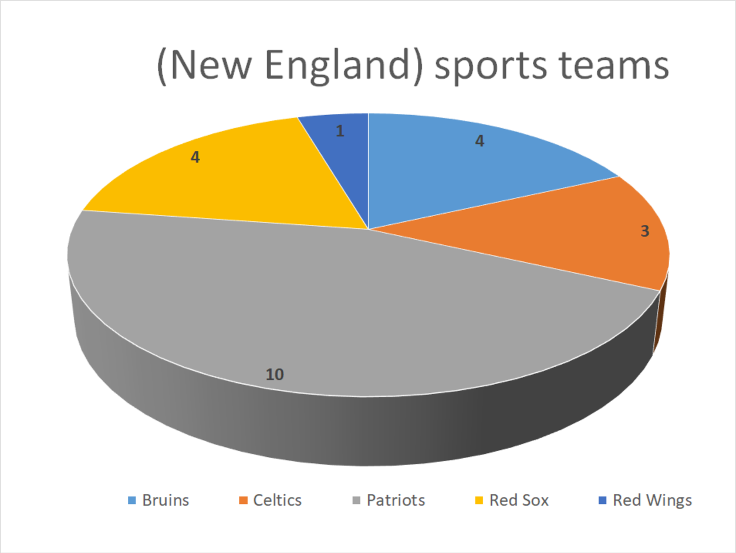


# Plan for the day

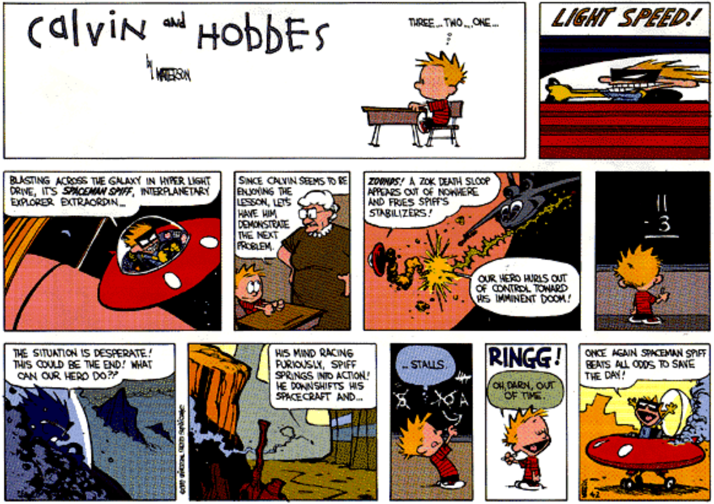
- Today, we finish discussing the Heckscher-Ohlin trade model:
    - Finish example
    - "Big 3" Theorem #3 (the original)
    - Factor price equalization
- Reminders:
    - Problem Set 4 due next Tuesday.
    - Midterm #2 next Thursday.

# Today’s Teams

# Today's Teams



# In class example (concluded)



# Exogenous Model Parameters

- Suppose now there are two countries (U.S. and Mexico).
- Factor endowments: $L_i$ and $K_i$, $i \in \{US, MEX\}$
- Production functions: $Q^{FB}(K, L)$ and $Q^{SB}(K, L)$.
- Preferences: $U\left(C^{FB}, C^{SB}\right)$.
- Note: preferences and production functions are assumed to be the same in both countries.

# Endogenous Model Outcomes

- Allocation of factors to production of goods:
  $L_i^{FB},\ L_i^{SB},\ K_i^{FB},\ K_i^{SB},\ i \in \{US, MEX\}$.

- Factor prices: $w_i$ and $r_i$, $i \in \{US, MEX\}$.

- Relative goods prices: $\frac{p^{FB}}{p^{SB}}$.

- Production: $Q_i^{FB}$ and $Q_i^{SB}$, $i \in \{US, MEX\}$.

- Consumption: $C_i^{FB}$ and $C_i^{SB}$, $i \in \{US, MEX\}$.

# Free trade equilibrium conditions

For any set of exogenous model parameters, equilibrium is a set of endogenous model outcomes such that:

1. Given factor prices and goods prices:
   1.1 Both workers and capital owners in both countries choose what to produce to maximize their income.
   1.2 Producers of both soccer balls and footballs in both countries choose how much labor and capital to use to maximize their profits.
2. Given goods prices and the income of each country, the representative agent maximizes its utility in each country.
3. Markets clear. In particular:
   3.1 Factor markets clear: The total amount of labor and capital used in production in each country is equal to the country's endowment in labor and capital.
   3.2 Goods markets clears: The total amount of soccer balls and footballs produced is equal to the total number of soccer balls and footballs consumed.

# Solving for the equilibrium

- We now are going to write down the equations that must hold for the equilibrium.
- From equilibrium condition #1(a) and #1(b), assuming both goods are produced, we have that the wage in both sectors and in both countries is equal to the price in that sector multiplied by the marginal product of labor:

$$w_i = p^{FB} \frac{\partial Q\left(L_i^{FB}, K_i^{FB}\right)}{\partial L_i^{FB}} = p^{SB} \frac{\partial Q\left(L_i^{SB}, K_i^{SB}\right)}{\partial L_i^{SB}}$$

  for $i \in \{US, MEX\}$
- Equilibrium condition #1 implies a similar thing for the rental rate:

$$r_i = p^{FB} \frac{\partial Q\left(L_i^{FB}, K_i^{FB}\right)}{\partial K_i^{FB}} = p^{SB} \frac{\partial Q\left(L_i^{SB}, K_i^{SB}\right)}{\partial K_i^{SB}}$$

# Solving for the equilibrium

- You can solve for the equilibrium relationship between the labor to capital ratio in the football sector and the labor to capital ratio in the soccer ball sector by dividing the two
$$\frac{MPL_i^{FB}}{MPK_i^{FB}} = \frac{MPL_i^{SB}}{MPK_i^{SB}}$$
for $i \in \{US, MEX\}$.
- This allows you to write the labor to capital ratio in either sector (and hence the wage and rental rate) solely as a function of the relative prices.
- It is important to emphasize that the wage and rental rate only depend on the labor to capital ratios and the price and do not depend on the endowment (assuming that both goods are produced)!

# Solving for the equilibrium

- The next step is to apply equilibrium condition #3 to ensure that the labor to capital ratio in both sectors is consistent with the labor and capital endowments in a country:
$$\frac{L_i}{K_i} = \frac{L_i^{FB}}{K_i^{FB}}\frac{K_i^{FB}}{K_i} + \frac{L_i^{SB}}{K_i^{SB}}\frac{K_i^{SB}}{K_i}$$
for $i \in \{US, MEX\}$.
- Note that because $K_i^{FB} + K_i^{SB} = K_i$, we have $\frac{K_i^{FB}}{K_i} = \frac{K_i - K_i^{SB}}{K_i} = 1 - \frac{K_i^{SB}}{K_i}$.
- Since in the previous step we solved for the labor to capital ratios in both sectors (as a function of the relative price of footballs to soccer balls), we can use this equation to solve for $\frac{K_i^{SB}}{K_i}$ (and hence also solve for $\frac{K_i^{FB}}{K_i}$).

# Solving for the equilibrium

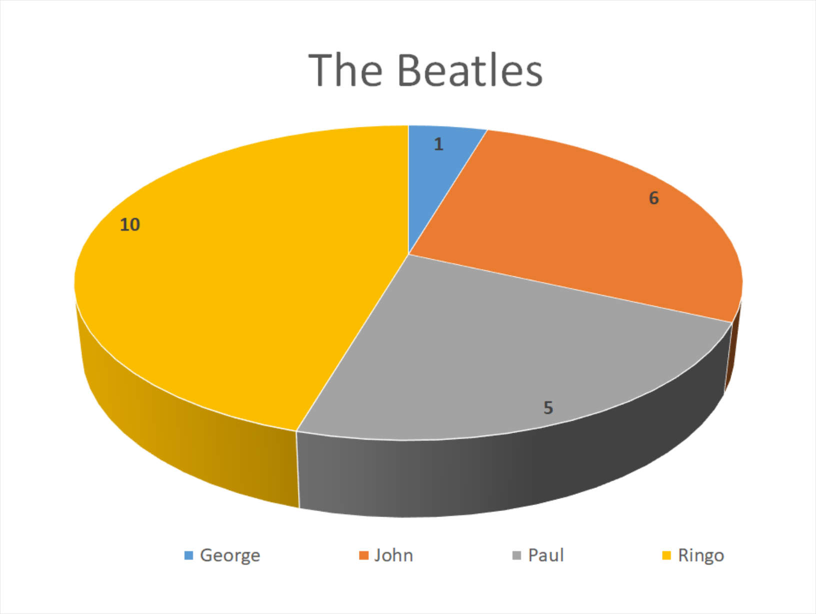
- Once you know how much capital and labor is allocated to each sector, you can figure out the quantity produced in each sector using the production functions (as a function of the relative price of footballs to soccer balls).
- At this point, you have solved for all endogenous model outcomes solely as a function of the relative price of footballs to soccer balls and exogenous model parameters.
- The remaining thing to do is to solve for the world relative price.
- To do so, you apply equilibrium condition #2 (utility maximization) combined with the fact that world consumption of each good has to equal world production.
- This part normally gets messy, so it usually is not emphasized.

# Plan for the day

- Today, we finish discussing the Heckscher-Ohlin trade model:
  - "Big 3" Theorem #3 (the original)
  - Factor price equalization
- Reminders:
  - Problem Set 4 due today.
  - Midterm #2 on Thursday!
    - Covers specific factors - end of today.
    - OH today 4:30-5:30pm
    - X-hours tomorrow 3:30-5:30pm.

# Today's Teams

# Today's Teams



# Patterns of trade

- Let us suppose that $\frac{L_{US}}{K_{US}} < \frac{L_{MEX}}{K_{MEX}}$, i.e. that the U.S. is endowed with less labor per unit of capital than Mexico.
- If this is the case we say that Mexico is **labor abundant** and the U.S. is **capital abundant**.
- [Class question: is it always the case that one country is labor abundant and the other is capital abundant?]
- [Class question: if the two countries open up to trade, who do you think will export footballs and who do you think will export soccer balls?]

# Patterns of trade

- Let me first state the result and then we will show that it is true.

- **Heckscher-Ohlin Theorem**: *The country that is abundant in a factor exports the good whose production is intensive in that factor.*

# Patterns of trade

- How do we see this?
- Suppose first that the world endowment of capital and labor is evenly divided between the U.S. and Mexico, so that both countries have the same capital to labor ratio:

$$\frac{L_{US} + L_{MEX}}{K_{US} + K_{MEX}}$$

- In this case, the two countries will not trade and the autarkic equilibrium price in both countries will be same (and hence will be equal to the equilibrium world price).

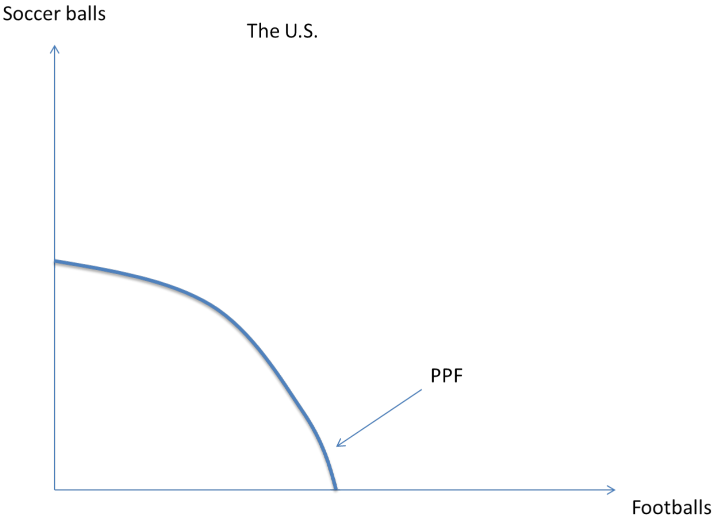
# Patterns of trade

- Now let us reallocate the capital and labor back to the original endowments. Note that:
$$\frac{L_{US}}{K_{US}} < \frac{L_{US} + L_{MEX}}{K_{US} + K_{MEX}} < \frac{L_{MEX}}{K_{MEX}}$$
- We have to increase the endowed labor to capital ratio in Mexico and decreasing the endowed labor to capital ratio in the U.S.
- From the Rybczynski Theorem, the production of the capital intensive good (footballs) in the U.S. will increase and production of the labor intensive good (soccer balls) in the U.S. will decrease (and vice versa for Mexico).
- The U.S. will have an excess supply of footballs, so it will export footballs and import soccer balls (and vice versa for Mexico).
- [Class question: why is the world price is the same as for a single country with endowment $\frac{L_{US}+L_{MEX}}{K_{US}+K_{MEX}}$?]

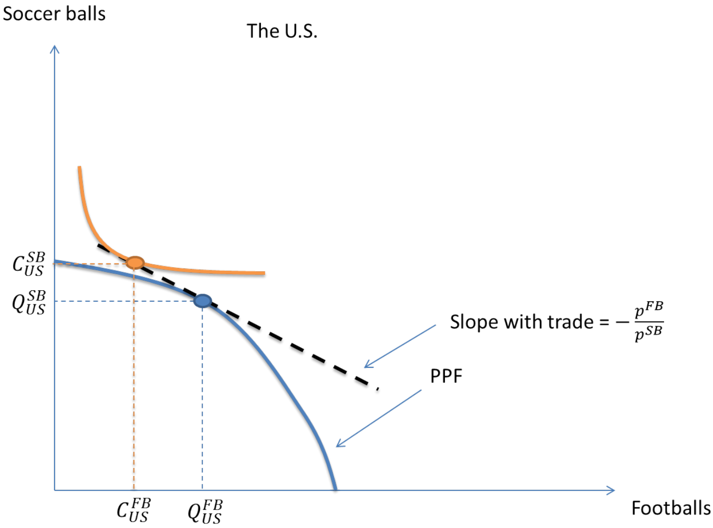
# Winners and losers of trade

- We just saw that at the world price, each country will have an excess supply of the good that is intensive in the factor that the country is abundantly endowed with.
- Claim: This implies that the equilibrium relative price for the abundant factor is higher with free trade than in autarky.
- How do we see this? First, consider the U.S. in the free trade equilibrium.

# Winners and losers of trade



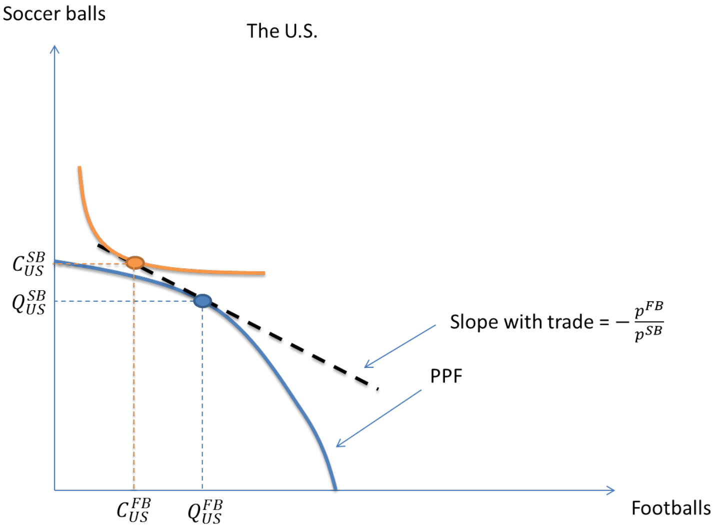
# U.S. in the free trade equilibrium



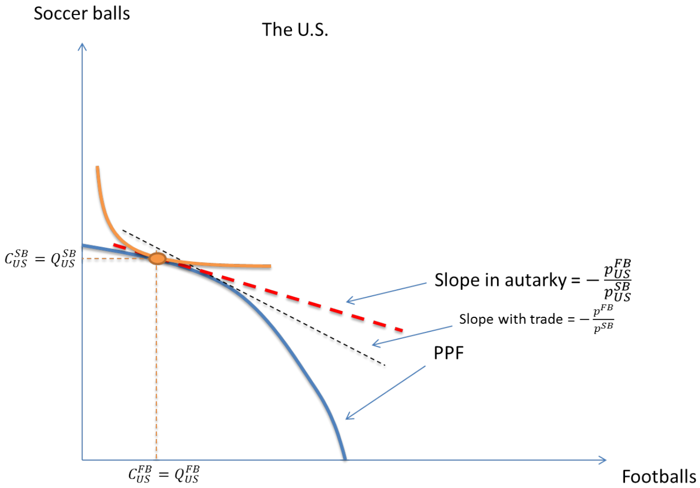
# Winners and losers of trade

- Hence, at the world price, the U.S. is producing more footballs than it consumes.
- If the U.S. were in autarky, total production has to equal total consumption.
- To make this happen, we have to lower the relative price of footballs.

# U.S. in the free trade equilibrium



# U.S. in autarkic equilibrium



# Winners and losers of trade

- Implication: opening up to trade increases the relative price of the good that is intensive in the factor that a country is abundant in.
- From the Stolper-Samuelson theorem, we then know who benefits from trade:
  - The owners of the abundant factor are made better off from opening up to trade.
  - The owners of the scarce factor are made worse off from opening up to trade.
- [Class question: If the U.S. is abundant in capital and scarce in labor, who will lobby most strongly against freer trade?]

# Factor price equalization

- In a free trade equilibrium, the relative price of footballs to soccer balls is the same in both countries.
- What about the factor prices (wages and rental rates)?
- The (shocking) implication of this model is that if both countries produce both goods, then the wages and rental rates will be the same in both countries.
- Intuitively, as a result of trade, each country will expand production of the good that is intensive in their abundant factor until profits are maximized.

# Factor price equalization

- Formally, equilibrium condition #1(a) and #1(b), imply that:

$$w_i = p^{FB} \frac{\partial Q\left(L_i^{FB}, K_i^{FB}\right)}{\partial L_i^{FB}} = p^{SB} \frac{\partial Q\left(L_i^{SB}, K_i^{SB}\right)}{\partial L_i^{SB}}$$

$$r_i = p^{FB} \frac{\partial Q\left(L_i^{FB}, K_i^{FB}\right)}{\partial K_i^{FB}} = p^{SB} \frac{\partial Q\left(L_i^{SB}, K_i^{SB}\right)}{\partial LK_i^{SB}}$$

  for $i \in \{US, MEX\}$.

- In each country, these equations can be solved to determine the equilibrium wage and rental rate.
- Note that the endowments do not enter these equations! Hence, the solution for both countries is identical.

# Factor price equalization: discussion

- Empirically, we know that wages (or rental rates) are not equalized across countries!
- This implies that something is not realistic in the model.
- [Class question: what assumptions that the model made are not realistic and how could this help explain why factor prices are not equalized?]

# Conclusion and next steps

- This concludes our discussion of the Heckscher-Ohlin model.
- Key questions:
  - What is the relationship between factor prices and good prices?
  - How are the patterns of trade determined?
  - Who wins and loses from trade?
- Next steps:
  - "New trade theory" which emphasizes the role of firms and increasing returns.