ECO364H1S: International Trade Theory

Lecture 3

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- Last Class
  - Gains from Trade, Trade Equilibrium, Relative Wages

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- Today
  - Heckscher-Ohlin (HO) Model
    - Introduction and Definitions
    - Relate Factor Prices to Factor Demand (FF Curve)
    - Relate Good Prices to Factor Prices (SS Curve)

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- Readings
  - KMO Ch. 5 (including appendix)
  - Economist "In the Shadow of Prosperity"
  - Hanson "The Rise of Middle Kingdoms"

Heckscher-Ohlin Model

HO Model

- In the Ricardian model, we assumed that only technological differences in production gave rise to specialization and trade
- We also assumed that only one factor is used in production
- Although the Ricardian model was able to make predictions about welfare, the worst that could happen to a country is to have similar welfare as the autarky scenario under trade conditions
    - No welfare loss when moving from autarky to trade

HO Model

- But welfare losses could arise if a factor benefits more than the other in a trading equilibrium
  - Some sectors do get hurt by international trade
- Perhaps the welfare outcomes under trade in the Ricardian model is too far remove from reality

HO Model

- In addition, we may be interested in
  - The structure of production before and after trade
  - How factor endowments determine specialization
- A model that explicitly accounts for factor endowment differences may be better in addressing these issues
  - Where in the Ricardian model trade arises from difference in technology, in the HO model trade arises from difference in factor endowment

HO Model

- Ultimately, our goal in developing the HO model is to answer the following question:
- **How does the income distribution in a country change following a price shock arising from international trade?**

Model Environment and Assumptions

- Two countries: North and South
- Two goods: Computers and Textiles
- Two factors: Capital (K) and Labour (L)
  - K: buildings, machinery
  - Supply of K and L are fixed and differ between the two countries
- Production exhibits constant returns to scale
  - Scale all inputs by a factor of 2 results in an increase in output by the same factor

Model Environment and Assumptions

- Countries face the same production function (i.e. same technology)
  - For any good j and inputs, $F_j^N(K_j, L_j) = F_j^S(K_j, L_j)$
- Perfect competition
  - Firms take prices as given, marginal revenue = marginal cost
- Factors are mobile across sectors but not across countries
  - Factor returns–wage and rental rate–will equalize across sectors within each country

Model Environment and Assumptions

- Assume that North's stock of factors is such that they are **relatively abundant** in capital:

$$\frac{K^N}{L^N} > \frac{K^S}{L^S}$$

Model Environment and Assumptions

- The production functions for the two goods are

$$F_C(K_C, L_C) \text{ and } F_T(K_T, L_T)$$

  - In the Ricardian model, this was $F_C(L) = \frac{1}{a_C} L$

- These production functions will be increasing in each input, but at a diminishing rate:
  - $\frac{\partial F(K,L)}{\partial K} > 0$ and $\frac{\partial^2 F(K,L)}{\partial^2 K} < 0$
  - $\frac{\partial F(K,L)}{\partial L} > 0$ and $\frac{\partial^2 F(K,L)}{\partial^2 L} < 0$
  - First-order derivatives are the marginal products of each input
    - e.g. Adding a second cook to the kitchen provides a significant increase in output, but the 10th cook provides much less

Input Intensity of a Good

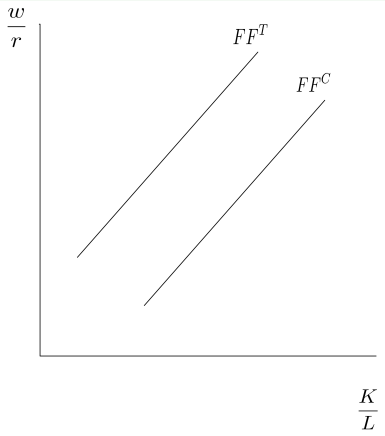
- Because there are now two factors used in production, goods differ in terms of how each factor is used in their production:
  - Computers are relatively more capital intensive than textiles
  - Textiles are relatively more labour intensive than computers

Input Intensity of a Good

- Definition: *A good is **relatively capital intensive** if, for a given relative factor price, the capital-labour ratio used in production is higher than the capital-labour ratio used in the production of the other good*
- Relative factor price is $\frac{w}{r}$, where w is the factor price of labour and r is the factor price of capital
- We can represent differences in relative capital intensity using what is called the **FF curve**

FF Curve: Factor Prices and Input Ratio

- For a fixed value of $\frac{w}{r}$, computers uses more capital relative to labour than textile
- As wages go up relative to capital, producers will use more capital relative to labour



Example

- Suppose that computers are relatively capital intensive and textiles are relatively labour intensive
- The production function below reflects these properties:

$$Q_C = K_C^{2/3} L_C^{1/3} \qquad\qquad Q_T = K_T^{1/3} L_T^{2/3}$$

- To derive the optimal values of $K_C,\ K_T,\ L_C,\ L_T$, we maximize the profit functions

$$P_C Q_C - rK_C - wL_C$$

$$P_T Q_T - rK_T - wL_T$$

- The derivatives of these profit functions with respect to each input give us the necessary conditions for optimality

Example

$$P_C K_C^{2/3} L_C^{1/3} - rK_C - wL_C$$
$$P_T K_T^{1/3} L_T^{2/3} - rK_T - wL_T$$

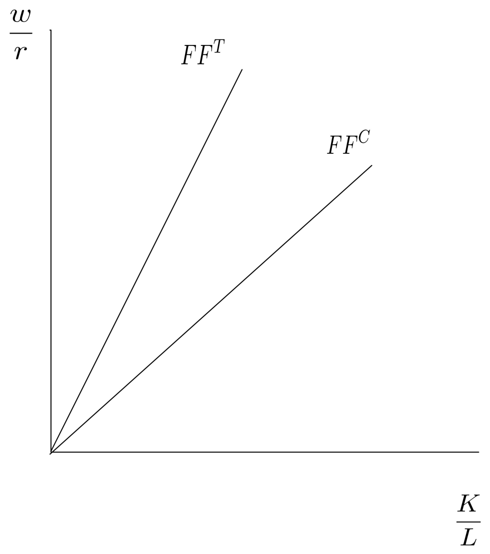
- When profits are maximized, marginal cost = marginal revenue

$$w = P_T \frac{2}{3} K_T^{1/3} L_T^{-1/3} \qquad w = P_C \frac{1}{3} K_C^{2/3} L_C^{-2/3}$$
$$r = P_T \frac{1}{3} K_T^{-2/3} L_T^{2/3} \qquad r = P_C \frac{2}{3} K_C^{-1/3} L_C^{2/3}$$

- Take the ratio of wage to capital factor prices for each good

$$\frac{w}{r} = 2\frac{K_T}{L_T}, \quad \frac{w}{r} = \frac{1}{2}\frac{K_C}{L_C}$$

Example



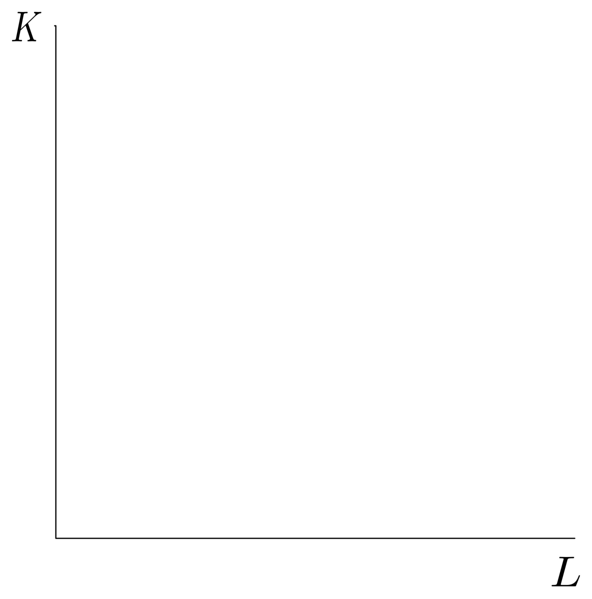
What Determines Factor Prices?

- The FF curves provides the relationship between relative factor price and relative factor demands
- But what drives relative factor price?
  - It turns out that in our model, it is the relative price of goods

What Determines Factor Prices?

- To show this, we derive what's called the **Stolper-Samuelson** curve (SS curve)
  - The SS curve relates relative **good** price $\frac{P_T}{P_C}$ to relative **factor** price $\frac{w}{r}$
- But before we can derive the SS curve, we need to introduce the **Lerner Diagram**
  - The Lerner Diagram will help us understand the underlying mechanism for the relationship between relative good price and relative factor price
  - It contains two curves: the **iso-value** curve and the **iso-cost** curve

Lerner Diagram

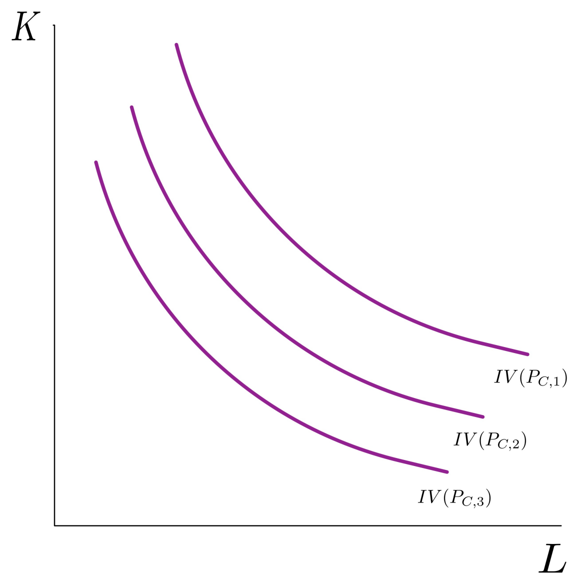


Lerner Diagram: Iso-Value Curves

- Iso-value curves maps all the combinations of capital and labour that yield \$1 of revenue for some given price
  - Start with $1 = P_C F_C(K, L)$, where $F_C(K, L)$ is the production function of computers (i.e. the output of computers for a given K and L)
  - For a given price of computers, P_C, what values of K and L produce \$1 of revenue?
    - Similar idea to indifference curves for consumer preferences

Lerner Diagram: Iso-Value Curves

Iso-value curves for prices $P_{C,3} > P_{C,2} > P_{C,1}$



Lerner Diagram: Iso-Cost Curves

- The iso-cost curves maps combinations of capital and labour that (as a bundle) cost \$1
- Given w and r, it is derived from

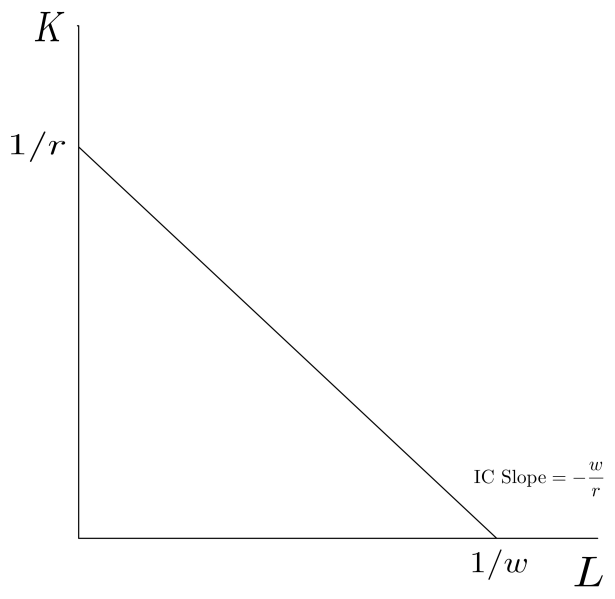
$$wL + rK = 1$$

- Rearranging gives

$$K = \frac{1}{r} - \frac{w}{r} L$$

- We can draw this curve in our Lerner Diagram

Lerner Diagram: Iso-Cost Curves



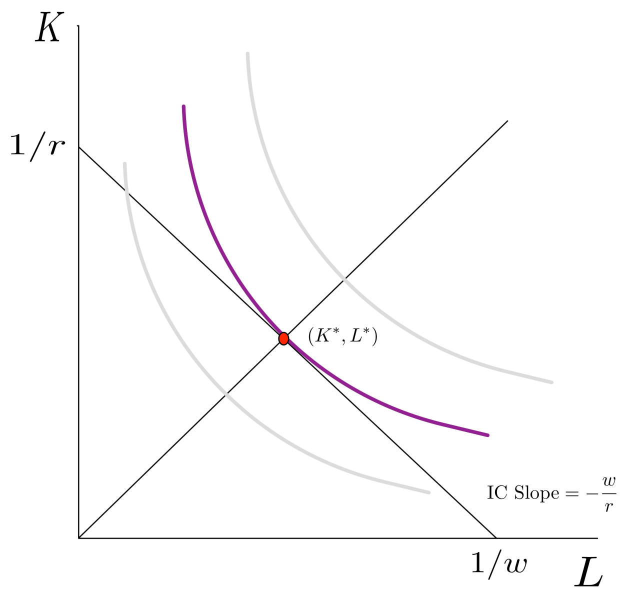
Lerner Diagram: Equilibrium

- Two conditions for an equilibrium:

1. The equilibrium bundle (K^*, L^*) must lie on **both** the iso-value and iso-cost curve
   - Why? because perfect competition results in revenue = cost
     - If profits were positive, firms enter driving down prices
     - If profits were negative, firms exit driving up prices
2. Both the iso-value and iso-cost curve have the same slope
   - The slope of the iso-cost curve is just $-\frac{w}{r}$ (which comes from the cost equation set to \$1)

- We derive the iso-value slope below

Lerner Diagram: Equilibrium



Lerner Diagram: Slope of the Iso-Value Curve

- The slope of the iso-value curve is the **marginal rate of technical substitution** (MRTS)
  - Similar idea as the **marginal rate of substitution** from consumer theory
- To derive the MRTS, start with

$$1 = P_C F_C(K, L)$$

- Move price to the left-hand side

$$\frac{1}{P_C} = F_C(K, L)$$

Lerner Diagram: Slope of the Iso-Value Curve

- In the Lerner Diagram we show the relationship between the input K *as a function* of L
- Keeping this in mind, take the total derivative of the equation $\frac{1}{P_C} = F_C(K, L)$ with respect to L
- In other words, take the derivative of both sides of the equation with respect to L

$$
\begin{aligned}
\frac{d(1/P_C)}{dL} &= \frac{dF_C(K,L)}{dL} \\
&= \frac{\partial F_C(K,L)}{\partial K}\frac{dK}{dL} + \frac{\partial F_C(K,L)}{\partial L}\frac{dL}{dL} \\
&= \frac{\partial F_C(K,L)}{\partial K}\frac{dK}{dL} + \frac{\partial F_C(K,L)}{\partial L}
\end{aligned}
$$

Lerner Diagram: Slope of the Iso-Value Curve

- Because $1/P_C$ is a constant, $\frac{d(1/P_C)}{dL} = 0$

$$0 = \frac{\partial F_C(K,L)}{\partial K}\frac{dK}{dL} + \frac{\partial F_C(K,L)}{\partial L}$$

- Rearranging the expression above

$$\frac{dK}{dL} = -\frac{\frac{\partial F_C(K,L)}{\partial L}}{\frac{\partial F_C(K,L)}{\partial K}}$$

- The derivatives on the right are the marginal products of labour and capital
  - They are a decreasing function of the inputs themselves based on our assumption on the production functions: $\frac{\partial F(K,L)}{\partial K} > 0$ and $\frac{\partial^2 F(K,L)}{\partial^2 K} < 0$, $\frac{\partial F(K,L)}{\partial L} > 0$ and $\frac{\partial^2 F(K,L)}{\partial^2 L} < 0$

Lerner Diagram: Equilibrium

- Now that we have the slope of both the iso-cost and iso-value curves, we can solve for the equilibrium input bundle
  - Iso-cost slope

$$-\frac{w}{r}$$

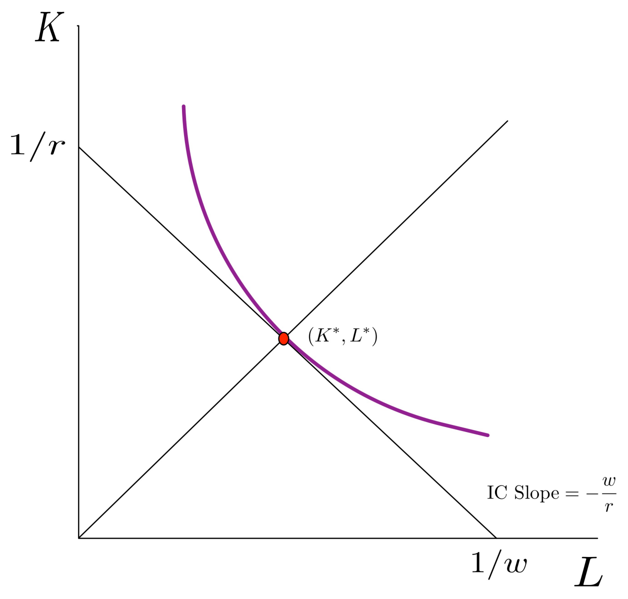
  - Iso-value slope

$$-\frac{\frac{\partial F_C(K,L)}{\partial L}}{\frac{\partial F_C(K,L)}{\partial K}}$$

Lerner Diagram: Equilibrium

- Recall that the equilibrium conditions must satisfy the following:
  1. The equilibrium bundle (K^*, L^*) must lie on both the iso-cost and iso-value curve
  2. The slopes of the iso-cost and iso-value curves must be equal
     - Note: In consumer theory, the equilibrium bundle is such that the slope of the indifference curve is equal to the slope of the budget constraint
- Therefore, the equilibrium set of inputs must be where the iso-cost curve and the iso-value curves are **tangent** to each other

Lerner Diagram: Equilibrium



Lerner Diagram: Two Industries

- So far, we have only considered one industry: computers
- With two industries, both industries share the same iso-cost curve (their cost functions are the same)

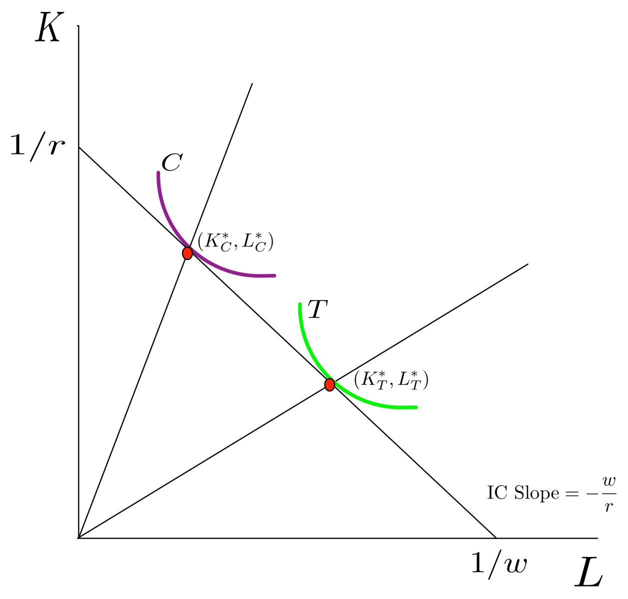
$$1 = rK + wL$$

  - Note: Wages and rental rates are the same across industries due to perfect labour/capital mobility

- Their iso-value curves are different because each industry face a different production function and prices

$$\begin{aligned} 1 &= P_C F_C(K, L) \\ 1 &= P_T F_T(K, L) \end{aligned}$$

Lerner Diagram: Two Industries



Lerner Diagram: Two Industries

- The straight line from the origin is the **Output Expansion Path (OEP)**
  - They reflect the factor intensity of a good
  - Steeper OEP means the good is more capital intensive

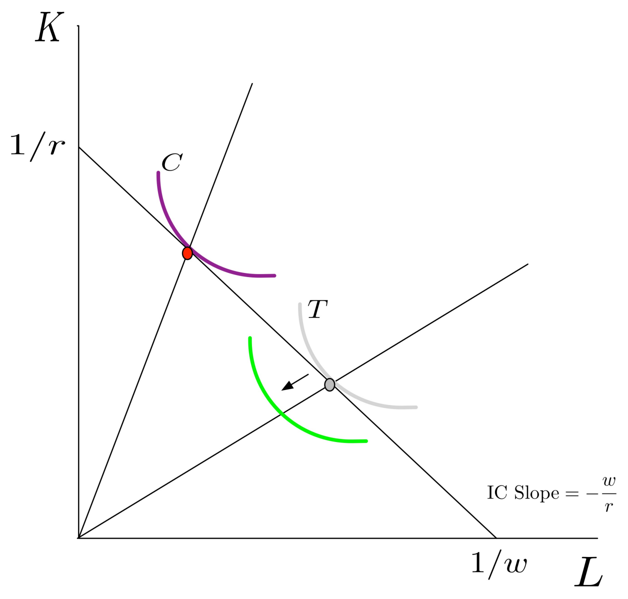
Drawing the SS Curve

- So how does any of this relate back to the SS curve
  - The curve that show the relationship between $\frac{P_T}{P_C}$ and $\frac{w}{r}$
- Let's conduct a thought experiment to see how a change in relative price changes relative factor returns in the model

Thought Experiment

- Suppose there was some exogenous shock causing an increase in price of textile, P_T
- To produce \$1 worth of revenue for textiles, we now need *fewer* inputs (both capital or labour) than before
  - $1 = P_T F_T(K, L)$
- Thus, the iso-value curve for textiles shifts *in*
- The iso-value curve for computers does not change

Thought Experiment



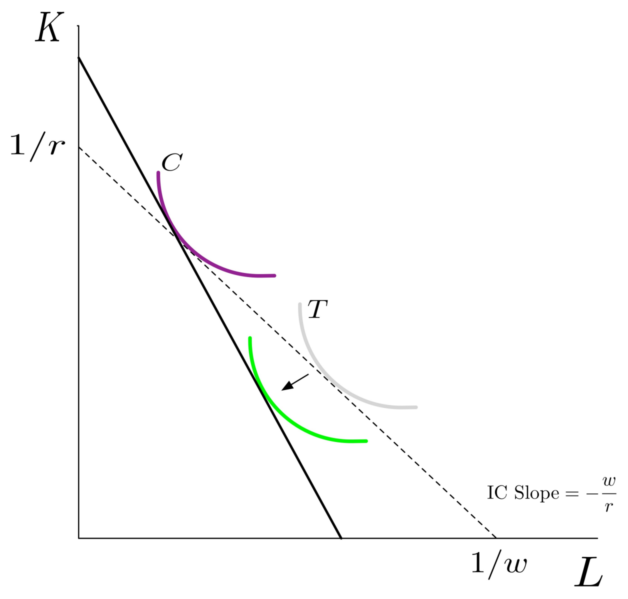
Thought Experiment

- Following this increase in textile price, there are now profits to be earned in the textile industry
  - Wages and rental of capital have not changed
- This will induce new firms to enter (or incumbent firms to expand their production)
  - As a result, capital and labour will flow into the textile industry to satisfy production demands by the new firms
- The economy produces more textiles and fewer computers
- Since textile is relatively labour-intensive, the increase demand for labourers will cause an increase in wages
- On the other hand, return to capital will decrease

Thought Experiment

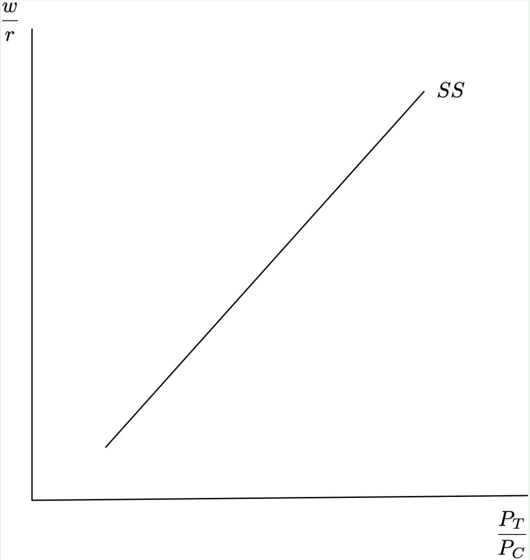
- The increase in $\frac{w}{r}$ is a combination of an increase in w due to greater labour demand *and* a decrease in r
  - For every unit of labour that leaves the computer industry, firms manufacturing computers must give up more capital than what's demanded by textile firms
  - The supply of capital increases and as a result returns to capital, r, decreases
  - The decrease in r and the corresponding increase in w causes the iso-cost curve to pivot
  - Adjustment continues until firms in each industry make zero profit

Thought Experiment



SS Curve

- When $\frac{P_T}{P_C}$ increases, $\frac{w}{r}$ rises



Next Class

- The thought experiment allows us to map changes in relative prices to changes in relative factor returns
  - We call the curve describing this relationship the SS curve
- Next class, we will bring this together with the FF curve to relate relative goods prices, relative factor prices, and the resulting optimal capital-labour ratio in each industry
- We will then introduce the Stolper-Samuelson Theorem, which will confirm our theoretical prediction about how changes in goods prices affects the real returns of the factors used in the production for those goods

Next Class

- From this we are going to be able to answer the question we stated in the beginning of the lecture: **How does the income distribution in a country change following a price shock arising from international trade?**