Announcements
Measuring the Gains of Trade
Summary

Econ 191: Measuring the Gains from Trade
Preparatory lecture for Professor Andrés Rodríguez-Clare

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Nov. 6, 2012
1 Announcements

2 Measuring the Gains of Trade
   - Introduction
   - The Armington Model
Announcements

- Assignment due:
  - Data (empirical papers)
  - Model setup (theoretical papers)
- General feedback handouts on the course webpage
- If you change your topic, submit a new 2-page research proposal ASAP
Next week, Prof. Rodriguez-Clare will discuss:

Measuring the Gains from Trade

Introduction

The Armington Model

Background for Nov. 13: “Measuring Gains from Trade”
Outline

1. Announcements

2. Measuring the Gains of Trade
   - Introduction
   - The Armington Model
Samuelson (1939): There are gains in international trade.
**Samuelson (1939):** There are gains in international trade.

- Under perfect competition, opening up to trade expands the PPF and leads to Pareto superior outcomes.
Samuelson (1939): There are gains in international trade.

- Recall Econ 1: Assume that the production technologies in countries A and B produce the following yields per acre for wheat and cotton:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>2 bushels</td>
<td>6 bushels</td>
</tr>
<tr>
<td>Cotton</td>
<td>6 bales</td>
<td>2 bales</td>
</tr>
</tbody>
</table>

Who has the absolute advantage in producing wheat? The comparative advantage?
Assuming that each country has 100 acres of farmland, and both economies are closed, their PPFs look as the following:
Side note: Without trade, where will these countries produce on the PPF?

Hint: Recall last week’s lecture...
A: Depends on the preferences of each country’s consumers for cotton in relation to wheat. If both countries’ consumers get equal utility from cotton and wheat, these preferences could be represented in the indifference curves below (assuming preferences can be aggregated here).
Okay, back to trade: **Because each country has an absolute advantage in producing one product, specialization and trade will benefit both.**

Consider the total production of each country before and after specialization and trade, assuming each country’s consumers get equal utility from wheat and cotton:

**Before trade:**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>(75 acres)*(2 bushels/acre)</td>
<td>(25 acres)*(6 bushels/acre)</td>
</tr>
<tr>
<td>Cotton</td>
<td>(25 acres)*(6 bales/acre)</td>
<td>(75 acres)*(2 bales/acre)</td>
</tr>
</tbody>
</table>

In this scenario, each country produces and consumes 150 bushels of wheat and 150 bales of cotton.
Okay, back to trade: **Because each country has an absolute advantage in producing one product, specialization and trade will benefit both.**

Consider the total production of each country before and after specialization and trade, assuming each country’s consumers get equal utility from wheat and cotton:

### After trade:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wheat</strong></td>
<td>0 acres = 0 bushels</td>
<td>(100 acres)*(6 bushels/acre)</td>
</tr>
<tr>
<td><strong>Cotton</strong></td>
<td>(100 acres)*(6 bales/acre)</td>
<td>0 acres = 0 bales</td>
</tr>
</tbody>
</table>

In this scenario, each country produces 600 units of the commodity for which it has the absolute advantage, and trades half for half of the other country’s commodity.
Where does this new production level fall on each country’s PPF?
Outline

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CES utility functions

We’ve already looked at utility functions in general in previous weeks, so let’s focus on building up the concept of constant elasticity of substitution (CES).
Marginal rate of substitution (MRS): The rate at which a consumer is ready to give up one good in exchange for another good while maintaining the same level of utility.

E.g. If goods A and B are continuously divisible, then at levels $(a, b)$ of goods A and B, a consumer’s MRS of A for B (i.e. willingness to give up units of good A for units of good B) is:

$$MRS_{a,b} = \frac{MU_a}{MU_b} = d\ln\left(\frac{U_a}{U_b}\right)$$

where $MU_a$ is the marginal utility of consuming one unit beyond $a$ of good A, and where the last result is derived from the properties of natural logs.
Tools for the Armington Model

CSES utility functions

- **Elasticity of substitution (in a utility function):** For a generic utility function $U(c_1, c_2)$ where $c_1$ and $c_2$ represent the amounts consumed of goods 1 and 2 respectively, the **elasticity of substitution** of $c_1$ for $c_2$ is the amount by which the consumer’s willingness to give up $c_1$ for units of $c_2$ changes when the relative MUs of consuming goods 1 and 2 change:

$$
\varepsilon = \frac{\ln(c_2 / c_1)}{\ln(\text{MRS}_{1,2})} = -\frac{\ln(c_2 / c_1)}{\ln(\text{MRS}_{2,1})} = -\frac{\ln(c_2 / c_1)}{\ln(U_{c_2} / U_{c_1})} = -\frac{\ln(c_2 / c_1)}{\ln\left(\frac{dU_{c_2} / U_{c_2}}{dU_{c_2} / U_{c_1}}\right)}
$$

where $U_{c_1}$ is the derivative of $U$ WRT $c_1$, and where we again exploit the properties of natural logs to simplify the expression.


**Tools for the Armington Model**

**CES utility functions**

Different consumers may display (theoretically) different elasticities of substitution:

- **Constant elasticity of substitution (CES):** For every value of consumption ratio $\frac{c_2}{c_1}$, a particular percentage change in $MRS$ will cause $\frac{c_2}{c_1}$ to change at a constant rate (i.e. to experience a constant percentage change).

- **Increasing elasticity of substitution (IES):** As consumption ratio $\frac{c_2}{c_1}$ increases, a particular percentage change in $MRS$ will cause $\frac{c_2}{c_1}$ to change at an increasing rate (i.e. to experience increasing percentage changes).
CES utility functions

Different consumers may display different types of elasticity of substitution:

- **Decreasing elasticity of substitution (DES):** As consumption ratio $\frac{c_2}{c_1}$ increases, a particular percentage change in $MRS$ will cause $\frac{c_2}{c_1}$ to change at a decreasing rate (i.e. to experience decreasing percentage changes).
Tools for the Armington Model

CES utility functions

We have now built our way to describe a CES utility function:

- **Constant elasticity of substitution (CES) utility function:** A utility function that displays a constant elasticity of substitution.
  - An individual with CES utility choosing levels of each good \( i = 1, 2, \ldots, n \) would have the following utility function:

\[
C = \left( \sum_{i=1}^{n} c_i^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}
\]

where \( c_i \) is the individual’s demand for good \( i \), and where \( \sigma > 1 \) is the (constant) elasticity of substitution between goods.
Gravity equation

Gravity equation (Tinbergen 1962): Countries with larger GDPs, or who are closer to each other, have more trade between them.

- Underlying idea: Models of monopolistic competition predict that countries with large GDP should trade the most with each other because:
  1. Larger countries export more because they produce more product varieties
  2. Larger countries import more because their demand is higher.
Tools for the Armington Model

Gravity equation

Newton’s Universal Law of Gravitation: Suppose two objects have mass $M_1$ and $M_2$ and are located distance $d$ apart. The force of gravity $F_g$ between these two objects is

$$F_g = G \times \frac{M_1 \times M_2}{d^2}$$

where $G$ is a constant describing the magnitude of the relationship between mass and distance and force.

Punchline: $M \uparrow$ or $d \downarrow \implies F \uparrow$. 
Gravity equation

The gravity equation in trade: Suppose two countries have \( GDP_1 \) and \( GDP_2 \), respectively, and are located distance \( d \) apart. The amount of trade predicted to occur between the countries is:

\[
Trade = B \times \frac{GDP_1 \times GDP_2}{d^n}
\]

Note here that \( n \) is not necessarily set equal to 2 because we do not have complete information on the precise relationship between distance and trade.

Punchline: \( GDP_{1,2} \uparrow \) or \( d \downarrow \implies Trade \uparrow \).
Tools for the Armington Model

Gravity equation

\[ Trade = B \times \frac{GDP_1 \times GDP_2}{d^n} \]

Also note one of the differences between theoretical and econometric models here:

- In theoretical models, we can assume causality because we are proposing an idea about a system works in absence of confounding variables.
- In both lab and field research, however, confounding variables will always be present: The only way to convincingly argue that they don’t affect your results is to achieve conditional independence through research design.
Tools for the Armington Model

Gravity equation: Criticism and evolution


However, the last 10 years has seen an 'explosion’ of alternative microtheoretical foundations underlying gravity equations, which give:

- The same macro-level prediction regarding the structure of bilateral trade flows as a function of cost
- Additional micro-level predictions that vary with the market structure assumed.
Gravity equation: Use in international trade

Trade economists use multi-country gravity models for counterfactual analysis.

- **Counterfactual analysis** here involves the use of gravity models to quantify the gains from international trade that would be associated with moving one country from the current, observed trade equilibrium to a counterfactual equilibrium with no trade.

The Armington Model

Brief description: The Armington Model is the simplest gravity equation used in the study of international trade.

Assumptions and Setup

- Consider a world economy comprising $j = 1, \ldots, n$ countries.
- Each country is endowed with $Q_i$ units of a distinct good $i = 1, \ldots, n$.
- Note that, because each country produces one good distinct from all other goods, the country and good notations are interchangeable to some extent.
The Armington Model

Assumptions and Setup

- Each country is populated by a representative agent whose preferences are represented by a CES utility function:

\[ C_j = \left( \sum_{i=1}^{n} C_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)} \]

where \( C_{ij} \) is the demand for good \( i \) in country \( j \), and \( \sigma \) is the elasticity of substitution between goods \( i = 1, \ldots, n \).
Assumptions and Setup

- The associated price index in country $j$ for goods goods $i = 1, ..., n$ is given by

$$P_j = \left( \sum_{i=1}^{n} P_{ij}^{1-\sigma} \right)^{1/(1-\sigma)}$$

where $P_{ij}$ is the price of good $i$ in country $j$. 

The Armington Model

Assumptions and Setup

- Each country is subject to iceberg transport costs in international trade:
  - **Iceberg trade costs** (Samuelson 1954): A cost of transporting a good that uses up only some fraction of the good itself, rather than using any other resources.
  - One way to formally model iceberg trade costs is to introduce the following assumption:

In order to sell one unit of good $i$ in country $k$, firms from country $j$ must ship $\tau_{i,jk} \geq 1$ units, where country $j$’s domestic transport cost for good $i$ $\tau_{i,jj}$ equals 1.
The Armington Model

Assumptions and Setup

- Assume no opportunities for arbitrage exist.
- **Arbitrage**: A trading strategy that requires the investment of no capital, cannot lose money, and has a positive probability of making money.
  
  E.g. If a commodity is listed at different prices simultaneously on different stock exchanges, a trader could purchase the commodity at the cheaper price and sell it on the other market at the more expensive price.

- For this **no-arbitrage condition** to hold, the price of country \( j \)'s good \( i \) in country \( k \) must only be a function of the good's domestic price and transport cost:
  
  \[ P_{i,jk} = \tau_{i,jk} P_{i,jj}. \]
Assumptions and Setup

- The domestic price $P_{i,jj}$ of good $i$, then, is a function of country $j$’s total income $Y_j$, and $j$’s endowment of its distinct good $i$, $Q_{i,j}$:

  $$P_{i,jj} = \frac{Y_j}{Q_{i,j}}.$$  

- Combining this expression with the no-arbitrage condition, we get the price of country $j$’s good $i$ in country $k$:

  $$P_{i,jk} = \tau_{i,jk} \frac{Y_j}{Q_{i,j}}.$$
Assumptions and Setup

- Let $X_{jk}$ denote the total value of country $j$’s imports from country $k$.

- Given CES utility functions, bilateral trade flows satisfy

$X_{jk} = \left( \frac{P_{i,jk}}{P_j} \right)^{1-\sigma} E_j$

where $E_j = \sum_{i=1}^{n} \sum_{k=1}^{n} X_{jk}$ is country $j$’s total expenditure on goods from all countries.
Combining the expressions for $P_{i,jj}$, $P_{i,jk}$, and $X_{jk}$, we obtain the following gravity equation:

$$X_{jk} = \frac{\chi_{i,j}(E_j^\tau_{i,jk})^{-\varepsilon}}{\sum_{l=1}^{n} \chi_{l,j}(E_l^\tau_{l,jk})^{-\varepsilon}} E_j$$

where

- **trade elasticity** $\varepsilon \equiv (\sigma - 1)$ denotes how the demand for imports relative to domestic demand ($\frac{X_{jk}}{X_{jj}}$) changes as bilateral trade costs $\tau_{i,jk}$ change.

- exogenous import demand shifter $\chi_{i,j} \equiv Q_i^\sigma j^{-1}$ is a function of country $j$’s endowment and its trade elasticity.
Assumptions and Setup

- Assume market-clearing conditions for goods:
  \[ Y_j = \sum_{i=1}^{n} \sum_{k=1}^{n} X_{i,k,j}. \]

- Assume that each country spends its entire income:
  \[ E_j = Y_j. \]
Finally, we combine the market-clearing and budget constraint equality conditions to construct the trade-balance condition:

\[
\sum_{i=1}^{n} \sum_{k=1}^{n} X_{i,jk} = \sum_{i=1}^{n} \sum_{k=1}^{n} X_{i,kj}.
\]
Solution:

A trade equilibrium in the Armington model is thus composed of the matrix of bilateral trade flows $\mathbf{X} \equiv \{X_{i,jk}\}$ and the vector of country expenditure levels $\mathbf{E} \equiv \{E_j\}$ such that the above gravity equation and trade balance condition hold simultaneously.
The Armington Model

Strengths and Weaknesses of the Armington Model

Strengths:

- Simple.

  Makes the counterfactual equilibrium with no trade (in the next section) easy to compute.

Weaknesses:

- Makes the ad-hoc assumption that each country is exogenously endowed with a distinct good.
Recall that international trade economists use the gravity equation for trade to quantify the gains from international trade via counterfactual analysis.

- In this context, the **gains from international trade** equals the (absolute value of) the percentage change in real income associated with moving one country from the current, observed trade equilibrium to a counterfactual equilibrium.
Rodríguez-Clare and Costinot (2012; Hereafter RCC) illustrate how the gravity equation can be used in 2 steps to quantify the welfare consequences of globalization, which they model as an exogenous shock to transport costs $\tau$ and exogenous import demand shifters $\chi$:

1. They show how changes in real consumption (i.e. gains from trade) can be observed from changes in two observable macro variables: bilateral trade $X$ and income expenditures $E$.

2. They compute the effects of exogenous shocks to $\tau$ and $\chi$ on $X$ and $E$. 
Assumptions and Setup

- Define country $j$’s real (i.e. price-adjusted) consumption as

$$C_j \equiv \frac{E_j}{P_j}.$$
The Armington Model

Counterfactual Analysis

Step 1: Show how changes in $C_j$ can be inferred from changes in bilateral trade and income expenditures alone.

Step 1a: Show that, for small shocks, changes in $C_j$ can be inferred from 2 statistics alone:

1. $\lambda_{jj} \equiv \frac{X_{i,jj}}{\sum_i \sum_k X_{i,jk}}$, changes in country $j$’s share of expenditures on domestic goods

2. $\varepsilon$, the trade elasticity from the gravity equation

$$X_{jk} = \frac{\chi_{i,j}(E_j \tau_{i,jk})^{-\varepsilon}}{\sum_{l=1}^{n} \chi_{l,j}(E_l \tau_{l,jk})^{-\varepsilon}} E_j.$$

Recall that trade elasticity here is change in imports relative to domestic demand ($\frac{X_{jk}}{X_{jj}}$) caused by changes in bilateral trade costs $\tau_{i,jk}$.

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Background for Nov. 13: “Measuring Gains from Trade”
Step 1a: Show that, for small shocks, $\lambda_{jj}$ and $\varepsilon$ are sufficient to infer changes in $C_j$.

- Note that CES utility functions for each country $j$ allow us to decompose changes in $P_j$ into changes in domestic and import prices:

$$d\ln P_j = \lambda_{jj} d\ln P_{jj} + (1 - \lambda_{jj}) d\ln P_j^M$$

where $P_j^M \equiv (\sum_{j \neq k} P_{i,jk}^{1-\sigma})^{\frac{1}{1-\sigma}}$ is the component of the price index associated with imports.
Step 1a: Show that, for small shocks, $\lambda_{jj}$ and $\varepsilon$ are sufficient to infer changes in $C_j$.

- Also note that by differentiating bilateral trade flow condition

$$X_{jk} = \left(\frac{P_{i,jk}}{P_j}\right)^{1-\sigma} E_j,$$

we can show that

$$d\ln(1 - \lambda_{jj}) - d\ln\lambda_{jj} = (1 - \sigma)(d\ln P_j^M - d\ln P_{jj}).$$
Step 1a: Show that, for small shocks, $\lambda_{jj}$ and $\varepsilon$ are sufficient to infer changes in $C_j$.

Combining this result with the decomposition of $P_j$, and by applying the arithmetic natural log identity

$$\lambda_{jj} d\ln \lambda_{jj} = -(1 - \lambda_{jj}) d\ln(1 - \lambda_{jj}),$$

we get that

$$d\ln P_j = d\ln P_{jj} - \frac{d\ln \lambda_{jj}}{1 - \sigma}.$$
The Armington Model

Counterfactual Analysis

Step 1a: Show that, for small shocks, $\lambda_{jj}$ and $\varepsilon$ are sufficient to infer changes in $C_j$.

- Plugging this result into real consumption definition $C_j \equiv \frac{E_j}{P_j}$ and taking natural logs and derivatives, we can express changes in real consumption resulting from changes in $\lambda_{jj}$ as:

$$d\ln C_j = (d\ln E_j - d\ln P_{jj}) + \frac{d\ln \lambda_{jj}}{1-\sigma}.$$ 

- Moreover, we can have $\varepsilon$ enter this expression by recalling that $\varepsilon \equiv 1 - \sigma$:

$$d\ln C_j = (d\ln E_j - d\ln P_{jj}) - \frac{d\ln \lambda_{jj}}{\varepsilon}.$$
Step 1a: Show that, for small shocks, $\lambda_{jj}$ and $\varepsilon$ are sufficient to infer changes in $C_j$.

$$d\ln C_j = (d\ln E_j - d\ln P_{jj}) - \frac{d\ln \lambda_{jj}}{\varepsilon}.$$

Finally, we can simplifying the expression by noting that the exogeneity of each country $j$’s endowment $Q_i$ in the Armington model causes $(d\ln E_j - d\ln P_{jj})$ to equal 0 by the definitions above, implying:

$$d\ln C_j = -\frac{d\ln \lambda_{jj}}{\varepsilon}.$$
The Armington Model

Counterfactual Analysis

Step 1a: Show that, for small shocks, $\lambda_{jj}$ and $\varepsilon$ are sufficient to infer changes in $C_j$.

$$d\ln C_j = -\frac{d\ln \lambda_{jj}}{\varepsilon}$$

In sum, whatever the origins of the exogenous shock to $X$ and $E$ may be, two statistics—trade elasticity $\varepsilon$ and changes in the share of expenditure on domestic goods $\lambda_{jj}$—are sufficient to infer welfare changes.
Step 1: Show how changes in $C_j$ can be inferred from changes in bilateral trade and income expenditures alone.

Step 1b: Show that, for large shocks, integration of the result derived in Step 1a is sufficient to infer changes in $C_j$. 

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Background for Nov. 13: “Measuring Gains from Trade”
Step 1b: Show that, for large shocks, integration of the result derived in Step 1a is sufficient to infer changes in $C_j$.

- Since the previous expression

$$d \ln C_j = -\frac{d \ln \lambda_{jj}}{\varepsilon}$$

holds for any small shock to $\tau$ and $\chi$, the welfare (i.e. consumption) consequences of large shocks to $\tau$ can be calculated by integrating the result from Step 1a over all values of $\lambda_{jj}$:

$$\hat{C}_j = \hat{\lambda}_{jj}^{-1/\varepsilon},$$

where the “hat”-value $\hat{\cdot}$ of any variable $\nu$ denotes the change in the variable between the initial and counterfactual equilibria.
Step 2: Compute the effects of exogenous shocks to $\tau$ and $\chi$ on $X$ and $E$.

Dekle, Eaton and Kortum (2008):

- Let $\lambda_{i,jk} \equiv \frac{X_{i,jk}}{\sum_l X_{lk}}$ denote the share of country $k$’s total expenditure on goods from country $j$.

- Because the gravity equation holds in both the initial and counterfactual equilibria, the difference in $\lambda_{i,jk}$ between the initial and counterfactual equilibria can be estimated from the observed differences in equilibrium values of $E$, $\tau$, and $\chi$:

$$\hat{\lambda}_{i,jk} = \frac{\hat{x}_{i,j}(\hat{E}_j \hat{\tau}_{i,jk})^{-\varepsilon}}{\sum_{l=1}^n \lambda_{lj} \hat{x}_{l,j}(\hat{E}_l \hat{\tau}_{l,jk})^{-\varepsilon}}.$$
The Armington Model
Counterfactual Analysis

Step 2: Compute the effects of exogenous shocks to \( \tau \) and \( \chi \) on \( X \) and \( E \).

Dekle, Eaton and Kortum (2008):

- The trade balance condition \( \sum_{k=1}^{n} X_{jk} = \sum_{k=1}^{n} X_{kj} \) of the Armington model implies that each country’s expenditures equals the sum of every other country’s expenditures on country \( j \)’s good \( i \):

\[
E'_{j} = \sum_{i=1}^{n} \sum_{k=1}^{n} \chi_{i,kj} E'_{k}.
\]

Note that this condition holds in both the initial and counterfactual equilibria, but we will only exploit it in the counterfactual case.
Step 2: Compute the effects of exogenous shocks to $\tau$ and $\chi$ on $X$ and $E$.

Dekle, Eaton and Kortum (2008):

- Combining the above trade balance condition with the expression for $\hat{\lambda}_{i,jk}$ above, we get

$$\hat{E}_j E_j = \sum_{i=1}^{n} \sum_{k=1}^{n} \frac{\lambda_{i,kj} \hat{\chi}_{i,j}(\hat{E}_j \hat{\tau}_{i,kj})^{-\varepsilon} \hat{E}_k E_k}{\sum_{l=1}^{n} \lambda_{i,lj} \hat{\chi}_{i,l}(\hat{E}_l \hat{\tau}_{lj})^{-\varepsilon}}.$$

- This expression allows us to compute $\hat{E}_j$, the effect of exogenous shocks to $\tau$ and $\chi$ on country $j$’s expenditure levels, as long as we also know $\varepsilon$’s value.

- However, we still need to compute the effect of exogenous shocks to $\tau$ and $\chi$ on bilateral trade $X$. We will represent $X$ by $\lambda_{i,jk}$, the share of country $k$’s total expenditures spent on goods from country $j$. 

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Background for Nov. 13: “Measuring Gains from Trade”
Step 2: Compute the effects of exogenous shocks to $\tau$ and $\chi$ on $X$ and $E$.

Dekle, Eaton and Kortum (2008):

- Recall the formula for $\hat{\lambda}_{i,jk}$, the change in country $k$’s total expenditure on goods from country $j$:

$$
\hat{\lambda}_{i,jk} = \frac{\hat{\chi}_{i,j}(\hat{E}_j\hat{\tau}_{i,jk})^{-\varepsilon}}{\sum_{l=1}^{n} \lambda_{lj}\hat{\chi}_{l,j}(\hat{E}_l\hat{\tau}_{l,jk})^{-\varepsilon}}.
$$

- Because changes $\hat{E}_j$ were calculated from $\hat{\tau}$ and $\hat{\chi}$ in the previous slide, we can now use this formula to compute $\hat{\lambda}_{i,jk}$.

We now have $\hat{E}_j$ and $\hat{\lambda}_{i,jk}$, the effects of exogenous shocks to $\tau$ and $\chi$ on $X$ and $E$. 
The Armington Model
Counterfactual Analysis

Summary

In order to calculate the welfare gains from international trade, RCC:

1. Show how changes in real consumption (i.e. gains from trade) can be observed from changes in two observable macro variables: bilateral trade $X$ and income expenditures $E$.

2. Compute the effects of exogenous shocks to $\tau$ and $\chi$ on $X$ and $E$. 
In order to demonstrate the usefulness of the simple Armington model, RCC examine a counterfactual exercise in which they move to autarky (a closed economy).
Assumptions

- Assume that the iceberg trade costs in the counterfactual equilibrium are now infinite, i.e. $\tau'_{i,jk} = +\infty$ for any pair of countries $j \neq k$, so that no international trade occurs.

- All other structural parameters are the same as in the initial equilibrium.
The Armington Model
Counterfactual Analysis: Practical Example

Setup

- Here, RCC define country $j$’s gains from international trade $G_j$ as the absolute value of the percentage change in real income associated with moving to the counterfactual equilibrium.

- Note that, because $\lambda_{jj}$, the share of expenditure on domestic goods in autarky, equals 1, it will be the case that $\hat{\lambda}_{jj} = \frac{1}{\lambda_{jj}}$.

- Combining this fact with the general counterfactual analysis model’s formula for welfare consequences of a foreign shock

$$\hat{C}_j = \hat{\lambda}_{jj}^{-1/\varepsilon},$$

we get the following formula for gains of trade:

$$G_j = 1 - \lambda_{jj}^{1/\varepsilon}.$$
The Armington Model
Counterfactual Analysis: Practical Example

Setup

\[ G_j = 1 - \lambda_j^{1/\varepsilon} \]

- In order to compute \( G_j \), we still need measures of trade elasticity \( \varepsilon \) and \( \lambda_{jj} \), country \( j \)'s share of expenditure on domestic goods \( \lambda_{jj} \) in the current equilibrium.
Setup

Computing trade elasticity $\varepsilon$ using data, however, is problematic econometrically (Hummels and Hillberry 2012; Head and Mayer 2012).

- RCC ID a common practice in the literature: Estimating $\varepsilon$ by running a cross-sectional regression analogous to the log form of the Armington model’s gravity equation:

$$
\ln X_{i,jk} = \delta^X_j + \delta^M_k - \varepsilon \ln \tau_{i,jk} + \delta_{i,jk},
$$

where

- $\delta^X_j \equiv \ln \chi_{i,j} - \varepsilon \ln Y_j$ is treated as an exporter FE
- $\delta^M_j \equiv \ln Y_k - \ln [\sum_{l=1}^n \chi_{i,l}(Y_l \tau_{lk})^{-\varepsilon}]$ is treated as an importer FE
- $\delta_{i,jk}$ is treated as ME in trade flows orthogonal to $\ln \tau_{i,jk}$. 

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### The Armington Model

**Counterfactual Analysis: Practical Example**

#### Solution

\[
\ln X_{i,j_k} = \delta_j^X + \delta_k^M - \varepsilon \ln \tau_{i,j_k} + \delta_{i,j_k}.
\]

- Because RCC is a theoretical paper, rather than estimating the coefficient \( \varepsilon \) with data, they set trade elasticity \( \varepsilon = 5 \), a value found commonly in the empirical literature (Anderson and Van Wincoop 2004).
Setup

However, RCC are able to calculate $\lambda_{jj}$ from year-2000 OECD-STAN Input-Output tables by algebraically exploiting the definition of $\lambda_{jj}$:

$$
\lambda_{jj} \equiv \frac{X_{jj}}{E_j} = 1 - \frac{\sum_{j \neq k} X_{jk}}{\sum_{j=1}^{n} X_{jk}}
$$
Results

- When RCC calculate each country $j$’s gains from trade

\[ G_j = 1 - \lambda_{jj}^{1/\varepsilon} \]

using trade elasticity $\varepsilon = 5$ recommended in the literature and country-level share of expenditure on domestic goods $\lambda_{jj}$ calculated from OECD data, they conclude:

There is a considerable amount of variation in the magnitude of the gains from trade predicted by the simple Armington model: $G_j$ ranges from 0.6 percent (Japan) to 4.6 percent (Slovakia).
The Armington Model

Resources

Resources used for Armington model tools, setup, solution, and applications:

- Rodríguez-Clare and Costinot, 2012: “Trade Theory with Numbers: Quantifying the Consequences of Globalization.”
- Rodríguez-Clare, Graduate International Trade 280A, UC Berkeley, Lecture 1 notes.
- Feenstra and Taylor, *International Trade*. 

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Summary

- Trade economists use multi-country gravity models for counterfactual analysis.
  - The Armington model is the simplest gravity model used in international trade.
- Counterfactual analysis in the context of international trade models the gains from international trade defined as the percentage change in real income associated with moving one country from the current, observed trade equilibrium to a counterfactual equilibrium with no trade.
Announcements
Measuring the Gains of Trade
Summary

10-minute Break

Stay tuned for a skills lecture: “How to Obtain and Present Results”...