Ricardian Theory

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ECON4415 International Trade, Lecture 1, Fall 2018

Today's lecture

- Taxonomy of neoclassical trade models
- Standard Ricardian model
- Multi-goods extension (DFS 1977)
  1. Free trade equilibrium
  2. Comparative statics
- Multi-country extensions

Basic law of comparative advantage: further issues

- The basic law of comparative advantage is often written as follows

$$(p^{Ak} - p) \cdot M^k \geq 0 \text{ for all } k.$$

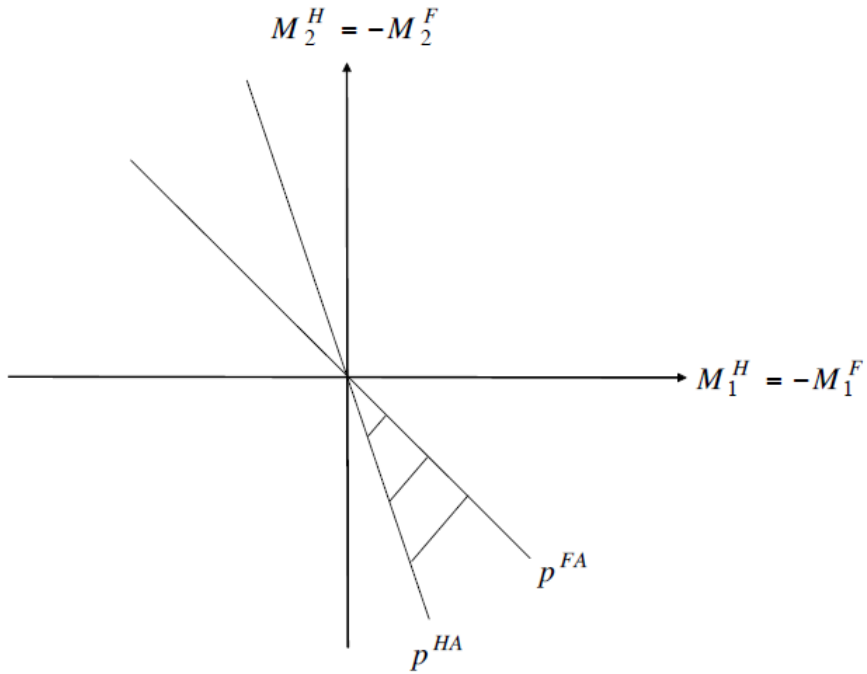
- According to this law there is a positive "association" across products between the autarky-trade price difference and net imports. On average, every country imports (exports) goods with autarky price relative higher (lower) than trading-equilibrium prices.

Basic law of comparative advantage: a useful normalization

- Alternatively, we can normalize prices to lie on the unit simplex: $\sum_i p_i = \sum_i p_i^{Ak} = 1$ for all k. This is equivalent to fixing a bundle of one unit of each good as the numeraire.
- With this normalization, $\sum_i (p_i^{Ak} - p_i) = 0$ and $(p^{Ak} - p) \cdot M^k \geq 0$ imply that
$$corr(p^{Ak} - p, M^k) \geq 0.$$
- In the case of two countries, we can obtain a sharper result (only need autarky prices):
$$corr(p^{Ak} - p^{A(-k)}, M^k) \geq 0.$$
- And with 2 commodities and our choice of numeraire,
$$M_i^k > 0 \iff p^{Ak} > p^{A(-k)} \text{ for } i = 1, 2.$$

2 countries and 2 goods

- In this case of 2 countries and 2 goods, we can represent the net import vectors as follows:



- The vector $M^H = -M^F$ has to be in the shaded cone.

What determines autarky prices?

- Our treatment of the basic law of comparative advantage highlighted the role of differences in autarky prices in determining trade patterns and volumes.
  - with $p^{Ak} = p^A$ for all k, we have no trade
- In a neoclassical trade model, comparative advantage, i.e. differences in relative autarky prices, is the rationale for trade
- Fundamental sources of autarky price differences:

  - Demand (periphery of the field)
    - Taste differences: Non-homothetic demand; exogenous taste differences across countries

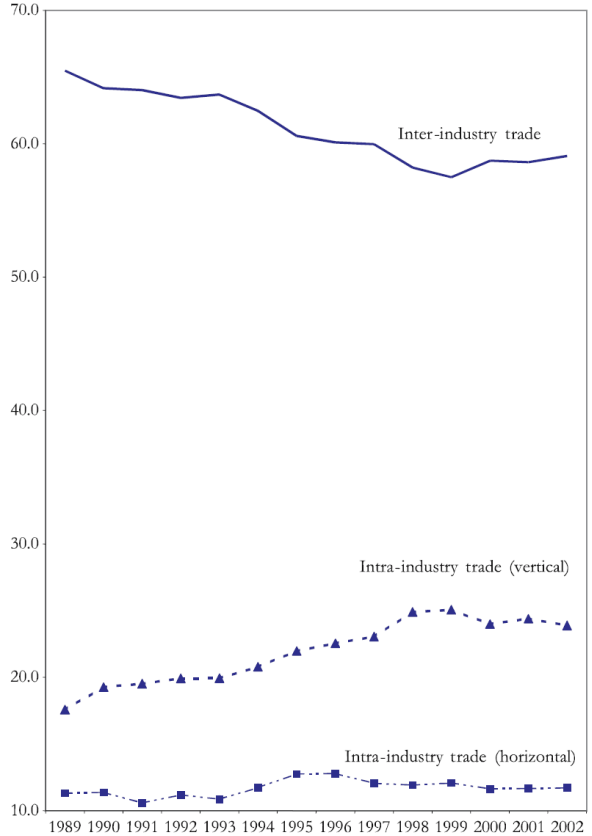
  - Supply (core of the field)
    - Technological differences: **Ricardian theory**
    - Factor endowment differences: **Factor proportion theory**

Assumptions

- In order to shed light on the role of technological and factor endowment differences:
  - Ricardian theory assumes only one factor of production
  - Factor proportion theory rules out technological differences
- Neither set of assumptions is realistic, but both may be useful depending on the question one tries to answer:
  - If you want to understand the impact of the rise of China on real wages in the US, Ricardian theory may be the natural place to start
  - If you want to study its effects on the skill premium, more factors will be needed
- Note that:
  - Technological and factor endowment differences are exogenously given (c.e. Trade and growth?)
  - No relationship between technology and factor endowments (c.e. Skill-biased technological change?)

Inter- or intra-industry trade?

Figure 4: *Evolution 1989–2002 of the Trade Types (per cent of world trade)*

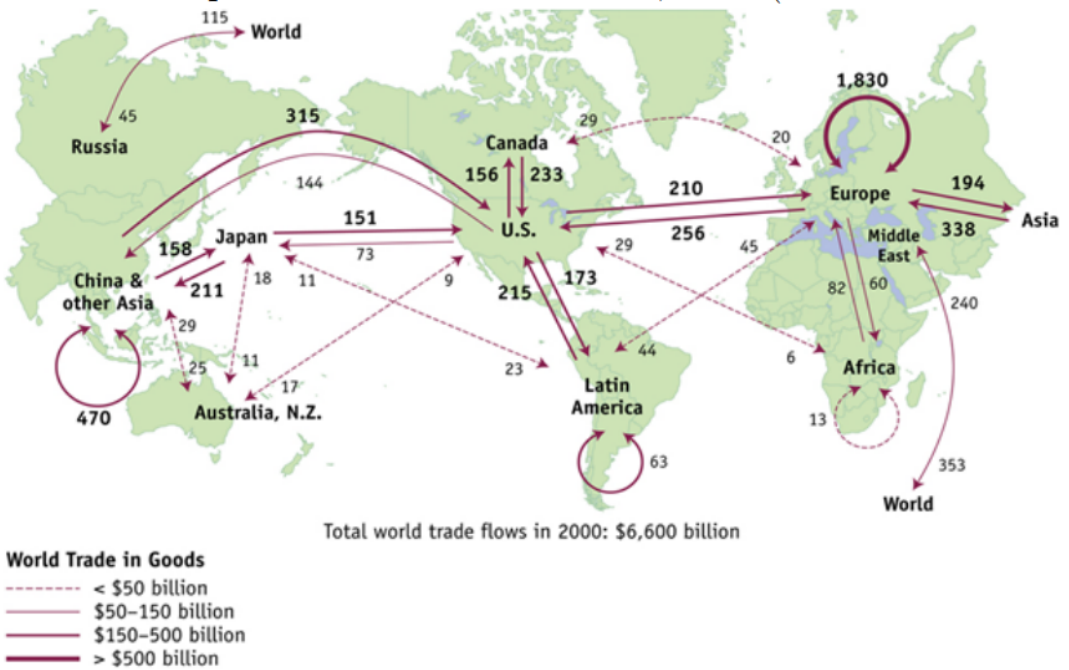


Note: Non-allocated trade flows have not been plotted. They account for roughly 3 per cent of total trade flows each year. We rely on a sub-sample of data passing the filters in every year, as explained in the text.
Source: COMTRADE, authors' calculations.

Who trade with who?

Recall lecture 0: most trade is between similar countries

Figure 1 –
Map of World Trade in Goods, 2000 (US billion dollars)



Source: Feenstra and Taylor, 2008, Chapter 1.

Note: The thickness of links is proportional to the volume of trade. Intra-regional trade flows are depicted by loops.

Empirical Relevance

Since most trade seems to flow between similar countries, it may seem that emphasizing cross-country differences is not useful.

- Still, neoclassical trade theories provide valuable insights into the structure of trade flows and are an essential benchmark for realistic models.

Standard Ricardian model

Two-country two-goods

- Consider a world with 2 countries (H and F), two goods and one factor of production, labor.
- Technology is summarized by four unit input requirements: ${a_i}^k$ for $k = H, F$, $i = 1, 2$.
- **Result:**

$$\text{Country } H \text{ exports good 1 if } \frac{a_1^H}{a_2^H} < \frac{a_1^F}{a_2^F}.$$

Proof.

Assume prices lie on the unit simplex. Because labor is the only factor,

$$p_i^{Ak} = \frac{a_i^k}{\sum_l a_l^k}.$$

Now note that $p_1^{AH} < p_1^{AF} \iff a_1^H / a_2^H < a_1^F / a_2^F$. But from one of our previous results, this implies $M_1^H < 0$.

Standard Ricardian model

DFS 1997

- Consider a world economy with **two countries**: Home and Foreign
- Asterisks denote variables related to the Foreign country
- We denote by:
  - L and L^* the endowments of labor (in efficiency units) in the two countries
  - w and w^* the wages (in efficiency units) in the two countries

- *Note: Ricardian models differ from other neoclassical trade models in that there only is* **one factor** *of production*
  - Equivalently, you can think that there are many (non-tradable) factors, but that they can all be aggregated into a single composite

Standard Ricardian model

Supply-side assumptions

- There is a **continuum** of goods indexed by $z \in [0, 1]$
- Since there are CRS, we can define the (constant) unit labor requirements in both countries: $a(z)$ and $a^*(z)$
- $a(z)$ and $a^*(z)$ capture all we need to know about technology in the two countries
- W.i.o.g., we order goods such that $A(z) \equiv a^*(z)/a(z)$ is decreasing in z
  - Hence Home has a comparative advantage in the low-z goods
  - For simplicity, we'll assume strict monotonicity

Standard Ricardian model

Free trade equilibrium I: efficient international specialization

- Previous supply-side assumptions are all we need to make qualitative predictions about pattern of trade
- Let $p(z)$ denote the price of good z under free trade
- Profit-maximization requires

$$p(z) - wa(z) \leq 0, \text{ with equality if } z \text{ is produced at Home} \quad (1)$$

$$p(z) - w^* a^*(z) \leq 0, \text{ with equality if } z \text{ is produced Abroad} \quad (2)$$

- **Proposition** *There exists* $\widetilde{z} \in [0,1]$ *such that Home produces all goods* $z < \widetilde{z}$ *and Foreign produces all goods* $z > \widetilde{z}$

Standard Ricardian model

Free trade equilibrium I: efficient international specialization

- **Proof:** By contradiction. Suppose that there exists $z' < z$ such that z produced at Home and z' is produced abroad. (1) and (2) imply

$$\begin{aligned} p(z) - wa(z) &= 0 \\ p(z') - wa(z') &\leq 0 \\ p(z') - w^* a^*(z') &= 0 \\ p(z) - w^* a^*(z) &\leq 0 \end{aligned}$$

This implies

$$wa(z)w^* a^*(z') = p(z)p(z') \leq wa(z')w^* a^*(z),$$

which can be rearranged as

$$a^*(z')/a(z') \leq a^*(z)/a(z).$$

This contradicts A strictly decreasing.

Standard Ricardian model

Free trade equilibrium I: efficient international specialization

- Previous proposition simply states that Home should produce and specialize in the goods in which it has a CA
- Note that:
  - Proposition does not rely on continuum of goods
  - Continuum of goods + continuity of A is important to derive

$$A(\widetilde{z}) = \frac{w}{w^*} \equiv \omega \tag{3}$$

- Equation (3) is the first of DFS's two equilibrium conditions:
  - Conditional on wages, goods should be produced in the country where it is cheaper to do so
- To complete characterization of free trade equilibrium, we need look at the demand side to pin down the relative wage ω

Standard Ricardian model

Demand-side assumptions

- Consumers have **identical Cobb-Douglas** preferences around the world
- We denote by $b(z) \in (0,1)$ the share of expenditure on good z:

$$b(z) = \frac{p(z)c(z)}{wL} = \frac{p(z)c^*(z)}{w^*L^*},$$

  where $c(z)$ and $c^*(z)$ are consumptions at Home and Abroad
- By definition, shares of expenditure satisfy: $\int_0^1 b(z)dz = 1$

Standard Ricardian model

Free trade equilibrium II: trade balance

- Let us denote by $\theta(\widetilde{z}) = \int_0^{\widetilde{z}} b(z)dz$ the fraction of income spent (in both countries) on goods produced at Home
- Trade balance requires

$$\underbrace{\theta(\widetilde{z})w^*L^*}_{\text{Home Exports}} = \underbrace{[1-\theta(\widetilde{z})]wL}_{\text{Home Imports (Foreign Exports)}}$$

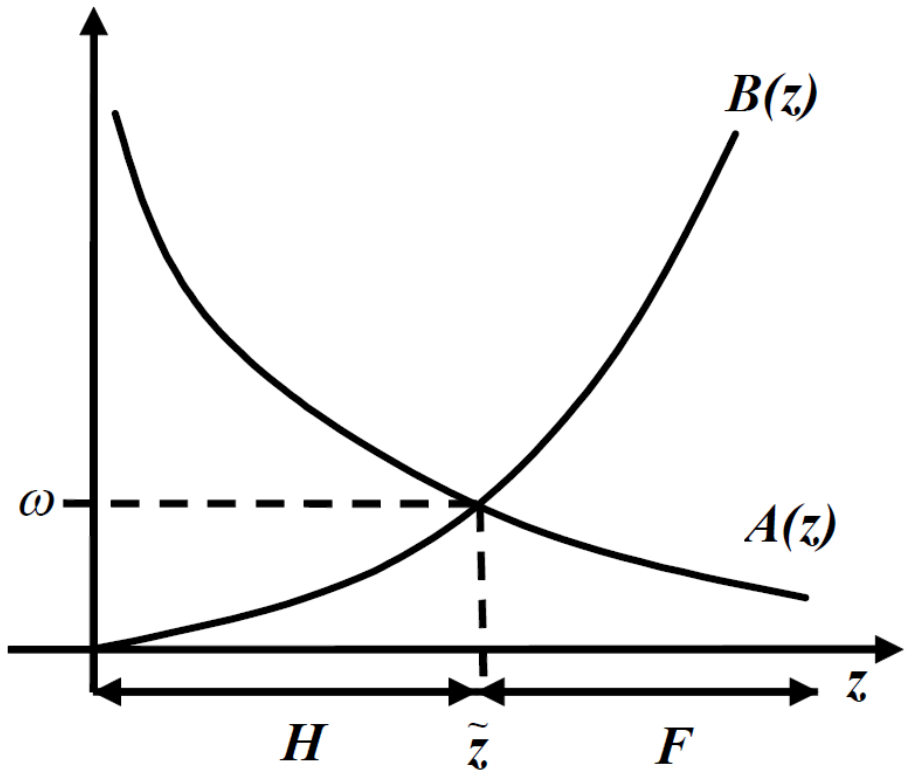
- Previous equation can be rearranged as

$$\omega = \frac{\theta(\widetilde{z})}{1-\theta(\widetilde{z})}\frac{L^*}{L} \equiv B\left(\widetilde{z}; \frac{L^*}{L}, \theta\right) \tag{4}$$

- Note that $B' > 0$: an increase in $\widetilde{z}$ leads to a trade surplus at Home, which must be compensated by an increase in Home's relative wage ω

Standard Ricardian model

Putting things together



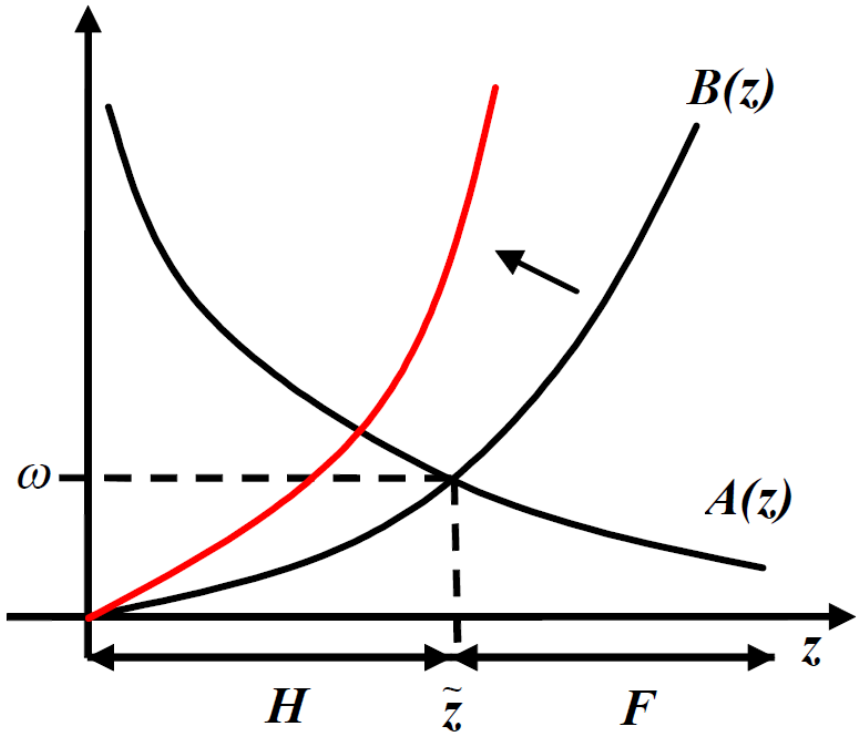
- Efficient international specialization, (3), and trade balance,(4), jointly determine $(\widetilde{z}, \omega)$

Standard Ricardian model

A quick note on the gains from trade

- Since Ricardian model is a neoclassical model, general results derived in previous lecture hold
- However one can directly show the existance of gains from trade in this environment
- **Argument:**
  - Set $w = 1$ under autarky and free trade
  - Indirect utility of Home representative household only depends on $p(\cdot)$
  - For goods z produced at Home under free trade: no change compared to autarky
  - For goods z produced abroad under free trade: $p(z) = w^* a^*(z) < a(z)$
  - Since all prices go down (weakly), indirect utility must go up

What are the Consequences of (relative) country growth?



- Suppose that L^*/L goes up (rise of China):
  - ω goes up (but less than L^*/L) and $\widetilde{z}$ goes down
  - At initial wages, an increase in L^*/L creates a trade deficit in Foreign, which must be compensated by an increase in ω

What are the Consequences of (relative) country growth?

- A rise in L^*/L raises in real income in Home and reduces real income in *Foreign*.
  - Set $w = 1$ before and after L^*/L goes up
  - For goods whose production remains at Home:no change in $p(z)$
  - For goods whose production remains in Foreign:
    $\omega \nearrow \Longrightarrow w^* \searrow \Longrightarrow p(z) = w^* a^*(z) \searrow$
  - For goods whose production moves to Foreign:
    $w^* a^*(z) \leq wa(z) \Longrightarrow p(z) \searrow$
  - Home gains and Foreign is worse off (per unit of labor) despite the migration of industries from home to foreign.
- **Comments**:
  - In spite of CRS at the industry-level, everything is as if we had DRS at the country-level
  - If Foreign's size increase, it specializes in sectors where it is relatively less competitive $\Longrightarrow$ $ToT \searrow$ and lowers real income per capita
  - The flatter the A schedule, the smaller this effect

What are the Consequences of technological change?

- There are many ways to model technological change:
  1. Global uniform technological change: for all z, $\widehat{a}(z) = \widehat{a^*}(z) = x > 0$
  2. Foreign uniform technological change: for all z, $\widehat{a}(z) = 0$, and $\widehat{a^*}(z) = x > 0$
  3. International transfer of the most efficient technology: for all z, $a(z) = a^*(z)$ (Offshoring?)

- Using the same logic as in the previous comparative static exercise, one can easily check that:
  1. Global uniform technological change increases welfare everywhere
  2. Foreign uniform technological change increases welfare everywhere (for Foreign, this depends on Cobb-Douglas assumption)
  3. If Home has the most efficient technology, $a(z) < a^*(z)$ initially, then it will lose from international technology transfer (no gains from trade)

Other comparative static exercises

Transfer problem

- Suppose that there is $T > 0$ such that:
  - Home's income is equal to $wL + T$
  - Foreign's income is equal to $w^*L^* - T$
- If preferences are identical in both countries, transfers do not affect the trade balance condition:

$$[1 - \theta(\widetilde{z})](wL + T) - \theta(\widetilde{z})(w^*L^* - T) = T$$

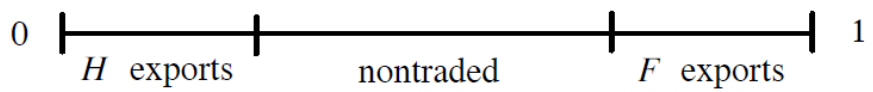
$$\Longleftrightarrow$$

$$\theta(\widetilde{z})w^*L^* = [1 - \theta(\widetilde{z})]wL$$

- So there are no terms-of-trade effect
- If Home consumption is biased towards Home goods, $\theta(z) > \theta^*(z)$ for all z, then transfer further improves Home's terms of trade

DFS extension: transport costs and nontraded goods

- DFS also analyze economies with melting iceberg transportation costs. In this event the specialization pattern is as follows:



Multi-country extensions

- DFS 1977 provides extremely elegant version of the Ricardian model:
  - Characterization of free trade equilibrium boils down to finding $(\widetilde{z}, \omega)$ using efficient international specialization and trade balance
- Problem is that this approach does not easily extend to economies with more than two countries
  - In the two-country case, each country specializes in the goods in which it has a CA compared to the other country
  - Who is the other country if there are more than two?
- Multi-country extensions of the Ricardian model:
  - Jones (1961)
  - Costinot (2009)
  - Wilson (1980)
  - Eaton and Kortum (2002)

Multi-country extensions

Jones (1961)

- Assume N countries, G goods
- **Trick:** restrict attention to "class of assignments" where
  - Each country only produces one good
  - Each good is produced by the same number of countries
- Characterize the properties of optimal assignment within a class
- **Main result:** *Optimal assignment of countries to goods within a class will minimize the product of their unit labor requirements*

Multi-country extensions

Costinot (2009)

- Assume N countries, G goods
- **Trick:** Put enough structure on the variation of unit-labor requirements across countries and industries to bring back two-country intuition
- Assume a strong version of log-supermodularity in which countries can be index by j so that $a^{j+1}(i)/a^j(i)$ is a strictly decreasing function of i for every $j = 1, 2, ..., C-1$, in a world of C countries. This implies that labor productivity $1/a^j(i)$ is log supermodular.
- Then if country j has a weakly higher cost than country $j+1$ of producing good i' in equilibrium, i.e., if $w^j a^j(i') \geq w^{j+1} a^{j+1}(i')$, then $w^j a^j(i) \geq w^{j+1} a^{j+1}(i)$ for every $i > i'$. It follows that j and $j+1$ can share at most one product. And the same applies to the comparison of country j with $j+n$, $n > 1$.
- Now assume that there is a positive demand for all products. Then it follows that each country produces an interval of products, with the interval of country j being below that of $j+1$ except possibly for a single product. Moreover, the union of these intervals fully covers $[0, 1]$, and therefore the intervals of specialization are ordered according to j.

Multi-country extensions

Wilson (1980)

- Same as in DFS 1977, but with multiple countries and more general preferences
- **Trick:** Although predicting the exact pattern of trade may be difficult, one does not need to know it to make comparative static predictions
- At the aggregate level, Ricardian model is similar to an exchange-economy in which countries trade their own labor for the labor of other countries
  - Since labor supply is fixed, changes in wages can be derived from changes in (aggregate) labor demand
  - Once changes in wages are known, changes in all prices, and hence, changes in welfare can be derived

Multi-country extensions

Eaton and Kortum (2002)

- Same as Wilson (1980), but with functional form restrictions on $a(z)$
- **Trick:** For each country i and each good z, they assume that productivity, $1/a(z)$, is drawn from a Fréchet distribution

$$F(1/a) = exp(-T_i a^{\theta})$$

- Like Wilson (and unlike Jones), no attempt at predicting which goods countries trade:
  - Instead focus on bilateral trade flows and their implications for wages
- Unlike Wilson, trade flows only depends on a few parameters (T_i, θ)
  - Allow for calibration and counterfactual analysis
- Profound impact on the filed, study it in detail later

Acknowledgment

Slides of this course are inspired by those taught by N. Berman, T. Chaney, A. Costinot, M. Crozet, D. Donaldson, E. Helpman, T. Mayer, I. Mejean