# International Trade

UNIL - HEC MScE
Matthieu Crozet

## International Trade

- Webpage:
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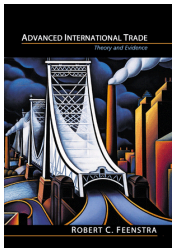
## International Trade

- Bibliography

Robert Feenstra, *Advanced International Trade: Theory and Evidence*, Princeton University Press.

List of (more or less) recent papers published or forthcoming in leading academic journals (Top 5 and *Journal of international economics*)




## International Trade

**Evaluation:**

- Presentation in class and Exercises = 20%
  - Presentation of a research paper by groups of 1, 2 or 3 (depending on the number of students attending)
  - Empirical exercises
- Final written exam = 80%
  - Rapid discussion of a short research paper
  - Question on one of the topics of the course
  - Question on one of the papers presented by the students

# General introduction

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## General introduction

1. Some basic facts about international trade
2. An overview of trade theories

## Globalization: Some facts

Let's start with 4 (very basic) facts

## # 1: Globalization is not new

- Merchandise are traded on long distances for centuries
- And new trade routes have been continuously opened since Antiquity

The silk road

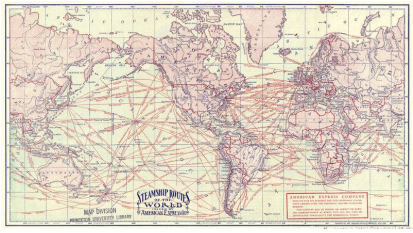
Peacefully…

The opium wars

or not

## # 1: Globalization is not new

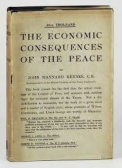
– At the end of the XIXth century, all countries are exposed to world trade




## # 1: Globalization is not new

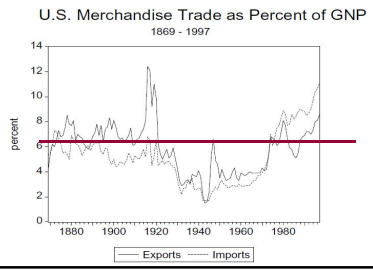
John Keynes

[…] The inhabitant of London could order by telephone, sipping his morning tea in bed, the various products of the whole earth, in such quantity as he might see fit, and reasonably expect their early delivery upon his doorstep.




## # 1: Globalization is not new

- Trade openness in developed nations in 1913 is comparable to the one in 1970s

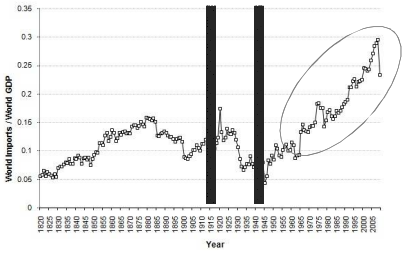



## #2: Some features of the recent globalization are new

What is new is:

– The importance reached by international trade in the 80's and 90's

## #2: Some features of the recent globalization are new




Source: Christopher Chase-Dunn and Roy Kwon (Chase-Dunn, Kawano, and Brewer 2000; World Development Indicators, 2011)

## #2: Some features of the recent globalization are new

What is new is:

- The importance reached by international trade in the 80's and 90's
- The very rapid surge of emerging countries

## #2: Some features of the recent globalization are new

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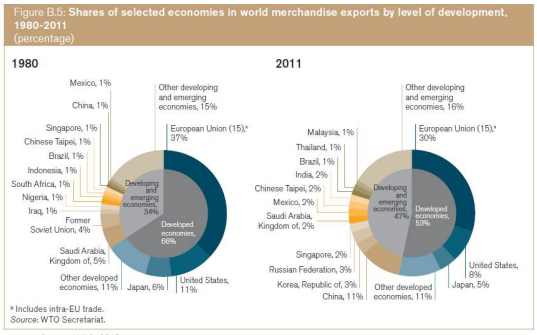



Source: WTO, 2013

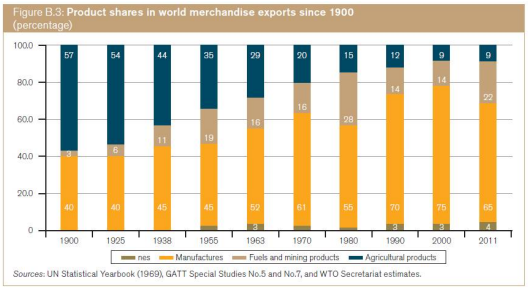
## #2: Some feature of recent globalization are new

What is new is:

- The importance reached by international trade in the 80's and 90's
- The very rapid surge of emerging countries
- What is traded

## #2: Some features of the recent globalization are new

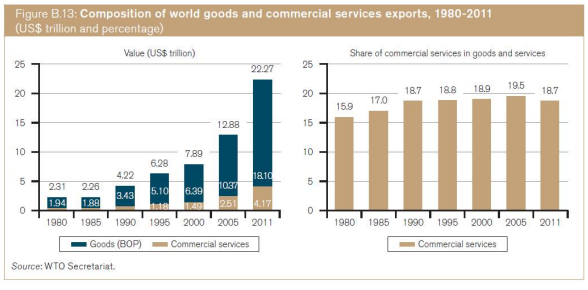
Less agricultural products, more manufactured goods




Source: WTO, 2013

## #2: Some features of the recent globalization are new

More services?




Source: WTO, 2013

## #2: Some features of the recent globalization are new

More services… especially in terms of value added trade (when one removes double counts of manufacturing trade)

Source: WTO, 2013

## #3: Globalization is a political decision

Decrease in trade costs is not the main driver of world trade growth

## #3: Globalization is a political decision

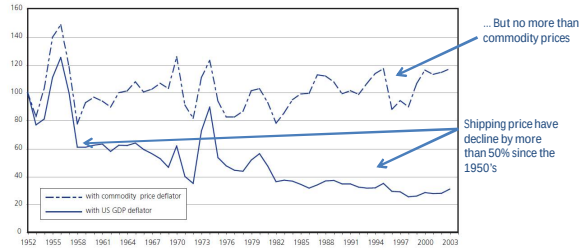
- 90% of world trade by volume is carried by ship
- Maritime traffic doubled since 2003 level
- In be
  - 
  - 
  -

terdam…)

970s' to be" fait 400

## #3: Globalization is a political decision

Chart 9
Tramp price index




Source: Hummels (2007).

WTO

## #3: Globalization is a political decision

Air transport still represents a miror share of world trade in volume… but a much greater one in value

US: Air share of trade value

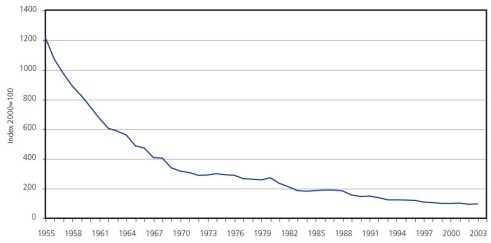
| Year | excluding N America Imports | excluding N America Exports |
|---|---|---|
| 1965 | 8.1 | 11.9 |
| 1970 | 12.1 | 19.5 |
| 1975 | 12.0 | 19.3 |
| 1980 | 13.9 | 27.6 |
| 1985 | 19.8 | 36.3 |
| 1990 | 24.6 | 42.3 |
| 1995 | 33.1 | 44.3 |
| 2000 | 36.0 | 57.6 |
| 2004 | 31.5 | 52.8 |

Hummels 2007

## #3: Globalization is a political decision

Air transport transport cost decreased significantly

Worldwide air revenue per ton-km




*Source:* Hummels (2007).

WTO

## #3: Globalization is a political decision

Especially for long-distance flights

**German real air transport prices by destination, 1954-99**
(Indices,1954=100)

| | Index | | Average annual percentage change |
|---|---|---|---|
| | 1954-56 | 1997-99 | |
| Intra-Europe | | | |
| Rome | 95 | 105 | 0.2 |
| Paris | 95 | 111 | 0.4 |
| London | 95 | 114 | 0.4 |
| Average of 3 destinations | 95 | 110 | 0.3 |
| Inter-continental | | | |
| Hong Kong, China | 97 | 24 | -3.2 |
| New York | 95 | 27 | -2.9 |
| Bangkok | 97 | 28 | -2.9 |
| Montreal | 95 | 28 | -2.8 |
| Caracas | 95 | 36 | -2.2 |
| Mexico City | 95 | 37 | -2.2 |
| Teheran | 97 | 50 | -1.5 |
| Tokyo | 97 | 66 | -0.9 |
| Johannesburg | 97 | 73 | -0.7 |
| Tel Aviv | 98 | 73 | -0.7 |
| Cairo | 97 | 73 | -0.7 |
| Sydney | 95 | 72 | -0.6 |
| Rio de Janeiro | 97 | 88 | -0.2 |
| Average of 13 destinations | 97 | 52 | -1.4 |

*Note:* Based on outbound (Frankfurt/M.) freight rates in US$ per kg deflated by (WTO) world export unit value index of manufactured goods.
*Source:* German Federal Statistical Office, Fachserie 17, Reihe 9, various issues and WTO calculations.

WTO

## #3: Globalization is a political decision

– Limited technological progress

1967

2007

## #3: Globalization is a political decision

– Limited technological progress

– But public decisions
- Investment in infrastructures (airports)
- Deregulations

Pan Am : 1930-1991

Swiss Air: 1931- 2002

Air Afrique : 1961-2002

TWA: 1925 - 2001

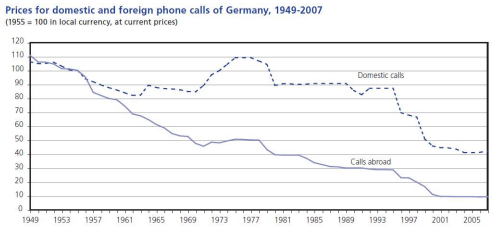
Ryanair : 1985

EasyJet : 1995

## #3: Globalization is a political decision

– Massive technological progress in telecomunications

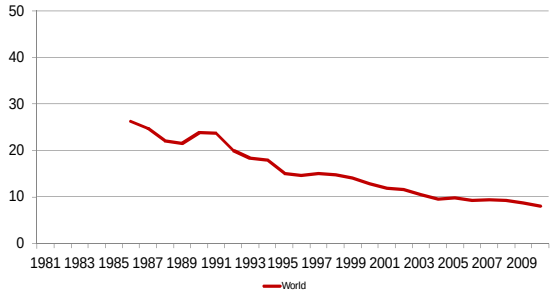
## #3: Globalization is a political decision




## #3: Globalization is a political decision

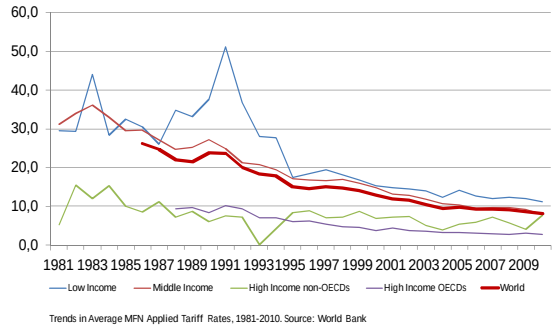
Trade liberalization policies are the main driver of world trade growth

## #3: Globalization is a political decision



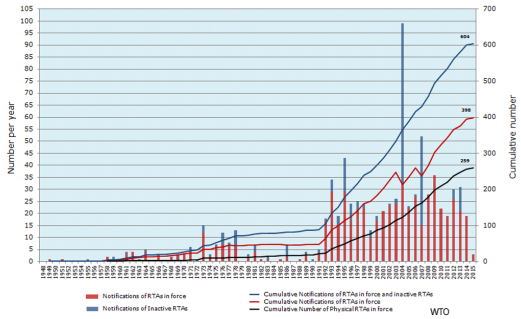

Trends in Average MFN Applied Tariff Rates, 1981-2010. Source: World Bank

## #3: Globalization is a political decision




Trends in Average MFN Applied Tariff Rates, 1981-2010. Source: World Bank

## #3: Globalization is a political decision




## #3: Globalization is a political decision

So what?

- Globalization is reversible
- Public authorities are responsible for negative consequences of globalization (need to compensate the losers)

## #4: The world is still fragmented

Of course, globalization has standardized the consumption modes

## #4: The world is still fragmented

You probably know this TV show

## #4: The world is still fragmented

... as most people in the world

## #4: The world is still fragmented

- Of course, globalization has standardized the consumption modes
- But not that much

## #4: The world is still fragmented

One week grocery

In Germany

In Tchad

http://www.menzelphoto.com/hungryplanet/

## #4: The world is still fragmented

- Of course, globalization has standardized the consumption modes
- But not that much
- And trading (especially on long distances) is still difficult and very rare

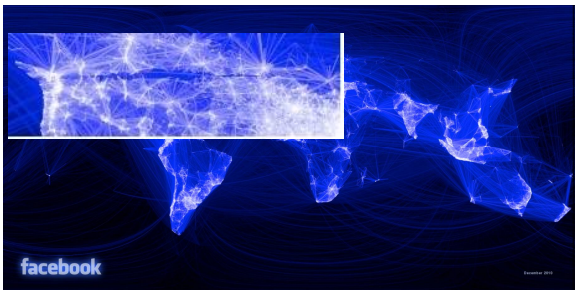
## #4: The world is still fragmented

• Borders still matter

US-Mexico border (Tijuana)

## #4: The world is still fragmented

• Borders still matter




## #4: The world is still fragmented

• Borders (customs procedures) matter

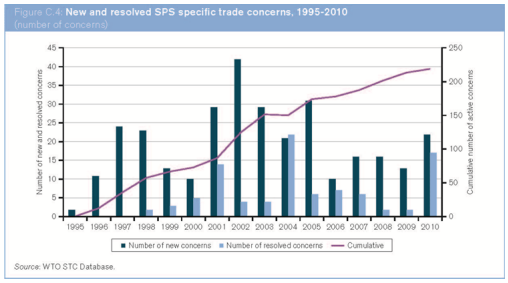
| | Documents to import (number) | Time to import (days) | Cost to import (US$ per container) |
|---|---|---|---|
| East Asia & Pacific | 6.7 | 21.6 | 895.6 |
| Europe & Central Asia | 8.0 | 25.9 | 2,435.9 |
| Latin America & Caribbean | 6.8 | 18.7 | 1,691.1 |
| Middle East & North Africa | 7.8 | 23.8 | 1,307.0 |
| OECD high income | 4.3 | 9.6 | 1,100.4 |
| South Asia | 9.4 | 34.4 | 2,117.8 |
| Sub-Saharan Africa | 8.9 | 37.6 | 2,930.9 |
| China | 5 | 24.0 | 800.0 |
| France | 2 | 11.0 | 1,445.0 |
| Switzerland | 4 | 8.0 | 1,440.0 |
| United States | 5 | 5.4 | 1,289.0 |

## #4: The world is still fragmented

- Borders (Norms) matter

## #4: The world is still fragmented

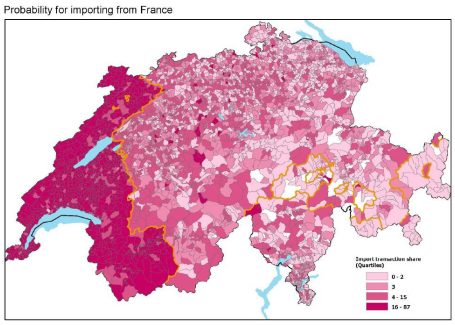
- Borders (Norms) matter




## #4: The world is still fragmented

- Language matters

Figure 5: Share of transactions from France in total transactions by zip code in %



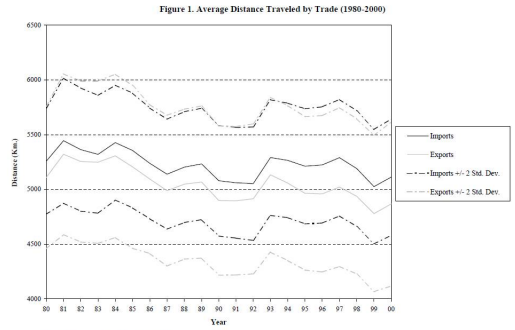

Data source: Swiss Federal Customs Administration 2006–2011 and 1990 Census, Swiss Federal Statistical Office. Bold yellow lines represent language borders, thin lines indicate zip code regions.

Egger & Lassmann

## #4: The world is still fragmented

• Distance matters

## #4: The world is still fragmented




Berthelon and Freund 2004

## #4: The world is still fragmented

• Etc: Cultural, geographical, institutional, religious, (…) differences matter

## #4: The world is still fragmented

• As a consequences, trading across borders is still very difficult

Table B.12: **Share of exporting firms in total number of manufacturing firms** (percentage)

| | Year | Share of exporters in total number of manufacturing firms |
|---|---|---|
| United States | 1987 and 2002 | 18 |
| Norway | 2003 | 39.2 |
| France | 1986 | 17.4 |
| Japan | 2000 | 20 |
| Chile | 1999 | 20.9 |
| Colombia | 1990 | 18.2 |
| Indonesia | 1991-2000 | 19 |

*Sources:* WTO (2008) and Amiti and Cameron (2012) for Indonesia.

Table B.13: **Share of exports accounted for by the largest exporters** (percentage)

| Country | Year | Top 1% | Top 5% | Top 10% |
|---|---|---|---|---|
| United States | 1993 | 78.2 | 91.8 | 95.6 |
| | 2002 | 80.9 | 93 | 96.3 |
| European Countries | | | | |
| Belgium | 2003 | 48 | 73 | 84 |
| France | 2003 | 44 | 73 | 84 |
| Germany | 2003 | 59 | 81 | 90 |
| Hungary | 2003 | 77 | 91 | 96 |
| Italy | 2003 | 32 | 59 | 72 |
| Norway | 2003 | 53 | 81 | 91 |
| United Kingdom | 2003 | 42 | 69 | 80 |
| Developing Countries* | | | | |
| Brazil | 2009 | 56 | 82 | 98 |
| Mexico | 2009 | 67 | 90 | 99 |
| Bangladesh | 2009 | 22 | 52 | 90 |
| Turkey | 2009 | 56 | 78 | 96 |
| South Africa | 2009 | 75 | 90 | 99 |
| Egypt | 2009 | 49 | 76 | 96 |
| Iran | 2009 | 51 | 72 | 94 |

*Sources*: Bernard and Jensen (1995), Bernard et al. (2007), Mayer and Ottaviano (2007), Cebeci et al. (2012).

*For developing countries reported in the WBEDD, we report the exports share by the top 25% firms instead of top 10% firms due to data availability.

## An overview of trade theories

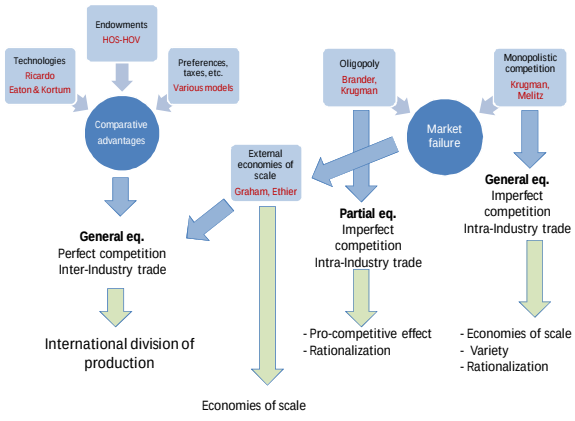
- **What is this course about?**

It will try to understand the determinants of the pattern of trade and the consequences of trade openness

A large part of the semester will be devoted to the exploration of trade theories (+ corresponding empirical validations)

## An overview of trade theories

- **Basic question of international trade theories:**
  - Why do countries trade?
- **Basic answers:**
  1. Because countries are different
     - They have different "abilities" to produce different goods
     - They could be better off producing only a subset of goods and importing the others
  2. Well… countries do not trade, but firms do
     - Firms export because they find it profitable to do so



## (Indicative) Road map

I. The toolbox: Trade theories and basic empirics
   1. Comparative advantages
      a. Technological differences: Ricardo
      b. Comparative advantages: Factor endowments,HOS/HOV
   2. Firms in the global economy
      a. The oligopolistic model of trade
      b. Monopolistic models of trade (1): Krugman (1979, 1980)
      c. Heterogeneous firms
   3. The empirics of international trade: The gravity equation

II. Issues and policies
   6. Trading jobs? Trade employment and wages
   7. Vertical specialization: trade quality and trade prices
   8. Multinational firms and outsourcing
   9. Trade policy (?)

## (Indicative) Road map

I. The toolbox: Trade theories and basic empirics
   1. Comparative advantages
      a. Technological differences: Ricardo **Chap. 1**
      b. Comparative advantages: Factor endowments,HOS/HOV **Chap. 2**
   2. Firms in the global economy
      a. The oligopolistic model of trade **Chap. 3**
      b. Monopolistic models of trade (1): Krugman (1979, 1980) **Chap. 4**
      c. Heterogeneous firms **Chap. 5**
   3. The empirics of international trade: The gravity equation **Chap. 6**

II. Issues and policies
   6. Trading jobs? Trade employment and wages **Chap. 7**
   7. Vertical specialization: trade quality and trade prices **Chap. 8**
   8. Multinational firms and outsourcing **Chap. 9**
   9. Trade policy (?) **Chap. 10**

# Chapter I

# Technological differences: The Ricardian model

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## Road map

1. Introduction
2. The originalRicardian model
3. Extending Ricardo (a bit): DFS model
4. Extending further Ricardo: EK
5. Empirical validations

## Introduction

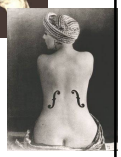
- Basic question in international trade:
  - Why do countries trade?
- Basic answer:
  - Because countries are different
  - They have different "abilities" to produce different goods
  - They could be better off producing only a subset of goods and importing the others

## 1. Introduction

- Which kind of difference matters?
  - If a foreign country is better than Home in the production of a given good, it's worth importing this good rather than producing it.
  - But what appends if the Home country is better at making all good?
  - If home is substantially better in one production and only slightly better in one other, there is still some gains to produce relatively more of the first good.

## 1. Introduction

- This is Ricardo's principle of comparative advantages
- Which is important is not to do better, but to do **relatively** better
- Ingres is a good example:
  - Very good violinist… but exceptional painter



## 1. Introduction

- Problem :
  - How decide which goods a country should produce and which ones it should import?
- As usual in economics, these choices are driven by price incentives.
- ⇨ Price differences are the source of specialization and international trade.
- ⇨ **Countries trade because autarky relative prices differ across countries.**

## 1. Introduction

- All trade models based on comparative advantage have the same logic:
  - Some initial differences between countries generate differences in relative autarky prices
  - Price differences encourage countries to specialize and trade
- The Ricardian model(s) assume that technological differences are the source of the comparative advantages

## Road map

1. Introduction
2. **The originalRicardian model**
3. Extending Ricardo (a bit): DFS model
4. Extending further Ricardo: EK
5. Empirical validations

## 2. Original ricardian model

- Ricardo's example (Ricardo 1871)
  - 2 countries: England and Portugal
  - 2 goods: Wine and Cloth
  - 1 factor: Labor

*Labor unit requirements (how many workers to make a unit of good)*

| | Cloth | Wine |
|---|---|---|
| England | 100 | 120 |
| Portugal | 90 | 80 |

## 2. Original ricardian model

*Labor unit requirements (how many workers to make a unit of good)*

| | Cloth | Wine |
|---|---|---|
| England | 100 | 120 |
| Portugal | 90 | 80 |

Producing one unit of wine requires 120 workers in England, only 80 in Portugal

Producing one unit of cloth requires 100 workers in England, only 90 in Portugal

Productivity is higher in Portugal in both industries… but the productivity gap is smaller in cloth

## 2. Original ricardian model

Imagine now that the relative price of cloth is 1 (i.e. one exchanges 1 unit of wine against one unit of cloth)

With the effort of 100 workers, England can produce 1 unit of cloth… and trade it against 1 unit of wine =

➡ By trading England can obtain 1 unit of wine with the effort of 100 workers instead of 120.

With the effort of 80 workers, Portugal can produce 1 unit of wine… and trade it against 1 unit of cloth =

➡ By trading Portugal can obtain 1 unit of cloth with the effort of 80 workers instead of 90

## 2. Original ricardian model

- **A more general framework**
  - $a_i$ = Labor needed to produce one unit of good *i* at Home (*i=1,2*)
  - $a^*_i$ = Labor needed to produce one unit of good *i* in the Foreign country
  - L and L* are the total labor forces in H and F countries.
  - *w* and *w** are the wages
  - Labor cannot migrate, but it is perfectly mobile between industries

## 2. Original ricardian model

- International trade (with no trade cost) implies unique prices
- Maximizing producers + perfect competition imply:

$$\begin{cases} p_1 - a_1 w \le 0 \\ p_2 - a_2 w \le 0 \end{cases} \qquad \begin{cases} p_1 - a_1^* w^* \le 0 \\ p_2 - a_2^* w^* \le 0 \end{cases}$$

## 2. Original ricardian model

- In autarky, countries produce simultaneously the 2 goods.
- … which determines the relative autarky prices

$$p^a = \frac{p_1^a}{p_2^a} = \frac{a_1}{a_2} \quad \text{and} \quad p^{a^*} = \frac{p_1^{a^*}}{p_2^{a^*}} = \frac{a_1^*}{a_2^*}$$

## 2. Original ricardian model

- If the Home country as a comparative advantage in producing good 1:
  - The relative cost of producing 1 is lower at Home than abroad:

$$\frac{a_1}{a_2} < \frac{a_1^*}{a_2^*}$$

  - Then, the relative autarky price of 1 is lower in H

$$p^a < p^{a*}$$

## 2. Original ricardian model

- Lower relative prices of good 1 in country H is an incentive to trade:
  - Country F is likely to import good 1 (relatively cheap abroad) against good 2 (relatively expensive abroad)
  - Inversely Country H is likely to import good 2 and export good 1.

## 2. Original ricardian model

- At which international price trade may occur?

= what is the equilibrium price $p$ at which world supply equals world demand?

If $p < \frac{a_1}{a_2}$ then $p < p^a < p^{a*}$

⇨ Good 2 pays relatively more than it costs in all countries (it worth selling good 2 against good 1).

⇨ both countries are fully specialized in good 2.

If $p > \frac{a_1^*}{a_2^*}$ then $p > p^a > p^{a*}$

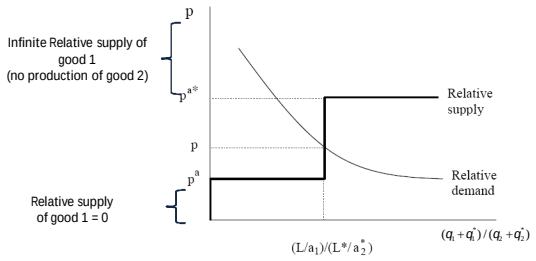
⇨ both countries are fully specialized in good 1.

If $\frac{a_1}{a_2} < p < \frac{a_1^*}{a_2^*}$ then $p^a < p < p^{a*}$

⇨ Country H produces good 1 and country F produces good 2.

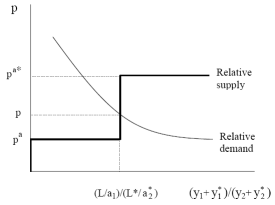
## 2. Original ricardian model

- With homothetic preferences, relative demand of good 1 is a decreasing function of relative price $p$.



## 2. Original ricardian model

- If world relative price *p* lies between $p^a$ and $p^{*a}$:
  - Each country is specialized in one industry
- If not, one country remains diversified…
- … and world relative prices equals its autarky relative prices




## 2. Original ricardian model

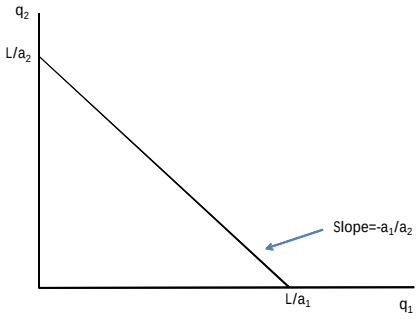
- **Full employment**

$$L = a_1 q_1 + a_2 q_2 \Leftrightarrow q_2 = \frac{L}{a_2} - \frac{a_1}{a_2} q_1$$

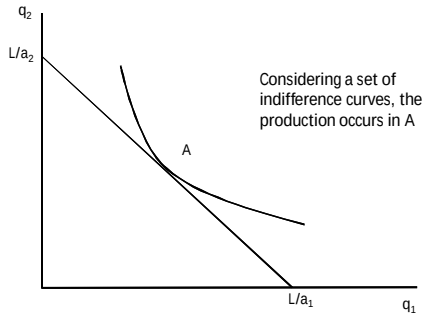
This is the production possibility frontier (PPF)

## 2. Original ricardian model

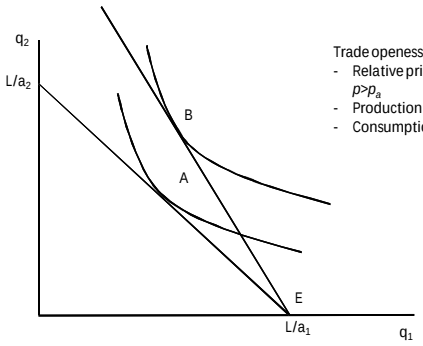
- **The PPF**




## 2. Original ricardian model

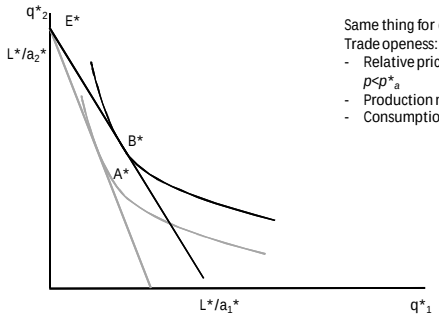


## 2. Original ricardian model




Trade openess:
- Relative price moves from $p_a$ to $p>p_a$
- Production moves form A to E
- Consumption moves from A to B

## 2. Original ricardian model




Same thing for country F
Trade openess:
- Relative price moves from $p^*_a$ to $p<p^*_a$
- Production moves form A* to E*
- Consumption moves from A*to B*

## 2. Original ricardian model

- The role of wages
  - If Country H has an absolute disadvantage in both goods:
    $a_1 > a_1^*$ and $a_2 > a_2^*$
  - More labor is needed to produce one unit of either good at home than abroad.
  - Trade still occurs according to comparative advantages
  - Home country can export good 1, despite that its cost in terms of labor input is higher than abroad… <u>because wages are lower.</u>
  - Trade patterns are determined by comparative advantage
  - The level of wages across countries is determined by absolute advantage

## 2. Original ricardian model

- Nice model isn't it?...
- Yes, but not really informative:
  - Perfect competition… well, why not
  - Complete specialization… quite odd
  - Two countries and two goods…
    - The UN trade database COMTRADE reports annual bilateral trade flows for more than 200 countries in more than 5,000 products, i.e. 199 millions possible combinations.
    - (among them many zeros… Actually, the database contains more than 3.1 billions positive trade records, starting from 1962, i.e. about 62 millions positive records per year)
- *"The Ricardian model became something like a family heirloom, brought down from the attic to show a new generation of students, and then put back, allowing them to pursue more fruitful lines of study and research."* (Eaton and Kortum, *JEP* 2012).

## Road map

1. Introduction
2. The originalRicardian model
3. **Extending Ricardo (a bit): DFS model**
4. Extending further Ricardo: EK
5. Empirical validations

## 3. Extending Ricardo: Many products

- Let's consider again the original example

*Labor unit requirements (how many workers to make a unit of good)*

| | Cloth | Wine |
|---|---|---|
| England | 100 | 120 |
| Portugal | 90 | 80 |

## 3. Extending Ricardo: Many products

- Now assume English wage is w and set Portuguese wage = 1

*Production costs*

| | Cloth | Wine |
|---|---|---|
| England | 100*w* | 120*w* |
| Portugal | 90 | 80 |

## 3. Extending Ricardo: Many products

- With free trade and perfect competition, the price of cloth and wine will be the same in each locations
- And the production of a good will occur where it is cheaper

If $w > \frac{90}{100}$, both cloths and wine are more expensive in UK than in Portugal

If $w < \frac{80}{120} = \frac{2}{3}$, both cloths and wine are cheaper in UK than in Portugal

Under free trade, UKwage must lie between $\frac{2}{3}$ and $\frac{9}{10}$

Then, UK can produce cloth and Portugal can produce wine

## 3. Extending Ricardo: Many products

- Let's add a new good: Linen
- Assume both UK and Portugal need 100 workers to produce one unit, so that UK has an even stronger comparative advantage in linen than in cloth
- We now have a ***chain* of comparative advantages**

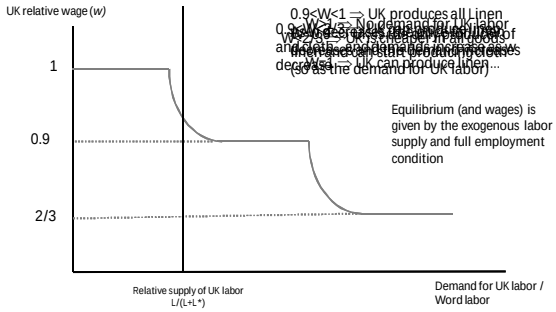
$$\underset{\text{(linen)}}{\frac{100}{100}=1} > \underset{\text{(cloth)}}{\frac{90}{100}=0.9} > \underset{\text{(wine)}}{\frac{80}{120}=2/3}$$

- And, again, the level of relative wage, *w*, will break the chain and determine where the production will take place

## 3. Extending Ricardo: Many products

- With a relative wage in UK above 1, all goods are more expensive in UK which leaves the British labor out of work
- With a relative wage in UK between 1 and 0.9, linen is cheaper in UK
- With a relative wage in UK between 0.9 and 2/3, the chain of comparative advantages breaks between cloths (cheaper in UK) and wine (cheaper in Portugal)

## 3. Extending Ricardo: Many products




## 3. Extending Ricardo: Many products

- **More goods than one can count: The DFS model**
- Dornbusch, Fischer and Samuelson (1977) extend and simplify the model assuming a continuum of goods.
- 2 countries: Home and Foreign (*)
- 1 factor of production (or several aggregated into a composite)
- L and L* are endowments.
- w and w* are wages.

## 3. Extending Ricardo: Many products

- There is a continuum of goods indexed by $z \in [0,1]$
- Since there are CRS and only one factor, we can define the (constant) unit labor requirements in both countries: **a(z)** and **a*(z)**, which capture all we need to know about technology in the two countries.
- Order goods such that $A(z) \equiv a^*(z)/a(z)$ is decreasing.
- Hence, Home has a comparative advantage in the low-z goods.

## 3. Extending Ricardo: Many products

- Let *p(z)* denote price of good *z* in both countries, under free trade.
- Maximizing producers + perfect competition imply:

$$\begin{cases} p(z) - wa(z) \le 0 & \text{(Equality if z is produced at Home)} \\ p(z) - w^* a^*(z) \le 0 & \text{(Equality if z is produced Abroad)} \end{cases}$$

- **DFS proposition**: There is a $\tilde{z} \in [0,1]$ such that Home produces all goods $z < \tilde{z}$ and Foreign produces all goods $z > \tilde{z}$

## 3. Extending Ricardo: Many products

- The technologies used to produce the threshold good, $\tilde{z}$ determine the relative wage

$$\begin{cases} p(\tilde{z}) - wa(\tilde{z}) = 0 \\ p(\tilde{z}) - w^* a^*(\tilde{z}) = 0 \end{cases}$$

$$\Rightarrow \frac{a^*(\tilde{z})}{a(\tilde{z})} = A(\tilde{z}) = \frac{w}{w^*} = \omega$$

- First DFS's equilibrium condition
- We need to inspect the demand side of the model to pin down the relative wage

## 3. Extending Ricardo: Many products

- We assume that consummers have identiqual Cobb-Douglas preferences
- Denote by $b(z) \in [0,1]$ the share of expenditure on good z, and c(z) the consumption of that good at Home:

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

- By definition $\int_0^1 b(z)dz = 1$

## 3. Extending Ricardo: Many products

- Denote $\theta(\tilde{z}) = \int_0^{\tilde{z}} b(z)dz$ the fraction of income spent (in both countries) on good produced at Home
- Balanced trade implies:

$$\underbrace{\theta(\tilde{z})w^*L^*}_{\text{Total spending Abroad X share of spending on Home products = Foreign imports = Home exports}} = \underbrace{[1-\theta(\tilde{z})]wL}_{\text{Total spending at Home X share of spending on Foreign products = Home imports = Foreign exports}}$$

## 3. Extending Ricardo: Many products

- Re-aranging gives:

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

$$\Rightarrow \frac{w}{w^*} = \omega = \frac{\theta(\tilde{z})}{1-\theta(\tilde{z})}\frac{L^*}{L} \equiv B(\tilde{z})$$

- Note that B' >0 : an increase in $\tilde{z}$ (i.e. an increase in the number of good produced at Home) leads to a trade suplus at Home, leading to a compensating increase in Home's relative wage.

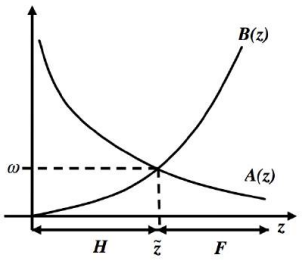
## 3. Extending Ricardo: Many products

- We now have two equilibrium conditions:

$$\omega = \frac{a^*(\tilde{z})}{a(\tilde{z})} = A(\tilde{z}) \quad \text{, whith A(z) decreasing in z}$$

$$\omega = \frac{\theta(\tilde{z})}{1-\theta(\tilde{z})}\frac{L^*}{L} \equiv B(\tilde{z}) \text{ , with B(z) increasing in z}$$

## 3. Extending Ricardo: Many products



## 3. Extending Ricardo: Many products

- **Trade gains**
  - Take the Home wage, *w*, as a numeraire
  - So indirect utility of Home representative household only depend on prices, p(z)
  - For goods $z < \tilde{z}$ produced at home under free trade, no change.
  - For imported goods, $\tilde{z} < z$ :

$$p(z) = w^* a^*(z) < a(z)$$

  - Since all prices are constant or go down, indirect utility must go up

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## 4. Extending Ricardo: Many countries

- Adding countries to the original 2-goods model is not a problem
- Ex: Add France with labor requirement 120 in cloth and 60 in wine.

| | Cloth | Wine |
|---|---|---|
| England | 100 | 120 |
| Portugal | 90 | 80 |
| France | 120 | 60 |

## 4. Extending Ricardo: Many countries

- We have:

$$\frac{120}{100} > \frac{80}{90} > \frac{60}{120}$$

UK Portugal France

- UK will produce cloth
- France will produce wine
- Portugal will produce either cloth or wine (or both) depending of Portugese relative wages

## 4. Extending Ricardo: Many countries and many goods

- But with more than 2 countries and more that 2 goods, thing are not that simple
  - Chains of comparative advantages are defined by the ratios of unit labor requirement, a(z).
  - But with many countries and many goods, we have many possible ratios… and they are not helpful
  - Solution: Eaton and Kortum (2002)

## 4. Extending Ricardo: Many countries and many goods

- Their trick?
  - Replace the numbers (i.e. the $a$) by a probability distribution
  - The "a" are realizations of random variables drawn from a well known (and arbitrarily defined) distribution.
  - This way of thinking about technologies has two advantages:
    - If the distribution is smooth, we obtain a continuum of input requirement across products (as in DFS) and countries = provides general conclusions with explicit solutions
    - We do not need to know all the input requirements. It is enough to know the parameters of the distribution.

## 4. Extending Ricardo: Many countries and many goods

- For each country *i* and each good *g*, they assume that productivity, 1/a, is drawn from a Fréchet distribution.
- We note $\varphi_{ig} = 1/a_{ig}$ the productivity of the production of good *g* in country *i*.

## 4. Extending Ricardo: Many countries and many goods

- The probability that the productivity is lower than *x* is:

$$\Pr\left[\varphi_{ig} \leq x\right] = e^{-T_i x^{-\theta}}$$

  - $T_i$>0 determines the location of the distribution for country *i*: a higher $T_i$ implies that a high efficiency draw for any good is more likely = countries' absolute advantages
  - $\theta$>0 is common to all countries and determines the shape of the distribution (a bigger $\theta$ implies less variability, i.e. more homogenous productivity across goods).

## 4. Extending Ricardo: Many countries and many goods

- Structure of the model:
  - Continuum of homogenous goods, which enter a CES utility.
  - Perfect competition.
  - They assume trade costs: cost of good *g* produced in country *i* and consumed in country *n* is:

$$(w_i / \varphi_{ig})\tau_{ni}$$

Production cost (unilateral) — Trade cost (bilateral)

  - Consumers will shop for the lowest cost producer of each good

## 4. Extending Ricardo: Many countries and many goods

- Consumers' behavior:
  - For each of the goods, the probability of buying it from country *i* is:

$$\Pr\left[\left(\frac{w_i}{\varphi_{ig}}\right)\tau_{ni} < \left(\frac{w_\ell}{\varphi_{\ell g}}\right)\tau_{n\ell}, \forall \ell\right]$$

  - This is equal to $\dfrac{T_i(w_i\tau_{ni})^{-\theta}}{\sum_\ell T_\ell(w_\ell\tau_{n\ell})^{-\theta}}$

## 4. Extending Ricardo: Many countries and many goods

- To show this, note that the probability that country *i* serves country *n* is :

$$\pi_{ni} = \Pr\left(p_{ni} \le \min_{\ell \ne i} p_{n\ell}\right)$$

- Let's consider a possible value for $p_{ni}$: $p_{ni} = p$
- The probability that *p* is the cheapest for consumers in county *i* is:

$$\prod_{\ell \ne i} \Pr(p_{n\ell} > p) = \prod_{\ell \ne i} \Pr\left(\frac{w_\ell\tau_{n\ell}}{\varphi_\ell} > p\right) = \prod_{\ell \ne i} \Pr\left(\varphi_\ell < \frac{w_\ell\tau_{n\ell}}{p}\right)$$

$$= \prod_{\ell \ne i} \exp\left(-T_\ell\left(\frac{w_\ell\tau_{n\ell}}{p}\right)^{-\theta}\right) = e^{-p^\theta\Phi_n^{-i}}$$

where $\Phi_n^{-i} = \sum_{\ell \ne i} T_\ell (w_\ell\tau_{n\ell})^{-\theta}$

## 4. Extending Ricardo: Many countries and many goods

- Now, we have to integrate over all possible *p* , times the density of the distribution of *p*.

$$\int_0^\infty e^{-p^\theta\Phi_n^{-i}} T_i(w_i\tau_{ni})^{-\theta}\theta p^{\theta-1} e^{-T_i(w_i\tau_{ni})^{-\theta}p^\theta} dp$$

- Which boils down into:

$$\pi_{ni} = \left(\frac{T_i(w_i\tau_{ni})^{-\theta}}{\Phi_n}\right)$$

## 4. Extending Ricardo: Many countries and many goods

$$\pi_{ni} = \left( \frac{T_i (w_i \tau_{ni})^{-\theta}}{\Phi_n} \right)$$

Is the probability that, for any good, country *n supplies country i.*

This is quite intuitive: this is simply the comparison between the expected price, on market *i*, for the goods produced in *n*, and all expected prices for goods produced elsewhere (including *n*).
= Multinomial logit (Mac Fadden)

The parameter $\Phi_n$ is important.
It summarizes:
- The states of technologies around the world ($\theta$ and, above all, $T_i$)
- The states of input costs around the world ($w_i$)
- How trade barriers govern prices in each country

## 4. Extending Ricardo: Many countries and many goods

- With a CES demand structure, countries spread their overall expenditure $X_n$, on each good g according to:

$$x_{ng} = X_n \frac{p_{ng}^{1-\sigma}}{\sum_{g'} p_{ng'}^{1-\sigma}}$$

- where $p_{ng}$ is the best available price for good g in county n.

## 4. Extending Ricardo: Many countries and many goods

- Total export flow from *i* to n is then:

$$Export_{ni} = \sum_g \left( x_{ng} \pi_{ni} \right) = \pi_{ni} \sum_g \left( x_{ng} \right) = \pi_{ni} X_n$$

$$Export_{ni} = X_n \frac{T_i (w_i \tau_{ni})^{-\theta}}{\sum_\ell T_\ell (w_\ell \tau_{\ell i})^{-\theta}}$$

## 4. Extending Ricardo: Many countries and many goods

- Total export flow from *i* to n is then:

$$Export_{ni} = X_n \frac{T_i (w_i \tau_{ni})^{-\theta}}{\sum_\ell T_\ell (w_\ell \tau_{\ell i})^{-\theta}}$$

Exporter's ability

Transport costs

Importer's market size

"Multilateral resistance" = captures competition pressure

- With no comparative advantage and no trade barrier, export is simply $X_n$ over the number of countries (all countries have the same market share everywhere)
- With CA and trade costs, this is a gravity equation (see chap. 5)
- Note that the trade elasticity is $-\theta$

## 4. Extending Ricardo: Many countries and many goods

- Note that the trade elasticity is $-\theta$:
  - Larger $\theta$ means that the productivities are closer across products (they are less heterogeneous).
  - A marginal increase in one country's advantage (lower marginal cost, lower trade cost) reduces the (potential) delivered price for all good.
  - With a large $\theta$, such a marginal change of (potential) delivered prices more products start to be exported
  - Because countries always source a given product from a single origin, the extensive margin plays a great role in this model.

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5. **Empirical validations**

## 5. Testing Ricardo

- Testing Ricardo's prediction is not an easy task.
- **DFS predictions are simple**
  - Take two countries (USA and UK), and many goods
  - Rank the goods according to the relative productivities of each country (comparative advantages)

$$\frac{a_{uk}(1)}{a_{us}(1)} > \frac{a_{uk}(2)}{a_{us}(2)} > \ldots > \frac{w_{us}}{w_{uk}} > \ldots > \frac{a_{uk}(n-1)}{a_{us}(n-1)} > \frac{a_{uk}(n)}{a_{us}(n)}$$

  - If Ricardo is right (DFS formally), USA should exports goods on the left of the chain (i.e. the ones for which its relative productivity is larger than relative wage), and UK should export the other goods
  - One can test the relationship between the ratio of productivities and the ratio of exports

## 6. Testing Ricardo

- Mac Dougal, 1951

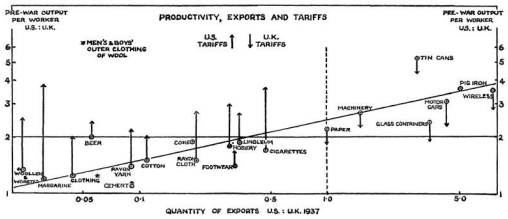


Figure : Ratios of productivities vs. exports for the US & the UK – 1937.
Source: MacDougall, 1951

## 5. Testing Ricardo

- Stern, 1962

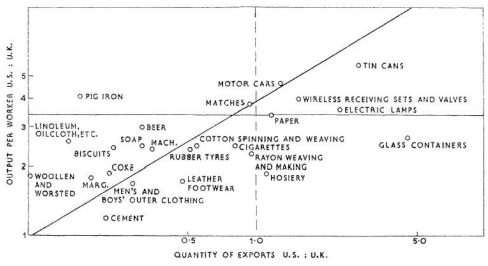


Figure : Ratios of productivities vs. exports for the US & the UK – 1950.
Source: Stern, 1962

## 5. Testing Ricardo: an example

- **But things are not that simple**
- The problem:
  - Consider Ricardo's famous example, where English workers are relatively better at producing cloth than wine compared to Portuguese workers.
  - Then England will produce cloth, Portugal will produce wine, and at least one of these two countries will be completely specialized in one of these two sectors.
  - Accordingly, the key explanatory variable in Ricardo's theory, i.e. relative labor productivity, cannot be directly observed because we do not observe British workers in the wine industry.

## 5. Testing Ricardo: an example

- The solutions:
  1. Move back to the essence of comparative advantage, and compare relative autarky price… but autarky situation are never observed (but in exceptional cases, e.g. Bernhofen and Brown 2004)
  2. Make explicit assumptions on the distribution function of productivities across different economic activities. Then, unobserved productivity might be inferred (cf. Costinot et al. *RES* 2012).
  3. Focus on a specific factor for which productivity might be measured independently of the use of the factor.

Costinot and Donaldson (AER P&P, 2012) use the third solution

## 5. Testing Ricardo: an example

- **Costinot and Donaldson (AER P&P, 2012):**
- They argue that:

*Land (and thus agricultural goods) is a good candidate because agronomists are able to predict how productive is a given parcel of land in the production of a given good, considering the nature of the soil, the climatic conditions…*

**Global Agro-Ecological Zones project** aims to make agronomic predictions, i.e. compute the production that would be obtain for a given crop in a given location.

## 5. Testing Ricardo: an example

- **Costinot and Donaldson (AER P&P, 2012):**
- The model considers:
  - *C* countries
  - *G* goods (crops)
  - *F* factors of production (a parcel of land).
  - Of course, the factors of productions are immobile across countries, but can be used for producing any kind of crops (i.e. they are "mobile" across "industries").

## 5. Testing Ricardo: an example

- **Costinot and Donaldson (AER P&P, 2012):**

$A_{cf}^{g}$ is the (exogenous) productivity of land *f,* in country *c* when producing the crop *g.*

$L_{cf}^{g}$ is the quantity of factor *f* allocated to crop *g* in country *c*

## 5. Testing Ricardo: an example

- **Costinot and Donaldson (AER P&P, 2012):**

The variation in $A_{cf}^{g}$ is the source of the comparative advantages

For example: if two pieces of land, $f_1$ and $f_2$ , located in country *c* are such that:

$$A_{cf_2}^{g_2} / A_{cf_2}^{g_1} > A_{cf_1}^{g_2} / A_{cf_1}^{g_1}$$

then, $f_1$ is relatively less productive than $f_2$ in the production of good 2 and relatively more in the production of good 2.

In other words, the piece of land $f_2$ has a comparative advantage in the production of good 2.

## 5. Testing Ricardo: an example

- **Costinot and Donaldson (AER P&P, 2012):**

The comparative advantages determine the optimal allocation of land across the products… and thus the level of production.

**Optimal allocation:** A land will be used in the production of a good *g* if the value of the output of *g* that is generated, (i.e. Productivity X Price) is larger than the value of output generated by an alternative production.

$$\widetilde{F}_c^g = \left\{ f = 1,..F \;\middle|\; \frac{A_{cf}^{g}}{A_{cf}^{g'}} > \frac{p_c^{g'}}{p_c^{g}} \text{ if } g' \neq g \right\}$$

This give the total level of production of good *g* in country *c*

$$Q_c^g = \sum_{f=1}^{\widetilde{F}_g} A_{cf}^{g} L_{cf}^{g}$$

## 5. Testing Ricardo: an example

- **Costinot and Donaldson (AER P&P, 2012):**

The test will consist to compute the production of each crop in each country $Q_c^g$, predicted by the model, using data on land productivity and commodity prices and then, to compare it to actual output levels, $\overline{Q}_c^g$

**Data:**

FAO provides, for 55 countries and 17 crops:

– Actual outputs levels $\overline{Q}_c^g$

– Producer prices $p_c^g$

The Global Agro Ecological Zone provides information on $A_{cf}^g$

## 5. Testing Ricardo: an example

- **Costinot and Donaldson (AER P&P, 2012):**

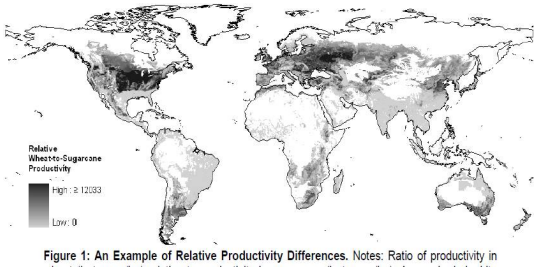


**Figure 1: An Example of Relative Productivity Differences.** Notes: Ratio of productivity in wheat (in tonnes/ha) relative to productivity in sugarcane (in tonnes/ha). Areas shaded white have either zero productivity in wheat, or zero productivity in both wheat and sugarcane. Areas shaded dark, with the highest value (">12,033"), have zero productivity in sugarcane and strictly positive productivity in wheat. Source: GAEZ project.

## 5. Testing Ricardo: an example

- **Costinot and Donaldson (AER P&P, 2012):**

**Table 1: Comparison of Predicted Output to Actual Output**

| Dependent variable: | log (output) | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| log (predicted output) | 0.212*** (0.057) | 0.244*** (0.074) | 0.096** (0.038) | 0.143** (0.062) | 0.273*** (0.074) |
| sample | all | all | all | major countries | major crops |
| fixed effects | none | crop | country | none | none |
| observations | 349 | 349 | 349 | 226 | 209 |
| R-squared | 0.06 | 0.26 | 0.54 | | |

Notes: All regressions include a constant. Standard errors cluster parentheses. ** indicates statistically significant at 5% level and *** at the

**Fairly good correlation between predicted and actual productions... but the coef is quite far from unity**

## Conclusion

- We have seen the ricardian model of trade
- The key characteristics are:
  - Perfect competition (not that important)
  - Comparative advantages based on productivity differences
  - Unique factor that generates complete specialization
- Of course, perfect competition does not really exist, and complete specialization is a quite strong conclusion...
- ... However, it seems reasonable to consider that international difference in productivities plays an important role in international trade.

## Conclusion

- There are two key mechanisms here:

1. *Comparative* advantages. It is not absolute productivity that matters, but relative productivity.
2. Trade is driven by differences in relative prices: differences in relative productivity generates differences in relative prices… and thus incentives to import and export