Econ 39: International Trade

Week #4: Testing the Ricardian Model

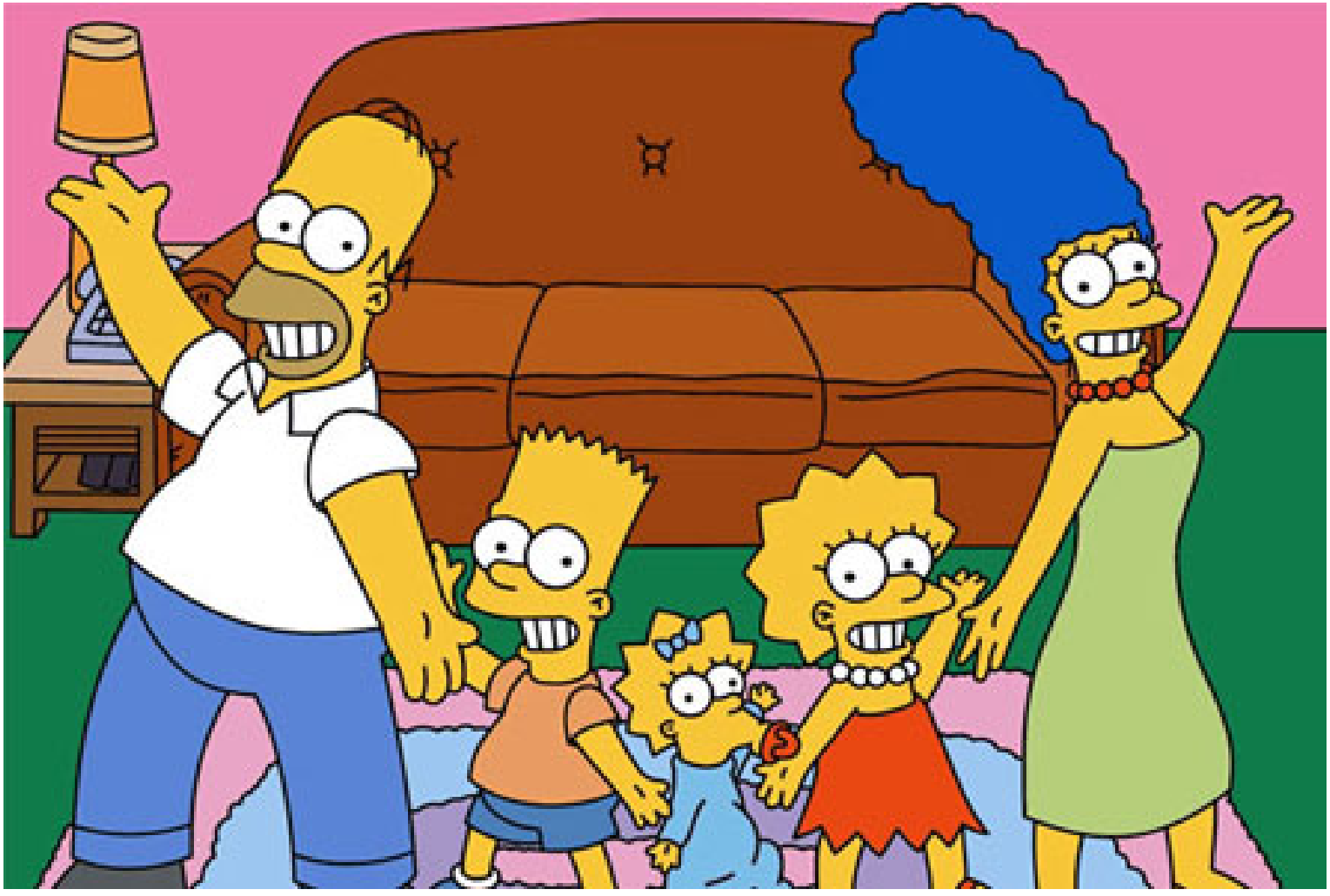
Treb Allen

Winter 2017

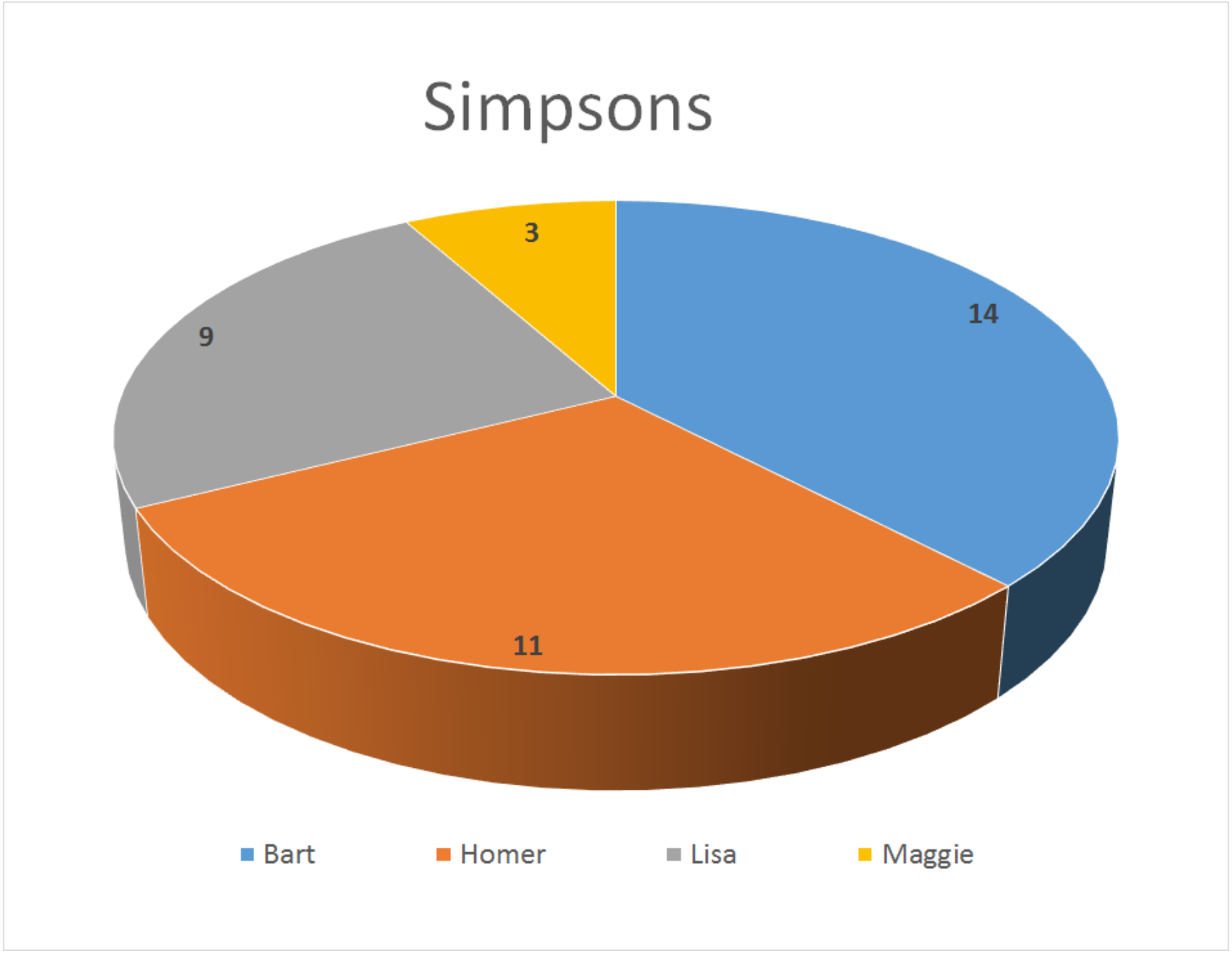
Plan for the week

- Today:
  - Finish (if necessary) the Eaton Kortum '02 model.
  - Does the Ricardian model predict patterns of specialization and trade in the real world?
    - Patterns of specialization: Costinot and Donaldson (2012)
    - Patterns of trade: Bernhofen and Brown (2004)
- Wednesday (during X-hours):
  - Midterm review: Will answer any last minute questions you have.
- Thursday: Midterm #1!
  - Midterm covers all material through the end of today.
  - Show up to class early, midterm will begin promptly.

Today's Teams



Today's Teams



Arnaud Costinot

- 2005 Princeton Ph.D.
- MIT Economist (2008-)
- #2 Young Economist (10 years or less)
- Jumped on by my dog.

Dave Donaldson

- 2009 LSE Ph.D.
- MIT Economist (2009-2014)
- Stanford Economist (2014-)
- Former neighbor.

Patterns of specialization in comparative advantage models

- Consider the two country / two good Ricardian model.
  - Suppose $\frac{\alpha_{US}^{SB}}{\alpha_{MEX}^{SB}} > \frac{\alpha_{US}^{FB}}{\alpha_{MEX}^{FB}}$.
  - [Class question: which country will specialize in what?]
- Consider now the two country / many good Ricardian model.
  - Order goods such that $A(g) \equiv \frac{\alpha_{MEX}(g)}{\alpha_{US}(g)}$ is downward sloping.
  - Suppose relative wage in the U.S. $w = A(g^*)$ for some $g^* \in [0, 1]$.
  - [Class question: which country will specialize in what?]
- Implication: *relative* productivities determines which country produces what (given prices).

Testable prediction of the patterns of specialization

- Now suppose we want to test how well the Ricardian model predicts patterns of specialization in the data.

- [Class question: what is the Ricardian model prediction?]
  - A country will specialize (and export) the goods for which it has a higher relative productivity and not produce (import) the goods for which it has a lower productivity.
- [Class question: Suppose we observed everything about the world. How could we test this prediction?]
  - We could correlate relative productivity of a country with the quantity it produces (or its relative exports) of a good.

The central problem

- [Class question: What variables do we typically observe?]
  - Prices.
  - Who produces what (and the quantities produced).
  - Unit labor costs of the goods being produced (maybe).
- [Class question: What variables do we typically *not* observe?]
  - Unit labor costs of the goods not being produced.
- The central problem: We do not observe the productivity of goods a country does not produce!
  - "The difference in labor requirements cannot be observed, since imported goods will almost never be produced in the importing country." (Deardorff, 1984).

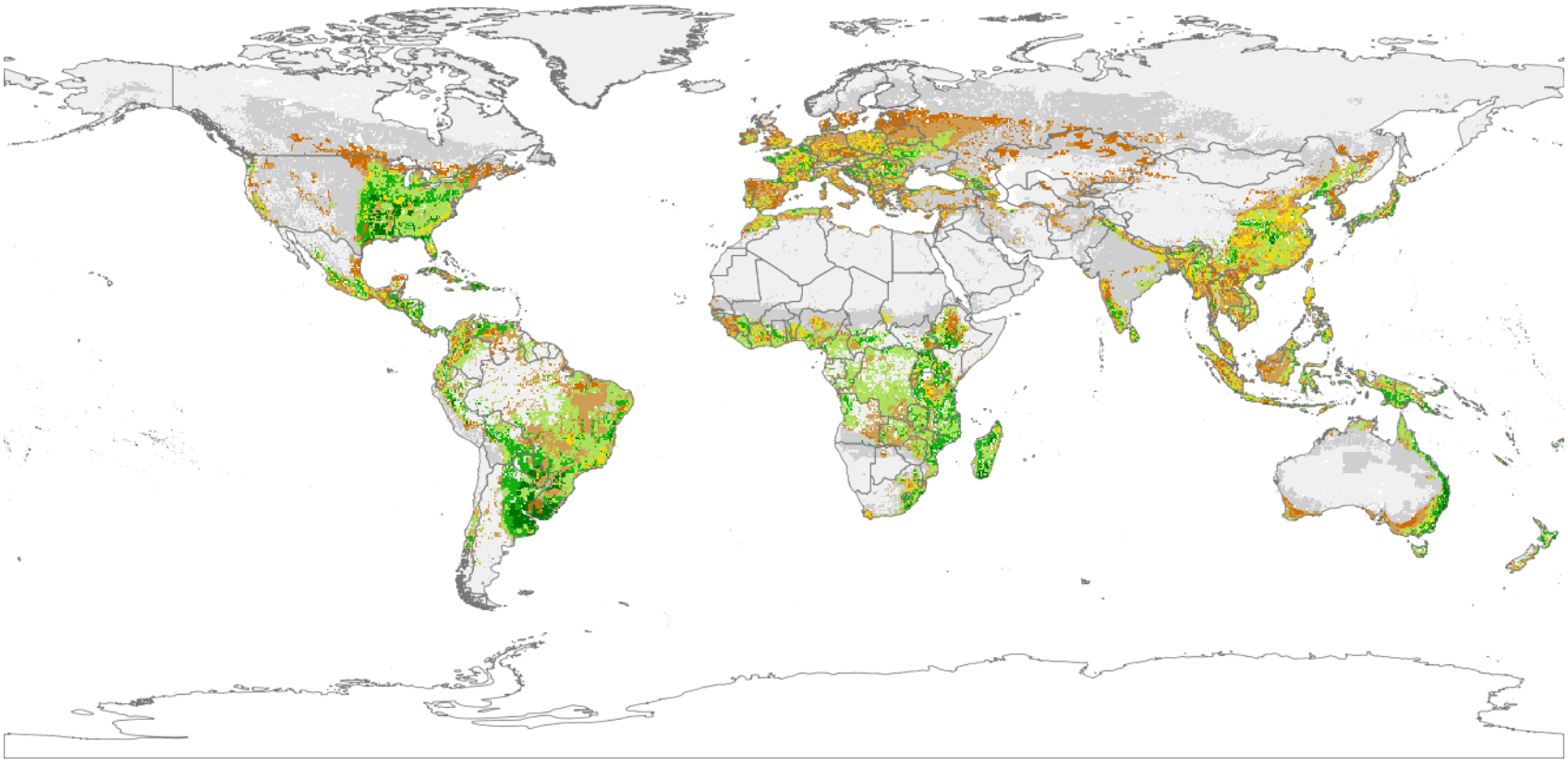
Options for circumventing the difficulty

- [Class question: How can we get around not observing the productivity of goods a country does not produce?]
  - Option #1: Can make (unverifiable) assumptions on the distribution of productivities. (Sound familiar?)
  - Option #2: Focus on a sector where we have a good measure of productivity, even if a country does not produce a good.
- Costinot and Donaldson '12: Agriculture is such a sector!

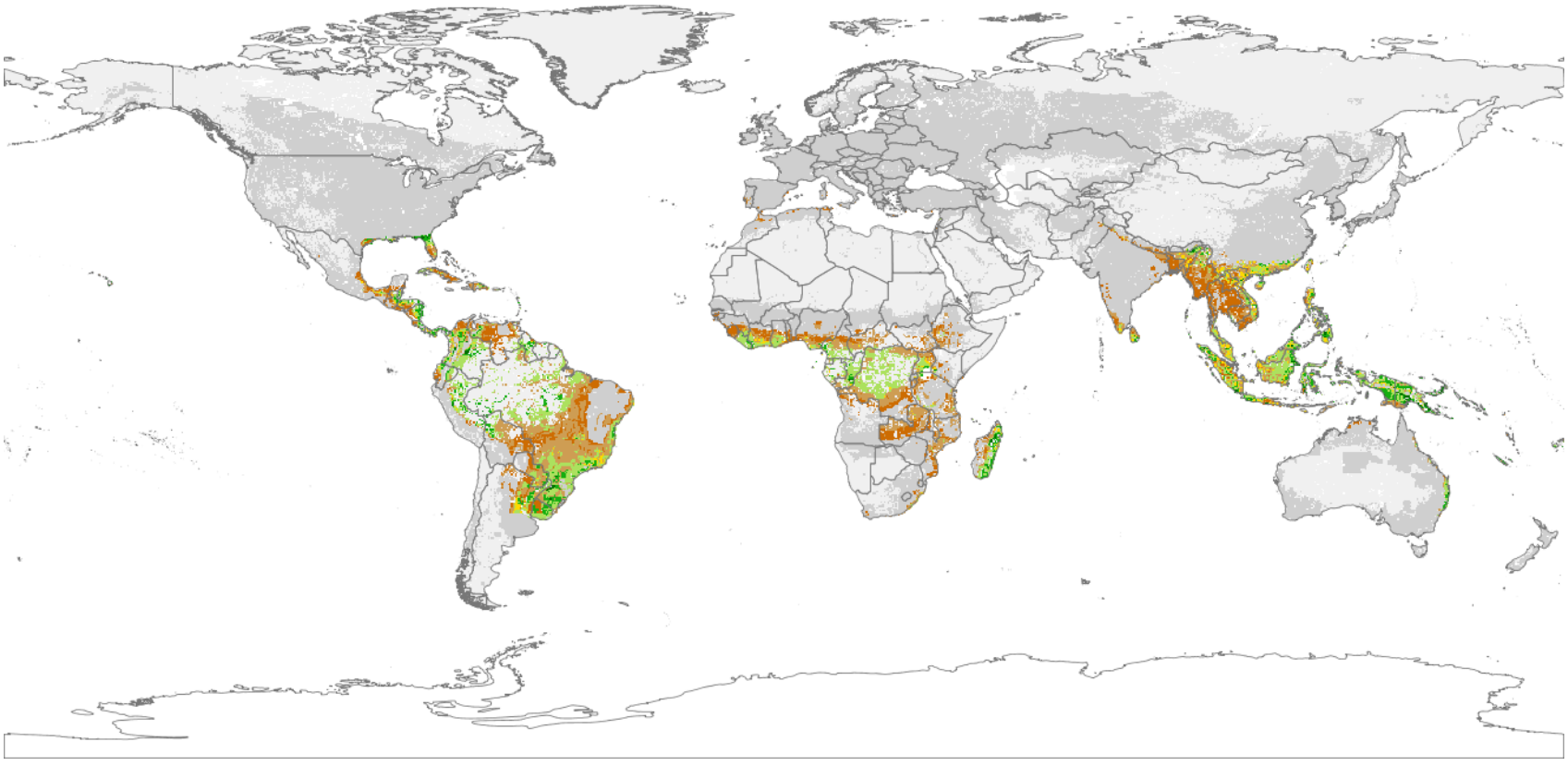
Data on the agricultural sector

- The Food and Agricultural organization (FAO) collects data on crop *output* and *prices* across:
  - 17 major agricultural crops
  - 55 major agricultural countries
- More importantly, the Global Agro-Ecological Zones (GAEZ) project by the FAO predicts the productivity of land across the globe for each crop
  - Uses information on soil characteristics, elevation, climate, water availability, etc.
  - And combines with agricultural models (where parameters have been estimated from various field and lab experiments).

GAEZ: Alfalfa



GAEZ: Banana



How to use this data to test the Ricardian model

- For each (5 arc-minute) grid-cell on Earth, observe productivity of land for each crop.
- For each country and crop, observe price and quantity of output.
- Would like to test if relative productivity determines patterns of specialization.
- [Class question: How do we apply the Ricardian model to do so?]
  - C&D solution: treat each grid cell in a country as a different factor.

Setup

- Many countries: $c \in \{1, ..., C\}$.
  - One country for each country in the data.
- Many goods: $g \in \{1, ..., G\}$.
  - One good for each crop in the data.
- Many factors $f \in \{1, ..., F\}$
  - One factor for each grid-cell ("field") in the data.
- [Class question: What about labor?]

Productivity

- Consider a particular field f in country c.
- We observe the productivity of the field in producing each good g, which we call A_{fc}^{g}.
  - [Class question: what is the unit "field" requirement?]
- Consider two fields f_1 and f_2 in the same country c and two goods g_1 and g_2.
  - Suppose $\frac{A_{cf_2}^{g_2}}{A_{cf_2}^{g_1}} > \frac{A_{cf_1}^{g_2}}{A_{cf_1}^{g_1}}$.
  - [Class question: which field has a comparative advantage in which crop?].
- Notation:
  - Let L_{cf}^{g} be the land area in field f allocated to the production of good g in country c.
  - Let L_{cf} be the total land area of field f.
  - Let F_c be the set of fields in country c.

Patterns of specialization

- Take the price of good g in country c, p_c^g as given.
- [Class question: What is the quantity of good g produced by country c?]
  - Answer:

$$Q_c^g = \sum_{f \in F_c} A_{cf}^g L_{cf}^g$$

- [Class question: What problem do producers in country c solve?]
  - Answer:

$$\max_{\left\{L_{cf}^g\right\}_{g,f}} \sum_{g=1}^{G} p_c^g Q_c^g \text{ s.t. } \sum_{g=1}^{G} L_{cf}^g \leq L_{cf}$$

Patterns of specialization (ctd).

- From last slide:

$$\max_{\left\{L_{cf}^{g}\right\}_{g,f}} \sum_{g=1}^{G} p_c^g Q_c^g \text{ s.t. } \sum_{g=1}^{G} L_{cf}^{g} \leq L_{cf}$$

- Use the fact that $Q_c^g = \sum_{f \in F_c} A_{cf}^{g} L_{cf}^{g}$ so that problem becomes:

$$\max_{\left\{L_{cf}^{g}\right\}_{g,f}} \sum_{g=1}^{G} \sum_{f \in F_c} A_{cf}^{g} p_c^g L_{cf}^{g} \text{ s.t. } \sum_{g=1}^{G} L_{cf}^{g} \leq L_{cf}$$

- Implication: Allocate field f to good g where $A_{cf}^{g} p_c^g$ is greatest.

Patterns of specialization (ctd).

- Implication: Allocate field f to good g where $A^g_{cf} p^g_c$ is greatest.
- Total production can be written as:

$$Q^g_c = \sum_{f \in \mathcal{F}^g_c} A^g_{cf} L_{cf}, \tag{1}$$

  - where:

$$\mathcal{F}^g_c \equiv \left\{ f \in F_c | \frac{A^g_{cf}}{A^{g'}_{cf}} > \frac{p^{g'}_c}{p^g_c} \text{ for all } g' \neq g \right\} \tag{2}$$

- Comparative advantage with multiple factors: relative productivity differences determines factor allocation.

Testing the model

- Generate model predicted quantities produced.
  - Given observed prices $\left\{p_c^g\right\}$, observed land areas L_{cf}, and GAEZ predicted productivities $\left\{A_{cf}^g\right\}$, can use equations (1) and (2) to predict the quantity each country c produces of each good g.
  - Call these predicted quantities Q_c^g.
- FAO also reports observed quantities produced of each good in each country.
  - Call these observed quantities $\tilde{Q}_c^g$.
- A simple test of the model: do the predicted quantities look anything like the observed quantities?

Testing the model (ctd).

- C&D implement this test using a simple regression:

$$\ln \tilde{Q}_g^c = \beta \ln Q_c^g + \varepsilon_c^g$$

  - [Class question: Why take logs of the variables?]

  - [Class question: What should β equal?]

Results

TABLE 1—COMPARISON OF ACTUAL OUTPUT TO PREDICTED OUTPUT

Dependent variable:	log (output)				
	(1)	(2)	(3)	(4)	(5)
log (predicted output)	0.212***	0.244***	0.096**	0.143***	0.273***
	(0.057)	(0.074)	(0.038)	(0.062)	(0.074)
Sample	All	All	All	Major countries	Major crops
Fixed effects	None	Crop	Country	None	None
Observations	349	349	349	226	209
R^2	0.06	0.26	0.54	0.04	0.07

Note: Standard errors clustered by country are in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

- [Class question: How do we interpret the estimated coefficient?]

Discussion of results

- Result: a 10% increase in the predicted output of a good in a country is associated with about a 2% increase in actual output.
- [Class question: Does this validate or disprove the Ricardian model?]
- [Class question: What are possible reasons that the prediction is not perfect?]
  - Other uses of land?
  - Other factors / costs of producing?
  - Predicted productivity from GAEZ may not be true productivity?
  - Others?

Prices and Patterns of Trade

- C&D show that relative productivities do a fairly good job of predicting patterns of specialization (given prices).
- But only a part of the Ricardian model: Says little about the pattern of trade.
- Key prediction of the Ricardian model: going from autarky to free trade causes a country to export the good it has a comparative advantage in.
  - Implication of this result: At autarky prices, the value of exports is lower than the value of imports.

Values of exports and imports at autarky prices

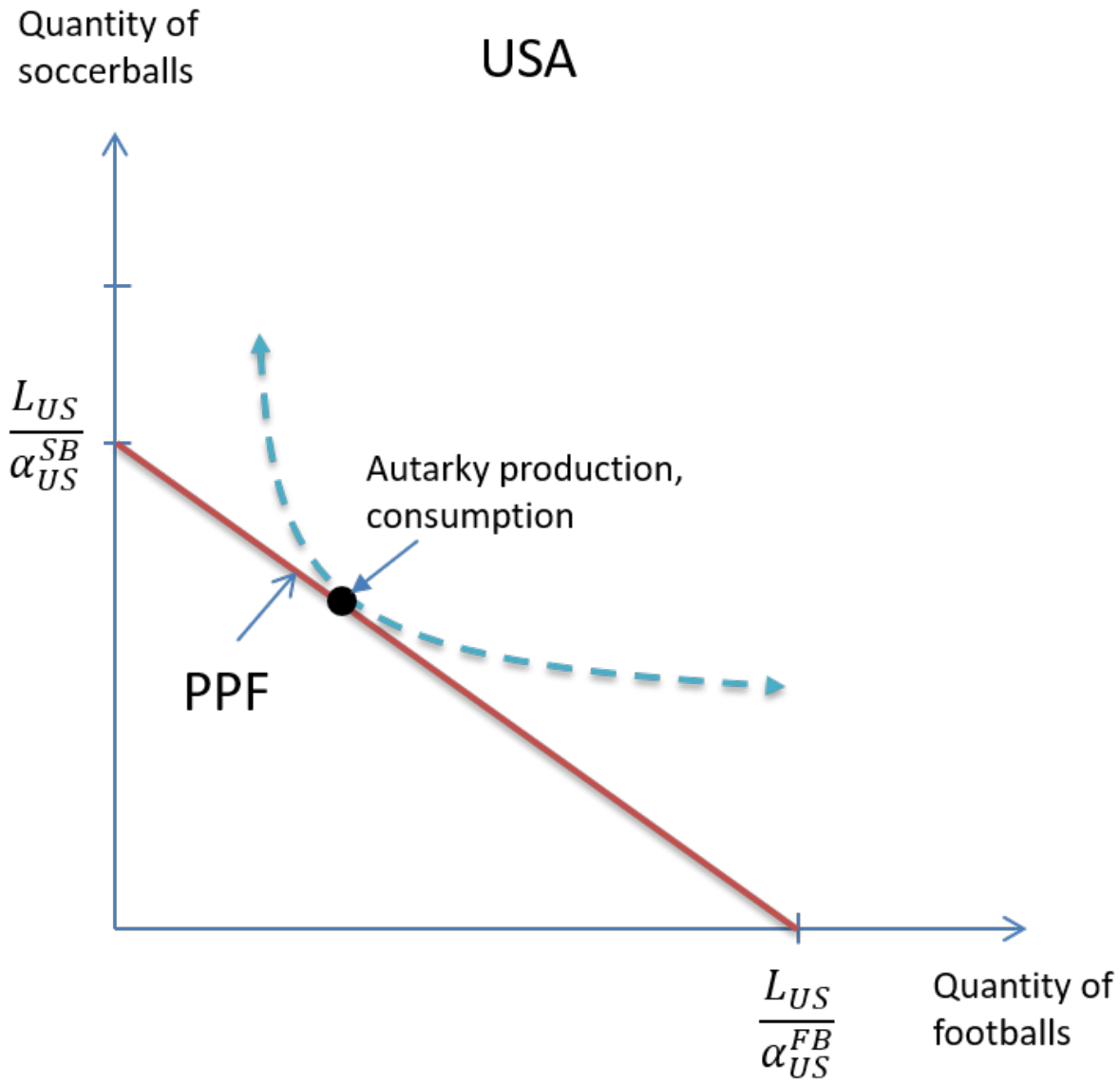
- Example: U.S. goes from autarky to free trade.

- Suppose that world prices are such that:

$$\frac{p^{FB}}{\alpha_{US}^{FB}} > \frac{p^{SB}}{\alpha_{US}^{SB}} \iff$$
$$\frac{\alpha_{US}^{FB}}{\alpha_{US}^{SB}} < \frac{p^{FB}}{p^{SB}}$$

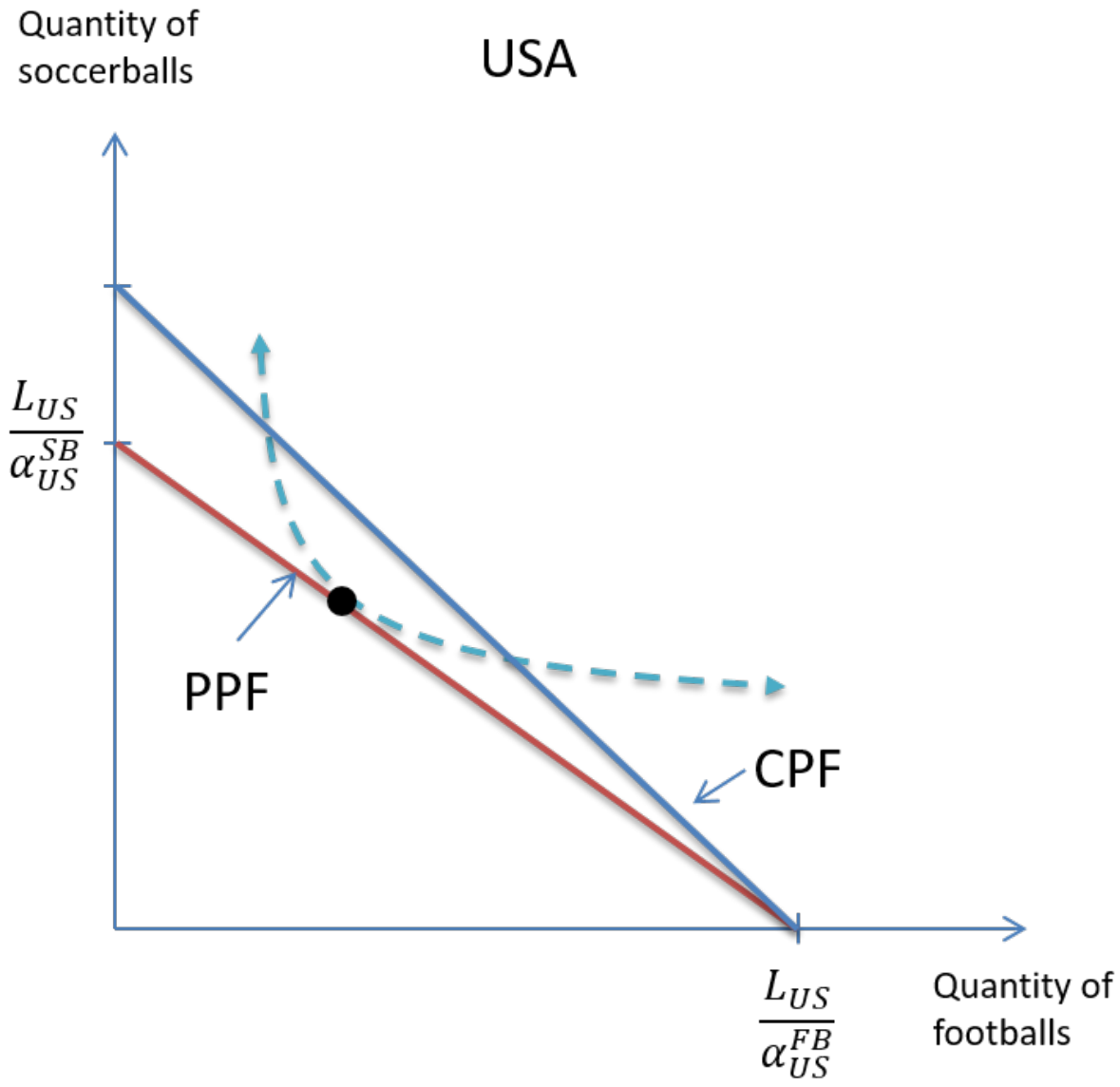
  - [Class question: What will the U.S. specialize in?]

Values of exports and imports at autarky prices



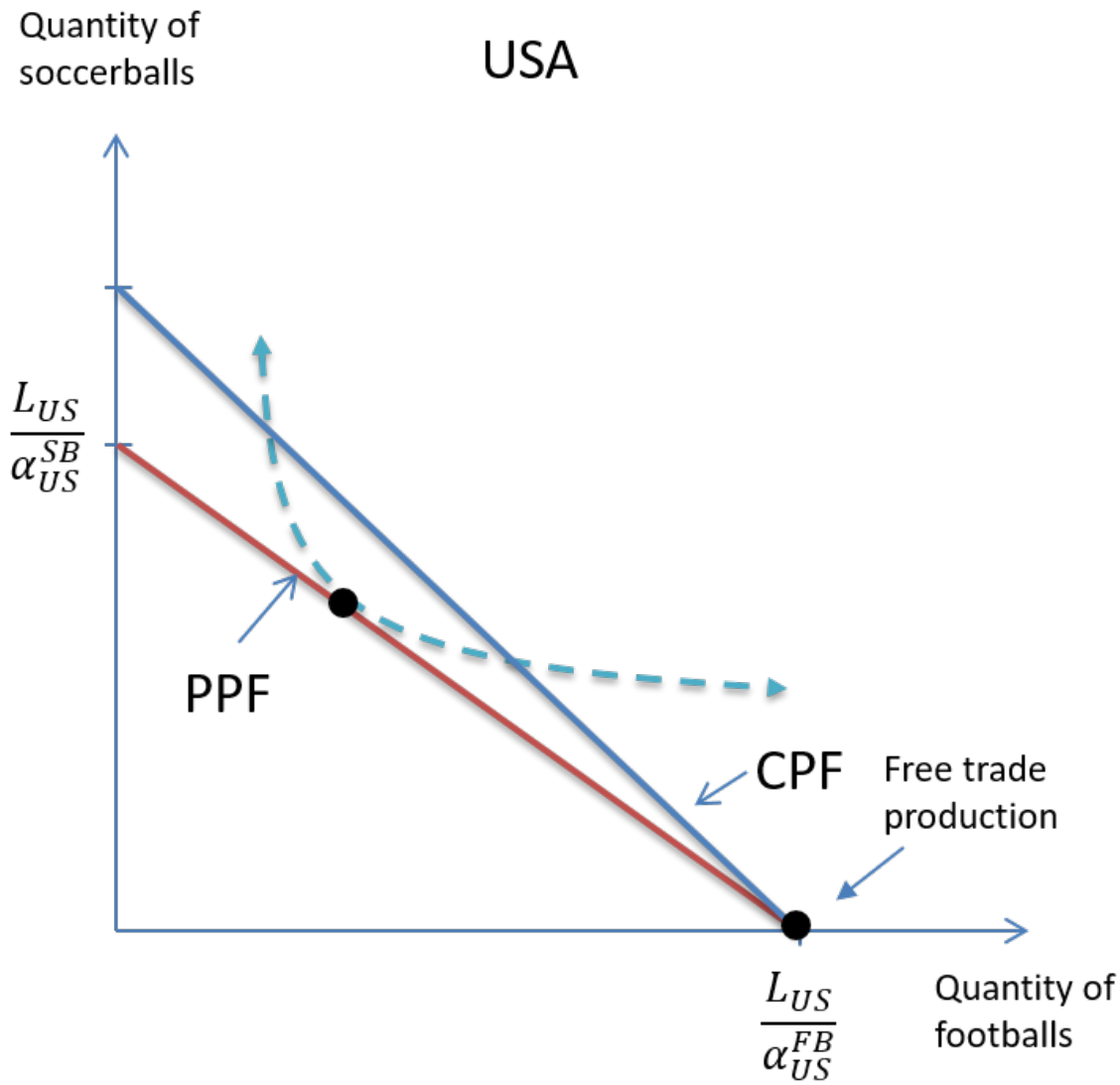
- [Class question: What does the CPF look like with trade?]

Values of exports and imports at autarky prices



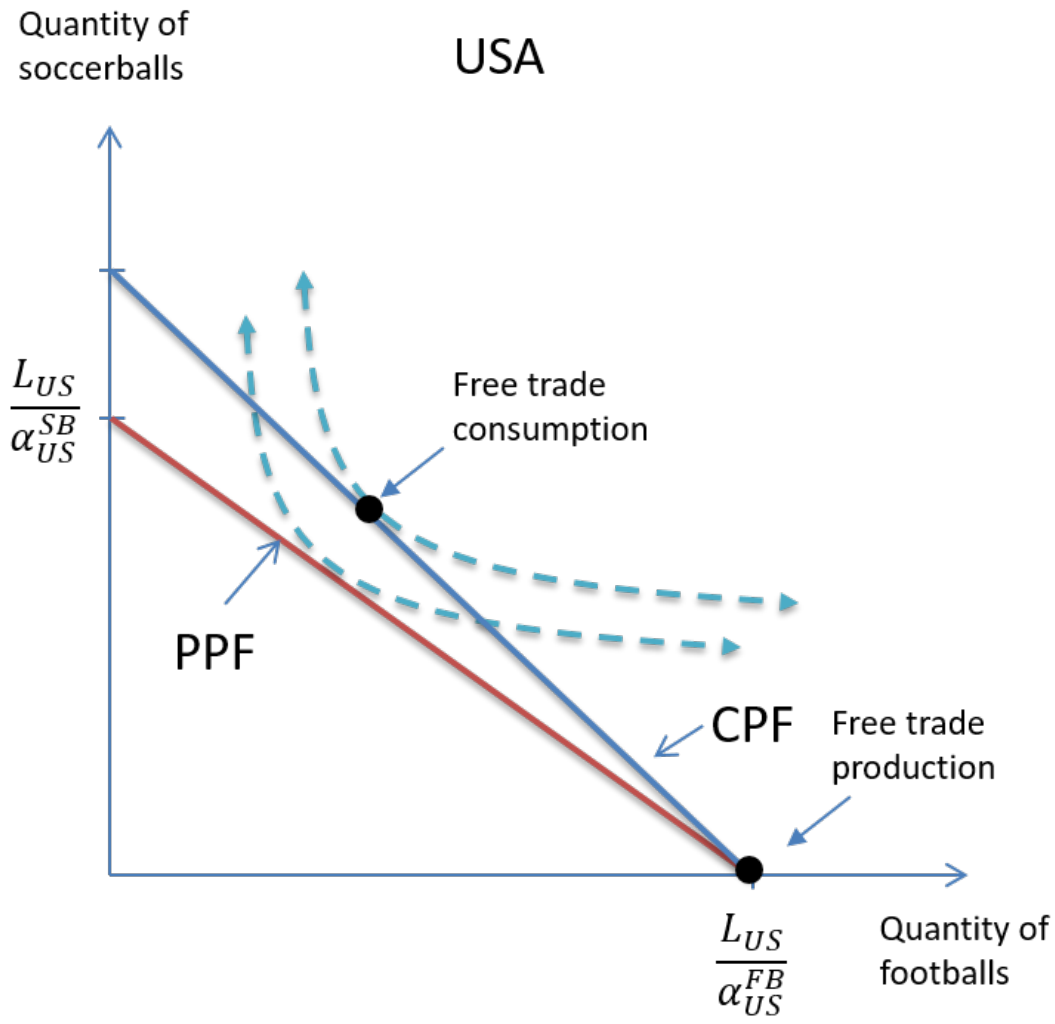
- [Class question: Where will the US produce with trade?]

Values of exports and imports at autarky prices



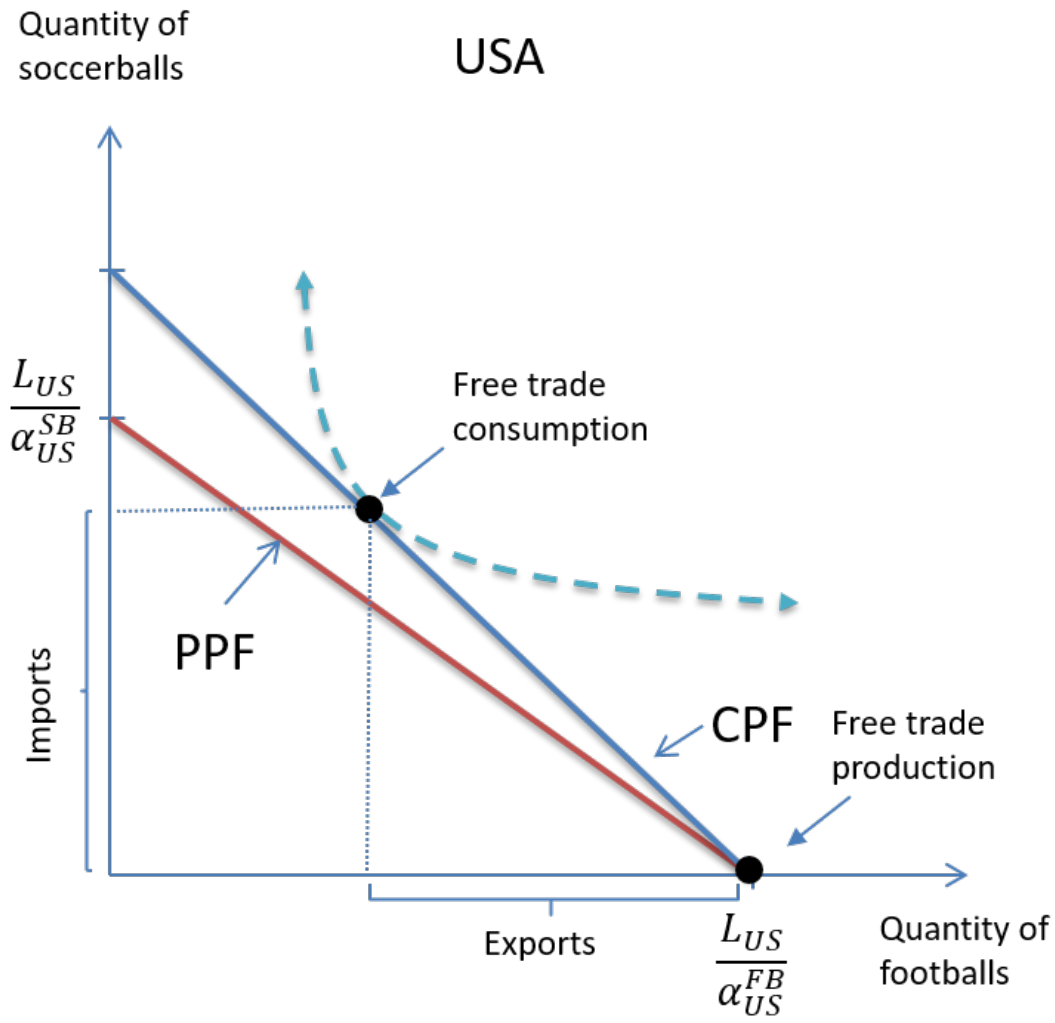
- [Class question: Where will the US consume with trade?]

Values of exports and imports at autarky prices



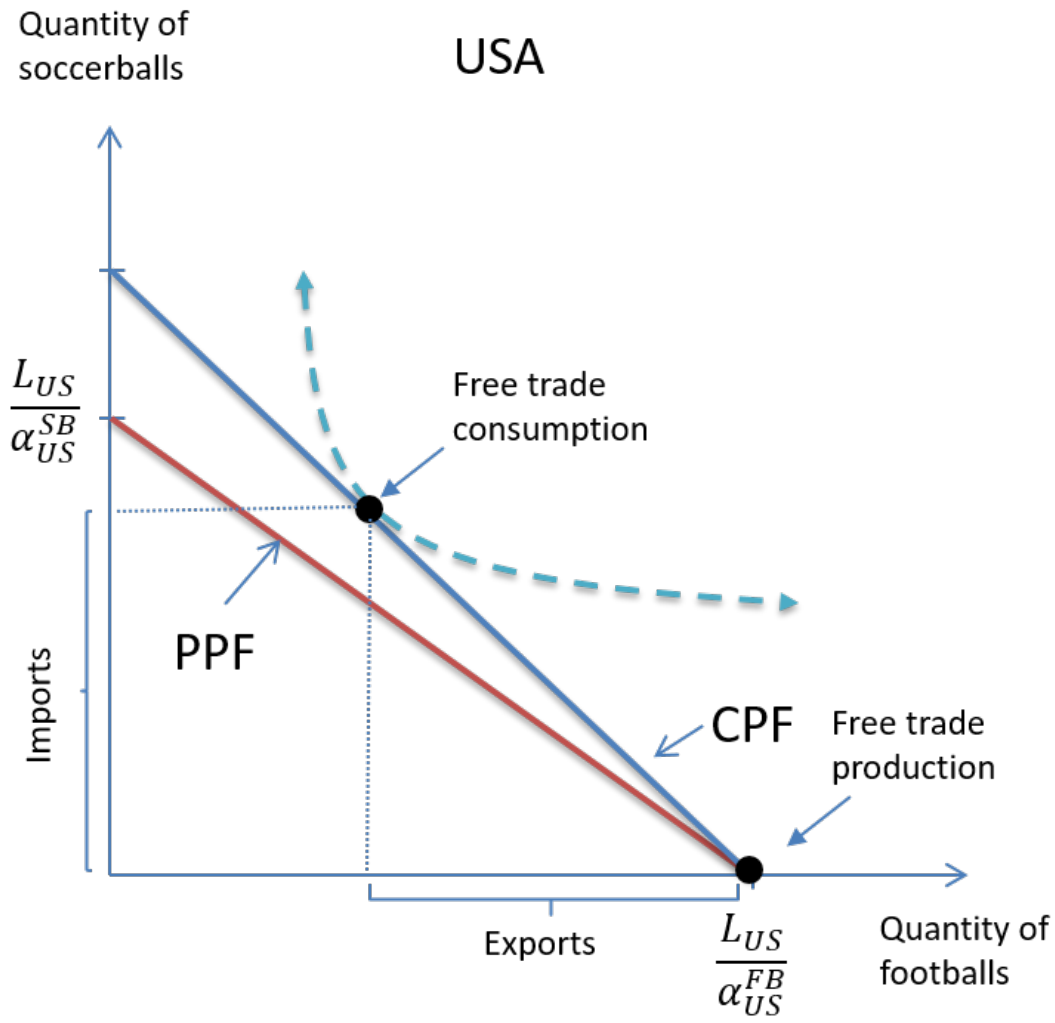
- [Class question: How much does the U.S. import and export?]

Values of exports and imports at autarky prices



- [Class question: What is the value of U.S. imports and exports at world prices?]

Values of exports and imports at autarky prices



- [Class question: What is the value of U.S. imports and exports at *autarky* prices?]

Values of exports and imports at autarky prices

- Value of imports greater than value of exports at autarky prices.

Testing the Ricardian model: Prices and patterns of trade

- Ricardian model predicts value of imports greater than value of exports at autarky prices.
  - It turns out that this prediction holds true even with more than two goods (Deardorff 1980).
- Ideal experiment:
  - Observe a country in autarky, note the price of goods.
  - Observe the same country in trade, note the quantity it exports and imports.
  - Calculate the value of imports and exports at autarky prices.
  - Verify that value of imports $>$ value of exports.

The central problem

- How can we observe the same country in autarky and with free trade?

- Typically countries trade (at least a little bit)...
  - ... And countries that open up to trade rapidly tend to do so for reasons that affect much of the economy (e.g. economic crises).
- Bernofen and Brown (2004)'s idea: Look at the case of Japan in the 19th century!

A brief history of Japan

- In 1639, Japan forbid all contact with outsiders, shutting down trade
- In 1853, Commodore Matthew Perry arrived, forced Japan to open up several ports.
- Further military interventions by Western countries meant by 1860s trade was virtually unrestricted.

A brief history of Japan (ctd.)

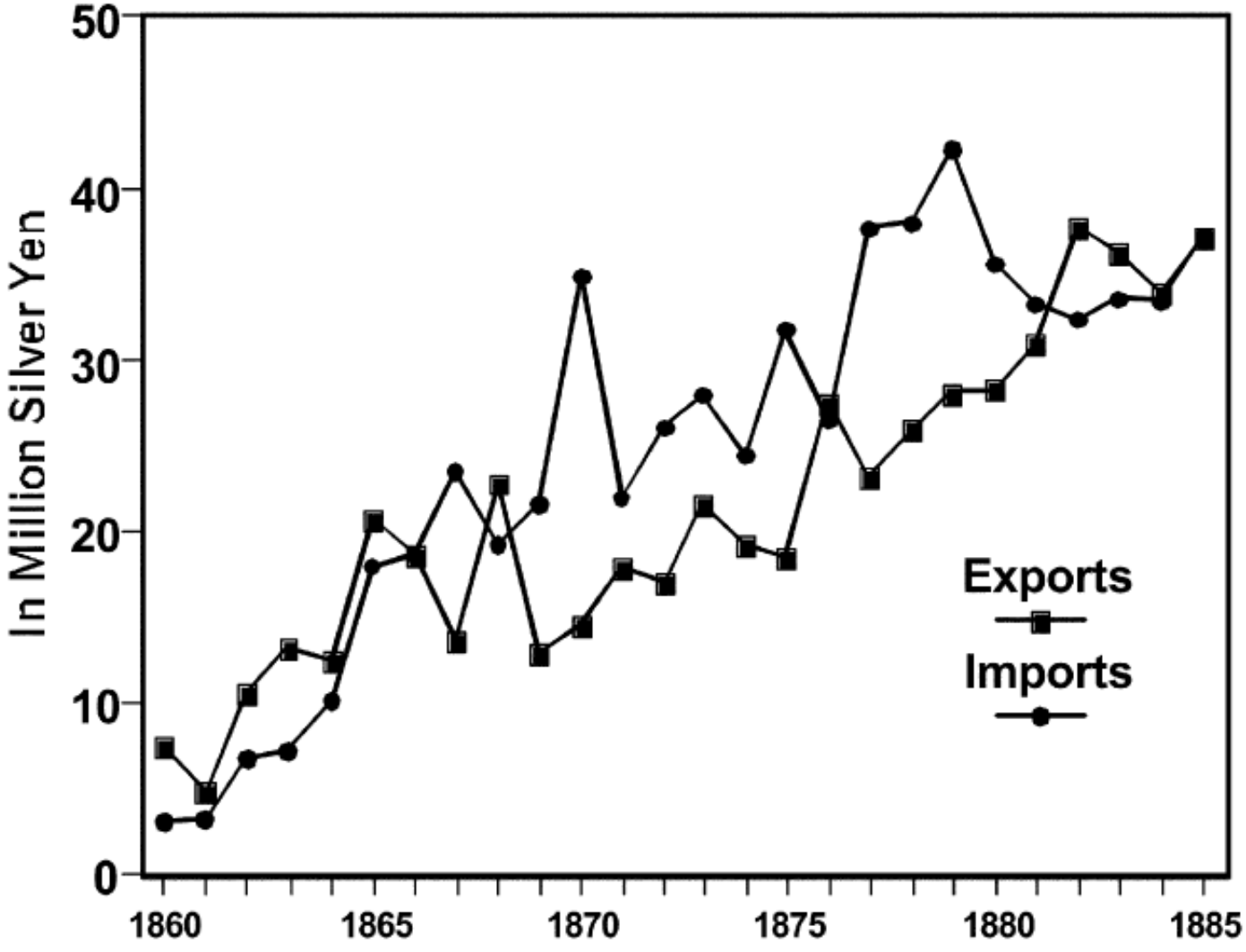


FIG. 3.—The development of Japan's external trade, 1860–85. Source: Sugiyama (1988, table 3-4).

Price changes and patterns of trade

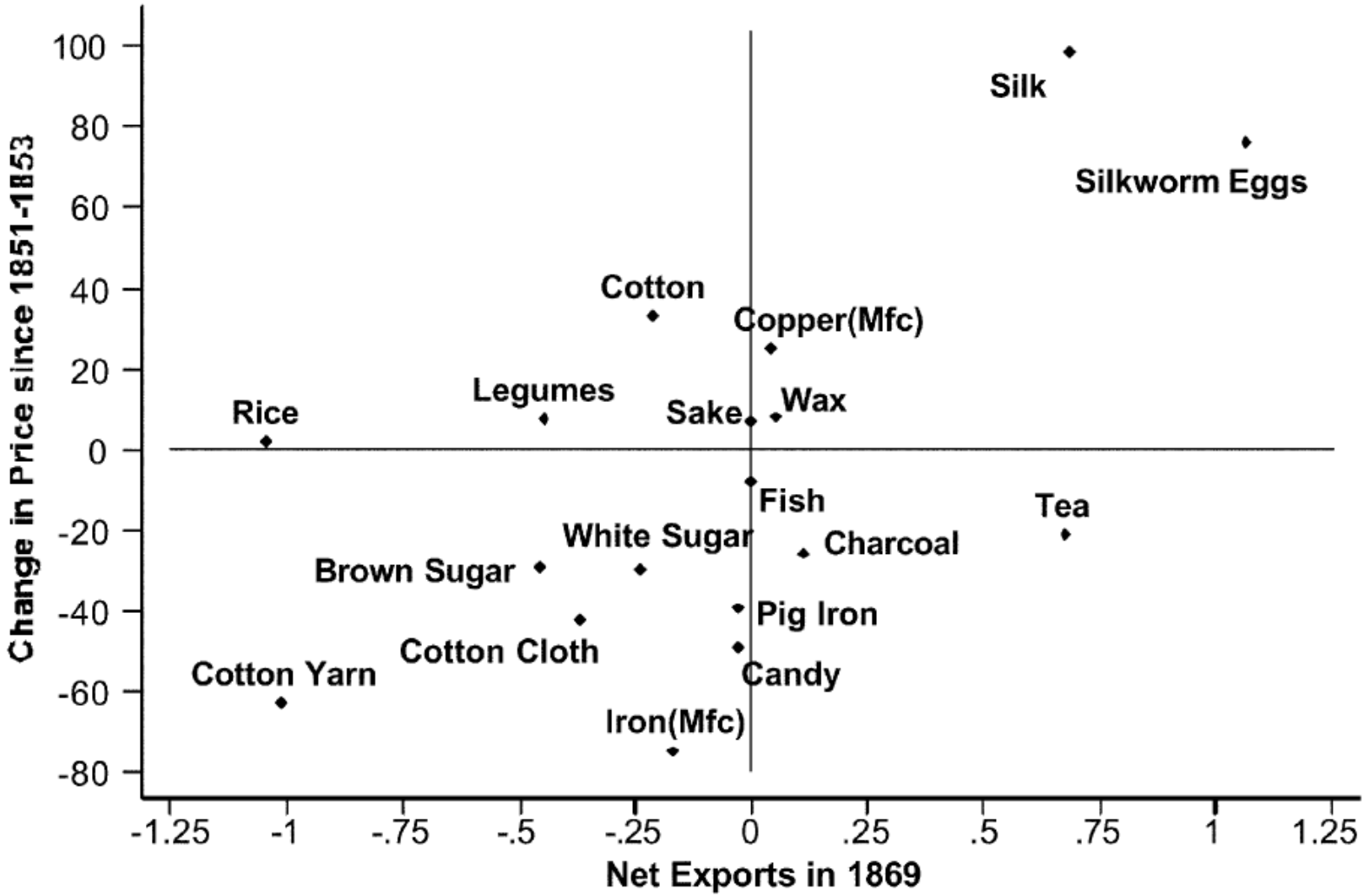


FIG. 4.—Net exports and price changes for 1869. Source: Japan Bureau of Revenue (1893) for trade data and Kinyu Kenkyukai (1937), Miyamoto (1963), Ono (1979), Yamazaki (1983), and Mitsui Bunko (1989) for price data.

Value of Net Exports and Autarky Prices

TABLE 2

APPROXIMATE INNER PRODUCT IN VARIOUS TEST YEARS (Millions of Ryō)

COMPONENTS	YEAR OF NET EXPORT VECTOR							
	1868	1869	1870	1871	1872	1873	1874	1875
1. Imports with observed autarky prices	−2.24	−4.12	−8.44	−7.00	−5.75	−5.88	−7.15	−7.98
2. Imports of woolen goods	−.98	−.82	−1.29	−1.56	−2.16	−2.50	−1.56	−2.33
3. Imports with approximated autarky prices (Shinbo index)	−1.10	−.95	−.70	−.85	−1.51	−2.08	−1.60	−2.65
4. Exports with observed autarky prices	4.07	3.40	4.04	5.16	4.99	4.08	5.08	4.80
5. Exports with approximated autarky prices (Shinbo index)	.09	.03	.07	.07	.15	.07	.11	.10
Total inner product (sum of rows 1–5)	**−.18**	**−2.47**	**−6.31**	**−4.17**	**−4.28**	**−6.31**	**−5.11**	**−8.06**

SOURCE.—For sources of price data, see Sec. IV*B* and n. 17. For rows 3 and 5, current silver yen values are converted to values of 1851–53 by deflating them with the price indices for exports and imports found in Shinbo (1978, table 5–10).

NOTE.—All values are expressed in terms of millions of ryō. The ryō equaled about $1.00 in 1873 and was equivalent to the yen when it was introduced in 1871. The estimates are of the approximation of the inner product ($\tilde{\mathbf{p}}_1^a\tilde{\mathbf{T}}$) valued at autarky prices prevailing in 1851–53. An explanation of the assumptions underlying the approximation is contained in the text.

Discussion of results

- Data largely provides support for Ricardian predictions for both patterns of specialization and patterns of trade.
- [Class question: What aspects of trade are missing from the Ricardian model?]
- Next part of the class: models with both winners and losers from trade.
  - Apparently a large part of recent debates over trade!