What Goods Do Countries Trade? A Quantitative Exploration of Ricardo's Ideas (2012)

Arnaud Costinot, Dave Donaldson and Ivana Komunjer

Guangzhi Ye

Boston University

November 14, 2016

Outline

Overview

- Key words: Ricardian model, Comparative advantage
- Question:Seen through the lens of Ricardian model, how important are productivity differences across countries and industries?
- Build on Eaton and Kortum(2002), develop a structural Ricardian model to quantify the importance of Ricardian comparative advantage, estimate the impact of productivity differences on pattern of trade across countries and industries

Contribution

- First, show how micro-foundation of Eaton and Kortum (2002) can be used to contrast the cross-sectional predictions of the Ricardian model with the data
  -The elasticity of bilateral exports with respect to observed productivity is positive and equal to 6.53
- Second, show how estimates obtained from regressions can be used to measure the welfare impact of Ricardian comparative advantage at the industry level
  -Removal of Ricardian comparative advantage at the industry level would lead to a 5.3% decrease in total gains from trade

Literature

- Empirical tests of Ricardian model: MacDougall (1951), Stern (1962), Balassa (1963), and Golub and Hsieh (2000)
- Multisector extensions of Eaton and Kortum (2002) model: Shikher (2004,2008), Costinot (2005), Chor (2008), Donaldson (2008), Caliendo and Parro (2009), Kerr (2009), Burstein and Vogel (2010), and Levchenko and Zhang (2011)
- Role of various sources of comparative advantage: Harrigan (1997), Beck (2003), Romalis (2004), Yeaple and Golub (2007), Nunn (2007), Manova (2008), and Morrow (2010)

Theoretical Framework

- $i = 1, ..., I$ countries, one factor of production-labor, $k = 1, ...K$ industries/goods, Li and wi are number of workers and wage in country i
- **Techonogy**: Each industry k has infinite number of **varieties** $\omega \in \Omega \equiv \{1, ..., +\infty\}$, $z_i^k(\omega)$ is the number of units of the ωth variety of good k can be produced by one unit of labor in country i
  A1. $z_i^k(\omega)$ is a r.v from a Frechet distribution s.t

$$F_i^k(z) = exp[-(z/z_i^k)^-\theta], z_i^k > 0 \quad and \quad \theta > 1. \tag{1}$$

- z_i^k is **fundamental productivity** of country i in industry k: affect all producers in a given country and industry. For each k, variation in z_i^k pins down variation in relative labor productivity
- θ measures **intra-industry heterogeneity**, parameterizes the impact of change in z_i^k on aggregate trade flows

Theoretical Framework

- **Trade costs**: "iceberg" form
  A2. 1 unit of good k shipped from i to j, only $1/d_{ij}^k \leq 1$ arrives

- **Market Structure**: perfect competition
  A3. $p_j^k(\omega)=\min[c_{ij}^k(\omega)]$, $c_{ij}^k(\omega)=(d_{ij}^k \cdot w_i)/z_i^k(\omega)$

- **Preference**: representative consumer with a two-level utility function
  A4. total expenditure on variety ω of good k in j:

$$x_j^k(\omega) = [p_j^k(\omega)/p_j^k]^{1-\sigma_j^k} \cdot a_j^k w_j L_j \tag{2}$$

where $0 \leq a_j^k \leq 1$, $\sigma_j^k < 1 + \theta$, and $p_j^k \equiv [\sum_{\omega \in \Omega} p_j^k(\omega)^{1-\sigma_j^k}]^{1/(1-\sigma_j^k)}$
a_j^k: measures the share of expenditures on varieties from industry k in country j
σ_j^k: the elasticity of substitution between varieties

Theoretical Framework

- **Trade balance**: $x_{ij}^k \equiv \sum_{\omega \in \Omega_{ij}^k} x_j^k(\omega)$ the value of total exports from i to j in industry k, where $\Omega_{ij}^k \equiv \{\omega \in \Omega | c_{ij}^k(\omega) = min\ c_{i'j}^k(\omega)\}$. And $\pi_{ij}^k \equiv x_{ij}^k / \sum x_{i'j}^k$ is share of exports from i in country j and industry k
  A5. For any country i, trade is balanced

$$\sum_{j=1}^{I} \sum_{k=1}^{K} \pi_{ij}^k a_j^k \gamma_j = \gamma_i \tag{3}$$

  where $\gamma_i \equiv w_i L_i / \sum_{i'=1}^{I} w_{i'} L_{i'}$ is the share of country i in world income

- Cross-sectional predictions

  Theorem 1. Suppose that Assumptions A1-A4 hold, then for any importer j, any pair of exporters, i and i', and any pair of goods, k and k',

$$ln(\frac{\tilde{x}_{ij}^{k}\tilde{x}_{i'j}^{k'}}{\tilde{x}_{ij}^{k'}\tilde{x}_{i'j}^{k}}) = \theta ln(\frac{\tilde{z}_{i}^{k}\tilde{z}_{i'}^{k'}}{\tilde{z}_{i}^{k'}\tilde{z}_{i'}^{k}}) - \theta ln(\frac{d_{ij}^{k}d_{i'j}^{k'}}{d_{ij}^{k'}d_{i'j}^{k}}) \tag{4}$$

  where $\tilde{x}_{ij}^{k} \equiv x_{ij}^{k}/\pi_{ii}^{k}$, $\tilde{z}_{i}^{k} \equiv E[z_{i}^{k}(\omega)|\Omega_{i}^{k}]$: observed productivity in country i and industry k. $\frac{z_i^k}{z_{i'}^k} = \frac{\tilde{z}_i^k}{\tilde{z}_{i'}^k} \cdot (\frac{\pi_{ii}^k}{\pi_{i'i'}^k})^{1/\theta}$ .Originally $x_{ij}^{k} = \frac{(w_i d_{ij}^{k}/z_i^k)^{-\theta}}{\sum_{i'=1}^{I}(w_{i'} d_{i'j}^{k}/z_{i'}^{k})^{-\theta}} \cdot a_j^k w_j L_j$

  (Correction for trade-driven selection)

Theoretical Predictions

- Counterfactual predictions
  If for any pair of exporters, there were no fundamental relative productivity differences across industries, what would be the consequences for aggregate trade flows and welfare?

  Fix a reference country i_0, assume $(z_{i0}^k)' \equiv z_{i0}^k$ for all k. For $i \neq i_0$, $(z_i^k)' \equiv Z_i \cdot z_{i0}^k$, Z_i is chosen such that the value of the relative wage $(w_i/w_{i0})'$ is the same as the initial (w_i/w_{i0}).
  Then for any pair of countries i_1 and i_2, and any pair of sectors k_1 and k_2,

$$\frac{(z_{i1}^{k1})'}{(z_{i2}^{k1})'} = \frac{(z_{i1}^{k2})'}{(z_{i2}^{k2})'} \tag{5}$$

Theoretical Predictions

- Counterfactual predictions

  Theorem 2. Suppose that Assumptions A1-A5 hold. If we remove country i_0's Ricardian comparative advantage, then

  1. Counterfactual changes in bilateral trade flows x_{ij}^k, satisfy

$$\hat{x}_{ij}^k = \frac{(z_i^k/Z_i)^{-\theta}}{\sum_{i'=1}^{I} \pi_{i'j}^k (z_{i'}^k/Z_{i'})^{-\theta}}, \tag{6}$$

  for all i, j, k

  2. Counterfactual changes in country i_0's welfare, $W_{i_0} \equiv w_{i_0}/p_{i_0}$, satisfy

$$\widehat{W_{i_0}} = \prod_{k=1}^{K} [\sum_{i=1}^{I} \pi_{ii_0}^k (\frac{z_i^k}{z_{i0}^k Z_i})^{-\theta}]^{a_{i0}^k/\theta} \tag{7}$$

Data

- **Trade flows**: OECD STAN Bilateral Trade Database (edition 2008) relating to year of 1997; 21 countries and 13 industries; get measure of x_{ij}^k and π_{ii}^k
- **Productivity**:A1-A3 imply $\frac{\tilde{z}_i^k \tilde{z}_{i'}^{k'}}{\tilde{z}_i^{k'} \tilde{z}_{i'}^k} = \frac{E[p_{i'}^k(\omega)|\Omega_{i'}^k] E[p_i^{k'}(\omega)|\Omega_i^{k'}]}{E[p_i^k(\omega)|\Omega_i^k] E[p_{i'}^{k'}(\omega)|\Omega_{i'}^{k'}]}$, producer price data are taken from Groningen Growth and Development Centre (GGDC) Productivity Level Database, prices then aggregate into a unique producer price index at industry level
- **Instrumental variables**: Research and development (R&D) expenditures at country-industry level data from the Analytical Business Research and Development (ANBERD) database collected by the OECD

Cross-sectional Results

- Following Theorem 1, estimate the following log-linear model:

$$ln(\frac{\tilde{x}_{ij}^{k}\tilde{x}_{i'j}^{k'}}{\tilde{x}_{ij}^{k'}\tilde{x}_{i'j}^{k}})=\theta ln(\frac{\tilde{z}_{i}^{k}\tilde{z}_{i'}^{k'}}{\tilde{z}_{i}^{k'}\tilde{z}_{i'}^{k}})+ln(\frac{\varepsilon_{ij}^{k}\varepsilon_{i'j}^{k'}}{\varepsilon_{ij}^{k'}\varepsilon_{i'j}^{k}})$$

Cross-sectional results—baseline

Dependent variable	log (corrected exports)	log (exports)	log (corrected exports)	log (exports)
	(1)	(2)	(3)	(4)
log (productivity based on producer prices)	1·123***	1·361***	6·534***	11·10***
	(0·0994)	(0·103)	(0·708)	(0·981)
Estimation method	OLS	OLS	IV	IV
Exporter × importer fixed effects	YES	YES	YES	YES
Industry × importer fixed effects	YES	YES	YES	YES
Observations	5652	5652	5576	5576
R^2	0·856	0·844	0·747	0·460

Cross-sectional Results

- Without adjustment between fundamental and observed productivity, one tend to overestimate importance of productivity differences, since observed productivity differences are smaller than fundamental productivity differences
- Two potential sources of bias: (i) simultaneity bias, due to agglomeration effects through which higher export levels lead to higher productivity levels and (ii) attenuation bias, due to measurement error in productivity. So productivity levels instrumented with research and development (R&D) expenditures at the country-industry level.
- Preferred estimate of $\theta = 6.53$ in Column 3 with IV estimation and correction for trade-driven wedge

Counterfactual Results

Follow Theorem 2, what if for any pair of exporters, there were no fundamental relative productivity differences across indutries? What would be the consequences for aggregate trade flows and welfare?

- **Reveled productivity**:

$$lnx_{ij}^k = \delta_{ij} + \delta_j^k + \delta_i^k + \varepsilon_{ij}^k \tag{8}$$

where δ_{ij},δ_j^k and δ_i^k are exporter-importer, importer-industry, and exporter-industry fixed effects. According this model, bilateral trade flows satisfy

$$lnx_{ij}^k = \delta_{ij} + \delta_j^k + \theta lnz_i^k + \varepsilon_{ij}^k \tag{9}$$

Hence, estimates of δ_i^k can be used to constructed revealed measures of productivity $e^{\delta_i^k}/\theta$ in country i and industry k

Counterfactual Results

Counterfactual results—baseline

	Outcome variable of interest			
	% change in in total exports	Change in index of interindustry trade	% change in welfare	% change in welfare relative to the total gains from trade
Reference country	(1)	(2)	(3)	(4)
Australia	18·52	24·57	−2·90	−39·11
Belgium and Luxembourg	−1·76	4·12	0·71	2·64
Czech Republic	3·91	5·62	−0·12	−1·26
Denmark	0·60	−2·64	−0·40	−2·18
Spain	3·68	−3·89	−0·46	−7·08
Finland	−5·62	3·44	0·14	1·65
France	0·80	−0·49	−0·20	−3·09
Germany	−2·10	−8·46	0·14	2·22
Greece	26·35	−11·23	−4·37	−40·47
Hungary	1·70	−5·28	−0·25	−1·62
Ireland	−5·48	−4·31	0·20	0·74
Italy	−4·76	−9·85	0·14	2·78
Japan	−6·12	−24·75	0·35	24·48
Korea	2·68	−10·15	−0·44	−9·60
Netherlands	1·95	−0·94	−0·64	−2·81
Poland	12·33	−22·35	−1·68	−23·09
Portugal	8·44	−13·62	−0·92	−9·12
Slovakia	2·33	14·11	0·82	4·64
Sweden	−2·98	3·03	0·34	3·30
U.K.	3·45	−4·04	−0·26	−2·94
U.S.	3·82	−3·83	−0·42	−11·71
World average	2·94	−5·72	−0·49	−5·32

Counterfactual Results

Impact of "removing a country's Ricardian comparative advantage"

- **Trade flows**:
  Changes in total trade volumes are small, not surprising since by construction wages hence GDP levels are unchanged in counterfactual equilibrium;
  Index of inter-industry trade computed as $100x \sum_{j \neq i} |x_{ij}^k - x_{ji}^k| / \sum_{j \neq i}(x_{ij}^k + x_{ji}^k)$, if all trade were intra-industry trade, index would be zero, conversely, equal 100 if all trade were inter-industry trade. Extent of inter-industry trade goes down for most reference countries.

  Notes: inter-industry trade may go up for some countries, simple explanations are existence of heterogeneous trade costs and heterogeneous preferences across countries

Counterfactual Results

Impact of "removing a country's Ricardian comparative advantage"

- **Welfare**:
  With

$$\widehat{W_{i_0}} = \prod_{k=1}^{K}[\sum_{i=1}^{I} \pi_{ii_0}^{k}(\frac{z_i^k}{z_{i0}^k Z_i})^{-\theta}]^{a_{i0}^k/\theta} \tag{10}$$

  Eliminating relative industry-level productivity differences across countries leads, on average, to a 0.5% decrease of real income(spend on manufacturing) or a 5.3% decrease in overall gains from trade(to ignore considerations related to size of non-tradable sector).

Conclusion

- Estimate of the elasticity with which increases in observed productivity levels lead to increased exports $\theta = 6.53$, is positive and robust to alternative estimation procedures.
- Disapperance of inter-industry Ricardiean forces would lead to a 5.3% decrease in the total gains from trade.