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

ARNAUD COSTINOT and DAVE DONALDSON
And IVANA KOMUNJER

Hareem Fasih
Uni id: 4025340
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Overview

- The Ricardian model predicts that a country should produce and export relatively more in industry in which they are relatively more productive.
- In this paper, we develop theoretical foundations to guide the empirical analysis on Ricardian model and use them to quantify the importance of Ricardian comparative advantage at the industry level.
- Using trade and productivity data, we can therefore offer the first theoretically consistent Ricardian test.
- In the theoretical framework, we consider an economy with multiple countries, multiple industries, and one factor of production, labour and we assume that each good is available in many varieties and that labour productivity differs across varieties.
- Labour productivity can be separated onto two parts: Deterministic component and stochastic component.
- Deterministic component captures factors that affect the productivity of all producers in a given country and industry.
- The latter, by contrast, reflects idiosyncratic differences in technological know-how across varieties.

- The first set of predictions are cross-sectional in nature and describe how productivity differences affect trade patterns across countries and industries in any trading equilibrium
- Our preferred estimate implies that, ceteris paribus, the elasticity of (adjusted) bilateral exports with respect to observed productivity is positive, as our Ricardian model predicts, and equal to 6·53.
- Further, our clear theoretical foundations allow us to do general equilibrium counterfactual analysis.
- The second set of predictions explore by how much aggregate trade flows and welfare would change if, for any pair of exporters, there were no fundamental relative productivity differences across industries.
- Our analysis allows us to estimate the extent of intra-industry heterogeneity, "θ", which is the key structural parameter governing the relationship between productivity and exports in this Ricardian world.
- According to our estimates, the removal of Ricardian comparative advantage at the industry level would only lead, on average, to a 5·3% decrease in the total gains from trade.
- The magnitude of this estimate is related to two important features of the data: heterogeneous preferences and heterogeneous trade costs

Literature

- Relative to this literature, our first contribution is to show how micro-foundations laid by Eaton and Kortum (2002) in their paper, can be used to contrast the cross-sectional predictions of the Ricardian model with the data.
- Our preferred estimate of θ, key structural parameter governing the relationship between productivity and exports in this Ricardian world, equal to 6·53, is in line with previous estimates of θ obtained using different methodologies (see, e.g., Eaton and Kortum, 2002; Bernard et al., 2003; Donaldson, 2008; Simonovska and Waugh, 2009).
- The counterfactual results, although not the main focus of our paper, provides a theoretically consistent alternative to Balassa's (1965) well-known index of "revealed comparative advantage.
- Our paper is also related both to previous empirical tests of the Ricardian model—MacDougall (1951), Stern (1962), Balassa (1963), and Golub and Hsieh (2000)—and to a much more recent but rapidly growing literature based on multisector extensions of the 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)

Theoretical Framework

- We consider a world economy comprising $i = 1, \dots, I$ countries and one factor of production, labour. There are $k = 1, \dots, K$ industries or goods and constant returns to scale in the production of each good. We denote by L_i and w_i the number of workers and the wage in country i, respectively.
- The following are the assumptions of the Ricardian model we use here:

A1: For all countries i, goods k, and their varieties ω, $z_i^k(\omega)$is a random variable drawn independently for each triplet (i, k, ω) from a Fréchet distribution $F_i^k(.)$ such that

$$F_i^k(z) = \exp\left[-\left(\frac{z}{z_i^k}\right)^{-\theta}\right], \text{ for all } z \geq o$$

where $z_i^k > 0$ and $\theta > 1$

A2: For each unit of good k shipped from country i to country j, only $1/d_{ij}^k \leq 1$ units arrive, with d_{ij}^k such that (i) $d_{ii}^k = 1$ and (ii) $d_{il}^k \leq d_{ij}^k \,.\, d_{jl}^k$ for any third country l.

A3. In any country j, the price $p_j^k(\omega)$ paid by buyers of variety ω of good k is

$$p_j^k(\omega) = \min_{1 \le i \le I}[\, c_{ij}^k(\omega)],$$

where $c_{ij}^k(\omega) = (d_{ij}^k.\,\omega_i)\,/z_i^k(\omega)$ is the cost of producing and delivering one unit of this variety from country i to country j.

A4. In any country j, total expenditure on variety ω of good k is

$$x_j^k(\omega) = [p_j^k(\omega)/p_j^k]^{1-\sigma_j^k} \cdot \alpha_j^k \omega_j L_j$$

where $0 \le \alpha_j^k \le 1$, $\sigma_j^k < 1 + \theta$, and $p_j^k \equiv [\sum_{\omega' \epsilon \Omega} p_j^k(\omega')^{1-\sigma_j^k}]^{1/(1-\sigma_j^k)}$

A5. For any country i, trade is balanced,

$$\textstyle\sum_{j=1}^{I} \sum_{k=1}^{K} \pi_{ij}^k \alpha_j^k \gamma_j = \gamma_i,$$

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

Theoretical Predictions

- Using the previous theoretical framework, Assumptions A1–A5, we derive two types of predictions

i. how differences in labour productivity across countries and industries affect the pattern of trade in a given equilibrium.

ii. Demonstration of how changes in labour productivity would affect trade and welfare across equilibria

- we first describe the impact of fundamental productivity and trade costs on bilateral exports at the industry level.
- **Lemma 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'

$$ln\left(\frac{x_{ij}^{k}x_{i'j}^{k'}}{x_{ij}^{k'}x_{i'j}^{k}}\right) = \theta\ln(\frac{z_i^k z_{i'}^{k'}}{z_i^{k'} z_{i'}^{k}}) - \theta\ln(\frac{d_{ij}^k d_{i'j}^{k'}}{d_{ij}^{k'} d_{i'j}^{k}})$$

- Under Assumptions A1–A4, bilateral exports from country i to country j in sector k can be expressed as

$$x_{ij}^k = \frac{\left(\omega_i d_{ij}^k / z_i^k\right)^{-\theta}}{\sum_{i'}^I \left(\omega_{i'} d_{i'j}^k / z_{i'}^k\right)^{-\theta}} . \alpha_j^k \omega_j L_j,$$

Corollary 1. Suppose that Assumptions A1–A4 and equation (7) hold. Then for any importer, j, and any pair of exporters, $i, i' \neq j$, the ranking of relative fundamental productivity determines the ranking of relative exports, $\frac{z_i^1}{z_{i'}^1} \leq \cdots \leq \frac{z_i^K}{z_{i'}^K} \Leftrightarrow \frac{x_{ij}^1}{x_{i'j}^1} \leq \cdots \leq \frac{x_{ij}^K}{x_{i'j}^K}$

- Assumption A1 and ranking (8) further imply $\frac{z_{i_1}^1(\omega)}{z_{i_2}^1(\omega)} \preccurlyeq \cdots \preccurlyeq \frac{z_{i_1}^K(\omega)}{z_{i_2}^K(\omega)}$
- We assume that statistical agencies perfectly observe $z_i^k(\omega)$ for all varieties of good k produced in country i.
- But this is impossible since labour productivity for varieties of good k which are not produced in country i because such varieties are being imported from another country, cannot be observed.
- So we proceed by taking $\tilde{z}_i^k \equiv E[z_i^k(\omega) | \Omega_i^k]$, based on the set of varieties actually produced in country i, $\Omega_i^k \equiv \bigcup_{j=1,\dots,I} \Omega_{ij}^k$, as observed productivity in country i and industry k and contrast this variable repeatedly with fundamental productivity, z_i^k .

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',

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

- Theorem 1 offers cross-sectional predictions that will help us to test and quantify the importance of Ricardian comparative advantage in the data.
- An alternative way of quantifying Ricardian forces is to do counterfactual analysis, i.e., to evaluate the effects of moving to a world in which Ricardian forces do not operate across industries.
- By construction, for any pair of countries, i_1 and i_2, and any pair of sectors, k_1 and k_2, we have $\frac{(z_{i_1}^{k_1})'}{(z_{i_2}^{k_1})'} = \frac{(z_{i_1}^{k_2})'}{(z_{i_2}^{k_2})'}$.

Lemma 2. Suppose that Assumptions A1–A5 hold. Adjustments in absolute productivity, $\{Z_i\}_{i \neq i_o}$, can be computed as the solution of the system of equations

$$\sum_{j=1}^{I}\sum_{k=1}^{K}\frac{\pi_{ij}^{k}(z_i^k/Z_i)^{-\theta}\alpha_j^k\gamma_j}{\sum_{i'=1}^{I}\pi_{i'j}^{k}(z_{i'}^{k}/Z_{i'})^{-\theta}} = \gamma_i, \text{ for all } i \neq i_o$$

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

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

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

Cross-sectional Results

- We test Theorem 1 using the best available data on internationally comparable productivity and trade flows across countries and industries.
- We use the value of bilateral exports from each of these 21 countries i to each of these 21 countries j in each industry k as our measure of x and how much each exporting country i imports in each industry k relative to its total expenditure in that industry, in order to correct for the endogenous selection of varieties that are actually produced domestically, i.e., π_{ii}^{k} in Theorem 1 above.
- **Productivity.** In a Ricardian world, variations in relative productivity levels should be fully reflected in relative producer prices i.e.,

$$\frac{\tilde{z}_i^k \tilde{z}_{i'}^{k'}}{\tilde{z}_i^{k'} \tilde{z}_{i'}^{k}} = \frac{E[p_{i'}^k(\omega)|\Omega_{i'}^k]\mathrm{E}[p_i^{k'}(\omega)|\Omega_i^{k'}]}{E\left[p_i^k(\omega)\middle|\Omega_i^k\right]E[p_{i'}^{k'}(\omega)|\Omega_{i'}^{k'}]}$$

for any pair of goods, k and k’ , and any pair of countries, i and I’ , Assumptions A1–A3 imply the above equation.

- Our relative productivity measures across countries and industries are reported in Table 2.
- Following Theorem 1, we estimate the following log-linear model using the data described above:

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

- relative productivity differences across any pair of countries and industries drive relative export levels to any market j.
- The more simpler and econometrically relevant estimation is $ln\tilde{x}_{ij}^{k} = \delta_{ij} + \delta_{j}^{k} + \theta ln\tilde{z}_{i}^{k} + \varepsilon_{ij}^{k}$
- Our findings in Table 3 highlight the importance of the endogeneity of relative productivity (and hence the importance of IV estimation relative to OLS estimation) and the importance of correcting for the trade-driven wedge between observed and fundamental productivity levels, as emphasized in Theorem 1.
- Estimates of θ based on these alternative productivity measures are both somewhat lower than our preferred estimate 6.53.
- Our estimates of θ are robust to a number of sample restrictions that alleviate, among other things, concerns of bias due to endogenous trade protection

Counterfactual Results

- To investigate the quantitative importance of productivity differences, we use Theorem 2 to ask the following counterfactual questions: What 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?
- We estimate $lnx_{ij}^k = \delta_{ij} + \delta_j^k + \delta_i^k + \varepsilon_{ij}^k$
- Bilateral trade flows satisfy $lnx_{ij}^k = \delta_{ij} + \delta_j^k + \theta lnz_i^k + \varepsilon_{ij}^k$
- We see the impact of “removing a country’s Ricardian comparative advantage” on trade flows.
- For each country and industry, we compute changes in total exports (to all destination countries combined) using equation (12). On average, changes in total trade volumes are small.
- Also, if there were no trade costs and no differences in preferences across countries, then “removing a country’s Ricardian comparative advantage” would eliminate all inter-industry trade, i.e., trade would be balanced industry by industry.

- For each country i and industry k we compute $100 \times \sum_{i \neq j} \left| x_{ij}^{k} - x_{ji}^{k} \right| / \sum_{i \neq j} \left| x_{ij}^{k} + x_{ji}^{k} \right|$
- To assess the welfare importance of Ricardian comparative advantage at the industry level, we now compute changes in welfare in the reference country using equation (13). By eliminating relative industry level productivity differences across countries leads, on average, to a 0·5% decrease of real income (spent on manufacturing) or only a 5·3% decrease in the overall gains from trade.
- the quantitative importance of the two previous explanations is to redo our counterfactual exercises under the assumption that expenditure shares do not differ across countries and that trade costs satisfy $d_{ij}^{k} = d_{ij} - d_{j}^{k}$, which, as shown in Corollary 1, implies that trade costs no longer affect the pattern of inter-industry trade.
- On average, the welfare impact of Ricardian comparative advantage as a fraction of the total gains from trade (reported in Column (4) of Table 8) goes up from 5·3% in our baseline scenario to (i) 11·7% in the absence of preference differences; (ii) 9·9% in the absence of trade costs violating $d_{ij}^{k} = d_{ij} - d_{j}^{k}$; and (iii) 27·3% in the absence of both.

Conclusion

- The reason for the little empirical content about Ricardian model is the difference between real world and the extreme assumptions of the standard two-country Ricardian model.
- the present paper has developed a structural Ricardian model that puts productivity differences at the forefront of the analysis of a central question in international economics: What goods do countries trade?
- Using this model, we have estimated the impact of productivity differences on the pattern of trade across countries and industries without having to rely on bilateral comparisons inspired by a two-country model, unclear orthogonality conditions, ad hoc measures of export performance, or measures of productivity that are systematically biased due to trade-driven selection.
- the key structural parameter of the model, θ, which governs the elasticity with which increases in observed productivity levels, ceteris paribus, lead to increased exports.
- Our estimate of this elasticity, $\theta = 6{\cdot}53$, is positive (in agreement with our Ricardian theory), robust.
- We also used our model to quantify the importance of inter-industry Ricardian forces in today’s world economy by measuring the welfare consequences of removing Ricardian comparative advantage at the industry level. According to our estimates, the disappearance of such forces would only lead, on average, to a 5·3% decrease in the total gains from trade.