Welfare Analysis: *Part II*

International Trade (PhD), Fall 2019

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General Setup

- Many countries ($i = 1,...,N$), each endowed with L_i units of labor.
- Every country supplies a composite good produced with only labor.
- The representative consumer in country i has a CES utility:

$$U_i(Q_{1i}, ..., Q_{Ni}) = \left(Q_{1i}^{\frac{\sigma-1}{\sigma}} + ... + Q_{Ni}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

- P_{ji} is the price index of the good supplied by country j to market i.

Aggregate Price Indexes in Quantitative Trade Models

Following *Costinot and Rodriguez-Clare (2014)*:

$$P_{ji} = \tau_{ji} w_j \times \left(\left(\frac{L_i}{f_{ji}} \right)^{\frac{\delta}{1-\sigma}} \frac{\tau_{ji} w_j}{P_i} \right)^{\eta} \times \left(\frac{L_j}{f_j^e} \right)^{\frac{\delta}{1-\sigma}} \times \xi_{ji}$$

- f_{ji}: fixed operating cost
- f_j^e: sunk entry cost
- ξ_{ji} is composed of structural parameters

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- Krugman: $\delta = 1$ and $\eta = 0$
- Eaton-Kortum $\delta = 0$ and $\eta = \left(\frac{\theta}{\sigma-1}\right)\left(1 + \frac{1-\sigma}{\theta}\right)$
- Melitz-Pareto $\delta = 1$ and $\eta = \left(\frac{\gamma}{\sigma-1}\right)\left(1 + \frac{1-\sigma}{\gamma}\right)$

National Welfare from the Lens of Trade Models

Given that (i) $\lambda_{ii} = \left(P_{ii}/P_i\right)^{1-\sigma}$; (ii) $W_i \equiv w_i/P_i$; and (iii) $\epsilon \equiv (\sigma - 1)(1 + \eta)$, we can use the expression for P_{ii} to write the **real GDP p/c** of country i as

$$W_i = A_i \ \tau_{ii}^{-1} \ \lambda_{ii}^{-\frac{1}{\epsilon}} \ f_{ii}^{-\frac{\delta\eta}{\epsilon}} \ \left(f_i^e\right)^{-\frac{\delta}{\epsilon}} \ L_i^{\frac{\delta}{\sigma-1}}$$

Application I: Asymmetric Trade Costs and Cross-Country Income Differences

Perfectly Competitive Models ($\delta = 0$)

$$W_i = A_i \times \lambda_{ii}^{-\frac{1}{\epsilon}} \times \tau_{ii}^{-1}$$

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Trade Openness

$$W_i = A_i \times \lambda_{ii}^{-\frac{1}{\epsilon}} \times \tau_{ii}^{-1}$$

Structural TFP

Domestic trade frictions

Waugh (2010, AER)

- The cross-country heterogeneity in real GDP p/c is puzzlingly large.

- This is partly due to poor countries facing higher export costs:

$$\tau_{ns} < \tau_{sn}$$

  where n denotes *North* and s denotes *South*.

- Under balanced trade (*Total Imports* = *Total Exports*)

$$\lambda_{nn} = 1 - \frac{\sum_{i=1}^{N} X_{ni}}{Y_N} < 1 - \frac{\sum_{i=1}^{N} X_{si}}{Y_s} = \lambda_{ss}$$

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- Eliminating asymmetries in trade costs can reduce North-South income differences:

$$\frac{\tau_{sn}}{\tau_{ns}} \downarrow \implies \frac{\lambda_{ss}}{\lambda_{nn}} \downarrow \implies \frac{W_s}{W_n} \propto \left(\frac{\lambda_{ss}}{\lambda_{nn}}\right)^{-\frac{1}{\epsilon}} \uparrow$$

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TABLE 4—INCOME DIFFERENCES WITH COUNTERFACTUAL TRADE COSTS

	Baseline	Autarky	$\min(\tau_{ij},\tau_{ji})$	OECD τ	$\tau_{ij} = 1$
var $[\log(y)]$	1.30	1.35	1.05	1.13	0.76
y_{90}/y_{10}	25.7	23.5	17.3	19.8	11.4
Mean change in y, percent	—	-10.5	24.2	10.0	128.0

Application I: The Income-Size Elasticity Puzzle

Krugman Models ($\delta = 1; \eta = 0$)

$$W_i = A_i \times \lambda_{ii}^{-\frac{1}{\epsilon}} \times \tau_{ii}^{-1} \times \left(f_i^e\right)^{-\frac{1}{\epsilon}} \times L_i^{\frac{1}{\sigma-1}}$$

Krugman Models ($\delta = 1; \eta = 0$)

Scale Effects

$$W_i = A_i \times \lambda_{ii}^{-\frac{1}{\epsilon}} \times \tau_{ii}^{-1} \times \left(f_i^e\right)^{-\frac{1}{\epsilon}} \times L_i^{\frac{1}{\sigma-1}}$$

Barriers to Entry

Ramondo, Rodríguez-Clare, Saborío-Rodríguez (2016, AER)

The Income-Size Elasticity Puzzle

- Quantitative trade models predicts that even after controlling for trade openness (i.e., λ_{ii})

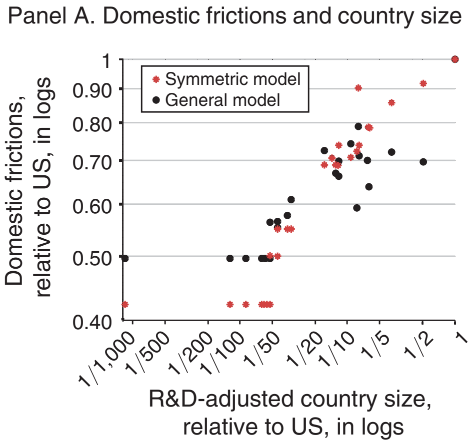
$$\frac{\partial \ln \text{Real GDP p/c}_i}{\partial \ln \text{Population Size}_i} \equiv \frac{\partial \ln W_i}{\partial \ln L_i} = \frac{1}{\sigma - 1} > 0$$

- Actual data indicate that after controlling for trade openness:

$$\frac{\partial \ln \text{Real GDP p/c}_i}{\partial \ln \text{Population Size}_i} \approx 0$$

Ramondo, Rodríguez-Clare, Saborío-Rodríguez (2016, AER)

– The *income-size elasticity puzzle* can be partially explained by the fact that domestic trade frictions are higher in larger countries: $\frac{\partial \ln \tau_{ii}}{\partial \ln L_i} > 0$



- Real income p/c in country i

$$W_i = A_i \;\; \tau_{ii}^{-1} \;\; \lambda_{ii}^{-\frac{1}{\epsilon}} \;\; \left(f_i^e\right)^{-\frac{1}{\epsilon}} \;\; L_i^{\frac{1}{\sigma-1}}$$

- The *conditional* elasticity of real income p/c w.r.t. population size

$$\frac{\partial \ln W_i}{\partial \ln L_i} \mid \lambda_{ii} \;=\; \frac{1}{\sigma - 1} \;-\; \underbrace{\frac{\partial \ln \tau_{ii}}{\partial \ln L_i}}_{>0}$$

- So, accounting for domestic trade frictions lowers the predicted income-size elasticity.

Ramondo, Rodríguez-Clare, Saborío-Rodríguez (2016, AER)

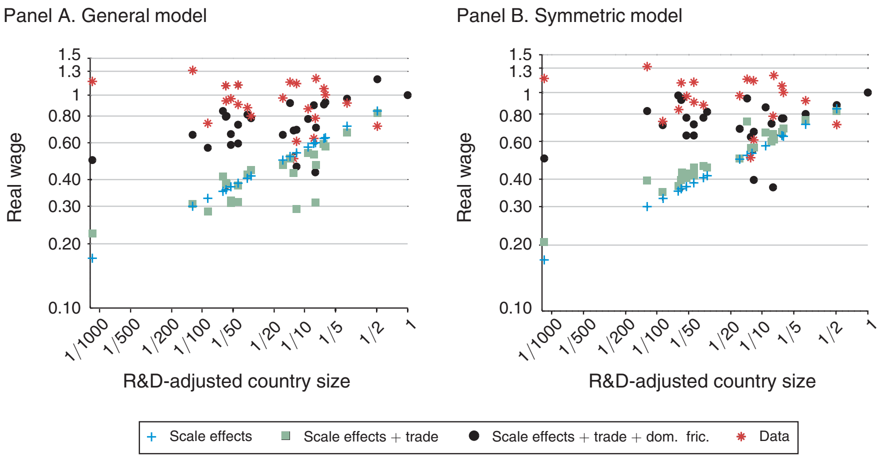


FIGURE 3. SCALE EFFECTS, TRADE OPENNESS, AND DOMESTIC TRADE COSTS (*Relative to US in logs*)

Domestic Trade Friction do not Fully Resolve the Puzzle!

Explanation 1

- A_i or f_i^e are correlated with L_i (no convincing evidence for this!)

Explanation 2 (Lashkaripour & Lugovskyy, 2019)

- Trade models artificially assume that

  degree of firm-level market power $=$ *degree of love-for-variety*

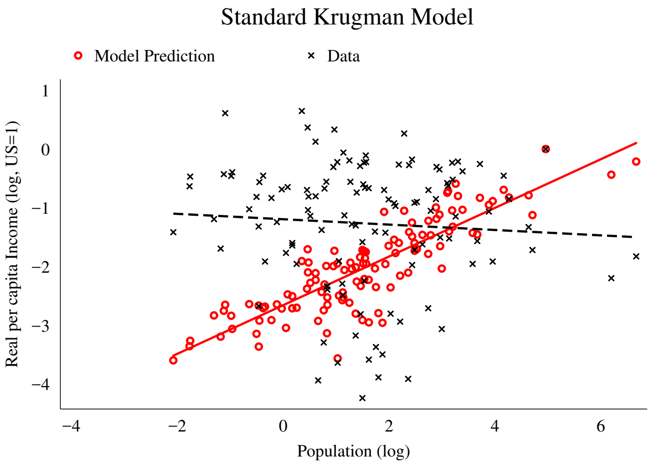
- The above assumption imposes that

$$\partial \ln W_i / \partial \ln L_i = 1/\text{trade elasticity}$$

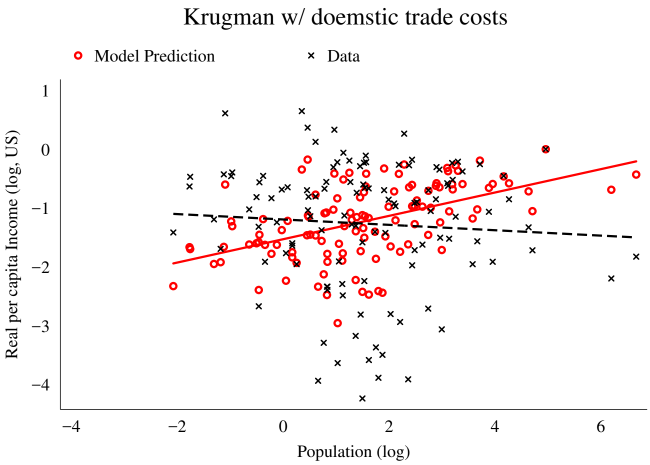
- Using micro-level data we can separately estimate (a) the degree of firm-level market power, and (b) the degree of love-for-variety:

$$\partial \ln W_i / \partial \ln L_i \approx 0.65/\text{trade elasticity}$$

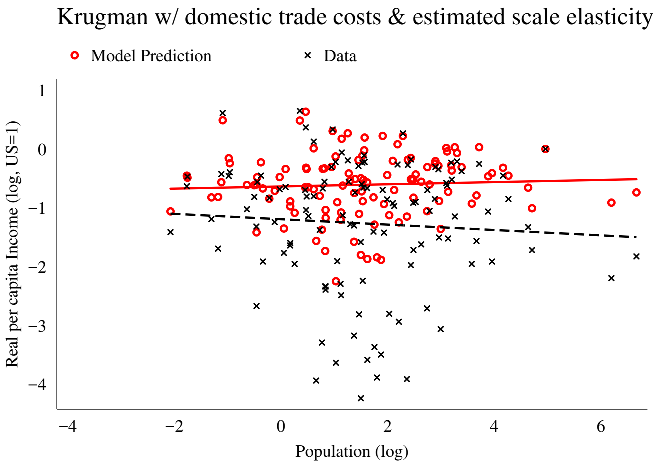
Standard Krugman Model



Krugman + Domestic Trade Frictions



Krugman + DTF + Micro-Estimated Scale Elasticity



The Exact Hat-Algebra Approach

Definition of Equilibrium

– In the class of models we considered, equilibrium is a vector of wages $\boldsymbol{w} = \{w_i\}$ that satisfy

$$w_i L_i = \sum_{j=1}^{N} \lambda_{ij}(\boldsymbol{w}) w_j L_j, \quad \forall i$$

where

$$\lambda_{ij}(\boldsymbol{w}) = \frac{\chi_{ij}\left(\tau_{ij} w_i\right)^{-\epsilon}}{\sum_{\ell=1}^{N} \chi_{\ell j}\left(\tau_{\ell j} w_\ell\right)^{-\epsilon}}$$

– χ_{ij}, L_i, and ϵ are structural parameters that do not vary with τ_{ji}.

Hat-Algebra Notation

- For any variable, let x denote the factual value and x' denote the counterfactual value.

- Define $\hat{x}$ as follows:

$$\hat{x} \equiv \frac{x'}{x}$$

- **Example:** suppose countries i and j sign an agreement that lowers the bilateral trade cost by 20% $\Longrightarrow \hat{\tau}_{ji} = \hat{\tau}_{ij} = 0.8$

The Counterfactual Equilibrium in Hat-Algebra Notation

– Policy change of interest: $\{\hat{\tau}_{ji}\}$

– Given (a) the *multiplicatively separability* of the gravity equation and (b) that fact that $\chi'_{ji} = \chi_{ji}$, we can write

$$\lambda'_{ji} = \frac{\chi_{ji}\left(\hat{\tau}_{ji}\tau_{ji}\hat{w}_j w_j\right)^{-\epsilon}}{\sum_{\ell=1}^{N}\chi_{\ell i}\left(\tau_{\ell i}\hat{\tau}_{\ell i}\hat{w}_\ell w_\ell\right)^{-\epsilon}} = \frac{\lambda_{ji}\left(\hat{\tau}_{ji}\hat{w}_j\right)^{-\epsilon}}{\sum_{\ell=1}^{N}\lambda_{\ell i}\left(\hat{\tau}_{\ell i}\hat{w}_\ell\right)^{-\epsilon}}$$

– Balanced trade in the counterfactual equilibrium:

$$\underbrace{\hat{w}_i w_i}_{w'_i} L_i = \sum_{j=1}^{N} \underbrace{\frac{\lambda_{ij}\left(\hat{\tau}_{ij}\hat{w}_i\right)^{-\epsilon}}{\sum_{\ell=1}^{N}\lambda_{\ell j}\left(\hat{\tau}_{\ell j}\hat{w}_\ell\right)^{-\epsilon}}}_{\lambda'_{ij}} \underbrace{\hat{w}_j w_j}_{w'_j} L_j$$

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Solving for Wage and Welfare Effects

- The following system involves N equations and N unknowns, $\{\hat{w}_i\}$:

$$\hat{w}_i w_i L_i = \sum_{j=1}^{N} \frac{\lambda_{ij} \left(\hat{\tau}_{ij} \hat{w}_i\right)^{-\epsilon}}{\sum_{\ell=1}^{N} \lambda_{\ell j} \left(\hat{\tau}_{\ell j} \hat{w}_\ell\right)^{-\epsilon}} \hat{w}_j w_j L_j$$

- $w_i L_i$ and λ_{ji}, are observable; ϵ is estimable.

- The solution, $\{\hat{w}_i\}$, automatically determines the gains from policy:

$$\hat{W}_i = \hat{\lambda}_{ii}^{-\frac{1}{\epsilon}} = \frac{\hat{w}_i}{\left(\sum_{\ell=1}^{N} \lambda_{\ell i} \left(\hat{\tau}_{\ell i} \hat{w}_\ell\right)^{-\epsilon}\right)^{-1/\epsilon}}$$

Example: *the US and the Rest of the World*

- *Two countries*: US ($i = 1$) and ROW ($i = 2$)

$$\lambda = \begin{bmatrix} 0.88 & 0.98 \\ 0.12 & 0.02 \end{bmatrix}; \quad Y_{\text{scaled}} = \begin{bmatrix} 1 \\ 4 \end{bmatrix}$$

- Suppose international trade costs fall by 20%:

$$\hat{\tau} = \begin{bmatrix} 1 & 0.8 \\ 0.8 & 1 \end{bmatrix}$$

Example: *the US and the Rest of the World*

- System of equations characterizing balanced trade :

$$\hat{w}_1 = \frac{0.88\left(\hat{w}_1\right)^{-\epsilon}}{0.88\left(\hat{w}_1\right)^{-\epsilon} + 0.12\left(0.8\cdot\hat{w}_2\right)^{-\epsilon}}\hat{w}_1 + \frac{0.02\left(0.8\cdot\hat{w}_1\right)^{-\epsilon}}{0.02\left(0.8\cdot\hat{w}_1\right)^{-\epsilon} + 0.98\left(\hat{w}_2\right)^{-\epsilon}}\hat{w}_2\cdot 4$$

$$\hat{w}_2\cdot 4 = \frac{0.12\left(0.8\cdot\hat{w}_1\right)^{-\epsilon}}{0.88\left(\hat{w}_1\right)^{-\epsilon} + 0.12\left(0.8\cdot\hat{w}_2\right)^{-\epsilon}}\hat{w}_1 + \frac{0.98\left(\hat{w}_1\right)^{-\epsilon}}{0.02\left(0.8\cdot\hat{w}_1\right)^{-\epsilon} + 0.98\left(\hat{w}_2\right)^{-\epsilon}}\hat{w}_2\cdot 4$$

- Assuming $\epsilon = 5$, solving the system implies[1]

$$\hat{\boldsymbol{w}} = \begin{bmatrix} 0.982 \\ 1.006 \end{bmatrix} \implies \%\Delta W = \begin{bmatrix} 3.79\% \\ 0.96\% \end{bmatrix}$$

[1] See Canvas for the Matlab code that generates these numbers.

Discussion

- Note that the choice of micro-foundation is inconsequential for the numbers produced on the previous slide!
- So, the ACR2012 argument applies irrespective of what counterfactual policy analysis we wish to conduct.
- What is key is the CES assumption, which ensures *multiplicative separability.*
- *Adao, Costinot, and Donaldson (2018, AER)* present a technique to perform counterfactual analyses without the CES assumption.