Isomorphism & Welfare Analysis

International Trade (PhD), Fall 2024

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General Setup

- The representative consumer in country i has a CES utility aggregator over composite goods sourced from various origin countries $n = 1, .., N$. Namely,

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

where $Q_{ni} = \left(\int_{\omega \in \Omega_{ni}} q_{ni}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$ over individual goods indexed by ω.

- Utility maximization *s.t.* budget constraint ($\sum_n P_{ni} Q_{ni} \leq E_i$) implies

$$\lambda_{ni} \equiv \frac{P_{ni} Q_{ni}}{E_i} = \left(\frac{P_{ni}}{P_i} \right)^{1-\sigma}, \qquad P_i = \left[\sum_{n'=1}^{N} P_{n'i}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

- Trade is balanced + labor is the sole factor of production $\longrightarrow E_i = Y_i = w_i L_i$

A General Representation of Aggregate Price Indexes

Following Costinot and Rodriguez-Clare (2014) we can specify the price indexes implied by quantitative trade models including Krugman, Eaton-Kortum, and Melitz-Pareto as

$$P_{ni} = \tau_{ni} w_n \times \left(\left(\frac{L_i}{f_{ni}} \right)^{\frac{\delta}{1-\sigma}} \frac{\tau_{ni} w_n}{P_i} \right)^{\eta} \times \left(\frac{L_n}{f_n^e} \right)^{\frac{\delta}{1-\sigma}} \times \xi_{ni}$$

- τ_{ni}: iceberg trade cost
- f_{ni}: fixed operating cost
- f_n^e: sunk entry cost
- ξ_{ni} is composed of structural parameters unrelated to τ_{ni}

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The Welfare Impacts of an Arbitrary Change to Trade Costs

- Let W_i denote welfare in country i

$$W_i = \frac{E_i}{P_i} \qquad \xrightarrow{\text{balanced trade}} \qquad W_i = \frac{Y_i}{P_i}$$

- The welfare impacts of a generic shock to trade costs, $\{\mathrm{d}\ln\tau_{in}\}_{i,n}$:

$$\mathrm{d}\ln W_i = \mathrm{d}\ln Y_i - \mathrm{d}\ln P_i$$

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- We can update the expression for $\mathrm{d}\ln W_i$ by appealing to the CES demand structure:

$$\mathrm{d} \ln \lambda_{ni} - \mathrm{d}\ln\lambda_{ii} = (1-\sigma)\left(\mathrm{d} \ln P_{ni} - \mathrm{d} \ln P_{ii}\right)$$

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$$\mathrm{d}\ln P_{ni} = \mathrm{d}\ln P_{ii} + \frac{1}{1-\sigma}\left(\mathrm{d}\ln \lambda_{ni} - \mathrm{d}\ln \lambda_{ii}\right)$$

Growth Accounting in the Armington Model

- Plugging the expression for $\mathrm{d}\ln P_{ni}$ into the welfare equation yields

$$\begin{aligned}
\mathrm{d}\ln W_i &= \mathrm{d}\ln Y_i - \sum_{n=1}^{N} \lambda_{ni}\mathrm{d}\ln P_{ni} \\
&= \mathrm{d}\ln Y_i - \mathrm{d}\ln P_{ii} - \frac{1}{1-\sigma}\sum_{n}\left[\lambda_{ni}\left(\mathrm{d}\ln \lambda_{ni} - \mathrm{d}\ln \lambda_{ii}\right)\right]
\end{aligned}$$

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\mathrm{dln} W_i &= \mathrm{d}\ln Y_i - \sum_{n=1}^{N} \lambda_{ni} \mathrm{d}\ln P_{ni} \\
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\end{aligned}
$$

- Noting that $\sum_n \lambda_{ni} \mathrm{d}\ln \lambda_{ni} = 0$ and $\sum_n \lambda_{ni} = 1$, the last line reduces to

$$
\mathrm{dln} W_i = \frac{1}{1-\sigma} \mathrm{d}\ln \lambda_{ii} + \left(\mathrm{d}\ln Y_i - \mathrm{d}\ln P_{ii}\right)
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$$

Dissecting the Welfare Gains from Trade Liberalization

The welfare gains from trade liberalization, $\{\mathrm{d}\ln\tau_{ni}\}_{n,i} < 0$, can be decomposed as

$$\mathrm{dln}W_i = \underbrace{\frac{1}{1-\sigma}\mathrm{d}\ln\lambda_{ii}}_{\text{gains from variety}} + \underbrace{\left(\mathrm{d}\ln w_i - \mathrm{d}\ln P_{ii}\right)}_{\text{productivity gains}}$$

- With CES preferences, a country always gains from importing differentiated varieties from the rest of the world.
- In some settings (*e.g.*, Eaton-Kortum, Melitz) trade liberalization also increases aggregate labor productivity (TFP):

$$P_{ii}Q_i = w_i L_i \quad \longrightarrow \quad \frac{w_i}{P_{ii}} = \frac{Q_i}{L_i} \sim \mathrm{TFP}_i \quad \longrightarrow \quad \mathrm{d}\ln w_i - \mathrm{d}\ln P_{ii} = \mathrm{d}\ln \mathrm{TFP}_i$$

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$\boxed{\text{effective ouput adjusted for iceberg \& fixed cost payments}}$

A Special Case Reviewed Earlier: *The Armington Model*

- Aggregate TFP in the Armington model is invariant to trade by assumption:

$$P_{ni} = \underbrace{\frac{1}{A_n}\tau_{ni}}_{\text{constant}} w_n \qquad \longrightarrow \qquad \left(\mathrm{d}\ln w_i - \mathrm{d}\ln P_{ii}\right) = 0$$

- The welfare gains from incremental trade liberalization are, therefore,

$$\mathrm{d}\ln W_i = \frac{1}{1-\sigma}\mathrm{d}\ln\lambda_{ii}$$

- Considering that $\tau^{\text{autarky}} = \infty$ and $\lambda_{ii}^{\text{autarky}} = 1$, the overall gains from trade are

$$\mathrm{GT}_i \equiv -\int_{\tau}^{\infty}\mathrm{d}\ln W_i = -\int_{\lambda_{ii}}^{1}\frac{1}{1-\sigma}\mathrm{d}\ln\lambda_{ii} = \frac{1}{1-\sigma}\ln\lambda_{ii}$$

Welfare Impacts Beyond Armington

- To characterize $(\mathrm{d}\ln w_i - \mathrm{d}\ln P_{ii})$, appeal to our earlier expression for price indexes:

$$P_{ni} = \tau_{ni} w_n \times \underbrace{\left(\left(\frac{L_i}{f_{ni}} \right)^{\frac{\delta}{1-\sigma}} \frac{\tau_{ni} w_n}{P_i} \right)^{\eta}}_{\text{firm-selection effects}} \times \underbrace{\left(\frac{L_n}{f_n^e} \right)^{\frac{\delta}{1-\sigma}}}_{\text{entry effects}} \times \xi_{ni}$$

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$$P_{ii} = \underbrace{\tau_{ii}}_{=1} w_i \times \underbrace{\left(\left(\frac{L_i}{f_{ii}}\right)^{\frac{\delta}{1-\sigma}} \frac{\tau_{ii}}{L_i}\frac{Y_i}{P_i}\right)^{\eta}}_{\text{firm-selection effects}} \times \underbrace{\left(\frac{L_i}{f_i^e}\right)^{\frac{\delta}{1-\sigma}}}_{\text{entry effects}} \times \xi_{ii}$$

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$$\frac{P_{ii}}{w_i} = \left(\frac{Y_i}{P_i}\right)^{\eta} \times \underbrace{\left(\left(\frac{L_i}{f_{ii}}\right)^{\frac{\delta}{1-\sigma}} \frac{1}{L_i}\right)^{\eta} \left(\frac{L_i}{f_i^e}\right)^{\frac{\delta}{1-\sigma}} \xi_{ii}}_{\text{invariant to } \mathrm{d}\ln\tau}$$

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$$(\mathrm{d}\ln w_i - \mathrm{d}\ln P_{ii}) = -\eta\,\mathrm{d}\ln\left(\frac{Y_i}{P_i}\right) = -\eta\,\mathrm{d}\ln W_i$$

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Beyond Armington: *The Gains from Trade*

- Plugging $(\mathrm{d}\ln w_i - \mathrm{d}\ln P_{ii}) = -\eta\,\mathrm{d}\ln W_i$ back into our earlier formula for $\mathrm{d}\ln W_i$, yields

$$\mathrm{d}\ln W_i \;=\; -\frac{1}{\epsilon}\mathrm{d}\ln\lambda_{ii} \;\sim\; \frac{1}{(1-\sigma)\,(1+\eta)}\mathrm{d}\ln\lambda_{ii}$$

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where ϵ is the ***trade elasticity*** that is defined as

$$\epsilon \equiv -\frac{\partial\ln\left(\frac{\lambda_{ni}}{\lambda_{ii}}\right)}{\partial\ln\tau_{ni}} = -\frac{\partial\ln\left(\frac{\lambda_{ni}}{\lambda_{ii}}\right)}{\partial\ln\left(\frac{P_{ni}}{P_{ii}}\right)}\times\frac{\partial\ln\left(\frac{P_{ni}}{P_{ii}}\right)}{\partial\ln\tau_{ni}} = (\sigma-1)\times(1+\eta)$$

Procedure for Computing the Gains from Trade

- Use data on trade shares, $\{\lambda_{ji}\}$, and trade costs, $\{\tau_{ji}\}$, to estimate ϵ as

$$\log\left(\frac{\lambda_{ni}}{\lambda_{ii}}\right) = -\epsilon \log \tau_{ni} + \varepsilon_{ni}$$

- Use the estimated $\hat{\epsilon}$ and data on λ_{ii}, to compute the gains from trade as

$$GT_i = \lambda_{ii}^{-\frac{1}{\epsilon}}$$

- **Note:** the above procedure is model-blind, but the interpretation of ϵ depends on the underlying model (*e.g.*, Krugman *vs.* Eaton-Kortum *vs.* Melitz)

Taking Stock

- Arkolakis, Costinot, Rodriguez-Clare (2012, ACR) where to first to popularize the sufficient statistics approach to the gains from trade.

Caveat 1:

- The ACR result is occasionally interpreted as gains from trade being blind to firm heterogeneity
- A different interpretation is that the ACR result speaks to strong distributional assumptions (like Pareto) rather than firm-heterogeneity per se.

Caveat 2:

- τ_{ni} is often unobservable; so ϵ is often estimated using tariff data
  - $\tilde{\epsilon} \equiv$ the elasticity of trade w.r.t. tariffs
  - without firm-election, $\epsilon = \tilde{\epsilon}$
  - with firm-election, $\epsilon \neq \tilde{\epsilon}$

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the choice of model determines

how the estimated $\tilde{\epsilon}$ maps into ϵ

Some Number Using Data from 2008 and $\epsilon = 5$

	λ_{ii}	% GT
Ireland	0.68	8%
Belgium	0.70	7.5%
Germany	0.80	4.5%
China	0.88	2.6%
U.S.	0.92	1.8%

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- Based on the above numbers ACR (2012) conclude that gains from trade are *small*.

The Gains from Trade: *Reduced-Form Evidence*

- Reduced-from evidence from Frankel & Romer (1999) indicate that

$$\ln\left(\text{Real GDP}_i\right) = 3.94 \underbrace{\left(1-\lambda_{ii}\right)}_{\frac{1}{2}\text{OPENNESS}} + \varepsilon_i$$

- Considering that $\ln\lambda_{ii} \approx -\left(1-\lambda_{ii}\right)$ for small λ_{ii}, quantitative trade model predict

$$\ln\left(\text{Real GDP}_i\right) \approx \frac{1}{\epsilon}\left(1-\lambda_{ii}\right) + \tilde{\varepsilon}_i$$

- If we believe that $\epsilon \approx 5 \Longrightarrow$ reduced-form evidence imply gains that are *20-times* larger than those predicted by quantitative trade models!

The Gains from Trade: *Reduced-Form Evidence*

- The gap between the gains predicted by quantitative trade models and the gains predicted by Frankel & Romer (1999) can be *partially* eliminated if we account for
  - multiple industries with different trade elasticities
  - intermediate input trade (input-output linkages)
  - trade-led technology adoption

- However, even after adding all the above elements, the gap still persists!