Measured Aggregate Gains from Trade

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Introduction

- Two approaches to measuring aggregate gains from intl trade:

  Structural model to infer welfare gains Δs trade costs, trade patterns

  - e.g. Eaton-Kortum 2001, Arkolakis-Costinot-Rodriguez Clare 2011

  Empirical relationship btw trade & aggregate measures (real GDP)

  - e.g. Frankel-Romer 1999, Rodriguez-Rodrik 2001, Feyrer 2009

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- How do gains from trade in our models translate into aggregate measures in NIPA (real GDP, real consumption)

  Are aggregate measures informative of theoretical gains from trade?

Aggregate measures may not reflect gains from trade

- **Δ prices no 1^{st} effects on aggregate productivity**
  - Kohli (04), Kehoe-Ruhl (08), Bajona-Gibson-Kehoe-Ruhl (10)

$$\pi(p) = \max_{q,l} p \cdot q - L \text{ subject to } q \in F$$

Revealed production choices with fixed production feasibility set F

$$\begin{aligned} p_0 \cdot q_1 &\leq p_0 \cdot q_0 \\ p_1 \cdot q_1 &\geq p_1 \cdot q_0 \end{aligned}$$

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- **Price indices do not capture changes in varieties**
  - Feenstra (94), Broda-Weinstein (06), Feenstra-Reinsdorf-Slaughter (09)
  - Aggregate measures may underestimate gains from trade

Link theoretical and measured gains from trade

- Does aggregate productivity, real GDP $\Uparrow$ with trade?
- Under what conditions measured $\simeq$ theoretical gains from trade?
- Sufficient statistics across models for **measured** gains from trade
  - Extends AB 2010, Arkolakis-Costinot-Rodriguez Clare 2011

Workhorse models (roadmap)

1. Armington (exogenous specialization), e.g. Anderson
2. Ricardian (endogenous specialization), perfect comp, e.g. EK
3. Monopolistic competition, heterogeneous firms, constant markups, e.g. Krugman, Melitz + endogenous quality choice

   Common factor intensities across producers

- Trade costs: Variable iceberg trade costs, import tariffs, fixed costs
- Measurement follows broad outline of BEA procedures

Key Results

- Aggregate productivity $\Uparrow$ if price indices reflect $\Downarrow$ trade costs
  - Key: are trade costs incurred domestically or abroad?
  - Measured aggregate productivity captures Δ production feasibility set
  - Endog reallocation across producers not $\Uparrow$ measured productivity

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- Real consumption & welfare-based consumption (CPI vs. P_{welfare})
  - Δ variable trade costs: Δ world real C $\simeq$ %Δ world theoretical C
  - Stronger conditions: %Δreal $\simeq$ %Δtheoretical C, ctry by ctry
  - Biases in *CPI* cancel-out in GE

    Adjusting price index for $\Uparrow$ imported varieties overstates welfare gains

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    Adjusting price index for $\Uparrow$ imported varieties overstates welfare gains

- Given trade shares and %Δ in *variable* trade costs, %Δ real GDP and %Δ world real consumption $\simeq$ across models

  - Richer models no new measured gains because no new welfare gains

Related Papers

- Bajona-Gibson-Kehoe-Ruhl (2010), Kehoe-Ruhl (JEP 2010)

  Focus on implications of trade liberalization on real GDP when price indices do not capture Δ in trade costs
  We also study relation between real GDP, real C & welfare

- Feenstra-Reinsdorf-Slaughter (2009)

  Standard prodtivity measures may overstate prodtivity $\Uparrow$ in US IT
  GDP function approach of Diewort -Morrison (1986)

- Feenstra (1994), Broda-Weinstein (2006)

  Measure bias in price indices due to growth in varieties
  We show that, in response to variable change in trade costs, no bias at the world (or country) level when jointly accounting for all biases

Armington Model with Exogenous Specialization and Perfect Competition

Environment

- Model of a representative industry

- Utility

$$U_n = \sum_{t=0}^{\infty} \beta^t u\left(C_{nt}\right)$$

- Theoretical consumption

$$C_{nt} = \left[\int_{\Omega_{nt}} q_{nt}\left(\omega\right)^{\frac{\rho-1}{\rho}} d\omega\right]^{\frac{\rho}{\rho-1}}$$

Ω_{nt}: set of available goods in country n

- Price level: $P_{nt} = \left[\int_{\Omega_{nt}} p_{nt}\left(\omega\right)^{1-\rho} d\omega\right]^{\frac{1}{1-\rho}}$

- Assume C (or price, P), not directly observable

Production

- Each producer specializes in single differentiated good
- Production function: $y = zl$
- Denote producers by i,z
- Distribution of producers $M_{it}(z)$
- Results extend to multiple factors of production:
  - C-D, CRS, production functions
  - Common factor intensities across producers
  - Fixed supply, or endogenous supply produced with final good

International Trade

- Ω_{int}: set of country i producers selling positive quantity in country n
  - Allows for non-exporting producers

- Exogenous specialization: $\Omega_{int} = \Omega_{in}$
  - Unless autarky, $\Omega_{int} = \varnothing$

- Variable trade costs: $(\tau_{int} - 1) / z$ units of labor in country i
  - by producer or by domestic intermediary

- Aggregate resource constraint:

$$\sum_n \int_{\Omega_{int}} \tau_{int} q_{int} / z \mathrm{d} M_{it} = \bar{L}_i$$

Perfect Competition

- Producer prices: $\bar{p}_{int} = W_{it} / z$
- Shipping prices: $\bar{p}^s_{int} = (\tau_{int} - 1) \, W_{it} / z$
  - Includes any costs applying differentially to exports
    - Anderson and Van Wincoop 2004
  - Can also be carried within the producer: $\bar{p}_{int} + \bar{p}^s_{int}$
- Consumer prices: $p_{int} = \tau_{int} W_{it} / z$

NIPA

- Consumption expenditures

$$E_{nt} = P_{nt} C_{nt} = \sum_{n} \int_{\Omega_{int}} p_{int} q_{int} \mathrm{d} M_{it}$$

- Current-dollar GDP

$$\begin{aligned}
&= \sum_{n} \int_{\Omega_{int}} \left(\bar{p}_{int} + \bar{p}^{s}_{int} \right) q_{int} \mathrm{d} M_{it} \\
&= W_{it} \bar{L}_{i} + \Pi_{it} \\
&= E_{it} + \sum_{n \neq i} \int_{\Omega_{int}} p_{int} q_{int} \mathrm{d} M_{it} - \sum_{n \neq i} \int_{\Omega_{nit}} p_{nit} q_{nit} \mathrm{d} M_{nt}
\end{aligned}$$

Aggregate measurement

- Detailed components of GDP: industries, sectors, groups of goods
- Real GDP in period t relative to period $t-1$

$$\frac{RGDP_t}{RGDP_{t-1}} = \left(\frac{\sum p_{t-1} q_t}{\sum p_{t-1} q_{t-1}}\right)^{0.5} \left(\frac{\sum p_t q_t}{\sum p_t q_{t-1}}\right)^{0.5}$$

- Real GDP in period T relative to 0:

$$\frac{RGDP_T}{RGDP_0} = \prod_{t=1}^{T} \frac{RGDP_t}{RGDP_{t-1}}$$

- Estimates of $p_t q_t$ typically available, q_t often not
- Deflation method using price index $\mathcal{P}_t / \mathcal{P}_{t-1}$

$$p_{t-1} q_t = (p_t q_t) \,/\, (\mathcal{P}_t / \mathcal{P}_{t-1})$$

$$p_t q_{t-1} = (p_{t-1} q_{t-1}) \times (\mathcal{P}_t / \mathcal{P}_{t-1})$$

Real GDP Using Aggregate Deflator

- $$\frac{RGDP_{it}}{RGDP_{it-1}} = \left(\frac{\frac{GDP_{it}}{PPI_{it}/PPI_{it-1}}}{GDP_{it-1}} \right)^{0.5} \left(\frac{GDP_{it}}{GDP_{it-1} \times \frac{PPI_{it}}{PPI_{it-1}}} \right)^{0.5} = \frac{GDP_{it}}{GDP_{it-1}} \frac{PPI_{it-1}}{PPI_{it}}$$

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- $GDP_{it} / GDP_{it-1} = W_{it} / W_{it-1}$

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- $GDP_{it} / GDP_{it-1} = W_{it} / W_{it-1}$
- PPI using FOB prices, exclude shipping services incurred abroad

$$\frac{PPI_{it}}{PPI_{it-1}} = \frac{\sum_n \int_{\Omega_{int}^c} p_{int_0} q_{int_0} \left(\frac{p_{int}}{p_{int-1}} \right) \mathrm{d}M_{it_0}}{\sum_n \int_{\Omega_{int}^c} p_{int_0} q_{int_0} \, \mathrm{d}M_{it_0}} = \sum_n \bar{\lambda}_{int} \frac{\tau_{int}}{\tau_{int-1}} \frac{W_{it}}{W_{it-1}}$$

  - $\Omega_{int}^c = \Omega_{int_0} \cap \Omega_{int-1} \cap \Omega_{int}$, $\bar{\lambda}_{int} = \frac{\int_{\Omega_{int}^c} p_{int_0} q_{int_0} \mathrm{d}M_{it_0}}{\sum_n \int_{\Omega_{int}^c} p_{int_0} q_{int_0} \mathrm{d}M_{it_0}}$

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- $\frac{PPI_{it}}{PPI_{it-1}} = \sum_n \bar{\lambda}_{int} \frac{\tau_{int}}{\tau_{int-1}} \frac{W_{it}}{W_{it-1}}$

$$\frac{RGDP_{it}}{RGDP_{it-1}} = \frac{1}{\sum_n \frac{\tau_{int}}{\tau_{int-1}} \bar{\lambda}_{int}}$$

- **If** $\tau_{int} < \tau_{int-1}$ **for some** i, n**, then** $RGDP_{it} / RGDP_{it-1} > 1$

Real GDP and Reallocation

- $\frac{RGDP_{it}}{RGDP_{it-1}} = \frac{\sum_n \int_{\Omega_{int}} \frac{l_{int}}{L_{it}} \times \frac{p_{int} q_{int}}{l_{int}} \mathrm{d}M_{it}}{\sum_n \int_{\Omega_{int-1}} \frac{l_{int-1}}{L_{it-1}} \times \frac{p_{int-1} q_{int-1}}{l_{int-1}} \mathrm{d}M_{it-1}} \frac{L_{it}}{L_{it-1}} \frac{1}{PPI_{it} / PPI_{it-1}}$

- Value added per worker same across producers, $\frac{p_{int}(z) q_{int}(z)}{l_{int}(z)} = W_{it}$

- Endogenous reallocation of production towards more productive producers does not contribute to measured productivity, conditional on trade shares

Real GDP Using Disaggregated Deflators

- Destination specific deflators

- $\frac{RGDP_{it}}{RGDP_{it-1}} = \left(\frac{\sum_n \frac{GDP_{int}}{PPI_{int}/PPI_{int-1}}}{\sum_n GDP_{int-1}} \right)^{0.5} \left(\frac{\sum_n GDP_{int}}{\sum_n \frac{GDP_{int-1}}{PPI_{int}/PPI_{int-1}}} \right)^{0.5}$

- $\frac{PPI_{int}}{PPI_{int-1}} = \frac{\tau_{int}}{\tau_{int-1}} \frac{W_{it}}{W_{it-1}}$

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- Note that $\sum_n \frac{GDP_{int}}{PPI_{int}/PPI_{int-1}} = \sum_n \int_{\Omega_{int}} p_{int-1} q_{int} \mathrm{d}M_{it}$

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- $\frac{RGDP_{it}}{RGDP_{it-1}} = \left(\frac{\sum_n \lambda_{int} \frac{\tau_{int-1}}{\tau_{int}}}{\sum_n \lambda_{int-1} \frac{\tau_{int}}{\tau_{int-1}}} \right)^{0.5}$, $\lambda_{int} = \frac{GDP_{int}}{GDP_{it}}$
- Real GDP based on aggr, disaggr deflators $=$ to a 1^{st} approx

Real GDP: Trade Costs Incurred Abroad

- Producer prices: $\bar{p}_{int} = W_{it} / z$

- $PPI_{it} = W_{it} / W_{it_0}$ and $RGDP_{iT} / RGDP_{i0} = 1$

- More generally: If trade liberalization changes prices, at fixed production feasibility set, then to a first-order approximation, real GDP unchanged

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- More generally: If trade liberalization changes prices, at fixed production feasibility set, then to a first-order approximation, real GDP unchanged
- Suppose all trading services produced in country i_s

$$GDP_{i_s t} = \sum_n \int_{\Omega_{i_s nt}} \left(\bar{p}_{i_s nt} + \bar{p}^s_{i_s nt}\right) q_{i_s nt} \mathrm{d}M_{i_s t} + \sum_{i \neq i_s} \sum_n \int_{\Omega_{int}} \bar{p}^s_{int} q_{int} \mathrm{d}M_{it}$$

- **If τ_{in} falls for at least one pair of countries, real GDP$_{i_s}$ rises**

Real GDP: Tariffs

- Add valorem import tariff: $d_{int} \geq 1$
- Consumer prices: $p_{int} = d_{int} \left(\bar{p}_{int} + \bar{p}^s_{int} \right)$
- Current-dollar GDP inclusive of tariff revenues

$$
\begin{aligned}
&= \sum_n \int_{\Omega_{int}} \left(\bar{p}_{int} + \bar{p}^s_{int} \right) q_{int} \mathrm{d} M_{it} + \Upsilon_{it} \\
&= W_{it} \bar{L}_i + \Pi_{it} + \Upsilon_{it} \\
&= E_{it} + \sum_{n \neq i} \int_{\Omega_{int}} p_{int} q_{int} \mathrm{d} M_{it} - \sum_{n \neq i} \int_{\Omega_{nit}} p_{nit} q_{nit} \mathrm{d} M_{nt}
\end{aligned}
$$

- Tariff revenues: $\Upsilon_{it} = \sum_n \left(d_{nit} - 1 \right) \int_{\Omega_{nit}} \left(\bar{p}_{nit} + \bar{p}^s_{nit} \right) q_{nit} \mathrm{d} M_{nt}$

Real GDP from the expenditure side: Tariffs

- Exports, import prices exclude tariffs, CPI includes tariffs

- Real GDP index at $t-1$ base prices:

$$\frac{RGDP_{it}}{RGDP_{it-1}} = \frac{\sum_n \frac{E_{nit}}{CPI_{nit}/CPI_{nit-1}} + \sum_{n\neq i}\left[\frac{\text{Exports}_{int}}{EPI_{int}/EPI_{int-1}} - \frac{\text{Exports}_{nit}}{EPI_{nit}/EPI_{nit-1}}\right]}{GDP_{it-1}} =$$

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$$\frac{\sum_n \int_{\Omega_{int}} \left(\bar{p}_{int-1}+\bar{p}^s_{int-1}\right) q_{int} \mathrm{d}M_{it-1} + \sum_n \int_{\Omega_{nit}} (d_{nit-1}-1)\left(\bar{p}_{nit-1}+\bar{p}^s_{nit-1}\right) q_{nit} \mathrm{d}M_{nt-1}}{\sum_n \int_{\Omega_{int-1}} \left(\bar{p}_{int-1}+\bar{p}^s_{int-1}\right) q_{int-1} \mathrm{d}M_{it-1} + \sum_n \int_{\Omega_{nit-1}} (d_{nit-1}-1)\left(\bar{p}_{nit-1}+\bar{p}^s_{nit-1}\right) q_{nit-1} \mathrm{d}M_{nt-1}}$$

- **Real GDP rises if value of tariff revenues evaluated at base-prices and base-tariffs $\Uparrow$**

  Imported physical quantities must $\Uparrow$ weakly.

Real Consumption and Theoretical Consumption

- Real consumption using aggregate deflators

$$\frac{RC_{nt}}{RC_{nt-1}} = \frac{E_{nt} / E_{nt-1}}{CPI_{nt} / CPI_{nt-1}}$$

where $\frac{CPI_{nt}}{CPI_{nt-1}} = \frac{\sum_i \int_{\Omega^c_{int}} \left(p_{int_0} q_{int_0}\right) \left(\frac{p_{int}}{p_{int-1}}\right) \mathrm{d}M_{it_0}}{\sum_i \int_{\Omega^c_{int}} p_{int_0} q_{int_0} \, \mathrm{d}M_{it_0}}$

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where $\frac{CPI_{nt}}{CPI_{nt-1}} = \frac{\sum_i \int_{\Omega^c_{int}} \left(p_{int_0}\, q_{int_0}\right)\left(\frac{p_{int}}{p_{int-1}}\right) \mathrm{d}M_{it_0}}{\sum_i \int_{\Omega^c_{int}} p_{int_0}\, q_{int_0}\, \mathrm{d}M_{it_0}}$

- Difference between real-consumption and theoretical consumption: CPI vs welfare-based price index

- Fixed set of consumed goods: standard substitution bias

$$\left.\frac{CPI_{nt}}{CPI_{nt-1}}\right|_{t_0=t} \leq \frac{P_{nt}}{P_{nt-1}} \leq \left.\frac{CPI_{nt}}{CPI_{nt-1}}\right|_{t_0=t-1}$$

- **With fixed set of goods, $\%\Delta$CPI $=$ $\%\Delta$P to a 1^{st} order approx**

Real GDP and Real Consumption

- $d \log RGDP_{it} = d \log W_{it} - \sum_n \lambda_{int} d \log PPI_{int}$

  $d \log RC_{it} = d \log E_{it} - \sum_i E_{nit} / E_{it} d \log CPI_{nit}$

  $d \log PPI_{int} = d \log CPI_{int} = d \log \left(W_{it} \tau_{int} \right)$

Real GDP and Real Consumption

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  $d \log RC_{it} = d \log E_{it} - \sum_i E_{nit} / E_{it} d \log CPI_{nit}$

  $d \log PPI_{int} = d \log CPI_{int} = d \log (W_{it} \tau_{int})$

- Trade balance, $d \log W_{it} = d \log E_{nt}$

- Define country weights, $s_{it} = GDP_{it} / \sum_n GDP_{nt}$

$$\sum_i s_{it} d \log RGDP_{it} = \sum_i s_{it} d \log RC_{it} = \sum_i s_{it} d \log C_{it}$$

$$\sum_i s_{it} d \log RGDP_{it} = -\frac{1}{\sum GDP_{it}} \times \sum_i \sum_n \text{Exports}_{int} \times d \log \tau_{in}$$

- **World RGDP=RC, both specifications of trade costs and tariffs**

Summary of Results, Armington Model

- Real GDP and measured productivity $\Uparrow$ in response to $\Downarrow$ in variable trade costs if GDP and price indices capture $\Downarrow$ trade costs
  - Key: Do changes in trade costs change production feasibility set?
- Real GDP from expenditure side $\Uparrow$ rises if real value of tariffs $\Uparrow$
- $\%\Delta$ Real $\simeq$ $\%\Delta$ theoretical consumption, country-by-country
- With balanced-trade, $\%\Delta$ world real consumption $\simeq$ $\%\Delta$ world real GDP $\simeq$ $\%\Delta$ world theoretical consumption, independently of where trade services produced

Model with Endogenous Specialization and Perfect Competition

Ricardian model

- All goods consumed every period

$$p_{nt}(\mathbf{z}) = \min_i \left\{ \bar{p}_{int}(\mathbf{z}) + \bar{p}^s_{int}(\mathbf{z}) \right\}$$

- Results on real consumption unchanged
- Aggregate price index uses prices of continuing producers:

$$\frac{RGDP_{it}}{RGDP_{it-1}} = \frac{1}{\sum_n \frac{\tau_{int}}{\tau_{int-1}} \bar{\lambda}_{int}}$$

$\bar{\lambda}_{int}$ = trade share of *continuing* producers Ω^c_{int}

- If use disaggregated deflators expressions for real GDP unaffected by switching
  - Equal to using aggregate deflators, to a first-order approximation

Model with Endogenous Specialization and Monopolistic Competition

Model with Monopolistic Competition

- Constant markups:

$$\bar{p}_{in}(z) + \bar{p}^s_{in}(z) = p_{in}(z) = \frac{\rho}{\rho - 1} \frac{W_{it} \tau_{int}}{z}$$

- Ω_{int} and M_i:

  Fixed domestic labor costs of selling in country n: f_{int}

  Free entry cost f_{Ei} to draw productivity from $G_i(z)$

  Both expensed

Model with Monopolistic Competition

- Assume $\Pi_{it} = \kappa_i \times$ aggregate revenues by country i producers at $t = 0$ and at least one $t = T \geq 1$

  Three special case where this holds in steady-state

  1. No fixed costs of selling in each market (i.e. $f_{int} = 0$)
  2. Discount factor approaches zero ($\beta \to 1$), $\kappa_i = 0$
  3. $G_i(z)$ is Pareto, with free-entry or with restricted entry

Real GDP

- $GDP_{it} = W_{it}\bar{L}_i \,/\, (1-\kappa_i)$, same change as perfect competition
- Aggregate price index uses prices of continuing producers:

$$
\begin{aligned}
\frac{RGDP_{iT}}{RGDP_{i0}} &= \prod_{t=1}^{T}\left(\frac{GDP_{it}\,/\,GDP_{it-1}}{PPI_{it}\,/\,PPI_{it-1}}\right) \\
&= \frac{GDP_{iT}}{GDP_{i0}}\prod_{t=1}^{T}\left(\frac{1}{PPI_{it}\,/\,PPI_{it-1}}\right) \\
&= \frac{1}{\sum_n \frac{\tau_{in1}}{\tau_{in0}}\bar{\lambda}_{in1}},
\end{aligned}
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&= \frac{1}{\sum_n \frac{\tau_{in1}}{\tau_{in0}}\bar{\lambda}_{in1}},
\end{aligned}$$

- **Δ fixed costs, foreign size: trade shares Δ, real GDP not**

Real GDP

- $GDP_{it} = W_{it}\bar{L}_i / (1-\kappa_i)$, same change as perfect competition
- Aggregate price index uses prices of continuing producers:

$$\begin{aligned}\frac{RGDP_{iT}}{RGDP_{i0}} &= \prod_{t=1}^{T}\left(\frac{GDP_{it} / GDP_{it-1}}{PPI_{it} / PPI_{it-1}}\right) \\ &= \frac{GDP_{iT}}{GDP_{i0}}\prod_{t=1}^{T}\left(\frac{1}{PPI_{it} / PPI_{it-1}}\right) \\ &= \frac{1}{\sum_n \frac{\tau_{in1}}{\tau_{in0}}\bar{\lambda}_{in1}},\end{aligned}$$

- **Δ fixed costs, foreign size: trade shares Δ, real GDP not**
- If use disaggregated deflators, real GDP unaffected by switching, same as with exogenous specialization
  - Equal to using aggregate deflators, to a first-order approximation

Real Consumption and Theoretical Consumption

- CPI does not capture:

  Substitution within continuing products

  Changes in mass of consumed goods

- Country by country, real consumption $\neq$ theoretical consumption

World Real Consumption and Theoretical Consumption

- Assume trade balance in each country

  In response to marginal changes in variable trade costs

$$\sum_i s_{it} d \log RGDP_{it} = \sum_i s_{it} d \log RC_{it} = \sum_i s_{it} d \log C_{it}$$

$$\sum_i s_{it} d \log RGDP_{it} = -\frac{1}{\sum GDP_{it}} \times \sum_i \sum_n \text{Exports}_{int} \times d \log \tau_{in}$$

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  Indirect effect on world theoretical price index from changes in set of consumed goods (changes in mass of entering firms and changes in exit and export thresholds) $\simeq 0$ (AB 2010)

  - **CPI biases cancel-out at the world level in GE**

World Theoretical Consumption

- Free-entry in steady-state:

$$\hat{\beta} \sum_n \int_{\Omega_{in}} \frac{\pi_{in}(z)}{W_i} \mathrm{d} G_i(z) - \hat{\beta} \sum_n \left[1 - G_i(\bar{z}_{int})\right] f_{in} = f_{Ei}$$

$\frac{\pi_{int}(z)}{W_{it}} = \frac{z^{\rho-1}\tau_{int}^{1-\rho}}{\bar{\rho}} \left(\frac{W_{it}}{P_{it}}\right)^{-\rho} C_{nt} = \frac{z^{\rho-1}\tau_{int}^{1-\rho}}{\bar{\rho}} \left(\frac{\bar{L}_i}{1-\kappa_i}\right)^{\rho} C_{it}^{1-\rho} S_{int}$,
$S_{int} = \frac{P_{nt}^{\rho} C_{nt}}{P_{it}^{\rho} C_{it}}$

World Theoretical Consumption

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$S_{int} = \frac{P_{nt}^{\rho} C_{nt}}{P_{it}^{\rho} C_{it}}$

- Log-differentiating and using envelope condition on $\bar{z}_{int}$,

$$d \log C_{it} = -\sum_n \lambda_{int} d \log \tau_{int} + \frac{1}{\rho - 1} \sum_n \lambda_{int} d \log S_{int}.$$

World Theoretical Consumption

- Free-entry in steady-state:

$$\hat{\beta}\sum_{n}\int_{\Omega_{in}}\frac{\pi_{in}(z)}{W_i}\mathrm{d}G_i(z)-\hat{\beta}\sum_{n}\left[1-G_i(\bar{z}_{int})\right]f_{in}=f_{Ei}$$

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$S_{int}=\frac{P_{nt}^{\rho}C_{nt}}{P_{it}^{\rho}C_{it}}$

- Log-differentiating and using envelope condition on $\bar{z}_{int}$,

$$d\log C_{it}=-\sum_{n}\lambda_{int}d\log\tau_{int}+\frac{1}{\rho-1}\sum_{n}\lambda_{int}d\log S_{int}.$$

- Trade balance ($s_{it}\sum_n\lambda_{int}=s_{nt}\sum_n\lambda_{nit}$) and $d\log S_{int}=-d\log S_{nit}$, implies $\sum_i s_{it}\sum_n\lambda_{int}d\log S_{int}=0$, so

$$\sum_{i}s_{it}d\log C_{it}=-\sum_{i}s_{it}\sum_{n}\lambda_{int}d\log\tau_{int}.$$

Measured Gains From Trade Across Models

- $\%\Delta$ real GDP and 1st-order $\%\Delta$ in world $RC =$ across models, given trade shares and $\%\Delta$ in variable trade costs
- Not arising from inadequacy of aggregate measures of real consumption
- Arising from underlying equivalence in welfare implications of these models under some restrictions

Real, Theoretical Consumption Country by Country

- Fixed export costs paid in importing country and $G_i(z)$ is Pareto
  - Eaton, Kortum and Kramarz (2010)

- **%Δ real C $\simeq$ %Δ theoretical C country by country**

  - Globally, model = Armington (ex-ante result in ACR)

Two country numerical example

- $\tau_{12t} = \tau_{21t} = \tau_t$ and $f_{12t} = f_{21t}$
- Pareto productivity G with slope 5 – EKK 2010
- $\rho = 3$
- $\lambda_{120} = 7\%$, $\lambda_{210} = 15\%$
- $\bar{L}_1 / \bar{L}_2 = 2.05$
- Variable trade costs incurred domestically
- Fixed costs incurred in exporting or importing country
- Use disaggregated deflators to minimize substitution bias

Figure 1: Gains from reductions in variable trade costs, Fixed costs in exporting country

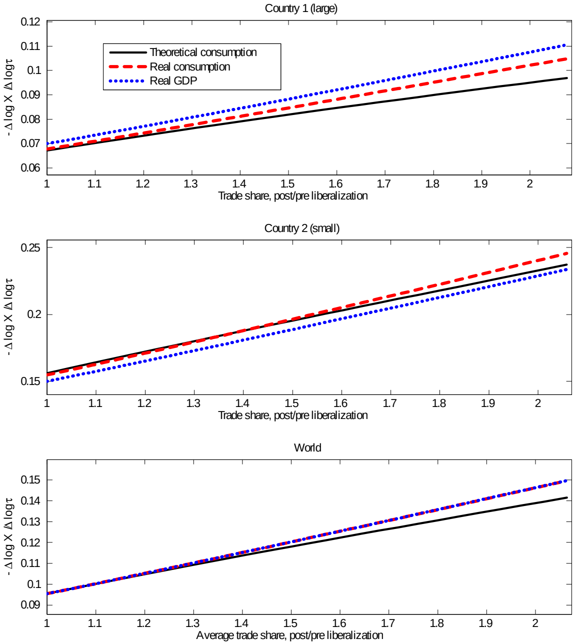
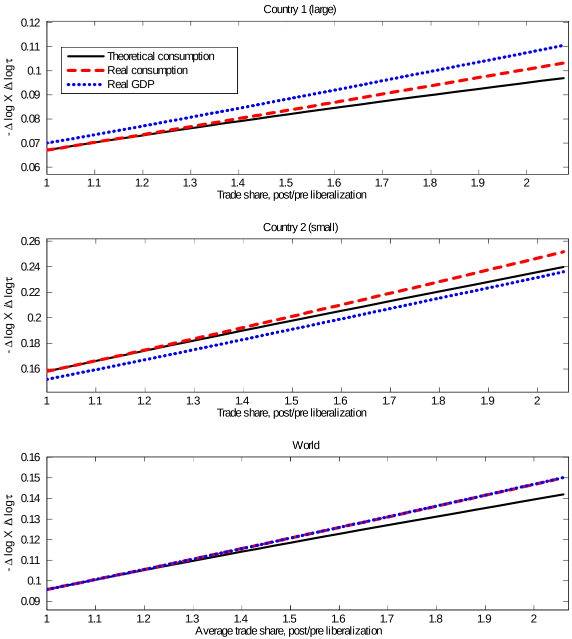


Figure 2: Gains from reductions in variable trade costs, Fixed costs in importing country



Endogenous Quality

- $C_{nt} = \left[\int_{\Omega_{nt}} a_{nt} \left(\omega \right)^{\frac{1}{\rho}} \left(\omega \right) q_{nt} \left(\omega \right)^{\frac{\rho-1}{\rho}} d\omega \right]^{\frac{\rho}{\rho-1}}$
- Fixed (expensed) labor costs to choose quality $h\left(z; a_{int}\right)$
- Constant share of profits in steady-state if either
  1. $\beta \rightarrow 1$
  2. Pareto G, $h\left(z; a\right) = \frac{\gamma_0}{\gamma} \bar{h}\left(z\right) a^{\gamma}$

Endogenous Quality

- If prices in PPI and CPI do not reflect Δ in product quality
  - same expression for real GDP
  - $\%\Delta$ world real C $\simeq$ $\%\Delta$ world theoretical C
  - country by country if $h(z; a) = z^{\mu} a^{\gamma}$, Pareto G, fixed costs abroad
  - Indirect effect on theoretical price index from Δ in set of consumed goods (changes in the mass of entering firms and changes in exit and export thresholds) and endogenous quality changes $\simeq 0$
- If prices in PPI and CPI adjust for changes in quality (or productivity), $\%\Delta RC > \%\Delta C$

Multiple Factors

- $y = zl^{\alpha_L} \prod_{j=1}^{J} k_j^{\alpha_j}$, $\alpha_L + \sum_{j=1}^{J} \alpha_j = 1$

- Some inputs accumulated at the aggregate level (e.g. capital), other inputs exogenously supplied

- Consumption and accumulable inputs produced using final good

  $C_{it} + \sum_{j=1}^{J_F} K_{j,it} = Q_{it}$

  Also interpretable as intermediate inputs

- Real GDP: $\frac{RGDP_{iT}}{RGDP_{i0}} = \prod_{j=1}^{J} \left[\frac{K_{j,iT}}{K_{j,i0}}\right]^{\alpha_i} \frac{1}{\sum_n \frac{\tau_{in1}}{\tau_{in0}} \bar{\lambda}_{in1}}$

- First-order equivalence between real C and theoretical C
  $\sum_i s_{it} d \log C_{it} = -\sum_i s_{it} \left[\sum_n \lambda_{int} d \log \tau_{int} + d \log c_{it} / W_{it}\right]$

Conclusions

- Measured aggregate productivity $\Uparrow$ when trade costs $\Downarrow$ if production feasibility set improves
- Real consumption $\simeq$ welfare-based consumption (world or country-by-country) when variable trade costs Δ
  - Multiple biases in *CPI* cancel-out in GE
- Conditional on trade shares (of continuing producers) and Δ in variable trade costs, all models considered deliver $\simeq$ measured aggregate gains from trade
  - Richer models no new measured gains because no new welfare gains
- Caution: measurement procedures in individual countries may differ from US and recommended by UN
- Measured gains from trade from additional sources? Variable markups