New Terrain in International Trade

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Map of the Terrain

- Starting Point: Ricardian Trade:
  - Multiple countries, with Jonathan Eaton (2002)
  - Counterfactuals, with Dekle and Eaton (2007, 2008)

- New Terrain: Intranational Trade and Labor Mobility

- New Terrain: Dynamics and Global Accounting
Navigational Tools

- Focus on two ideas/tools we’ve found useful:
  1. Extreme-value distributions to model producers in many countries
  2. Hat algebra to calibrate to data
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• As in the world of Lucas (2009), they didn’t come out of nowhere:

  1. Modeling idea: antecedent in McFadden and discrete choice models
  2. Calibration idea: antecedent in growth accounting and CGE modeling
Recent Contributions

• Bridging models: Arkolakis, Costinot and Rodríguez-Clare (ACR 2012)

• Estimating the trade elasticity: Simonovska and Waugh (2014)

• Quantitative analysis of NAFTA: Caliendo and Parro (2015)

• Quantitative analysis of trade wars and policy: Ossa (2014)

• Overview, coining “exact hat algebra”: Costinot and Rodríguez-Clare (2014)
Simplest Ricardian Setting

- Endowments: $L_i$, for countries $i = 1, \ldots, N$

- Preferences: tradables share $\alpha$, symmetric over $j \in [0, 1]$

- Technology: efficiency $z_i(j)$ (efficiency in services $a_i$ will disappear)

- Labor perfectly mobile across sectors

- Iceberg trade costs (shipping to $n$ from $i$) $d_{ni} \geq 1$ and $d_{ii} = 1$
I. Modeling Idea

- Summarize efficiencies with Fréchet distribution:
  \[
  \Pr [ z_i(j) \leq z ] = e^{-T_i z^{-\theta}}
  \]

- Most efficient producer of \( j \) has same distribution: \( T = \sum_k T_k \)
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- Most efficient producer of \( j \) has same distribution: \( T = \sum k T_k \)

- Probability low-cost producer for \( n \) is from country \( i \):

\[
\pi_{ni} = \frac{T_i (w_i d_{ni})^{-\theta}}{\sum_k T_k (w_k d_{nk})^{-\theta}}
\]
II. Calibration Idea

- Data on bilateral trade shares (of \( n \)'s tradable spending imported from \( i \)):

\[
\frac{X_{ni}}{\alpha X_n} = \pi_{ni} = \frac{T_i (w_i d_{ni})^{-\theta}}{\sum_{k=1}^{N} T_k (w_k d_{nk})^{-\theta}}
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- Use them to calibrate $T_i$'s and $d_{ni}$'s to calculate ...

- ... change in trade shares if wages are $w'_k$ instead ($\hat{w}_k = w'_k / w_k$):
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- Use them to calibrate \( T_i \)'s and \( d_{ni} \)'s to calculate ...

- Change in trade shares if wages are \( w_k' \) instead (\( \hat{w}_k = w_k'/w_k \)):

\[
\pi'_{ni} = \frac{T_i (w_i \hat{w}_i d_{ni})^{-\theta}}{\sum_{k=1}^{N} T_k (w_k \hat{w}_k d_{nk})^{-\theta}} = \frac{\pi_{ni} (\hat{w}_i)^{-\theta}}{\sum_{k=1}^{N} \pi_{nk} (\hat{w}_k)^{-\theta}}
\]
An ACR Detour

- Given wages $w_k$, home share is:

$$\frac{X_{ii}}{\alpha X_i} = \pi_{ii} = T_i \left( \frac{w_i}{p_i/\gamma} \right)^{-\theta}$$

- Why not invert it? (don't forget equation 15 in EK!)

$$w_i = \gamma \left( \frac{T_i}{\pi_{ii}} \right)^{1/\theta} \frac{p_i}{p_i}$$

- Real wage relative to autarky:

$$\frac{W}{W_A} = \left( \pi_{ii} \right)^{-\alpha/\theta}$$
Table 1: Welfare Relative to Autarky

<table>
<thead>
<tr>
<th>Country</th>
<th>Basic Model</th>
<th>Multiple Sectors &amp; Intermediates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poland</td>
<td>1.05</td>
<td>1.51</td>
</tr>
<tr>
<td>USA</td>
<td>1.02</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Calculations based on Costinot and Rodriguez-Clare (2014)
General Equilibrium

- Income: \( Y_i = w_i L_i \)

- Trade imbalances: \( X_n = Y_n + D_n \)

- Market clearing:
  \[
  Y_i - (1 - \alpha) (Y_i + D_i) = \sum_n \pi_{ni} \alpha (Y_n + D_n)
  \]

- If \( \alpha = 1 \) and \( d_{ni} = 1 \) then \( D \)'s drop out, otherwise affect specialization
Counterfactual Trade Balance

- Given data on $Y_i$ and $\pi_{ni}$, moving from our world ...

- ... to a world of $D' = 0$ implies wage changes satisfying:

$$Y_i' = \hat{w}_i Y_i = \sum_n \pi'_{ni} \hat{w}_n Y_n$$

$$\pi'_{ni} = \frac{\pi_{ni} (\hat{w}_i)^{-\theta}}{\sum_{k=1}^{N} \pi_{nk} (\hat{w}_k)^{-\theta}}$$
### Table 2: Rebalancing Counterfactual

<table>
<thead>
<tr>
<th>CA deficit (% of GDP)</th>
<th>Counterfactual change from 2004 base change in GDP</th>
<th>Real GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mobile</td>
<td>immobile</td>
</tr>
<tr>
<td>Germany 2004</td>
<td>-3.8</td>
<td>1.03</td>
</tr>
<tr>
<td>Greece 2004</td>
<td>5.0</td>
<td>0.96</td>
</tr>
<tr>
<td>USA 2004</td>
<td>5.6</td>
<td>0.96</td>
</tr>
</tbody>
</table>

From Dekle, Eaton, and Kortum (2008)
Issues Raised by Counterfactual

- Modeling labor immobility
- Modeling trade deficits
- Modeling trade elasticities (short and long run)
- Modeling slow wage adjustment
- Explore first two issues in new terrain
New Terrain: Intranational Trade
Burst of Activity


- Ramondo, Rodríguez-Clare, and Saborio (2014)

- Redding (2015); Monte, Redding, and Rossi-Hansberg (2015)

- Tombe and Zhu (2015); Fajgelbaum, Suárez-Serrato, and Zidar (2015)

- Follow: Caliendo, Dvorkin, and Parro (CDP 2015)
New Elements

- Ricardian model: but locations $i$ within and between countries

- Cost of moving from $n$ to $i$ is $\tau_{ni}$ (can be prohibitive)

- Dynamic discrete choice as in Artuç and McLaren (2010)

- Amenity draws $a_{i,t}(\omega)$ distributed Fréchet ($\epsilon$)
Let $V_{n,t}$ be the value of residing in location $n$ at date $t$:

$$V_{n,t} = \ln\left(\frac{w_{n,t}}{p_{n,t}}\right) + E\left[\max_i \left\{\rho V_{i,t+1} + \ln a_{i,t+1}(\omega) - \ln \tau_{ni}\right\}\right]$$

Migration shares (of individuals in $n$ relocating to $i$), letting $u_{i,t} = e^{V_{i,t}}$:

$$\mu_{ni,t+1} = \frac{\left(\left(\frac{u_{i,t+1}^\rho}{\tau_{ni}}\right)^\epsilon\right)}{\sum_k \left(\left(\frac{u_{k,t+1}^\rho}{\tau_{nk}}\right)^\epsilon\right)}$$

State variables $L_{i,t}$ evolve according to these migration shares.
Counterfactuals

- Counterfactual: dynamic response to a new path, such as \( \{ \hat{T}_{i,t+1} \} \)

- (“hat” now means temporal change, \( \hat{x}_{t+1} = x_{t+1}/x_t \))

- Condition on data \( Y_{i,t}, L_{i,t}, \pi_{ni,t}, \) and \( \mu_{ni,t} \) for initial period only ...

- ... leaving only three parameters! \( \theta, \epsilon, \) and \( \rho \)

- Perfect foresight: initial \( \hat{u}_{n,t} \)’s get you on path to the steady state of...
\[
(\hat{u}_{n,t})^\varepsilon = \sum_i \mu_{ni,t} \left( \frac{\hat{T}_{i,t+1}/\hat{\pi}_{ii,t+1}}{\hat{u}_{i,t+1}} \right)^{\varepsilon/\theta} (\hat{u}_{i,t+1})^{\rho \varepsilon}
\]

\[
\mu_{ni,t+1} = \frac{\mu_{ni,t} (\hat{u}_{i,t+1})^{\rho \varepsilon}}{\sum_k \mu_{nk,t} (\hat{u}_{k,t+1})^{\rho \varepsilon}}
\]

\[
L_{n,t+1} = \sum_i \mu_{in,t+1} L_{i,t}
\]

\[
\pi_{ni,t+1} = \frac{\pi_{ni,t} \hat{T}_{i,t+1} (\hat{w}_{i,t+1})^{-\theta}}{\sum_{k=1}^N \pi_{nk,t} \hat{T}_{k,t+1} (\hat{w}_{k,t+1})^{-\theta}}
\]

\[
\hat{w}_{i,t+1} L_{i,t+1} Y_{i,t} = \sum_n \pi_{ni,t+1} \hat{w}_{n,t+1} L_{n,t+1} Y_{n,t},
\]
New Terrain: Dynamics

What happened to world trade? ...
Log Index (2008Q3=0)

-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5

Data


08Q3 09Q2 11Q1
Log Index (2008Q3=0)

Data

Contributions

- Alessandria, Kaboski, and Midrigan (2010, 2011)

- Fitzgerald (2012)

- Mutreja, Ravikumar, and Sposi (2014)

- Kehoe and Ruhl (2014)

- Follow: Eaton, Kortum, Neiman, and Romalis (EKNR 2015)
New Elements

- Ricardian trade, country as unit of observation, discrete time

- Factors of production: $L_i$ fixed (share $\beta$) and $K_{i,t}$ evolving

- Tradeable goods invested to build capital (efficiency of invest $\chi_{i,t}$):

$$K_{i,t+1} = \chi_{i,t} \left( I_{i,t} \right)^{\eta} \left( K_{i,t} \right)^{1-\eta} - (1 - \delta)K_{i,t}$$

- Nontradable goods consumed to max log preferences (shocks $\phi_{i,t}$)

- Solved by a global social planner (weights $\omega_i$), complete markets
EKNR Relationships

- Consumption spending: \( X_{i,t}^C = \omega_i \phi_{i,t} \)

- Investment spending: \( X_{i,t}^I = p_{i,t} I_{i,t} \)

- Value of GDP: \( Y_{i,t} = X_{i,t}^C + \sum_n \pi_{n,t} X_{n,t}^I \)

- Payments to labor: \( w_{i,t} L_i = \beta Y_{i,t} \)

- Payments to capital: \( r_{i,t} K_{i,t} = (1 - \beta) Y_{i,t} \)

- Bilateral trade equations unchanged ...
• Investment Euler equation:

- cost of building one more unit of capital

\[
\frac{p_{i,t}}{\eta x_{i,t}} \left( \frac{I_{i,t}}{K_{i,t}} \right)^{1-\eta}
\]

- equals benefit

\[
\rho \left( r_{i,t+1} + \frac{(1-\eta)p_{i,t+1}I_{i,t+1}}{\eta K_{i,t+1}} + \frac{(1-\delta)p_{i,t+1}}{\eta x_{i,t+1}} \left( \frac{I_{i,t+1}}{K_{i,t+1}} \right)^{1-\eta} \right)
\]

• Trade deficit:

\[
D_{i,t} = X^I_{i,t} - \sum_n \pi_{ni,t} X^I_{n,t} = X^C_{i,t} + X^I_{i,t} - Y_{i,t}
\]
Computing a Perfect Foresight Path

- Shocks paths: $\{d_{ni,t+1}\}, \{\hat{T}_{i,t+1}\}, \{\hat{\phi}_{i,t+1}\}, \{\hat{\chi}_{i,t+1}\}$, eventually 1

- Condition on initial data $Y_{i,t}, X_{i,t}^C, X_{i,t}^I$ and $\pi_{ni,t}$

- Initial $\hat{K}_{i,t+1}$'s get you on perfect-foresight path to steady state of:

  - change in consumption spending: $\hat{X}_{i,t}^C = \hat{\phi}_{i,t}$

  - price change equation: $\hat{p}_{i,t+1} = \hat{w}_{i,t+1}^{\hat{\beta}} \hat{r}_{i,t+1}^{1-\hat{\beta}} \left(\hat{\pi}_{ii,t+1}/\hat{T}_{i,t+1}\right)^{1/\theta}$
• trade share evolution:

\[ \pi_{ni,t+1} = \frac{\pi_{ni,t} \hat{T}_i,t+1 (\hat{w}_{i,t+1} \hat{r}_{i,t+1}^{1-\beta} \hat{d}_{ni,t+1})^{\theta}}{\sum_{k=1}^{N} \pi_{nk,t} \hat{T}_k,t+1 (\hat{w}_{k,t+1} \hat{r}_{k,t+1}^{1-\beta} \hat{d}_{nk,t+1})^{\theta}} \]

• GDP changes, wage changes, and rental rate changes

• Euler equation to solve for change in investment spending

• Update change in capital with

\[ \hat{K}_{i,t+2} - (1 - \delta) = \hat{X}_{i,t+1} \left( \frac{\hat{X}_{I,t+1}}{\hat{p}_{i,t+1} \hat{K}_{i,t+1}} \right)^{\eta} (\hat{K}_{i,t+1} - (1 - \delta)) \]
The Algorithm

• Starting from 2012:Q4, shocks fixed thereafter, solve for $\hat{K}$'s

• Work backwards using data to form paths for the $\hat{K}_{i,t+1}$

• Using capital paths (in changes) back out shocks during data period

• Intertemporal preference shock is easy: $\hat{\phi}_{i,t} = \hat{X}_{i,t}^C$

• Other three are a bit deeper!
Backing out Shocks

- Trade Frictions:
  \[ \hat{d}_{n_i,t+1} = \left( \frac{\hat{\pi}_{n_i,t+1}}{\hat{\pi}_{i_i,t+1}} \right) \frac{\hat{p}_{n,t+1}}{\hat{p}_{i,t+1}} \]

- Productivity:
  \[ \hat{T}_{i,t+1} = \hat{\pi}_{i_i,t+1} \left( \left( \hat{w}_{i,t+1} \right)^\beta \left( \hat{r}_{i,t+1} \right)^{1-\beta} / \hat{p}_{i,t+1} \right)^\theta \]

- Efficiency of investment:
  \[ \hat{\chi}_{i,t+1} = \left( \frac{\hat{X}_{i,t+1}}{\hat{p}_{i,t+1}\hat{K}_{i,t+1}} \right)^{-\eta} \frac{\hat{K}_{i,t+2} - (1 - \delta)}{\hat{K}_{i,t+1} - (1 - \delta)} \]
Counterfactuals for Accounting

- Perfect foresight path, given the shocks we back out, reproduces the data

- Assess contributions: compute with only a single set of shocks

- Breaks the Euler equation at the date when new future becomes apparent

- If a shock can explain the data on its own, its important

The Cross-Country Dimension
Changes in Counterfactual

Changes in Trade/GDP in Data

Aggregate Demand Shocks
Investment Efficiency in Durables Shocks

Changes in Counterfactual
Changes in Trade/GDP in Data
Changes in Counterfactual

All Demand and Investment Efficiency Shocks

Changes in Trade/GDP in Data
Conclusion