Trade, Migration and Regional Income Differences: Evidence from China

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Motivation

- Aggregate gains from trade widely studied
- What about spatial distribution of gains from trade?

- Aggregate and spatial effects of trade liberalization depend on costs to internal trade and factor movements
  - How large are internal trade and migration costs? Do they differ across space? ... change through time? ... interact with each other?

- To answer these questions, we develop a model and apply it to a useful setting (China)
  - Significant recent liberalizations (internal and external)
  - Large inter-province worker flows (40M in 2005; 86M in 2010)
  - Massive internal income differences
Related Literature

• International trade with multi-region countries:

• Costly Internal Trade (no labour frictions):
  • Ramondo et al. (2011); Allen and Arkolakis (2012); Cosar and Fajgelbaum (2012); Caliendo et. al. (2014); Redding (2014); Fajgelbaum and Redding (2014); Tombe and Winter (2014)

• Trade Induced Labour Reallocation (no internal trade):
  • Kambourov (2009); Artuc et al. (2010); Menezes-Filho and Muendler (2011); Cosar (2013); Dix-Carneiro (2014)

• Commuting Decisions:
  • Ahlfeldt, Redding, Sturm, and Wolf (2012)

• Occupational Choice:
  • Cortes and Gallipoli (2014)
This Paper

- Build **unique dataset** for China: 2000/02 – 2005/07

- We develop a general equilibrium model of internal and external trade with goods and **factor market frictions**
  - *We introduce factor mobility frictions: model migration decisions* (Artuc et al., 2008; Ahlfeldt et al., 2012; Redding, 2014; Cortes and Gallipoli, 2014)

- Measure and quantify the effect of (1) international trade liberalization, (2) internal trade liberalization, (3) factor market liberalization, (4) productivity change on:
  - Welfare — aggregate and regional
  - Migration — between provinces
  - Income Differences — between provinces
Data (in brief)

- **Migration**: 2000 and 2005 census data
  - *From 2005 census, we can identify for each province those who have immigrated between 2000 and 2005*
  - *Individual earnings data (2005 only) will prove important*

- **Trade Flows**: Extended regional I/O tables 2002 and 2007
  - *Information on international trade for each province and bilateral trade for each pair of provinces (2002) or regions (2007)*
  - *Province-level gross output and total expenditures*

- **Real Income**: Price and GDP data
  - *Nominal GDP by provinces*
  - *Province-specific price levels*
  - *1990 common basket price levels + provincial CPI changes*
Visualizing Key Features of the Data

Figure: The Geography of China

Table 5/36
Visualizing Key Features of the Data

Figure: Output per Capita (90th/10th ∼ 7)
Visualizing Key Features of the Data

Figure: Home-Share of Spending (90th=0.86, 10th=0.62)

Map showing the home-share of spending across different provinces in China.
Visualizing Key Features of the Data

Figure: Migrant Worker Shares (90th=0.2, 10th=0.006)
### Table: Migrant Characteristics (from Census Data)

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2000</th>
<th>2005</th>
</tr>
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<tbody>
<tr>
<td><strong>Total Migrants</strong></td>
<td>32.7 M</td>
<td>130.6 M</td>
<td>165.4 M</td>
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<tr>
<td><strong>Inter-Provincial Migrants</strong></td>
<td>10.5 M</td>
<td>35.8 M</td>
<td>53 M</td>
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<tr>
<td><strong>Inter-Provincial Migrant Workers</strong></td>
<td>2 M</td>
<td>28 M</td>
<td>40 M</td>
</tr>
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</table>

(a) Migrant Stock

<table>
<thead>
<tr>
<th></th>
<th>All Migrants</th>
<th>Inter-Provincial Migrants</th>
<th>Employed Inter-Provincial Migrants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
<td>165.4 M</td>
<td>53 M</td>
<td>40 M</td>
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</table>

**Reason for Migrating**

<table>
<thead>
<tr>
<th></th>
<th>All Migrants</th>
<th>Inter-Provincial Migrants</th>
<th>Employed Inter-Provincial Migrants</th>
</tr>
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<tbody>
<tr>
<td>Work</td>
<td>45%</td>
<td>73%</td>
<td>91%</td>
</tr>
<tr>
<td>Family</td>
<td>30%</td>
<td>21%</td>
<td>6%</td>
</tr>
<tr>
<td>Education</td>
<td>6%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>18%</td>
<td>4%</td>
<td>0.3%</td>
</tr>
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</table>

**Other Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>All Migrants</th>
<th>Inter-Provincial Migrants</th>
<th>Employed Inter-Provincial Migrants</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Children</td>
<td>30%</td>
<td>28%</td>
<td>27%</td>
</tr>
<tr>
<td>Agricultural Hukou</td>
<td>62%</td>
<td>83%</td>
<td>86%</td>
</tr>
<tr>
<td>Male</td>
<td>50%</td>
<td>53%</td>
<td>57%</td>
</tr>
</tbody>
</table>

(b) Characteristics of Migrant Stock (Census 2005)
Migration Costs

Wide variety of very large costs to live outside one’s Hukou region:

- Lack of employment contracts (no provision of benefits or other legal rights; reform 2007)
- Difficult to find housing (couldn’t rent an apartment in Beijing until 2005)
- Unregistered migrants detained/deported (until 2003, following a death)
- Limited health insurance access
- Children attend school barred or expensive fees (can be 20% of income)
- Other (more standard) costs:
  - communication with and travel to home province
  - language/ethnic differences
Internal Trade Barriers

Pre-2001:
- Strong local protectionism and high internal trade barriers in the 1980s and 1990s (Young, 2000; Poncet, 2003)
- The degree of local market protection is positively associated with the size of the state sector in the region

Post-2001:
- Downsizing the state-owned sector
- State council’s directive about eliminating local market protection in 2001
Main Results

• Welfare gains are, by far, largest for domestic reforms (especially internal trade cost reductions)

• Trade flows respond very little to changes in migration costs

• Internal migration responds very little to changes in trade costs

• Internal (not external) liberalization lowers income differences
Model
Regions and Preferences

- $N + 1$ regions: $N$ within China + rest of the world
- **Endowments:**
  - $L^0_n$ initial Hukou registrants
  - *Each of whom differ in productivity (more on this later)*
  - $S_n$ fixed land used for housing and production
- **Representative H.H. Objective:**
  - Maximize utility per effective-worker
  \[ u_n = c_n^{\alpha} s_{u_n}^{1-\alpha} \]
  subject to
  \[ P_n c_n + r_n s_{u_n} \leq v_n \]
Production

- **Final Good**: composite of a continuum of intermediates

\[ Y_n = \left( \int_0^1 y_n(j)^{(\sigma-1)/\sigma} \, dj \right)^{\sigma/(\sigma-1)} \]

- **Elasticity of substitution** $\sigma > 1$
- **Final goods are consumed** ($C$) and **used in production** as inputs ($Q$); **market clearing** $\Rightarrow$ $Y_n = C_n + Q_n$

- ** Tradable Intermediates**: $y$ produced with CRS technology using effective-labour ($H$), land ($S_Y$), and inputs ($Q$)

\[ y_n(j) = \varphi_n(j) H_n(j)^{\beta} S_Y(n)^{\eta} Q_n(j)^{1-\beta-\eta} \]

- **TFP** $\varphi$ differs across firms; as in Eaton and Kortum (2002)
Prices and Trade Patterns

- Iceberg trade costs $\tau_{ni}$ + perfect competition $\Rightarrow$

$$p_{ni}(\varphi) = \tau_{ni}MC_i(\varphi) \propto \tau_{ni}w_i^\beta r_i^\eta P_i^{1-\beta-\eta}/\varphi$$
Prices and Trade Patterns

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$$p_{ni}(\varphi) = \tau_{ni}MC_i(\varphi) \propto \tau_{ni}w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta}/\varphi$$

- With TFP $\varphi$ distributed Frechet: $F_i(\varphi) = e^{-T_i\varphi^{-\theta}}$, fraction of region $n$ spending allocated to goods produced in region $i$ is

$$\pi_{ni} = \frac{T_i \left( \tau_{ni}w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta} \right)^{-\theta}}{\sum_{k=1}^{N+1} T_k \left( \tau_{nk}w_k^{\beta} r_k^{\eta} P_k^{1-\beta-\eta} \right)^{-\theta}}$$
Prices and Trade Patterns

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  \[ p_{ni}(\varphi) = \tau_{ni} MC_i(\varphi) \propto \tau_{ni} w_i^\beta r_i^\eta P_i^{1-\beta-\eta}/\varphi \]

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  \[
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  \]

- Aggregate price index in region $n$ (for tradables)
  \[
  P_n \propto \left[ \sum_{k=1}^{N+1} T_k \left( \tau_{nk} w_k^\beta r_k^\eta P_k^{1-\beta-\eta} \right)^{-\theta} \right]^{-1/\theta}
  \]

- Finally, market clearing for land $\Rightarrow r_n \propto w_n H_n / S_n$
Regional Income

- Nominal Income (Expenditures) per Effective Worker:

\[ v_n = \underbrace{w_n}_{\text{Labour Income}} + \underbrace{(1 - \alpha)v_n + \eta w_n / \beta}_{\text{Spending on Land}} \]

\[ = \left( \frac{\beta + \eta}{\alpha \beta} \right) w_n \]

- Total expenditures: \( X_n = v_n H_n \)
Regional Income

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\[
= \left( \frac{\beta + \eta}{\alpha \beta} \right) w_n
\]

- Total expenditures: \( X_n = v_n H_n \)

- Real Income per Effective Worker \((v_n/P_n r_n^{1-\alpha})\):

\[
V_n \propto \underbrace{T_n^{-\theta(\beta + \eta)}}_{\text{Technology}} \cdot \underbrace{\pi_{nn}^{-\alpha}}_{\text{Market Access}} \cdot \underbrace{(S_n/H_n)^{\eta + (1 - \alpha) \beta}_{\beta + \eta}}_{\text{Land / effective worker}}
\]
Inter-Provincial Migration

• **Real Income per Effective Worker:** $V_i$ in region $i$

• **Worker Productivity:** different across region
  
  • *Denote the effective labour units by* $z$
  
  • *Effective labour is i.i.d. across individuals and locations*

• **Real Cost of Migration:** share time/income lost, $1 - \mu_{ni}$

• **Rule:** Migrate from $n$ to $i$ iff $\mu_{ni}z_i V_i = \max_{k=1,\ldots,N} \{\mu_{nk}z_k V_k\}$

• If $z$ follows a Frechet distribution $F_z(x) = e^{-(\frac{x}{\gamma})^{-\kappa}}$, then share of region $n$ registered workers that move to region $i$ is

$$m_{ni} = \frac{(V_i \mu_{ni})^\kappa}{\sum_{k=1}^{N} (V_k \mu_{nk})^\kappa}$$
Expected Income and Aggregate Welfare

**Proposition 2:** If worker productivities $z_i$ are distributed Frechet with mean 1 and variance parameter $\kappa$, and agents are able to migrate between regions at cost $\mu_{ij}$, then the expected real income net of migration costs for workers from region $i$ is

$$V_i^0 = V_i m_{ii}^{-1/\kappa},$$

and aggregate average real income (welfare) is therefore

$$W = \sum_{i=1}^{N} \lambda_i^0 V_i m_{ii}^{-1/\kappa},$$

where $\lambda_i^0 = \frac{L_i^0}{\sum_{j=1}^{N} L_j^0}$ is region $i$’s registration share.

**Proof:** See paper. **Intuition:** $\max \{\mu_{nk}z_k V_k\} \sim \text{Frechet} \left(\kappa, V_n m_{nn}^{-1/\kappa}\right)$
Eq’m Effective Labour in Each Region

- Workers in Region $n$: $L_n = \sum_{i=1}^{N} m_{in}L_i^0$
Eq’m Effective Labour in Each Region

- **Workers in Region** \( n \): \( L_n = \sum_{i=1}^{N} m_{in} L_i^0 \)

  - Analogous to Eaton-Kortum, where \( \pi_{ni} \) is both (1) share of goods and (2) share of spending, we can show \( m_{ni} \) is both
    1. Share of workers registered in \( n \) that work in region \( i \)
    2. Share of income earned by all workers registered in \( n \) from those workers working in region \( i \)

- **Effective Workers in Region** \( n \):

\[
H_n V_n = \sum_{i=1}^{N} m_{in} L_i^0 V_i m_{ii}^{-1/\kappa}
\]

\[
\Rightarrow H_n = \sum_{i=1}^{N} \left( \mu_{in} m_{in}^{-1/\kappa} \right) m_{in} L_i^0
\]
Eq’m Effective Labour in Each Region

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  \]
  \[
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  \]

- Useful with data on real GDP \( (H_i V_i) \), migration \( (m_{ni}, m_{nn}) \), and hukou registrations \( (L_n^0) \) → solves for \( V_i \), then \( H_i \)
Quantitative Analysis
The Equilibrium Conditions

- Trade balance: $v_n H_n = \sum_{i=1}^{N+1} \pi_{in} v_i H_i$

- Trade flows: $\pi_{ni} \propto P_n^\theta T_i \left( \tau_{ni} w_i^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta}$
The Equilibrium Conditions

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- Trade flows: \( \pi_{ni} \propto P_n^\theta T_i \left( \tau_{ni} w_i^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta} \)

- Final good price: \( P_n^{-\theta} \propto \sum_{i=1}^{N+1} T_i \left( \tau_{ni} w_i^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta} \)

- Land rental price: \( r_n \propto w_n H_n / S_n \)

- Real income: \( V_n \propto w_n / P_n^\alpha r_n^{1-\alpha} \)
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- Migration flows: \( m_{ni} = \frac{(V_i \mu_{ni})^\kappa}{\sum_{k=1}^{N}(V_k \mu_{nk})^\kappa} \)
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- Migrant real incomes: \( H_n V_n \propto \sum_{i=1}^{N} m_{in} L_i^0 V_i m_{ii}^{-1/\kappa} \)
The Equilibrium Conditions

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- Land price: \( r_n \propto w_n H_n / S_n \)

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- Migrant real incomes: \( H_n V_n \propto \sum_{i=1}^N m_{in} L_i^0 V_i m_{ii}^{-1/\kappa} \)
Exact-Hat Algebra (Dekle et al., 2008)

- Solving for relative changes eases the analysis

\[
\hat{r}_n \propto w_n H_n / S_n
\]

\[
\Rightarrow \hat{r}_n = \hat{w}_n \hat{H}_n
\]

- Another (less trivial) example:

\[
\hat{P}_n^{-\theta} = \frac{\sum_{i=1}^{N+1} T_i' (\tau_{ni} w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta})^{-\theta}}{\sum_{i=1}^{N+1} T_i (\tau_{ni} w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta})^{-\theta}}
\]

\[
= \frac{\sum_{i=1}^{N+1} \hat{T}_i (\hat{\tau}_{ni} \hat{w}_i^{\beta} \hat{r}_i^{\eta} \hat{P}_i^{1-\beta-\eta})^{-\theta} T_i (\tau_{ni} w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta})^{-\theta}}{\sum_{i=1}^{N+1} T_i (\tau_{ni} w_i^{\beta} r_i^{\eta} P_i^{1-\beta-\eta})^{-\theta}}
\]

\[
\equiv \sum_{i=1}^{N+1} \hat{T}_i (\hat{\tau}_{ni} \hat{w}_i^{\beta} \hat{r}_i^{\eta} \hat{P}_i^{1-\beta-\eta})^{-\theta} \pi_{ni}
\]
Exact-Hat Algebra (Dekle et al., 2008)

Model mapping $F : \left( \hat{\tau}_{ni}, \hat{T}_n, \hat{\mu}_{ni} \right) \rightarrow \left( \hat{V}_n, m'_ni, \pi'_ni \right)$, given $(\pi_{ni}, L_n, m_{ni}, X_n, L^0_n)$

Our strategy: infer $\left( \hat{\tau}_{ni}, \hat{T}_n, \hat{\mu}_{ni} \right)$ from $F^{-1} \left( \hat{V}_n, m'_ni, \pi'_ni \right)$

\[
\hat{w}_n \hat{H}_n X_n = \sum_{i=1}^{N+1} \pi'_ni \hat{w}_i \hat{H}_i X_i,
\]

\[
\pi'_ni = \hat{P}_n^{\theta} \pi_{ni} \hat{T}_i \left( \hat{\tau}_{ni} \hat{w}_i^{\beta+\eta} \hat{P}_i^{1-\beta-\eta} \hat{L}_i^{\eta} \right)^{-\theta},
\]

\[
\hat{P}_n^{-\theta} = \sum_{i=1}^{N+1} \pi_{ni} \hat{T}_i \left( \hat{\tau}_{ni} \hat{w}_i^{\beta+\eta} \hat{P}_i^{1-\beta-\eta} \hat{L}_i^{\eta} \right)^{-\theta},
\]

\[
\hat{V}_n = \frac{\hat{w}_n}{\hat{P}_n^{\alpha} \hat{H}_n^{1-\alpha}} = \frac{\hat{w}_n^\alpha}{\hat{P}_n^{\alpha} \hat{H}_n^{1-\alpha}},
\]

\[
m'_ni = \frac{m_{ni} \left( \hat{V}_n \hat{\mu}_{ni} \right)^\kappa}{\sum_{k=1}^{N} m_{ik} \left( \hat{V}_k \hat{\mu}_{ik} \right)^\kappa},
\]

\[
H'_n V'_n = \sum_{i=1}^{N} m'_ni L^0_i V'_i m''_{ji}^{-1/\kappa}.
\]
Calibrating the Model

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<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
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<tbody>
<tr>
<td>$\eta$</td>
<td>0.1</td>
<td>Land’s share of gross output</td>
</tr>
<tr>
<td>$1 - \beta - \eta$</td>
<td>0.6</td>
<td>Intermediate’s share of output</td>
</tr>
<tr>
<td>$1 - \alpha$</td>
<td>0.13</td>
<td>Housing’s share of expenditure</td>
</tr>
<tr>
<td>$L_i$</td>
<td>Data</td>
<td>National Employment Level</td>
</tr>
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<td>$\pi_{ij}$</td>
<td>Data</td>
<td>Bilateral Trade Shares</td>
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<td>$X_n$</td>
<td>Model-Implied</td>
<td>Initial Eq’m GDP</td>
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<td>$\theta$</td>
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<td>Elasticity of Trade</td>
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Details to Follow

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<tr>
<th>$\hat{r}_{ni}$</th>
<th>Pair Specific</th>
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<tr>
<td>$\kappa$</td>
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</tr>
<tr>
<td>$\hat{\mu}_{ni}$</td>
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<td>Migration and Real Income Gaps</td>
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<tr>
<td>$\hat{T}_n$</td>
<td>Region Specific</td>
<td>Real Income Data</td>
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</table>
Estimating Trade Costs

• Flexible trade costs index (Head and Ries, 2001; Novy, 2013)

• Recall: $\pi_{ni} \propto P^n_i T_i \left( \tau_{ni}^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta}$

• $\Rightarrow \ln \left( \frac{\pi_{ni}}{\pi_{nn}} \right) = \ln \left( \frac{P^n_i T_i \left( \tau_{ni}^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta}}{P^n_i T_n \left( w_n^\beta r_n^\eta P_n^{1-\beta-\eta} \right)^{-\theta}} \right) \equiv S_n - S_i - \theta \ln(\tau_{ni})$
Estimating Trade Costs

- Flexible trade costs index (Head and Ries, 2001; Novy, 2013)
- Recall: \( \pi_{ni} \propto P_n^\theta T_i \left( \tau_{ni} w_i^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta} \)

\[ \Rightarrow \ln \left( \frac{\pi_{ni}}{\pi_{nn}} \right) = \ln \left( \frac{P_n^\theta T_i \left( \tau_{ni} w_i^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta}}{P_n^\theta T_n \left( w_n^\beta r_n^\eta P_n^{1-\beta-\eta} \right)^{-\theta}} \right) \equiv S_n - S_i - \theta \ln(\tau_{ni}) \]

\[ \Rightarrow \ln \left( \frac{\pi_{ni}}{\pi_{nn}} \right) + \ln \left( \frac{\pi_{in}}{\pi_{ii}} \right) = -\theta \left[ \ln(\tau_{ni}) + \ln(\tau_{in}) \right] \]
Estimating Trade Costs

- Flexible trade costs index (Head and Ries, 2001; Novy, 2013)

- Recall:  $\pi_{ni} \propto P_n^\theta T_i \left( \tau_{ni} w_i^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta}$

- $\Rightarrow \ln \left( \frac{\pi_{ni}}{\pi_{nn}} \right) = \ln \left( \frac{P_n^\theta T_i \left( \tau_{ni} w_i^\beta r_i^\eta P_i^{1-\beta-\eta} \right)^{-\theta}}{P_n^\theta T_n \left( w_n^\beta r_n^\eta P_n^{1-\beta-\eta} \right)^{-\theta}} \right) \equiv S_n - S_i - \theta \ln(\tau_{ni})$

- $\Rightarrow \ln \left( \frac{\pi_{ni}}{\pi_{nn}} \right) + \ln \left( \frac{\pi_{in}}{\pi_{ii}} \right) = -\theta \left[ \ln(\tau_{ni}) + \ln(\tau_{in}) \right]$

- The Head-Reis Index: $\bar{\tau}_{ni} \equiv \sqrt{\tau_{ni} \tau_{in}} = \left( \frac{\pi_{nn} \pi_{ii}}{\pi_{ni} \pi_{in}} \right)^{1/2\theta}$

- Notice: it’s symmetric ($\bar{\tau}_{ni} = \bar{\tau}_{in}$)
- We modify the index to incorporate region-specific costs
- i.e. an exporter-specific cost $t_i$ implies

$$\tau_{ni} = \bar{\tau}_{ni} \sqrt{t_i/t_n}$$
Estimating Trade Cost Asymmetries

• If asymmetries are export costs, then $\tau_{ni} = d_{ni}t_i$

• Waugh (2010): asymmetries are exporter-specific
  • Tombe and Winter (2014) show this is also true within countries

• Models imply $\ln(\pi_{ni}/\pi_{nn}) = S_i - S_n - \theta \ln(\tau_{ni})$; so, estimate

$$\ln\left(\frac{\pi_{ni}}{\pi_{nn}}\right) = \rho_{ni} + \iota_n + \eta_i + \epsilon_{ni},$$

where $\rho_{ni}$ is a directionless pair-effect such that $\rho_{ni} = \rho_{in}$, and $\iota_n$ and $\eta_i$ are importer- and exporter-effects

• As the exporter effect is $\eta_i = S_i - \theta \ln(t_i)$ and the importer effect is $\iota_n = -S_n$, we infer export costs as

$$t_n = e^{-\left(\iota_n + \eta_n\right)/\theta}$$
## Relative Change in Trade Costs

**Table: % Change in Trade Costs** \( \left( \frac{\tau_{ni}^{2007}}{\tau_{ni}^{2002}} \right) \)

<table>
<thead>
<tr>
<th>Importer n</th>
<th>NE</th>
<th>B&amp;T</th>
<th>N Cst</th>
<th>C Cst</th>
<th>S Cst</th>
<th>Cntrl</th>
<th>NW</th>
<th>SW</th>
<th>WLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE</td>
<td>-11.8</td>
<td>-16.7</td>
<td>-23.5</td>
<td>-24.7</td>
<td>-23</td>
<td>-18</td>
<td>-18.5</td>
<td>-27.7</td>
<td></td>
</tr>
<tr>
<td>B&amp;T</td>
<td>-14.2</td>
<td>-15</td>
<td>-15.5</td>
<td>-13.8</td>
<td>-23.9</td>
<td>-25.7</td>
<td>-18.5</td>
<td>-26.9</td>
<td></td>
</tr>
<tr>
<td>N Cst</td>
<td>-5.7</td>
<td>-1</td>
<td>-1</td>
<td>-11.2</td>
<td>-20.7</td>
<td>-22.6</td>
<td>-20.7</td>
<td>-20.3</td>
<td></td>
</tr>
<tr>
<td>C Cst</td>
<td>-16.4</td>
<td>-5.2</td>
<td>-4.5</td>
<td>-11.2</td>
<td>-15.9</td>
<td>-17.9</td>
<td>-12.4</td>
<td>-19.1</td>
<td></td>
</tr>
<tr>
<td>S Cst</td>
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<td>-12</td>
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<td>-20.8</td>
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</tr>
<tr>
<td>Cntrl</td>
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<td>-5.2</td>
<td>-15.1</td>
<td>-6.7</td>
<td>-11.2</td>
<td>-19.1</td>
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<td></td>
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<tr>
<td>NW</td>
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<td>-20</td>
<td>-12</td>
<td>-18.6</td>
<td>-21.9</td>
<td>-17.8</td>
<td>-37.8</td>
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<tr>
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<td>-1.2</td>
<td>-17.5</td>
<td>-5.4</td>
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<td>-17.2</td>
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</tr>
<tr>
<td>WLD</td>
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<td>0.2</td>
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<td>-1.6</td>
<td>9.7</td>
<td>-21</td>
<td>-29.4</td>
<td>-18.5</td>
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</tr>
</tbody>
</table>

Distance, not \( \rho_{ni} \)  
By Sector
Calibrating the Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta$</td>
<td>0.1</td>
<td>Land’s share of gross output</td>
</tr>
<tr>
<td>$1 - \beta - \eta$</td>
<td>0.6</td>
<td>Intermediate’s share of output</td>
</tr>
<tr>
<td>$1 - \alpha$</td>
<td>0.13</td>
<td>Housing’s share of expenditure</td>
</tr>
<tr>
<td>$L_i$</td>
<td>Data</td>
<td>National Employment Level</td>
</tr>
<tr>
<td>$\pi_{ij}$</td>
<td>Data</td>
<td>Bilateral Trade Shares</td>
</tr>
<tr>
<td>$X_n$</td>
<td>Model-Implied</td>
<td>Initial Eq’m GDP</td>
</tr>
<tr>
<td>$\theta$</td>
<td>4</td>
<td>Elasticity of Trade</td>
</tr>
</tbody>
</table>

**Details to Follow**

| $\hat{r}_{ni}$ | Pair Specific | Bilateral Trade Shares                     |
| $\kappa$       | 2.21          | Ex-Post Income Dispersion                  |
| $\hat{\mu}_{ni}$ | Pair Specific | Migration and Real Income Gaps             |
| $\hat{T}_n$    | Region Specific| Real Income Data                           |
**Heterogeneity of Labour Productivity, $\kappa$**

- Variation in the ex-post wage distribution given by a simple function of this parameter (Cortes and Gallipoli, 2014)

- Ex-post income is r.v. $Z = \max \{\mu_{nk}z_k V_k\}$, which is Frechet
  - CDF given by $Pr(Z < x) \equiv F_i(x) = e^{-\left(\frac{x}{\left[\sum_{j=1}^{N}(c_{ij}V_j)^{\kappa}\right]^{1/\kappa}}\right)^{-\kappa}}$

- Log income is therefore $\sim$Gumbel, with s.d. $\pi / (\kappa \sqrt{6})$

- Census 2005 has individual earnings data; the average standard deviation within origin-destination pairs implies $\kappa \approx 2.21$
  - Controlling for age, occupation, hukou location, marital status, industry, gender, education, etc... implies $\kappa \approx 2.85$
Migration Costs

- As with trade, \( \mu_{ni} = \left( \frac{m_{ni}}{m_{nn}} \right)^{1/\kappa} \left( \frac{V_n}{V_i} \right) \)

(a) Histogram of \( c_{ni} \)
(b) Histogram of \( c_{ni}z_i \)

- Average migration cost: 89.6% of income
- Average migration costs for migrants: 9.6% of income
- Average change in migration costs, 2000-2005: \( \hat{\mu}_{ni} = 1.14 \)
Calibrating the Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta$</td>
<td>0.1</td>
<td>Land’s share of gross output</td>
</tr>
<tr>
<td>$1 - \beta - \eta$</td>
<td>0.6</td>
<td>Intermediate’s share of output</td>
</tr>
<tr>
<td>$1 - \alpha$</td>
<td>0.13</td>
<td>Housing’s share of expenditure</td>
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<td>Data</td>
<td>National Employment Level</td>
</tr>
<tr>
<td>$\pi_{ij}$</td>
<td>Data</td>
<td>Bilateral Trade Shares</td>
</tr>
<tr>
<td>$X_n$</td>
<td>Model-Implied</td>
<td>Initial Eq’m GDP</td>
</tr>
<tr>
<td>$\theta$</td>
<td>4</td>
<td>Elasticity of Trade</td>
</tr>
</tbody>
</table>

Details to Follow

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>$\hat{\tau}_{ni}$</td>
<td>Pair Specific</td>
<td>Bilateral Trade Shares</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>2.21</td>
<td>Ex-Post Income Dispersion</td>
</tr>
<tr>
<td>$\hat{\mu}_{ni}$</td>
<td>Pair Specific</td>
<td>Migration and Real Income Gaps</td>
</tr>
<tr>
<td>$\hat{T}_n$</td>
<td>Region Specific</td>
<td>Real Income Data</td>
</tr>
</tbody>
</table>
Infer Productivity Changes from Real Income Growth

(c) Real Income, when $\hat{T}_n = 1$

(d) Required Change in $\hat{T}_n^{\frac{\alpha}{\theta(\beta+\eta)}}$

Notes: Compares the model-implied change in each province’s real income $\hat{V}_n$ when underlying productivity is constant to real income changes measured in data. Both are expressed relative to the mean. In order for the model implies real income changes to match data, we require changes in underlying productivity draws $\hat{T}_n$. The implied productivity change in display in the right panel, adjusted as $\hat{T}_n^{\frac{\alpha}{\theta(\beta+\eta)}}$. 

Inner Mongolia, Shandong, Shanghi, Jiangsu, Shannxi, Tianjin, Hunan, Sichuan, Chongqing, Beijing.
Counterfactual Exercises

• We run a variety of counterfactuals
  1. Internal Trade: \( \hat{\tau}_{ni} \) for \( i, n \neq N + 1 \) only
  2. External Trade: \( \hat{\tau}_{ni} \) for \( i, n = N + 1 \) only
  3. All Trade: \( \hat{\tau}_{ni} \) for all pairs
  4. Migration: \( \hat{\mu}_{ni} \) for all pairs
  5. All Domestic: Internal Trade + Migration
  6. Everything

• We then repeat all of the above with \( \hat{T}_n \) changes

• Changes in outcomes of interest
  • Internal and external trade
  • Stock of migrants
  • Income differences (variance of log-income)
  • Aggregate welfare
## Counterfactual Aggregate Outcomes

<table>
<thead>
<tr>
<th>Measured Cost Reduction of</th>
<th>Change in Trade</th>
<th>Income Differences</th>
<th>Aggregate Welfare</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP Ratio (p.p.)</td>
<td>Migrant Stock</td>
<td></td>
</tr>
<tr>
<td>Internal Trade</td>
<td>38.7</td>
<td>-1.8%</td>
<td>-3.6%</td>
</tr>
<tr>
<td>External Trade</td>
<td>-3.1</td>
<td>0.8%</td>
<td>2.1%</td>
</tr>
<tr>
<td>All Trade</td>
<td>34.2</td>
<td>-0.9%</td>
<td>-1.5%</td>
</tr>
<tr>
<td>Migration</td>
<td>0.0</td>
<td>37.1%</td>
<td>-8.9%</td>
</tr>
<tr>
<td>All Domestic</td>
<td>38.7</td>
<td>33.1%</td>
<td>-11.9%</td>
</tr>
<tr>
<td>Everything</td>
<td>34.1</td>
<td>34.2%</td>
<td>-10.2%</td>
</tr>
</tbody>
</table>

| Data (2002-07) | 17  | 12  | 18.5% | -0.1% | –    |
Lower Migration Costs: Employment and Real Income

Notes: Displays the percentage change in employment $\hat{L}_n$ and real income $\hat{V}_n$ by province in response to lower inter-provincial migration costs.
Lower Migration Costs: Trade Volumes

Notes: Displays the percentage change in trade volumes, both internationally and internally, for each province resulting from lower migration costs. Aggregate trade changes little, but there is substantial variation across provinces. Coastal regions trade more more as a result of lower internal migration costs; interior regions trade less.
Distributional Effects on Real Income Differences

(i) Internal Trade

(j) International Trade

Notes: Displays the percentage change in real incomes for each province resulting from selected counterfactual.
Distributional Effects on Real Income Differences

Notes: Displays the percentage change in real incomes for each province resulting from selected counterfactual.
... with Productivity Changes

<table>
<thead>
<tr>
<th>Change in Productivity and ...</th>
<th>p.p. Change in Trade/GDP Ratio</th>
<th>Change in Migrant Stock</th>
<th>Regional Income Variance</th>
<th>Aggregate Welfare</th>
<th>Marginal Welfare Change</th>
<th>Prior Welfare Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity Only</td>
<td>-1.1</td>
<td>-4.6</td>
<td>-9.3%</td>
<td>11.5%</td>
<td>40.3%</td>
<td>–</td>
</tr>
<tr>
<td>Internal Trade</td>
<td>36.8</td>
<td>-6.9</td>
<td>-12.3%</td>
<td>6.2%</td>
<td>50.2%</td>
<td>7.1%</td>
</tr>
<tr>
<td>External Trade</td>
<td>-3.8</td>
<td>11.4</td>
<td>-8.3%</td>
<td>13.1%</td>
<td>43.3%</td>
<td>2.2%</td>
</tr>
<tr>
<td>All Trade</td>
<td>32.9</td>
<td>7.9</td>
<td>-11.2%</td>
<td>8.0%</td>
<td>53.1%</td>
<td>9.2%</td>
</tr>
<tr>
<td>Migration</td>
<td>-1.1</td>
<td>-4.6</td>
<td>22.4%</td>
<td>3.1%</td>
<td>40.8%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Internal Reform</td>
<td>36.8</td>
<td>-6.8</td>
<td>17.2%</td>
<td>-1.5%</td>
<td>50.7%</td>
<td>7.5%</td>
</tr>
<tr>
<td>Everything</td>
<td>32.8</td>
<td>7.9</td>
<td>18.5%</td>
<td>-0.1%</td>
<td>53.7%</td>
<td>9.5%</td>
</tr>
<tr>
<td>Data (2002-07)</td>
<td>17</td>
<td>12</td>
<td>18.5%</td>
<td>-0.1%</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>


Conclusion

• We develop a general equilibrium model of internal-external trade with partial factor mobility
  
  • *Highly tractable; easy to implement quantitative exercises*
  • *Useful for “measure” magnitude of trade and migration costs*

• We apply the model to China and quantify the impacts of trade liberalization and migration on aggregate welfare and regional income differences

• Domestic reforms substantially more important than external liberalization
  
  • *Lower migration and trade costs are complementary policies*

• Opening up is important for China, but not because of goods trade
## Cross-Province Differences

<table>
<thead>
<tr>
<th>Importer</th>
<th>Summary Metric Across Province</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Real GDP per Capita</td>
<td>1</td>
</tr>
<tr>
<td>Exports per Capita</td>
<td>1</td>
</tr>
<tr>
<td>Home Share</td>
<td>0.74</td>
</tr>
<tr>
<td>Migration Share</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Migration and Gravity

- Evidence that gravity equations capture commuting decisions 
  \textit{(Erlander and Stewart, 1990; Sen and Smith, 1995; Ahlfeldt et al., 2012)}
- Inter-provincial migration also consistent with gravity

\begin{figure}[h]
\centering
\begin{subfigure}{0.45\textwidth}
\includegraphics[width=\textwidth]{migration_vs_travel_time}
\caption{Migration vs. Travel Time}
\end{subfigure}
\begin{subfigure}{0.45\textwidth}
\includegraphics[width=\textwidth]{migration_vs_income_diff}
\caption{Migration vs. Income Differences}
\end{subfigure}
\end{figure}
Trade Cost Changes, Using Distance (not $\rho_{ni}$)

- Capture symmetric effect with bilateral distances $d_{ni}$

$$\ln \left( \frac{\pi_{ni}}{\pi_{nn}} \right) = \delta \ln(d_{ni}) + \nu_n + \eta_i + \epsilon_{ni}$$

Table: % Change in Trade Costs

<table>
<thead>
<tr>
<th>Importer</th>
<th>NE</th>
<th>B&amp;T</th>
<th>N Cst</th>
<th>C Cst</th>
<th>S Cst</th>
<th>Cntrl</th>
<th>NW</th>
<th>SW</th>
<th>WLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE</td>
<td>-9.7</td>
<td>-9.4</td>
<td>-16.0</td>
<td>-20.6</td>
<td>-17.6</td>
<td>-17.3</td>
<td>-12.3</td>
<td>-19.9</td>
<td></td>
</tr>
<tr>
<td>B&amp;T</td>
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<td>-9.7</td>
<td>-9.4</td>
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<td>-26.7</td>
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<tr>
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<td>-21.6</td>
<td>-19.0</td>
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</tr>
<tr>
<td>C Cst</td>
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<td>-11.6</td>
<td>-5.4</td>
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<td>-18.1</td>
<td>-24.5</td>
<td>-14.2</td>
<td>-18.5</td>
<td></td>
</tr>
<tr>
<td>S Cst</td>
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<td>-6.8</td>
<td>-12.4</td>
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<td>-19.6</td>
<td>-27.9</td>
<td>-19.2</td>
<td>-6.2</td>
<td></td>
</tr>
<tr>
<td>Cntrl</td>
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<td>-13.6</td>
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<td>NW</td>
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<td>-12.3</td>
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<tr>
<td>WLD</td>
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<td>-7.6</td>
<td>-8.1</td>
<td>-2.3</td>
<td>4.6</td>
<td>-23.6</td>
<td>-35.6</td>
<td>-20.7</td>
<td></td>
</tr>
</tbody>
</table>
Notes: Displays the tariff-equivalent (in percentage points) region-specific export costs. All expressed relative to the average for the year. A value of 30 for a certain region implies it is 30 percent more costly to export from that region to any other, relative to the export costs for the average region.
As with trade, \( \mu_{ni} = \left( \frac{m_{ni}}{m_{nn}} \right)^{1/\kappa} \left( \frac{V_n}{V_i} \right) \)

**Figure:** Costs of Migrating Into Beijing
## Trade Patterns, by Region

**Table:** Expenditure Shares $\pi_{ni}$, Year 2002

<table>
<thead>
<tr>
<th>Importer</th>
<th>NE</th>
<th>B&amp;T</th>
<th>N Cst</th>
<th>C Cst</th>
<th>S Cst</th>
<th>Cntrl</th>
<th>NW</th>
<th>SW</th>
<th>WLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE</td>
<td>0.879</td>
<td>0.007</td>
<td>0.010</td>
<td>0.008</td>
<td>0.013</td>
<td>0.011</td>
<td>0.008</td>
<td>0.009</td>
<td>0.055</td>
</tr>
<tr>
<td>B&amp;T</td>
<td>0.039</td>
<td>0.634</td>
<td>0.094</td>
<td>0.030</td>
<td>0.026</td>
<td>0.033</td>
<td>0.014</td>
<td>0.012</td>
<td>0.119</td>
</tr>
<tr>
<td>N Cst</td>
<td>0.018</td>
<td>0.033</td>
<td>0.798</td>
<td>0.034</td>
<td>0.018</td>
<td>0.038</td>
<td>0.009</td>
<td>0.008</td>
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<td>0.002</td>
<td>0.006</td>
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<td>0.024</td>
<td>0.005</td>
<td>0.005</td>
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<td>0.004</td>
<td>0.005</td>
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<td>0.015</td>
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<td>0.003</td>
<td>0.011</td>
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## % Change in Internal Bilateral Costs (2002-07)

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<th>Importer</th>
<th>Mean</th>
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<th>Min</th>
<th>Max</th>
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<td>-6.96</td>
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<td>Food and Tobacco</td>
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