Production network in quantitative spatial models (II)

Yuwan Duan (SITE,CUFE)
duanyuwan@cufe.edu.cn

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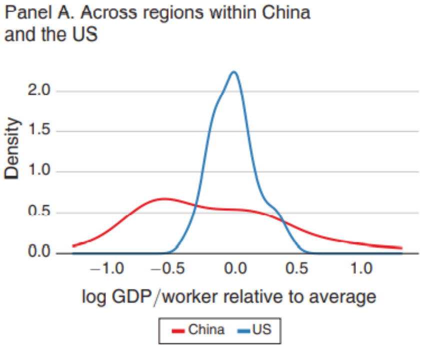
Tombe, T., and Zhu, X. (2019). Trade, migration, and productivity: A quantitative analysis of china. American Economic Review, 109(5), 1843-72.

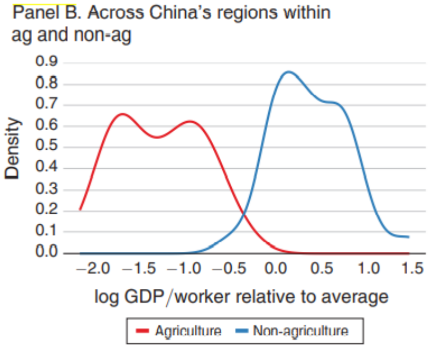
Main Contribution

- Investigating expansion of both trade and internal migration.
- Study specific sources of misallocation in an important developing economy.
- Model the sources of misallocation.

Background



Panel A. Across regions within China and the US
Density
2.0
1.5
1.0
0.5
0.0
−1.0
−0.5
0.0
0.5
1.0
log GDP/worker relative to average
China
US



Panel B. Across China's regions within ag and non-ag
Density
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
log GDP/worker relative to average
Agriculture
Non-agriculture

Background

TABLE 1—STOCK OF MIGRANT WORKERS IN CHINA

	Inter-provincial		Intra-provincial	
	2000	2005	2000	2005
Total migrant stock (millions)	26.5	49.0	90.1	120.4
Share of total employment (%)				
Total migrants	4.2	7.2	14.3	17.7
Agriculture-to-non-agriculture migrants	3.4	5.6	13.1	16.4

Notes: Migrants are defined based on their *hukou* location. Inter-provincial migrants are workers registered in another province from where they are employed. Intra-provincial migrants are workers registered in the same province where they are employed, but are either non-agricultural workers holding agricultural *hukou* or vice versa.

Background

Table 2—Internal and External Trade Shares of China

Importer	Exporter: Northeast	Beijing Tianjin	North Coast	Central Coast	South Coast	Central region	Northwest	Southwest	Abroad	Total other prov.
Year 2002										
Northeast	87.9	0.7	1.0	0.8	1.3	1.1	0.8	0.9	5.5	6.6
Beijing/Tianjin	3.9	63.4	9.4	3.0	2.6	3.3	1.4	1.2	11.9	24.8
North Coast	1.8	3.3	79.8	3.4	1.8	3.8	0.9	0.8	4.4	15.8
Central Coast	0.2	0.2	0.6	81.0	1.5	2.4	0.5	0.5	13.3	5.7
South Coast	0.5	0.4	0.5	2.6	72.3	1.9	0.4	1.5	19.8	7.9
Central region	0.6	0.3	1.1	4.8	2.3	87.8	0.7	0.7	1.8	10.4
Northwest	2.0	0.8	2.1	3.3	4.5	3.6	77.4	3.8	2.6	20.0
Southwest	0.9	0.3	0.4	1.8	4.3	1.4	0.9	88.0	2.0	10.0
Abroad	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	99.6	–
Year 2007										
Northeast	78.7	2.0	2.0	0.9	2.7	1.0	1.4	0.9	10.4	10.9
Beijing/Tianjin	3.8	62.3	10.1	1.5	2.4	1.8	2.1	0.7	15.5	22.2
North Coast	2.1	5.8	76.8	1.5	1.5	3.7	2.3	0.8	5.5	17.7
Central Coast	1.1	0.7	1.4	76.8	1.8	4.8	1.7	0.9	10.8	12.4
South Coast	1.5	0.9	1.7	5.2	68.5	3.6	1.8	2.8	14.1	17.4
Central region	1.7	1.4	4.5	4.9	4.0	73.0	2.9	1.8	5.9	21.1
Northwest	2.3	2.2	4.8	2.7	5.5	3.6	65.6	3.6	9.8	24.6
Southwest	1.6	1.2	1.7	1.7	8.4	1.9	3.2	73.8	6.6	19.6
Abroad	0.0	0.1	0.1	0.4	0.2	0.0	0.0	0.0	99.1	–

Introduction

- How migration and trade affect gains of a region?

A first view

- Aggregate GDP per worker: $y = \sum_{n,j} y_n^j l_n^j$
  - N regions (by i and n) and J sectors (by j and k).
  - y_n^j:real GDP per worker
  - l_n^j:real employment share in region n and sector j
- The relative change:
  $\hat{y} = \sum_{n,j} \omega_n^j \hat{y}_n^j \hat{l}_n^j = 1 + \sum_{n,j} \omega_n^j g_{y_n^j} + \sum_{n,j} \omega_n^j g_{l_n^j} + \sum_{n,j} \omega_n^j g_{y_n^j} g_{l_n^j}$
  where $\hat{x} = x'/x$, $g_x = \hat{x} - 1$, and $\omega_n^j \propto y_n^j l_n^j$
- According to ACR (2012), $\hat{y}_n^j = \hat{A}_n^j \left(\hat{\pi}_{nn}^j \right)^{-1/\theta}$
- A_n^j region-n-sector-j's labor productivity under autarky.
  $g_{y_n^j} \approx g_{A_n^j} - \frac{1}{\theta} \frac{\Delta \pi_{nn}^j}{\pi_{nn}^j}$, and $\Delta \pi_{nn}^j = -\Delta \pi_{nc}^j - \Delta \pi_{nw}^j$

A first view

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$$g_y = \underbrace{\sum_{n,j} \omega_n^j \frac{1}{\theta} \frac{\Delta \pi_{nc}^j}{\pi_{nn}^j}}_{\substack{\text{Internal Trade} \\ 4.9\%}} + \underbrace{\sum_{n,j} \omega_n^j \frac{1}{\theta} \frac{\Delta \pi_{nw}^j}{\pi_{nn}^j}}_{\substack{\text{Extemal Trade} \\ 0.5\%}} + \underbrace{\sum_{n,j} \omega_n^j g_{l_n^j}}_{\substack{\text{Migration} \\ 10.8\%}} + \underbrace{\sum_{n,j} \omega_n^j g_{A_n^j}}_{\substack{\text{Residual} \\ 40.9\%}}$$

Introduction

- Structural model to:
  - Take into account the equilibrium relationship between trade and migration;
  - Quantify how reductions in migration and trade costs matter;
  - Treated sectors with input-output linkages
  - Take into account differences in fixed factor endowments (land) and regional comparative advantage.

Model

- N+1 regions (by i and n, N provinces and ROW) and 2 sectors (agriculture,non-agriculture).
- S_n^j: Fix factor(land structure) by province and sector.
- $\bar{L}_n^j$: Workers with hukou in region n and sector j.
- v_{in}^{kj}: Nominal income of a worker in region n sector j with hukou registration in region i and sector k.

Model

Household

- Preferences

$$u_n^j = \varepsilon_n^j \left[\left(C_n^{j,ag} \right)^{\psi^{ag}} \left(C_n^{j,na} \right)^{\psi^{na}} \right]^{\alpha} \left(S_n^{j,h} \right)^{1-\alpha}$$

$$s.t,\ P_n^{j,ag} C_n^{j,ag} + P_n^{j,na} C_n^{j,na} + r_n^j S_n^{j,h} \leq v_{in}^{kj}$$

- Number of workers: $L_n^j = \sum_{k \in \{ag,na\}} \sum_{i=1}^{N} L_{in}^{kj}$
- Average income: $v_n^j = \sum_{k \in \{ag,na\}} \sum_{i=1}^{N} v_{in}^{kj} L_{in}^{kj} / L_n^j$
- Final demand for good: $D_n^j = \alpha \psi^j \sum_{k \in \{ag,na\}} v_n^k L_n^k$
- Final demand for housing: $(1-\alpha) \sum_{k \in \{ag,na\}} v_n^k L_n^k$

Production

- Production technology $q_n^j = \phi[l_n^j]^{\beta^j}[S_n^j]^{\eta^j}\prod_{k=1}^{J}[m_n^k]^{\sigma^{jk}}$
- Unit cost of a input bundle:

$$c_n^j(\varphi) \propto \frac{1}{\varphi}\left[\left(w_n^j\right)^{\beta^j}\left(r_n^j\right)^{\eta^j}\left(\sum_{k\in\{ag,na\}}\left(P_n^k\right)^{\sigma^{jk}}\right)\right]$$

P_n^k: the price of a composite intermediate good from sector k.

Composite intermediate goods

- Composite intermediate goods :

$$Y_n^j = \left(\int_0^1 y_n^j(\nu)^{(\sigma-1)/\sigma} d\nu \right)^{\sigma/(\sigma-1)}$$

- Demand on variety :

$$q_n^j(\nu) = (\frac{p_n^j(\nu)}{P_n^j})^{-\sigma} Q_n^j$$

- Price of the composites :

$$P_n^j = [\int p_n^j(\nu)^{1-\sigma} d\nu]^{\frac{1}{1-\sigma}}$$

International trade costs and prices

- Trade cost : τ_{ni}^{j} with $\tau_{nn}^{j} = 1$
- Consumer price :

$$p_n^j(\phi) = min_i\{\frac{\tau_{ni}^j c_i^j}{\phi}\}$$

International trade costs and prices

- Technology: (EK)
  - ϕ follows a Fréchet distribution with parameter T_n^j and shape parameter, θ.
  - The composite intermediate good prices:

$$P_n^j = \gamma[\sum_{i=1}^{N+1} T_i^j (c_i^j \tau_{ni}^j)^{-\theta}]^{-1/\theta}$$

where $\gamma = \Gamma(\frac{1-\sigma+\theta}{\theta})^{1/(1-\sigma)}$

Expenditure shares

- $X_n^j = P_n^j Q_n^j$: total expenditure on sector j goods in region n
- Expenditure in region n of sector j goods from region i.

$$\pi_{ni}^j = Pr[\frac{c_n^j \tau_{ni}^j}{\phi_i^j} \leq min_{h \neq i} \frac{c_h^j \tau_{nh}^j}{\phi_h^j}]$$

- Trade share (region n's share of expenditure on goods from i):

$$\pi_{ni}^j = \frac{T_i^j (c_i^j \tau_{ni}^j)^{-\theta}}{\sum_{h=1}^N T_h^j (c_h^j \tau_{nh}^j)^{-\theta}}$$

- Market clearing:

$$X_n^j = D_n^j + \sum_k \sigma^{kj} R_n^k$$

where $R_n^j = \sum_{i=1}^{N+1} \pi_{in}^j X_i^j$ is total production revenue.

Income of workers

- Labor market clearing condition: $w_n^j L_n^j = \beta^j \sum_{i=1}^{N+1} \pi_{in}^j X_i^j$
- Spending on fixed factor:

$$(1-\alpha) v_n^j L_n^j + \eta^j R_n^j = (1-\alpha) v_n^j L_n^j + \eta^j \beta^{j-1} w_n^j L_n^j$$

- Land market clearing condition:

$$r_n^j \bar{S}_n^j = (1-\alpha) v_n^j L_n^j + \eta^j \beta^{j-1} w_n^j L_n^j$$

- Total income:

$$v_n^j L_n^j = (1-\alpha) v_n^j L_n^j + \eta^j \beta^{j-1} w_n^j L_n^j + w_n^j L_n^j$$

- Sloving for $v_n^j L_n^j$:

$$v_n^j L_n^j = \frac{\eta^j + \beta^j}{\alpha \beta^j} w_n^j L_n^j$$

and the total fixed-factor income in region n sector j is

$$r_n^j \bar{S}_n^j = \left[\frac{(1-\alpha)\beta^j + \eta^j}{\alpha \beta^j} \right] w_n^j L_n^j$$

Income of workers

- Only workers with local hukou receive fixed-factor income.
  - Income of a local worker

$$v_{nn}^{jj} = w_n^j + r_n^j \bar{S}_n^j / L_{nn}^{jj}$$

  - Income of a migrant worker

$$v_{ni}^{jk} = w_i^k$$

- effective fixed-factor "rebate rate" to workers

$$\delta_{ni}^{jk} = \begin{cases} 1 + \left(\frac{(1-\alpha)\beta^j + \eta^j}{\alpha\beta^j}\right) \frac{L_n^j}{L_{nn}^{jj}} & \text{if } n = i \text{ and } j = k \\ 1 & \text{if } n \neq i \text{ or } j \neq k \end{cases}$$

- So we have

$$v_{ni}^{jk} = \delta_{ni}^{jk} w_i^k$$

Internal migration

- Migrants forgo land returns and incur a utility cost that lowers welfare by a factor. Workers differ in their location preferences ϵ_n^j with $F_\varepsilon(x) = e^{-x^{-\kappa}}$
- Real wage: $V_i^k \equiv \frac{w_i^k}{\left(P_i^{ag\psi^{ag}} P_i^{na\psi^{na}}\right)^{\alpha} \left(r_i^k\right)^{1-\alpha}}$
- Utility: $\varepsilon_i^k \delta_{ni}^{jk} V_i^k / \mu_{ni}^{jk}$
- Migration share registered in (n,j) who migrated to (i,k):

$$m_{ni}^{jk} = \Pr\left(\varepsilon_i^k \delta_{ni}^{jk} V_i^k / \mu_{ni}^{jk} \geq \max_{i',k'} \left\{\varepsilon_{i'}^{k'} \delta_{ni'}^{jk'} V_{i'}^{k'} / \mu_{ni'}^{jk'}\right\}\right)$$

$$= \frac{\left(V_i^k \delta_{ni}^{jk} / \mu_{ni}^{jk}\right)^{\kappa}}{\sum_{k'} \sum_{i'=1}^{N} \left(V_{i'}^{k'} \delta_{ni'}^{jk'} / \mu_{ni'}^{j'}\right)^{\kappa}}$$

Solving the model

Cost of input bundles:

$$\hat{c}^j_{ni} = \hat{w}_i^{j\beta^j} \hat{r}_i^{j\eta^j} \left(\prod_{k \in \{ag,na\}} \hat{P}_i^{k\sigma^{jk}} \right)$$

Bilateral trade share:

$$\hat{\pi}^j_{ni} = \frac{\hat{T}^j_i \left(\hat{\tau}^j_{ni} \hat{c}^j_i \right)^{-\theta}}{\sum_{m=1}^{N+1} \pi^j_{nm} \hat{T}^j_m \left(\hat{\tau}^j_{nm} \hat{c}^j_m \right)^{-\theta}}$$

Price index:

$$\hat{P}^j_n = \left[\sum_{m=1}^{N+1} \pi^j_{nm} \hat{T}^j_m \left(\hat{\tau}^j_{nm} \hat{c}^j_m \right)^{-\theta} \right]^{-1/\theta}$$

Trade balance:

$$X_n^{j\prime} = D_n^{j\prime} + \sum_k \sigma^{kj} R_n^{k\prime},$$

where $R_n^{j\prime} = \sum_{i=1}^{N+1} \pi'^{\,j}_{in} X_i^{j\prime}$, and $D_n^{j\prime} = \alpha \psi^j \sum_{k \in \{ag,na\}} v_n^{k\prime} L_n^{k\prime}$

Solving the model

Real income:

$$\hat{V}_n^j = \frac{\hat{w}_n^{j\alpha}}{\left(\hat{P}_n^{ag\,\psi^{ag}}\,\hat{P}_n^{na\,\psi^{na}}\right)^{\alpha}\hat{L}_n^{j\,1-\alpha}},$$

Migration share when given change of migration cost :

$$\hat{m}_{ni}^{jk} = \frac{\left(\hat{\delta}_{ni}^{jk}\hat{v}_i^k/\hat{\mu}_{ni}^{jk}\right)^{\kappa}}{\sum_{k'}\sum_{i'=1}^{N} m_{ni'}^{jk'}\left(\hat{\delta}_{ni'}^{jk'}\hat{v}_{i'}^{k'}/\hat{\mu}_{ni'}^{jk'}\right)^{\kappa}}$$

where $L_n^{j'} = \sum_{i,k} m_{in}^{kj'}\bar{L}_i^k$, and $\hat{\delta}_{ni}^{jk}$ from equation (9).

Solving the model

Change of aggregate welfare:

$$\hat{W} = \sum_{j} \sum_{n=1}^{N} \omega_n^j \hat{V}_n^j \hat{\delta}_{nn}^{jj} \left(\hat{m}_{nn}^{jj}\right)^{-1/\kappa}$$

Change of real GDP :

$$\hat{Y} = \sum_{j} \sum_{n=1}^{N} \phi_n^j \hat{V}_n^j \hat{L}_n^j$$

where $\phi_n^j \propto V_n^j L_n^j$

Solving the model

- Solving for relative changes eases the calibration by eliminating many fixed components of the model. We must calibrate parameters $(\alpha, \psi^k, \beta^j, \eta^j, \sigma^{jk}, \theta, \kappa)$ and initial values $(\pi^j_{ni}, m^{jk}_{ni}, \bar{L}^j_i, V^j_i)$ only. And our quantitative analysis requires only changes in trade and migration costs, not levels, so our results are robust to any bias in estimated trade and migration cost levels that are constant over time.

Calibration

Table 3—Calibrated Model Parameters and Initial Values

Parameter	Value	Description
(β^{ag}, β^{na})	$(0.29, 0.22)$	Labor's share of output
(η^{ag}, η^{na})	$(0.28, 0.03)$	Land's share of output
$(\sigma^{ag,na}, \sigma^{na,ag})$	$(0.60, 0.06)$	Intermediate input shares
ψ^{ag}	0.095	Agriculture's share of final demand
α	0.87	Goods' expenditure share
θ	4	Elasticity of trade
κ	1.5	Elasticity of migration
π_{ni}^{j}	Data	Bilateral trade shares
m_{ni}^{j}	Data	Bilateral migration shares
$\bar{L}_{n}^{j}$	Data	Hukou registrations

Calibration

- Data or parameters we need:
  - β^j: Adamopoulos et al. (2017)
  - η^j: Adamopoulos et al. (2017)
  - σ^{jk} :Input-output data
  - ψ^j: Input-output data
  - α:China Statistical Yearbook
  - π^j_{ni}: 2002 China Regional Input Output Tables
  - m^{jk}_{ni}:China's 2000 Population Census
  - $\bar{L}^j_n$:China's 2000 Population Census
  - θ:set 4 according to existed references
  - κ need to be estimated

Calibration

Elasticity of migration:

- According to equation determining migration share, we have:

$$m_{ni}^{jk}/m_{nn}^{jj} = \left(V_i^k/\delta_{nn}^{jj}\mu_{ni}^{jk}V_n^j\right)^{\kappa}$$

- Two alternative assumption about migration cost:
  - $\mu_{ni}^{jk} = \bar{\mu}_n^j d_{ni}^{\rho}\xi_{ni}^{jk}$,
  - $\mu_{ni}^{jk} = \bar{\mu}_n^j \bar{\mu}_{ni}\xi_{ni}^{jk}$
- Then we have:

$$\ln\left(\frac{m_{ii}^{jk}}{m_{nn}^{jj}}\right) = \kappa \ln\left(V_i^k\right) - \varrho\kappa \ln d_{ni} + \gamma_n^j + \varsigma_{ni}^{jk}, \quad \text{for } (n,i) \neq (i,k)$$

$$\ln\left(\frac{m_{ni}^{jk}}{m_{nn}^{j}}\right) = \kappa \ln\left(V_i^k\right) + \gamma_{ni} + \gamma_n^j + \varsigma_{ni}^{jk}, \quad \text{for } (n,i) \neq (i,k)$$

where $\gamma_n^j = -\kappa \ln \bar{\mu}_n^j - \kappa \ln\left(\delta_{nn}^{jj}V_n^j\right)$, $\gamma_{ni} = -\kappa \ln \bar{\mu}_{ni}^j$,
$\varsigma_{ni}^{jk} = -\kappa \ln \xi_{ni}^{jk} + \vartheta_{ni}^{jk}$

Calibration

Elasticity of migration:

Destination income may still be influenced by other factors that are potentially related to migration costs, so we use IV strategy:

- Distance weighted average income of neighboring provinces.
- Bartik-style expected income instrument: $\tilde{v}_n^j = \sum_{k=1}^{K} \bar{w}^k l_n^k$
- Our estimates vary between 1.19 and 1.61, so we opt to set $\kappa = 1.5$ and explore a range of [1,3]

Quantify the migration costs

- According to equation determining migration share, we have:

$$\mu_{ni}^{jk} = \frac{1}{\delta_{nn}^{jj}} \left(\frac{V_i^k}{V_n^j}\right) \left(\frac{m_{nn}^{ij}}{m_{ni}^k}\right)^{1/\kappa}, \quad \text{for } n \neq i$$

- Why is estimate of migration cost large?
  - Estimated migration costs are strongly correlated with the distance between regions.
  - The older have larger migration cost than the younger.
  - Typical rural-urban migrants earn four times what they believe they would earn at home, workers who did not move should have larger migration cost.
  - Without considering amenity difference, migration cost may be overestimated.

Quantify the trade costs

- According to equation determining trade share and Head & Ries (2001):

$$\bar{\tau}^j_{ni} \equiv \sqrt{\tau^j_{ni}\tau^j_{in}} = \left(\frac{\pi^j_{nn}\pi^j_{ii}}{\pi^j_{ni}\,i^j_{in}}\right)^{1/2\theta}$$

when $\tau^j_{ni} = t^j_{ni} t^j_i$, with $\left(t^j_{ni} = t^j_{in}\right)$, then $\tau^j_{ni} = \bar{\tau}^j_{ni}\sqrt{t^j_i / t^j_n}$

- $$ln\left(\pi^j_{ni}/\pi^j_{nn}\right) = S^j_i - S^j_n - \theta \ln\left(\tau^j_{ni}\right)$$

- If trade cost have only a symmetric and exporter-specific component:

$$ln\left(\pi^j_{ni}/\pi^j_{nn}\right) = \delta^j \ln\left(d_{ni}\right) + \iota^j_n + \eta^j_i + \varepsilon^j_{ni}$$

so $\hat{\eta}^j_i = S^j_i - \theta \ln\left(t^j_i\right)$, and $\hat{\iota}^j_n = -S^j_n$,

- Combine these two estimates:

$$\ln\left(\hat{t}^j_n\right) = -\left(\hat{\iota}^j_n + \hat{\eta}^j_n\right)/\theta.$$

Steps to solve the model

There are three loops, we guess $\hat{L}_n^j$ in the outer loop, guess $\hat{w}_n^j$ in the medium loop, and guess $\hat{X}_n^j$ in the inner loop.

- Step 1: In the medium loop, given $\hat{L}_i^j$, we guess a $\hat{w}_i^j$, then calculate $\hat{r}_i^j$, using $r_n^j \bar{S}_n^j = \left[\frac{(1-\alpha)\beta^j + \eta^j}{\alpha\beta^j}\right] w_n^j L_n^j$ Then solve for change of price, trade share, and unit cost.

$$\hat{c}_{ni}^j = \hat{w}_i^{j\beta^j} \hat{r}_i^j \eta^j \left(\prod_{k \in \{ag, na\}} \hat{P}_i^{k\sigma^{jk}} \right)$$

$$\hat{\pi}_{ni}^j = \frac{\hat{T}_i^j \left(\hat{\tau}_{ni}^j \hat{c}_i^j \right)^{-\theta}}{\sum_{m=1}^{N+1} \pi_{nm}^j \hat{T}_m^j \left(\hat{\tau}_{nm}^j \hat{c}_m^j \right)^{-\theta}}$$

$$\hat{P}_n^j = \left[\sum_{m=1}^{N+1} \pi_{nm}^j \hat{T}_m^j \left(\hat{\tau}_{nm}^j \hat{c}_m^j \right)^{-\theta} \right]^{-1/\theta}$$

Steps to solve the model

- Step 2: In the inner loop, given $\hat{\pi}^j_{ni}$, $\hat{w}^j_i$, we solve counterfactual expenditures $X^{j}_{ni}{}'$, using

$$v^{j\prime}_n L^{j}_n{}' = \frac{\eta^j + \beta^j}{\alpha\beta^j} w^{j\prime}_n L^{j}_n{}'$$

$$X^{j\prime}_n = \alpha\psi^j \sum_{k\in\{ag,na\}} v^{k\prime}_n L^{k\prime}_n + \sum_k \sigma^{kj} R^{k\prime}_n$$

$$R^{j\prime}_n = \sum_{i=1}^{N+1} \pi^{j}_{in}{}' X^{j\prime}_i$$

Steps to solve the model

- Step 3: with $\hat{V}_n^j$, $\hat{w}_n^j$ and $\hat{P}_n^j$ in the inner loop and medium loop, we guess $\hat{L}_n^j$, then in the outer loop, we solve for change of migration flow, $\hat{m}_{ni}^{jk}$ and $\hat{L}_n^j$.

$$\hat{V}_n^j = \frac{\hat{w}_n^{j\,\alpha}}{\left(\hat{P}_n^{ag\,\psi^{ag}}\,\hat{P}_n^{na\,\psi^{na}}\right)^{\alpha}\,\hat{L}_n^{j\,1-\alpha}},$$

$$\hat{m}_{ni}^{jk} = \frac{\left(\hat{\delta}_{ni}^{jk}\,\hat{V}_i^k/\hat{\mu}_{ni}^{jk}\right)^{\kappa}}{\sum_k \sum_{i'=1}^{N} m_{ni'}^{jk'}\left(\hat{\delta}_{ni'}^{jk'}\,\hat{V}_{i'}^{k'}/\hat{\mu}_{ni'}^{jk'}\right)^{\kappa}}$$

where $\mathrm{L}_n^{j'} = \sum_{i,k} m_{in}^{kj'}\,\bar{L}_i^k$.

Quantitative Analysis

- Lower Migration Costs

Table 7—Effects of Various Migration Cost Changes

	Trade shares (p.p. change)		Migrant stock (%)		Real GDP per worker (%)	Aggregate welfare (%)
	Internal	External	Within province	Between province		
All	0.1	0.1	14.5	80.8	4.8	11.1
No land inputs	0.1	0.2	14.4	85.6	5.3	8.4
And no housing	0.1	0.2	13.8	90.4	6.5	7.6
And $\theta \rightarrow \infty$	−0.2	0.1	23.2	119.2	11.8	6.2
Agriculture to non-agriculture migration cost changes						
Overall	0.1	0.1	15.2	52.9	4.3	9.1
Within provinces	−0.0	−0.1	22.8	−9.7	2.0	5.9
Between provinces	0.1	0.2	−7.0	69.9	2.8	3.5
Between provinces migration cost changes						
Overall	0.2	0.3	−7.8	97.9	3.2	5.5
Within agriculture	−0.0	0.0	−0.1	2.3	−0.0	0.1
Within non-agriculture	0.1	0.1	−1.0	30.9	0.7	2.2

Quantitative Analysis

- Lower trade Costs

TABLE 8—EFFECTS OF TRADE COST CHANGES

	Trade shares (p.p. change)		Migrant stock (%)		Real GDP per worker (%)	Aggregate welfare (%)
	Internal	External	Within province	Between province		
Internal trade	9.2	−0.7	0.8	−1.8	11.2	11.4
External trade	−0.7	3.9	1.8	2.4	4.0	2.9
All trade	8.2	2.8	2.5	0.5	15.2	14.1
No Change in migration						
Internal trade	9.1	−0.7	–	–	11.2	11.2
External trade	−0.7	3.9	–	–	3.4	3.4
All trade	8.2	2.8	–	–	14.5	14.5
No intermediate inputs						
Internal trade	8.6	−0.5	0.3	−1.4	3.0	3.3
External trade	−0.7	3.9	1.5	1.6	1.1	0.3
All trade	7.6	3.2	1.6	0.1	4.1	3.5
No intermediate inputs and no change in migration						
Internal trade	8.6	−0.5	–	–	3.1	3.1
External trade	−0.7	3.9	–	–	0.6	0.6
All trade	7.6	3.2	–	–	3.7	3.7

Quantitative Analysis

- Change of productivity and decomposing

Table 9—Decomposing China's Aggregate Labor Productivity Growth

	Marginal effects		
	Real GDP per worker growth (%)	Share of growth	Standard deviation (%)
Overall (all changes)	57.1	–	–
Productivity changes	36.9	0.64	1.3
Internal trade cost changes	10.2	0.18	0.3
External trade cost changes	4.5	0.08	0.7
Migration cost changes	5.6	0.10	0.9
Of the migration cost changes			
Between-province, within-non-agriculture	0.9	0.02	0.4
Between-province, within-agriculture	0.0	0.00	0.0
Between-province, agriculture-non-agriculture	3.2	0.06	0.9
Within-province, agriculture-non-agriculture	1.5	0.03	0.3

Potential Gains from Further Reform

- Trade and Migration Costs

TABLE 10—POTENTIAL GAINS FROM FURTHER TRADE AND MIGRATION LIBERALIZATION

	Relative to 2005 equilibrium	
	Change in real GDP (%)	Aggregate welfare (%)
Average internal trade costs as in Canada	12.5	16.3
A 1/3 inter-provincial migrant share	12.8	45.6
Both together	26.0	69.2

Notes: Reports the change in real GDP and welfare that result from changing China's internal trade and migration costs such that average trade costs correspond to estimates for Canada, and one-third of workers are outside their province of registration (a similar share as the United States). Percentage changes are expressed relative to the 2005 equilibrium.

Potential Gains from Further Reform

- Land reform

TABLE 11—EFFECT OF INDIVIDUAL OWNERSHIP LAND REFORM

	Percent change	
Welfare	11.8	
Real GDP	−2.4	
Migration, within-province	96.3	
Migration, between-province	38.0	
	Share of population (%)	
	Initial equilibrium	New equilibrium
Agricultural workers	52.9	56.6
Stock of migrants, urban-rural	2.1	10.9
Stock of migrants, rural-urban	14.0	19.1

Notes: Reports the change in various outcomes that results from a counterfactual where workers are permitted to keep land income, regardless of where they live. All workers registered in (n,j) receive an equal per capita land rebate $r_n^j S_n^j / \bar{L}_n^j$, even if they move to another region.