The Long and Short-Run Spatial Impacts of Trade

Lin Ma, Singapore Management University
Yunlong Song, Singapore Management University
Yang Tang, Nanyang Technological University

ABFER / 2024-05-22

Outline

Motivation

- The spatial impacts of trade within a country depends on geography and endowments:
  - Migration frictions / sectoral composition / factor abundance.

Motivation

- The spatial impacts of trade within a country depends on geography and endowments:
  - Migration frictions / sectoral composition / factor abundance.
- Many insights are based on static models with fixed endowments at regional or aggregate level. This is fine for short-run analysis.
- However, in the long-run, many key variables are no longer exogenous:
  - **Capital** accumulates endogenously at different rates across locations.
  - Workers could endogenously upgrade their **skill**.
  - Both forces are functions of trade shocks, and also lead to long-term changes in a location's comparative advantage.
- What are the spatial impacts of trade in the long-run, when factor endowments respond to trade shocks?

What we do

- We build a dynamic spatial framework to study the distributional impacts of trade. Key elements:
  - Endogenous capital accumulation, a la Kleinman, Liu, and Redding (2023).
  - Multiple types of workers with endogenous skill formation.
  - Multiple sectors with varying factor intensity.

What we do

- We build a dynamic spatial framework to study the distributional impacts of trade. Key elements:
  - Endogenous capital accumulation, a la Kleinman, Liu, and Redding (2023).
  - Multiple types of workers with endogenous skill formation.
  - Multiple sectors with varying factor intensity.
- Multiple channels through which trade affects skill premium.
  - In the short-run:
    - Stolper-Samuelson forces through product and factor prices.
    - Capital-skill complementarity.
    - Internal migration.
  - In the long-run:
    - Capital accumulation.
    - Skill formation.
    - Long-term changes in comparative advantage.

What we do

- We build a dynamic spatial framework to study the distributional impacts of trade. Key elements:
  - Endogenous capital accumulation, a la Kleinman, Liu, and Redding (2023).
  - Multiple types of workers with endogenous skill formation.
  - Multiple sectors with varying factor intensity.
- Multiple channels through which trade affects skill premium.
  - In the short-run:
    - Stolper-Samuelson forces through product and factor prices.
    - Capital-skill complementarity.
    - Internal migration.
  - In the long-run:
    - Capital accumulation.
    - Skill formation.
    - Long-term changes in comparative advantage.
- Quantifies the model in the context of China, a country with relative abundance of unskilled workers and comparative advantage in unskilled-intensive industries.

Key findings

The long- and short-run spatial impacts of trade are drastically different.

- How do skilled and unskilled workers migrate in response to trade shocks?

Key findings

The long- and short-run spatial impacts of trade are drastically different.

- How do skilled and unskilled workers migrate in response to trade shocks?
- Unskilled workers are more likely to migrate to coastal locations in the short run but not in the long-run.
  - Capital accumulation and the changes in comparative advantage.
  - Endogenous skill formation works to counteract the effects of capital accumulation.
    - The initial boom in unskilled intensive industries discourages skill-upgrading.
    - In the long-run, capital-skill complementarity encourages skill-upgrading.
- The **distance elasticity of skill composition** switches signs between the short- and the long-run.

Key Findings

- The same applies to the **distance elasticity of skill premium**:
  - e.g, the skill premium declines in coastal locations in the short run but increases in the long run.
- and the **distance elasticity of migration flows**:
  - The long-run elasticity is 7 times higher than the short-run: the attractiveness of coastal locations accumulate over time.
- Implications for **place-based policy:**
  - Migration policies aimed at retaining population in inland locations need to be strengthened in the long-run.
  - Education policies that encourages skill upgrading needs to shift their spatial focus.

Literature

- The distributional impacts of trade
  - Lawrence and Slaughter (93), Feenstra and Hanson (96), Goldberg and Pavcnik (07), Helpman, Itskhoki, and Redding (10), Autor, Dorn and Hanson (13), Parro (13), Burstein and Vogel (17).
  - Specific factors (SR) and Stolper-Samuelson (LR): we endogenize factor endowments: "trade drives trade" patterns in the long-run.
- Endogenous endowment models (Findlay and Kierzkowski, 83; Borsook, 87; Blanchard and Willmann, 16): we add in the spatial dimension
- Quantitative spatial models:
  - Allen and Arkolakis (14, 22), Ahlfeldt et al. (15), Redding (16), Caliendo et al. (19), Cai et al. (22), Kleinman, Liu and Redding (23).
  - Relative to KLR (23): we add in elements to study skill premium and skill formation.
- In the context of China:
  - Fan (19), Tombe and Zhu (20), Ma and Tang (20), Zi (20), Chang, Chen, Hsu, Yi (22), Liu and Ma (23)
  - Relative to Fan (19), we highlight the differences between the short and the long-term distributional impacts of trade.

Outline

The Model: Overview

- $N+1$ locations, and time is discrete indexed with $t = 1, 2, \cdots$
- Two types of workers: unskilled (l) and skilled (s)
  - Forward-looking decisions:
    1. whether to upgrade their skill types
    2. location to move to next period
  - Subject to type-specific migration frictions across locations
- J sectors differ in capital and skill intensity.
- Capital accumulates endogenously at each location.
  - Capital is geographically **immobile** and investment is **local**.
    - Extension: results robust with cross-location investment.
    - In the extension, landlords in A could investment in B.
  - Landlords determine the investment rates through saving/consumption decision.

Workers' Choices

A type $d \in \{l, s\}$ worker living in location i at t's value function:

$$V_{it}^d = \ln b_{it} + \ln \frac{w_{it}^d}{p_{it}} + \max_{\{n,e\}} \{\xi \beta \mathbb{E} V_{nt+1}^e - \kappa_{ni,t}^d - \kappa_e^d + \rho \epsilon_{nt}^e\}. \tag{1}$$

- b_{it}: amenity. w_{it}^d / p_{it}: the real wage. $\kappa_{ni,t}^d$ is the **migration cost** from i to n.

Workers' Choices

A type $d \in \{l, s\}$ worker living in location i at t's value function:

$$V_{it}^{d} = \ln b_{it} + \ln \frac{w_{it}^{d}}{p_{it}} + \max_{\{n,e\}} \{\xi \beta \mathbb{E} V_{nt+1}^{e} - \kappa_{ni,t}^{d} - \kappa_{e}^{d} + \rho \epsilon_{nt}^{e}\}. \tag{1}$$

- b_{it}: amenity. w_{it}^{d}/p_{it}: the real wage. $\kappa_{ni,t}^{d}$ is the **migration cost** from i to n.
- κ_{e}^{d} is the **skill-changing cost** from d to e.
  - can be extended to include the opportunity cost of skill upgrading (lost wage).
  - or a nested choice that allows for different elasticities.
- $2N$ **simultaneous choices** with the same elasticity, ρ.
  - ρ as the (inverse) skill-upgrading elasticity: around 2 (Hu and Ma, 2023).
  - β is the discount rate, and ξ is the survival rate.
    - With probability $1 - \xi$ an individual exits the model and is replaced with an unskilled worker at the same location.

Landlords (the same as in KLR)

- Landlords consume, invest locally, but do not migrate. Their lifetime utility is:

$$v_{it}^{k} = \sum_{s=0}^{\infty} (\xi\beta)^{t+s} \ln c_{it+s}^{k}, \tag{2}$$

Landlords (the same as in KLR)

- Landlords consume, invest locally, but do not migrate. Their lifetime utility is:

$$v_{it}^{k} = \sum_{s=0}^{\infty} (\xi\beta)^{t+s} \ln c_{it+s}^{k}, \tag{2}$$

- Budget constraint at period t

$$r_{it}k_{it} = p_{it}(c_{it}^{k} + k_{it+1} - (1-\delta)k_{it}) \tag{3}$$

Landlords (the same as in KLR)

- Landlords consume, invest locally, but do not migrate. Their lifetime utility is:

$$v_{it}^k = \sum_{s=0}^{\infty} (\xi\beta)^{t+s} \ln c_{it+s}^k, \tag{2}$$

- Budget constraint at period t

$$r_{it}k_{it} = p_{it}(c_{it}^k + k_{it+1} - (1-\delta)k_{it}) \tag{3}$$

- Solution: landlords invest with a constant saving rate β:

$$k_{it+1} = \xi\beta \left(1 - \delta + \frac{r_{it}}{p_{it}}\right) k_{it}. \tag{4}$$

Landlords (the same as in KLR)

- Landlords consume, invest locally, but do not migrate. Their lifetime utility is:

$$v_{it}^k = \sum_{s=0}^{\infty} (\xi\beta)^{t+s} \ln c_{it+s}^k, \tag{2}$$

- Budget constraint at period t

$$r_{it} k_{it} = p_{it}(c_{it}^k + k_{it+1} - (1-\delta)k_{it}) \tag{3}$$

- Solution: landlords invest with a constant saving rate β:

$$k_{it+1} = \xi\beta \left(1 - \delta + \frac{r_{it}}{p_{it}}\right) k_{it}. \tag{4}$$

  - Positive shocks drive up the real interest rate $\frac{r_{it}}{p_{it}}$ and accelerate **local** capital accumulation.

Production: Nested CES with Capital-Skill Complementarity

Firms produce variety in sector j and location i according to:

$$y_{it}^j = z_{it}\left[(\mu^j)^{\frac{1}{\sigma}}(z_{it}^{-\psi}l_{it}^j)^{\frac{\sigma-1}{\sigma}} + (1-\mu^j)^{\frac{1}{\sigma}}(z_{it}^{\psi}h_{it}^j)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{5}$$

$$h_{it}^j = \left[(\lambda^j)^{\frac{1}{\eta}}(k_{it}^j)^{\frac{\eta-1}{\eta}} + (1-\lambda^j)^{\frac{1}{\eta}}(s_{it}^j)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}. \tag{6}$$

- l_{it}^j: unskilled labor; s_{it}^j: skilled labor; k_{it}^j: capital.
  - Elasticity of substitution (EoS) between skilled worker and capital is η.
  - EoS between unskilled worker and the composite input is σ.
  - Assuming *capital-skill complementarity:* $\eta < \sigma$.
- ψ captures the complementarity between productivity and skill.
  - Assuming skill-biased productivity production: $\psi(\sigma-1) > 0$
- Agglomeration: $z_{it} = \bar{z}_i(l_{it}+s_{it})^{\alpha_z}$

Equilibrium

- **General Equilibrium.** Given labor and capital stock at initial period, the equilibrium is a sequence of prices and factor allocations such that
  1. workers migrate and choose skills optimally
  2. capital accumulates according to optimal investment decision
  3. all markets clear. details
- **Steady State.** A steady state of the economy is an equilibrium in which the endogenous variables are constant over time: $\{w_i^{l*}, w_i^{s*}, r_i^*, v_i^{l*}, v_i^{s*}, l_i^*, s_i^*, k_i^*\}$

Outline

Quantification and Data

- 196 prefecture-level cities in China plus ROW
- Four sectors details
  - Skilled and unskilled manufacturing sector, tradable
  - Skilled and unskilled service sector, non-tradable
- Initial population by location and skills
  - China 2000 census, 2010 census
  - OECD Statistics
- Initial capital stock details
  - China Statistical Yearbooks
  - Penn World Table
- Factor income share by sectors
  - China 2005 mini census, China 2002 IO table
  - IPUMS USA 2000, US 2007 IO table
- Trade flow
  - WIOD ICIO table from 2000-2006

Parameters: Overview

External calibrated parameters:

- Annual discount rate $\beta = 0.97$.
- Trade elasticity $\theta = 5$ (Costinot and Rodríguez-Clare 2014)
- Inverse of migration elasticity $\rho = 3\beta$ (Kleinman, Liu and Redding 2023)
- Elasticities of substitution in production, σ and η, 1.67 and 0.67 (Krusell et al. 2000)
- Agglomeration elasticity α_z and congestion elasticity α_b, 0.1 and -0.3 (Redding and Turner 2015) & (Allen and Arkolakis 2022)
- Internal trade cost τ (Ma and Tang 2024)
- Skill-biased productivity parameter $\psi = 0.5$ (Burstein and Vogel 2017)
- Survival rate per year $\xi = 0.993$ (World Bank 2000-2020 data for China)

Parameters: Overview

All the other parameters calibrated in three steps:

1. PPML based on structural equations without solving the model: details
   - Migration cost by skill type $\{\kappa^d_{gi,t}\}$.
2. Static initial equilibrium: details
   - Production function: the sector specific weights on unskilled labor μ and on capital λ in production technology
   - Location specific exogenous productivities $\bar{z}$
3. Full transition path: details
   - Location specific exogenous amenities $\bar{b}$
   - Trade cost with ROW τ^j_{ROW}
   - Skill-upgrading cost κ^l_s

model fit

Outline

Skill Premium, Capital Accumulation, and Skill Formation

- Without skill-upgrading, capital accumulation leads to very high skill premium due to capital-skill complementarity.
- Without capital accumulation, skill-upgrading dampens skill premium in the long-run.

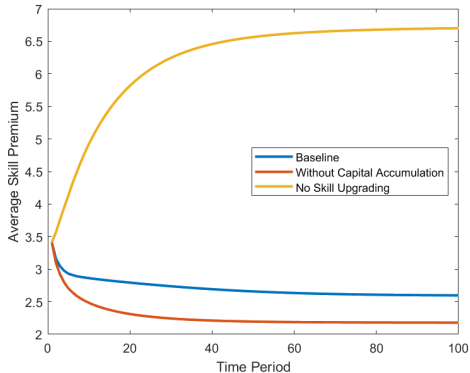


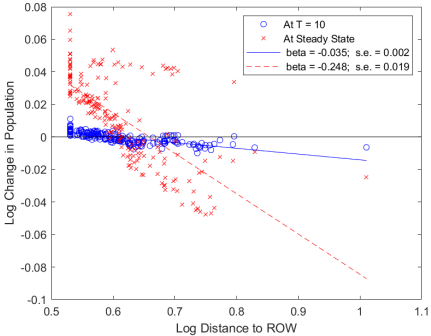
Figure: Average Skill Premium

The Spatial Impacts of Trade

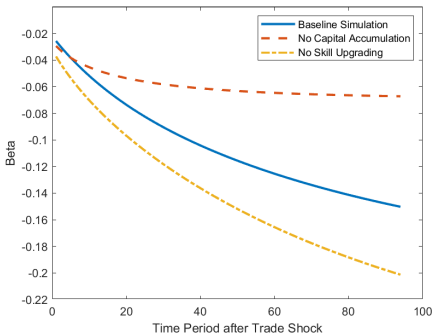
- Counterfactual world: Trade barriers between China and ROW stayed at the pre-WTO level in 2000.
- We show that the distributional impacts of trade:
  - differ substantially over time, and
  - depend critically on capital accumulation.
- Subsequently, placed-based policies should be a function of time.

Trade-Induced Migration

- Opening up to trade drives population towards the coastal locations.
- The distance elasticity in the steady state is roughly 7 times larger than in the short run



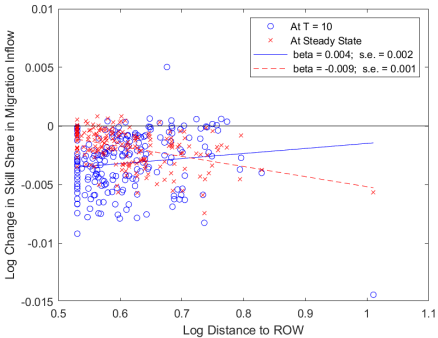
(a) Baseline



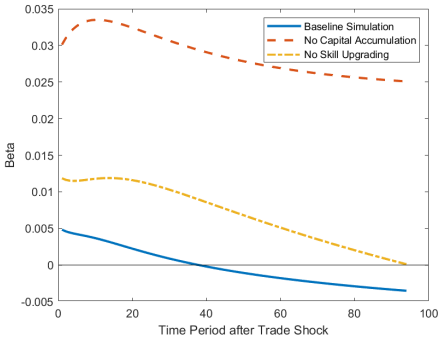
(b) Distance Elasticity

Skill Composition of Migrants

- As the coastal locations get richer, capital accumulates faster there, attracting skilled workers.
- The sign of the distance elasticity switches over time.
- Without capital accumulation, the distance elasticity of skill ratio is always positive.



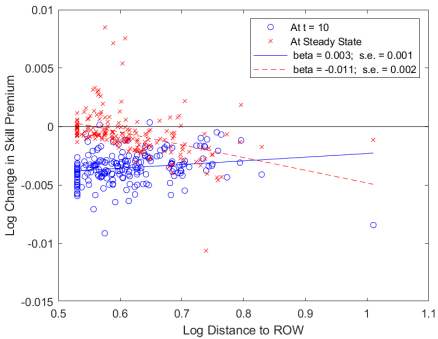
(c) Baseline



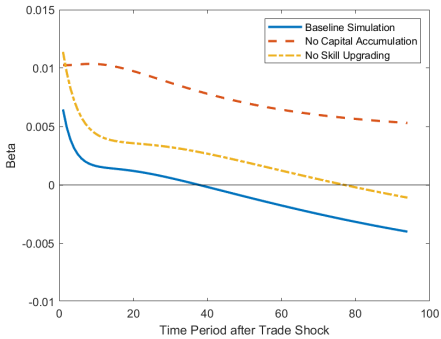
(d) Distance Elasticity

Skill Premium

- In the short run, the coastal locations have C.A. in unskilled manufacturing
  - Stolper-Samuelson predicts declining skill premium.
- Capital accumulation shifts C.A. in coastal locations towards skilled-intensive.
  - Stolper-Samuelson predicts higher skill premium.



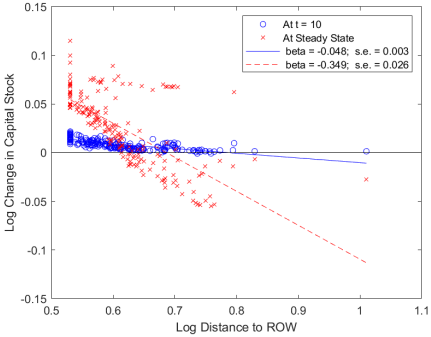
(e) Baseline



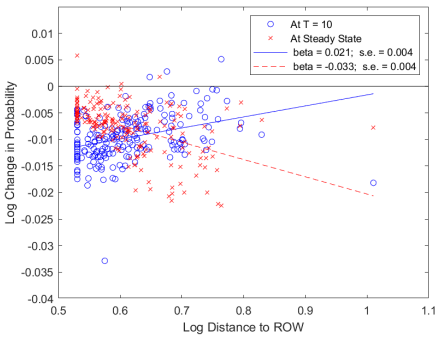
(f) Distance Elasticity

Mechanism: Trade-Induced Factor Accumulation

- The results shown above hinges on the differential impacts of trade on capital accumulation and skill acquisition across space.
- Capital accumulates faster on along the coast, triggering skill acquisition and population movement.



(g) Capital Accumulation



(h) Skill Acquisition

Place-Based Policy

- Subsidizing workers in the less developed inland regions to prevent trade-induced population loss?
- To achieve the same target, subsidies in SS need to be more than 50 percent higher than in the short-term.

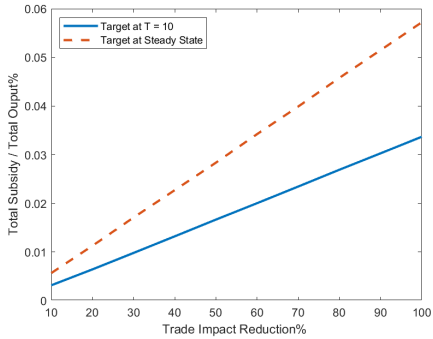


Figure: Wage Subsidy to Reduce Trade-Induced Emigration

Robustness Checks

The contrast between the short- and the long-run spatial impacts of trade are robust to:

- No skill-productivity complementarity ($\psi = 0$).
- No country-specific production functions ($\lambda_j^{\text{ROW}} = \lambda_j^{\text{CHN}}$, $\mu_j^{\text{ROW}} = \mu_j^{\text{CHN}}$).
- No skill-upgrading ($\kappa_l^s = \kappa_s^l = \infty$).
- Reduced form estimation of trade costs reduction.
- Cross-location investments.

Conclusion

- We study the short and the long-run spatial impacts of trade.
- The spatial impacts of trade depend critically on time horizon, due to endogenous capital accumulation and changing comparative advantage.
  - Trade liberalization allows faster capital accumulation in coastal locations, which affects internal migration and comparative advantage across locations.
  - In the short run, unskilled workers are attracted towards the coastal locations; in the long-run, the skilled workers do.
  - The spatial variations in skill premium also change over time due to capital accumulation.
- Policies designed to mitigate the spatial impacts of trade would be ineffective if they disregard temporal variations.

Trade

- Price of i's variety in location n is

$$p_{ni,t}^{j} = \frac{\tau_{ni,t}}{z_{it}} \left[\mu^{j} z_{it}^{\psi(1-\sigma)} (w_{it}^{l})^{1-\sigma} + (1-\mu^{j}) z_{it}^{-\psi(1-\sigma)} \left(w_{it}^{h} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \quad (7)$$

  where $w_{it}^{h} = \left[\lambda^{j} (r_{it})^{1-\eta} + (1-\lambda^{j}) (w_{it}^{s})^{1-\eta} \right]^{\frac{1}{1-\eta}}$.

- Trade share is given by:

$$S_{nit}^{j} = \frac{(p_{ni,t}^{j})^{-\theta}}{\sum_{m=1}^{N} (p_{nm,t}^{j})^{-\theta}}. \quad (8)$$

- Location i's total income is

$$X_{it}^{j} = \sum_{n=1}^{N} S_{nit}^{j} \left[\gamma^{j} \sum_{s=1}^{J} X_{nt}^{s} \right]. \quad (9)$$

back

Market Clearing

- Labor supply at location i:

$$l_{it+1} = \underbrace{\xi \sum_{n=1}^{N} D_{in}^{ll} l_{nt}}_{\text{Migrants}} + \underbrace{\left(\frac{l_{it} + s_{it}}{\sum_{n=1}^{N} (l_{nt} + s_{nt})} \right) (1 - \xi)}_{\text{New Born}}, \tag{10}$$

$$s_{it+1} = \xi \left(\underbrace{\sum_{n=1}^{N} D_{in}^{ss} s_{nt}}_{\text{Migrants}} + \underbrace{\sum_{n=1}^{N} D_{in}^{sl} l_{nt}}_{\text{Upgraders}} \right). \tag{11}$$

back

Appendix: Sectors

Table: Manufacturing Sectors

Panel A: Unskilled Manufacturing		Panel B: Skilled Manufacturing	
Classification No.	Description	Classification No.	Description
C13	Food Processing	C15	Beverage
C14	Food Manufactures	C16	Tobacco Manufactures
C17	Textile	C25	Petroleum, Coke and Nuclear Fuel
C18	Clothing, Shoes and Hats	C26	Chemicals
C19	Leather, Hide and Feather Manufactures	C27	Medicinal and pharmaceutical Products
C20	Wood Processing	C28	Chemical Fiber Manufactures
C21	Furniture	C32	Iron and Steel
C22	Pulp and Paper	C33	Non-ferrous Metals
C23	Printing	C35	General Equipment
C24	Educational and Sporting Products	C36	Specialized Equipment
C29	Rubber Manufactures	C37	Transport Equipment
C30	Plastics Manufactures	C39	Electrical machinery, apparatus and appliances
C31	Non metallic mineral manufactures	C40	Telecommunication and Computer Manufactures
C34	Manufactures of Metal	C41	Instrument and Office Equipment
C42	Handicrafts and Other Manufactures		

back

Appendix: Sectors

Table: Service Sectors

Panel A: Unskilled Service		Panel B: Skilled Service	
Classification No.	Description	Classification No.	Description
D45	Gas production and supply	D44	Electricity and Heat Production and Supply
D46	Water production and supply	G60	Information Transmission Service
E47-E50	Construction	G61	Computer Service
F51-F59	Transportation	G62	Software Service
H63	Wholesale	J68-J71	Financial Service
H65	Retail	K72	Real Estate
I66-I67	Accommodation and Catering	L73-L74	Leasing and Business Services
N80	Environment Management	M75-M78	Scientific research, technical services and geological prospecting
N81	Public Facilities Management	N79	Water Management
O82-O83	Residential and Other Service	P84	Education
		Q85-Q87	Health, social security and social welfare
		R88-R92	Culture, sports and entertainment
		S93-S97	Public Administration and Social Organization

back

Constructing Capital Stock

- Observe yearly investment by location in the data, I_{it}.
- Construct the capital stock, K_{it}, using the perpetual inventory method:

$$K_{it} = (1 - \delta)K_{it-1} + I_{it}$$

  - We use investment from 1994 to 2000 to construct the capital stock in year 2000.
  - Real investment I_{it}: I_{it} = Gross Fixed Capital Formation$_{it}$ $\times$Investment Deflator$_{it}$
- Capital stock in 1994 inferred as: $K_{i,1994} = I_{i,1994}/\delta$
- Set capital depreciation rate $\delta = 0.1$, consistent with Zhang, Wu and Zhang (2004)

back

Calibration (1): PPML

- Assume migration cost takes the form

$$\kappa^d_{gi,t} = \kappa^d_g + \bar{\kappa}_{gi,t}, \tag{12}$$

  - $\bar{\kappa}_{gi,t}$ is symmetric travel cost, determined by geography and infrastructure, from Ma and Tang (2024)
  - κ^d_g is type-specific entry barrier for migrating to location g, due to policy.

Calibration (1): PPML

- Assume migration cost takes the form

$$\kappa^d_{gi,t} = \kappa^d_g + \bar{\kappa}_{gi,t}, \tag{12}$$

  - $\bar{\kappa}_{gi,t}$ is symmetric travel cost, determined by geography and infrastructure, from Ma and Tang (2024)
  - κ^d_g is type-specific entry barrier for migrating to location g, due to policy.

- Double-differencing the migration share:

$$\frac{D^d_{gi}}{D^d_{ii}}\frac{D^d_{ig}}{D^d_{gg}} = \exp\left[-\frac{1}{\rho}(\kappa^d_g + \kappa^d_i + 2\bar{\kappa}_{gi})\right]. \tag{13}$$

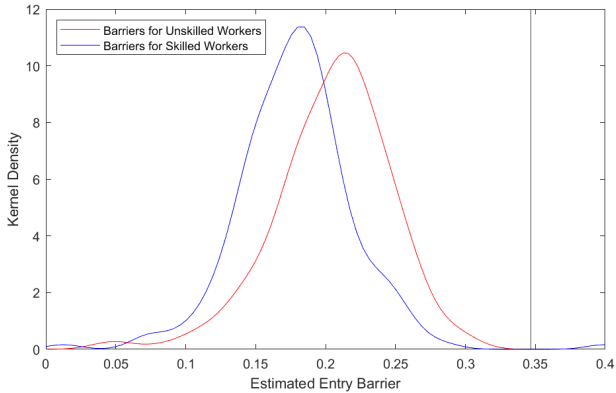
  - The double-differencing eliminates the impacts of current and future endogenous variables, v^d_{it}.
  - Left-hand side observed from data, and $\bar{\kappa}_{gi}$ comes from Ma and Tang (2024).
  - Estimate κ^d_g and κ^d_i using PPML.

back

Calibration (1): PPML

- Unskilled labors face larger entry barriers overall.
- Median migration barrier is around 15% of life-time utility.
- Vertical line is the cost of skill-upgrading (estimated later).
  - Getting a college degree costs about 1/3 of life time utility of an unskilled worker.

back



Calibration (2): Initial Static Equilibrium

- The second step is to calibrate some parameters to match the initial state of the economy in year 2000.
  - This step only requires solving the initial static equilibrium, not the steady state or transition path.
  - $\Longrightarrow$ the target moments cannot depend on the dynamic elements of the model: population distribution or investment.
- The parameters: $\{\bar{z}_i, \mu^j, \lambda^j, \tau^j_{ROW,2000}\}$.
- The targets:
  - Each locations' output, for $\bar{z}_i$
  - Unskilled labor income share and capital income share, for μ^j and λ^j
  - Sectoral trade-to-output ratio, for $\tau^j_{ROW,2000}$

back

Calibration (2): Initial Static Equilibrium

	Unskilled M.	Skilled M.	Unskilled S.	Skilled S.
	China			
μ^j	0.33	0.17	0.27	0.04
λ^j	0.91	0.86	0.85	0.75
	ROW			
μ^j	0.29	0.16	0.27	0.07
λ^j	0.80	0.89	0.82	0.89

- Production functions differ by sectors and countries
  - μ^j is the weight on unskilled workers in sector j,
  - and λ^j is the weight on capital.
- Differences in production technology between China and ROW:
  - Unskilled manufacturing sectors are more capital intensive than skilled ones (0.91 v.s. 0.86). Mainly due to the primary metal industry.

back

Calibration (3): Transition Path

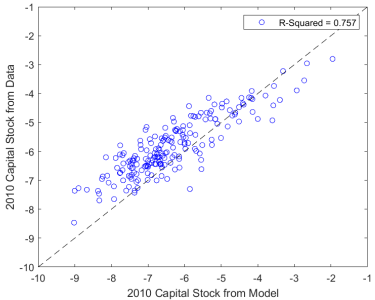
The last group of parameters is calibrated on the transition path, conditional on all the other parameters:

- Each location's fundamental amenity, $\bar{b}_i$:
  - matching 2010's population distribution.
- Trade costs with the ROW at year after 2000, $\tau^j_{ROW,t}$:
  - Targeting corresponding year's trade-to-output ratio
- Skill-upgrading cost, κ^l_s:
  - Targeting aggregate skill ratio in 2010.
  - Skill ratio is $\frac{\text{Skilled Population}}{\text{Total Population}}$.
  - Set $\kappa^l_s = \infty$.

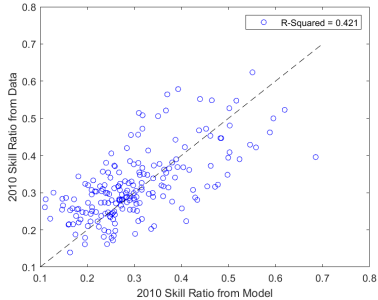
back

Model Fit

- The model captures the spatial distribution of physical and human capital reasonably well on the transition path.



(a) Capital Stock



(b) Skill Ratio

Figure: Model Fit: Untargeted Moments

Notes: each dot represents a prefecture.

back