The Global Welfare Impact of China: Trade Integration and Technological Change

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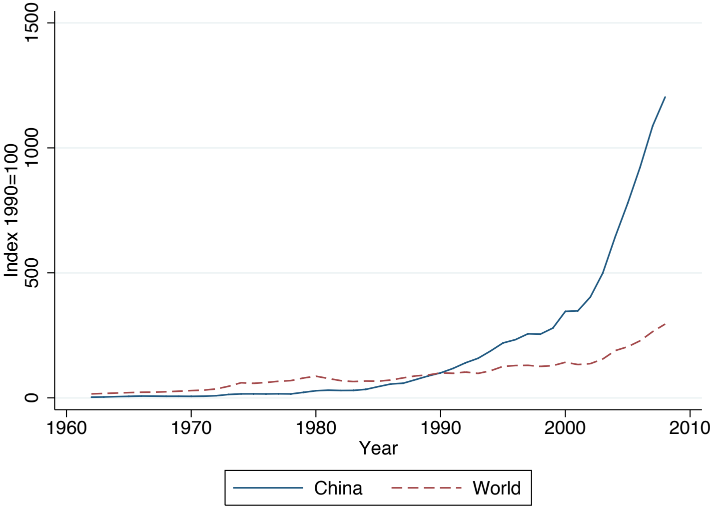
25 May, 2012

Motivation

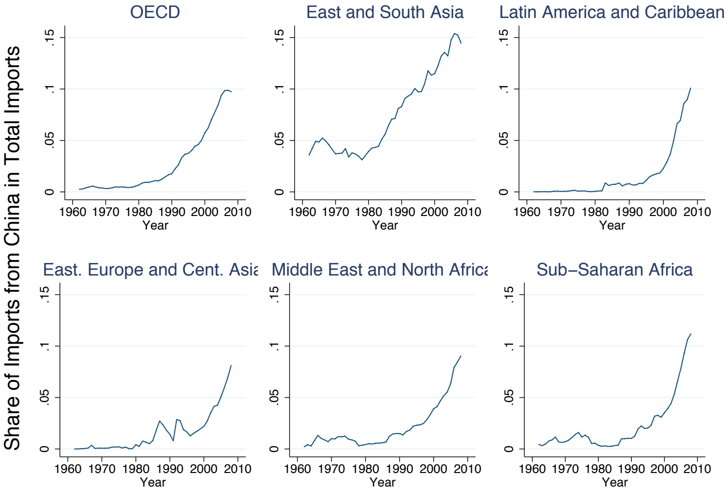
- Trade integration of China
  - 1.3 billion people
  - 12-fold growth in exports since 1990
  - 10% of global imports now come from China

China's Exports

1990=100



Share of China in Global Imports



Concerns

- Among developing countries: China's integration might lower welfare due to similar comparative advantage

  Devlin, Estevaeordal and Rodriguez-Clare, eds (2005), Gallagher, Moreno-Brid and Porzecanski (2008)

- Among advanced countries: China catching up in its comparative disadvantage sectors might reduce welfare

  Hicks (1953), DFS (1977), Ju and Yang (2009); Samuelson (2004)

- Evaluating these concerns is challenging: a rich/tractable model with multilateral trading relations, reliable measures of sectoral comparative advantage across countries

This Paper

- Assess the welfare impact of
  - China's trade integration to date
  - Balanced and unbalanced productivity growth in China
- Construct a Ricardian-HO model of 75 countries 20 sectors
  - Multiple factors of production; fully fledged input-output linkages; a non-tradeable sector; inter- and intra-sectoral trade
  - Analytical results on the "Samuelson conjecture" when there are more than 2 countries
- Measure comparative advantage following EK
  - Trade data reveal CA after netting out differences in factor costs and trade costs

Quantitative Results

- Welfare gains in two counterfactual growth scenarios:
  - World: balanced (0.01%) $<<$ unbalanced (0.42%)
  - Diametrically opposite to the Samuelson conjecture
- Welfare gains from China's trade integration today
  - China: 3.72%; the world: 0.13%; Asia: 0.23%
  - 9 countries lose (mostly textile and apparel producers): Honduras (-0.27%), El Salvador (-0.21%)

Analytical Results

- In a simplified 2-sector model, vary country 1's *relative* productivity, keeping its *average* productivity constant.
- Which level of relative productivity minimizes welfare?
  - With only 2 countries, welfare in country 2 is lowest when relative productivity is identical across countries.
  - With more than 2 countries, welfare in country 2 is lowest when relative productivity is identical to the relative average productivity *of all other countries serving country 2*, weighted by unit and trade costs.
- Intuition: China's pattern of comparative advantage is "common" in the world. Unbalanced growth actually makes China *more* different from the average country.

Preferences

- Countries $n, i = 1, .., N$; sectors $j, k = 1, ..., J+1$; sector $J+1$ nontradeable
- Consumption of the final good:

$$Y_n = \left(\sum_{j=1}^{J} \omega_j^{\frac{1}{\eta}} \left(Y_n^j \right)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}\xi_n} \left(Y_n^{J+1} \right)^{1-\xi_n},$$

where Y_n^{J+1} is the nontradable-sector composite good, and Y_n^j is the composite good in tradable sector $j = 1, .., J$.

- Budget constraint/ trade balance in country N:

$$P_n Y_n = w_n L_n + r_n K_n,$$

where $P_n = B_n \left(\sum_{j=1}^{J} \omega_j (p_n^j)^{1-\eta} \right)^{\frac{1}{1-\eta}\xi_n} (p_n^{J+1})^{1-\xi_n}$

Technology

- Each sector's output Q_n^j aggregates a continuum of varieties $q \in [0, 1]$ unique to each sector:

$$Q_n^j = \left[\int_0^1 Q_n^j(q)^{\frac{\varepsilon - 1}{\varepsilon}} dq \right]^{\frac{\varepsilon}{\varepsilon - 1}}$$

- Producing one unit of good q in sector j in country n requires $\frac{1}{z_n^j(q)}$ input bundles.
    - $z_n^j(q)$ is drawn from the Fréchet distribution with cdf

$$F_n^j(z) = e^{-T_n^j z^{-\theta}},$$

where T_n^j varies by country and sector

- Costly trade: $d_{ni}^j \geq 1$

Quantitative Model Setup

- Input bundle has a cost:

$$c_n^j = \left(w_n^{\alpha_j} r_n^{1-\alpha_j}\right)^{\beta_j} \left(\prod_{k=1}^{J+1} \left(p_n^k\right)^{\gamma_{k,j}}\right)^{1-\beta_j}$$

- Production is Cobb-Douglas in L, K, and intermediate inputs coming from sectors $1, .., J+1$
- Full set of I-O linkages between all sectors, including nontradeable
- Factor and intermediate input intensities differ by sector – HO feature

Prices and Trade Shares

- Multilateral resistance Φ_n^j summarizes country n's access to production technology in sector j

$$\Phi_n^j = \sum_{i=1}^{N} T_i^j \left(c_i^j d_{ni}^j \right)^{-\theta}$$

- Price p_n^j in sector j and country n:

$$p_n^j = \Gamma \left(\Phi_n^j \right)^{-\frac{1}{\theta}}$$

- Share of sector j's varieties originating in country i that country n consumes π_{ni}^j

$$\pi_{ni}^j = \frac{T_i^j \left(c_i^j d_{ni}^j \right)^{-\theta}}{\Phi_n^j}$$

Closing the Model

- Goods market clearing:

$$p_n^j Q_n^j = p_n^j Y_n^j + \sum_{k=1}^{J} (1-\beta_k)\gamma_{j,k} \left(\sum_{i=1}^{N} \pi_{in}^k p_i^k Q_i^k \right) + (1-\beta_{J+1})\gamma_{j,J+1} p_n^{J+1} Q_n^{J+1}$$

- Factor market clearing:

$$\sum_{j=1}^{J+1} L_n^j = L_n \text{ and } \sum_{j=1}^{J+1} K_n^j = K_n$$

Simplified Version

- One factor of production: labor
- Two EK sectors (A and B) and one homogeneous good H
  - H is freely traded and produced in all countries
  - Wages are pinned down by productivity of good H (Helpman, Melitz and Yeaple, 2004, Chaney, 2008)
- Utility: $U_n = A_n^{\frac{\alpha}{2}} B_n^{\frac{\alpha}{2}} H_n^{1-\alpha}$
- Thought experiment:
  - Vary $\frac{T_1^A}{T_1^B}$ while keeping $\left(T_1^A T_1^B\right)^{\frac{1}{2}} = c$ to examine the impact of "technological similarity" across countries

Welfare in Simplified Model

- Price in sector $j \in \{A, B\}$ and country n:

$$p_n^j = \Gamma \left(\Phi_n^j\right)^{-\frac{1}{\theta}} = \Gamma \left(\sum_{i=1}^{N} T_i^j \left(w_i d_{ni}^j\right)^{-\theta} \right)^{-\frac{1}{\theta}}$$

- Aggregate price level:

$$P_n \propto \left(p_n^A p_n^B\right)^{\frac{1}{2}\alpha} \left(p_n^H\right)^{1-\alpha}$$

- Welfare (indirect utility):

$$w_n / P_n = w_n \left(p_n^A p_n^B\right)^{-\frac{1}{2}\alpha} \left(p_n^H\right)^{\alpha-1}$$

Result

Lemma 1

The relative technology $\left(\frac{T_1^A}{T_1^B}\right)_n$ *of country 1 that minimizes welfare in country n subject to the constraint that* $\left(T_1^A T_1^B\right)_n^{\frac{1}{2}} = c$ *is given by:*

$$\left(\frac{T_1^A}{T_1^B}\right)_n = \frac{\sum_{i=2}^N T_i^A \left(\frac{w_i d_{ni}^A}{d_{n1}^A}\right)^{-\theta}}{\sum_{i=2}^N T_i^B \left(\frac{w_i d_{ni}^B}{d_{n1}^B}\right)^{-\theta}}.$$

Example: 2 vs. 3 Countries

Suppose trade is costless. Then the country 1 relative technology T_1^A/T_1^B that minimizes welfare in countries 1 and 2 is: With 2 countries:

$$\left(\frac{T_1^A}{T_1^B}\right)_1 = \left(\frac{T_1^A}{T_1^B}\right)_2 = \frac{T_2^A}{T_2^B}.$$

With 3 countries:

$$\left(\frac{T_1^A}{T_1^B}\right)_1 = \left(\frac{T_1^A}{T_1^B}\right)_2 = \left(\frac{T_1^A}{T_1^B}\right)_3 = \frac{T_2^A w_2^{-\theta} + T_3^A w_3^{-\theta}}{T_2^B w_2^{-\theta} + T_3^B w_3^{-\theta}}.$$

Estimation Strategy

- Three types of parameters:
  - Estimated by us from the data: α_j, β_j, $\gamma_{k,j}$, L_n, K_n, ξ_n
  - Estimated by others/commonly used: θ, η, ε
  - Estimated by us within the model: T_n^j, d_{ni}^j, ω_j
- 2 major steps of estimation strategy:
  - Tradeable T_n^j relative to U.S.: gravity-based estimation following EK and others
  - T_n^j for the U.S., T_n^{J+1} for $n = 1, ..., N$, ω_j for $j = 1, ..., J$

Tradeable Sectors

- Eaton-Kortum procedure:

$$\frac{\pi_{ni}^j}{\pi_{nn}^j} = \frac{T_i^j (c_i^j d_{ni}^j)^{-\theta}}{T_n^j (c_n^j)^{-\theta}}$$

in logs:

$$\ln\left(\frac{\pi_{ni}^j}{\pi_{nn}^j}\right) = \ln\left(T_i^j (c_i^j)^{-\theta}\right) - \ln\left(T_n^j \left(c_n^j\right)^{-\theta}\right) - \theta \ln d_{ni}^j$$

- Iceberg costs:

$$\ln d_{ni}^j = \delta_k^j + b_{ni}^j + CU_{ni}^j + RTA_{ni}^j + ex_i^j + \nu_{ni}^j$$

- d_{ni}^j will vary by j; generally $d_{ni}^j \neq d_{in}^j$; fixed effect on the exporter (Waugh 2010)

Estimating Equation

$$\ln\left(\frac{\pi^j_{ni}}{\pi^j_{nn}}\right) = \underbrace{\ln\left(T^j_i (c^j_i)^{-\theta}\right) - \theta ex^j_i}_{\text{Exporter Fixed Effect}} \underbrace{- \ln\left(T^j_n \left(c^j_n\right)^{-\theta}\right)}_{\text{Importer Fixed Effect}}$$
$$\underbrace{-\theta\delta^j_k - \theta b^j_{ni} - \theta CU^j_{ni} - \theta RTA^j_{ni}}_{\text{Bilateral Observables}} \underbrace{-\theta\nu^j_{ni}}_{\text{Error Term}}$$

- Importer fixed effect yields technology-cum-unit-cost term relative to a reference country—the US:

$$S^j_n = \frac{T^j_n}{T^j_{us}}\left(\frac{c^j_n}{c^j_{us}}\right)^{-\theta}$$

Extracting T_n^j's

- Cost of the input bundle relative to the U.S.:

$$\frac{c_n^j}{c_{us}^j} = \left(\frac{w_n}{w_{us}}\right)^{\alpha_j \beta_j} \left(\frac{r_n}{r_{us}}\right)^{(1-\alpha_j)\beta_j} \left(\prod_{k=1}^{J} \left(\frac{p_n^k}{p_{us}^k}\right)^{\gamma_{k,j}}\right)^{1-\beta_j} \left(\frac{p_n^{J+1}}{p_{us}^{J+1}}\right)^{\gamma_{J+1,j}(1-\beta^j)}$$

- Price level in tradable sector j relative to the U.S.:

$$\frac{p_n^j}{p_{us}^j} = \left(\frac{\pi_{nn}^j}{\pi_{us,us}^j} \frac{1}{S_n^j}\right)^{\frac{1}{\theta}}$$

- Use data for the rest: $\frac{w_n}{w_{us}}$, $\frac{r_n}{r_{us}}$, $\frac{p_n^{J+1}}{p_{us}^{J+1}}$

Data

- 19 tradable sectors; 75 countries; 2000-2007
- Output, wages, value added, α_j, β_j: UNIDO
- Bilateral, sector-level trade: COMTRADE
- Distance, RTA, currency Union: CEPII, WTO, Rose (2004)
- $\gamma_{k,j}$, α_{J+1}, β_{J+1}, ω_j: U.S. 1997 Detailed Make and Use tables
- L_n, K_n, per capita income: Penn World Tables
- p_n^{J+1}/p_{us}^{J+1}, p_n^{J+1}/p_n^T: ICP Program
- ξ_n: Yi and Zhang (2010)
- $\theta = 8.28$ (EK preferred value); $\eta = 2$; $\varepsilon = 4$

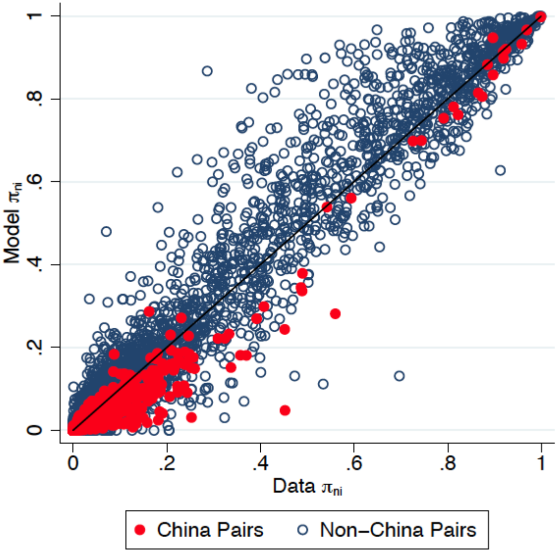
Sectors

ISIC code	Sector Name	α_j	β_j	$\gamma_{J+1,j}$	ω_j
15	Food and Beverages	0.315	0.281	0.303	0.209
16	Tobacco Products	0.264	0.520	0.527	0.01
17	Textiles	0.467	0.371	0.295	0.025
18	Wearing Apparel, Fur	0.493	0.377	0.320	0.089
19	Leather, Leather Products, Footwear	0.485	0.359	0.330	0.014
20	Wood Products (Excl. Furniture)	0.452	0.372	0.288	0.009
21	Paper and Paper Products	0.366	0.344	0.407	0.012
22	Printing and Publishing	0.484	0.469	0.407	0.004
23	Coke, Refined Petroleum Products, Nuclear Fuel	0.244	0.243	0.246	0.092
24	Chemical and Chemical Products	0.308	0.373	0.479	0.002
25	Rubber and Plastics Products	0.385	0.387	0.350	0.014
26	Non-Metallic Mineral Products	0.365	0.459	0.499	0.071
27	Basic Metals	0.381	0.299	0.451	0.002
28	Fabricated Metal Products	0.448	0.398	0.364	0.012
29C	Office, Accounting, Computing, and Other Machinery	0.473	0.390	0.388	0.094
31A	Electrical Machinery, Communication Equipment	0.405	0.380	0.416	0.057
33	Medical, Precision, and Optical Instruments	0.456	0.428	0.441	0.036
34A	Transport Equipment	0.464	0.343	0.286	0.175
36	Furniture and Other Manufacturing	0.460	0.407	0.397	0.065
4A	Nontradeables	0.561	0.651	0.788	
	Mean	0.414	0.393	0.399	0.053
	Min	0.244	0.243	0.246	0.002
	Max	0.561	0.651	0.788	0.209

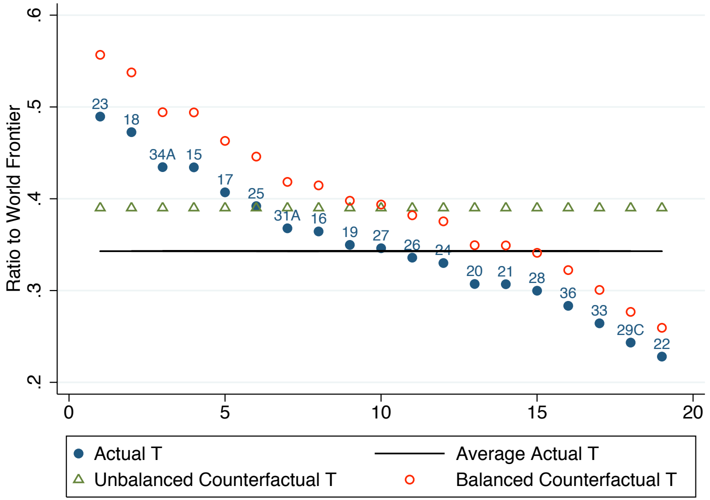
Model Fit

		Model	Data
Wages:			
	mean	0.369	0.333
	median	0.133	0.145
	corr(model, data)	*0.993*	
Return to capital:			
	mean	0.850	0.919
	median	0.718	0.698
	corr(model, data)	*0.955*	
π^j_{nn}			
	mean	0.626	0.568
	median	0.690	0.611
	corr(model, data)	*0.911*	
π^j_{ni}, $i \neq n$			
	mean	0.0054	0.0058
	median	0.0002	0.0002
	corr(model, data)	*0.902*	

Model Fit



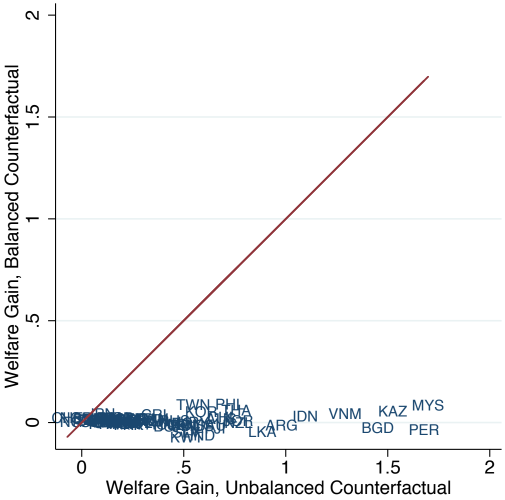
Welfare Impact of Balanced vs. Unbalanced Growth



Welfare Impact of Balanced vs. Unbalanced Growth

	Mean	Median	Min	Max	Countries
	Gains from Balanced Growth in China				
China	11.43				
OECD	0.01	0.02	-0.01	0.04	22
East and South Asia	0.03	0.04	-0.05	0.09	12
East. Europe and Cent. Asia	0.01	0.01	-0.02	0.06	11
Latin America and Caribbean	-0.01	0.00	-0.06	0.04	15
Middle East and North Africa	-0.01	-0.01	-0.07	0.02	6
Sub-Saharan Africa	0.00	0.01	-0.02	0.02	8
	Gains from Unbalanced Growth in China				
China	10.57				
OECD	0.17	0.12	-0.07	0.77	22
East and South Asia	0.84	0.74	0.22	1.70	12
East. Europe and Cent. Asia	0.42	0.34	0.07	1.52	11
Latin America and Caribbean	0.50	0.49	0.09	1.68	15
Middle East and North Africa	0.48	0.52	0.19	0.77	6
Sub-Saharan Africa	0.23	0.21	-0.03	0.57	8

Balanced vs. Unbalanced Growth



Intermediate Step: Fixed w and r

- True change in welfare between baseline and counterfactual:

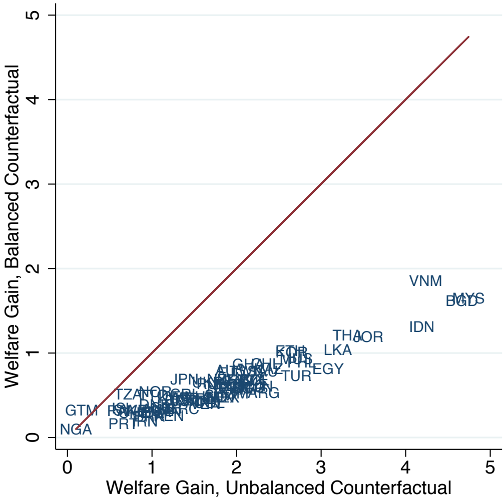
$$\Delta\left(\frac{w_n(\mathbf{T}) + r_n(\mathbf{T})k_n}{P_n(\mathbf{T}, \mathbf{w}, \mathbf{r})}\right)$$

- "Intermediate" Change in Welfare: hold w, r at their baseline values:

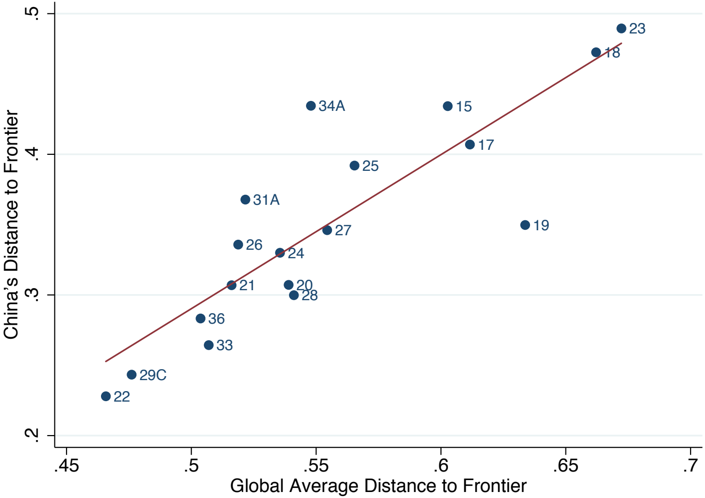
$$\Delta\left(\frac{\overline{w_n} + \overline{r_n}k_n}{P_n(\mathbf{T}, \overline{\mathbf{w}}, \overline{\mathbf{r}})}\right)$$

- Isolate the multilateral similarity effect operating through the price levels – counterpart to the analytical results with fixed factor prices

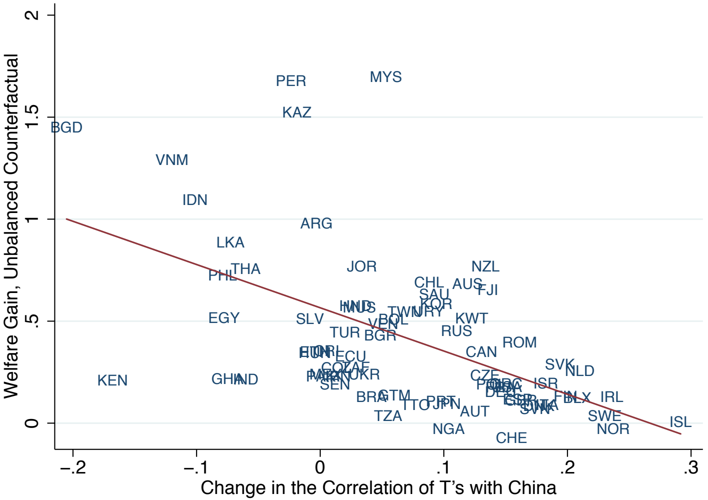
Intermediate Step: Fixed w and r



China's Comparative Advantage and the World Average



Unbalanced Gains and Technological Similarity



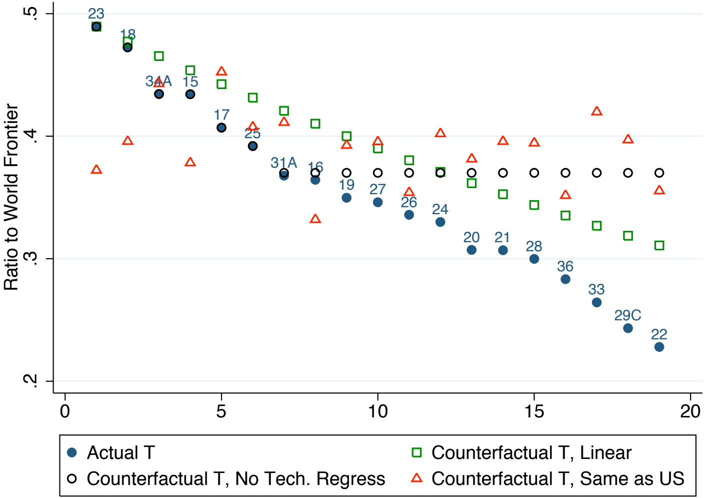
Robustness

- Trade imbalances à la Dekle, Eaton, and Kortum (2007, 2008)
  - D_n is a transfer; taken directly from the data

$$\sum_{j=1}^{J+1} p_n^j Y_n^j = w_n L_n + r_n K_n - D_n.$$

- Adding Agriculture and Mining sectors (14% of world trade)
- Directly estimated sectoral productivity for those countries where data are available (STAN: Austria, Belgium, Czech Republic, Denmark, Finland, France, Greece, Italy, Norway, Slovenia, and Sweden)
- Alternative unbalanced counterfactuals: no absolute productivity loss, exactly the same as the US.

Alternative Unbalanced Counterfactuals



Conclusion

- China's entry into world trade has been dramatic
- Concerns: for developing countries with respect to trade integration; for developed countries with respect to technological change
- This paper: analytical exploration and quantitative assessment of the global welfare impact of China's integration and sectoral growth
  - Trade integration: global impact $\sim 0.13\%$, $\sim 0.23\%$ in Asia; winners (Malaysia, Kazakhstan, Japan, Australia/NZ) and losers (Textile and Apparel producers)
  - Technological change: world is 40 times (!) better off with unbalanced productivity growth in China