Multinational Production and Comparative Advantage

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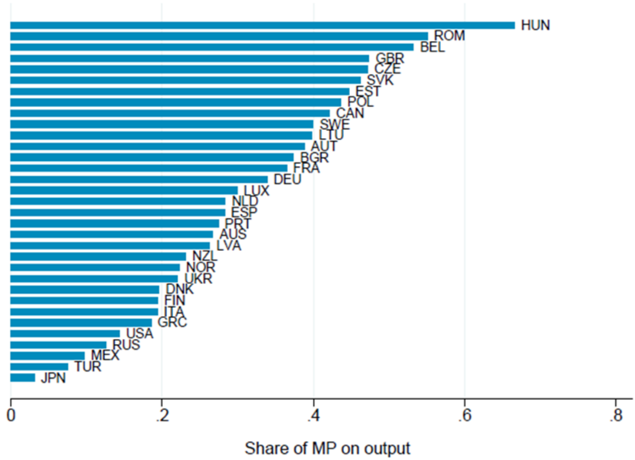
Multinational Production (MP) and Sectoral Productivity

- What is the relationship between MP and differences in relative productivity across sectors?

  Observations:

  - MP represents a large fraction of output, employment and trade
  - The fraction of MP on output is significantly heterogeneous across sectors
  - Significant cross-country differences in the sectoral heterogeneity of MP
  - MP and sectoral productivity are negatively correlated

Relevance of Multinational Production



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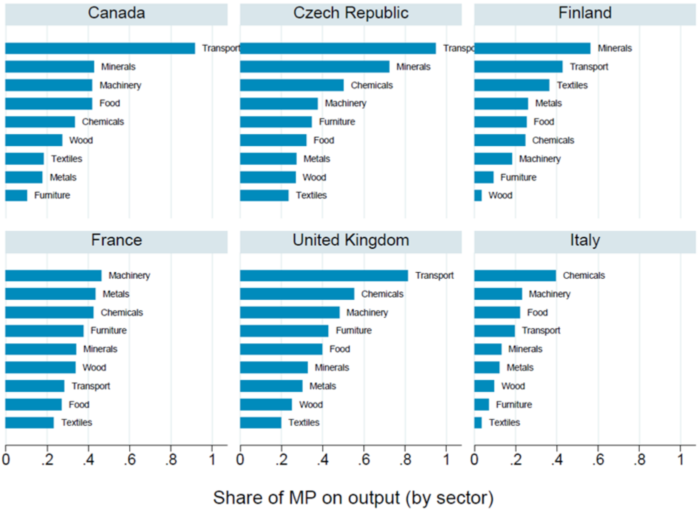
Sectoral Heterogeneity of MP shares



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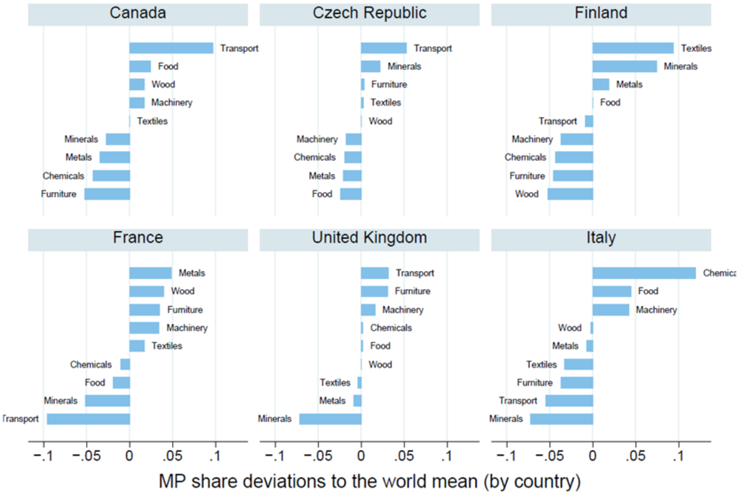
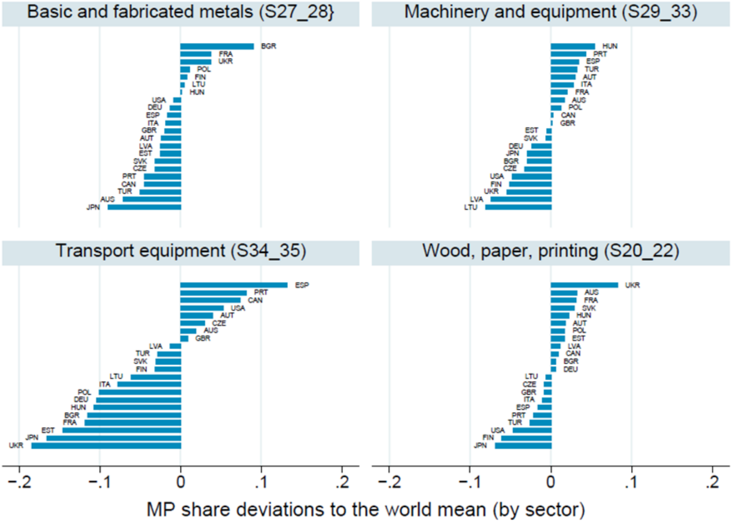
Cross-country differences in MP heterogeneity



Cross-country differences in MP heterogeneity

▸ index



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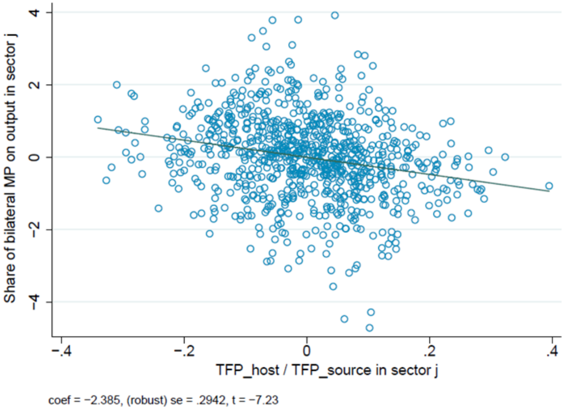
MP is correlated with sectoral productivity

Negative Correlation Between $(MP^j_{hs}/output^j_h)$ and Relative TFP

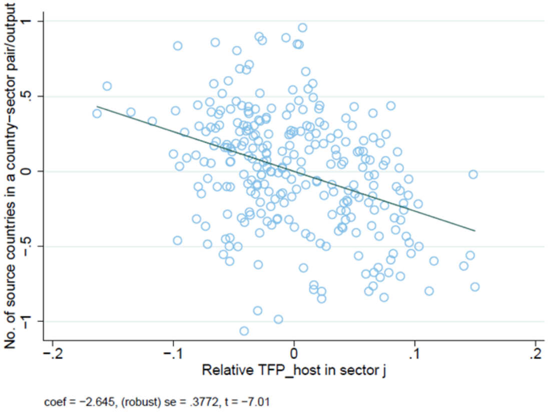
- Foreign affiliate sales are higher in sectors where the host economy is relatively less productive.



MP is correlated with sectoral productivity

Negative Correlation Between ($\#sources^j_{hs}/output^j_h$) and Relative TFP

- More source countries invest in sectors where the host economy is relatively less productive.



Bilateral MP and Productivity Differences

Dep. Variable $ln\left(MP^j_{hs}/output^j_h\right)$	Relative Productivity Measures: Model Base Productivity (1)	(2)	RCA Index (3)	(4)	GDDC productivity (5)	(6)
$ln\left(TFP^j_h/TFP^j_s\right)$	–1.872***	–1.657***	–1.359***	–1.387***	–0.428**	–0.392**
	(0.3260)	(0.3304)	(0.4376)	(0.4464)	(0.2023)	(0.1709)
ln(Distance)	–0.5130***		–0.168		–0.161	
	(0.0926)		(0.1923)		(0.1572)	
Common Language	0.077		0.6093**		0.0692	
	(0.1996)		(0.297)		(0.2164)	
Colony	0.643***		0.2961		0.5254***	
	(0.1496)		(0.2768)		(0.1703)	
Border	0.188		0.225		0.666***	
	(0.1819)		(0.2094)		(0.2411)	
RTA	0.259		0.300		0.865***	
	(0.1832)		(0.3604)		(0.2495)	
Hecksher-Ohlin:						
$log(K/L)^j \times log(K/L)_h$	–0.2676	–0.258	–0.1529	–0.1612	–0.163	–0.168
	(0.2502)	(0.2518)	(0.1756)	(0.1767)	(0.1432)	(0.1449)
Controls						
Source-country FE	Yes	–	Yes	–	Yes	–
Host-country FE	Yes	–	Yes	–	Yes	–
Host-source FE	No	Yes	No	Yes	No	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	10,098	7,101	1,404	1,242	2,448	2,200
Adjusted R^2	0.29	0.42	0.59	0.69	0.34	0.47

Interaction between Multinational Production (MP) and Comparative Advantage

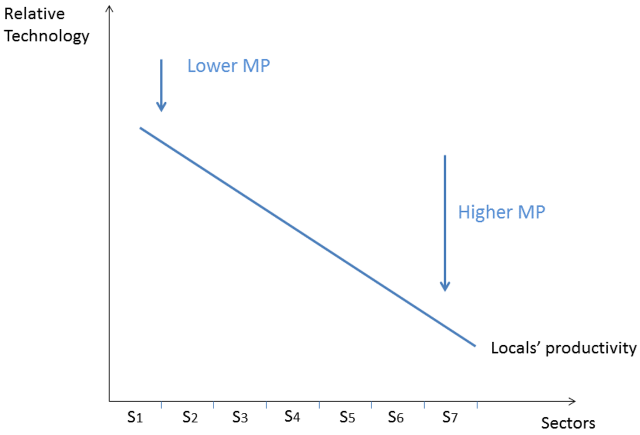
- Are the observed uneven allocation of MP across sectors related to differences in sectoral productivity?
- Does multinational production affect the average productivity of each industry differently?
- What are the welfare implications of the interaction between MP and relative differences in sectoral productivity?

Can MP affect relative productivity differences across sectors?

- Multinationals bring knowhow, innovative knowledge, and managerial skills.
- MP induces larger transfer of technology in sectors where the host country is relatively less productive
  - Reducing differences in relative productivity across sectors

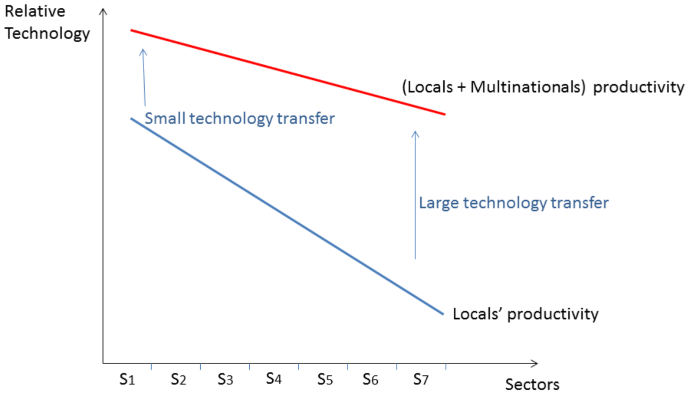
CA → MP

Effect of Comparative Advantage on MP allocation



MP → CA

Effect of MP on Comparative Advantage



This paper

1. Assembles an industry-level dataset of bilateral foreign affiliates' sales to document some empirical regularities

2. Incorporates a sectoral dimension into a multi-country model of trade and MP:
   - Estimates productivities at the sectoral level for *domestic* and *all* producers in the economy
   - Derives analytical implications for welfare
   - Conducts counterfactual exercises to evaluate the effects of MP
   - Unisectoral models of Trade and MP are silent with respect to the interaction between MP and comparative advantage

Preview of Results

- The increase in real income following an opening to multinational activity is 15 percentage points higher compared to the case where MP is homogeneous across sectors (27% compared to 12%)

- The increase in real income following a trade liberalization is about half of what it would be if MP does not affect comparative advantage (10% compared to 19.4%)

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Contribution to Related Literature

- Uni-sector MP-trade models:
  - Ramondo and Rodriguez-Clare (2011); Shikher (2011)
  - Arkolakis, Ramondo, Rodriguez-Clare and Yeaple (2012)
  - Alfaro and Chen (2012, 2011)

- Multi-sector trade-only models:
  - Costinot, Donalson and Komunjer (2012), Caliendo and Parro (2013), Levchenko and Zhang (2012)

- Horizontal MP and technology transfer:
  - Guadalupe, Kuzmina and Thomas (2012), Fons-Rosen et al (2013), Chen and Alfaro (2011), Békeé, Kleinert and Toubal (2009), Blyde et al. (2004)
  - Brainard (2009, 2011), Ramondo et al. (2012), Neary (2007)

Roadmap

- Presents a GE model of trade and MP that incorporates the sectoral dimension.
- Estimates productivity parameters of local producers and overall economy for each country-sector pair.
- Evaluates the welfare implications of the effect of MP on comparative advantage.

A Multi-Sector Trade-MP Model

Environment

- N countries: source (s), host (h) and destination market (m)
- J tradable sectors and one ($J+1$) non-tradable sector
  - Each sector has a continuum of varieties $\omega = [0, 1]$
- MP by source country s in host country h occurs when a technology from s is used in h to produce variety ω.
  - Trade: Country produces from their own market to sell to a foreign market $s = h$.
  - MP: Country produces at the destination market $h = m$.
  - Export Platforms: Country s produces in h to sell from there to destination market m.

preferences

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▸ preferences

A Multi-Sector Trade-MP Model

Environment

- Using technology to produce in a foreign country entails a cost:
  - Iceberg MP costs: $g^{j}_{hs} > 1$, and $g^{j}_{ss} = 1$
- Trade across countries is costly:
  - Iceberg trade costs: $d^{j}_{nh} > 1$, and $d^{j}_{hh} = 1$
- Factors of Production: capital (K), labor (L)
- Productivity of each country-sector pair is described by:

$$\mathbf{z^j_s}(\omega) \equiv \left\{ z^{j}_{1s}(\omega), z^{j}_{2s}(\omega), ..., z^{j}_{Ns}(\omega) \right\} \quad \forall i, j = 1 : N$$

technology

Production Structure

- Production function:

$$Q^j_{mhs}(\omega) = \left[\left(L^j_h\right)^{\alpha_j}\left(K^j_h\right)^{1-\alpha_j}\right]^{\beta_j}\left[\prod_{k=1}^{J+1}\left(Q^k_s\right)^{\gamma_{kj}}\right]^{1-\beta_j}\left(\frac{z^j_{hs}(\omega)}{g^j_{hs}}\right)$$

$$\Rightarrow \quad p^j_{mhs}(\omega) = \left(\frac{c^j_h g^j_{hs}}{z^j_{hs}(\omega)}\right) d^j_{mh}$$

where:

$$c^j_h = \left[\left(w^j_h\right)^{\alpha_j}\left(r^j_h\right)^{1-\alpha_j}\right]^{\beta_j}\left[\prod_{k=1}^{J+1}\left(p^k_h\right)^{\gamma_{kj}}\right]^{1-\beta_j}.$$

Production Structure

- Seller s will choose the location h to reach country m with the lowest possible price

$$p^j_{ms}(\omega) = min\left\{p^j_{m1s}(\omega), p^j_{m2s}(\omega), ..., p^j_{mNs}(\omega)\right\}$$

- Consumers in m will choose to buy from the source technology country s that offers the cheapest price

$$p^j_{m}(\omega) = min\left\{p^j_{m1}(\omega), p^j_{m2}(\omega), ..., p^j_{mN}(\omega)\right\}$$

Market Structure

- Hence, the probability that country (m) imports sector (j) goods from country (h) using country (s) technologies is described as:

$$\pi^j_{mhs} = \underbrace{\frac{T^j_s \left(\Delta^j_{ms}\right)^{-\theta_j}}{\sum_s T^j_s \left(\Delta^j_{ms}\right)^{-\theta_j}}}_{\text{Term 1}} \cdot \underbrace{\frac{\left(\delta^j_{mhs}\right)^{-\theta_j}}{\sum_h \left(\delta^j_{mhs}\right)^{-\theta_j}}}_{\text{Term 2}}.$$

where $\Delta^j_{ms} = \left(\sum_h \left(\delta^j_{mhs}\right)^{-\theta_j}\right)^{-\frac{1}{\theta_j}}$ and $\delta^j_{mhs} = d^j_{mh} c^j_h g^j_{hs}$.

Trade Shares: π_{mh}^{j}

- Summing up π_{mhs}^{j} across source countries s

$$\pi_{mh}^{j} = \sum_{s=1}^{N} \pi_{mhs}^{j}$$

$$\frac{X_{mh}^{j}}{X_{m}^{j}} = \pi_{mh}^{j} = \frac{\widetilde{T_h^j}\left(c_h^j d_{mh}^j\right)^{-\theta}}{\sum_{k=1}^{N} \widetilde{T_k^j}\left(c_k^j d_{mk}^j\right)^{-\theta}}$$

Where $\widetilde{T_h^j}$ is the *effective technology*:

$$\widetilde{T_h^j} = T_1^j {g_{h1}^j}^{-\theta} + T_2^j {g_{h2}^j}^{-\theta} + \ldots + T_N^j {g_{hN}^j}^{-\theta}$$

MP Shares: y^j_{hs}

- MP sales: summing up $\pi^j_{mhs} X^j_m$ across destination countries m; where $X^j_m = p^j_m Q^j_m$

$$I^j_{hs} = \sum_{m=1}^{N} \pi^j_{mhs} X^j_m$$

$$I^j_{hs} = \frac{T^j_s \left(g^j_{hs} c^j_h\right)^{-\theta}}{\left(p^j_h\right)^{-\theta}} \frac{\left(X_h\right)^2}{X_{hh}}$$

- MP shares are given by:

$$y^j_{hs} = \frac{I^j_{hs}}{\sum_s I^j_{hs}} = \frac{I^j_{hs}}{I^j_h} = \frac{T^j_s \left(g^j_{hs}\right)^{-\theta}}{\widetilde{T}^j_h}$$

Closing the Model

- Given the set of prices $\left\{w_h, r_h, P_h, \left\{p_h^j\right\}_{j=1}^{J+1}\right\}_{h=1}^{N}$, production is allocated across countries and sectors as follows:

$$p_h^j Q_h^j = p_h^j Y_h^j + \sum_{k=1}^{J+1} \left(1-\beta_k\right) \gamma_{j,k} \left(\sum_{m=1}^{N} \sum_{s=1}^{N} \pi_{mhs}^k p_m^k Q_m^k \right)$$

- The optimal sectoral factor allocations in country h and tradable sector j must thus satisfy:

$$\sum_{m=1}^{N} \sum_{s=1}^{N} \pi_{mhs}^j p_m^j Q_m^j = \frac{w_h L_h^j}{\alpha_j \beta_j} = \frac{r_h K_h^j}{\left(1-\alpha_j\right) \beta_j}.$$

Analytical predictions

Simplifying assumptions

- Cobb Douglas preferences and equal expenditure shares ▸ Preferences
- A mirror image of the fundamental productivity across sectors and countries: $T_1^a = T_2^b$ and $T_1^b = T_2^a$
- Country 2 has comparative advantage in sector a:

$$T_2^a > T_2^b$$

- Symmetry in trade and MP barriers
- The above assumptions ensure that wages are equal in both countries, $w_1 = w_2 = 1$

Welfare Analysis: Gains from Trade

- Welfare: an expression for real wage

$$W_s = \frac{w_s}{\left(p_s^a p_s^b\right)^{\frac{1}{2}}} = \Gamma^{-1}\left(T_s^a T_s^b\right)^{\frac{1}{2\theta}}\left(\pi_{ss}^a \pi_{ss}^b\right)^{-\frac{1}{2\theta}}\left(y_{ss}^a y_{ss}^b\right)^{-\frac{1}{2\theta}}$$

- Gains from trade: $\left(\pi_{ss}^a \pi_{ss}^b\right)^{-\frac{1}{2\theta}}$

$$GT_s = \frac{W_{d>0}^s}{W_{d\to\infty}^s} = \left(\frac{\left(\widetilde{T_1^a}/T_1^a\right)\left(\widetilde{T_1^b}/T_1^b\right)}{\sum_{j=a,b}(1+(dg^j)^{-\theta}) + \frac{T_1^{\neq j}}{T_1^j}(g^{j-\theta}+d^{-\theta})}\right)^{-1/2\theta}$$

Welfare Analysis: Gains from MP

- Welfare: an expression for real wage

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- Gains from MP:

$$GMP_s = \frac{W_{g>0}^s}{W_{g\to\infty}^s} = \left[\frac{\sum_{j=a,b}\left(1+\frac{T_1^{\neq j}}{T_1^j}d^{-\theta}\right)}{\sum_{j=a,b}\left(1+\left(dg^j\right)^{-\theta}\right)+\frac{T_1^{\neq j}}{T_1^j}\left({g^j}^{-\theta}+d^{-\theta}\right)}\right]^{-\frac{1}{2\theta}}$$

MP is disproportionately allocated in comparative disadvantage sectors

Proposition 1

In a two-country, two-sector world economy, the lower the technology of country 1 in sector a (country 1's comparative disadvantage sector) relative to sector b, the higher the probability that firms from country 2 will produce in sector a relative to sector b in country 1.

▸ Proposition 1

The higher the heterogeneity of MP across sectors, the higher the gains from MP

Proposition 2

The higher the heterogeneity of MP across sectors, the higher the gains from MP. When the share of domestically produced goods is the same across sectors ($y^a_{hh} = y^b_{hh}$), the gains from MP attain a minimum. Therefore, uni-sectoral trade-MP models understate the actual gains from MP as long as $y^a_{hh} \neq y^b_{hh}$

Gains from trade are lower the more heterogeneous the technology upgrade across sectors

Proposition 3

The more heterogeneous the technology upgrade across sectors toward comparative disadvantage sectors, the lower the dispersion of effective technologies and the lower the gains from trade

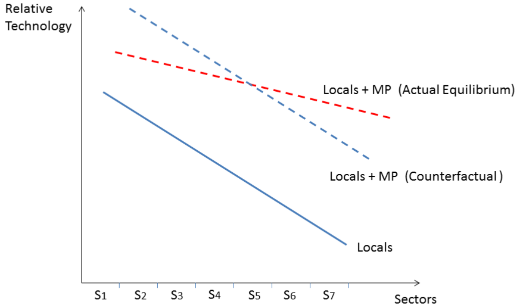

Figure: Proportional Technology Transfer

Bilateral MP Data: Sectoral Dimension

- Coverage:
  - 34 declaring countries
  - 9 manufacturing and 4 non-manufacturing sectors
- Variables:
  - Sales, and employment
- Unit of Analysis:
  - Each observation is a (source-host-sector) triplet, averaged over the period 2002-2010
- Sources:
  - OECD (Statistics on Measuring Globalization and IDIS)
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Estimating Model's Parameters

Trade and MP Gravity Equations

- Trade Gravity Equation

$$ln\left(\frac{X_{mh}^{j}}{X_{mm}^{j}}\right) = \underbrace{\ln\left(\widetilde{T_h^j}\left(c_h^j\right)^{-\theta}\right)}_{\text{exporter fixed effect}} - \underbrace{ln\left(\widetilde{T_m^j}\left(c_m^j\right)^{-\theta}\right)}_{\text{importer fixed effect}} - \underbrace{\theta ln\left(d_{mh}^j\right)}_{\text{bilateral observables}}$$

- Trade barriers are defined as:

$$ln\left(d_{mh}^j\right) = d_k^j + b_{mh}^j + CU_{mh}^j + RTA_{mh}^j + exporter_h^j + v_{mh}^j$$

◂ Two Step Procedure

Estimating Model's Parameters

Trade and MP Gravity Equations

- MP Gravity Equation

$$ln\left(\frac{I_{hs}^{j}}{I_{hh}^{j}}\right) = \underbrace{ln\left(T_{s}^{j}\right)}_{\text{source fixed effect}} - \underbrace{ln\left(T_{h}^{j}\right)}_{\text{host fixed effect}} - \underbrace{\theta ln\left(g_{hs}^{j}\right)}_{\text{bilateral observables}}$$

- MP barriers are defined as:

$$ln\left(g_{hs}^{j}\right) = d_{k}^{j} + b_{hs}^{s} + CU_{hs}^{j} + RTA_{hs}^{j} + source_{s}^{j} + \mu_{hs}^{j}$$

Estimating Model's Parameters

Recovering the T_h^j

- Recall that effective technology parameters are given by

$$\begin{bmatrix} \widetilde{T}_1^j \\ \widetilde{T}_2^j \\ .. \\ .. \\ \widetilde{T}_N^j \end{bmatrix} = \begin{bmatrix} g_{11}^j & g_{12}^j & .. & .. & g_{1N}^j \\ g_{21}^j & g_{22}^j & .. & .. & g_{2N}^j \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ g_{N1}^j & g_{N2}^j & .. & .. & g_{NN}^j \end{bmatrix} \times \begin{bmatrix} T_1^j \\ T_2^j \\ .. \\ .. \\ T_N^j \end{bmatrix}$$

- Given $\widetilde{T}_s^j$ and h_{si}^j we can solve for the fundamental productivity T_i^j using the above system of equations for each sector j

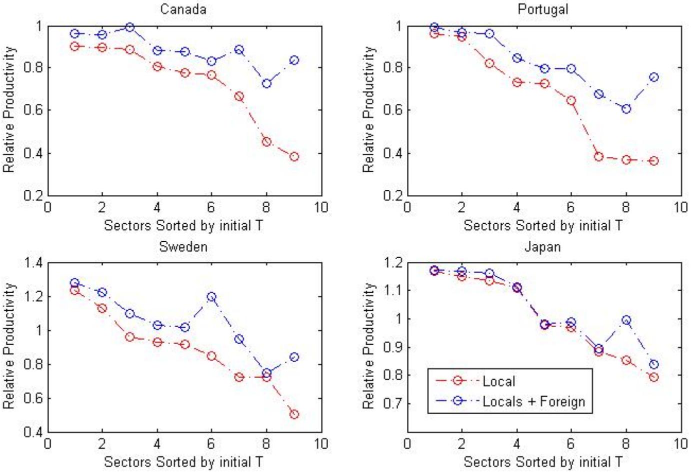
◂ Other methods

Table: Change in Absolute and Comparative Advantage

	Variable	Mean
Group 1 (10 countries)	ΔCV	-0.19
	ΔT	0.09
Group 2 (24 countries)	ΔCV	-0.29
	ΔT	0.17
All sample (34 countries)	ΔCV	-0.25
	ΔT	0.14

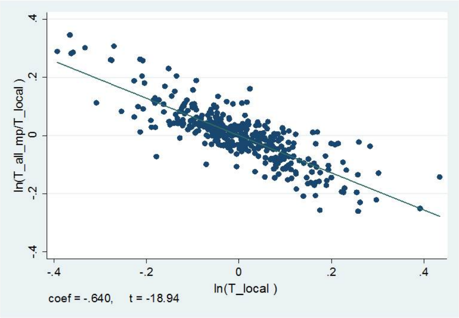
per country

MP Technology Transfer



MP technology transfer

$$ln\left(\widetilde{T}_h^j\right)^{1/\theta} - ln\left(T_h^j\right)^{1/\theta} = \beta_0 + \beta_1 ln\left(T_h^j\right)^{1/\theta} + \gamma_h + \delta_j + \epsilon_{hj}$$



The Fit of the Baseline Model with the Data

		Model	Data
Wages			
	Mean	0.761	0.650
	Median	0.790	0.710
	corr(model,data)	0.920	
Imports/GDP			
	Mean	0.364	0.359
	Median	0.342	0.291
	corr(model,data)	0.829	
Inward MP/Production			
	Mean	0.338	0.269
	Median	0.302	0.258
	corr(model,data)	0.758	

Proportional Technology Transfer

Counterfactual 1: Gains from Trade

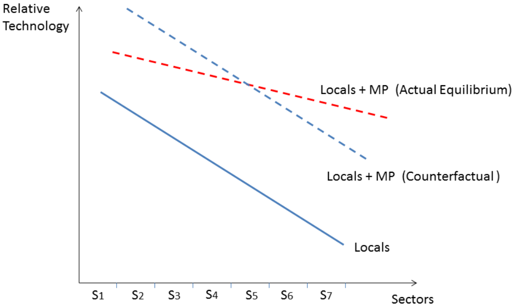


Figure: Counterfactual 2: Proportional Technology Transfer

Gains from MP: in a multisector framework

Counterfactual 1: Gains from MP

Table: Gains From MP

	Median	Mean	Std.Dev	Min	Max
	MP Gains (Multisector) (%)				
Counterfactual Vs Baseline	15.59	27.01	0.29	9.58	93.48
	MP Gains (Uni-sector) (%)				
Counterfactual Vs Baseline	8.42	12.03	0.17	0.02	79.35

Proportional Technology Transfer

Counterfactual 2: Gains from Trade

Table: Proportional Technology Transfer

	Mean	Median	Std.Dev	Min	Max
	Gains from Trade (%)				
Actual Gains	10.39	9.28	0.05	1.19	24.53
Counterfactual	19.05	17.42	0.08	9.18	33.81

Infinity barriers to MP in non-tradable sectors

Counterfactual 3: welfare effect

Table: MP in non-tradables

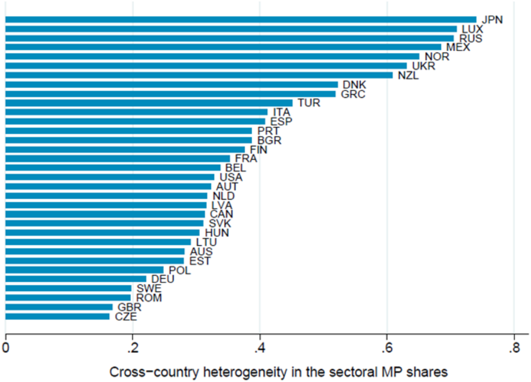
	Median	Mean	Std.Dev	Min	Max
	Welfare Change (%)				
Counterfactual Vs Baseline	4.69	6.53	0.05	1.54	12.33
	Tradable Price Index (%)				
Counterfactual Vs Baseline	1.87	1.62	0.04	0.63	2.13

Conclusion

- This paper documents a new empirical regularity: A negative relationship between MP and comparative advantage
- It shows that MP weakens countries comparative advantage
- It shows that uni-sectoral models systematically overstate the gains from trade and understate the gains from MP

Appendix

Cross-country differences in MP heterogeneity



▸ cross-country differences

Preferences

- Consumers in country m maximize utility subject to the budget constraint:

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

s.t.

$$\sum_{j=1}^{J+1} p_m^j Y_m^j = w_m L_m + r_m K_m$$

- P_m - price level in country m is given by:

$$P_m = B_m \left(\sum_{j=1}^{J} \omega_j \left(p_m^j \right)^{1-\eta} \right)^{\frac{1}{1-\eta}\xi_m} \left(p_m^{J+1} \right)^{1-\xi_m},$$

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Technology

- Productivity vectors are drawn independently across varieties ω in sector j and origin country i from a multivariate Frechet distribution

$$F_s^j(\mathbf{z}) = exp\left[-T_s^j\left(\sum_{h=1}^{N}\left(z_{hs}^j\right)^{-\theta_j}\right)\right].$$

- Productivity differences are characterized by :
  1. Inter-industry heterogeneity or relative technology differences in fundamental productivity across industries $\left(T_s^{j=a}/T_s^{j=b}\right)$
  2. Intra-industry heterogeneity, governed by θ^j

▸ technology

MP and sectoral productivity

	Employment	Sales	Value Added Added
		BEA	
Rel. Productivity	-3.71***	-1.98**	-2.12**
Obs.	1,089	1,089	1,353
		OECD	
Rel. Productivity	-1.39***	-1.05***	-1.08***
Obs.	1,260	1,366	1,100

Note: Standard errors are cluster at the country level. All regressions have country and year fixed effects

◂ MP and Productivity

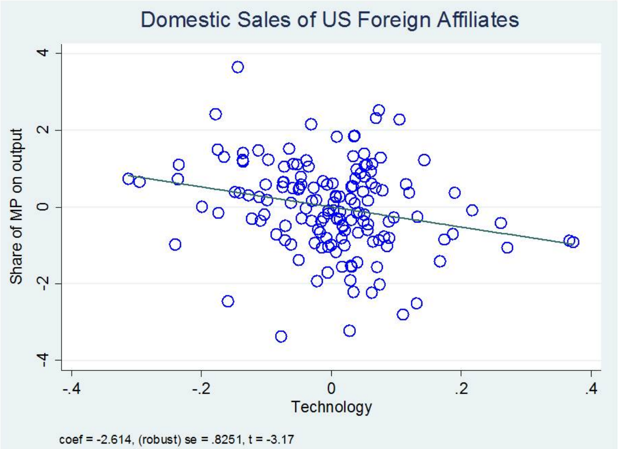
MP and Comparative Advantage

$$MPsales_n^j = \alpha + \beta \cdot TFP_n^j + \delta_n + \gamma_j + \epsilon_n^j$$

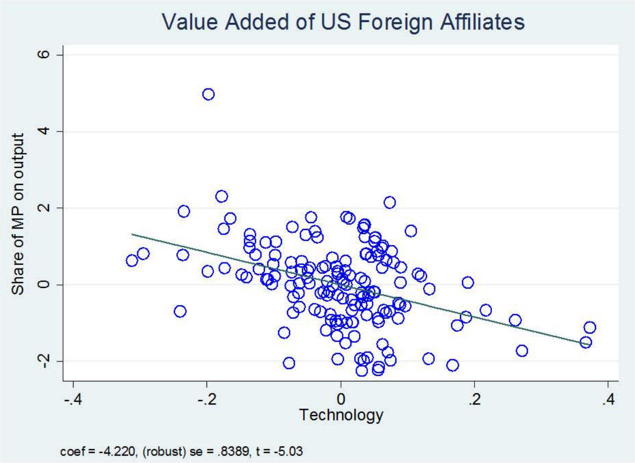
- MP sales are normalized by output in country n and sector j
- *Total Factor Productivity* (TFP_n^j) is measured relative to the frontier in sector j
- δ_n and γ_n denotes country and sector fixed effects
- robust to TFP correction by selection in open economies, and alternative measures of MP

▸ Robustness

MP and Comparative Advantage



MP and Comparative Advantage



MP in comparative disadvantage sectors

Proof: Lets define the ratio of probabilities $\frac{\pi^a_{112}}{\pi^b_{112}}$ that country 2 produce in country 1 as:

$$\frac{\pi^a_{112}}{\pi^b_{112}} = \frac{T^a_2}{T^b_2}\left[\frac{\frac{T^b_2}{T^a_1}\left(h^{-\theta}+d^{-\theta}\right)^{-\frac{1}{\theta}}+\frac{T^b_1}{T^a_1}\left[1+(hd)^{-\theta}\right]^{-\frac{1}{\theta}}}{\frac{T^a_1}{T^b_1}\left(h^{-\theta}+d^{-\theta}\right)^{-\frac{1}{\theta}}+\left[1+(hd)^{-\theta}\right]^{-\frac{1}{\theta}}}\right]$$

$$\partial\left(\frac{\pi^a_{112}}{\pi^b_{112}}\right)/\partial T^a_1 < 0$$

$$\partial\left(\frac{\pi^a_{112}}{\pi^b_{112}}\right)/\partial T^a_2 > 0$$

Proposition 1

Estimating Model's Parameters

Recovering the T_s^j

- Given T_s^j (obtained from the gravity equation fixed effects) and h_{si}^j we can calculate the effective productivity $\widetilde{T}_i^j$ for each sector j

$$\widetilde{T}_1^j = T_1^j {h_{11}^j}^{-\theta} + T_2^j {h_{12}^j}^{-\theta}$$
$$\widetilde{T}_2^j = T_1^j {h_{21}^j}^{-\theta} + T_2^j {h_{22}^j}^{-\theta}$$

Estimating Model's Parameters

Generalize Method of Moments

- Given h_{si}^{j} and d_{si}^{j}, T_i^j are chosen to minimize:

$$\min_{T_s^j} \left[(1 - R^T) + (1 - R^{MP}) \right]$$

where R^T and R^{MP} are given by:

$$R^T \equiv 1 - \frac{\sum_{i,n;n\neq i} \left[\widetilde{X}_{ni}^{j,data} - \widetilde{X}_{ni}^{j,model} \right]^2}{\sum_{i,n;n\neq i} \left(\widetilde{X}_{ni}^{j,data} \right)^2}$$

$$R^{MP} \equiv 1 - \frac{\sum_{i,n;n\neq i} \left[\widetilde{I}_{ni}^{j,data} - \widetilde{I}_{ni}^{j,model} \right]^2}{\sum_{i,n;n\neq i} \left(\widetilde{I}_{ni}^{j,data} \right)^2}$$

◂ preferred method

Effective technology: two step procedure

- The importer fixed effect

$$S_n^j = \frac{\widetilde{T}_n^j}{\widetilde{T}_{us}^j} \left(\frac{c_n^j}{c_{us}^j} \right)^{-\theta}$$

- The share of spending going to home-produced goods

$$\frac{X_{nn}^j}{X_{us}^j} = \widetilde{T}_n^j \left(\frac{c_n^j}{p_n^j} \right)^{-\theta}$$

- Dividing it by US, we have:

$$\frac{X_{nn}^j / X_n^j}{X_{us,us}^j / X_{us}^j} = \frac{\widetilde{T}_n^j}{\widetilde{T}_{us}^j} \left(\frac{c_n^j}{c_{us}^j} \right)^{-\theta} \left(\frac{p_n^j}{p_{us}^j} \right)^{-\theta} = S_n^j \left(\frac{p_{us}^j}{p_n^j} \right)^{-\theta}$$

Effective technology: two step procedure

- The ratio of price levels in sector j relative to US becomes

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

- The cost of the input bundles relative to the U.S can be written as:

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

◀ Trade Gravity Equation

Technology

- Productivity vectors are drawn independently across sector varieties ω in sector j and origin country i from univariate Frechet marginals combined by a copula

$$F_i^j(\mathbf{z}) = exp\left\{-T_i^j\left[\left(z_{1i}^j(\omega)\right)^{-\frac{\theta_j}{1-\rho_j}} + \left(z_{2i}^j(\omega)\right)^{-\frac{\theta_j}{1-\rho_j}}\right]^{1-\rho_j}\right\}$$

- There are three levels of heterogeneity in this model:
  1. Inter-industry heterogeneity or relative technology differences in fundamental productivity across industries T_i^1/T_i^2
  2. Intra-industry heterogeneity, governed by θ
  3. Correlation between draws from different locations ρ.

▸ technology

Preferences

- Two-tier preferences:
  - First tier: Cobb-Douglas (ξ_n) on aggregate tradable sectors Y_n^j

$$Y_n = (Y_n^a)^{\xi_n} \left(Y_n^b\right)^{1-\xi_n}$$

  - Second tier: CES (ε_n) on varieties $Y_n^j(\omega)$

$$Y_n^j = \left(\int_0^1 Y_n^j(\omega)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} d\omega\right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}}$$

- And the actual price in sector j, country n is given by:

$$P_n^j = B_n (p_{n1})^{\xi_n} (p_{n2})^{1-\xi_n}$$

◂ Assumptions

MP and trade barriers

Table: Estimated trade d^j_{nh} and g^j_{hs}

Sector	Trade	MP
Food	2.64	2.75
Textiles	2.13	2.64
Wood	2.65	2.16
Chemicals	2.28	3.14
Non-metallic	2.75	2.25
Metals	2.39	3.87
Machinery	1.98	2.91
Transport	2.37	3.76
Furniture	2.15	2.07

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Average Change		Relative Change	
Top 10: Largest Change Countries		Top 10: Largest Change Countries	
Czech Rep.	0.41	Poland	-0.53
Poland	0.35	Czech Rep	-0.52
Lithuania	0.30	Spain	-0.52
Hungary	0.29	Portugal	-0.52
Austria	0.24	Canada	-0.51
Netherlands	0.22	Austria	-0.48
Slovakia	0.22	Italy	-0.47
Portugal	0.22	Turkey	-0.43
Sweden	0.20	Russia	-0.42
Canada	0.17	Sweden	-0.41
Turkey	0.14	Slovenia	-0.39

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Average Change		Relative Change	
Bottom 10: Smallest Change Countries		Bottom 10: Smallest Change Countries	
Finland	0.09	Japan	-0.14
France	0.07	Belgium	-0.08
Switzerland	0.06	Denmark	-0.07
Denmark	0.04	Greece	-0.06
Norway	0.04	United Kingdom	-0.06
New Zealand	0.04	Norway	-0.04
Australia	0.03	Latvia	0.05
Belgium	0.02	Germany	0.08
Greece	0.01	France	0.14
Israel	0.01	Bulgaria	0.14

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Model's correlation of MP sales and T_s^j