Specialization Dynamics, Convergence, and Idea Flows

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Motivation

- There is strong convergence in industry-level manufacturing productivity (Rodrik, 2013; Levchenko and Zhang, 2016)
- Changes in industry-level productivity are driving the evolving patterns of international trade (Hanson, et al., 2016)
- They have important implications on
  - economic growth – catch-up effects
  - diversification – discovery of new export industries
  - labor market – great reallocation of workers across industries
  - welfare gains from trade – weakened comparative advantage

Convergence in Ricardian Comparative Advantage

Value added per worker, ISIC 2-digit, country and industry fixed effects controlled

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- What is driving cross-country convergence in Ricardian comparative advantage?
- Answer from growth theory: international knowledge diffusion (Grossman and Helpman, 1991).
- **Research Question: Can knowledge diffusion explain the convergence pattern in a quantitative manner?**
- This paper studies how knowledge diffusion gives rise to convergence in industry-level productivity and examines its quantitative implications on specialization dynamics.

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- Decompose contribution to global productivity growth into different channels.
- Quantify gains from trade (in a multi-industry setting taking into account input-output linkages).
- Identify the "key player," that is, the country (country-industry pair) that contributes most to knowledge diffusion.

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- The calibrated model reproduces the convergence pattern for industry-level TFP and a variety of measures of comparative advantage.
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  - Annual rate of convergence in TFP $\approx 1.5\%$
- It also captures substantial mobility in specialization.
- Contribution of each channel to global knowledge diffusion
  - Intra-industry domestic diffusion = 16%
  - Inter-industry domestic diffusion = 20%
  - Intra-industry international diffusion = 26%
  - Inter-industry international diffusion = 38%

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- Dynamic gains from trade = on average additional 8% of GDP
  - After opening up to trade, international knowledge diffusion leads to higher productivity growth. It brings about 8% gains.
- Analysis of the global diffusion network also reveals the important role as knowledge intermediaries played by emerging market economies.

Relation to the literature

- Specialization dynamics measured by value-added, advanced economies (Redding, 2002); export volume, Africa (Easterly and Reshef, 2010), export capability (Hanson, Lind, and Muendler, 2015).
- Convergence in unit value of products, (Hwang, 2006), value-added per worker (Rodrik, 2013), and industry-level TFP (Levchenko and Zhang, 2016).
- Quantifiable trade model: Eaton and Kortum (2002); dynamics (Eaton and Kortum, 1999; Somale, 2014); multi-industry (Shikher, 2011; Costinot, Donaldson, and Komunjer), +input-output linkage (Caliendo and Parro, 2014; Levchenko and Zhang, 2016), +multinational production (Alviarez, 2015).
- Idea–flow model: Kortum (1997); Alvarez, Buera, and Lucas (2013); Perla, Tonetti, and Waugh (2015); Sampson (2016); Buera and Oberfield (2016)

Relation to the literature

- International technology diffusion: theory (Grossman and Helpman, 1993); empirics (Coe and Helpman, 1995; Keller, 2002, 2004).
- Estimation of industry-level TFP: Fadinger and Fleiss, 2011; Shikher, 2012; Levchenko and Zhang, 2016.
- Network approach: Intersectoral linkage in production (Acemoglu, et al., 2012), innovation (Cai and Li, 2014), spillover (Jaffe, 1986; Hidalgo, et al., 2007; Kali, et al., 2012); trade linkage & growth (Duernecker, Meyer, and Vega-Redondo, 2014; Pinat, 2015).
- Gains from trade: Arkolakis, Costinot, and Rodriguez-Clare (2012); Costinot and Rodriguez-Clare (2014).
- Industrial and trade policy: Hausmann and Rodrik (2007); Sabel, et al. (2012); Lederman and Maloney (2012); Artopoulos, Friel and Hallak (2013).

Road Map

- Model
- Empirical specification and data
- Results
- Quantitative implication
- Conclusion

General Model Structure

- A multi-industry multi-country international trade model is married with a model of knowledge diffusion through trade.
  - International trade: Caliendo and Parro, 2014; Levchenko and Zhang, 2015.
  - Diffusion process: Buera and Oberfield, 2016.
- Cross section: productivity difference determines trade.
- Over time: trade pattern shapes productivity growth.
- Central focus: evolution of Ricardian comparative advantage.
- Continuous time, N countries (indexed by n), $I + 1$ industries (indexed by i), multiple inputs.

Cross-sectional Setting: Demand Side

- A representative consumer in country n

$$\max_{Y_n^1,\ldots,Y_n^{I+1}} \left[\sum_{i=1}^{I} \left(\omega_n^i\right)^{1-\kappa} \left(Y_n^i\right)^{\kappa} \right]^{\phi_n/\kappa} \left(Y_n^{I+1}\right)^{1-\phi_n},$$

subject to

$$\sum_{i=1}^{I+1} P_n^i Y_n^i \leq E_n.$$

Y_n^i: goods from industry i
ω_n^i: share parameter and $\sum_{i=1}^{I} \omega_n^i = 1$
ϕ_n: consumption share of tradeable goods
$\frac{1}{1-\kappa}$: elasticity of substitution across tradeable industries
P_n^i: industry-level price index
E_n: per-period expenditure

Production Technology

- Each industry has a continuum of varieties indexed by $\nu^i \in [0,1]$.
- Each variety is produced by perfectly competitive producers.
- Production technology is of Cobb-Douglas form

$$q_n^i(\nu^i) = z_n^i(\nu^i)[\ell_n^i(\nu^i)]^{\gamma^{iL}}[k_n^i(\nu^i)]^{\gamma^{iK}} \prod_{i'=1}^{I+1} [m_n^{ii'}(\nu^i)]^{\gamma_n^{ii'}}.$$

$z_n^i(\nu^i)$: variety-level productivity
$\ell_n^i(\nu^i)$: labor
$k_n^i(\nu^i)$: capital
$m_n^{ii'}(\nu^i)$: intermediate goods from industry i'
$\gamma^{iL}, \gamma^{iK}, \gamma_n^{ii'}$: input shares and $\gamma^{iL} + \gamma^{iK} + \sum_{i'=1}^{I+1} \gamma_n^{ii'} = 1$.

Production Technology

- Composite goods in each industry are produced by combining a continuum of varieties within the same industry. Production technology is of CES form

$$Q_n^i = \left[\int_0^1 q_n^i(\nu^i)^{(\sigma^i-1)/\sigma^i} d\nu^i \right]^{\sigma^i/(\sigma^i-1)},$$

  where σ^i is the elasticity of substitution.

- Varieties $\Longleftrightarrow$ composite goods $\Longrightarrow$ final goods.

  production-structure

International Trade

- Trade cost: it requires shipping $d^i_{nn'}$ units of goods from country n' to deliver one unit of good in country n.
  - $d^i_{nn} = 1$, $d^{I+1}_{nn'} = \infty$ for $n \neq n'$, triangular inequality
- Price of ν^i in country n

$$p^i_n(\nu^i) = \min\left\{\frac{c^i_1 d^i_{n1}}{z^i_1(\nu^i)}, \frac{c^i_2 d^i_{n2}}{z^i_2(\nu^i)}, ..., \frac{c^i_N d^i_{nN}}{z^i_N(\nu^i)}\right\},$$

where c^i_n is unit cost of input bundle in industry i in country n.

- (Eaton-Kortum) Assumption: z^i_n is a random draw from a Fréchet distribution

$$F^i_n(z) = \exp(-\lambda^i_n z^{-\theta^i}),$$

where $E(\ln z^i_n) \propto \ln \lambda^i_n$ and $Var(\ln z^i_n) \propto 1/\theta^i$.

Instantaneous Equilibrium

- At each moment of time, an instantaneous equilibrium is a pair of an allocation and a price system such that
  - Consumers/producers optimize, and decisions on trade are optimal
  - Factor and goods markets clear.

  Characterization Characterization-cont'd

- Productivity difference determines trade pattern

$$\frac{\pi^i_{nn'}}{\pi^i_{nn}} = \frac{\lambda^i_{n'}}{\lambda^i_n}\left(\frac{c^i_{n'}d^i_{nn'}}{c^i_n}\right)^{-\theta^i},$$

where $\pi^i_{nn'}$ is country n's expenditure on goods of industry i imported from country n'.

A General Diffusion Process

- Borrowed from Buera and Oberfield (2016)
- Engine of growth: firm-to-firm interaction
- Pick a firm f whose productivity is z drawn from a distribution F.
- This firm meets another firm g whose productivity z_G drawn from G (may or may not be the same as F).
- Firm f learns from firm g imperfectly, comparing z with $z_G^{\beta} z_H^{1-\beta}$ where z_H is drawn from a noise distribution H.
  - H Pareto, time invariant
- Firm f updates technology if and only if $z < z_G^{\beta} z_H^{1-\beta}$

A General Diffusion Process, Continued

- Assume $H(z) = 1 - (z/z_0)^{-\tilde{\theta}}, \quad \text{for } z > z_0.$
- Productivity distribution and its dynamics

$$F(z) = \exp(-\lambda z^{-\theta})$$

$$\frac{d\lambda}{dt} = \eta \int_0^{\infty} x^{\beta\theta} dG(x)$$

where η is arrival rate of meetings and $\theta \equiv \tilde{\theta}/(1-\beta)$

More Details

Channels of Knowledge Diffusion

- Channels of knowledge diffusion source distribution
  - Intra-industry knowledge diffusion from domestic and foreign sellers
  - Inter-industry knowledge diffusion from domestic and foreign sellers
- Trade pattern governs the source distribution G of each channel
- Flows of goods and ideas go hand in hand

Productivity Dynamics: Intra-Industry Diffusion

Law of Motion of Industry-level Productivity

- Only domestic intra-industry diffusion

$$\frac{d\lambda_{n,t}^{i}}{dt} = \eta_{n,t}^{i} {\lambda_{n,t}^{i}}^{\beta^{i}}$$

Productivity Dynamics: Intra-Industry Diffusion

Law of Motion of Industry-level Productivity

- Only domestic intra-industry diffusion

$$\frac{d\lambda_{n,t}^{i}}{dt} = \eta_{n,t}^{i} {\lambda_{n,t}^{i}}^{\beta^{i}}$$

- Only intra-industry diffusion

$$\frac{d\lambda_{n,t}^{i}}{dt} = \eta_{n,t}^{i} \left({\pi_{nn,t}^{i}}^{1-\beta^{i}} {\lambda_{n,t}^{i}}^{\beta^{i}} + \sum_{n' \neq n} {\pi_{nn',t}^{i}}^{1-\beta^{i}} {\lambda_{n',t}^{i}}^{\beta^{i}} \right)$$

Productivity Dynamics: Inter-Industry Diffusion

Law of Motion of Industry-level Productivity

- Industry i learns from industry i'

$$\frac{d\lambda_{n,t}^{i}}{dt} = \eta_{n,t}^{ii'} \left({\pi_{nn,t}^{i'}}^{1-\beta^{i'}} {\lambda_{n,t}^{i'}}^{\beta^{i'}} + \sum_{n' \neq n} {\pi_{nn',t}^{i'}}^{1-\beta^{i'}} {\lambda_{n',t}^{i'}}^{\beta^{i'}} \right)$$

Productivity Dynamics: Inter-Industry Diffusion

Law of Motion of Industry-level Productivity

- Industry i learns from industry i'

$$\frac{d\lambda^i_{n,t}}{dt} = \eta^{ii'}_{n,t} \left({\pi^{i'}_{nn,t}}^{1-\beta^{i'}} {\lambda^{i'}_{n,t}}^{\beta^{i'}} + \sum_{n' \neq n} {\pi^{i'}_{nn',t}}^{1-\beta^{i'}} {\lambda^{i'}_{n',t}}^{\beta^{i'}} \right)$$

- Industry i learns from all the other industries

$$\frac{d\lambda^i_{n,t}}{dt} = \sum_{i' \neq i} \eta^{ii'}_{n,t} \left({\pi^{i'}_{nn,t}}^{1-\beta^{i'}} {\lambda^{i'}_{n,t}}^{\beta^{i'}} + \sum_{n' \neq n} {\pi^{i'}_{nn',t}}^{1-\beta^{i'}} {\lambda^{i'}_{n',t}}^{\beta^{i'}} \right)$$

Industry-level Productivity Dynamics

Law of motion of industry-level productivity Comparison

$$d\lambda^i_{n,t}/dt =$$

$$\overbrace{\eta^i_{n,t}{\pi^i_{nn,t}}^{1-\beta^i}{\lambda^i_{n,t}}^{\beta^i}}^{\text{domestic intraindustry diffusion}} + \overbrace{\eta^i_{n,t}\sum_{n'\neq n}{\pi^i_{nn',t}}^{1-\beta^i}{\lambda^i_{n',t}}^{\beta^i}}^{\text{international intraindustry diffusion}}$$

$$+ \overbrace{\sum_{i'\neq i}\eta^{ii'}_{n,t}{\pi^{i'}_{nn,t}}^{1-\beta^i}{\lambda^{i'}_{n,t}}^{\beta^i}}^{\text{domestic interindustry diffusion}} + \overbrace{\sum_{i'\neq i}\eta^{ii'}_{n,t}\sum_{n'\neq n}{\pi^{i'}_{nn',t}}^{1-\beta^i}{\lambda^{i'}_{n',t}}^{\beta^i}}^{\text{international interindustry diffusion}},$$

Quantitative Exploration: Road Map

- Calibrate the law of motion of industry-level TFP
- Two steps
  - Estimate TFP parameters $\lambda^i_{n,t}$ and trade cost parameters $d^i_{nn',t}$
  - Calibrate diffusion parameters $\eta^i_{n,t}$, $\eta^{ii'}_{n,t}$ and β^i.
- Compare model-implied convergence rate and specialization dynamics with data

Data

- Production data: UNIDO industrial statistics database (INDSTAT2)
  - Industry-level total output, value-added, wage bills
- Trade data: Comtrade database
  - Bilateral trade volume
- Other data: Penn world table, CEPII gravity dataset, NBER-CES manufacturing industry database, etc. data source
- Time span: 1963 - 2011
- Country coverage: 32 OECD + 40 non-OECD country list
- 17 manufacturing industries (2-digit ISIC Rev. 3) list of industries
- 5-year window = 1 period

Quantitative Exploration: First Stage

- Main objective: estimate trade cost and industry-level TFP
- Follow Shikher (2012) and Levchenko and Zhang (2016)
- Key equation

$$\frac{\pi^i_{nn'}}{\pi^i_{nn}} = \frac{\lambda^i_{n'}}{\lambda^i_n} \left(\frac{c^i_{n'} d^i_{nn'}}{c^i_n} \right)^{-\theta^i},$$

  - estimation of trade cost | evolution of trade cost | evolution of trade cost by industry
  - estimation of tradeable TFP | non-tradeable TFP | convergence | convergence by industry

- Calculate technology coefficients: capital/labor share, I-O coefficients, tradeable consumption share, etc. Other variables

Quantitative Exploration: Second Stage

- Main objective: calibrate diffusion parameters
- Benchmark setting
  - $\eta^{ii'}$ proportional to US I-O coefficients ($\eta^{ii'}_{n,t} = \eta_{n,t}\gamma^{ii'}$)
  - same β^i_t across industries
  - same $\eta_{n,t}$ across countries – (η_t, β_t)
  - 1990 - 2010 sample
- Using TFP estimates for the first period, solve the model for trade shares $\hat{\pi}^i_{nm,t}$ at $t = t_0$.
- For a given set of diffusion parameters, calculate $\hat{\lambda}^i_{n,t}(\eta_t, \beta_t)$ at $t = t_0 + 1$
- Repeat above to obtain $\{\hat{\pi}^i_{n,m,t}(\eta_t, \beta_t), \hat{\lambda}_{n,t}(\eta_t, \beta_t)\}^T_{t=t_0}$

Quantitative Exploration: Second Stage, Cont'd

- Target: country-level TFP growth

$$\min_{\eta_t,\beta_t} \sum_{n,t} \left(\triangle \widehat{TFP}_{n,t}(\eta_t,\beta_t) - \triangle TFP_{n,t} \right)^2$$

- Method I: same β across periods
- Method II: β time specific
- Method III: same β across periods, using real trade data in the law of motion
- Method IV: β time specific, using real trade data in the law of motion
- Goodness of fit goodness-of-fit

Convergence

- Estimation equation

$$\triangle \ln X = \alpha \ln X_0 + \text{FixedEffects} + \varepsilon.$$

- Rate of convergence: α
- X: Revealed comparative advantage index, industry-level TFP, bilateral trade share, import share, export capability

Convergence

Variable	RCA	TFP	TFP	TFP	$\pi^i_{nn'}$
Sample	Full	Full	OECD	Non-OECD	Full
Data	-0.310	-0.258	-0.243	-0.342	-0.065
	(0.023)***	(0.037)***	(0.062)***	(0.054)***	(0.011)***
Method I	-0.395	-0.287	-0.186	-0.358	-0.072
($\beta = 0.285$)	(0.035)***	(0.022)***	(0.033)***	(0.028)***	(0.009)***
Method II	-0.394	-0.282	-0.177	-0.352	-0.071
	(0.035)***	(0.021)***	(0.032)***	(0.027)***	(0.009)***
Method III	-0.383	-0.257	-0.158	-0.325	-0.066
($\beta = 0.240$)	(0.035)***	(0.021)***	(0.031)***	(0.027)***	(0.009)***
Method IV	-0.385	-0.268	-0.181	-0.331	-0.068
	(0.036)***	(0.022)***	(0.038)***	(0.027)***	(0.009)***
No. of Obs.	967	992	483	509	83,464

Convergence in RCA: 1990 - 2010

Convergence: Robustness Check

- Alternative TFP estimates (OLS/PPML; WIOD; alternative rental rates; industry-specific trade elasticities) Alternative TFP estimates
- Alternative diffusion matrices (WIOD; patent citation)
  Alternative diffusion matrices
- Industry-specific diffusion parameter β^i
  Convergence: industry-specific β^i | β^i across industries
- Longer sample period: 1970 - 2010
  Longer sample period

Convergence in TFP by Industry, 1970 – 2010

	Data	Benchmark	WIOD	Patent	Obs.
Food, tobacco	-0.388	-0.417	-0.369	-0.482	51
	(0.082)***	(0.042)***	(0.042)***	(0.040)***	
Textiles	-0.344	-0.540	-0.516	-0.502	49
	(0.162)**	(0.069)***	(0.072)***	(0.070)***	
Apparel, footwear	-0.458	-0.104	-0.091	-0.085	35
	(0.137)***	(0.015)***	(0.014)***	(0.013)***	
Wood	-0.188	-0.441	-0.409	-0.478	48
	(0.088)**	(0.038)***	(0.037)***	(0.033)***	
Paper	-0.349	-0.543	-0.659	-0.533	49
	(0.072)***	(0.041)***	(0.032)***	(0.041)***	
Printing, Publishing	-0.126	-0.011	-0.017	-0.008	49
	(0.098)	(0.002)***	(0.003)***	(0.002)***	
Coke, petroleum	0.157	-0.779	-0.652	-0.908	51
	(0.143)	(0.035)***	(0.050)***	0.015)***	
Chemical	-0.360	-0.357	-0.292	-0.313	43
	(0.089)***	(0.033)***	(0.031)***	(0.031)***	
Rubber, plastic	-0.461	-0.267	-0.281	-0.215	48
	(0.090)***	(0.033)***	(0.034)***	(0.028)***	

Convergence in TFP by Industry, 1970 – 2010

	Data	Benchmark	WIOD	Patent	Obs.
Non-metallic mineral	-0.339 (0.064)***	-0.163 (0.023)***	-0.149 (0.022)***	-0.164 (0.022)***	47
Basic metals	-0.118 (0.100)	-0.429 (0.023)***	-0.449 (0.027)***	-0.408 (0.022)	42
Fabricated metal	-0.159 (0.068)**	-0.172 (0.016)***	-0.143 (0.015)***	-0.122 (0.014)***	48
Machinery, equipment	-0.311 (0.125)**	-0.568 (0.047)***	-0.597 (0.048)***	-0.483 (0.053)***	41
Electronics	-0.370 (0.114)***	-0.349 (0.045)***	-0.415 (0.052)***	-0.274 (0.041)***	40
Medical, precision	0.069 (0.171)	-0.026 (0.013)**	-0.029 (0.014)**	-0.012 (0.006)**	33
Vehicles	-0.230 (0.152)	-0.393 (0.031)***	-0.409 (0.031)***	-0.279 (0.026)***	46
Other manufacturing	-0.310 (0.140)**	-0.075 (0.024)***	-0.078 (0.026)***	-0.055 (0.017)***	47

Specialization Dynamics

- In each country, rank its industries according to their normalized productivity levels
  - Normalization: $\lambda^i_{n,t}$ divided by the productivity level at the 90 percentile of the distribution (world technology frontier)
- Construct a transition matrix
  - The ij-th element is the probability for a rank-group-i industry to move to rank-group-j from 1990s to 2010s.
- The model captures catch-up but misses fall-back

Transition Probability

		Data						Model			
Non-OECD Countries											
		2010 Rank						2010 Rank			
		1-4	5-8	9-12	13-17			1-4	5-8	9-12	13-17
1990 Rank	1-4	0.49	0.21	0.15	0.14	1990 Rank	1-4	0.74	0.22	0.04	0.00
	5-8	0.29	0.33	0.25	0.13		5-8	0.15	0.49	0.31	0.04
	9-12	0.14	0.33	0.29	0.24		9-12	0.03	0.19	0.38	0.41
	13-17	0.06	0.11	0.25	0.59		13-17	0.07	0.08	0.22	0.64
OECD Countries											
		2010 Rank						2010 Rank			
		1-4	5-8	9-12	13-17			1-4	5-8	9-12	13-17
1990 Rank	1-4	0.51	0.22	0.18	0.09	1990 Rank	1-4	0.89	0.11	0.00	0.00
	5-8	0.27	0.38	0.25	0.10		5-8	0.05	0.79	0.16	0.00
	9-12	0.11	0.29	0.30	0.30		9-12	0.01	0.07	0.73	0.20
	13-17	0.09	0.09	0.21	0.61		13-17	0.04	0.03	0.09	0.84

Quantitative Implication

- Decompose knowledge diffusion into different channels
- Identify "key players" in the network of knowledge diffusion
- Quantify gains from trade

Decomposition of Productivity Growth

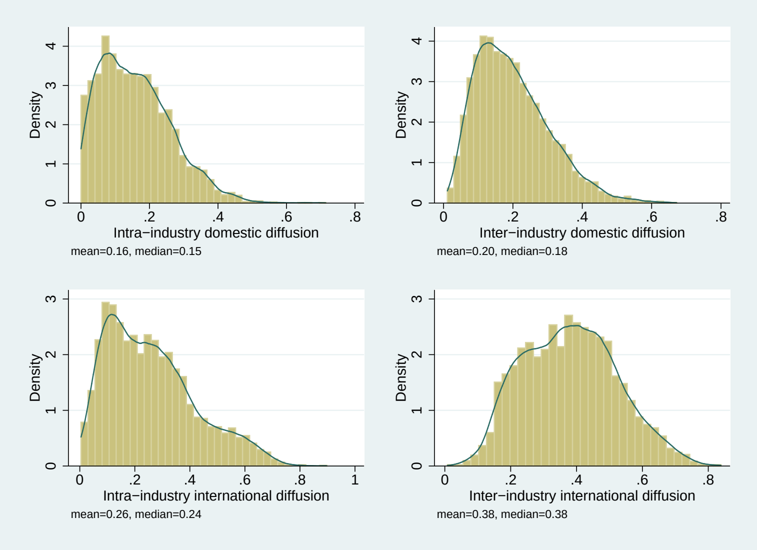
Recall

$$d\lambda^i_{n,t}/dt =$$

$$\overbrace{\eta^i_{n,t} {\pi^i_{nn,t}}^{1-\beta^i} {\lambda^i_{n,t}}^{\beta^i}}^{\text{domestic intraindustry diffusion}} + \overbrace{\eta^i_{n,t} \sum_{n' \neq n} {\pi^i_{nn',t}}^{1-\beta^i} {\lambda^i_{n',t}}^{\beta^i}}^{\text{international intraindustry diffusion}}$$

$$+ \overbrace{\sum_{i' \neq i} \eta^{ii'}_{n,t} {\pi^{i'}_{nn,t}}^{1-\beta^i} {\lambda^{i'}_{n,t}}^{\beta^i}}^{\text{domestic interindustry diffusion}} + \overbrace{\sum_{i' \neq i} \eta^{ii'}_{n,t} \sum_{n' \neq n} {\pi^{i'}_{nn',t}}^{1-\beta^i} {\lambda^{i'}_{n',t}}^{\beta^i}}^{\text{international interindustry diffusion}},$$

Decomposition of Productivity Growth



Contribution to Productivity Growth: 1990 - 2010

Decomposition of Productivity Growth, Cont'd

- OECD versus Non-OECD

  Decomposition (OECD) Decomposition (non-OECD)

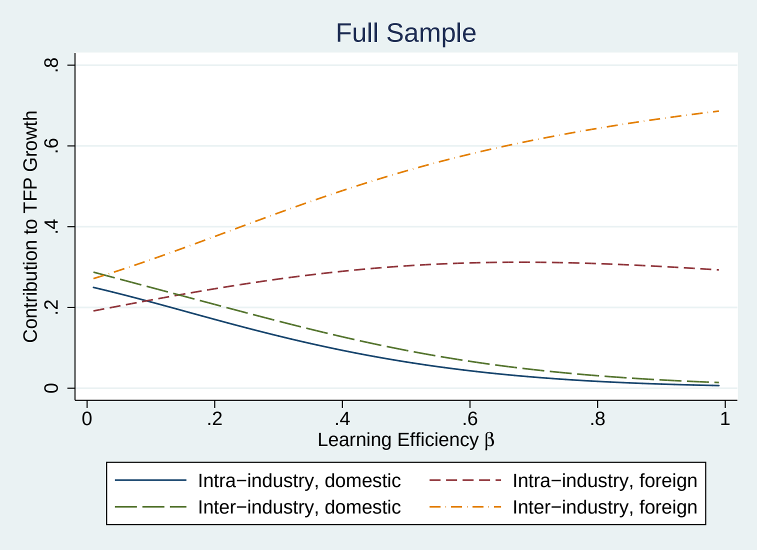
- Decomposition by industry

  Decomposition by industry I Decomposition by industry II

- Decomposition using patent citation matrix

  Decomposition-patent-citation

How Decomposition Varies with β



Contribution to Productivity Growth: 1990 - 2010

The "Key Player": Direct Measure

- The "key player": the country or country-industry pair that contributes most to global productivity growth
- Direct measure: average contribution to TFP growth
- Let $\alpha_{nn'}^{ii'}$ be the contribution from industry i' in country n' to TFP growth of industry i in country n

$$C_n^{Direct} = \frac{\sum_{n',i,i'} \alpha_{n'n}^{i'i}}{\sum_{n,n',i,i'} \alpha_{n'n}^{i'i}}; \quad C_{n,i}^{Direct} = \frac{\sum_{n',i'} \alpha_{n'n}^{i'i}}{\sum_{n,n',i,i'} \alpha_{n'n}^{i'i}}.$$

The "Key Player": Direct Measure

Simple Average (%)				Weighted Average (%)			
Top 5		"BRICS"		Top 5		"BRICS"	
			Benchmark				
USA	11.29	Brazil	2.16	USA	20.88	Brazil	1.77
Germany	7.52	Russia	1.28	Japan	18.31	Russia	0.70
Japan	6.95	India	1.77	Germany	8.23	India	1.15
Italy	5.26	China	3.78	Italy	5.10	China	5.43
France	4.73	S. Africa	1.13	France	4.88	S.Africa	0.48
			Country-specific I-O				
USA	11.64	Brazil	2.09	USA	20.49	Brazil	1.70
Germany	7.71	Russia	1.21	Japan	18.38	Russia	0.67
Japan	7.39	India	1.74	Germany	8.09	India	1.11
Italy	5.49	China	3.74	France	5.05	China	5.23
France	4.87	S. Africa	1.06	Italy	5.02	S.Africa	0.48
			Patent Citation				
USA	10.64	Brazil	2.17	USA	20.39	Brazil	1.73
Germany	7.24	Russia	1.34	Japan	17.84	Russia	0.76
Japan	6.53	India	1.86	Germany	7.98	India	1.16
Italy	5.38	China	3.68	Italy	5.11	China	5.41
UK	4.67	S. Africa	1.16	France	4.93	S.Africa	0.51

The "Key Player": Direct Measure

Simple Average (%)			Weighted Average (%)		
Country	Industry	Contribution	Country	Industry	Contribution
		Country-specific I-O			
USA	Measurement	2.26	Japan	Electronics	3.86
USA	Electronics	1.97	Japan	Vehicles	3.50
Japan	Electronics	1.74	USA	Measurement	3.34
USA	Machinery	1.55	USA	Vehicles	3.08
Japan	Vehicles	1.42	Japan	Machinery	2.48
Germany	Machinery	1.18	USA	Food	2.38
Japan	Machinery	1.16	USA	Electronics	2.13
Germany	Electronics	1.12	USA	Machinery	1.74
USA	Vehicles	1.10	USA	Printing	1.55
Germany	Measurement	1.06	Germany	Vehicles	1.48

The "Key Player": Degree Measure

- Degree centrality: a directed link ij is defined if i's contribution to j's productivity growth is above a pre-specified threshold

$$C_n^{Degree} = \sum_{n',i,i'} \mathbf{1}_{\alpha_{n'n}^{i'i} \geq \zeta}; \quad C_{n,i}^{Degree} = \sum_{n',i'} \mathbf{1}_{\alpha_{n'n}^{i'i} \geq \zeta},$$

where $\mathbf{1}$ is an indicator function and ζ is a pre-specified cutoff.

- Similar ranking of countries and country-industry pairs
- Degree distribution becomes less skewed over time – emerging markets play an increasingly large role Degree distribution
- Diffusion network is in line with the trade network Degree-Lorenz curve

The "Key Player": Counter-factual Measure

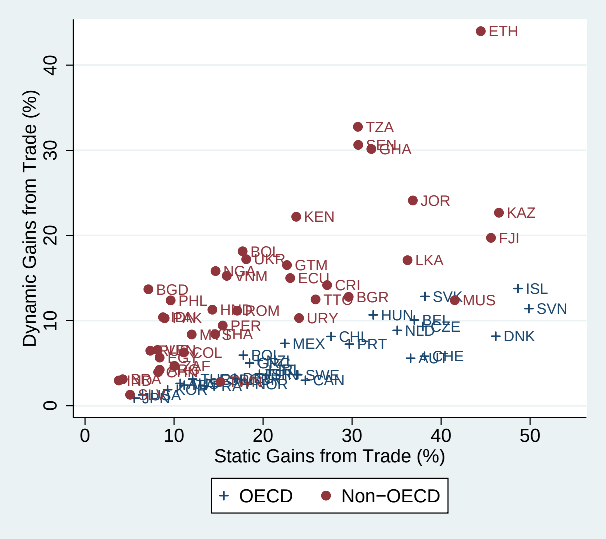
- Counter-factual measure: average decline of TFP growth if country n is excluded

Change of TFP Growth from 1990 to 2010 (%)					
OECD	World Average	Own	Non-OECD	World Average	Own
Japan	-5.81	-27.89	Taiwan	-3.50	-25.82
USA	-5.13	-44.70	Brazil	-1.63	-50.60
Germany	-3.75	-57.31	India	-1.42	-47.64
France	-2.82	-54.58	South Africa	-1.38	-54.21
Italy	-2.78	-50.65	Malaysia	-1.37	-33.84
UK	-2.71	-59.05	Russia	-1.37	-63.56
Canada	-2.51	-52.01	Thailand	-1.36	-55.31
Korea	-2.16	-48.09	Indonesia	-1.35	-45.46
Spain	-2.09	-54.34	Ukraine	-1.28	-58.68
Switzerland	-1.96	-26.61	Egypt	-1.25	-60.17
Average	-1.94	-52.15	Average	-1.18	-52.20

Gains from Trade

- Static gains from trade: percentage change of per-period real income from autarky to trade openness in 2001-2005
  - Taking into account input-output linkage
  - Trade elasticity = 4
- Dynamic gains from trade: percentage change of discounted sum of real income from autarky to trade openness in 2001-2005, fixing the diffusion parameters calibrated for the same period

Gains from Trade

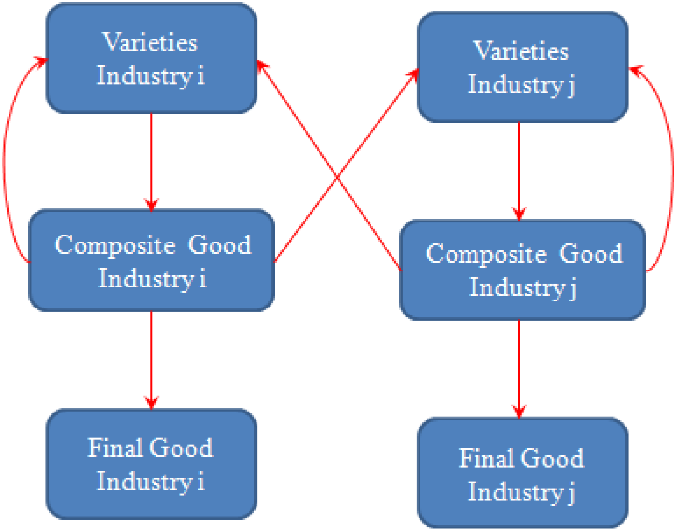


Conclusion

- Construct and calibrate a dynamic multi-industry model of international trade and knowledge diffusion. The model
  - Brings strengths of the two literatures together
  - Reproduces strong convergence observed in the trade and production data in a quantitative manner.
  - Partially captures specialization dynamics.
- International knowledge diffusion plays a more important role than domestic knowledge diffusion; inter-industry knowledge diffusion plays a more important role than intra-industry knowledge diffusion
- Increasing share of knowledge diffuses through emerging market economies.
- There are substantial dynamic gains from trade

Thank You!

Production Structure



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Instantaneous Equilibrium: Formal Characterization

- Consumers optimize

$$Y_n^i = \frac{\omega_n^i {P_n^i}^{\frac{\kappa}{\kappa-1}}}{\sum_{i'=1}^{I} \omega_n^{i'} {P_n^{i'}}^{\frac{\kappa}{\kappa-1}}} \cdot \frac{\phi_n E_n}{P_n^i}, \tag{1}$$

$$Y_n^{I+1} = \frac{(1-\phi_n)E_n}{P_n^{I+1}}. \tag{2}$$

- Unit cost function

$$c_n^i = \left(\frac{w_n}{\gamma^{iL}}\right)^{\gamma^{iL}} \left(\frac{r_n}{\gamma^{iK}}\right)^{\gamma^{iK}} \prod_{i'=1}^{I+1} \left(\frac{P_n^{i'}}{\gamma_n^{ii'}}\right)^{\gamma_n^{ii'}} . \tag{3}$$

- Trade pattern

$$\pi_{nn'}^i = \frac{\lambda_{n'}^i (c_{n'}^i d_{nn'}^i)^{-\theta^i}}{\sum_{n''=1}^{N} \lambda_{n''}^i (c_{n''}^i d_{nn''}^i)^{-\theta^i}}. \tag{4}$$

- Industry-level price index

$$P_n^i = \left[\Gamma\left(1 + \frac{1-\sigma^i}{\theta^i}\right)\right]^{1/(1-\sigma^i)} \left(\sum_{n'=1}^{N} \lambda_{n'}^i (c_{n'}^i d_{nn'}^i)^{-\theta^i}\right)^{-1/\theta^i} . \tag{5}$$

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Instantaneous Equilibrium: Formal Characterization

- Expenditure identity

$$E_n = w_n L_n + r_n K_n + D_n. \tag{6}$$

- Trade deficit

$$D_n = \sum_{i=1}^{I+1} \left(P_n^i Q_n^i - \sum_{n'=1}^{N} P_{n'}^i Q_{n'}^i \pi_{n'n}^i . \right) \tag{7}$$

- Product market clear

$$P_n^i Q_n^i = \sum_{i'=1}^{I+1} \gamma_n^{i'i} \sum_{n'=1}^{N} .P_{n'}^{i'} Q_{n'}^{i'} \pi_{n'n}^{i'} + P_n^i Y_n^i. \tag{8}$$

- Factor income

$$w_n L_n^i = \gamma^{iL} \sum_{n'=1}^{N} P_{n'}^i Q_{n'}^i \pi_{n'n}^i . \tag{9}$$

$$r_n K_n^i = \gamma^{iK} \sum_{n'=1}^{N} P_{n'}^i Q_{n'}^i \pi_{n'n}^i . \tag{10}$$

- Factor market clear

$$\sum_{i=1}^{I+1} L_n^i = L_n, \quad \sum_{i=1}^{I+1} K_n^i = K_n. \tag{11}$$

A General Diffusion Process, More Details

- Assume $H(z) = 1 - (z/z_0)^{-\tilde{\theta}}, \quad \text{for } z > z_0$.
- Let $\theta^i \equiv \tilde{\theta}/(1-\beta)$ and normalize $\eta \equiv \tilde{\eta} z_0^{\tilde{\theta}}$ to be a constant.
- It can be shown that

$$\lim_{z_0 \to 0} \frac{d}{dt} \ln F(z) = -\eta z^{-\theta} \int_0^\infty x^{\beta\theta} dG(x),$$

provided that $\lim_{x\to\infty}[1 - G(x)]x^{\beta\theta} = 0$.

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Source Distributions

- Intra-industry idea flows

$$G^{i}_{n,t}(z) = \int_0^z \sum_{n'=1}^{N} \prod_{n'' \neq n'} F^{i}_{n'',t}\left(\frac{c^{i}_{n'',t} d^{i}_{nn'',t}}{c^{i}_{n',t} d^{i}_{nn',t}} x \right) dF^{i}_{n',t}(x).$$

- Inter-industry idea flows

$$G^{ii'}_{n,t}(z) = \int_0^z \sum_{n'=1}^{N} \prod_{n'' \neq n'} F^{i'}_{n'',t}\left(\frac{c^{i'}_{n'',t} d^{i'}_{nn'',t}}{c^{j}_{n',t} d^{i'}_{nn',t}} x \right) dF^{i'}_{n',t}(x).$$

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Comparison to the Existing Work

How TFP is related to R&D stocks (Keller, 2002a, 2002b)

$$TFP_{n,t}^{i} = \eta_n^i \eta_t \times \left(\overbrace{\eta_S \sum_{m=1}^{N} \pi_{nm,t}^{i} R_{m,t}^{i}}^{\text{Intra + foreign}} + \overbrace{\eta_P \pi_{nn,t}^{i} R_{n,t}^{i}}^{\text{Intra + domestic}} \right.$$

$$\left. + \overbrace{\eta_{S'} \sum_{j \neq i} \kappa^{ij} \sum_{m=1}^{N} \pi_{nm,t}^{j} R_{m,t}^{j}}^{\text{Inter + foreign}} + \overbrace{\eta_{P'} \sum_{j \neq i} \kappa^{ij} \pi_{nn,t}^{j} R_{n,t}^{j}}^{\text{Inter + domestic}} \right)$$

- Evolution path (dynamic) vs long-run equilibrium (static)
    - Advantage of my framework: two-way relationship between productivity and trade, trade dynamics, cascade of diffusion (imitate imitators)

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List of Countries

Non-OECD	Year	Non-OECD	Year	Non-OECD	Year	Non-OECD	Year
Argentina	80-11	Bangladesh	72-07	Bolivia	63-11	Brazil	80-11
Bulgaria	90-11	China	73-11	Colombia	63-11	Costa Rica	63-11
Ecuador	63-11	Egypt	63-11	El Salvador	63-11	Ethiopia	80-11
Fiji	63-11	Ghana	63-11	Guatemala	63-11	Honduras	63-11
India	63-11	Indonesia	63-11	Jordan	63-11	Kazakhstan	92-11
Kenya	63-11	Malaysia	63-11	Mauritius	63-11	Nigeria	63-11
Pakistan	63-11	Peru	80-11	Philippines	63-11	Romania	90-11
Russia	96-11	Senegal	70-11	S. Africa	63-11	Sri Lanka	63-11
Taiwan	73-11	Tanzania	63-11	Thailand	63-11	Trinidad Tbg	63-10
Ukraine	92-11	Uruguay	63-11	Venezuela	63-11	Viet Nam	91-11
OECD	**Year**	**OECD**	**Year**	**OECD**	**Year**	**OECD**	**Year**
Australia	63-11	Austria	63-11	Belgium-Lux	63-11	Canada	63-11
Chile	63-11	Czech Rep	93-11	Denmark	63-11	Finland	63-11
France	63-11	Germany	91-11	Greece	63-11	Hungary	90-11
Iceland	63-11	Ireland	63-11	Israel	63-11	Italy	65-11
Japan	63-11	Korea Rep	63-11	Mexico	63-11	Netherlands	63-11
New Zealand	63-11	Norway	63-11	Poland	90-11	Portugal	63-11
Slovakia	93-11	Slovenia	92-11	Spain	63-11	Sweden	63-11
Switzerland	80-11	Turkey	63-11	UK	63-11	USA	58-11

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List of Industries

ISIC (Rev. 3)	Industry Description
15-16	Food products and beverages, tobacco products
17	Textiles
18-19	Wearing apparel, leather, luggage, footwear
20	Wood products except furniture, straw and plaiting materials
21	Paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Coke, refined petroleum products and nuclear fuel
24	Chemicals and chemical products
25	Rubber and plastic products
26	Other non-metallic mineral products
27	Basic metals
28	Fabricated metal products, except machinery and equipment
29-30	Office, accounting and computing machinery, other machinery
31-32	Electrical machinery, communication equipment
33	Medical, precision and optical instruments, watches and clocks
34-35	Transport equipment
36	Furniture, other manufacturing

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Main Data Sources

Variables/Parameters	Data Source & Construction Method
Bilateral trade share $\pi^i_{nn',t}$	UN Comtrade & UNIDO INDSTAT2
Trade deficit $D_{n,t}$	UN Comtrade
Labor income share γ^{iL}_t	UNIDO INDSTAT2, (wage bill)/(industrial output)
Capital income share γ^{iK}_t	UNIDO INDSTAT2, (value-added − wage bill)/(industrial output)
Input-output coefficients $\gamma^{ii'}_{n,t}$	BEA 1997 I-O accounts (grouped into 2-digit ISIC Rev.3); WIOD
Labor supply $L_{n,t}$	Penn World Table
Capital stock $K_{n,t}$	Penn World Table
Wage rate $w_{n,t}$	Penn World Table, (labor income)/(employment count)
Rental rate $r_{n,t}$	Penn World Table, (total income - labor income)/(capital)
	World Development Indicators; Caselli and Feyrer (2007)
Saving rate $s_{n,t}$	Penn World Table, implied by capital series and depreciation rate
Non-tradeable price $P^{I+1}_{n,t}$	ICP, interpolate and extrapolate for non-survey years
Tradable exp share ϕ_n	OECD national accounts, (fitting for non-OECD countries)
Trade elasticity θ^i	4; 8.28; Industry-specific (Caliendo and Parro, 2014)
Elasticity of subst. in consumption $\frac{1}{1-\kappa}$	2 (Levchenko and Zhang, 2015); 1 (Caliendo and Parro, 2014)
Elasticity of subst. in production σ^i	2
Tradeable consumption share ω^i_n	Levchenko and Zhang (2015)
US industry-level TFP	NBER-CES manufacturing industry database
Other country variables	Penn World Table
Other bilateral variables	CEPII gravity dataset
Industry-level TFP	KLEMS database (EU-, Asia, World- KLEMS)

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Estimation of Trade Cost

Trade cost can be written as

$$\ln d^i_{nn',t} = Dist^i_{nn',t} + Border^i_{nn',t} + Language^i_{nn',t} + CU^i_{nm,t} + RTA^i_{nm,t} + Exporter^i_{m,t} + \varepsilon^i_{nm,t}$$

- CU = Currency Union; RTA = Regional Trade Agreement
- Distance is intervalled: [0, 350), [350, 750), [750, 1500), [1500, 3000), [3000, 6000), and [6000, ∞).

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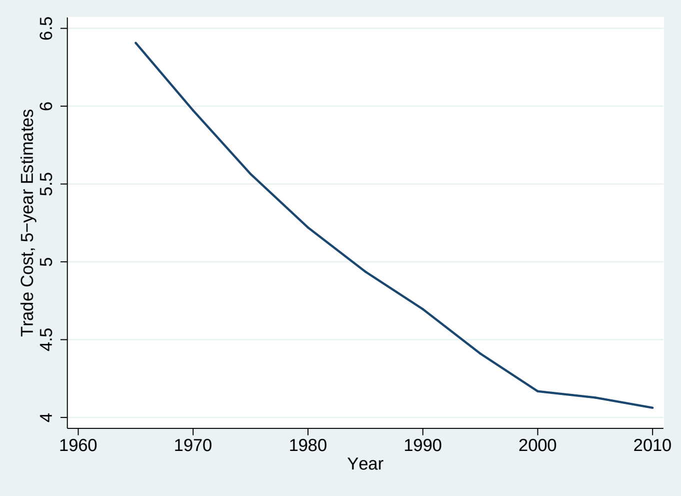
Trade Cost: 1960s - 2010s



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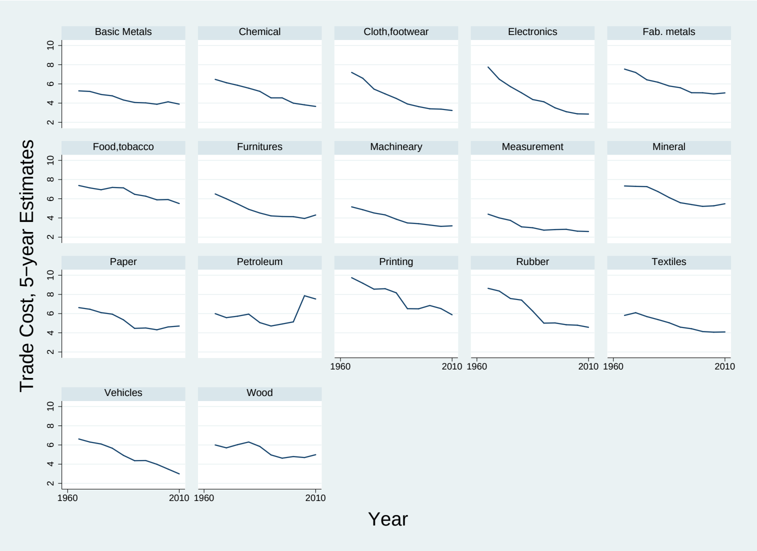
Trade Cost by Industry: 1960s - 2010s



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Estimation of Industry-level TFP

- Key equation for estimation

$$\frac{\pi^i_{nn',t}}{\pi^i_{nn,t}} = \frac{\lambda^i_{n',t}(c^i_{n',t}d^i_{nn',t})^{-\theta}}{\lambda^i_{n,t}(c^i_{n,t}d^i_{nn,t})^{-\theta}}$$

- Define $S^i_n \equiv \lambda^i_n {c^i_n}^{-\theta^i}$.

$$\ln\left(\frac{\pi^i_{nn'}}{\pi^i_{nn}}\right) = \ln S^i_{n'} - \theta^i Exp^i_{n'} - \ln S^i_n - \theta^i BilateralVar_{nn'} - \theta^i \varepsilon^i_{nn'}$$

- Combining with equilibrium conditions of the model

$$\frac{\lambda^i_n}{\lambda^i_{US}} = \frac{S^i_n}{S^i_{US}}\left(\frac{w_n}{w_{US}}\right)^{\theta\gamma^{iL}}\left(\frac{r_n}{r_{US}}\right)^{\theta\gamma^{iK}}\left(\frac{P^{I+1}_n}{P^{I+1}_{US}}\right)^{\theta\gamma^{i(I+1)}}\prod_{i'=1}^{I}\left(\frac{\pi^{i'}_{nn}}{\pi^{i'}_{US\,US}}\frac{S^{i'}_{US}}{S^{i'}_n}\right)^{\gamma^{ii'}}$$

- TFP estimates for the reference country, USA are adjusted for Ricardian selection (Finicelli, et al., 2013)

- 5-year window

Estimation of TFP in the Non-tradeable Sector

- Key equation for estimation

$$\frac{\lambda_n^{I+1}}{\lambda_{US}^{I+1}} = \left(\frac{c_n^{I+1} P_{US}^{I+1}}{c_{US}^{I+1} P_n^{I+1}} \right)^{\theta}$$

- Relative price: International Comparison Program
- Relative cost: obtained from estimation of industry-level TFP in tradeable sectors
- 5-year window

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Goodness of Fit

Period	Data Mean	Model Mean	Data Median	Model Median	Corr.
		Model-implied TFP			
Wage (2005 US $)					
1990-1995	6,165	5,127	4,647	4,044	0.97
1996-2000	6,451	5,350	4,759	4,302	0.97
2001-2005	6,651	5,717	4,728	4,485	0.96
2006-2010	6,934	5,872	5,053	4,517	0.94
Rent					
1990-1995	0.18	0.16	0.17	0.16	0.67
1996-2000	0.18	0.19	0.16	0.16	0.73
2001-2005	0.19	0.21	0.16	0.18	0.77
2006-2010	0.20	0.24	0.17	0.20	0.72
Bilateral Trade Share					
1990-1995	4.5e-3	3.8e-3	0	0	0.89
1996-2000	5.2e-3	4.7e-3	1.5e-5	0.9e-5	0.86
2001-2005	4.9e-3	4.5e-3	4.0e-5	3.2e-5	0.83
2006-2010	4.6e-3	4.0e-3	3.7e-5	1.6e-5	0.78
Domestic Absorption Share					
1990-1995	0.61	0.66	0.67	0.75	0.91
1996-2000	0.55	0.64	0.59	0.70	0.62
2001-2005	0.51	0.64	0.54	0.70	0.42
2006-2010	0.47	0.66	0.50	0.71	0.27

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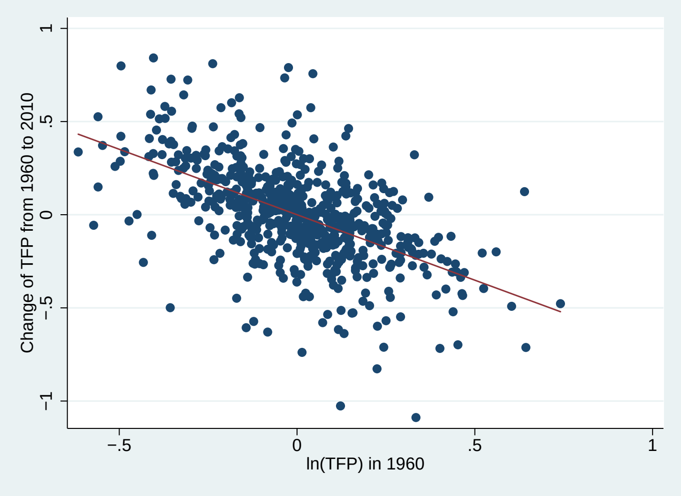
Convergence: 1960s - 2010s



Controlling for country and industry fixed effects

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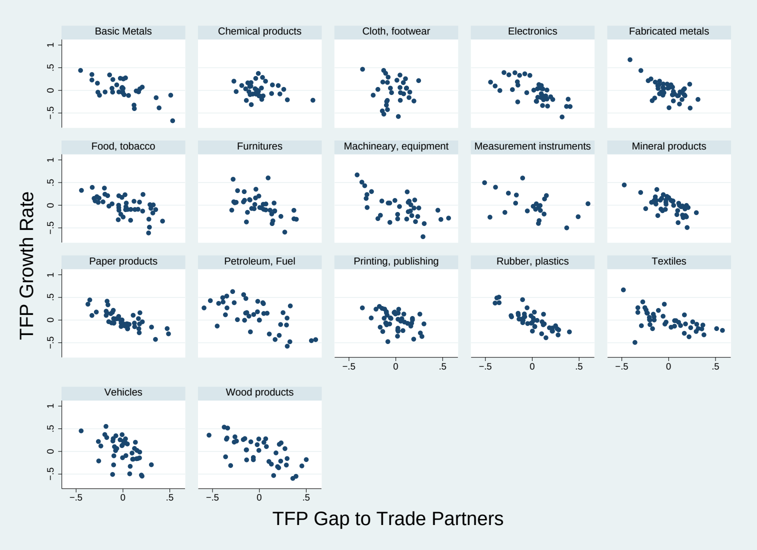
Convergence by Industry: 1960s - 2010s



Controlling for country and industry fixed effects

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Convergence: Alternative TFP Estimates

		Country-specific Input-output Table			
	Benchmark	$\theta = 4$		Industry-specific θ^i	
	PPML	OLS	PPML	OLS	PPML
		Industry-Level TFP: Data			
Full	-0.309	-0.270	-0.347	-0.172	-0.182
	(0.040)***	(0.037)***	(0.038)***	(0.036)***	(0.060)***
Non-OECD	-0.351	-0.339	-0.389	-0.227	-0.266
	(0.058)***	(0.054)***	(0.054)***	(0.047)***	(0.064)***
OECD	-0.310	-0.254	-0.343	-0.126	-0.064
	(0.059)***	(0.059)***	(0.057)***	(0.051)**	(0.121)
		Industry-Level TFP: Simulation			
Full	-0.337	-0.298	-0.372	-0.191	-0.160
	(0.020)***	(0.021)***	(0.021)***	(0.020)***	(0.013)***
Non-OECD	-0.389	-0.359	-0.426	-0.206	-0.181
	(0.026)***	(0.026)***	(0.028)***	(0.023)***	(0.018)***
OECD	-0.265	-0.214	-0.280	-0.172	-0.129
	(0.033)***	(0.040)***	(0.035)***	(0.035)***	(0.014)***

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Convergence: Alternative Diffusion Matrices

Variable Sample	RCA Index Full	TFP Full	TFP OECD	TFP Non-OECD	Trade Share Full	Export Cap. Full
Data	-0.310	-0.252	-0.239	-0.320	-0.066	-0.248
	(0.023)***	(0.037)***	(0.062)***	(0.053)***	(0.011)***	(0.024)***
			Country-specific I-O Table			
Method II	-0.399	-0.295	-0.191	-0.362	-0.078	-0.366
	(0.036)***	(0.020)***	(0.034)***	(0.026)***	(0.010)***	(0.039)***
Method IV	-0.393	-0.280	-0.175	-0.349	-0.074	-0.347
	(0.036)***	(0.021)***	(0.034)***	(0.027)***	(0.009)***	(0.038)***
			Patent Citation Matrix			
Method II	-0.366	-0.282	-0.192	-0.336	-0.065	-0.320
	(0.036)***	(0.024)***	(0.040)***	(0.028)***	(0.009)***	(0.040)***
Method IV	-0.356	-0.273	-0.202	-0.313	-0.061	-0.316
	(0.037)***	(0.021)***	(0.045)***	(0.028)***	(0.009)***	(0.041)***
No. of Obs.	967	992	483	509	83,464	952

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Convergence: Industry-specific β^i

Variable	RCA	TFP	TFP	TFP	Trade Share
Sample	Full	Full	OECD	Non-OECD	Full
Data	-0.304	-0.260	-0.230	-0.340	-0.071
	(0.023)***	(0.037)***	(0.059)***	(0.053)***	(0.011)***
			Benchmark		
Method II	-0.395	-0.349	-0.286	-0.386	-0.085
	(0.037)***	(0.027)***	(0.054)***	(0.030)***	(0.010)***
Method IV	-0.378	-0.325	-0.263	-0.356	-0.077
	(0.037)***	(0.027)***	(0.054)***	(0.029)***	(0.009)***
			Country-specific I-O Tables		
Method II	-0.389	-0.320	-0.239	-0.369	-0.074
	(0.036)***	(0.024)***	(0.053)***	(0.030)***	(0.010)***
Method IV	-0.394	-0.333	-0.260	-0.354	-0.077
	(0.038)***	(0.027)***	(0.042)***	(0.030)***	(0.010)***
			Patent Citation Matrix		
Method II	-0.358	-0.279	-0.251	-0.288	-0.058
	(0.036)***	(0.029)***	(0.057)***	(0.029)***	(0.010)***
Method IV	-0.347	-0.269	-0.217	-0.276	-0.054
	(0.036)***	(0.028)***	(0.054)***	(0.031)***	(0.010)***
No. of Obs.	967	992	505	487	83,464

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β^i across Industries

Industry	Method I	Method III
Food, tobacco	0.361	0.364
Textiles	0.368	0.383
Apparel, footwear	0.284	0.337
Wood	0.299	0.424
Paper	0.284	0.402
Printing, Publishing	0.349	0.305
Coke, petroleum	0.312	0.448
Chemical	0.443	0.353
Rubber, plastic	0.421	0.331
Non-metallic mineral	0.289	0.379
Basic metals	0.387	0.343
Fabricated metal	0.312	0.317
Machinery, equipment	0.455	0.336
Electronics	0.320	0.306
Medical, precision	0.347	0.307
Vehicles	0.451	0.304
Other manufacturing	0.280	0.334

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Convergence: Longer Sample Period

Variable	RCA	TFP	TFP	TFP	Import Share
Sample	Full	Full	OECD	Non-OECD	Full
Data	-0.500	-0.596	-0.533	-0.665	-0.746
	(0.028)***	(0.048)***	(0.054)***	(0.075)***	(0.045)***
			Benchmark		
Method II	-0.493	-0.356	-0.287	-0.454	-0.752
	(0.038)***	(0.025)***	(0.045)***	(0.030)***	(0.049)***
Method IV	-0.482	-0.334	-0.263	-0.432	-0.732
	(0.036)***	(0.025)***	(0.044)***	(0.030)***	(0.050)***
			Country-specific I-O Tables		
Method II	-0.492	-0.363	-0.287	-0.439	-0.747
	(0.037)***	(0.025)***	(0.043)***	(0.029)***	(0.049)***
Method IV	-0.485	-0.340	-0.260	-0.419	-0.729
	(0.038)***	(0.025)***	(0.042)***	(0.030)***	(0.050)***
			Patent Citation Matrix		
Method II	-0.479	-0.357	-0.294	-0.455	-0.723
	(0.037)***	(0.029)***	(0.048)***	(0.038)***	(0.050)***
Method IV	-0.473	-0.340	-0.277	-0.443	-0.733
	(0.039)***	(0.029)***	(0.048)***	(0.038)***	(0.053)***
No. of Obs.	782	732	377	355	908

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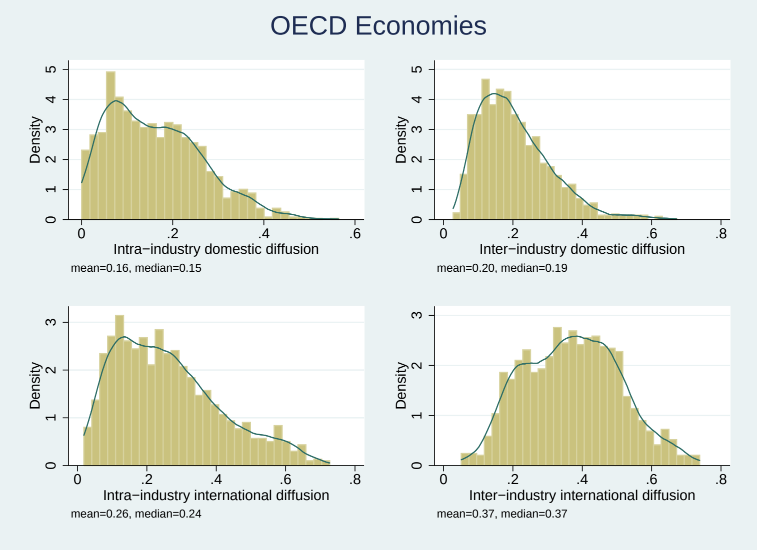
Decomposition of Productivity Growth, OECD



Contribution to Productivity Growth: 1990 - 2010

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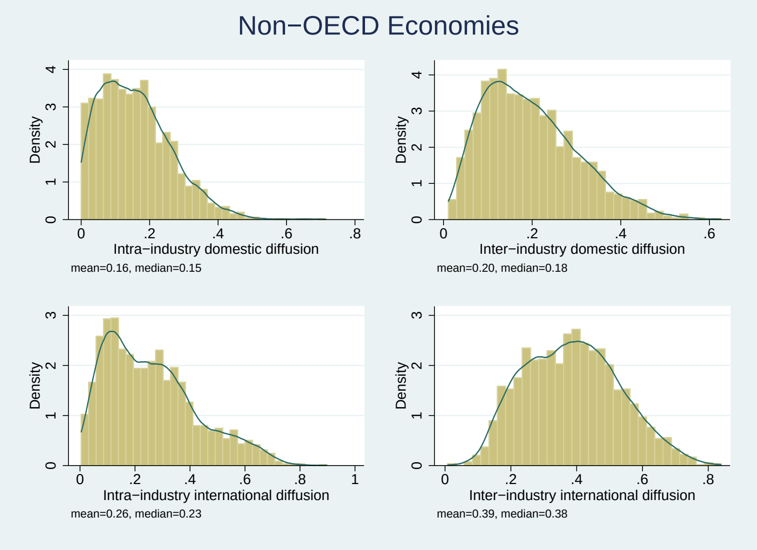
Decomposition of Productivity Growth, non-OECD



Contribution to Productivity Growth: 1990 - 2010

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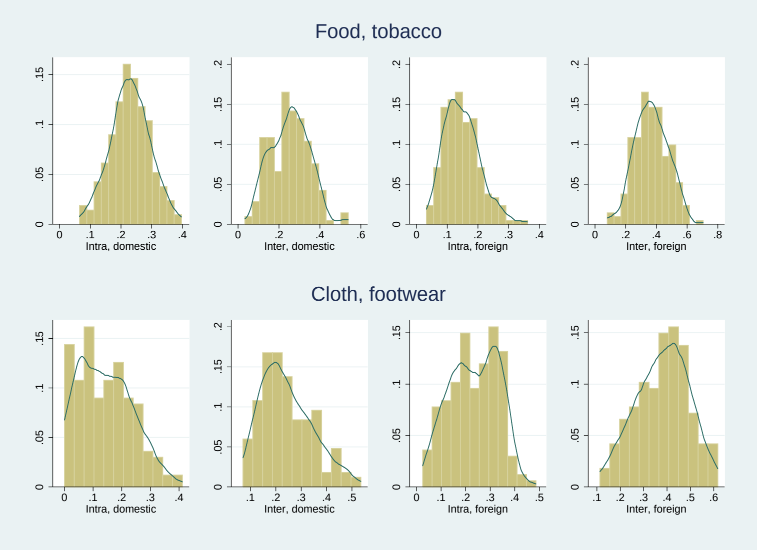
Decomposition of Productivity Growth by Industry



Contribution to Productivity Growth: 1990 - 2010

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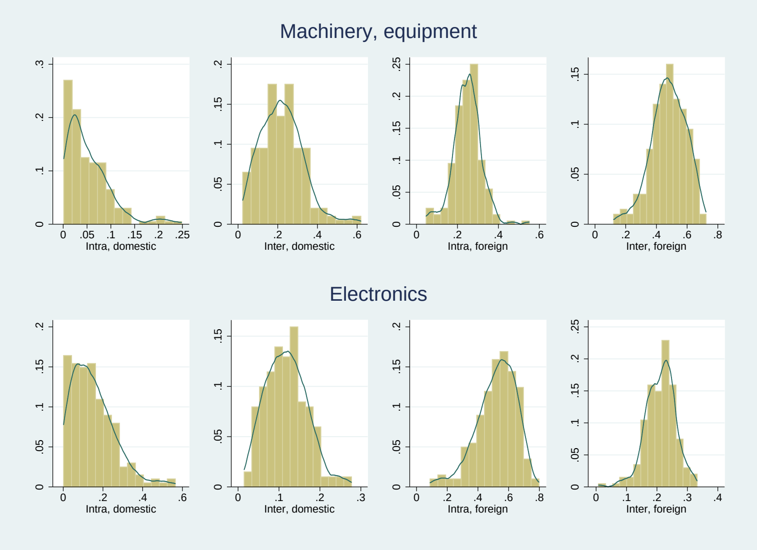
Decomposition of Productivity Growth by Industry



Contribution to Productivity Growth: 1990 - 2010

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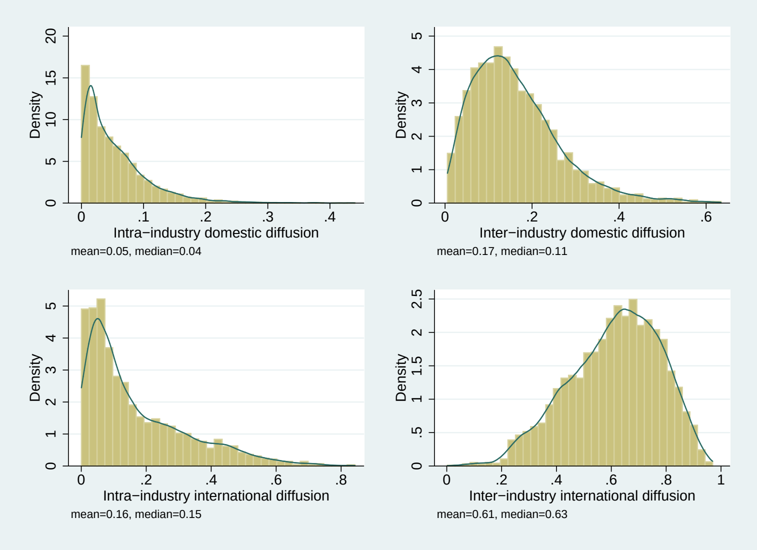
Decomposition under Patent Citation Matrix



Contribution to Productivity Growth: 1990 - 2010

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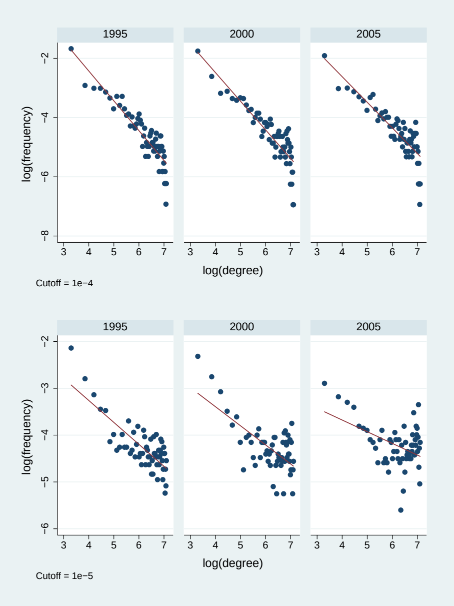
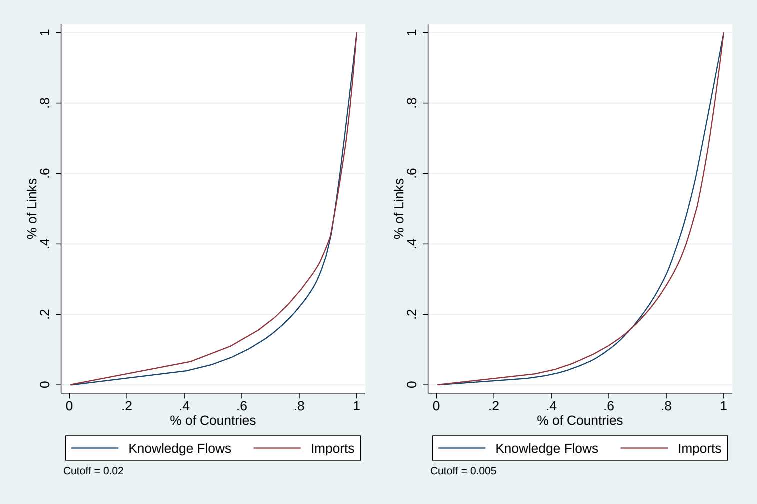
Degree Distribution



Lorenz Curve: Trade versus Knowledge Diffusion



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Dynamic Gains from Trade, OECD

	Gains from Trade (%)				
Country	Static	Dynamic	Country	Static	Dynamic
		Average			
OECD	23.62	6.07	Non-OECD	19.70	12.34
		OECD Economies			
Australia	11.45	3.08	Austria	38.93	7.54
Belgium-Lux	39.66	11.34	Canada	25.89	4.09
Chile	37.11	8.54	Czech	32.77	7.85
Denmark	44.07	10.41	Finland	23.36	4.91
France	17.33	4.17	Germany	20.41	4.23
Greece	19.11	5.51	Hungary	32.63	8.97
Iceland	28.64	11.26	Ireland	1.50	5.01
Israel	17.37	3.91	Italy	11.54	3.05
Japan	6.87	1.32	Korea	6.74	2.02
Mexico	20.89	8.52	Netherlands	28.33	7.57
New Zealand	20.83	6.27	Norway	16.85	2.81
Poland	21.57	6.34	Portugal	24.54	5.91
Slovakia	36.18	9.78	Slovenia	67.25	17.65
Spain	13.47	3.64	Sweden	20.38	4.38
Switzerland	34.05	5.72	Turkey	11.26	3.19
UK	18.32	3.80	USA	6.56	1.55

Dynamic Gains from Trade, Non-OECD

	Gains from Trade (%)				
Country	Static	Dynamic	Country	Static	Dynamic
Non-OECD Economies					
Argentina	5.68	1.60	Bangladesh	8.38	14.72
Bolivia	50.37	22.37	Brazil	4.02	2.92
Bulgaria	30.89	14.62	China	5.26	2.42
Colombia	12.33	6.10	Costa Rica	21.41	12.84
Ecuador	24.97	14.54	Egypt	12.43	7.84
El Salvador	5.34	1.86	Ethiopia	26.49	27.02
Fiji	59.24	22.61	Ghana	25.10	24.24
Guatemala	1.20	0.80	Honduras	8.20	10.02
India	4.03	3.01	Indonesia	9.48	9.68
Jordan	27.87	18.06	Kazakhstan	29.20	13.05
Kenya	28.56	26.07	Malaysia	12.82	7.68
Mauritius	51.43	17.87	Nigeria	17.16	12.48
Pakistan	10.59	11.32	Peru	14.56	10.73
Philippines	9.24	11.54	Romania	21.97	10.04
Russia	7.21	4.37	Senegal	37.37	32.73
South Africa	9.84	4.96	Sri Lanka	32.93	14.02
Taiwan	15.11	2.90	Tanzania	31.27	26.65
Thailand	21.74	10.52	Trinidad Tbg	17.01	11.06
Ukraine	18.28	15.18	Uruguay	28.42	11.06
Venezuela	10.65	8.83	Viet Nam	20.03	16.04