On the Geography of Global Value Chains

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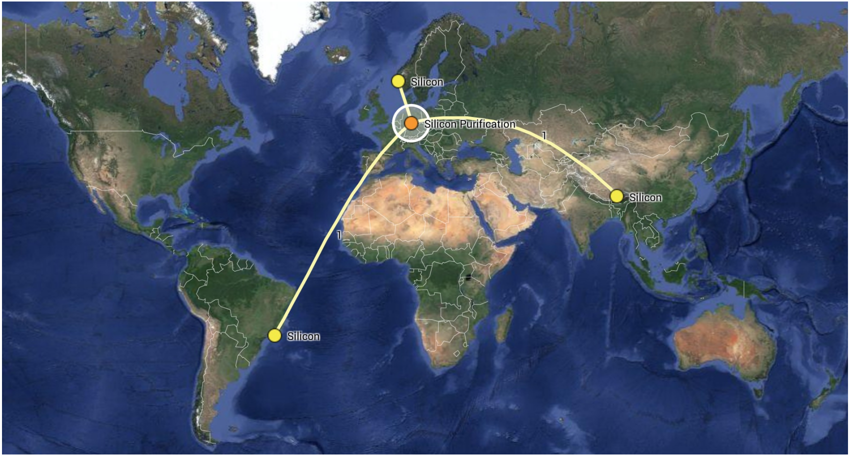

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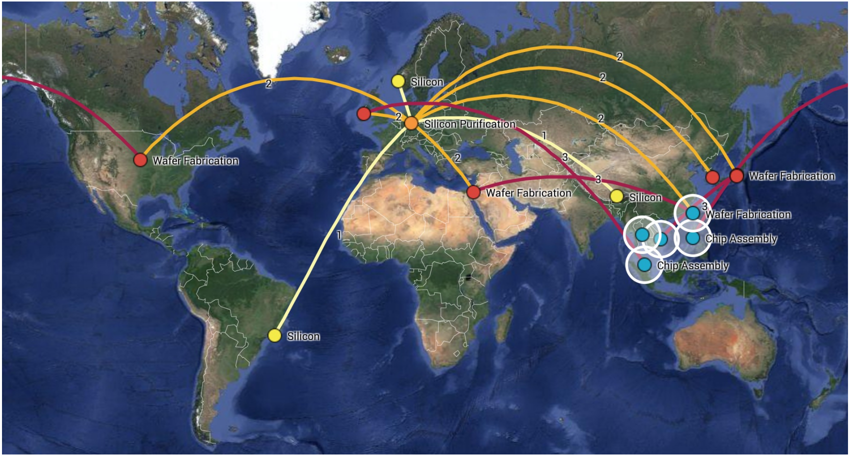

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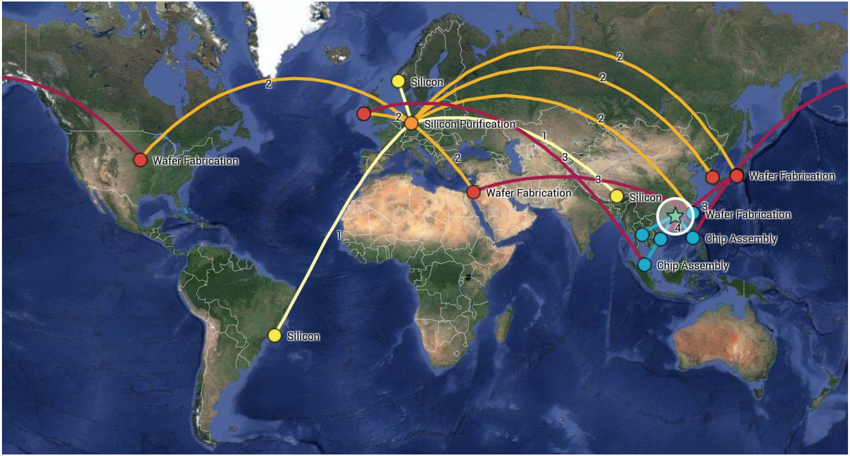

Why Do We Care?

- What are the implications of GVCs for the workings of general-equilibrium models?
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- **Past work**: non-existent or very stylized trade costs; generally two-country models

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- Connection with logistics literature

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2. Develop tools to solve the model in high-dimensional environments
3. Show how to map our model to world Input-Output tables
4. Structurally estimate the model and perform counterfactuals

Model: Partial Equilibrium

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- Countries also differ in their geography $J \times J$ matrix of iceberg trade cost coefficients τ_{ij}
- Technology features constant returns to scale and market structure is perfectly competitive

Partial Equilibrium: Sequential Production Technology

- Optimal path of production $\boldsymbol{\ell}^j = \left\{ \ell^j(1), \ell^j(2), ..., \ell^j(N) \right\}$ for providing the good to consumers in country j dictated by cost minimization

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- We summarize technology via the following sequential cost function associated with a path of production $\boldsymbol{\ell} = \{\ell(1), \ell(2), ..., \ell(N)\}$:

$$p^n_{\ell(n)}(\boldsymbol{\ell}) = g^n_{\ell(n)}\left(w_{\ell(n)}, p^{n-1}_{\ell(n-1)}(\boldsymbol{\ell})\, \tau_{\ell(n-1)\ell(n)} \right), \text{ for all } n.$$

where $p^1_{\ell(1)}(\boldsymbol{\ell}) = g^1_{\ell(1)}\left(w_{\ell(1)}\right)$ for all paths $\boldsymbol{\ell}$

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- A good assembled in $\ell(N)$ after following the path $\boldsymbol{\ell}$ is available in any country j at a cost $p^F_j(\boldsymbol{\ell}) = p^N_{\ell(N)}(\boldsymbol{\ell})\,\tau_{\ell(N)j}$

A Useful Benchmark

- Assume a Cobb-Douglas technology with Ricardian efficiency differences

$$p^{n}_{\ell(n)}(\boldsymbol{\ell}) = \left(a^{n}_{\ell(n)} w_{\ell(n)}\right)^{\alpha_n} \left(p^{n-1}_{\ell(n-1)}(\boldsymbol{\ell})\, \tau_{\ell(n-1)\ell(n)}\right)^{1-\alpha_n}, \text{ for all } n,$$

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- Iterating, the cost-minimization problem for a **lead firm** is:

$$\boldsymbol{\ell}^j = \arg\min_{\boldsymbol{\ell}\in\mathcal{J}^N} \left\{ \prod_{n=1}^{N} \left(a^n_{\ell(n)} w_{\ell(n)}\right)^{\alpha_n\beta_n} \times \prod_{n=1}^{N-1} \left(\tau_{\ell(n)\ell(n+1)}\right)^{\beta_n} \times \tau_{\ell(N)j} \right\}$$

where

$$\beta_n \equiv \prod_{m=n+1}^{N} (1-\alpha_m)$$

Two Lessons

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2. Trade-cost elasticity of the unit cost of serving consumers in country j increases along the value chain ($\beta_1 < \beta_2 < ... < \beta_N = 1$)
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- These results hold for any CRS technology

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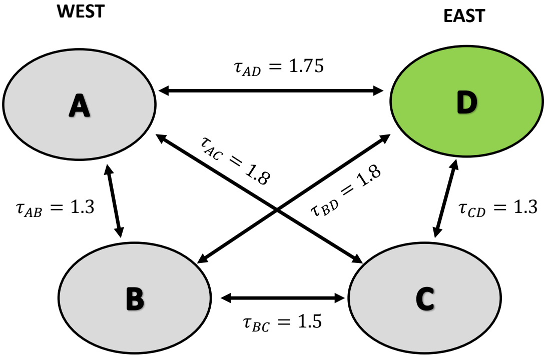
- But much lower dimensionality! ($J \times N \times J$ computations)

An Example: $N = J = 4$



- We explore the implications of shifts in trade costs by letting $\tau'_{ij} = 1 + s(\tau_{ij} - 1)$ for $s > 0$ ▸ Results
- We average across 1 million simulations in which $a_j^n w_j \sim \log \mathcal{N}(0, 1)$

General Equilibrium

A Multi-Stage Ricardian Model

- We next embed our framework into a general equilibrium model
- Framework will accommodate:
  - Ricardian differences in technology across stages and countries
  - A continuum of final goods
  - Multiple GVCs producing each of these final goods
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  - An arbitrary number of countries J and stages N
- Model will **not** predict the path of each specific GVC. Instead:
  - Characterize the relative prevalence of different possible GVC
  - Study average positioning of countries in GVCs
  - Trace implications for the world distribution of income

Formal Environment

- Preferences are

$$u\left(\left\{y_j^N(z)\right\}_{z=0}^{1}\right) = \left(\int_0^1 \left(y_j^N(z)\right)^{(\sigma-1)/\sigma} dz\right)^{\sigma/(\sigma-1)}, \quad \sigma > 1$$

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- Bundle of inputs comprises labor and CES aggregator in $u(\cdot)$
  - $c_i = (w_i)^{\gamma_i}(P_i)^{1-\gamma_i}$, where P_i is the ideal consumer price index

Probabilistic Representation of Technology

- In Eaton and Kortum (2002) with $N = 1$, they assume $1/a_j^N(z)$ is drawn for each good z independently from the Fréchet distribution

$$\Pr(a_j^N(z) \geq a) = e^{-T_j a^{\theta}}, \text{ with } T_j > 0$$

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- **Problem:** The distribution of the product of Fréchet random variables is **not** distributed Fréchet
  - The same would be true with fixed proportions (sum of Fréchets)

- How can one recover the magic of the Eaton and Kortum in a multi-stage setting?

The Challenge: Two Solutions

1. If a production chain follows the path $\{\ell(1), \ell(2), ..., \ell(N)\}$, then

$$\Pr\left(\prod_{n=1}^{N}\left(a^{n}_{\ell(n)}(z)\right)^{\alpha_n\beta_n} \geq a\right) = \exp\left\{-a^{\theta}\prod_{n=1}^{N}\left(T_{\ell(n)}\right)^{\alpha_n\beta_n}\right\}$$

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2. Decentralized equilibrium in which stage-specific producers do not observe realized prices before committing to sourcing decisions
   - Firms observe the productivity levels of their potential direct (or tier-one) suppliers
   - But not of their tier-two, tier-three, etc. suppliers

Some Results: GVC Shares

- Likelihood of a particular GVC ending in j is

$$\pi_{\ell j} = \frac{\prod_{n=1}^{N-1} \left(\left(T_{\ell(n)} \right)^{\alpha_n} \left(\left(c_{\ell(n)} \right)^{\alpha_n} \tau_{\ell(n)\ell(n+1)} \right)^{-\theta} \right)^{\beta_n} \times \left(T_{\ell(N)} \right)^{\alpha_N} \left(\left(c_{\ell(N)} \right)^{\alpha_N} \tau_{\ell(N)j} \right)^{-\theta}}{\Theta_j}$$

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- When $N = 1$

$$\pi_{\ell(N)j} = \frac{T_{\ell(N)} \left(c_{\ell(N)} \tau_{\ell(N)j} \right)^{-\theta}}{\Theta_j},$$

as in Eaton and Kortum (2002)

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$$\Pr\left(\Lambda_{k \to i}^n, j\right) = \sum_{\boldsymbol{\ell} \in \Lambda_{k \to i}^n} \pi_{\boldsymbol{\ell} j}, \text{ where } \Lambda_{k \to i}^n = \left\{ \boldsymbol{\ell} \in \mathcal{J}^N \mid \ell(n) = k \text{ and } \ell(n+1) = i \right\}$$

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- Can also express labor market clearing as a function of transformations of these probabilities

$$\frac{1}{\gamma_i} w_i L_i = \sum_{j \in \mathcal{J}} \sum_{n \in \mathcal{N}} \alpha_n \beta_n \times \Pr\left(\Lambda_i^n, j\right) \times \frac{1}{\gamma_j} w_j L_j$$

Gains from Trade

- Consider a ‘purely-domestic’ value chain that performs all stages in a given country j to serve consumers in the same country j
- Such value chain captures a share of country j’s spending equal to

$$\pi_{j^N} = \Pr(j, j, ..., j) = \frac{\left(\tau_{jj}\right)^{-\theta\left(1+\sum_{n=1}^{N-1}\beta_n\right)} \times \left(c_j\right)^{-\theta} T_j}{\Theta_j}$$

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- We can then show

$$\frac{w_j}{P_j} = \left(\kappa\,(\tau_{jj})^{1+\sum_{n=1}^{N-1}\beta_n}\right)^{-1/\gamma_j}\left(\frac{T_j}{\pi_{j^N}}\right)^{1/(\theta\gamma_j)}$$

- Under autarky $\pi_{j^N} = 1$, so the (percentage) real income gains from trade, relative to autarky, are given by

$$(\pi_{j^N})^{-1/(\theta\gamma_j)} - 1$$

The Centrality-Downstreamness Nexus

- Define the average upstreamness $U(i;j)$ of production of a given country i in value chains that seek to serve consumers in country j:

$$U(i;j) = \sum_{n=1}^{N} (N - n + 1) \times \frac{\Pr(i = \ell(n);j)}{\sum_{n'=1}^{N} \Pr(i = \ell(n');j)}$$

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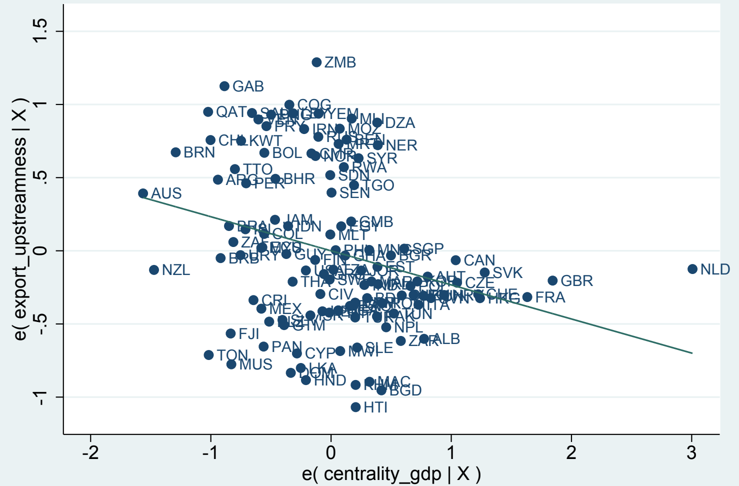
- Suppose we can decompose $\tau_{ij} = (\rho_i \rho_j)^{-1}$. Then:

Proposition (Centrality-Upstreamness Nexus)

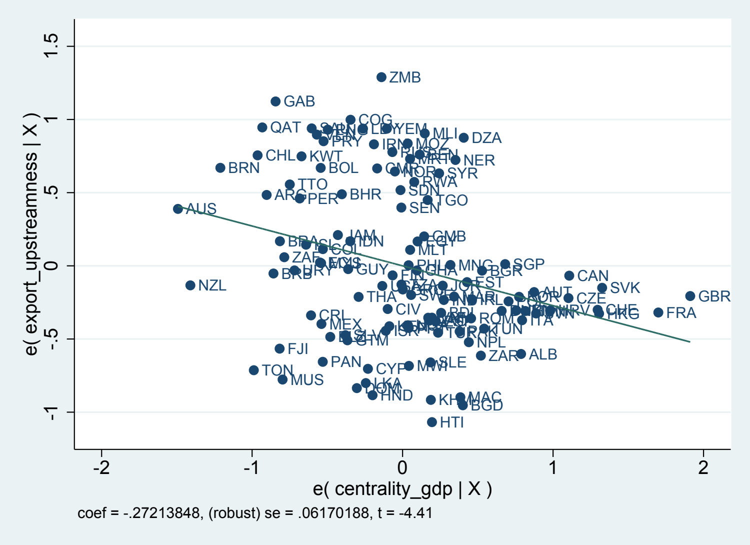
The more central a country i is (i.e., the higher is ρ_i), the lower is the average upstreamness $U(i;j)$ of this country in global value chains leading to consumers in any country j.

Centrality and Downstreamness: Suggestive Evidence



coef = -.23295721, (robust) se = .061446, t = -3.79

Centrality and Downstreamness: Suggestive Evidence



Increasing Trade Elasticity: Suggestive Evidence

Table 1. Trade Cost Elasticities for Final Goods and Intermediate Inputs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Distance	-1.111***	-0.823***	-1.144***	-0.851***	-1.210***	-0.903***	-0.794***
	(0.019)	(0.014)	(0.019)	(0.014)	(0.021)	(0.015)	(0.015)
Distance × Input					0.133***	0.106***	0.098***
					(0.006)	(0.006)	(0.006)
Contingity		2.187***		2.198***		2.287***	1.184***
		(0.111)		(0.112)		(0.120)	(0.099)
Contingity × Input						-0.177***	-0.054
						(0.037)	(0.040)
Language		0.480***		0.507***		0.596***	0.513***
		(0.026)		(0.027)		(0.029)	(0.027)
Language × Input						-0.179***	-0.169***
						(0.013)	(0.013)
Domestic							5.635***
							(0.187)
Domestic × Input							-0.599***
							(0.067)
Observations	32,400	32,400	64,800	64,800	64,800	64,800	64,800
R^2	0.98	0.982	0.972	0.974	0.972	0.974	0.976

Estimation

Calibration to World-Input Output Database

- We next map our multi-country Ricardian framework to world Input-Output Tables
- Core dataset: World Input Output Database (2016 release)
  - 43 countries (86% of world GDP) + ROW; available yearly 2000-2014
  - Provides information on input and final output flows across countries
- Also Eora dataset: 190 countries (but consolidate to 101)

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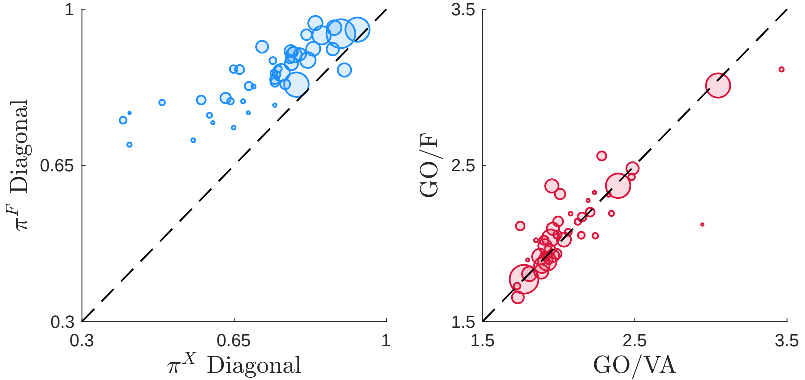
		Input use & value added			**Final use**			**Total use**
		Country 1	$\cdots$	Country J	Country 1	$\cdots$	Country J	
Intermediate inputs supplied	Country 1							
	$\cdots$							
	Country J							
Value added								
Gross output								

Some Key Features

- Asymmetries in input and final-output domestic shares
- Variation in GO/VA and GO/F (+ correlated)



Empirical Strategy

- Normalizing $\tau_{ii} = 1$, it turns out that

$$(\tau_{ij})^{-\theta} = \sqrt{\frac{\pi^F_{ij}}{\pi^F_{ii}} \frac{\pi^F_{ji}}{\pi^F_{jj}}}$$

- Estimate (T_j, γ_j) for all j and α_n for all n targeting:
  - Diagonal of intermediate input and final-good share matrices
  - Ratio of value added to gross output by country
  - GDP shares by country (also take into account trade deficits)

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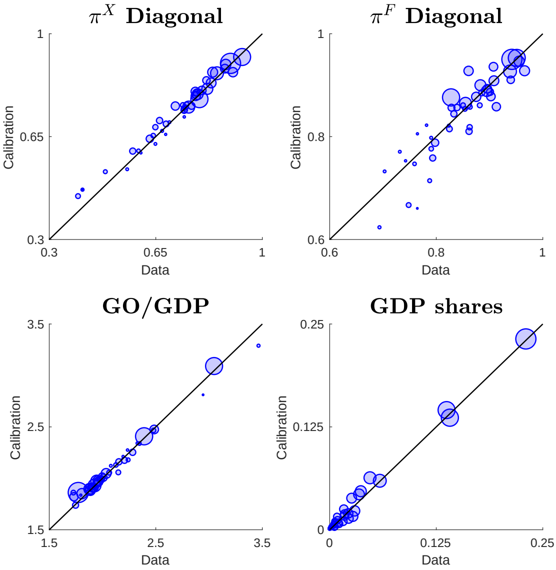
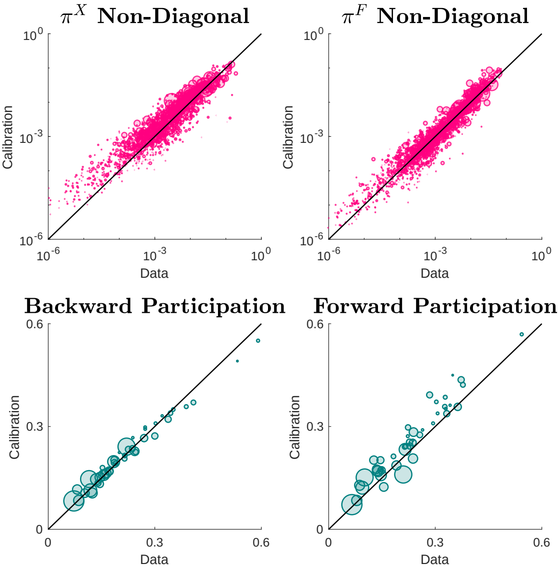
  - Diagonal of intermediate input and final-good share matrices
  - Ratio of value added to gross output by country
  - GDP shares by country (also take into account trade deficits)
- We set $N = 2$ (data 'rejects' $N > 2$) and $\theta = 5$
- We find $\alpha_2 = 0.16$ (remember $\alpha_1 = 1$); $\alpha_2 = 0.19$ with Eora
  - Hence, data rejects a standard roundabout model ($\alpha_2 = 1$)

Fit of the Model: Targeted Moments

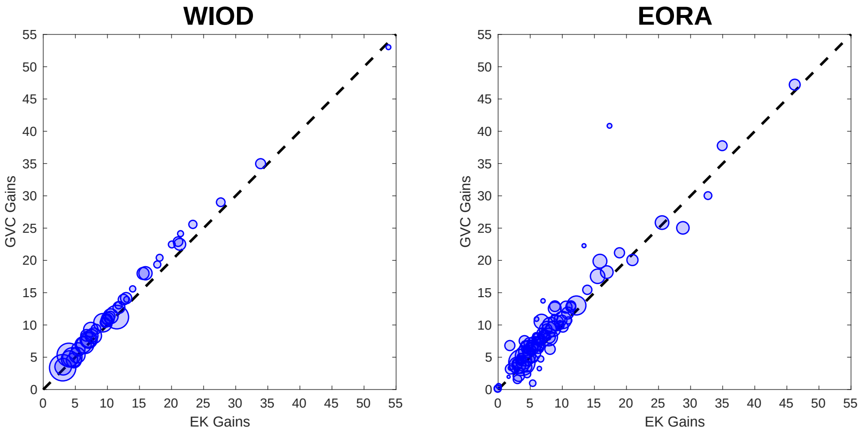


Fit of the Model: Untargeted Moments



Counterfactuals

Counterfactuals: Real Income Gains Relative to Autarky



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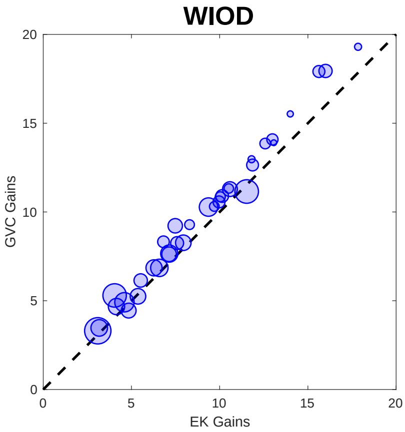

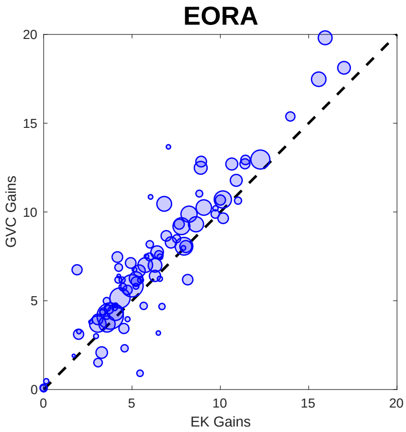

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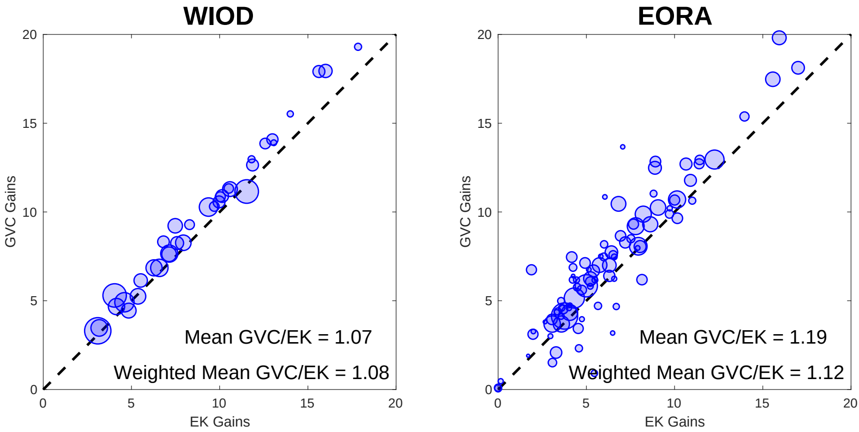
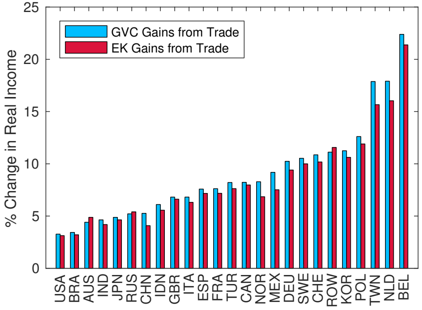
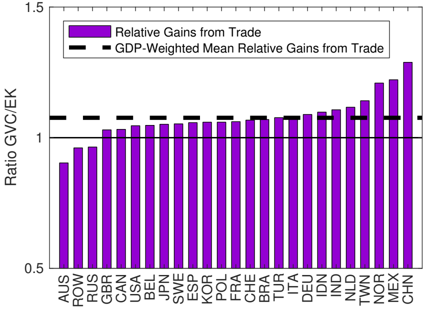


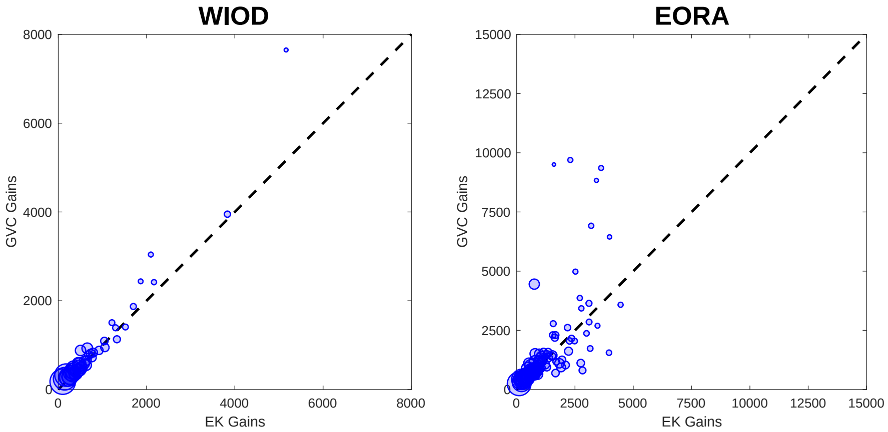
Counterfactuals: Real Income Gains Relative to Autarky



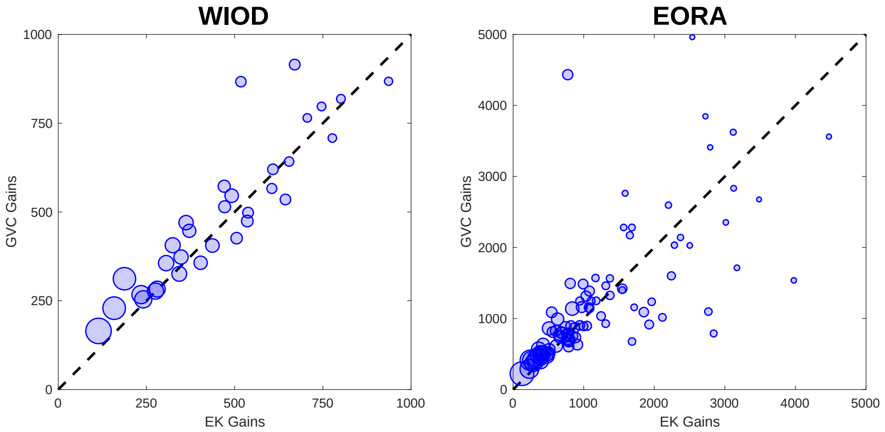


- GVC model with $N = 1$, i.e. EK model, underestimates gains from trade by 8% on average (11% in EORA)

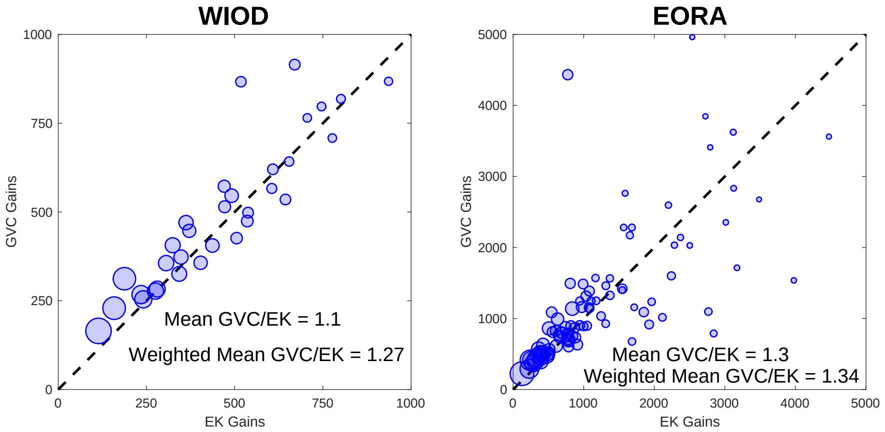
Counterfactuals: Free Trade Real Income Gains



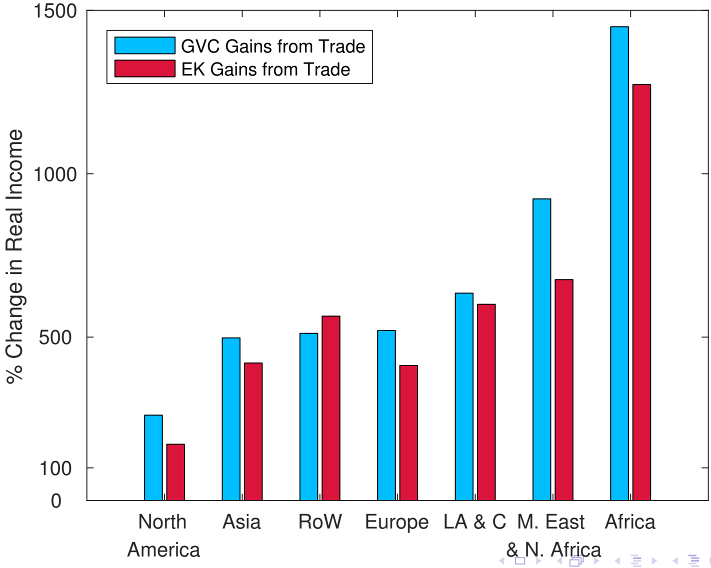
Counterfactuals: Free Trade Real Income Gains



Counterfactuals: Free Trade Real Income Gains

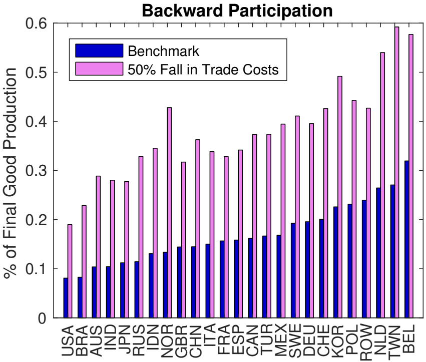


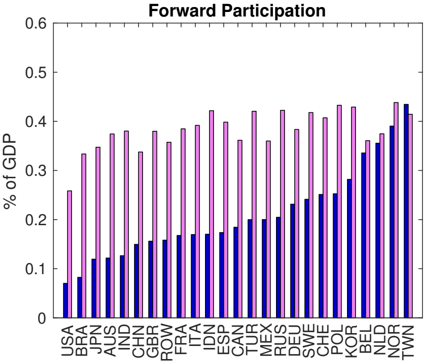
Counterfactuals: Real Income Gains from Free Trade



Counterfactuals: 50% Fall in Trade Costs

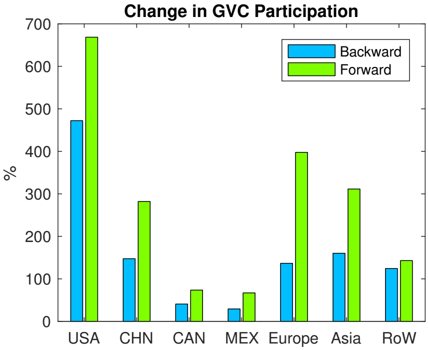
- All countries integrate more

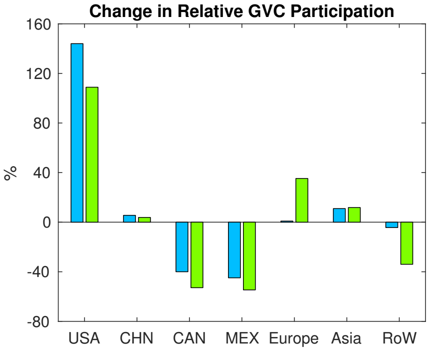




Counterfactuals: 50% Fall in Trade Costs

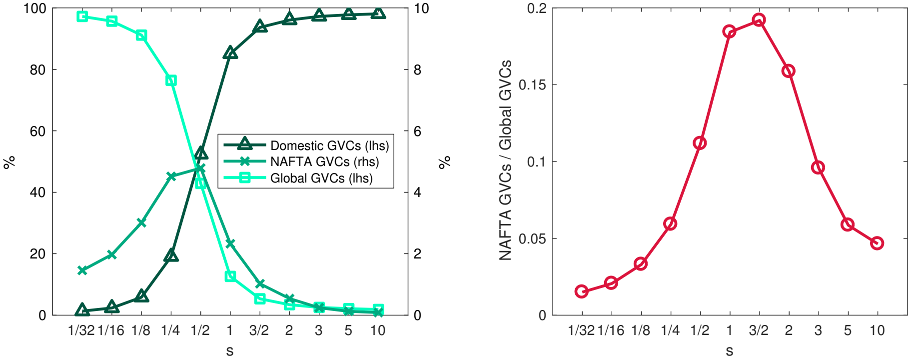
- USA integrates more with all regions...
- ...but global integration increases relative to regional integration





Counterfactuals: Local vs. Regional vs. Global Chains

- Consider $\tau'_{ij} = 1 + s(\tau_{ij} - 1)$ for $s > 0$
- Very much resembles partial equilibrium model results

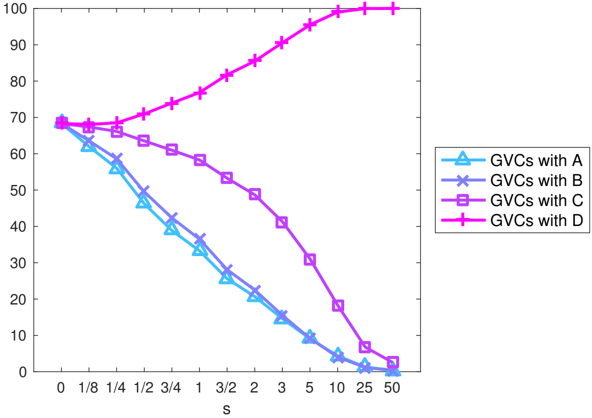


Conclusions

- We have studied how trade frictions shape the location of production along GVCs
- We have demonstrated a centrality-downstreamness nexus and have offered suggestive evidence for it
- Our framework can be used to quantitatively assess the implications of the rise of GVCs
- We view our work as a stepping stone for a future analysis of the role of **man-made** trade barriers in GVCs
  - Should countries use policies to place themselves in particularly appealing segments of global value chains?
  - What is the optimal shape of those policies?

An Example: Results

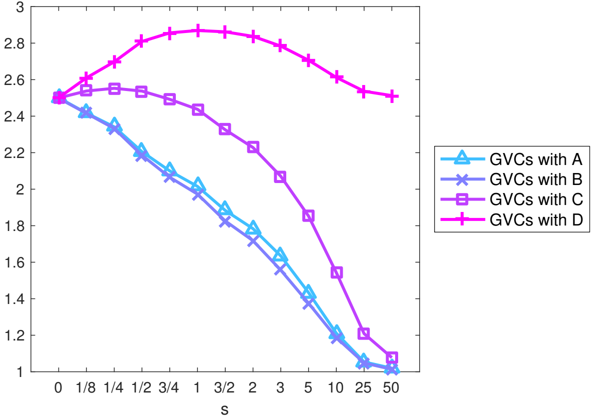
Figure: Average Propensity of Countries in GVCs Leading to Consumption in D



- B appears more often than A in GVCs leading to D

An Example: Results

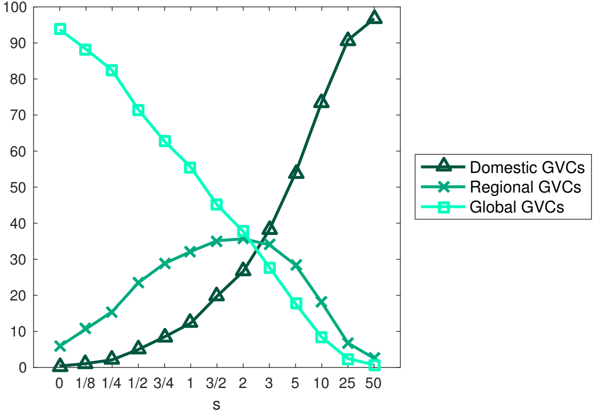
Figure: Average Upstreamness of Countries in GVCs Leading to Consumption in D



- Geography shapes the average position of a country in GVCs

An Example: Results

Figure: Regional vs Global GVCs Leading to Consumption in D



- GVCs are first local, then regional and finally global

BACK