Entrepôt

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Preliminary

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- Stiff historic and contemporary competition to become entrepôts
  - Saudi Arabia: $7bn to be the "major east-west marine transshipment location." (FT 2015)
  - India: $5bn in new ports to compete with established hubs (Reuters 2016)
  - Singapore: $1bn to "stay ahead of the curve as a world-class hub port" (Int. Port Tech. 2018) following $3bn in automation (Ship & Bunker 2012)

Research Agenda

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3. What are the positive (or negative) regional spillovers of entrepôts?

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    - Indirectness is ubiquitous, varied, and concentrated through entrepôts.
- Build & Estimate a GE model where producers optimally choose shipping routes and hubs emerge endogenously.
    - Use traffic flows to back out network structure – leg-specific transport costs.
- Counterfactuals: evaluate effects of (1) Hard Brexit and (2) opening NE passage.
    - Network generates first-order, localized effects.

Contributions and Related Literature

- Provide evidence on how global shipping networks inform international trade
  - Previous papers only utilize data on ships calling at ports (Kojaku et al (2019), Wang and Wang (2011))
  - Endogenize transport costs as part of a global network of shipping routes (Brancaccio et al (2019), Hummels (2007), Limao and Venables (2001))
  - Network effects of the container shipping technology on international trade (Bernhofen et al (2016), Cosar and Demir (2018), Rua (2014), Wong (2019))
- Quantify the effects of global shipping networks through a GE economic geography model
  - Extend Armington route choice framework (Allen and Arkolakis, AA (2019)) to include Ricardian industry-level comparative advantage (EK (2002))
  - Trade cost changes and infrastructure investment at nodes (entrepôts) and where spillovers between nodes may be negative due to scale economies (Fajgelbaum & Schaal (2017), Ducruet et al. (2019)
  - Economies of scale in shipping by estimating a scale economy with respect to volume of traffic (Anderson et al (2016), Holmes and Singer (2018))

Ports of Call

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- Containership movements do not necessarily capture the journey of container shipments.

Combined AIS and Bill of Lading Data

$$\begin{array}{c}\text{Origin}\\\text{(Foreign)}\end{array} \longrightarrow \underbrace{\begin{array}{c}\text{Stop 1}\\\text{(Foreign)}\end{array} \longrightarrow \begin{array}{c}\text{Stop 2}\\\text{(Foreign)}\end{array} \dashrightarrow \begin{array}{c}\text{Stop X}\\\text{(Foreign)}\end{array} \longrightarrow \begin{array}{c}\text{Destination}\\\text{(US)}\end{array}}_{\text{Containership}}$$

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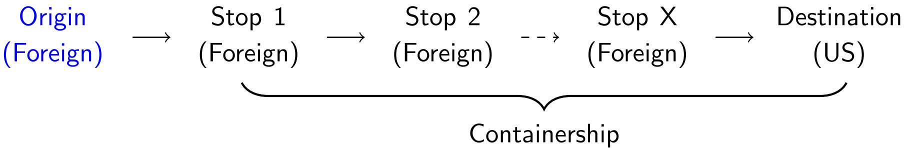

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Containership

- Origin: foreign location where shipment originated from

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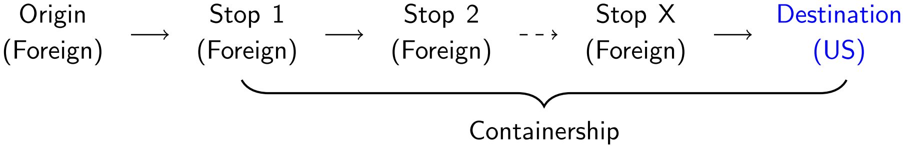

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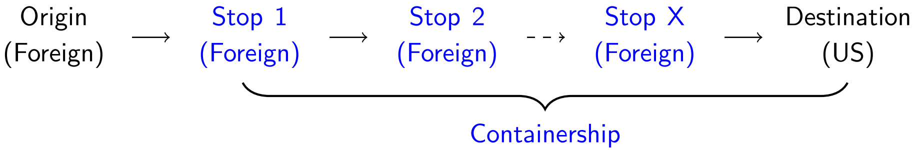
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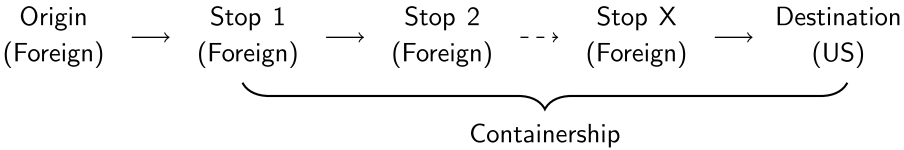

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- Shipment information: weight, container TEUs, product, value
- We match 90% of incoming containers

Data

Stylized Facts

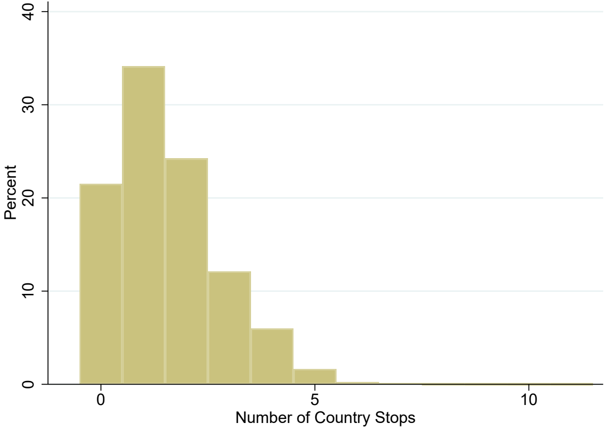
Model: Overview

Estimation

Counterfactual

Conclusion

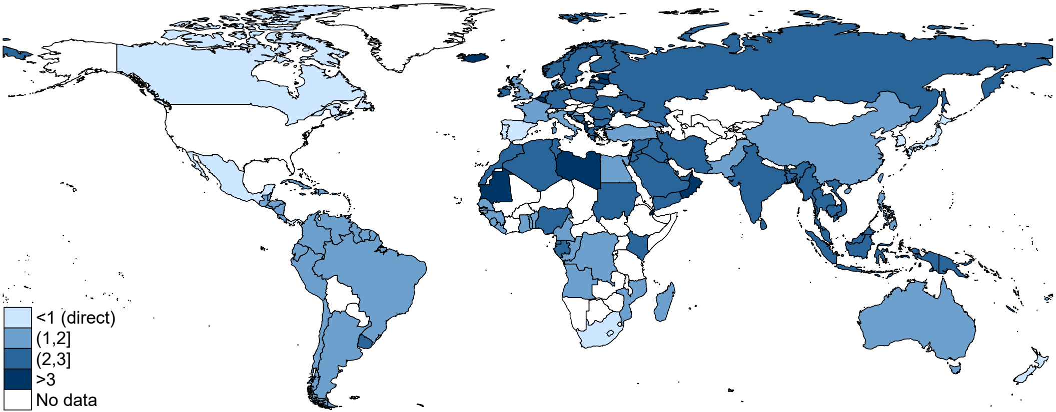
How indirect is trade?



- >70% by volume are indirect. Weight and Value Port Stops

How indirect is trade?

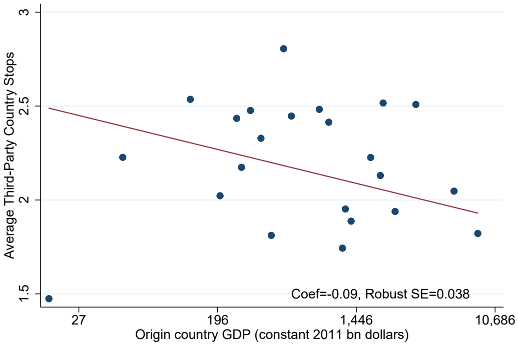
Stylized Fact 1: *The majority of containerized trade into the US is indirect.*



Average number of stops, by origin

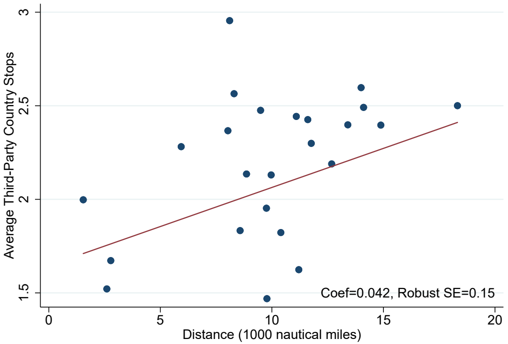
Variation in Directness

Stylized Fact 2: *There is significant variation in this indirectness across countries—larger and closer countries are more likely to ship directly.*



Robust Standard Errors weighted by TEUs.

(a) Stops vs. Country size

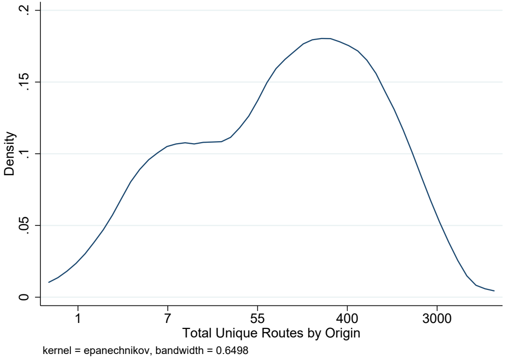


Robust Standard Errors weighted by TEUs.

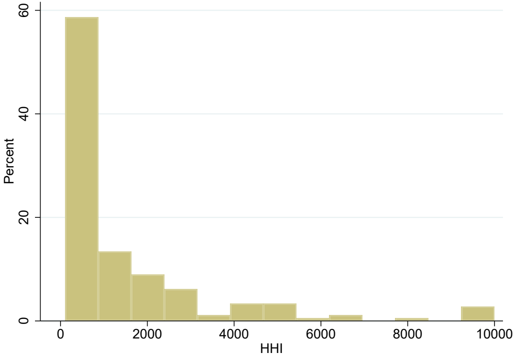
(b) Stops vs Distance

Within-country variation

Stylized Fact 3: *From a single origin, trade is on averaged dispersed through a large number of routes.*



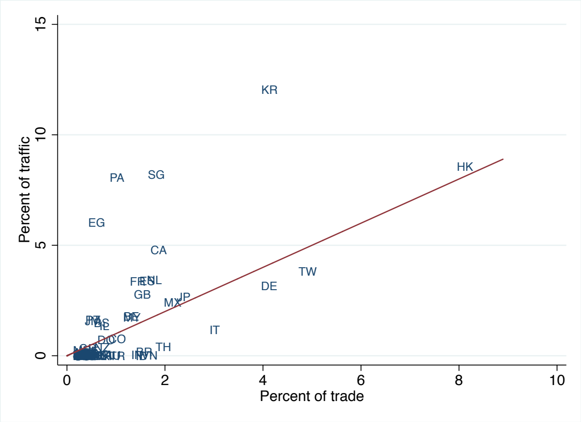
(a) Distribution of Unique Routes



(b) Distribution of Route Concentration

Concentration of Through-Shipments

Stylized Fact 4: *Shipping is concentrated through a minority of countries which account for a disproportionate share of third-party stops.*



Traffic vs. Trade

Concentration

Global Data

Transshipments

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  3. Multiple industries with variable trade and production costs
- Estimating equation backs out the costs of traveling each link in network from the observed traffic and trade volumes

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  where z_{in} is industry productivity, W_i is a vector of factor prices, P_{in} is a vector of intermediate good prices
- To export to any j, competitive producers pay tariffs κ_{ijn} and iceberg transport cost $\tau_{nijr}(\omega)$ that depends on their chosen shipping route r:

  $$p_{ijn}(\omega) = c_{in}\kappa_{ijn}\tau_{nijr}(\omega)$$

Endogenous Transport Costs (AA 2019)

- Total transport cost involves $\tilde{\tau}_{nijr}$ and a route-specific idiosyncratic cost shock

$$\tau_{nijr}(\omega) = \frac{1}{\epsilon_{ijnr}(\omega)} \tilde{\tau}_{nijr}$$

- The common transport cost from i to j on shipping route r is $\tilde{\tau}_{nijr}$

$$\tilde{\tau}_{ijr} = \prod_{k=1}^{K_r} t_{k_r - 1, k_r}$$

where t_{k_r-1,k_r} is the leg-specific cost going directly from $k_r - 1$ to k_r

Further Details

Equilibrium Traffic

- Summing across routes r that goes through leg k, l, express share of exports in industry n from origin i to destination j that pass through leg k, l as

$$\pi_{ijn}^{kl} = \left[\left(c_{in}\kappa_{ijn}\right) \cdot \tau_{nik} t_{nkl} \tau_{nlj}\right]^{-\theta} \cdot \Phi_{jn}^{-1}$$

  - τ_{nij} is the average cost to ship from i to j
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- For a set of industries that share transport costs, total traffic between k and l:

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- Objective: estimate transport cost between locations
  - One issue: land borders. Solution: parameterize

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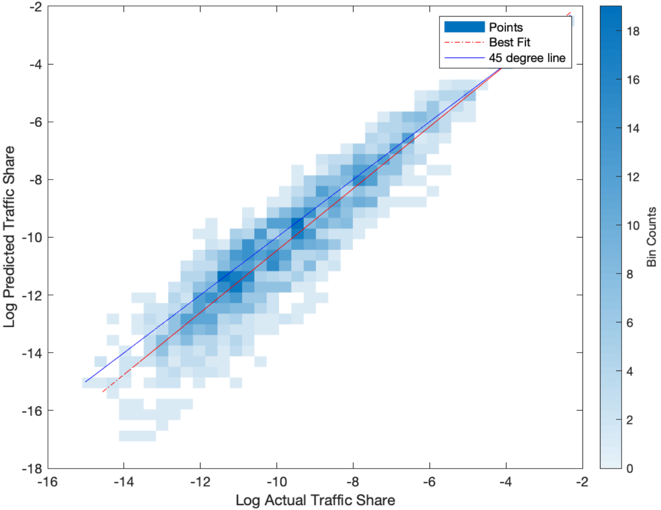
- Estimation routine:
  1. Guess β
  2. Find t_{kl}, τ_{kl}
  3. Find predicted traffic: $$\Xi_{kl}^{predicted} \equiv \sum_i \sum_j X_{ij} \cdot \left[\tau_{ik} t_{kl} \tau_{lj} \tau_{ij}^{-1}\right]^{-\theta}$$
  4. Minimize difference between predicted and observed:

$$\arg_\beta \min \sum_{kl \neq \text{land borders}} \left|\Xi_{kl}^{observed} - \Xi_{kl}^{predicted}\right|$$

Model Fit


Points
Best Fit
45 degree line
Log Predicted Traffic Share
Log Actual Traffic Share
Bin Counts
-2
-4
-6
-8
-10
-12
-14
-16
-18
-16
-14
-12
-10
-8
-6
-4
-2
18
16
14
12
10
8
6
4
2
0

Route Cost Estimates

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When $t_{kl} \downarrow$, first 3 terms will increase X_{ij}. The 4th term shows potential decrease if the shift differentially favors trade and production costs from other countries to j

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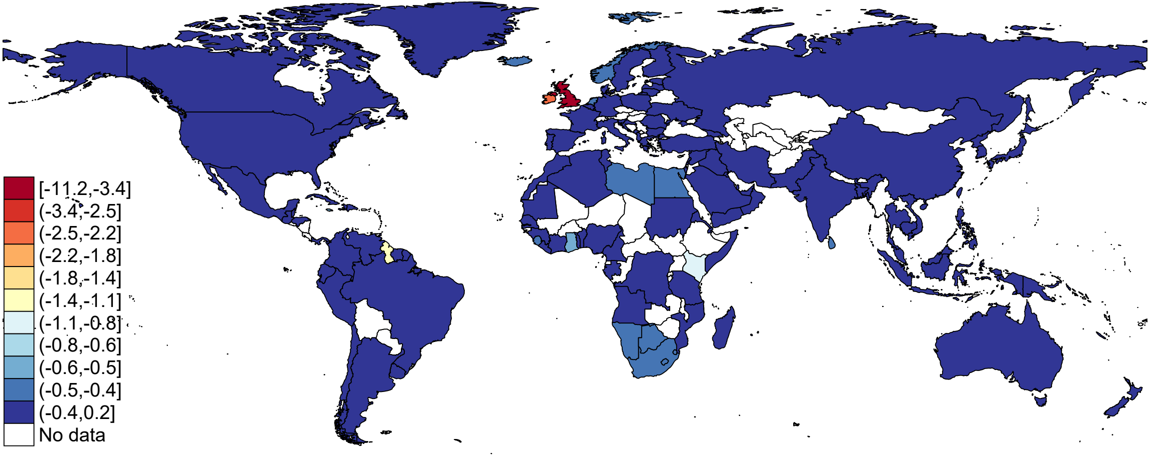
- Scale economies will change results

Hard Brexit: No Network Effects



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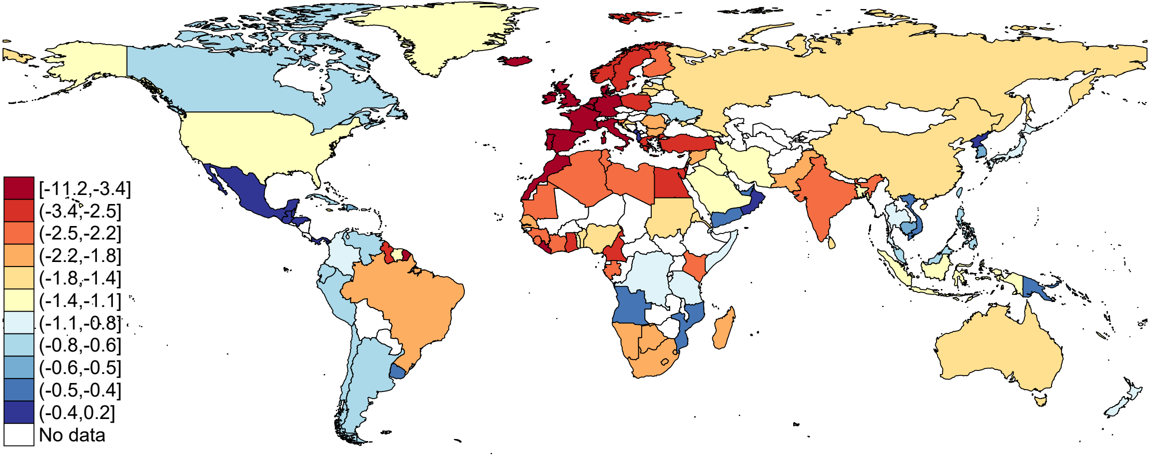

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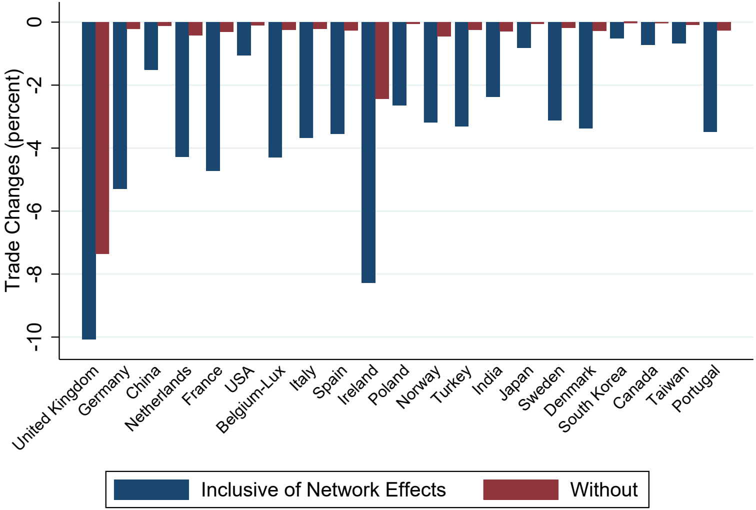

Top 20 countries in addition to UK ranked by their trade with UK (decreasing from left to right).

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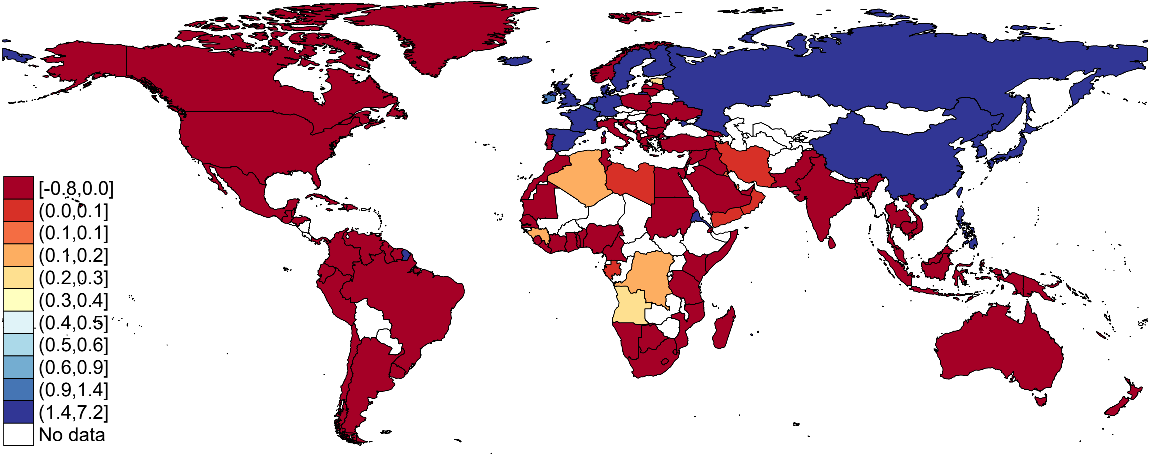

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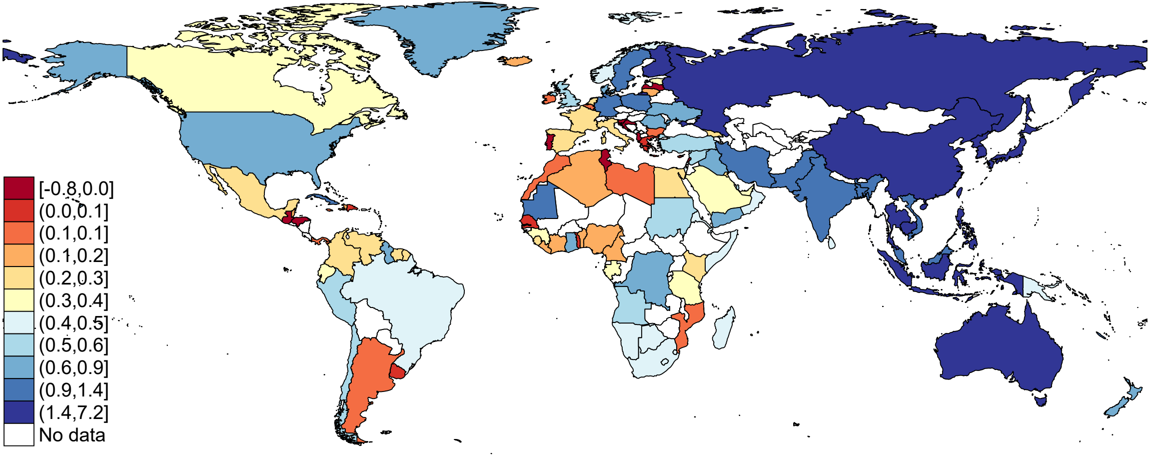

Scale Economies

- Counterfactuals assume exogenous changes to trade costs.
- Concentration levels (Fact 4) and model estimates suggest scale economy.

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- Concentration levels (Fact 4) and model estimates suggest scale economy.
- IV strategy:
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  - Instrument for traffic Ξ_{kl} using

$$z_{kl} = \sum_i Pop_i \sum_j Pop_j \frac{d_{ij}}{d_{ik} d_{lj}}$$

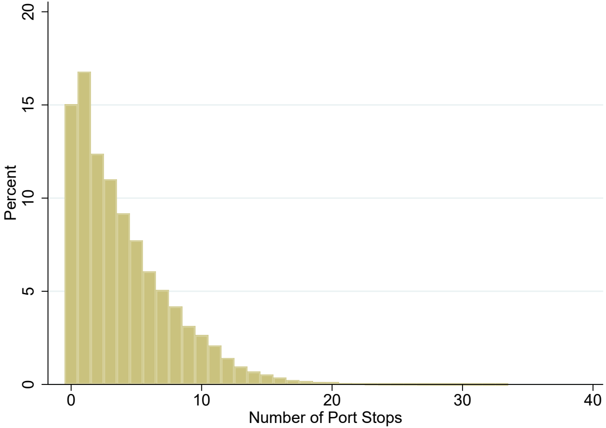
Results More details

Conclusion

- International trade is often indirect, varied, and concentrated through entrepôts
- Changes in trade costs of a node or links in the transportation network result in regional trade and welfare spillovers
- Brexit and NE passage counterfactuals: large network effects, network-localized
- Further work: integrate scale economies into counterfactuals

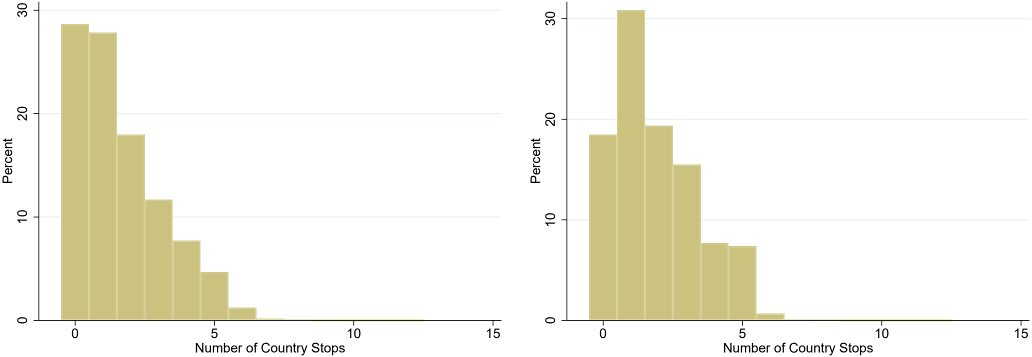
Indirectness of Trade

Number of port stops per TEU



About 15% of containers (TEUs) are direct, making no stops along the way, and the average number of port stops is 5.5 Back

Indirectness of Trade by Weight and Value

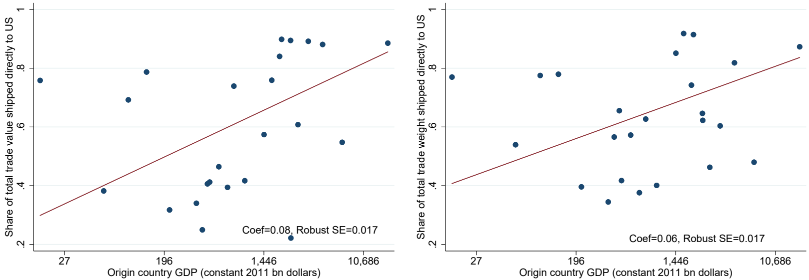


About 70% of shipment weight and more than 80% of shipment value is indirect

Back

Variation in Indirect Trade

Origin country GDP vs trade share at first stop



- By value and by weight, the share of direct shipments are more likely to be higher from bigger countries

Back

Shipping: Endogenous Transport Costs (AA 2019)

- Using familiar derivations pioneered in EK (2002), express expected trade cost τ_{ij} from i to j as

$$\tau_{ij} = \mathbf{c}\left(\sum_{K=0}^{\infty}\sum_{p\in P_K}\boldsymbol{\tilde{\tau}_{ij}(p)}^{-\theta}\right)^{-\frac{1}{\theta}} = \mathbf{c}\left(\sum_{K=0}^{\infty}\sum_{p\in P_K}\prod_{k=1}^{K_r} t_{p_{k-1},p_k}^{-\theta}\right)^{-\frac{1}{\theta}}$$

  where $\mathbf{c} \equiv \Gamma\left(\frac{\theta-1}{\theta}\right)$
- Characterize weighted adjacency matrix $\mathbf{A} = [a_{ij} \equiv t_{ij}^{-\theta}]$, $a_{ij} \in [0,1]$ where 0 is no connection between i and j and 1 is cost-less link
- Sum over all paths of length K:

$$\tau_{ij}^{-\theta} = \mathbf{c}^{-\theta}\sum_{K=0}^{\infty}\left(\sum_{k_1=1}^{N}\sum_{k_2=1}^{N}\dots\sum_{k_{K-1}=1}^{N} a_{i,k_1}\times a_{k_1,k_2}\times \dots a_{k_{K-2},k_{K-1}}\times a_{k_{K-1},j}\right)$$

where k_n is sub-index for the n^{th} location reached on a particular path

Back

Shipping: Endogenous Transport Costs (AA 2019)

- Expression in parenthesis equivalent to:

$$\tau_{ij}^{-\theta} = \mathbf{c}^{-\theta} \sum_{K=0}^{\infty} \mathbf{A}_{ij}^{K}$$

where $\mathbf{A}^K = [\mathbf{A}_{ij}^K]$: $\mathbf{A}_{ij}^K$ is the (i, j) element of matrix $\mathbf{A}$ to power K

- Express geometric sum of matrix $\mathbf{A}$ as $\sum_{K=0}^{\infty} \mathbf{A}_{ij}^K = (\mathbf{I} - \mathbf{A})^{-1} \equiv \mathbf{B}$ where $\mathbf{B} = [b_{ij}]$ is the route cost matrix Sufficient Condition

- Write expected trade cost from i to j as function of route cost matrix:

$$\tau_{ij} = \mathbf{c} b_{ij}^{-\frac{1}{\theta}}$$

which provides an analytical relationship between any given route network and the resulting bilateral trade cost between all locations

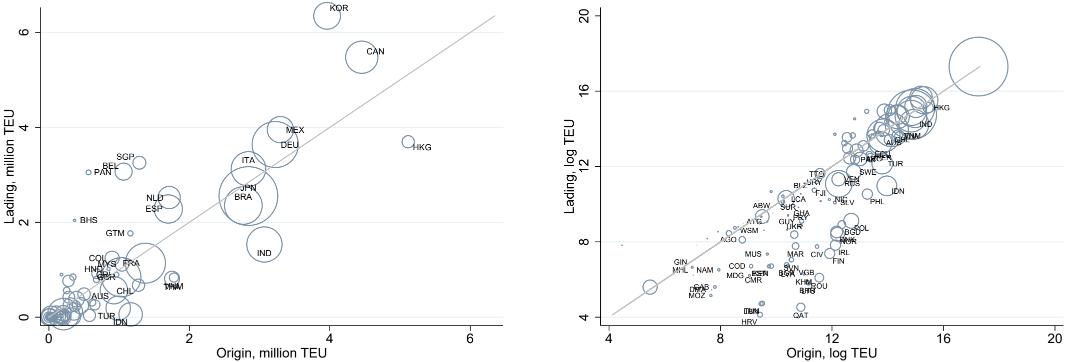
Back

Shipping: Endogenous Transport Costs (AA 2019)

- The geometric sum of matrix **A** is $\sum_{K=0}^{\infty} \mathbf{A}_{ij}^{K} = (\mathbf{I} - \mathbf{A})^{-1} \equiv \mathbf{B}$ as long as the spectral radius of **A** is less than one
- A sufficient condition for this is if $\sum_j t_{ij}^{-\theta} < 1$ for all i
- This will necessarily be the case if either
  1. Trade costs between connected locations are sufficiently large
  2. Adjacency matrix is sufficiently sparse (i.e. many locations are not directly connected)
  3. Heterogeneity across traders are sufficiently small (i.e. θ is sufficiently large)

Go Back

Concentration of Through-Shipments



(a) First stop v. trade

(b) First stop v. trade, log scale

Back

Concentration of Through-Shipments

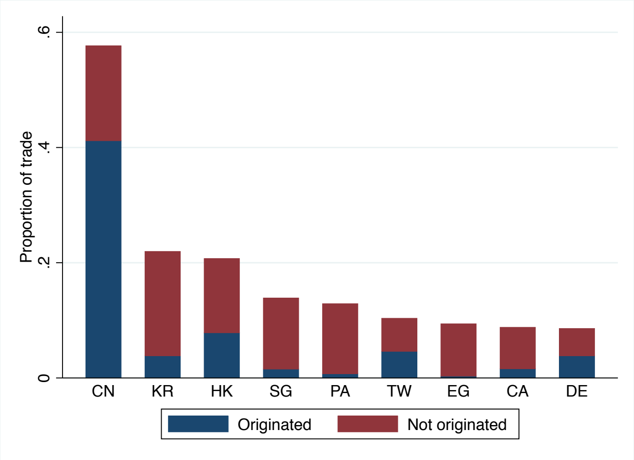
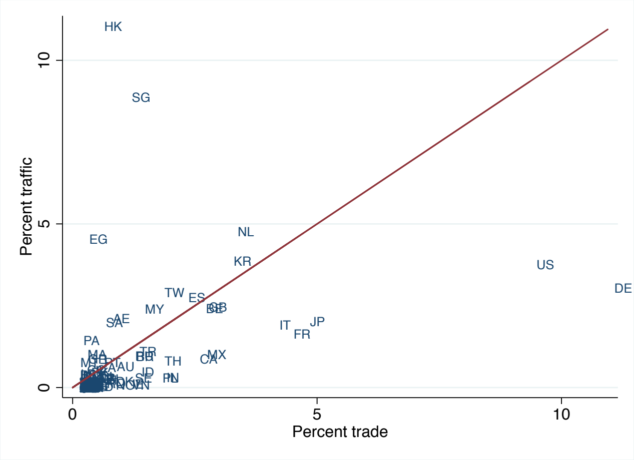


Figure: Percent of shipments making stops, by country

Concentration of Through-Shipments

Stylized Fact 4: *Shipping is concentrated through a minority of countries which account for a disproportionate share of third-party stops.*



Traffic vs. Trade

Back

Route Cost Estimates: IV

- New problem: we don't actually observe P, but $\hat{P} = P(Q)$.

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$$\hat{P}_{kl} = \alpha_0 + \alpha_1 \cdot Q_{kl} + \epsilon_{kl} + d_{kl}$$

where $d_{kl} = P_{kl}^{true} - \hat{P}_{kl}$.

- 2 (!) exclusion restrictions: $Cov(Z_{kl}, \epsilon_{kl}) = 0, Cov(Z_{kl}, d_{kl}) = 0$

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- 2 (!) exclusion restrictions: $Cov(Z_{kl}, \epsilon_{kl}) = 0$, $Cov(Z_{kl}, d_{kl}) = 0$
- Two proposed fixes:
  1. Test model validity to minimize scope for contanmination through d_{kl}:

$$\hat{P}^{external}_{kl} = \hat{P}_{kl} + d_{kl}$$

  2. Test exclusion restriction 2:

$$Cov(\hat{P}^{external}_{kl} - \hat{P}_{kl}, z_{kl}) = 0$$

Back

Scale Estimates

Table: Scale Estimates

	(1)	(2)	(3)	(4)
	OLS	RF	FS	IV
	Log $t_{kl}^{-\theta}$	Log $t_{kl}^{-\theta}$	Log Vol_{kl}	Log $t_{kl}^{-\theta}$
Log Vol_{kl}	0.8000	0.1048		0.4625
	(0.0108)	(0.0222)		(0.0549)
Log z_{kl}			0.2267	
			(0.0238)	
Log d_{kl}	-0.5759	-0.8235	-0.3287	-0.6714
	-0.0244	(0.0579)	(0.0425)	(0.0311)
Constant	-9.3310	-8.0010	-1.7422	-5.1450
	(0.2746)	(0.7400)	(3.2490)	(0.6931)
F-statistic			67	
Observations	2,284	2,284	2,284	2,284
R-squared	0.89	0.18	0.05	0.96

Note. Robust standard errors in parentheses clustered by node k

Back