Geography, Search Frictions and Endogenous Trade Costs

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Friday, December 1^{st}, 2017

Global Trade and Shipping

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  - shipping price from Australia to China: $10,000

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- 45% of ships currently in transit are without cargo (ballast)

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    - standard trade models predict trade costs -> trade flows
  - entire network of countries matters
    - rather than just bilateral distances
  - search frictions between exporters and ships can limit trade flows

How

- We collect a unique dataset of
  - bilateral shipping contracts
  - global vessel movements (ship location every 5 min+draft)
- Estimate dynamic spatial search model
  - Recover matching process between exporters and ships
    - flexibly obtain both the matching function and potential exporters
  - Recover ship costs, exporters' valuations and costs

Objective

- Use the framework for following questions:
  - Impact of improvement shipping efficiency on trade
  - Propagation of shocks: Chinese slow-down
  - Opening of the Northwest Passage
  - Loss due to search frictions

Related Literature

- Trade Costs - Gravity
  - Anderson and van Wincoop (2003), Hummels and Skiba (2004), Hummels, Lugovskyy and Skiba (2008), Eaton and Kortum (2002), Waugh (2010), Ishikawa and Tarui (2015), Asturias (2016), Wong (2017) and many others
- Trade and Economic Geography
  - Krugman (1991), Head and Mayer (2004), Allen and Arkolakis (2014, 2016), Donaldson (2012)
- Search and Matching
  - Diamond (1982), Mortensen and Pissarides (1994), Lagos (2000) Petrongolo and Pissarides (2001)
  - Taxis: Lagos (2003), Buchholz (2016), Frechette, Lizzeri and Salz (2016)
- Industry Dynamics
  - Hopenhayn (1992), Ericson and Pakes (1995), Kalouptsidi (2014, 2017)

Outline

1. Industry Description, Data, Facts
2. Model
3. Estimation
4. Counterfactuals

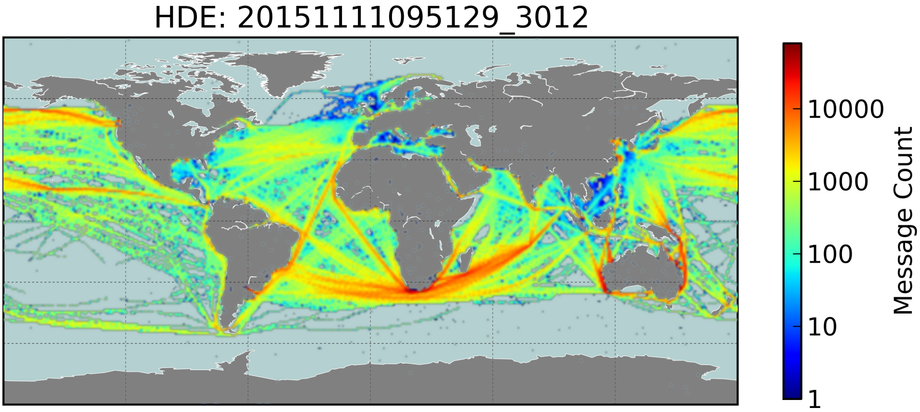
Industry Description, Data, Facts

Industry

Bulk shipping

- Homogeneous unpacked dry/liquid cargo, for individual shippers on non-scheduled routes
- Transports raw materials (iron ore, grain, coal, steel, etc.)
- Operate like "taxi drivers, not buses"
- Contracts through brokers
- Unconcentrated industry, homogeneous good ▸ firm size cdf ▸ evidence for homogeneity

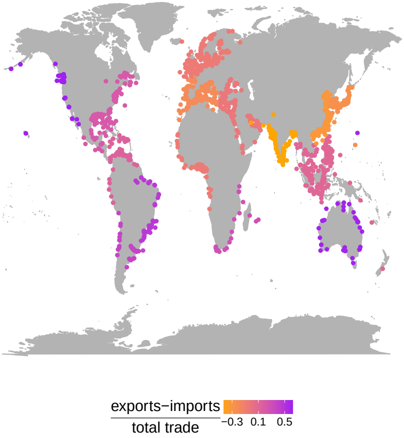
Vessel Movements: Message Count in 10 Days



one ship's path

Trade Imbalances

- Most countries are either net importers or net exporters



▸ most popular ballast routes

Prices & Geography

- High probability of ballast in destination j -> higher price to ship to j

	I	II	III	IV
	log(price)			
Handyamax	-0.148**	-0.136**	-0.123**	0.027
	(0.014)	(0.014)	(0.014)	(0.120)
Handysize	-0.397**	-0.330**	-0.343**	-0.209**
	(0.017)	(0.018)	(0.017)	(0.124)
Panamax	-0.223**	-0.214**	-0.212**	-0.117
	(0.013)	(0.013)	(0.013)	(0.119)
Coal				0.088**
				(0.045)
Fertilizer				0.245**
				(0.051)
Grain				0.131**
				(0.048)
Ore				0.124**
				(0.045)
Steel				0.135**
				(0.049)
Probability of ballast			0.234**	0.556**
			(0.030)	(0.081)
Average duration of ballast trip (log)			0.166**	0.065**
			(0.014)	(0.032)
Constant	10.304**	10.284**	9.127**	8.915**
	(0.068)	(0.103)	(0.099)	(0.408)
Destination FE	No	Yes	No	No
Origin FE	Yes	Yes	Yes	Yes
Product FE	No	No	No	Yes
Quarter FE	Yes	Yes	Yes	Yes
Obs	11,014	11,014	11,011	1,662
R^2	0.663	0.694	0.674	0.664

$^{**}p < 0.05$, $^{*}p < 0.1$

Search Frictions

- In labor markets, evidence for search frictions:
  - Wage dispersion
  - Coexistence of unemployed workers and vacancies

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    - Substantial price dispersion within time/origin/destination (coeff of variation 30%)
        - Price also depends on value of good

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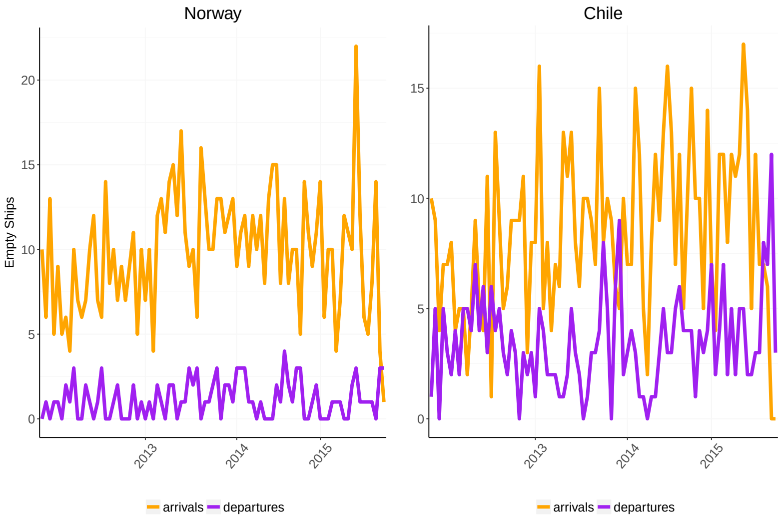
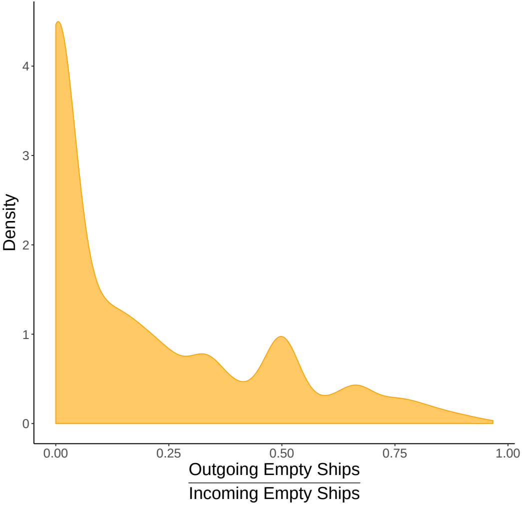
    - Matches $< min\{\text{ships, exporters}\}$
    - Simultaneous arrivals and departures of empty ships

Search Frictions

- Why do ships leave empty from exporting countries?



Search Frictions



▸ By Port ▸ Ship Heterogeneity? ▸ Dispatcher Simulation ▸ All Search Friction Evidence

Model

Model Overview

- Dynamic spatial search model
- There are I regions in the world
  - different trip durations between regions
- Agents:
  - Exporters (freights)
  - Ships

Environment

Exporters (Freights)

- In each region i there are f_i freights awaiting transportation
- Freights are heterogeneous in
  1. value of delivery, v
  2. destination, j

Environment

Ships

- Homogeneous ships can carry at most one freight
- In every period a ship is either:
  - Sailing toward a destination j, either full or empty at sailing cost c^s
    - ship traveling from i to j arrives with prob ξ_{ij} (avg trip duration $1/\xi_{ij}$)

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  - Sailing toward a destination j, either full or empty at sailing cost c^s
    - ship traveling from i to j arrives with prob ξ_{ij} (avg trip duration $1/\xi_{ij}$)
  - Waiting in port i at a cost c_i^u
    - randomly matches with an exporter
    - if unmatched choose where to search (either wait at port again, or ballast to another region)

Environment

Matching Process

- Exporters and ships search for each other
- $m_i(f_i, s_i)$ new matches
    - s_i unmatched ships and f_i unmatched freights in region i
    - probability of ship finding a freight is λ_i
- Search frictions generate rents to be split
    - price τ_{ijv} determined by Nash bargaining

▸ Timing

Behavior
Ships

- Traveling ship:

$$W_{ij} = -c^s + \xi_{ij}\beta U_j + (1 - \xi_{ij})\beta W_{ij}$$

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  - Ship that remained unmatched:

$$J_i = \max\left\{\beta U_i + \sigma\epsilon_{ii}, \max_{j\neq i} W_{ij} + \sigma\epsilon_{ij}\right\}$$

▸ Back to Likelihood

- Value of unmatched freight:

$$J^f_{ijv} = \lambda^f_i V^f_{ijv} + \left(1 - \lambda^f_i\right) \delta\beta J^f_{ijv}$$

- Value of matched freight:

$$V^f_{ijv} = v - \tau_{ijv}$$

Behavior
Prices

- Surplus sharing condition

$$\gamma \left(V_{ijv} - J_i \right) = (1 - \gamma) \left(V_{ijv}^{f} - J_{ijv}^{f} \right)$$

where γ is the exporter's bargaining power

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- Solve for price:

$$\tau_{ijv} = \frac{(1-\gamma)(1-\beta\delta)}{1-\beta\delta\gamma\left(1-\lambda^f_i\right)} \underbrace{v}_{\text{freight valuation}} - \frac{\gamma\left(1-\beta\delta\left(1-\lambda^f_i\right)\right)}{1-\beta\gamma\left(1-\lambda^f_i\right)} (\underbrace{W_{ij}}_{\text{traveler i,j value}} - \underbrace{E_\epsilon\left(J_i\right)}_{\text{ship outside option}})$$

Behavior

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  - price depends on v
  - price depends distance, conditions at destination, travel cost
    - since $W_{ij} = -\frac{c^s}{1-(1-\xi_{ij})\beta} + \frac{\xi_{ij}\beta}{1-(1-\xi_{ij})\beta} U_j$
  - price depends on all markets not just i, j

Entry of New Freights

- $\mathcal{E}_i$ ex ante homogeneous potential exporters in market i
  - choose whether and where to export, then draw v
- Potential entrant exporter:

$$J_i^{ef} = \max \left\{ \epsilon_0^f, \ \max_{j \neq i} \left\{ E_v J_{ijv}^f - \kappa_{ij} + \epsilon_j^f \right\} \right\}$$

where κ_{ij} is the production and exporting cost Go Back

Model Estimation

Estimation Outline

- Obtain primitives:
  - **matching function and freights**
  - travel and port costs, $\{c_1^u, ..., c_I^u\}$
  - distribution of freight values, v
  - production and exporting costs, κ_{ij}
- Use data on:
  - **number of ships and number of matches**
  - prices
  - ballast choices
  - trade flows

Matching Function

- Matching function estimation in the literature
  - Labor Markets: unemployed workers, vacancies, matches observed
  - Taxi Cabs: taxis, matches observed, passengers unobserved

- This literature:
  1. Takes stance on presence of search frictions *and*
  2. Imposes strong functional form assumptions (matters for welfare)

Matching Function: Existing Lit

- Presence of search frictions:
  - No search frictions:

$$\underbrace{m_{it}}_{\text{matches}} = \underbrace{\min\left(f_{it}, s_{it}\right)}_{\min\left(\text{freights,ships}\right)} \quad (1)$$

  - Search frictions:

$$\underbrace{m_{it}}_{\text{matches}} = \underbrace{m_i\left(f_{it}, s_{it}\right)}_{m(\text{freights,ships})} \leq \min\left(f_{it}, s_{it}\right) \quad (2)$$

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  - How do we distinguish (1) from (2), if one side unobserved/mismeasured?

Matching Function: Search Frictions

- Reduced-form evidence for search frictions
  - Consider markets with $\min\{s, f\} = f$
  - Then:
    - If $m = \min\{s, f\}$, changing s exogenously doesn't affect m
    - If $m \leq \min\{s, f\}$, changing s exogenously can affect m
    - Weather exogenously changes s- does it affect m?
- Matches affected by weather in all markets ▸ Results

Matching Function

- Use lit on nonparametric identification (Matzkin 2003)
- Intuition:

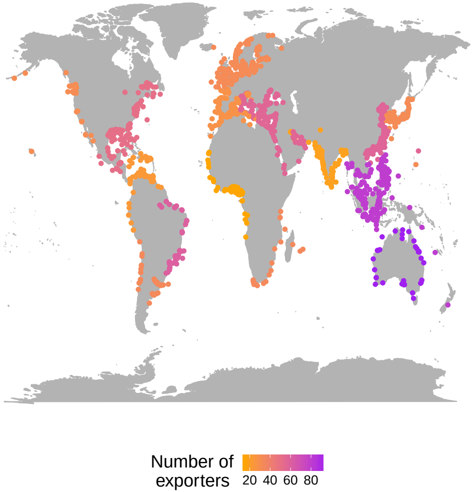
$$\underbrace{m_{it}}_{\text{matches}} = \underbrace{m_i\left(s_{it}, f_{it}\right)}_{m(\text{ships,freights})}$$

  - Independence s_{it}, f_{it}: Correlation between m_{it} and s_{it} is informative about $\frac{\partial m_i}{\partial s}$
  - Assume homogeneity of degree 1: knowing $\frac{\partial m_i}{\partial s}$ we also know $\frac{\partial m_i}{\partial f}$
  - Instrument: sea weather (wind speed) exogenously shocks ship arrivals

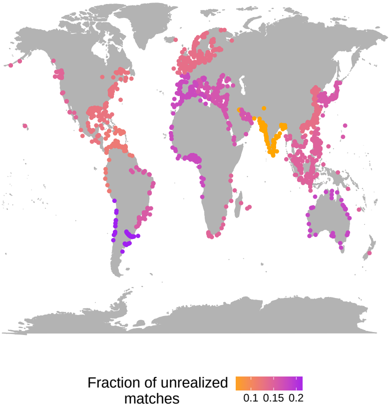
Details first stage

Matching Function: Results

Freights



- Unrealized matches $\frac{\min\{f,s\}-m}{\min\{f,s\}}$

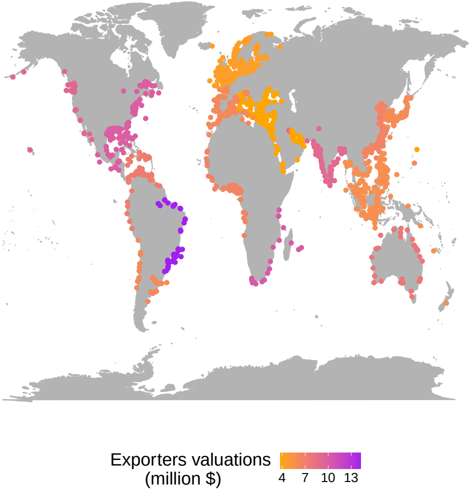


Go Back | confidence intervals

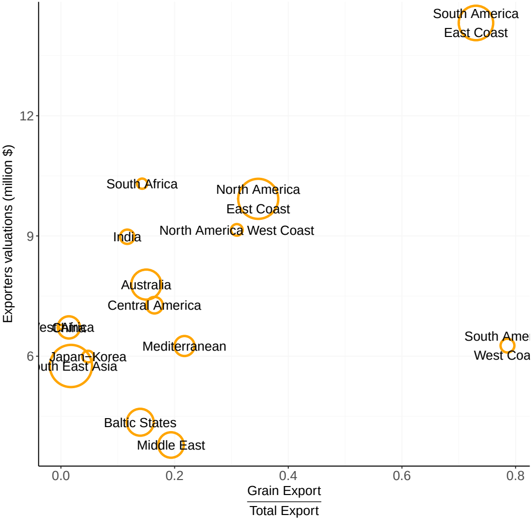
Estimation of Ship Costs, Exporter Valuations and Costs

- Ship costs, $\{c_1^u, ..., c_I^u\}$:
  - From observed choice probabilities (Rust-like) Details
- Exporter valuations, v
  - Price equation
  - Each contract price gives us the corresponding valuation point-wise Details
- Production and Exporting Costs, κ_{ij} Details
  - Trade flows

Results: Freight Valuations



Results: Freight Valuations and Grain Exports



All Results

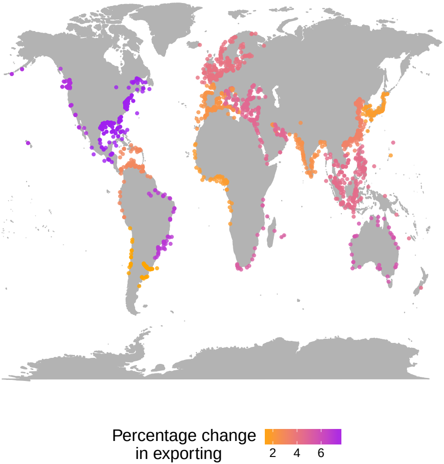
	Port Costs c_u	Cost of Travelling c_s	Exporters Valuations μ_v	Preference Shock σ
North America West Coast	2.458	0.693	79.605	
	(0.07)	(0.002)	(2.038)	
North America East Coast	2.271	0.691	103.145	
	(0.021)	(0)	(2.229)	
Central America	1.846	0.693	73.161	
	(0.022)	(0.002)	(3.007)	
South America West Coast	1.996	0.693	59.063	
	(0.026)	(0.002)	(1.679)	
South America East Coast	2.563	0.691	125.877	
	(0.027)	(0)	(3.001)	
West Africa	1.421	0.64	57.838	
	(0.015)	(0.002)	(2.658)	
Mediterranean	1.637	0.568	59.87	
	(0.018)	(0.003)	(2.475)	
Baltic States	1.399	0.568	49.199	
	(0.009)	(0.003)	(1.959)	
South Africa	2.478	0.64	99.074	
	(0.035)	(0.002)	(2.907)	
Middle East	1.273	0.568	44.203	
	(0.007)	(0.003)	(2.355)	
India	1.48	0.624	84.722	
	(0.014)	(0.003)	(4.2)	
South East Asia	1.67	0.56	72.282	
	(0.008)	(0.002)	(3.324)	
China	1.438	0.558	66.382	
	(0.01)	(0.002)	(3.61)	
Australia	2.635	0.56	70.507	
	(0.025)	(0.002)	(2.543)	
Japan-Korea	1.53	0.558	55.589	
	(0.022)	(0.002)	(2.514)	
				0.117
				(0.0008)

Note: all the estimates are in 100,000 USD. Standard errors computed from 500 bootstrap samples.

Counterfactuals

Improvement in Shipping Efficiency

- Decreasing travel cost c^s by 10%



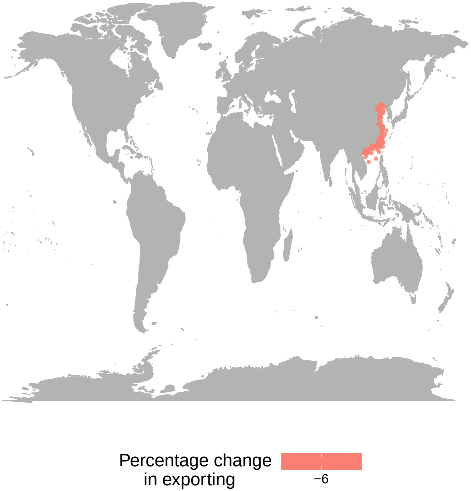
ships ballast to higher value regions

Improvement in Shipping Efficiency

- Decreasing travel cost c^s by 10%
  - Prices fall ->
  - Freights enter, exporting increases
- Ships' outside option, J, increases; ballasting less costly
  - Push price up, exporting down for net importers
  - Big and high value exporters benefit more ("polarization")

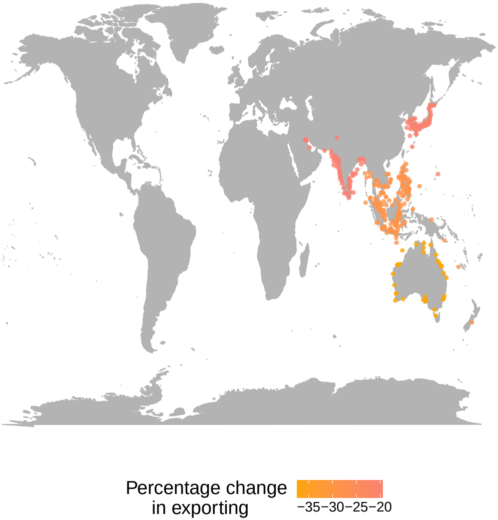
Chinese Slow-down

- Chinese slow-down (10% decrease in $\mu_{i,china}$)?
- China itself:



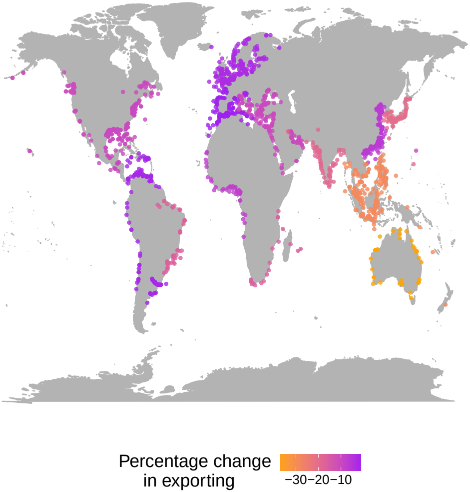
Chinese Slow-down

- China's neighbors:



Chinese Slow-down

- Everyone:



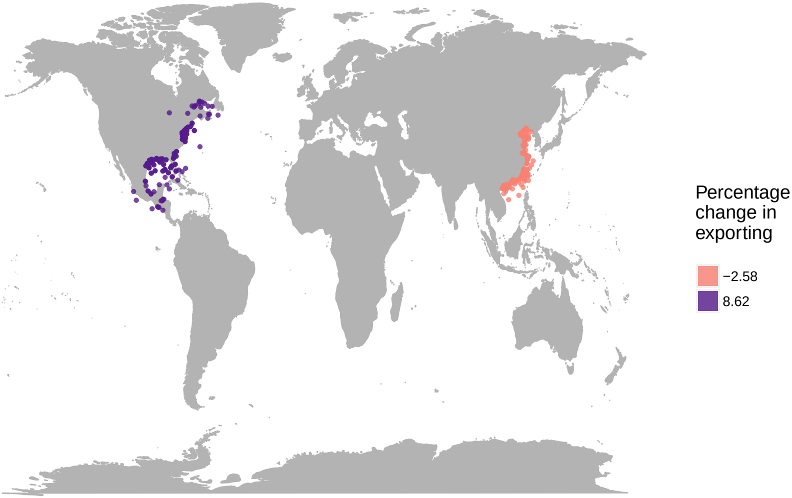
Chinese Slow-down

- Effect on China itself:
    - Import-Export Complementarity
- Neighboring countries:
    - Direct effect: lose big trading partner
    - Also: lose ship "glut" in region
- Distant countries:
    - Direct effect: lose big trading partner
    - Also: benefit from increased supply of ships (Brazil, North America)

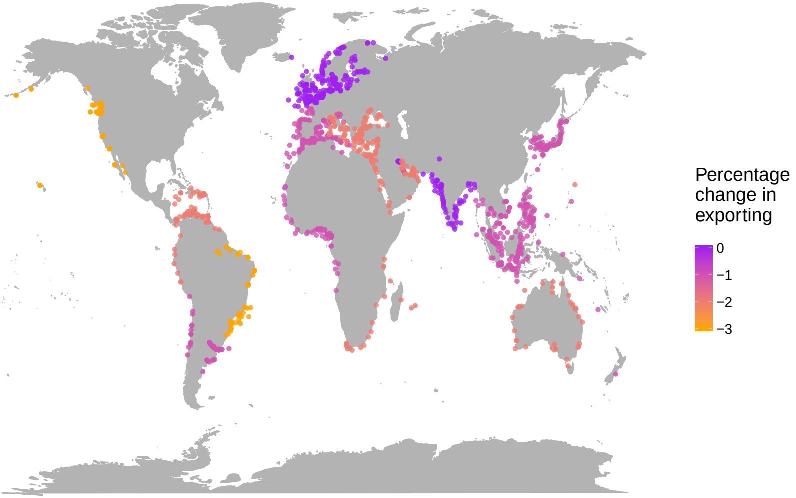
Northwest Passage

- Reduction in travel cost between east cost N America and Far East

Northwest Passage



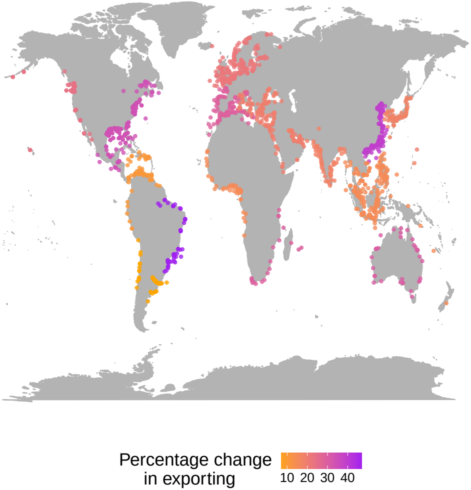
Northwest Passage



Northwest Passage

- N America sees exporting increase
- China/Japan-Korea exports fall: ships' outside option higher and don't stay
- Other countries: also affected by *distant and local* shock
  - Higher outside option of ships: increases price, decreases exports
  - Geography:
    - Exporters close to North America (e.g. Brazil) disproportionately hurt
    - Other exporters (e.g. Australia) shielded by closeness to China/India.

No Search Frictions



No Search Frictions

- No search frictions: naturally trade $\uparrow$
- Heterogeneous response, "Polarization"
    - Search is an impediment to trade
    - Now ship ballast to big exporters, exporting rises more there

Take Aways

- Counterfactuals showcase 3 key mechanisms:
  - Shocks also affect ships' outside option
    => indirect impact on prices & exports
  - Change in trade costs depends on trading network and geographical proximity to large net exporters/importers
  - Reductions in impediments to trade disproportionally benefit large, high value exporters (polarization)
    - ships more likely to reallocate there

Conclusion

- Microfound a portion of total trade costs
- Quantitative important that transport sector:
  - reacts to trade conditions (endogeneity)
  - suffers from search frictions
- What next?
  - Dig deeper into search aspect
  - Go broader in the trade aspect

Conclusion

- Comments most welcome, thanks!!

Appendix

Shipowner Size Distribution

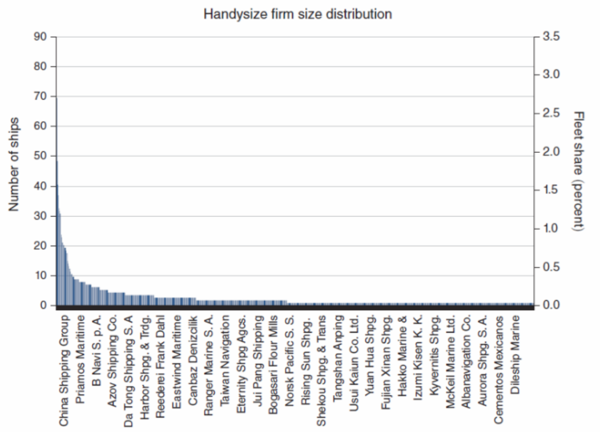
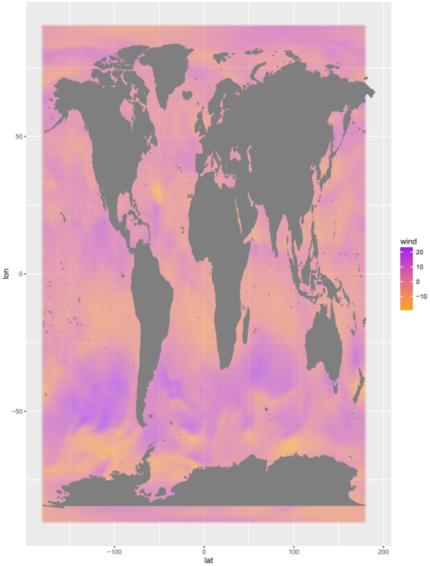


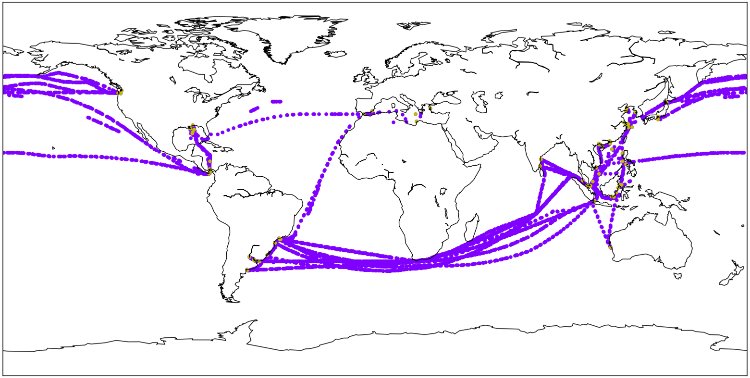
FIGURE 1. FLEET AND FLEET SHARES OF SHIPOWNING FIRMS

▸ Go Back

Weather Data



Vessel Movements: One Ship's Path



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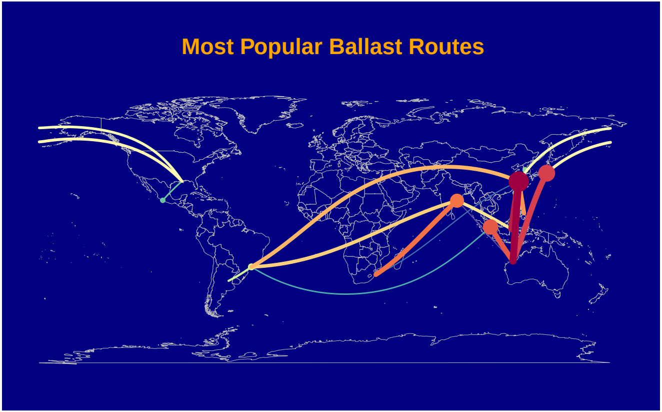
Ballast



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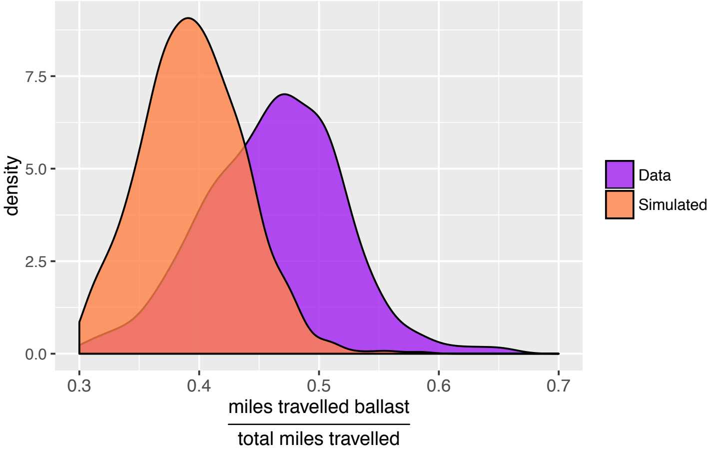
Search Frictions

- "Dispatcher" Simulation:



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Matching Function

- We show how to estimate $m_i(f_{it}, s_{it})$ nonparametrically *and* recover unobserved freights f_{it}
  - use lit on nonparametric identification (Matzkin 2003)

$$Y = m(X, \epsilon)$$

    - Can I recover both $m(\cdot)$ and “shock” ϵ?

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  - necessary assumptions
    - $m\left(X, \epsilon\right)$ str. increasing in ϵ
    - $X \perp \epsilon$, or a valid instrument (sea weather)

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  - necessary assumptions
    - $m(X, \epsilon)$ str. increasing in ϵ
    - $X \perp \epsilon$, or a valid instrument (sea weather)
  - flexible approach, up to a choosing the monotonic transformation
    - assume $m(\cdot)$ is homogeneous of degree 1

Matching Function (Details)

- Matzkin notation:

$$\begin{aligned} F_{Y|X}(y|X=x) &= F_{Y|X}(m(x,e)|X=x) = \Pr(Y \le m(x,e)|X=x) \\ \text{monotonicity} &= \Pr\left(e \le m^{-1}(x,y)|X=x\right) \\ \text{independence} &= \Pr\left(e \le m^{-1}(x,y)\right) \\ &= F_\epsilon(e) \end{aligned}$$

- Solution 1: assume F_ϵ (e.g. uniform) gives us both $m(\cdot)$ and ϵ point-wise Go Back

Matching Function (Details)

- Matzkin notation:

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\end{aligned}
$$

- Solution 2:
  - Homogeneity: $m(\alpha x, \alpha \epsilon) = \alpha y$
  - Suppose we know $m(\alpha x^*, \alpha \epsilon^*) = \alpha y^*$, some (y^*, x^*, ϵ^*)
  - Then,

    $$F_{\epsilon}(\alpha \epsilon^*) = F_{Y|X}(\alpha y^* | X = \alpha x)$$

    and move α
  - Set $1 = m(1, x^*)$, x^* such that in all markets $m_i \leq f_i$ (conservative wrt search frictions) Go Back

Matching Function: Search Frictions

- Reduced-form evidence for search frictions
  - Consider markets with $\min\{s, f\} = f$
  - Then:
    - If $m = \min\{s, f\}$, changing s exogenously doesn't affect m
    - If $m \leq \min\{s, f\}$, changing s exogenously can affect m
    - Weather exogenously changes s- does it affect m?

Matching Function: Search Frictions

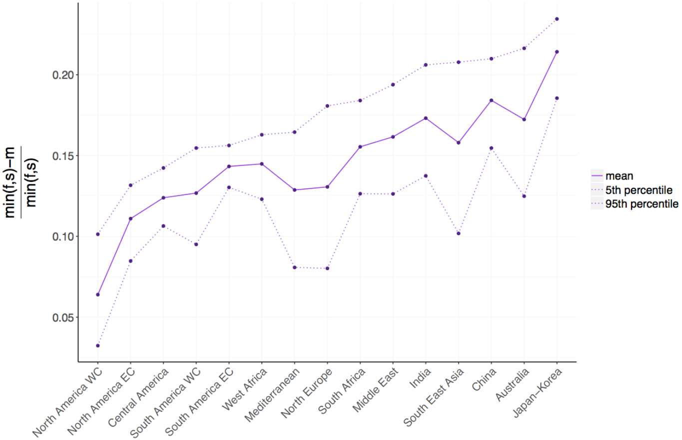
	N	R^2	Joint Significance	$\frac{s}{m}$
North America West Coast	193	0.146	0	2.706
North America East Coast	200	0.17	0.013	3.172
Central America	199	0.272	0	3.451
South America West Coast	198	0.246	0	2.913
South America East Coast	200	0.269	0	4.083
West Africa	200	0.261	0	5.862
Mediterranean	200	0.358	0	4.244
Baltic States	200	0.23	0	3.577
South Africa	200	0.083	0.01	2.862
Middle East	200	0.147	0.001	3.86
India	200	0.12	0.018	8.58
South East Asia	200	0.18	0.005	3.334
China	200	0.177	0	6.194
Australia	187	0.17	0.008	2.457
Japan-Korea	200	0.16	0.003	5.311

▸ Weather Data ▸ Go Back ▸ Go Back

First Stage Regression

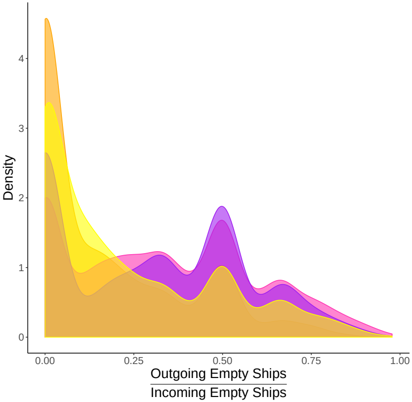
	N	R^2	Joint Significance
North America West Coast	200	0.101	0.004
North America East Coast	200	0.106	0.0002
Central America	200	0.175	0.0007
South America West Coast	198	0.418	0
South America East Coast	200	0.178	0
West Africa	200	0.138	0.0001
Mediterranean	200	0.181	0
North Europe	200	0.138	0.0003
South Africa	200	0.066	0.064
Middle East	200	0.162	0.0012
India	200	0.157	0.0001
South East Asia	200	0.081	0.0008
China	200	0.176	0
Australia	200	0.049	0.02
Japan-Korea	200	0.036	0.12

Matching Function: Search Frictions



▸ Go Back

By Port and Ship Type



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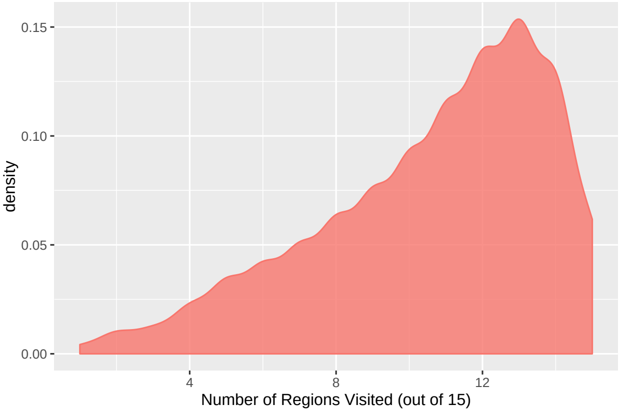
Ship Heterogeneity?

- How much ship heterogeneity is there?
    - Ships carry most products
    - Ships go to most regions
    - Ship fixed effects don't explain ballast
    - Ship fixed effects don't explain prices
    - Prior evidence (Kalouptsidi 2014, 2017): ship prices mostly explained by aggregates, ship size and ship age ▸ Go Back ▸ Go Back

Ship Heterogeneity?



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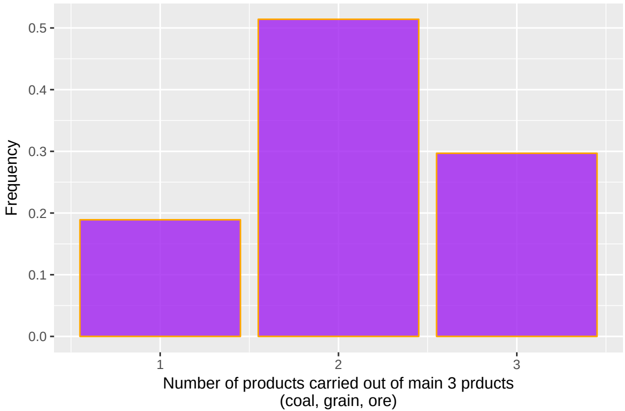
Ship Heterogeneity?



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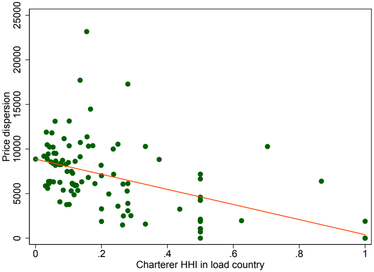
Price Dispersion

- Price dispersion and concentration of freight owners



Estimation of Travel and Port Costs

- Use ship choices to get travel cost c^s, port costs c_i^u, and σ

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  - Probability of staying at port i:

$$p_{ii} = \frac{\exp \beta U_i/\sigma}{\exp \beta U_i/\sigma + \sum_{j \neq i} \exp W_{ij}/\sigma}$$

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- For given set of parameters, solve value functions (nested fixed point), compute CCPs, calculate likelihood Implementation Details Go Back

Estimation of Freight Valuations

- Solve for equilibrium price for trip from i to j and valuation v:

$$\underbrace{\tau_{ijv}}_{\text{price data}} = \underbrace{\frac{(1-\gamma)(1-\beta\delta)}{1-\beta\delta\gamma\left(1-\lambda_i^f\right)}}_{\beta,\,\delta\text{calibrated, } \lambda_i^f,\,\gamma \text{ estimated}} v - \underbrace{\frac{\gamma\left(1-\beta\delta\left(1-\lambda_i^f\right)\right)}{1-\beta\delta\gamma\left(1-\lambda_i^f\right)}}_{\beta,\,\delta\text{calibrated, } \lambda_i^f,\,\gamma \text{ estimated}} \underbrace{\left(W_{ij}-J_i\right)}_{\text{computable from } \widehat{c_u},\,\widehat{c_s}}$$

  - Once costs are known, W, J are known too (given observed prices).

  - Obtain valuations v pointwise and their distribution non-parametrically

▸ Go Back

Estimation of Travel and Port Costs

- Details of implementation:
  - Restriction: use industry estimates for sailing cost c^s
  - Use observed, not equilibrium prices
  - Estimate probability of freights moved from i to j (frequencies) ▸ Donut
  - Construct 15 regions by minimizing port distances (ignore inter-regional trips) ▸ Regions ▸ Go Back

Production and Exporting Costs

- $\mathcal{E}_i$ potential exporters in market i
- Exporting destination choice prob:

$$G_{ij} = \frac{\exp\left(J_{ij}^f - \kappa_{ij}\right)}{1 + \sum_{l \neq i} \exp\left(J_{il}^f - \kappa_{il}\right)}$$

with J_{ij}^f known:

$$J_{ij}^f = \frac{\lambda_i^f \left(\mu_{ij} - \tau_{ij}\right)}{1 - \beta\delta\left(1 - \lambda_i^f\right)}$$

▸ model reminder

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▸ model reminder

- Can recover κ_{ij} from G_{ij} (Berry 94)

$$\ln G_{ij} - \ln G_{i0} = J_{ij}^f - \kappa_{ij}$$

- $\mathcal{E}_i$: total commodity production by country (EIA, FAO, etc.)

▸ outside option ▸ Go Back

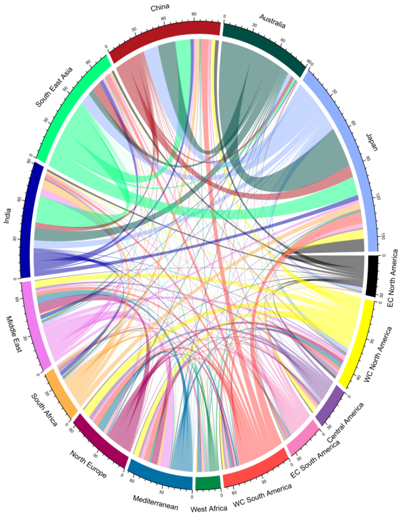
Costs Estimation: Details

- Maximum Likelihood:

$$\mathcal{L} = \sum_i \sum_j \sum_n y_{ijn} \log P_{ij}(c^u, c^s)$$

- Inside likelihood solve for U_i, W_{ij} via fixed point
  - Using observed average prices. Value Functions
- Alternative: add prices directly in the likelihood Go Back

Distribution of Freight Destinations



Valuations Alternative

- Alternative: we can get valuations "offline:
- Solve for equilibrium price for trip from i to j and valuation v:

$$\tau_{ijv} = \frac{(1-\gamma)(1-\beta)}{1-\beta\gamma\left(1-\lambda_i^f\right)} v - \frac{\gamma\left(1-\beta\left(1-\lambda_i^f\right)\right)}{1-\beta\gamma\left(1-\lambda_i^f\right)}\left(W_{ij}-J_i\right)$$

- Turns out that $W_{ij} - J_i$ is directly observed since

$$W_{ij} - J_i = -\log p_{ij} + \gamma^{euler}$$

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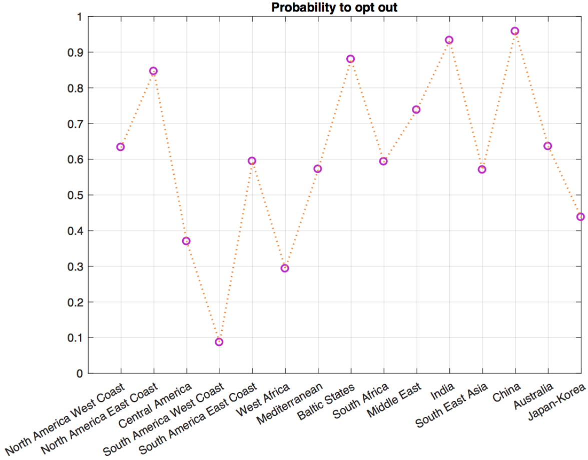
  - Therefore, we immediately obtain valuations v pointwise ▸ Go Back

Exporting Costs

- Outside share by origin



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Exporting Costs- Estimates

- Estimates

	North America West Coast	North America East Coast	Central America	South America West Coast	South America East Coast	West Africa	Mediterranean	Baltic States	South Africa	Middle East	India	South East Asia	China	Australia	Japan-Korea
North America West Coast	-	33.663	41.074	43.985	45.998	45.724	28.823	43.771	43.003	34.183	34.45	40.294	64.314	49.886	78.411
North America East Coast	80.026	-	62.8	53.353	47.692	62.12	81.898	50.915	91.138	72.197	115.42	129.625	121.367	154.431	122.639
Central America	76.592	28.396	-	61.767	36.386	66.036	75.297	46.045	57.918	67.747	17.147	77.929	77.637	55.643	41.056
South America West Coast	38.966	25.83	22.962	-	41.762	18.996	25.032	24.781	41.904	41.579	37.42	47.853	77.888	53.216	39.898
South America East Coast	160.227	53.656	48.502	86.18	-	54.774	71.481	61.266	111.676	82.725	95.028	143.302	162.532	106.969	148.168
West Africa	45.796	45.586	40.61	44.195	66.904	-	34.14	38.054	22.985	24.791	32.127	25.859	111.83	49.21	21.532
Mediterranean	46.253	39.52	41.57	36.206	49.292	16.076	-	49.027	22.265	55.765	62.201	66.217	58.062	53.792	49.498
Baltic States	40.238	42.04	85.78	16.925	33.167	29.239	28.939	-	25.809	17.995	43.695	47.631	41.286	17.244	48.242
South Africa	72.097	24.675	68.84	70.212	55.954	57.475	61.767	65.535	-	55.897	68.309	126.95	89.706	76.572	83.362
Middle East	48.721	20.643	74.854	28.596	45.578	27.452	37.717	20.498	5.28	-	14.438	31.089	22.128	34.55	13.792
India	60.443	8.846	58.236	108.131	46.807	27.935	19.817	46.674	41.175	47.548	-	86.373	91.111	116.788	65.769
South East Asia	23.876	30.095	106.843	39.733	37.298	39.327	44.331	63.438	47.724	35.735	26.217	-	32.464	41.962	41.772
China	108.295	19.927	33.039	24.171	38.845	26.598	31.365	13.614	22.472	22.18	30.9	34.333	-	51.992	38.786
Australia	44.103	49.683	61.446	28.792	16.778	35.146	58.023	28.122	40.598	44.227	47.854	38.735	55.893	-	62.862
Japan-Korea	61.359	5.83	23.167	25.923	32.013	5.834	28.949	13.263	29.205	19.736	18.389	30.673	27.55	44.528	-

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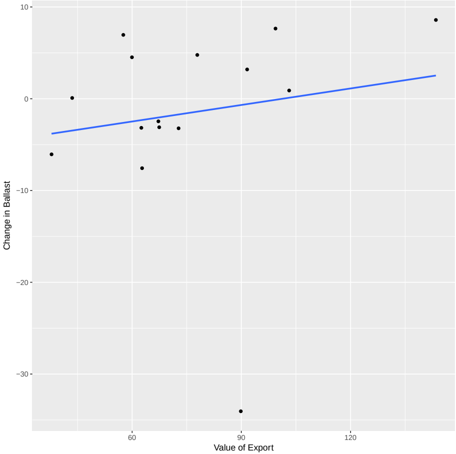
Transport Cost Elasticity



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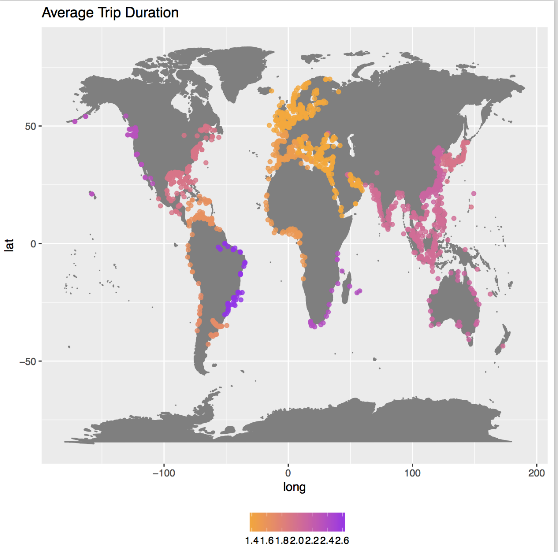

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Role of Distance

- It takes one week to go anywhere
- Cheaper to transport cargoes
    - Prices fall
    - Export increase
- Ballasting is cheaper
    - Exporters loose monopoly over ships in the market: ships are in a better bargaining position
    - Prices increase
- Countries close to China hit hardest

Environment

Timing

In every t and i:

1. Ships and freights match
2. Unmatched ships draw preference shocks ϵ and decide whether
    2.1 stay in current region and wait for freight or
    2.2 where to ballast
3. Unmatched ships that decided to ballast away begin traveling. All ships traveling from i to j arrives with probability ξ_{ij}. Existing exporters survive with probability δ
4. Potential exporters choose whether to export and if so their destination

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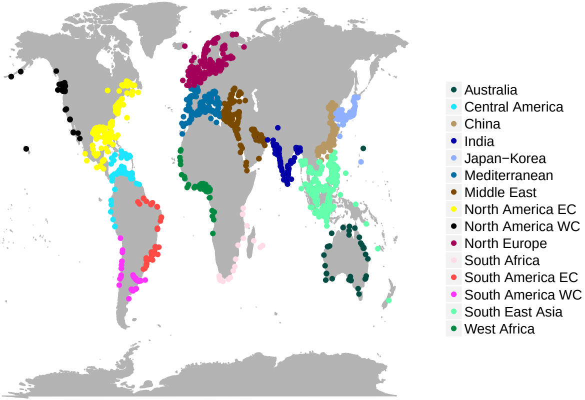
Market Definition



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Search Frictions

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  - Wage inequality among observationally identical workers
  - Coexistence of unemployed workers and vacancies

Search Frictions

- In labor markets, evidence pointing to the existence of search frictions:
  - Wage inequality among observationally identical workers
  - Coexistence of unemployed workers and vacancies
- In shipping market we observe:
  - Substantial price dispersion within quarter / origin / destination triplet (coeff of variation 30%)
    - Price also depends on value of good
  - Simultaneous arrivals and departures of empty ships in net exporters

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Data

- Shipping contracts (Clarksons), 2001-2015
  - price per day, origin, destination, signing and loading date
- Ship movements for 5,000 vessels (ExactEarth), 2009-2015
  - Exact location: Satellite tracking every 5 min
  - Speed, draft: water displacement indicates if ship is loaded
- Daily wind speed from oceanic stations (NDBC)

Steady State

- Compute steady state distribution (s, f)
- Steady State equations:
  - Ships:
$$s_i = \sum_j P_{ji}\left(s_j - m_j(f_j, s_j)\right) + \sum_j G_{ji} m_j(f_j, s_j)$$

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  - freight free entry condition

$$E_{jv} \frac{\delta \beta \lambda_i^f (s, f) \left(v - \pi_{ijv} (s, f) \right)}{1 - \delta \beta \left(1 - \lambda_i^f (s, f) \right)} = \kappa_i$$

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  - Get freight inflow from:

$$f_i = \delta_i\left(f_i - m_i(f_i, s_i)\right) + d_i$$

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