Transport Markets, Port Infrastructure, and World Trade

Giulia Brancaccio, Myrto Kalouptsidi, and Theodore Papageorgiou

NYU, Harvard, Boston College

Wednesday, May 25^{th}, 2022

Transportation and Global Supply Chains

- Global supply chains
  - have relied on "seamless" transportation services
- Until recently, this vital sector was "invisible" to the untrained eye

Transportation and Global Supply Chains

The New York Times

PLAY THE CROSS

ANALYSIS

In Suez Canal, Stuck Ship Is a Warning About Excessive Globalization

The shutdown of the vital waterway and its impact on trade underscore the world's reliance on global supply chains.

404

The Ever Given, a container ship operated by a company called Evergreen, blocked all traffic in the Suez Canal when it became wedged there. Khaled Elfiqi/EPA, via Shutterstock

- trade shut for a week (10 billion $ daily)

Transportation and Global Supply Chains

- pandemic: surging shipping prices and wait times

Transportation and Global Supply Chains

- This talk:
  - Role of transport markets in trade
  - Role of port infrastructure in trade

Transport Markets

Transportation and World Trade

- Is the current situation a “unique” event?
  - extreme yes, unique no
  - transport markets historically volatile and potentially disruptive

    ▸ one of several examples

- Is the current situation a "unique" event?
  - extreme yes, unique no
  - transport markets historically volatile and potentially disruptive
    ▸ one of several examples
- Why do transport markets have the potential for great disruption?

Transportation and World Trade

- Is the current situation a "unique" event?
  - extreme yes, unique no
  - transport markets historically volatile and potentially disruptive
    one of several examples

- Why do transport markets have the potential for great disruption?

1. Transport markets highly volatile. Why? *(Kalouptsidi, 2014)*
   - o volatile demand (macro shocks)

Transportation and World Trade

- Is the current situation a "unique" event?
  - extreme yes, unique no
  - transport markets historically volatile and potentially disruptive
    ▸ one of several examples
- Why do transport markets have the potential for great disruption?

1. Transport markets highly volatile. Why? *(Kalouptsidi, 2014)*
   - volatile demand (macro shocks)
   - sluggish supply:
     - short-run: cost convexities
     - and medium/long-run: irreversibilities, time to build

Transportation and World Trade

2. Trade response to transport costs substantial *(Brancaccio, Kalouptsidi and Papageorgiou, 2020)*

   - (focus on oceanic shipping - 90% of trade)
   - Elasticity of trade with respect to transport costs is high *(BKP estimate of 1, Wong (2019) estimate of 3)* details

Transportation and World Trade

2. Trade response to transport costs substantial *(Brancaccio, Kalouptsidi and Papageorgiou, 2020)*

    - (focus on oceanic shipping - 90% of trade)
    - Elasticity of trade with respect to transport costs is high *(BKP estimate of 1, Wong (2019) estimate of 3)* details
    - Can see this through different experiments
        - e.g. closure of chokepoints chokepoints

Transport Markets and Trade

3. Spatial propagation of shocks:
    - Ballasting because of trade imbalances ▸ see this
        - lack of containers ▸ the box
    - Network effects
        - e.g. queue in China's ports has ripple effects through reduced supply of ships globally ▸ shanghai

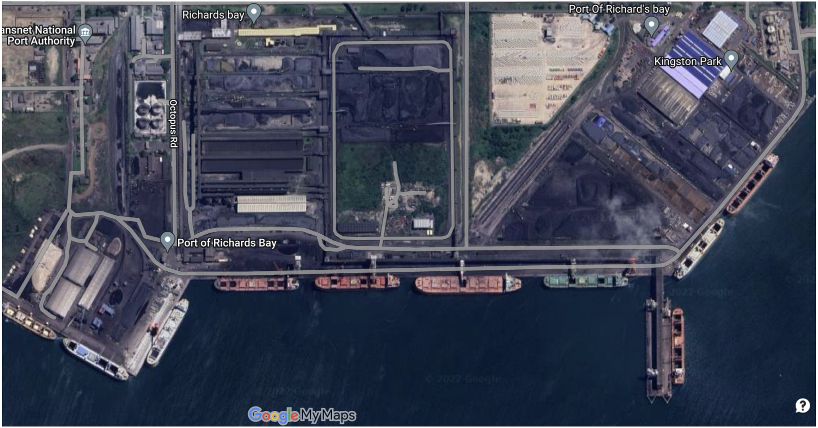
- To sum up: transport prices fluctuate wildly, trade actually responds, and spatial propagation patterns arise inherently

Ports

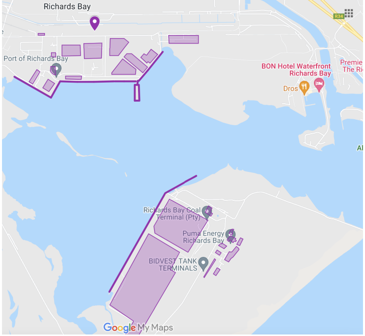
Ports

- Port: gateways of international trade
  - pivotal role during recent disruptions
- Determinants and implications of port performance?
  - infrastructure
  - productivity
- Work in progress
  - Data:
    - All port calls (arrival at anchorage, loading start/end, commodity), 2010-2021
    - Port infrastructure (manual collection from Google Earth)

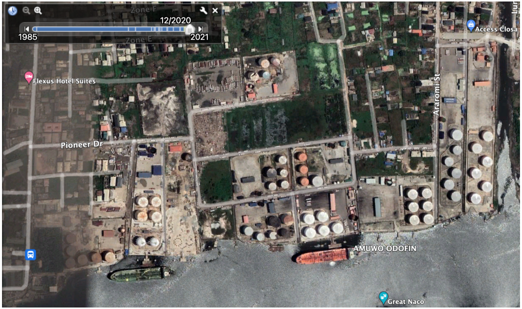
Data Collection: Richards Bay



Spatial Heterogeneity: Richards Bay vs. Rotterdam



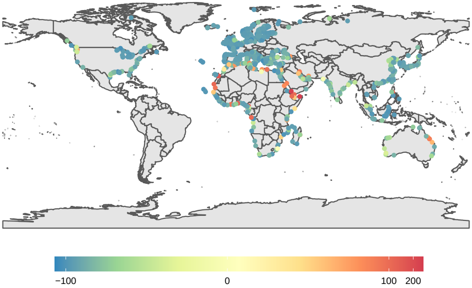
Timeseries: Lagos 2009 vs. 2021



Time at Port

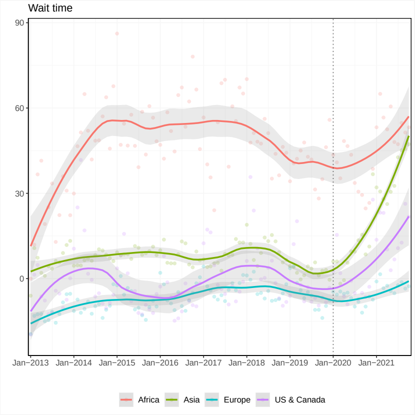
- Key object: time at port
  - actual service time (load/discharge time)
  - plus wait time (congestion)
- On average (median) 118 hours (83 hours)
  - +60% on top of total trip time
  - at $14K per day, direct cost $69K (plus ripple effects)
  - massive dispersion over both time and space

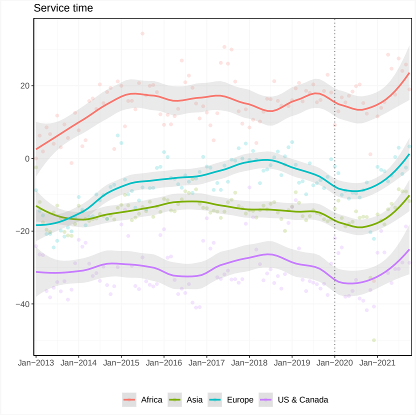
Time at Ports



residualized wait time on ship size and commodity

Time at Ports





▸ Go Back

A Model for Time at Port

- What is time at port of a ship arriving at port j in period t?

$$\underbrace{T_{jt}}_{\text{service time}} + \underbrace{\frac{Q_{jt}}{K_{jt}} T_{jt}}_{\text{queueing wait time}}$$

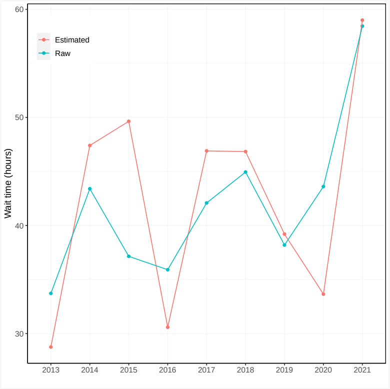
where

  - T_{jt}: service time (driven by *labor, productivity)*
  - K_{jt}: number of ships handled at a time (driven by *infrastructure*)
  - Q_{jt}: number of ships ahead of ship i (endogenous, also depends on port *demand*)

- We observe everything
- This model: M/M/K queueing model

A Model for Time at Port

Model fit



formula

Time at Port

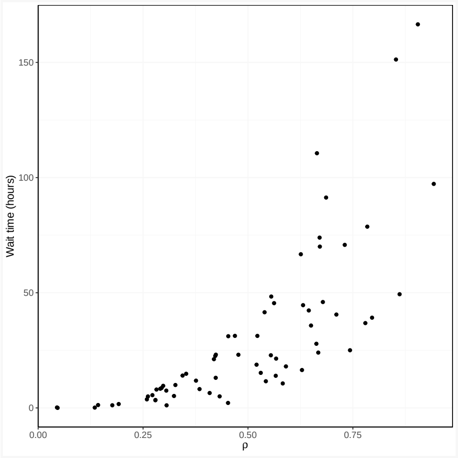
- Key statistic to understand queue stability:

$$\rho_{jt} = \frac{\text{arrival rate}_{jt} \times T_{jt}}{K_{jt}}$$

  - ρ measures fraction of time each berth is occupied
  - as $\rho \to 1$, port infrastructure gets overwhelmed and queue explodes

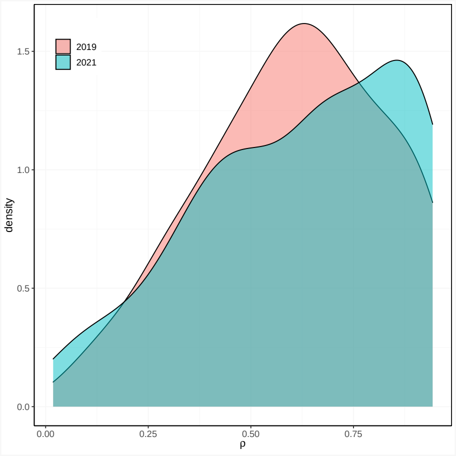
- Do US ports have slack before COVID? And after?

Time at Port



System stability 2019

Time at Port



Time at Port

- Disclaimer: *very* preliminary
- What is the role of port infrastructure in COVID disruptions?
- Compute
  - What is the increase in infrastructure required to avoid the 2021 increase in wait times in the US?
    - On average, 6%
    - Benchmark: Europe 13% higher infrastructure than US ▸ graph
    - Benchmark: a new port cost a few billion USD

Conclusion

- Comments most welcome, thanks!!

Appendix

Commodity Boom 2006

FIGURE 3. THE BALTIC DRY INDEX

Notes: Daily index based on weighted average of rates on 20 representative bulk routes. Compiled by the Baltic Exchange. 1/11/1999 = 1,334.

from Kalouptsidi 2014 Go Back

Trade Elasticity

- Do shipping prices have an impact on trade flows?

$$\underbrace{\log\left(Q_t^{i\to j}\right)}_{\text{trade flows}} = \beta_0 + \beta_1 \underbrace{\log\left(\tau_t^{i\to j}\right)}_{\text{trade costs}} + \epsilon_t^{i\to j}$$

- Idea: attractiveness of destination j affects the price to ship to j
- Instrument: (raw materials) tariffs on j's export
  - increase tariffs $\rightarrow$ fewer opportunities at j $\rightarrow$ higher price $\tau_t^{i\to j}$
- E.g. $\tau_t^{i\to j}$ from Indonesia to China instrumented w/ tariffs on Chinese exports

Trade Elasticity

	$\Delta \log \left(\tau_t^{i \to j}\right)$	$\Delta \log \left(Q_t^{i \to j}\right)$
	First Stage	IV
$\Delta \log \left(\tau_t^{i \to j}\right)$		-1.02^{**}
		(0.425)
$\Delta \log \left(\text{tariff}_t^{j \to (1)}\right)$	0.070^{*}	
	(0.040)	
$\Delta \log \left(\text{tariff}_t^{j \to (2)}\right)$	0.135^{**}	
	(0.027)	
$\Delta \log \left(\text{tariff}_t^{(1) \to i}\right)$	0.152	
	(0.096)	
$\Delta \log \left(\text{tariff}_t^{(2) \to i}\right)$	-0.034	
	(0.082)	
$\Delta \log \left(\text{tariff}_t^{i \to j}\right)$	0.123^{**}	-0.326^{**}
	(0.058)	(0.109)
Constant	-0.225^{**}	-2.173^{**}
	(0.021)	(0.647)
Controls (changes of)	GDP of i and j tariff on i's import (non-commod.) tariff on j's export (non-commod.)	GDP of i and j tariff on i's import (non-commod.) tariff on j's export (non-commod.)
Observations	470	470
R^2	0.143	-
F-stat instrument	7.04	
Note:		$^{*}p<0.1$; $^{**}p<0.05$

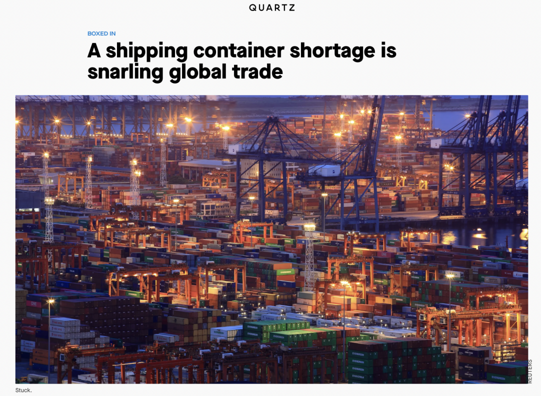
Go Back

Chokepoints

	Change in Exports	Max	Min	Most Affected	Change in Welfare
Suez	−3.51%	4.14%	−25.95%	Middle East	−5.25%
Panama	−3.23%	1.31%	−28.16%	Northeast America	−3.28%
Gibraltar	−6.37%	2.57%	−44.73%	Mediterranean	−5.03%

from Brancaccio, Kalouptsidi and Papageorgiou 2020 Go Back

Container Box Shortage


QUARTZ

BOXED IN

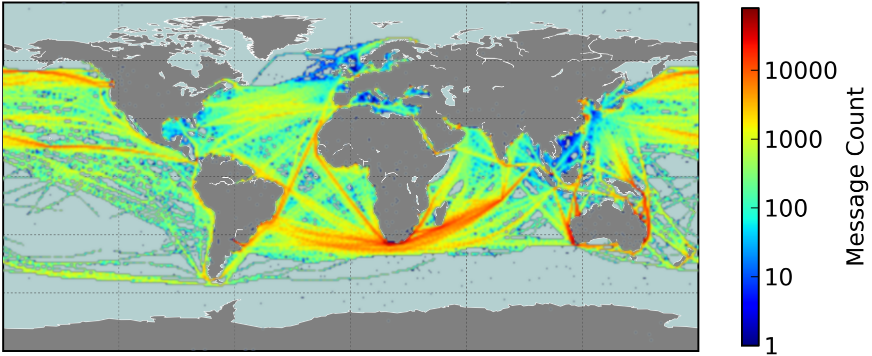
A shipping container shortage is snarling global trade

REUTERS

Stuck.

- *"The problem isn't that there aren't enough shipping containers in the world; it's that the containers are in the wrong spots."*
- This is **inherent** in the nature of transport markets (BKP, 2020) ▸ Go Back

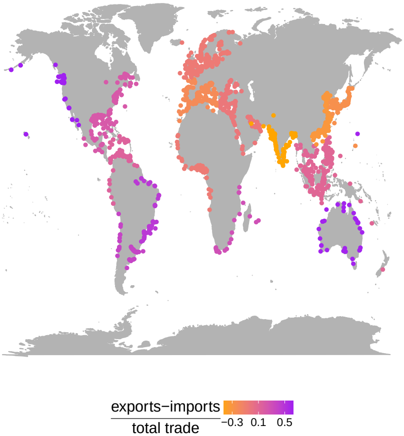
Vessel Movements: Message Count in 10 Days



▸ one ship's path

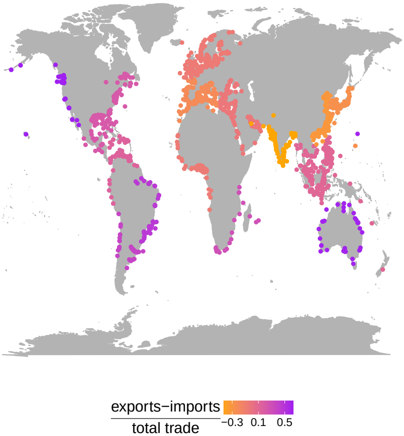
Trade Imbalances

- Most countries are either large net importers or large net exporters



Trade Imbalances

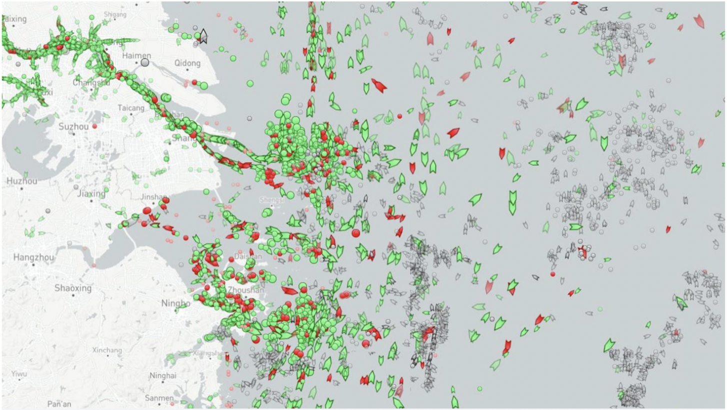
- Most countries are either large net importers or large net exporters



- 42% of ships currently in transit are without cargo (ballast)

most popular ballast routes Go Back

Congestion during COVID



The green and red dots show the mass congestion of cargo vessels and tankers off the coast of Shanghai. Pic: MarineTraffic

Go Back

M/M/K

- M/M/K queueing model:
  - M: arrival rates exponentially distributed with mean arrival rate λ
  - M: service rates exponentially distributed with mean service rate μ
  - K: number of servers (leads to M/M/1 with service rate $K\mu$)
- Expected time in the system:

$$\underbrace{\frac{1}{\mu}}_{\text{expected service time}} + \underbrace{\frac{C(K, \lambda/\mu)}{K\mu - \lambda}}_{\text{expected queueing time}}$$

where $C(K, \lambda/\mu)$ the prob of entering queue ("Erlang's C formula")

Go Back