Transport Markets, Port Infrastructure, and World Trade

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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
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.

• trade shut for a week (10 billion $ daily)
Transportation and Global Supply Chains

‘I’ve Never Seen Anything Like This’: Chaos Strikes Global Shipping

The pandemic has disrupted international trade, driving up the cost of shipping goods and adding a fresh challenge to the global economic recovery.

- 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

Why do transport markets have the potential for great disruption?
Is the current situation a “unique” event?
- extreme yes, unique no
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Why do transport markets have the potential for great disruption?

   - 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

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

     o volatile demand (macro shocks)
     o sluggish supply:
       o short-run: cost convexities
       o and medium/long-run: irreversibilities, time to build
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)
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)*  

- Can see this through different experiments
  - e.g. closure of chokepoints
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
residualized wait time on ship size and commodity
Time at Ports

Wait time

Service time

Go Back
A Model for Time at Port

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

$$T_{jt} = \text{service time} + \frac{Q_{jt}}{K_{jt}} T_{jt}$$

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

![Graph showing wait time (hours) over years with lines for Estimated and Raw data, indicating model fit.](image-url)
• Key statistic to understand queue stability:

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

• \( \rho \) 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

![Graph showing density over time at port for 2019 and 2021. The graph indicates a higher density in 2019 compared to 2021, especially towards the end of the time period.]
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

    • 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
Trade Elasticity

- Do shipping prices have an impact on trade flows?

\[ \log \left( Q_{t \rightarrow j} \right) = \beta_0 + \beta_1 \log \left( \tau_{t \rightarrow j} \right) + \epsilon_{t \rightarrow j} \]

- Idea: attractiveness of destination j affects the price to ship to j

- Instrument: (raw materials) tariffs on j’s export
  - increase tariffs → fewer opportunities at j → higher price \( \tau_{t \rightarrow j} \)

- E.g. \( \tau_{t \rightarrow j} \) from Indonesia to China instrumented w/ tariffs on Chinese exports
## Trade Elasticity

<table>
<thead>
<tr>
<th></th>
<th>$\Delta \log \left( \tau_{k}^{t+j} \right)$</th>
<th>$\Delta \log \left( \tau_{j}^{t+j} \right)$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Stage</strong></td>
<td></td>
<td>IV</td>
</tr>
<tr>
<td>$\Delta \log \left( \tau_{k}^{t+j} \right)$</td>
<td>0.070*</td>
<td>-1.62**</td>
</tr>
<tr>
<td></td>
<td>(0.040)</td>
<td>(0.425)</td>
</tr>
<tr>
<td>$\Delta \log \left( \text{tariff}_{i}^{t+j} \right)$</td>
<td>0.135**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td></td>
</tr>
<tr>
<td>$\Delta \log \left( \text{tariff}_{j}^{t+j} \right)$</td>
<td>0.152</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.096)</td>
<td></td>
</tr>
<tr>
<td>$\Delta \log \left( \text{tariff}_{i}^{1+t+j} \right)$</td>
<td>-0.034</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.082)</td>
<td></td>
</tr>
<tr>
<td>$\Delta \log \left( \text{tariff}_{j}^{1+t+j} \right)$</td>
<td>0.123**</td>
<td>-0.226**</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.109)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>-0.225**</td>
<td>-2.173**</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.647)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Controls (changes of)</th>
<th>GDP of $i$ and $j$</th>
<th>GDP of $i$ and $j$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tariff on $i$'s import (non-commod.)</td>
<td>tariff on $j$'s import (non-commod.)</td>
</tr>
<tr>
<td></td>
<td>tariff on $i$'s export (non-commod.)</td>
<td>tariff on $j$'s export (non-commod.)</td>
</tr>
<tr>
<td>Observations</td>
<td>470</td>
<td>470</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.143</td>
<td>0.143</td>
</tr>
<tr>
<td>F-stat instrument</td>
<td>7.64</td>
<td>-</td>
</tr>
</tbody>
</table>

**Note:** *p<0.1; **p<0.05
## Chokepoints

<table>
<thead>
<tr>
<th>Change in Exports</th>
<th>Max</th>
<th>Min</th>
<th>Most Affected</th>
<th>Change in Welfare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suez</td>
<td>−3.51%</td>
<td>4.14%</td>
<td>−25.95%</td>
<td>−5.25%</td>
</tr>
<tr>
<td>Panama</td>
<td>−3.23%</td>
<td>1.31%</td>
<td>−28.16%</td>
<td>−3.28%</td>
</tr>
<tr>
<td>Gibraltar</td>
<td>−6.37%</td>
<td>2.57%</td>
<td>−44.73%</td>
<td>−5.03%</td>
</tr>
</tbody>
</table>

from Brancaccio, Kalouptsidi and Papageorgiou 2020
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)
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)
The green and red dots show the mass congestion of cargo vessels and tankers off the coast of Shanghai. Pic: MarineTraffic
M/M/K

• M/M/K queueing model:
  
  • M: arrival rates exponentially distributed with mean arrival rate $\lambda$
  
  • M: service rates exponentially distributed with mean service rate $\mu$
  
  • K: number of servers (leads to M/M/1 with service rate $K\mu$)

• Expected time in the system:

$$\frac{1}{\mu} + \frac{C(K, \lambda/\mu)}{K\mu - \lambda}$$

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

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