Shipping to America

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>>> Motivation

- Recent disruptions (COVID-19, 2021 Suez Canal blockage, 2023 Red Sea crisis, 2025 Strait of Hormuz) highlighted vulnerabilities in the shipping sector with ripple effects on U.S. economy
- Most manufactured goods produced overseas have to be shipped via container ships
  - 30% of the world fleet capacity (UNCTAD (2024))
  - 60% of all imports from SE Asia and Pacific is done via containerized vessels

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Q: How much shipping is there across the different routes to the U.S.?
How do disruptions affect the shipping market?

>>> What we do in this paper

1. Empirical analysis

- Use micro data to track all container ships to the U.S. starting in 2017
  - Provide novel evidence on shipping capacity across different routes
  - Build measures of disruptions for each route over time

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- Shipping firms take goods from different regions along different routes
  - They choose how to allocate ships to different routes, their loading and speed
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3. Quantitative analysis

- Simulate the model to match evolution of shipping capacity and import flows
  - Entry of shipping firms led to ↑ capacity ⇒ Mostly allocated to most profitable route
  - Relative price of imported goods ↓ ⇒ ↑ demand and import share
- Impact of tariffs is ambiguous
  - If tariffs are high, retailers pass on costs to consumers and imports ↓
  - If tariffs are small, prices ↓ and imports ↑

Evolution of shipping services to the U.S.

>>> TRACKING CONTAINER SHIPS



Raymarine AIS 4000 Class A AIS Transceiver

RAYMARINE AIS 4000 Class A AIS - Designed for commercial vessels, luxury yachts, and SOLAS high-seas shipping, the AIS4000 Automatic Identification System (AIS) transceiver delivers robust Class A AIS network capability and is engineered to withstand the harsh weather, shock, and vibration of any vessel class. Power supply: 12 to 24 VDC. Frequency: 156.025 MHz to 162.025 MHz. E70601 **Free US Shipping.**

Reference: E70601 **In Stock:** 1

Reg Price: $2,799.99

CPlus Price: $2,701.99

What is Citimarine Plus Membership?
Click here for details



- Leverage real-time satellite-based tracking of container ships via the Automatic Identification System (UN International Maritime Organization)

>>> Similar to a bus route

Port rotation & proforma schedule	Departure day
Qingdao (CNTAO)	Wed
Shanghai (CNSHA)	Sat
Ningbo (CNNGB)	Tue
Nansha (CNNSA)	Fri
Port Klang (MYPKG)	Thu
Jeddah (SAJED)	Mon
Damietta (EGDAM)	Fri
Newark (USNWK)	Thu
Norfolk (USORF)	Sat
Charleston (USCHS)	Mon
Jacksonville (USJAX)	Wed
Damietta (EGDAM)	Wed
Jeddah (SAJED)	Wed
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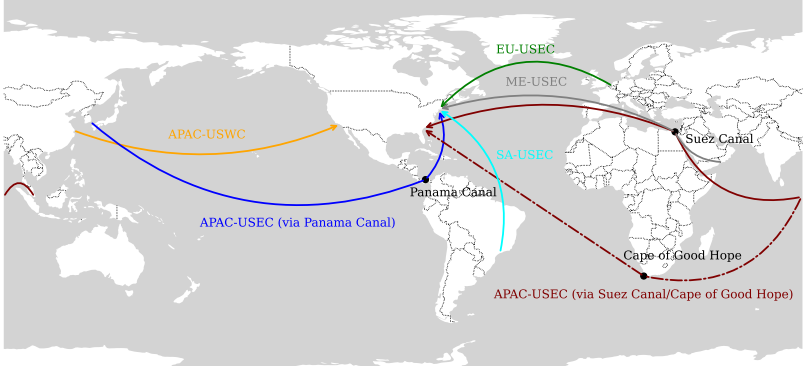
- Think of container ships as scheduled flights or bus lines: regular schedules, picking up/delivering containers from/to feeders
  - E.g. 43 days from Shanghai to Newark through the Suez Canal, leaving on a Saturday, arriving on Thursday

>>> DATA

- Lloyds List, January 2017-March 2025
  - Universe of containerized vessels en route to the US
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  - Consolidate port calls for each ship
  - Last port call in the region as origin and first U.S. port as destination

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- Lloyds List, January 2017-March 2025
- Group ships along 6 routes from 4 regions (Asia, Europe, Middle East, South America) to 2 U.S. destination ports (East and West Coast)
- 646 port calls across the world

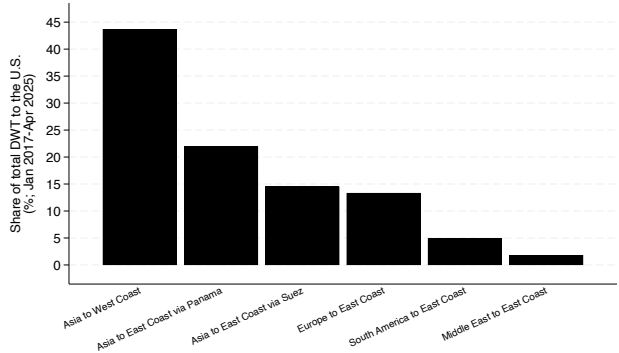
Ranking	Destination Port	Trip Share	Ranking	Origin Port	Trip Share	Major Routes
1	Newark (NJ)	20.0	1	Busan, South Korea	18.3	APAC–USEC (Panama), APAC–USWC
2	Los Angeles (CA)	11.1	2	Cartagena, Colombia	7.9	SA–USEC
3	Long Beach (CA)	8.7	3	Colón, Panama	6.1	SA–USEC
4	Savannah (GA)	5.7	4	Shanghai, China	5.9	APAC–USEC (Panama), APAC–USWC
5	Seattle (WA)	4.0	5	Shenzhen, China	5.5	Mostly APAC–USWC
6	Fort Lauderdale (FL)	3.9	6	Ningbo-Zhoushan, China	4.7	Mostly APAC–USWC
7	Houston (TX)	3.8	7	Valencia, Spain	4.6	EU–USEC
8	Tacoma (WA)	3.2	8	Bremerhaven, Germany	3.7	EU–USEC
9	Miami (FL)	3.2	9	Le Havre, France	3.0	EU–USEC
10	Philadelphia (PA)	3.1	10	Colombo, Sri Lanka	2.5	APAC–USEC (Suez/Cape)
11	Charleston (SC)	2.6	11	Tokyo, Japan	2.2	APAC–USEC (Panama), APAC–USWC
12	New York City (NY/NJ)	1.6	12	Yokohama, Japan	2.1	APAC–USEC (Panama), APAC–USWC
13	Norfolk (VA)	1.5	13	Kaohsiung, Taiwan	2.0	Mostly APAC–USWC
14	Boston (MA)	1.3	14	Mundra, India	1.6	APAC–USEC (Suez/Cape)
15	Port of Tampa (FL)	1.3	15	Singapore	1.6	APAC–USEC (Suez/Cape)
16	Oakland (CA)	1.3	16	Antwerp, Belgium	1.5	EU–USEC
17	Chester (PA)	0.9	17	Santa Marta, Colombia	1.5	SA–USEC
18	New Orleans (LA)	0.6	18	St. George's, Grenada	1.4	SA–USEC
19	Palm Beach (FL)	0.6	19	Xiamen, China	1.4	Mostly APAC–USWC
20	Mobile (AL)	0.5	20	Nhava Sheva, India	1.2	APAC–USEC (Suez/Cape)

>>> Measuring shipping capacity and disruptions

- Measure shipping capacity in tons (DWT) and ton-miles (DWT $\times$ Distance)
- Measure disruptions due to rerouting, congestion at ports, Panama and Suez Canals
  - $\text{Rerouting}_{r,t}$ = Dev. from shortest trip distance between origin-destination $\times$DWT
  - $\text{Port Congestion}_{r,t}$ = Time spent in anchorage areas of a port during port calls $\times$ Average speed (DWT-weighted) $\times$ DWT
  - $\text{Canal Congestion}_{r,t}$ = Time spent in along the Panama or Suez canals $\times$ Average speed (DWT-weighted) $\times$ DWT
  - $\text{Disruptions}_{r,t} = \text{Rerouting}_{r,t} + \text{Port Congestion}_{r,t} + \text{Canal Congestion}_{r,t}$

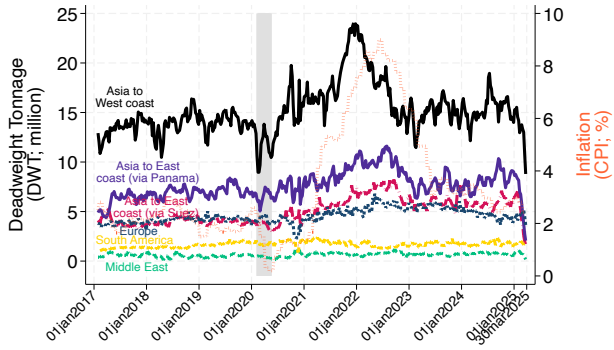
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   - East Coast via Panama (22%), East Coast via Suez (14%), and Europe (13%)



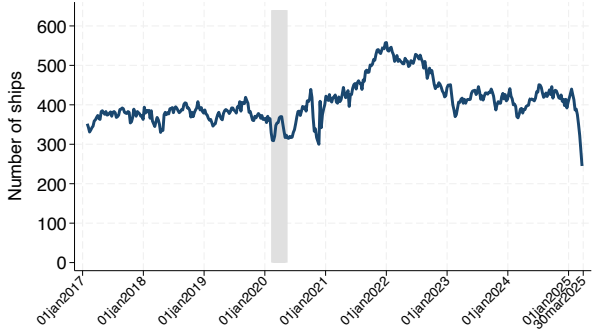
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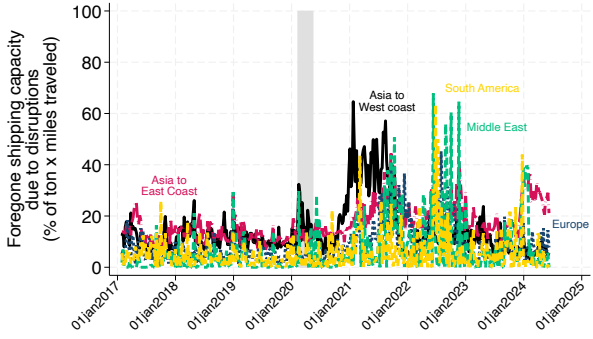
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3. Foregone capacity due to disruptions can be sizeable
   - Mostly due to port congestion



>>> TAKING STOCK

- Measure shipping capacity allocated to U.S. routes and disruptions
  - Bulk of containerized shipping goes through 2 routes: Asia to West coast and Asia to East coast via Panama
  - Disruptions affect how shipping firms reallocate capacity along different routes

Next

- Quantitative framework to study role of disruptions and reallocation across routes

Quantitative framework

>>> Environment

- GE model of the shipping market to the U.S.
- **Consumers** enjoy goods that have to be shipped from 4 ports of origin $o = \{\text{Asia, Europe, Middle East, South America}\}$ and domestically-produced goods
  - Imported goods from different regions are imperfect substitutes
  - Indifferent about routes goods originate from within a region

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- **Shipping firms** take goods along different routes $r = \{\text{Asia to East via Panama Canal, Asia to East via Suez Canal, Asia to West, Eur to East, ME to East, SA to East}\}$
  - Routes differ in their distance, d_r, and efficiency, ε_r (influenced by weather, presence of pirates)
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  - Few operating shipping firms compete oligopolistically (Cournot), N
- **Retailers** purchase imported goods and resell them to consumers
- *Later:* **Government** can impose tariffs on imported goods

>>> Shipping technology

- A shipping firm produces the shipping service, $q_{j,r}$

$$q_{j,r} = n_{j,r}(s) \times \ell\kappa_{j,r}$$

- Number of trips along route r depends on ships average speed, s, and productivity, $z_{j,r}$

$$n_{j,r}(s) = z_{j,r}s^{\alpha}$$

- Quantity transported per trip $\ell\kappa_{j,r}$ (ℓ fraction of capacity used)
  - Given its allocated capacity to the route, $\kappa_{j,r}$ (optimally chosen)

>>> Shipping inputs and markups

- Chooses ℓ and s to minimize total costs s.t. shipping service technology, $q_{j,r}$

$$tc_{j,r} = w(\varepsilon_r d_r)^{\zeta} + p_o\left(\ell \kappa_{j,r}\right)^{\gamma} \qquad \text{(with } \alpha/\zeta + 1/\gamma = 1\text{)}$$

  - Route distance $d_r = s \times \tau_{j,r}$ ($\tau_{j,r}$ time spent traveling)

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  - Solution yields marginal costs

$$mc_{j,r} = \frac{(\varepsilon_r \tau_{j,r})^{\alpha}}{z_{j,r}} \left(\frac{w}{\alpha/\zeta}\right)^{\alpha/\zeta} \left(\frac{p_o}{1/\gamma}\right)^{1/\gamma}$$

    - $\uparrow$ with input prices, route's efficiency, and time spent traveling
    - $\downarrow$ with firm's productivity

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- Chooses shipping services to maximize profits per route s.t. $p_r \equiv p(q_r)$

$$\pi_{j,r} = \max_{q_{j,r}} \left(p_r - mc_{j,r}\right) q_{j,r}$$

  - Solution yields a (endogenous) markup over marginal costs $p_r = m_{j,r} mc_{j,r}$

$$m_{j,r} = \frac{\xi_r}{\xi_r - \omega_{j,r}}$$

    - $\downarrow$ with retailers' endogenous price elasticity of demand for route r goods, ξ_r
    - $\uparrow$ with firm j's market share of the route, $\omega_{j,r} \equiv p_r q_{j,r} / p_r q_r$

>>> Shipping capacity

- Capacity is allocated to maximize shipping firm's aggregate profits

$$\pi_j = \max_{\{\kappa_{j,r}\}_r} \left\{ \sum_r \pi_{j,r} - w\varepsilon_\kappa \sum_r \frac{\kappa_{j,r}^2}{2} \right\}$$

s.t. capacity constraint $\kappa_j = \sum_r \kappa_{j,r} + \overline{\kappa}_j$ ($\overline{\kappa}_j$ idle/spare capacity)

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- Optimal capacity per route

$$\kappa_{j,r} \quad = \quad \frac{1}{|\mathcal{R}|}\left(\kappa_j - \overline{\kappa}_j\right) + \frac{1}{w}\left[\left(p_r - mc_{j,r}\right) n_r(s_{j,r})\, \ell_{j,r} - \frac{1}{|\mathcal{R}|}\sum_x \left(p_x - mc_{j,x}\right) n_x(s_{j,x})\, \ell_{j,x}\right]$$

  - $\uparrow$ capacity allocated to more profitable routes

>>> Retail market

- Identical retailers purchase goods from shipping firms at p_r and resell them to consumers at price $\widehat{p}_o$ to maximize profits

$$\Pi_r = \max_{q_r} \left\{ \widehat{p}_o \chi_r q_r^{\theta} - p_r q_r - f \right\} \qquad (f \text{ entry costs, } \mathcal{T}_o \text{ tariff rate})$$

  - Make losses on some routes

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$$o_r = \frac{e^{\lambda \Pi_r}}{\sum_x e^{\lambda \Pi_x}}$$

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- All markets clear and free entry in the shipping and retail markets

Taking the model to the data

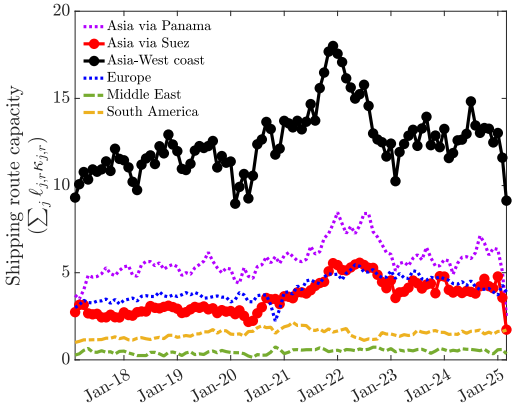
>>> Model ↔ Data

- Monthly frequency
- Calibrate model to match data in February 2017 ‣ Parameter values ‣ Targeted moments
  - *Exogenous/externally estimated:* Route distances (d_r), shipping elasticities (α, ζ, γ), retailers output elasticity (θ), consumers' elasticity of sub (ρ, ρ_d)
  - *Internally estimated:* Route productivity (z_r), cost shifters ($\varepsilon_r, \varepsilon_\kappa$), retail entry cost ($f$), retailers productivity (χ_r), utility weights (γ_o, γ_d), productivity of domestic (z_d) and foreign firms (p_o)

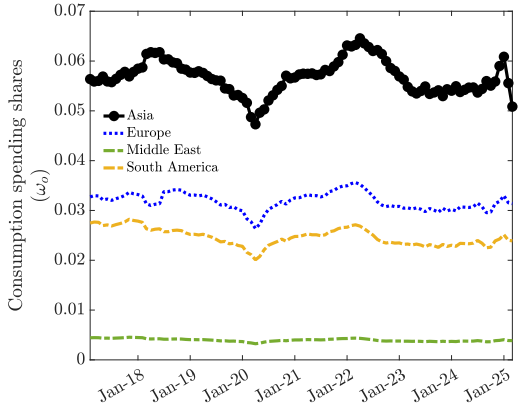
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- Simulate model to match 2017-2025 evolution ▸ Simulated shocks
  - Solve for productivities, cost shifters, and entry costs that match *import shares* ($\widehat{p}_o c_o/(w+\Lambda)$), *shipping route DWT shares* ($\sum_j \ell_{j,r}\kappa_{j,r}/\sum_{j,r}\ell_{j,r}\kappa_{j,r}$), *route speeds* ($s_r$), *number of shipping firms* (N), *inflation* (ΔP^{total})

>>> Simulated model targets time series very well



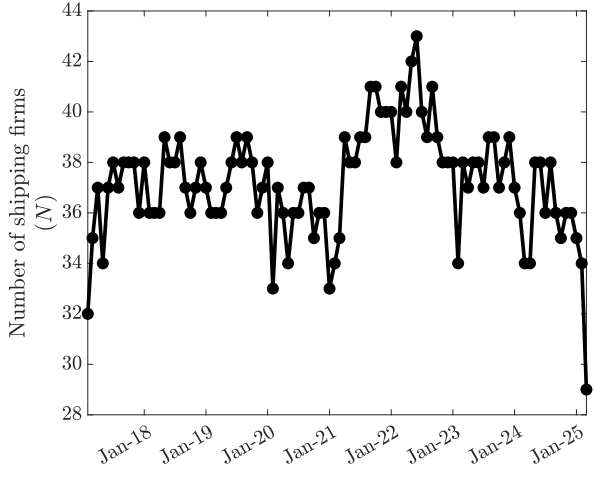
(A) DWT by route



(A) Import shares of GDP

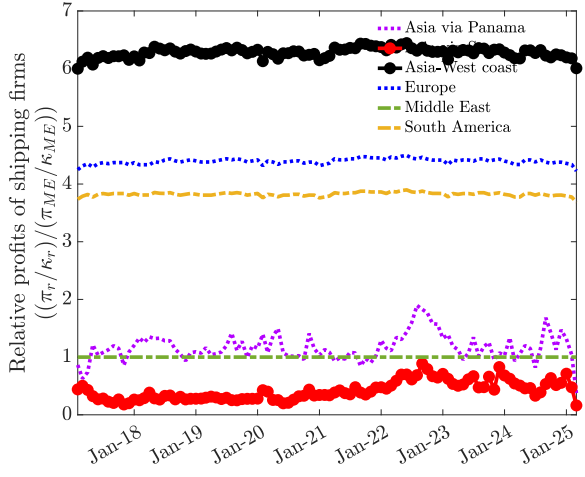
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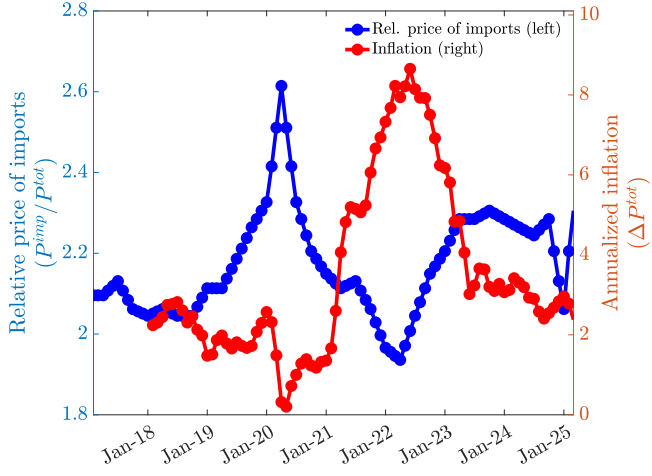
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  - Higher markups and faster travel times



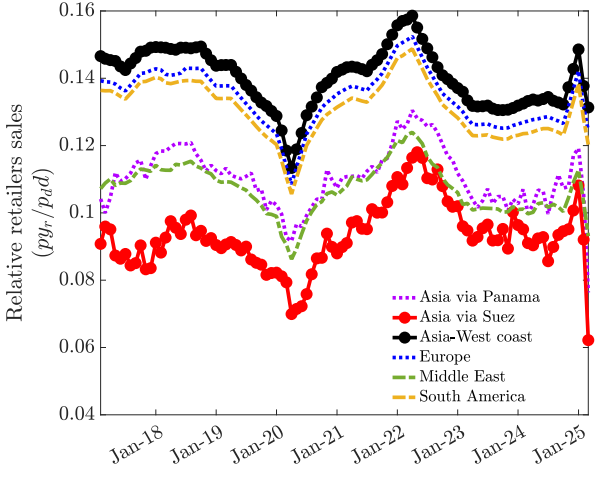
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- Relative price of imports ↓ ⇒ Imports ↑
  - Despite prices rising overall



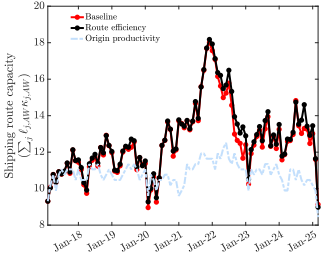
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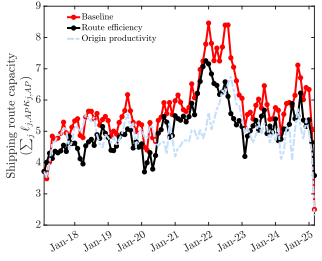
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  - Higher markups and faster travel times
- Relative price of imports ↓ ⇒ Imports ↑
  - Despite prices rising overall

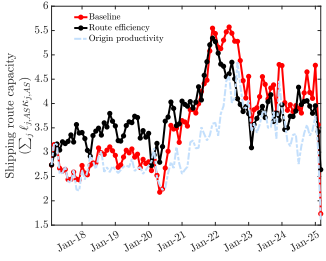


>>> DRIVERS

- Shut down exogenous forces one at a time: route efficiency and foreign producers productivity
- Rise in productivity of Asian firms help explain most of the rise in shipping in 2022

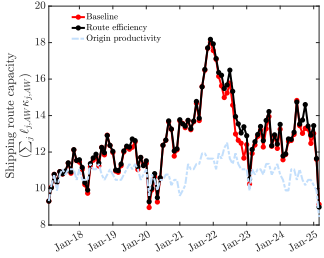


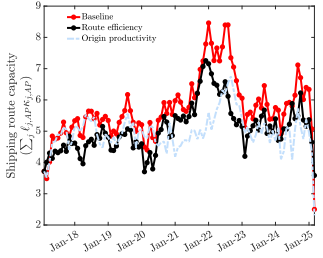


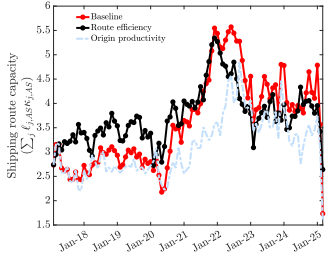


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- Yet little impact on import shares as prices and markups adjust
  - Need action on retailers' productivity and entry costs

Tariff policy

>>> Introducing a tariff

- **Government** can now impose tariffs on imported goods, $\mathcal{T}_o$ (rebated lump sum to consumers, T)
- Retailers' profits per route are now

$$\Pi_r = \max_{q_r} \left\{ \widehat{p}_o \chi_r q_r^{\theta} - (1 + \mathcal{T}_o) p_r q_r - f \right\}$$

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    As $\downarrow$ price of shipped goods $\Rightarrow$ demand picks up, $\uparrow q_r$ and $\uparrow o_r$

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    As $\downarrow$ price of shipped goods $\Rightarrow$ demand picks up, $\uparrow q_r$ and $\uparrow o_r$
- Which effect dominates dictates effect on macro aggregates

>>> Impact of tariffs on Asian goods

- *Experiments:* $\uparrow \mathcal{T}_A$ to 25/50/75%

		Δ% relative to Baseline		
	Baseline	25% Tariff	50% Tariff	75% Tariff
Capacity	216.91	-0.35	-15.99	-43.26
Shipping Firms	32	-0.97	-17.50	-44.10

- Number of shipping firms $\downarrow$ and more ships stay idle

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Imports/GDP	Total	12.10	+10.02	-2.56	-26.50
	A	5.64	+23.71	+19.40	-3.79
	E	3.27	-1.96	-21.80	-46.39
	M	0.44	-1.60	-21.27	-45.89
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	E	2.41	+0.59	+28.33	+93.36
	M	3.40	+0.22	+27.47	+91.57
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- Number of shipping firms $\downarrow$ and more ships stay idle
- Imports can $\uparrow$ if tariff is small
- Shipping firms and retailers $\downarrow$ markups and prices on Asian goods $\Rightarrow \uparrow$ demand
  - Prices on all other goods $\uparrow$

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	AW	0.13	-49.70	-53.73	-35.13
	EE	0.19	+2.83	+69.97	+291.61
	ME	0.50	+2.43	+68.90	+288.51
	SE	0.39	+2.69	+69.59	+290.45

- Number of shipping firms ↓ and more ships stay idle
- Imports can ↑ if tariff is small
- Shipping firms and retailers ↓ markups and prices on Asian goods ⇒ ↑ demand
  - Prices on all other goods ↑

Concluding remarks

>>> KEY TAKEAWAYS

1. Document the evolution of shipping to the US across different routes
   - Put together satellite-based data tracking ships to the US
   - Build a measure of shipping capacity and disruptions related to congestion and rerouting
   - Substantial reallocation to Asia-West Coast route in 2021-2022
2. Quantitative model to study effect of disruptions
   - Entry of shipping firms led to $\uparrow$ capacity $\Rightarrow$ Mostly allocated to most profitable route (Asia-West Coast)
   - Relative price of imported goods $\downarrow \Rightarrow \uparrow$ demand and import share
3. Impact of tariffs is ambiguous
   - If tariffs are small, prices $\downarrow$ and imports $\uparrow$
   - If tariffs are high, retailers pass on costs to consumers and imports $\downarrow$

Thank you

Appendix

>>> PARAMETER VALUES

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Parameter	Description	Value	Identification
Shipping market			
$d_{A,EP/ES/W}$	Distance, Asia to East coast via Panama/Suez/to West coast	12.0, 12.5, 6.0	-
$d_{E/M/S/,E}$	Distance, Europe, Middle East, South America to East coast	4.0, 7.5, 3.0	-
$\varepsilon_{A,EP/ES/W}$	Cost shifter, Asia to East coast via Panama/Suez/to West coast (%)	0.034, 0.121, 1.334	Shipping route share
$\varepsilon_{E/M/S/,E}$	Cost shifter, Europe, Middle East, South America to East coast (%)	1.301, 0.097, 1.464	Shipping route share
$z_{A,EP/ES/W}$	Route eff., Asia to East coast via Panama/Suez/to West coast	0.221, 0.205, 0.435	Average shipping speed
$z_{E/M/S/,E}$	Route eff., Europe, Middle East, South America to East coast	0.630, 0.349, 0.832	Average shipping speed
α	Exponent on speed	0.650	Elast. of MSI wrt speed
ζ	Exponent on distance	1.000	Normalization
ν	Exponent on quantity transported	2.857	Constraint
ε_{κ}	Capacity cost shifter	0.005	Number of shipping firms
$\overline{\kappa}$	Idle capacity	3.239	Idle capacity share
Retail market			
$\chi_{A,EP/ES/W}$	Productivity, Asia to East coast via Panama/Suez/to West coast	1.0, 1.893, 2.619	-
$\chi_{E/M/S/,E}$	Productivity, Europe, Middle East, South America to East coast	1.0, 1.0, 1.0	Normalization
θ	Exponent on retail output	0.500	Retail share
λ	Scale parameter in optimal shipping route	1.000	Exogenous
f	Entry cost in retail market	3.910	Normalization
Consumer preferences			
γ_d	Cons. weight on domestic goods	0.000	Import shares
$\gamma_{A/E/M/S}$	Cons. weight, Asia, Europe, Middle East, South America	0.242, 0.290 0.109, 0.359	Import shares
ρ_d	Elast. of sub. between domestic and imported goods	0.500	Exogenous
ρ	Elast. of sub. within imported goods	0.500	Exogenous
Government policy			
$\mathcal{T}_o$	Tariff rates on imported goods	0.0	Exogenous

>>> TARGETED MOMENTS

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Moment	Model	Data	Source
Share of shipping route in total DWT			
Asia to East coast via Panama Canal	0.145	0.145	AIS Vessel Tracker
Asia to East coast via Suez Canal	0.229	0.229	AIS Vessel Tracker
Asia to West coast	0.410	0.410	AIS Vessel Tracker
Europe to East coast	0.160	0.160	AIS Vessel Tracker
Middle East to East coast	0.026	0.026	AIS Vessel Tracker
South America to East coast	0.030	0.030	AIS Vessel Tracker
Average speed along shipping routes			
Asia to East coast via Panama Canal	16.15	16.15	AIS Vessel Tracker
Asia to East coast via Suez Canal	14.73	14.73	AIS Vessel Tracker
Asia to West coast	15.50	15.50	AIS Vessel Tracker
Europe to East coast	14.00	14.00	AIS Vessel Tracker
Middle East to East coast	15.64	15.64	AIS Vessel Tracker
South America to East coast	13.65	13.65	AIS Vessel Tracker
Import shares			
Asia	0.493	0.493	WITS
Europe	0.255	0.255	WITS
Middle East	0.037	0.037	WITS
South America	0.215	0.215	WITS
Other			
Shipping firms	10.0	10.0	AIS Vessel Tracker
Retail share	0.5	0.5	BEA

>>> SIMULATED SHOCKS

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