Price dispersion in maritime transportation: Evidence from the container shipping market

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Very first draft, preliminary and incomplete

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1. Introduction

- containerized ocean shipping plays a critical role in international trade and is often considered the backbone of the global economy
  - 80%-90% of the volume of international trade in goods is carried by sea (Review of Maritime Transport 2023)
  - more than 60% of international trade value is carried out by container shipping
- container freight rate is therefore a very important component of the trade cost
  - strong evidence of freight rate heterogeneity across routes (see Brancaccio et al., EcA, 2020): characteristics of goods, trade imbalances, market power of carriers, …
  - but freight rates within a route are usually assumed to be uniform in the international trade literature

- as emphasized in Ardelean and Lugovskyy (EER, 2023), assumption – ***POTENTIALLY*** – no longer relevant in the US since 1998 and the Ocean Shipping Reform Act
    - Reform Act taking effect May 1, 1999, but changes occurring even in 1998 (see Morgan Lewis report)

- deregulation of the international ocean shipping
    - transformation of a common carriage system (all pricing is filed with the government and made public) into a contract-based system (pricing becomes confidential)

- (almost) no work on the within-route dispersion in freight rates: old and new trade models still assume uniform freight rates at the route level
    - lack of data as emphasized in Wong (AEJ:AE, 2022) who focuses on the round trip effect using monthly port-level container freight rate data (so missing within differences)

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- first exception: Ignatenko (2020, unpublished)
  - focus on price discrimination by freight carriers using customs data from Paraguay
  - freight prices vary across shipments transported on the same vessel by the same carrier at the same time

- second exception: Ardelean and Lugovsky (EER, 2023)
  - use of import transaction level data from 2009-2019 from Chili
  - small importers (in terms of importing size) pay higher freight rates, but only on routes with enough competition (more than three carriers)

- … but still no evidence based on contract data and for the main routes, in particular Far East to North America and Far East to Asia

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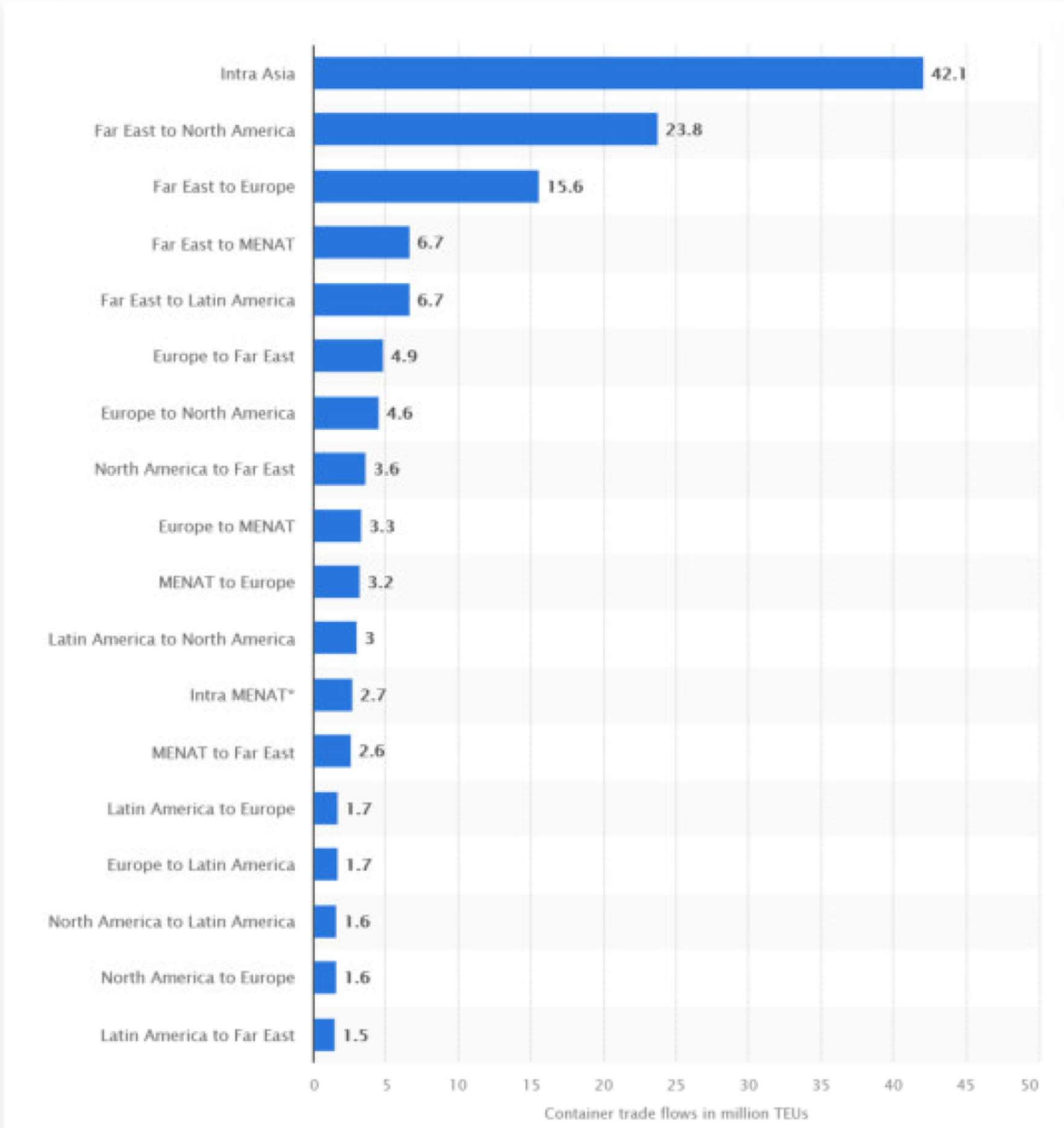
Global container trade in 2022, by trade lane

(in million TEUs)



- focus of our paper: price dispersion in container shipping
  - not so much across routes (from Far East to Europe and from Far East to US West America)
  - but ***WITHIN*** routes: barely documented so far

- use of unique data of freight rates at the individual contract level
  - more than 1M contracts between 2018 and 2023Q1, thus Covid impact can be investigated (interest as large variations in freight rates)
  - focus on the spot market (contract valid for less than a month)
- specifically, measurement of the price dispersion in container shipping and its persistence
  - no theoretical model, no structural estimation …
  - but nonetheless useful (… !): is the assumption of uniform trade costs on a given route, which prevails in the trade literature, relevant ?

2. Background

- in a competitive market, identical goods should have the same price: law of one price (LOP)
  - "price dispersion is a manifestation – and, indeed, it is the measure – of ignorance in the market" (Stigler, JPE, 1961)
- large body of theoretical/empirical evidence suggesting that most of the dispersion is related to information costs
  - customers' costs of acquiring information
  - firm costs of transmitting information to consumers
- price dispersion can arise under a variety of market conditions and search strategies
  - "economists have belatedly come to recognize that the law of one price is no law at all" (Varian, AER, 1980)

- on the empirical side, vast literature using data about prices posted by offline or online sellers or scanner data
    - Pratt et al. (QJE, 1979), Baylis and Perloff (RIO, 2002), Lach (REStat, 2002), Ancarani and Shankar (JAMS, 2004), Bayes et al. (JIE, 2004), Bayes et al. (JIM, 2004), Hong and Shum (2006), …
    - more recently Eden (IER, 2018), Kaplan et al. (AEJ Micro, 2019), Moen et al. (SJE, 2020), Pennerstorfer (IER, 2020), Gugler et al. (JPE Micro, 2023)…
- price dispersion is the rule rather than the exception in homogenous product markets
    - the decrease in information costs with the internet has not reduced, nor eliminated the level of price dispersion
- key questions: dispersion for cheap vs expensive goods / dispersion and purchase frequency / dispersion and search costs / dispersion and number of sellers / dispersion and price persistence

- on the theoretical side, different models to rationalize price dispersion

- search-theoretic models

  - consumers search for price information, search is costly, firms charge difference prices (Stigler, JPE, 1961)

  - relevant in offline or online environments: customers pay an extra cost (time) to obtain information

- models with an information clearinghouse (third party collecting prices, online comparison sites …)

  - it is costless for firm to list prices on the clearinghouse, but cost of assessing to the clearinghouse

  - price dispersion can arise when consumers have different ex ante information sets (Varian, AER, 1980)

- distinction between spatial and temporal price dispersion (Varian, AER, 1980)

- spatial price dispersion: different firms charge different prices over time, but no change in the firms' position in the price distribution

    - striking: with learning of where are low prices, models of spatial dispersion should lead to some convergence

- temporal price distribution

    - the ranking of sellers in the price distribution fluctuates over time, so impossible to learn by experience

    - mixed evidence: "consumers cannot learn about stores that consistently post low prices"

- back to shipping and our study …
- focus on price dispersion for a "homogenous" good
  - container rates are not related to the product being transported, but by the TEU capacity
  - potential impact of Covid
- study of the persistence of price dispersion over time
  - if carriers always provide container shipping capacity at low prices, and if shippers can learn to identify those carriers, then they will ship their cargoes with the low-price service providers and price dispersion will progressively vanish
  - in specific contexts (little capacity, strong demand), shippers may be "in need of" a carrier to transport containers and not really care about freight rates

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3. Pricing in maritime transportation and context

- shippers are sensitive to transportation prices amongst other attributes (transit time, reliability, after-sale services…), but prices remain the most important criteria used by shippers when selecting carriers (McGinnis, 1980; Saldanha et al., 2009; Lammgård et al., 2014; Hedvall et al., 2016)
    - because shippers perceive transit time and other transport attributes as rather homogeneous across carriers (Brooks, 2000)
- in the liner shipping market, the business practice is to add a surcharge to the basic ocean freight rate (BAS)
    - "… the structure of ocean container freight rates has become more complex. A growing number of surcharges are being imposed by the carriers on their customers…" (Slack and Gouvernal, JTG, 2011)

- many different types of surcharges

Table 1. Basic ocean freight and main surcharges

Basic Ocean Freight (BAS)	The BAS varies from customer to customer, depending on the type of cargo, the nature of the commodity, the total container volume controlled by the customer, the regularity and consistency of the cargo flow, the corridors involved, the routing, and the size of type of equipment.
Bunker Adjustment Factor (BAF)	The Bunker Adjustment Factor is intended to cover the unexpected fluctuation on fuel costs. BAF is primarily dependent on average oil prices and average bunker consumption for a corridor.
Terminal Handling Charges (OTHC) .	The handling of the container from the port's storage area to the berth and then to the vessel is handled by the port/terminal, and therefore the costs are charged to the container carrier. Container carriers pass these costs on to the customer in the form of Origin Terminal Handling Charges.
Bill of Lading Fee (B/L Fee)	The Bill of Lading is the standard document required for all shipments, therefore the Bill of Lading Fee is mandatory and charged as a separate surcharge.
Currency Adjustment Factor (CAF)	While Basic Ocean Freight is charged in USD, local freight surcharges are usually billed in the local currency of the country concerned. Container carriers therefore charge CAF to protect themselves from foreign exchange risks.
Suez or Panama Canal Transit Fee	This fee is charged in USD on a per-container basis.

Source: adapted from MarineInsight (2022).

- focus exclusively on the base rate (related to operating costs)
    - "… points to the need to clearly identify what is included in the freight rate data employed…" (Slack and Gouvernal, JTG, 2011)

- rate dispersion (if any) potentially explained by changes in demand and port congestion among other factors, but not because of changes in fuel costs or exchange rate for instance (this would occur through Bunker Adjustment Factor or by a Currency Adjustment Factor)

- Covid: huge increase in the cost of container shipping (Carrière-Swallow et al., IMF WP, 2022)
    - increased demand for intermediate inputs related to stronger manufacturing activity
    - shipping capacities constrained by logistical hurdles and bottlenecks, shortages in container shipping equipment
    - unreliable schedules and port congestion (leading to demurrage and detention fees)

4. Data and descriptive statistics

- data provided by a commercial company (*the Co.* hereafter) through a signed agreement
  - ocean freight rate benchmarking
- unique database of container rates
  - 40-foot dry container equipment type
  - focus on the spot market (as in Wong, 2022): spot prices play a major role
  - exclusion of low and top 0.5% of rates
  - two broad regions: Far East Main -> Europe + Far East Main -> US West Coast
  - 1,218,954 spot contracts

Table A1. List of ports of departure and arrival

Far East -> Europe				Far East -> US West coast			
Origin	N	Destination	N	Origin	N	Destination	N
Shanghai	61698	Rotterdam	179645	Shanghai	30328	Los Angeles	80011
Ningbo	60253	Antwerpen	178377	Yantian	27927	Long Beach	78553
Yantian	57928	Hamburg	173384	Ningbo	26926	Oakland	69163
Hong Kong	57569	Le Havre	151408	Hong Kong	25141	Seattle	63838
Qingdao	56942	Bremerhaven	75855	Qingdao	23843	Tacoma	40803
Xiamen	55337	Wilhelmshaven	66929	Busan	21580		
Tianjin	53631	Zeebrugge	60988	Kaohsiung	21435		
Dalian	51455			Xiamen	21060		
Busan	49082			Tianjin	16784		
Nansha	48952			Dalian	15023		
Kaohsiung	47515			Keelung (Chilung)	14376		
Taichung	39726			Nansha	13526		
Keelung (Chilung)	37435			Taichung	11422		
Shekou	28812			Shekou	10253		
Kobe	27670			Kobe	10154		
Nagoya, Aichi	25906			Tokyo	8767		
Tokyo	25596			Nagoya, Aichi	8041		
Yokohama	23932			Yokohama	6725		
Osaka	22490			Osaka	6025		
Hakata/Fukuoka	19855			Hakata/Fukuoka	5981		
Gwangyang	17487			Gwangyang	3053		
Incheon	10614			Chiwan	1760		
Chiwan	5750			Incheon	1173		
Shenzhen	951			Shenzhen	1065		

Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ rather homogenous routes (in terms of geography)

⇨ calculations for the whole sample, and by main regions

Table 1. Descriptive statistics of the sample

Monthly rate (in US $)	Contracts	Rate: transaction level			Rate: monthly level		
		Mean	St. dev.	CV (in %)	Mean	St. dev.	CV (in %)
A. All routes							
01/2018 – 03/2023	1218954	3749.3	3819.4	101.9	3749.3	1141.9	29.6
01/2018 – 12/2019	515679	1372.8	323.7	23.6	1372.8	280.5	20.5
01/2020 – 03/2023	703275	5491.9	4246.2	77.3	5491.9	1773.5	36.2
B. Far East -> Europe							
01/2018 – 03/2023	886586	3919.1	4012.4	102.4	3919.1	832.9	22.3
01/2018 – 12/2019	396385	1334.9	280.6	21.0	1334.9	234.1	17.8
01/2020 – 03/2023	490201	6008.8	4391.7	73.1	6008.8	1317.1	26.0
C. Far East -> US West America							
01/2018 – 03/2023	332368	3296.4	3205.3	97.2	3296.4	1237.1	34.1
01/2018 – 12/2019	119294	1498.8	413.3	27.6	1498.8	243.7	16.7
01/2020 – 03/2023	213074	4302.7	3620.6	84.1	4302.7	1793.2	43.8

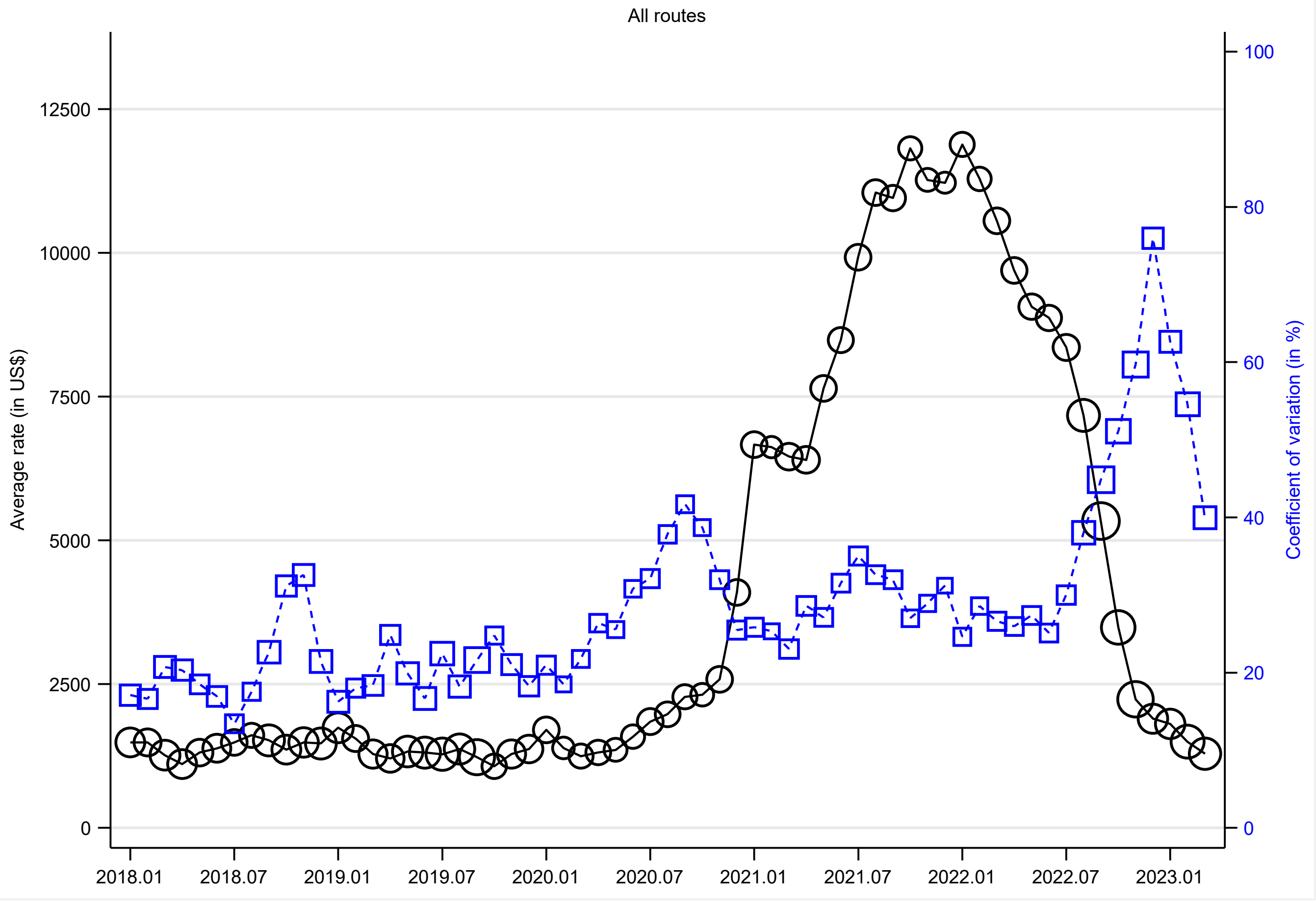
Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ large dispersion in container rates

⇨ dispersion in rates much higher at the transaction level than at the monthly level

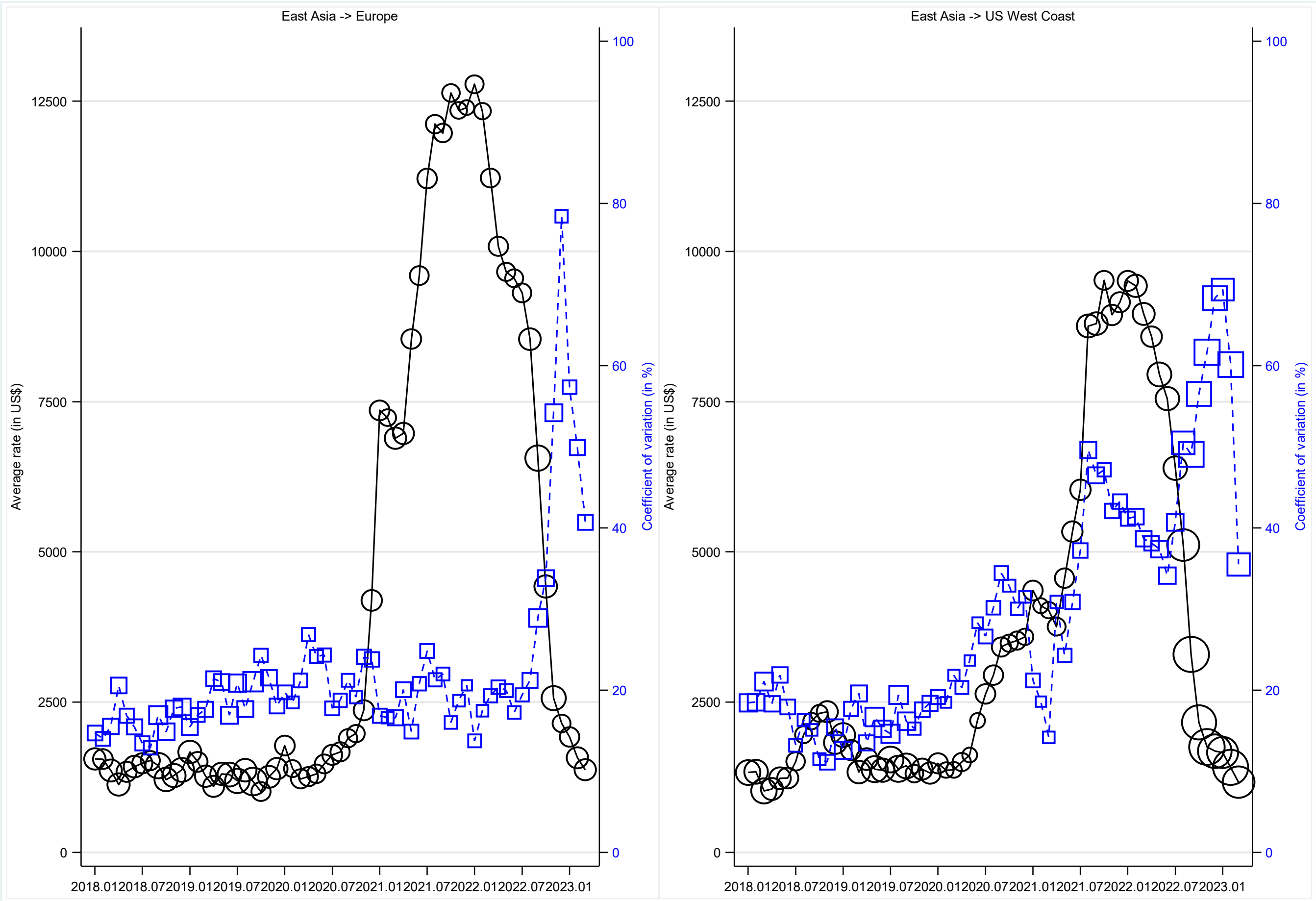
⇨ dispersion in rates seems to have increased during the Covid period (> from Far East to US WA)

Figure 1. Monthly average rate and coefficient of variation



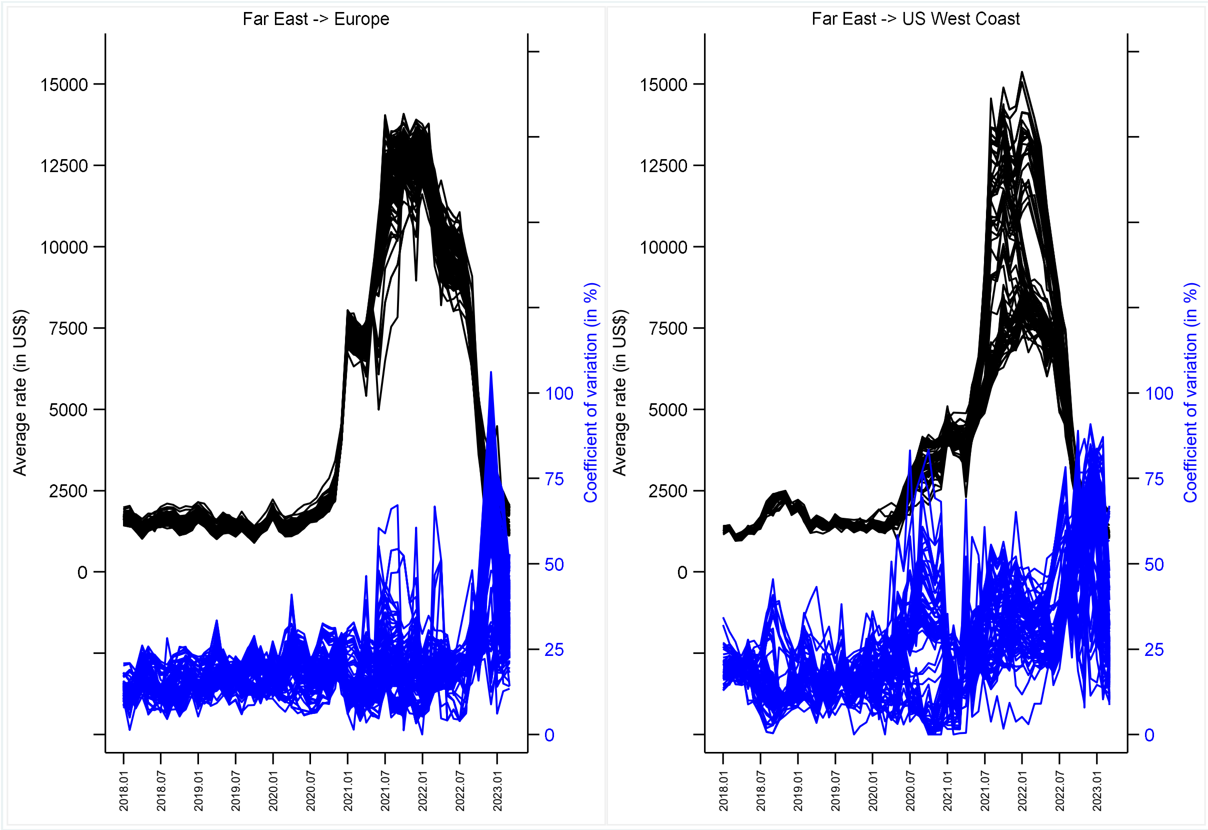
⇨ huge increase in rates during the Covid period

⇨ large dispersion (CV most often between 20%-40%)



⇨ the CV increases during the Covid period, especially at the end (temporal dispersion).

Figure 2. Monthly average rate and coefficient of variation by routes



Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ the dispersion in freight rates does not seem to be due to heterogeneity in routes (spatial dispersion).

Table A2. Descriptive statistics for the top 20 routes

Far East -> Europe					Far East -> US West America				
Origin	Destination	Obs	Rate (inUS$)	CV (in %)	Origin	Destination	Obs	Rate (inUS$)	CV (in %)
Shanghai	Rotterdam	13078	3880.0	25.8	Shanghai	Long Beach	7355	3156.4	35.0
Shanghai	Antwerpen	12885	3925.2	24.6	Shanghai	Los Angeles	7354	3273.8	35.8
Ningbo	Rotterdam	12877	3737.2	24.0	Yantian	Los Angeles	6814	3043.2	34.1
Ningbo	Antwerpen	12511	3777.2	23.3	Ningbo	Los Angeles	6495	3035.2	32.3
Yantian	Rotterdam	12164	3829.7	25.1	Ningbo	Long Beach	6481	2960.3	31.3
Shanghai	Hamburg	12143	3820.3	22.6	Yantian	Long Beach	6476	2969.1	30.6
Qingdao	Antwerpen	12140	3861.7	23.2	Hong Kong	Los Angeles	6366	3055.6	29.3
Ningbo	Hamburg	12062	3677.0	21.7	Qingdao	Long Beach	6031	2775.0	28.6
Qingdao	Rotterdam	11994	3692.5	24.2	Hong Kong	Long Beach	5860	3060.7	26.8
Hong Kong	Antwerpen	11865	3599.0	20.1	Shanghai	Oakland	5793	3055.9	32.5
Hong Kong	Rotterdam	11863	3603.0	21.4	Xiamen	Los Angeles	5724	2801.4	29.1
Yantian	Antwerpen	11778	3774.7	23.1	Qingdao	Los Angeles	5544	2851.2	31.4
Xiamen	Rotterdam	11612	3664.2	22.9	Shanghai	Seattle	5431	3209.2	34.9
Hong Kong	Hamburg	11523	3504.6	20.7	Yantian	Oakland	5404	3068.6	33.6
Yantian	Hamburg	11472	3793.8	22.8	Ningbo	Oakland	5320	3050.1	30.8
Tianjin	Rotterdam	11219	3722.7	22.2	Yantian	Seattle	5060	3176.6	34.1
Xiamen	Antwerpen	11162	3609.0	21.5	Qingdao	Oakland	5006	2872.6	29.4
Qingdao	Hamburg	11146	3562.5	21.5	Xiamen	Long Beach	4973	2912.3	29.7
Tianjin	Antwerpen	11119	3756.1	21.4	Kaohsiung	Los Angeles	4954	3612.1	34.7
Xiamen	Hamburg	10948	3537.2	21.0	Hong Kong	Oakland	4954	3207.5	25.9
Tianjin	Hamburg	10643	3607.0	20.2	Busan	Long Beach	4939	3601.9	29.0
Dalian	Antwerpen	10341	3836.5	19.9	Ningbo	Seattle	4933	3122.9	32.8
Shanghai	Le Havre	10279	4040.7	23.0	Busan	Los Angeles	4737	3655.8	30.4
Dalian	Rotterdam	10251	3833.4	19.6	Tianjin	Long Beach	4603	2746.1	26.1
Dalian	Hamburg	9895	3691.3	19.7	Hong Kong	Seattle	4582	3289.8	28.4
		886586	3919.1	20.5			332368	3296.4	30.2

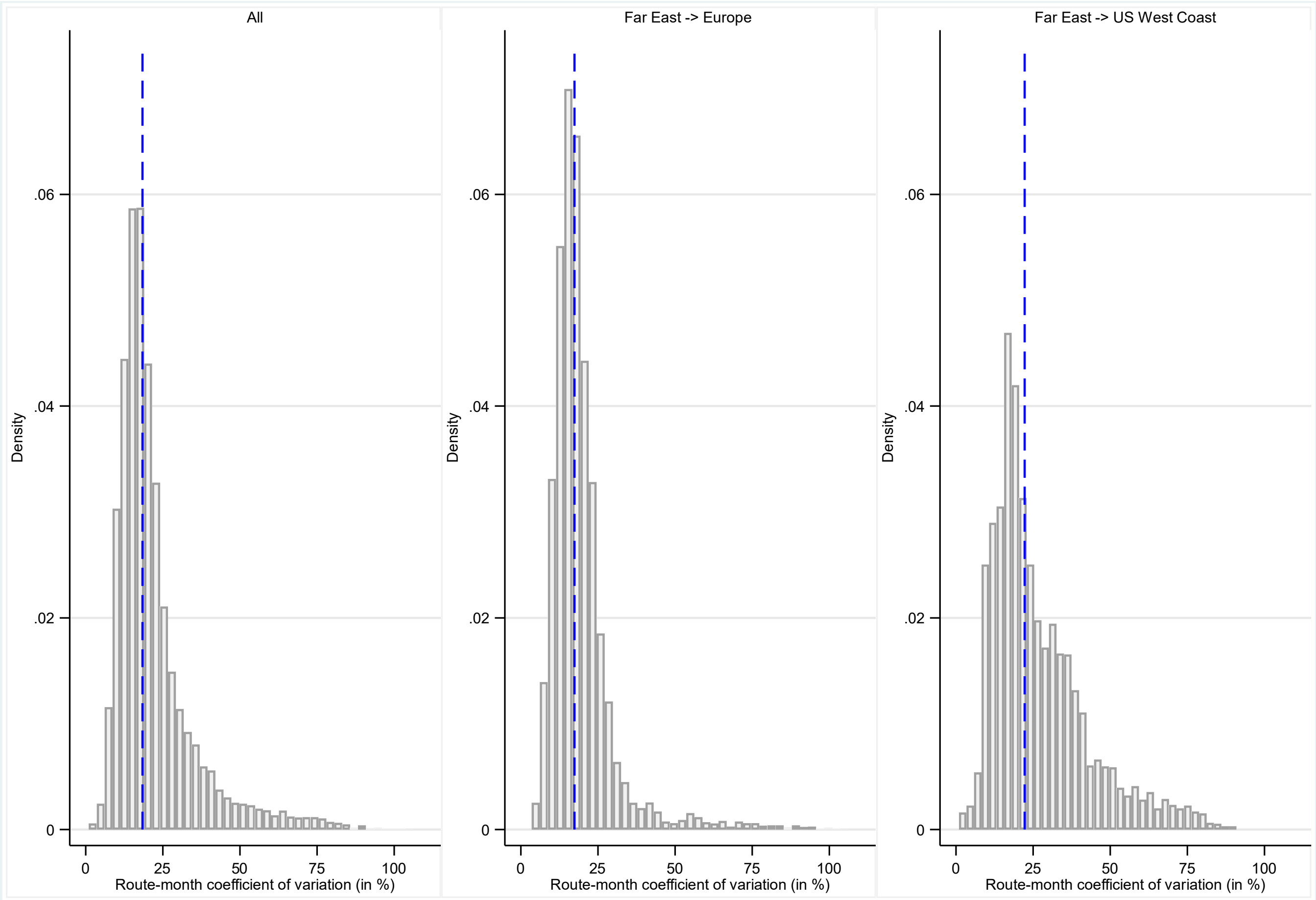
Source: authors’ calculations, data from The Co. (January 2018 – March 2023).

Note: the CV is calculated using the monthly average rates.

5. Is the LOP valid ?

- let P_{irt} be the rate for a container i on a route r at time t
- we construct a distribution of freight rates for each route-month combination (N=17478)
- for each route-month case, we calculate the CV
- we drop distributions with less than 20 observations

Figure 3. Histogram of the route-month coefficients of variation

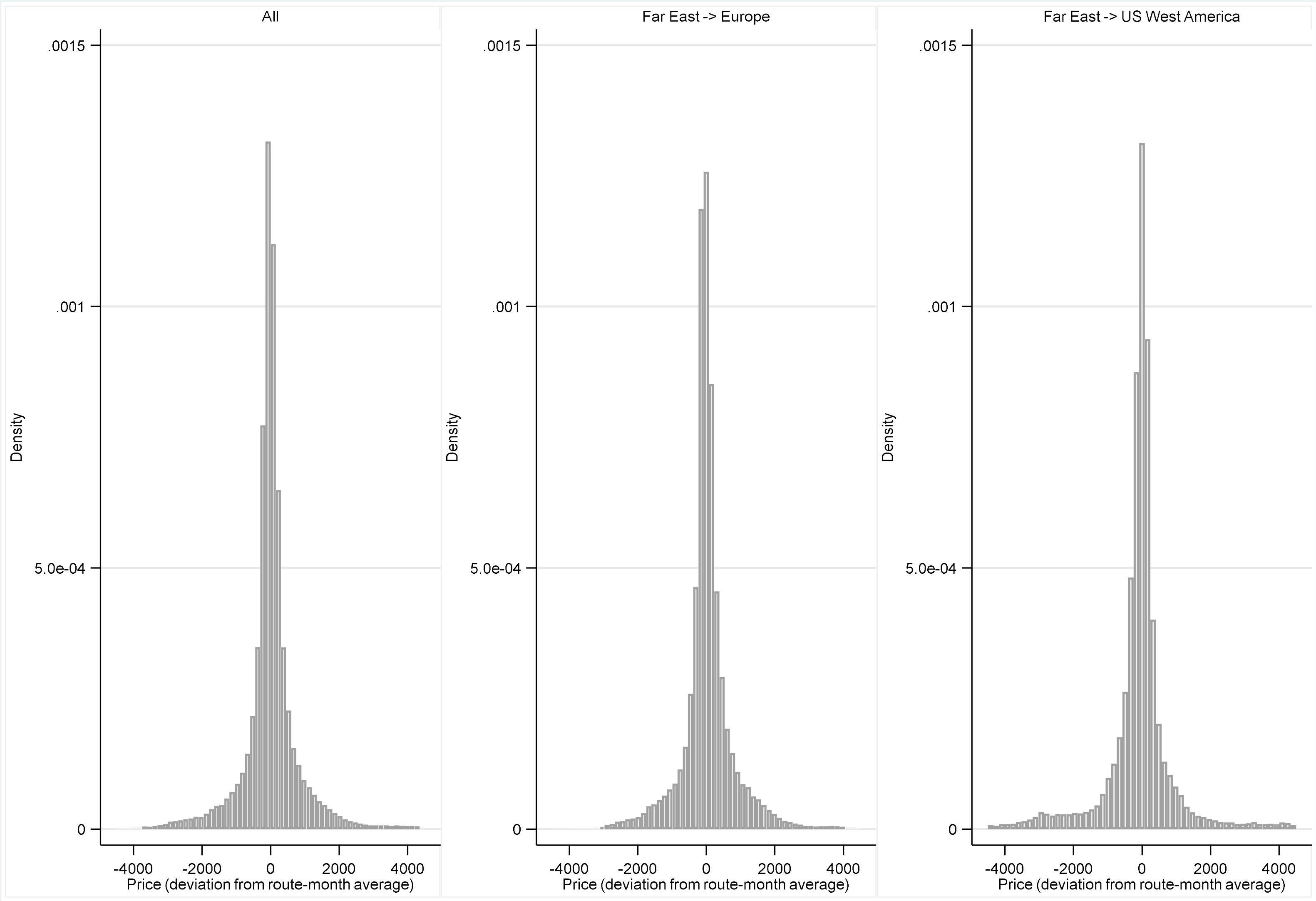


Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ The distribution is always right-skewed

⇨ The median CV is 18.4% for all routes, 17.3% for Far East to Europe, 22.3% for Far East to US

Figure A1. Histogram of the rate dispersion (deviation from route-month averages)



Source: authors' calculations, data from The Co. (January 2018 – March 2023).

- heterogeneity-controlled estimations using:

$$\ln P_{ir} \; = \theta_r + \mu_c + \gamma_t + \varepsilon_{irt}$$

with θ_r a route fixed effect, μ_c a carrier (including freight forwarder) fixed effect and γ_t a year-month fixed effect

- variance decomposition

$$V(\ln P_{irt}) = V(\theta_r) + V(\mu_c) + V(\gamma_t) + 2 * cov(\theta_r, \mu_c) + 2 * cov(\theta_r, \gamma_t) + 2 * cov(\mu_c, \gamma_t) + V(\varepsilon_{irt})$$

- heterogeneity related to routes, suppliers and time can be a concern, so calculation of a residual freight rate:

$$\hat{\varepsilon}_{irt} = \ln P_{irt} - \hat{\theta}_r - \hat{\mu}_c - \hat{\gamma}_t$$

Table 2. Variance decomposition of the logarithm of rate

Variables	All		2018-2019		2020-2023Q1	
	Value	%	value	%	value	%
Panel A. All routes						
Var(time)	0.630	83.3	0.013	23.3	0.628	78.7
Var(route)	0.008	1.0	0.005	9.0	0.025	3.2
Var(carrier)	0.011	1.5	0.006	11.1	0.020	2.5
2 * Cov(time,route)	-0.002	-0.2	0.000	-0.8	0.003	0.4
2 * Cov(time,carrier)	0.023	3.0	0.000	-0.8	0.015	1.9
2 * Cov(route,carrier)	-0.001	-0.1	0.000	0.2	-0.005	-0.6
Var(residual)	0.088	11.6	0.032	58.0	0.111	14.0
Var(log rate)	0.756	100.0	0.055	100.0	0.798	100.0

Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ main source of heterogeneity related to time especially during the Covid period (weight>70%)

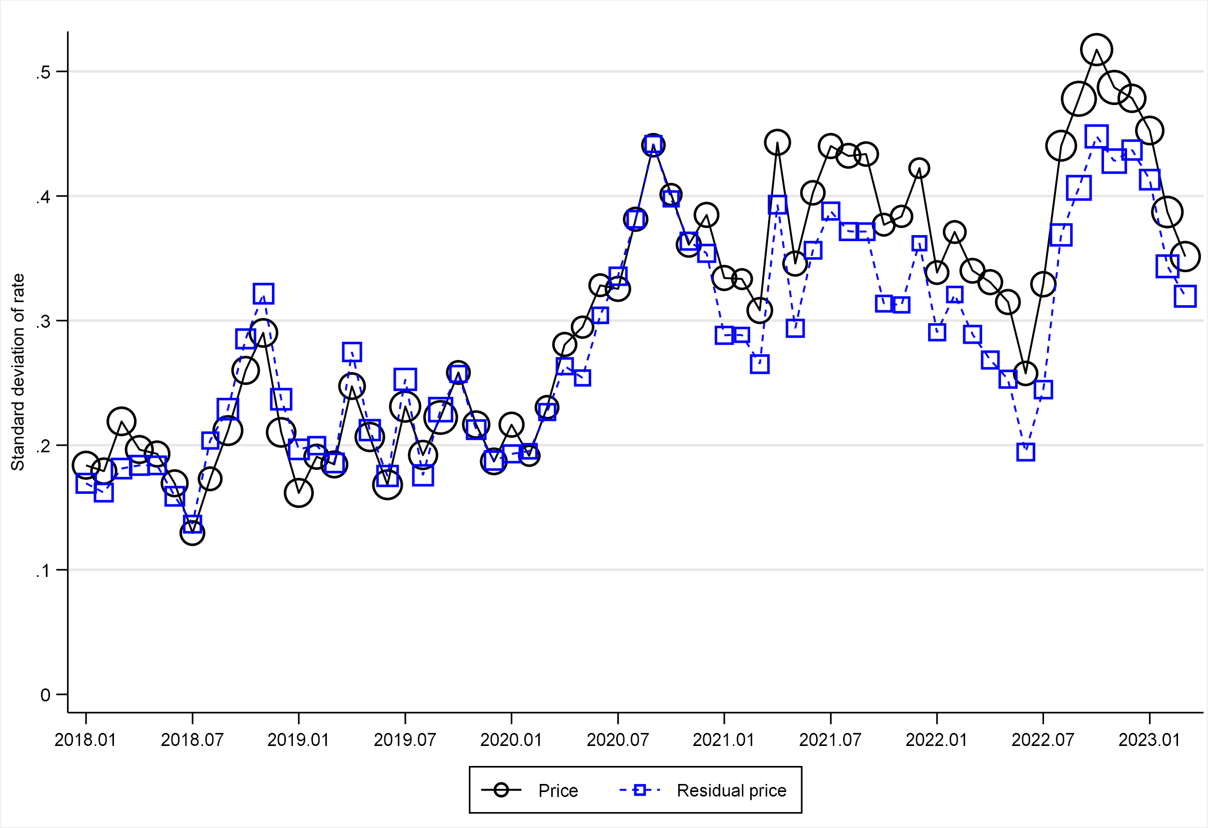
⇨ routes have very little influence

⇨ weight of more than 10% for the carrier effect before Covid

Table 2. Variance decomposition of the logarithm of rate

Variables	All		2018-2019		2020-2023Q1	
Panel B. Far East -> Europe						
Var(time)	0.733	89.6	0.015	33.8	0.724	87.2
Var(route)	0.003	0.3	0.003	7.1	0.003	0.4
Var(carrier)	0.010	1.2	0.006	12.8	0.016	1.9
2 * Cov(time,route)	0.002	0.3	0.000	-0.9	0.000	-0.1
2 * Cov(time,carrier)	0.019	2.3	-0.001	-1.9	0.016	2.0
2 * Cov(route,carrier)	0.001	0.1	0.001	1.6	0.000	0.0
Var(residual)	0.051	6.2	0.021	47.4	0.071	8.6
Var(log rate)	0.819	100.0	0.045	100.0	0.831	100.0
Panel C. Far East -> US America						
Var(time)	0.428	72.6	0.042	51.4	0.467	70.9
Var(route)	0.004	0.7	0.001	0.9	0.010	1.4
Var(carrier)	0.025	4.2	0.011	13.5	0.041	6.1
2 * Cov(time,route)	0.001	0.2	0.000	-0.1	0.001	0.1
2 * Cov(time,carrier)	0.039	6.7	0.002	2.9	0.025	3.8
2 * Cov(route,carrier)	-0.001	-0.2	0.000	-0.2	-0.003	-0.5
Var(residual)	0.092	15.7	0.026	31.5	0.119	18.1
Var(log rate)	0.589	100.0	0.081	100.0	0.659	100.0

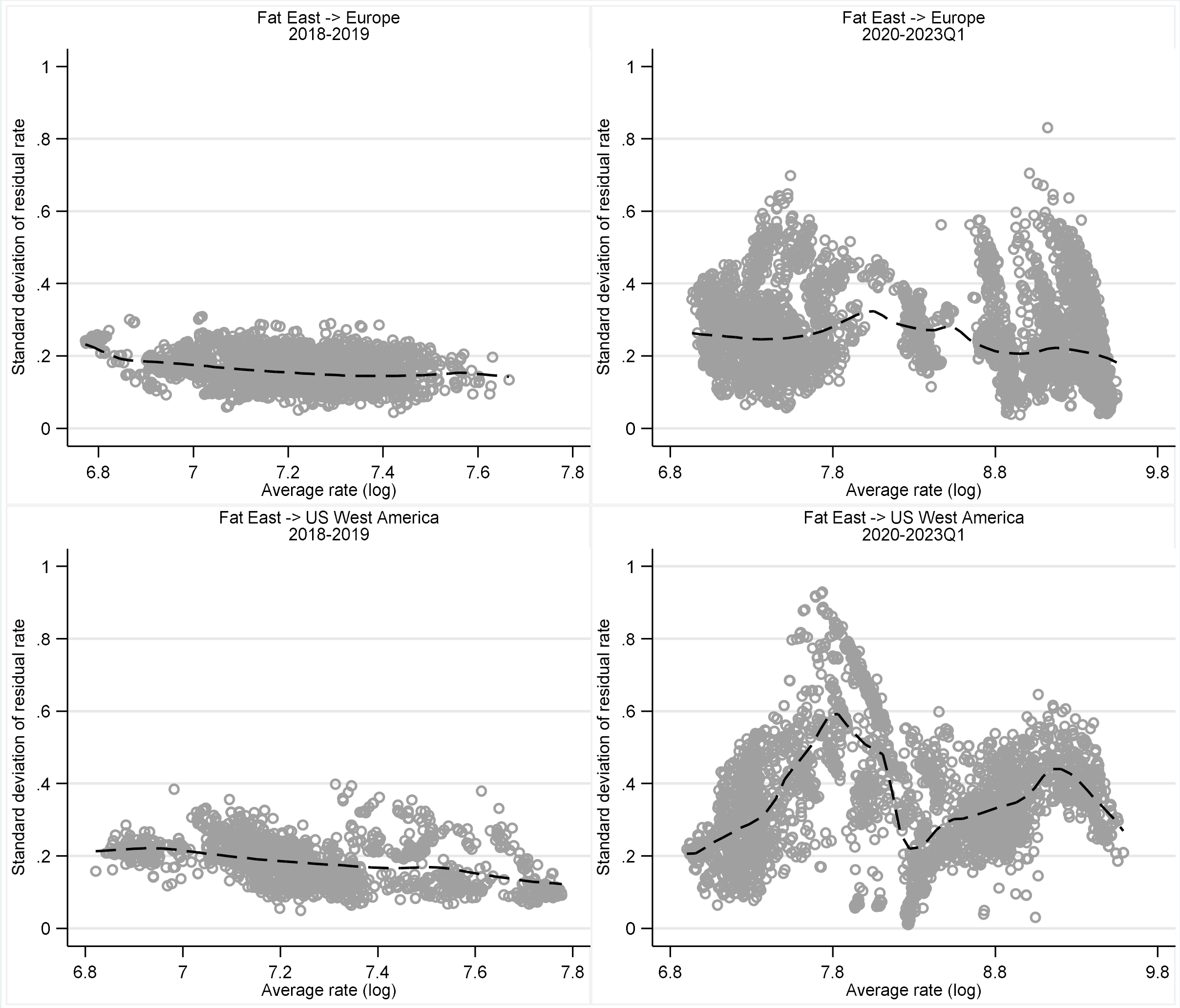
Figure A2. Rate dispersion and residual rate dispersion over time



Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ almost no difference when turning to the residual rate

Figure 4. Route-month standard deviations and logarithm of rates



Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ no clear relationship

- To summarize at this stage
  - evidence of price dispersion
  - median CV near 20%
  - rejection of the LOP after controlling for route-carrier-month heterogeneity
- But …
  - unobserved possibility of transshipment
  - unobserved duration of the voyage (no IMO number in the data)

- Could unobserved heterogeneity be a concern here ?
    - Cariou and Wolff (2023, ongoing) using quotation data from one European retailer in 2017

Table 3. Estimates of the logarithm of freight rates

Variables	20' standard	40' standard	40' high-cube
Panel A.			
Days n fixed effect	YES	YES	YES
Observations	7,809	7,986	7,819
R^2	0.223	0.267	0.264
Panel B.			
Voyage ℓd fixed effect	YES	YES	YES
Observations	7,809	7,986	7,819
R^2	0.856	0.856	0.857
Panel C.			
Days n (log)	-0.057***	-0.064***	-0.059***
	(-4.12)	(-4.96)	(-4.49)
Transshipment t	0.029***	0.024***	0.026***
	(3.86)	(3.32)	(3.58)
Voyage ℓd fixed effect	YES	YES	YES
Service s fixed effect	YES	YES	YES
Observations	7,809	7,986	7,819
R^2	0.938	0.933	0.935

Source: data from a confidential retailer, authors' calculations.
Note: estimates from two-way fixed effect regressions following the iterative demeaning strategy described in Rios-Avila (2015), with robust t-values in parentheses.

6. Understanding the persistence of price dispersion

- the container market is oligopolistic

- the combined market share of the 10 largest container carriers has jumped from around 50% in 2000 to >80% today

Table 3. Descriptive statistics, by carriers

[redacted]	[redacted]	Contracts		Rate		Market	
		Number	% of total	Mean	CV (in %)	Rank	Market share(%)
[redacted]	[redacted]	209354	17.2	4962.7	30.0	1	18.2
[redacted]	[redacted]	155527	12.8	2911.1	26.1	3	12.8
[redacted]	[redacted]	126640	10.4	2359.9	29.4	5	6.8
[redacted]	[redacted]	123242	10.1	3935.2	17.1	4	10.9
[redacted]	[redacted]	99290	8.1	4097.2	23.7	6	6.3
[redacted]	[redacted]	89859	7.4	4420.4	30.3	7	5.8
[redacted]	[redacted]	75456	6.2	1683.5	18.3	2	15.8
[redacted]	[redacted]	73643	6.0	3467.9	25.2	8	3.1
[redacted]		49974	4.1	3755.1	24.4	-	-
[redacted]		215969	17.7	4262.6	29.7	-	-
[redacted]		1218954	100.0	3749.3			

Source: authors' calculations, data from The Co. (January 2018 – March 2023).

[redacted] https://en.wikipedia.org/wiki/List_of_largest_container_shipping_companies

- selection of carriers in the top 8 companies
    - 953011 contracts (78.2% of all spot contracts)
    - all carriers: avg CV = 22.2 med CV = 18.4
    - top 8 carriers: avg CV = 20.7 med CV = 17.1

- how do carriers change their prices over time?
  - possibility of frequent up and down adjustments, so that customers would be unable to identify the cheapest carriers
- more complex than in Lach (2002) or Moen et al (2020) who use monthly price data
  - comparison between t and t+1 (or t+6) of the position of one store in the distribution of prices … but one price per store for a given product (so 1:1 ranking stores/prices)
- here multiple freight rates per carrier each month

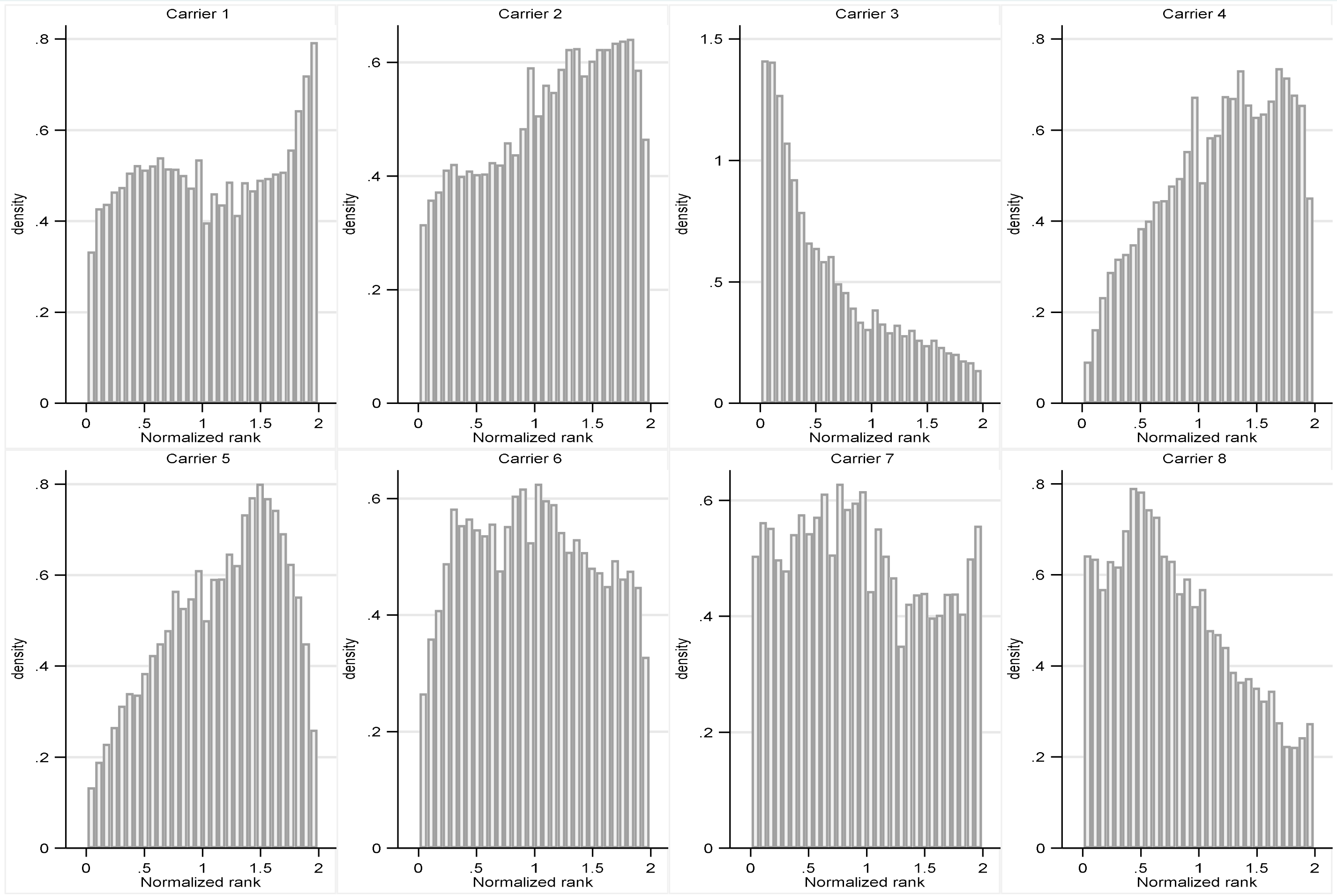
- investigation of the ranking of the top 8-carriers in the rate distribution at the route-month level

    - for each route-month, ranking of contracts: $rank_{irt} = 1$ for the lowest rank, $rank_{irt} = n_{rt}$ for the highest rate

    - as n_{rt} varies over routes and time, calculation of a normalized rank such that $\overline{Nrank}_{irt} = 1$ for each rt

$$Nrank_{irt} = rank_{irt}/(n_{rt} + 1)/2)$$

Figure 5. Distribution of route-month rankings, by carrier



Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ very heterogeneous situations, most often carriers are "almost everywhere" in the distribution

- calculation of 4x4 matrix transitions between periods for each carrier
    - calculation of the prob. of being in a quartile j in t+1 conditional on being in a quartile i in t
    - transition matrix $M_{c,t/t+1}$ are calculated for each combination of (t,t+1) for each carrier c
    - as the number of contracts varies in t and t+1 for each carrier, we consider two sets of contracts with the same number of obs (randow draws in the sample $\min(n_{c,t}, n_{c,t+1})$), 50 different draws to get an average matrix $M_{c,t/t+1}$
- the estimated matrices $M_{c,t/t+1}$ again averaged to produce a single transition matrix, with weights equal to the proportion of obs in each cell)
- measure of mobility (Prais index, Shorrocks, EconA, 1978)

$$Index = \frac{k - trace(M)}{k - 1}$$

Table 4. One-month transition matrix of residual rates, all carriers
A. All

In t	2018-2023Q1 Prais index: 0.925				2018-2019 Prais index: 0.942				2020-2023Q1 Prais index: 0.912			
In t+1	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Q1	0.340	0.252	0.192	0.215	0.319	0.255	0.207	0.219	0.357	0.250	0.179	0.214
Q2	0.250	0.282	0.248	0.220	0.254	0.274	0.246	0.227	0.249	0.288	0.249	0.215
Q3	0.193	0.245	0.296	0.266	0.203	0.244	0.284	0.269	0.185	0.245	0.306	0.264
Q4	0.214	0.218	0.262	0.306	0.213	0.223	0.266	0.298	0.214	0.215	0.260	0.312

Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ large off-diagonals probabilities, meaning very high mobility

Table 4. One-month transition matrix of residual rates, all carriers

B. Far East -> Europe

In t	2018-2023Q1 Prais index: 0.904				2018-2019 Prais index: 0.929				2020-2023Q1 Prais index: 0.882			
In t+1	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Q1	0.376	0.261	0.186	0.178	0.338	0.254	0.207	0.201	0.409	0.266	0.166	0.159
Q2	0.257	0.277	0.250	0.216	0.249	0.279	0.248	0.224	0.264	0.275	0.250	0.210
Q3	0.185	0.247	0.297	0.272	0.210	0.246	0.277	0.267	0.162	0.246	0.315	0.276
Q4	0.175	0.215	0.272	0.338	0.195	0.214	0.270	0.321	0.157	0.215	0.275	0.353

C. Far East -> US West America

In t	2018-2023Q1 Prais index: 0.802				2018-2019 Prais index: 0.881				2020-2023Q1 Prais index: 0.759			
In t+1	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Q1	0.491	0.226	0.153	0.130	0.328	0.304	0.226	0.143	0.581	0.183	0.114	0.121
Q2	0.239	0.355	0.251	0.154	0.291	0.304	0.247	0.158	0.210	0.385	0.252	0.153
Q3	0.163	0.249	0.311	0.276	0.233	0.250	0.274	0.243	0.123	0.249	0.332	0.296
Q4	0.129	0.165	0.269	0.438	0.152	0.154	0.242	0.453	0.116	0.172	0.285	0.427

⇨ mobility tends to have decreased during covid

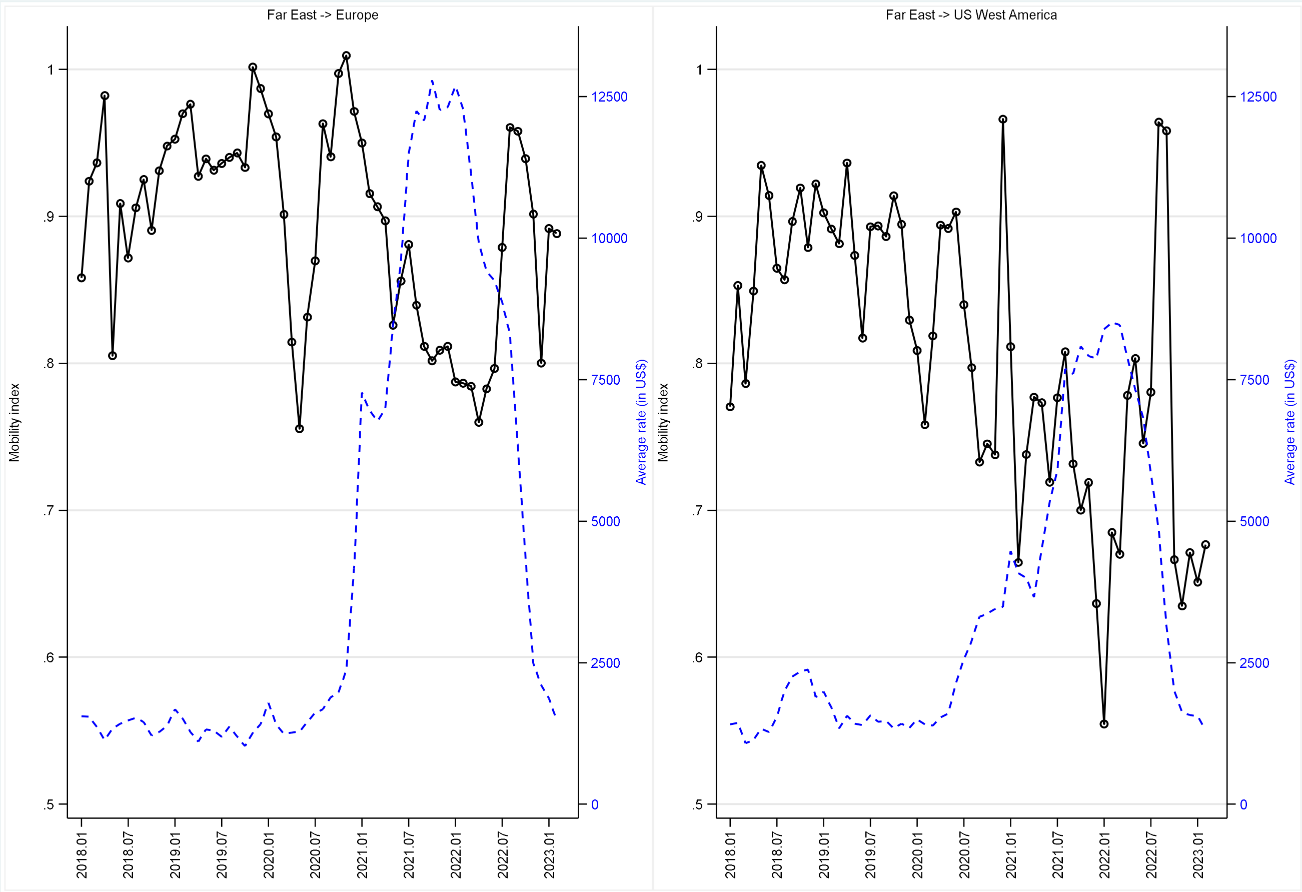
Table 5. One-month transition matrix of residual rates, by carrier

	Carrier 1: Prais index = 0.951					Carrier 2: Prais index = 0,943			
t \ t+1	Q1	Q2	Q3	Q4	t \ t+1	Q1	Q2	Q3	Q4
Q1	0.334	0.263	0.175	0.228	Q1	0.301	0.259	0.225	0.215
Q2	0.276	0.277	0.212	0.235	Q2	0.190	0.268	0.300	0.242
Q3	0.232	0.247	0.248	0.273	Q3	0.144	0.260	0.345	0.250
Q4	0.250	0.239	0.222	0.289	Q4	0.171	0.257	0.314	0.258
	Carrier 3: Prais index = 0.895					Carrier 4: Prais index = 0.941			
t \ t+1	Q1	Q2	Q3	Q4	t \ t+1	Q1	Q2	Q3	Q4
Q1	0.426	0.136	0.150	0.289	Q1	0.263	0.365	0.236	0.137
Q2	0.211	0.182	0.298	0.308	Q2	0.220	0.374	0.269	0.137
Q3	0.137	0.175	0.345	0.343	Q3	0.178	0.331	0.299	0.192
Q4	0.202	0.148	0.289	0.361	Q4	0.153	0.293	0.314	0.240
	Carrier 5: Prais index = 0.938					Carrier 6: Prais index = 0.947			
t \ t+1	Q1	Q2	Q3	Q4	t \ t+1	Q1	Q2	Q3	Q4
Q1	0.317	0.289	0.202	0.192	Q1	0.356	0.228	0.170	0.246
Q2	0.274	0.298	0.225	0.203	Q2	0.297	0.244	0.212	0.247
Q3	0.206	0.237	0.289	0.269	Q3	0.236	0.238	0.284	0.242
Q4	0.215	0.227	0.276	0.282	Q4	0.302	0.225	0.200	0.274
	Carrier 7: Prais index = 0.933					Carrier 8: Prais index = 0.896			
t \ t+1	Q1	Q2	Q3	Q4	t \ t+1	Q1	Q2	Q3	Q4
Q1	0.398	0.194	0.192	0.216	Q1	0.339	0.291	0.207	0.163
Q2	0.296	0.203	0.225	0.276	Q2	0.301	0.310	0.220	0.168
Q3	0.267	0.200	0.237	0.296	Q3	0.238	0.239	0.254	0.269
Q4	0.221	0.195	0.221	0.364	Q4	0.184	0.161	0.247	0.407

Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ High mobility of residual rates at the carrier level ….

Figure 6. Changes in mobility index over time

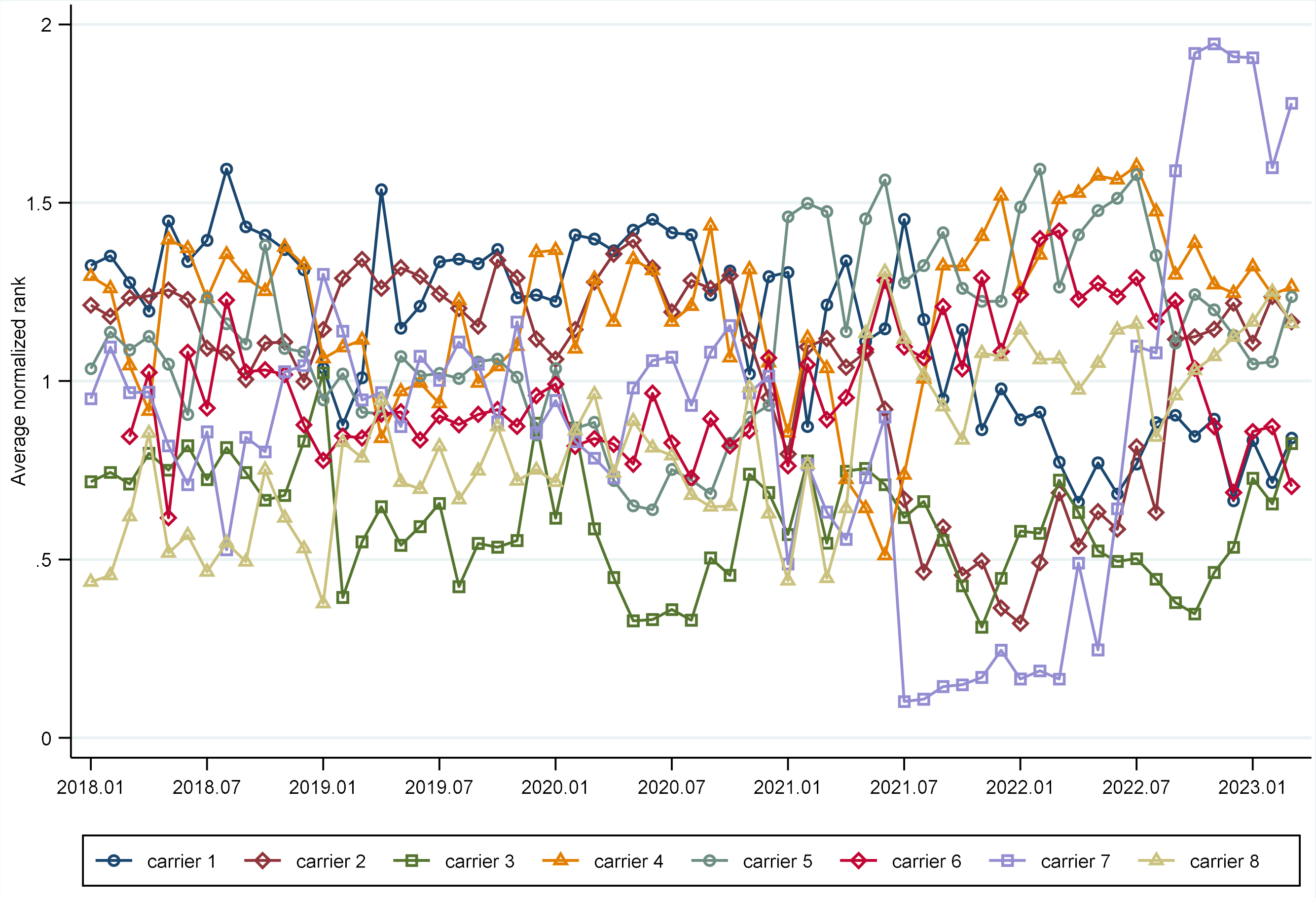


Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ on average lower mobility when rates are high ….

⇨ but still mobility remains prevalent: presumably frequent adjustment depending on market conditions, shipping capacities, port congestion, …

Figure 7. Changes in average normalized ranking over time



Source: authors' calculations, data from The Co. (January 2018 – March 2023).

⇨ definitely complex trajectories for the various carriers in the distribution of rates

7. Conclusion

- first empirical investigation of dispersion in freight rates using contract data on the main transit routes

- freight rate dispersion is significant, with a CV above 20% at the monthly level

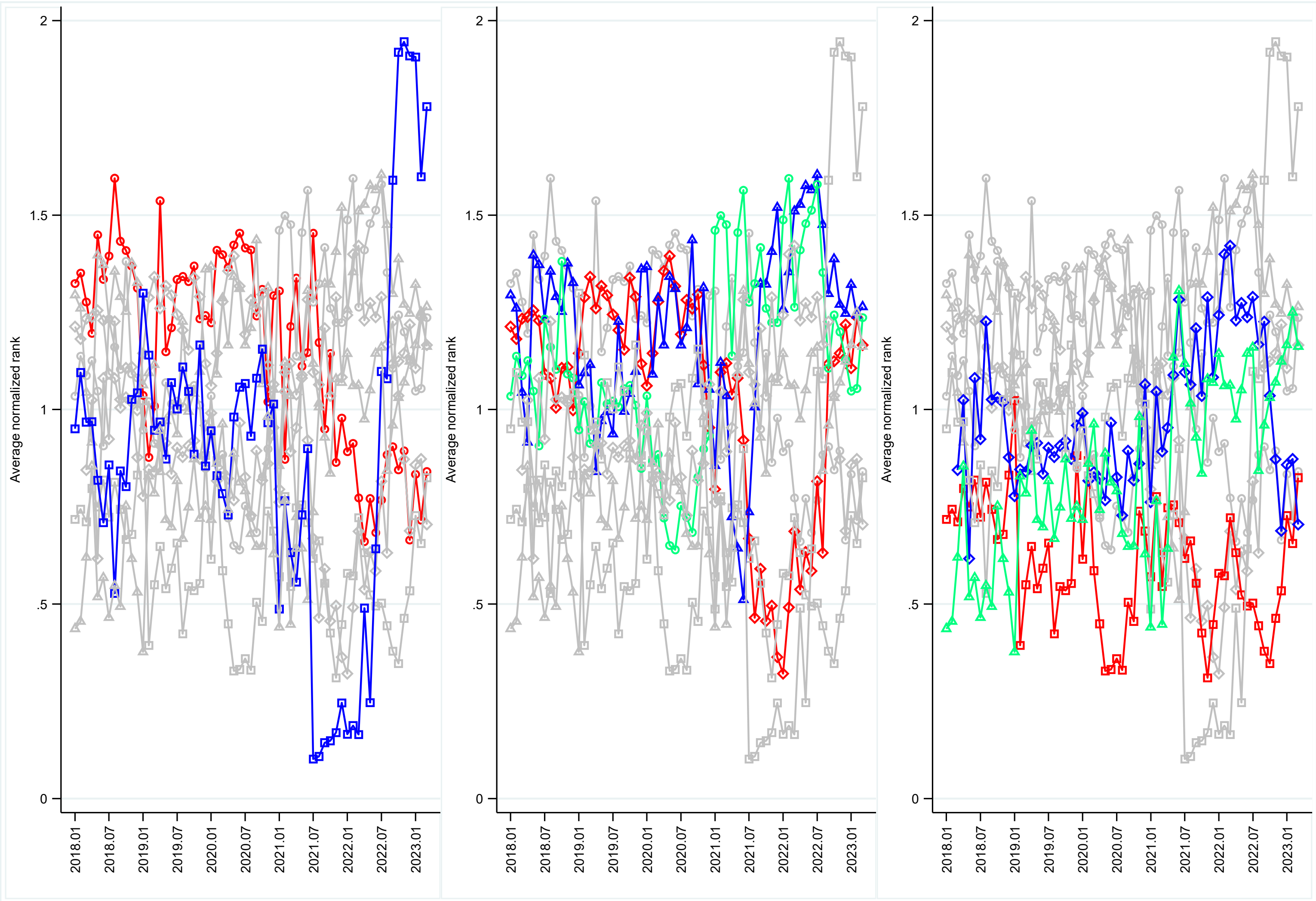
- little role for carriers in a model explaining freight rate: price dispersion remains persistent

  - it seems impossible to learn “who” are the cheapest carriers by looking at rates

  - but the product is “service” in shipping, so shippers do not constantly search for the lowest price possible

- the within-route freight rate heterogeneity suggests that the assumption of uniform within-routes in international trade should be revisited …

- data limitations: is the “good” really homogeneous ?
    - robustness to unobserved heterogeneity: small effect of transshipment and number of days, but sensitivity to an unobserved heterogeneity term to implement
- future work
    - role of alliance (but Hyundai switches from 2M to THE Alliance on April 1st, 2020)
    - investigation of the role of competition on pricing and rate dispersion
    - but need of additional data …



Average normalized rank
2
1.5
1
.5
0
2018.01
2018.07
2019.01
2019.07
2020.01
2020.07
2021.01
2021.07
2022.01
2022.07
2023.01