Impacts of Ocean Carrier Alliances on U.S. Trade

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Abstract

Since the turn of the 21st century, vessel sharing via strategic alliances has become the dominant cooperative strategy among maritime freight carriers. These alliances have increasingly captured the attention of economists, industry analysts, and regulators, yet few empirical analyses have been published that measure the impact of such cooperative agreements on the maritime freight economy. This paper analyses extensive trade data at the vessel and container level to assess the impacts of ocean carrier alliances on the maritime freight economy, with an emphasis on US agricultural exporters. While alliances are global in their permitted scope, the level of actual cooperation between allies varies substantially across lanes and across time. When alliances are highly utilized, we find some small impacts on service frequency as measured by the number of vessels operating on each lane, but economically insignificant impacts of alliance utilization on other quality metrics including average vessel capacity, total lane-level capacity, and the number of ports/countries accessible from each port.

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Introduction

The transition from the sailing vessel to the steamship in the early 1800s enabled the first regularly scheduled maritime freight services, and maritime shipping has been a vital part of the global economy ever since. By the dawn of the 20th century, the maritime freight economy was well established and enabled producers, typically referred to as "shippers", to deliver their products to any coastal market on the globe[1]. The firms operating the vessels that carried the cargoes between ports became known as "carriers," and the state of competition among carriers, or lack thereof, has been the subject of many volumes.

Profit maximization for ocean carriers requires maximizing capacity utilization (minimizing empty haul), as the cost of a sailing is primarily a fixed cost (i.e., the marginal cost of adding a container to an existing sailing is near zero). In pursuit of maximal capacity utilization, ocean carriers, since the earliest days of maritime shipping, have entered cooperative agreements that provide structure for capacity sharing and improve capacity utilization (Sjostrom 2010) (Panayides and Wiedmer 2011). The exact form of this cooperation has varied over time, and by the late 19th century, cooperation among carriers fully permeated the maritime industry in the form of cooperative groups of carriers called "conferences."

A primary concern of economists and regulators has been, since at least the work of Alfred Marshall in the early 20th century, that the economies of scale inherent in ocean shipping and the relatively small number of firms operating between port pairs enable carriers to act as monopolistic cartels (Marshall 1921). Despite these concerns, regulations in the United States have historically been favorable to cooperation between carriers, and in 1916 US regulators granted antitrust immunity to shipping conferences in exchange for regulatory oversight in an attempt to mitigate the oversupply issues common at that time (Sjostrom 2010) (Clyde and Reitzes 1998). In practice, this allowed shippers to enter conferences on a given lane (i.e., an origin-destination port pair) that collectively set rates, subject to regulatory approval and the publishing of said rates to the public. Conference members were forced to honor the published rates for any shipper wishing to send similar cargo on that lane. The resulting economic behavior of carriers under this system has been widely viewed as the exact kind of monopolistic cartel behavior that Marshall anticipated (Stewart and Inaba 2003) (Clyde and Reitzes 1998) (Tang and Sun 2018) (Fox 1992) (Wilson and Casavant 1991) (Sjostrom 2010).

Globalization skyrocketed the maritime shipping industry to prominence. Between 1970 and 2023, shipments of goods via maritime container ship increased by more than an order of magnitude and now account for some 90% of international trade (UNCTAD 2023, OECD 2024). This rise brought renewed focus on maritime shipping from the public and regulators, and support for the antitrust exemptions long enjoyed by carriers began to weaken in the late 20th century. The Ocean Shipping Reform Act of 1984 weakened the market power of the shipping conferences, and by 1998 the conference system was

[1] So long as the political relationship between the respective countries allowed, of course.

eliminated entirely. Since that time, carriers have been required to negotiate rates and service contracts with shippers in private under typical antitrust regulations. Although strategic alliances between carriers existed during the conference era, this regulatory change, along with concurrent advancements in supply chain management, quickly led to strategic alliances becoming the dominant cooperative strategy between ocean carriers (Evangelista and Morvillo 1999, Fussilo 2006, Sheppard and Seidman 2001, Panayides and Wiedmer 2011).

An Ocean Carrier Alliance (OCA) is a strategic alliance between two or more carriers that enable them to share space on each other's vessels, set service types and schedules, coordinate on vessel maintenance and repair, and even co-charter vessels. OCAs must be approved by the Federal Maritime Commission (FMC) and are highly similar to the vessel sharing agreements that carriers have been commonly utilizing both before and after the fall of the conference system; however, vessel sharing agreements are typically very limited in geographic scope—applying only to a handful of lanes within a single region—and in the expected number of vessels utilized, which is typically less than a dozen. OCAs, by contrast, are global agreements that allow for the use of hundreds of vessels (often a majority of the alliance members' combined fleets). The most recent filing of the THE Alliance agreement, for instance, applies to "ports in North Asia, South Asia, Middle East (including the Arabian Gulf and Red Sea Regions), Northern Europe, Mediterranean, Adriatic, and Black Sea, Egypt, Panama, Mexico, Canada, Central America and the Caribbean on the one hand, and ports on the East, Gulf, and West Coasts of the United States, by any route including via the Panama and Suez Canals or the Cape of Good Hope, on the other, as well as ports and points served via such U.S. and foreign ports" (THE Agreement 2024). OCAs, unlike vessel sharing agreements, also require standing committees and/or coordination centers to be jointly operated by the members in order to execute the alliance's joint operations.

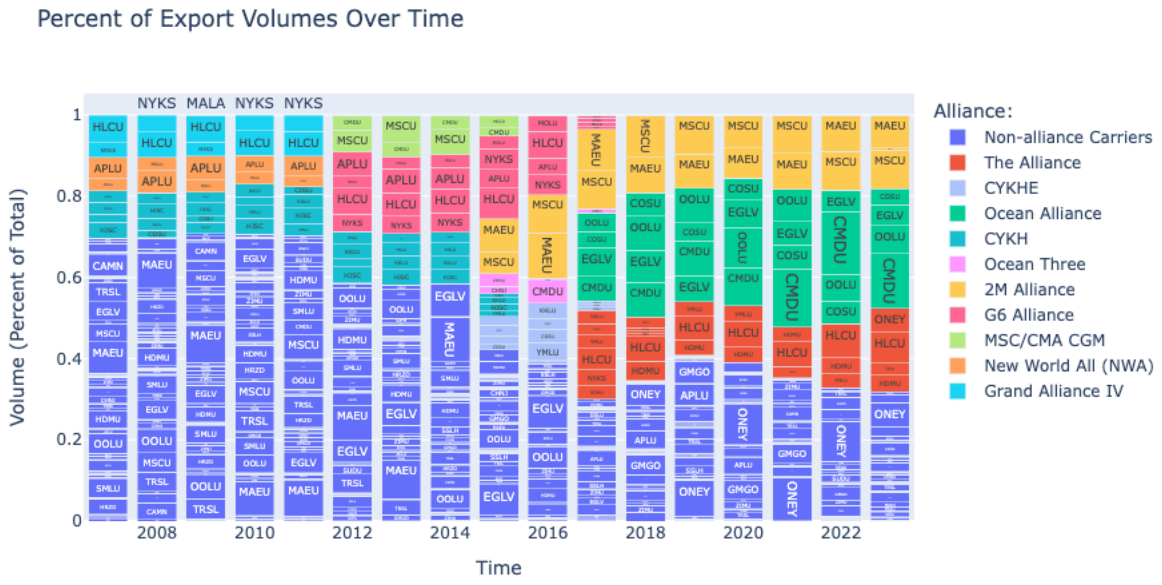
Furthermore, our analysis in this paper shows that membership in an OCA has a notable, sometimes quite dramatic, effect on a carrier's cargo sharing behavior. Figures X.1 and X.2 show examples of which other carriers Mediterranean and Evergreen, respectively, share cargo with before and after joining an OCA.



Unlike conferences, OCAs are barred from sharing rate information between the members, jointly marketing their services, or sharing revenues. These regulations undercut carriers' ability to engage in traditional cartel price-fixing behavior (Wang 2012, Stewart, Inaba and Blatner 2003).

OCA members are required by their alliance agreements to negotiate slot sharing prices—the price that the member charges for carrying an ally's container on vessels operated by the member—along with the specific number of slots on their ships that each member will allow their ally to utilize on that lane. This slot allocation and pricing is known to all members of the alliance, but it is not filed with the FMC nor made available to the public. Importantly, as of the time of this writing, all 3 active OCA agreements stipulate, either directly or indirectly, "the principle that the Parties' basic slot allocation will be equivalent to contribution" to the alliance (OCEAN Alliance Agreement, 2024). We discuss this allocation extensively below.

OCAs have been the subject of much review by economists, which we discuss in more detail in the next section, and have been viewed by many as allowing carriers to improve capacity utilization, reduce operational costs, and increase service quality (Sheppard and Seidman 2001) (Panayides and Wiedmer 2011) (Evangelista and Morvillo 1999). However, this has not dissuaded all concerns that the maritime freight economy under the alliance system is sufficiently competitive. Taken together, carriers in OCAs represent roughly 90% of global capacity, raising concerns that alliances may exercise market power in various ways (Evangelista and Morvillo 1999) (Ghorbani, et al. 2022) (Fusillo 2003); OCA shares of total US export volumes are presented below. Despite these concerns, few empirical studies have been conducted with the goal of measuring the impacts of OCAs on the maritime freight economy (Ghorbani, et al. 2022).



This paper provides empirical research into the impacts of OCAs, arguing that viewing the members of an OCA as a single collective entity, and especially viewing all services provided by all members on all lanes as related to the OCA, is a flawed approach. Rather, it is vital to account for the fact that, while global in their *permitted* scope, in practice OCAs are highly utilized on some lanes and minimally utilized, if at all, on other lanes. The same is true across time, as we will see below in our analysis of the PIERS Bill of Lading database, which includes carrier, commodity, vessel, and various other data on every container imported or exported from US maritime ports since 2006. We investigate whether OCAs improve capacity utilization and quality of service, as well as to what extent OCAs facilitate anti-competitive behavior among carriers.

This section introduced Ocean Carrier Alliances and provided the basic historical and regulatory context for our analysis, and the next section reviews the relevant economics

literature. We then discuss our research methodology, followed by a discussion of the data sets utilized in our analysis. The Results section presents the empirical findings, and we conclude with a discussion of OCA impacts and recommendations for future research.

Literature Review

As mentioned above, Alfred Marshal laid the foundation of analyzing anti-competitive behavior in the context of high economies of scale, and ocean carriers were used as a type example in his seminal book, *Industry and Trade*, first published in 1919. Marshal's warnings did not go unnoticed, but for the majority of the 20th century, concerns about the high costs of inefficiencies in maritime shipping and the benefits offered by collaboration between carriers won out over the concerns about cartel behavior. This was not only true of US regulators, as evidenced by the antitrust immunities granted to conferences that lasted from 1916 to 1998, but also of many economic analysts. We refer the reader to Sjostrom (2010) for a thorough overview of the economic models applied to the maritime freight economy throughout conference era. Our discussion picks up after the fall of the conferences and the rise of OCAs as the dominant cooperative strategy among carriers at the turn of the millennium.

Sheppard and Seidman (2001) were some of the first to address OCAs in economic journals. They provide a qualitative analysis of the benefits and potential disadvantages of alliances, arguing that cooperation via OCAs can provide carriers with the economies of scale necessary to operate efficiently without the difficulties associated with mergers and acquisitions. Subsequent works have elaborated on the benefits of OCAs, most often focusing on improved capacity utilization, e.g. (Cruijssn, Dullaert and Fleuren 2007, Fussilo 2006).

OCAs are not without their challenges, however. Early work by (Midoro and Pitto 2000) highlighted the instability of OCAs due to management complexities and especially intra-alliance competition. They argue that the transaction and coordination costs inherent in managing global alliances with multiple partners hinder the ability of alliances to achieve the intended efficiency gains, a concern echoed by (Bergantino and Veenstra 2002) in their network theoretic study of OCAs. Instability and management costs have been a consistent concern since then, and analysts have investigated various approaches to achieving stability. (Ghorbani, et al. 2022) provide a thorough review of this literature.

Empirical investigations into the impacts and performance of OCAs have been sparce. (Fusillo 2003) showed that, despite the theoretical potential of OCAs to improve capacity utilization, excess capacities changed very little, if at all, in the years since the conference era. Fusillo posits that holding excess capacity may be an intentional strategy among carriers with market power (either on their own or via their OCA) to construct barriers to entry for smaller firms. However, the data used in this analysis go only through 2001, so perhaps the instability marked by (Midoro and Pitto 2000) prevented OCAs from achieving their goals. Fusillo's 2003 analysis is also limited to industry averages, and does not

differentiate capacity utilization of ships operating under an OCA from those operating independently. We will inspect this issue in our analysis below.

In 2006, Fusillo published additional research using updated data from the same PIERS database that we utilize in this study. He provides a thorough discussion of the structure of the maritime freight economy, pointing out what we mentioned above, namely that while OCAs are not allowed to fix prices, they are permitted to meet regularly to discuss a wide array of supply and demand information. Fusillo states the concern of many analysts and regulators: "Whether this leads to illicit price fixing is an open question and, because of the paucity of adequate pricing data, not easy to answer" (Fussilo 2006) pg 465. This remains true to this day, almost two decades later.

Indeed, whether the maritime freight economy enables competitive equilibria to exist in the first place has been brought into question by researchers such as Pirrong (1992), who argue that the variable demand and indivisible production costs inherent in ocean shipping result in the persistence of excess production capacities that destabilize competitive equilibria. In this condition, core theory predicts that cooperation (even so far as "cartelization") among producers may be an efficient response.

Whether or not excess production capacities in ocean shipping result in an "empty core" is somewhat controversial[2] and beyond the scope of this study; however, the ability to reduce excess capacities has long been the primary argument for allowing cooperation among ocean carriers (Sheppard and Seidman 2001) (Sjostrom 2010) (Panayides and Wiedmer 2011). As is the case with anti-competitive behavior, though, empirical investigation into excess capacities has been scant—only one paper, (Fusillo 2003) mentioned above, is known to the authors to measure excess capacities.

Data

The primary data source used in this study is S&P Global's Port Import/Export Reporting Service (PIERS), which provides detailed data at the bill of lading (BOL)[3] level from US Customs and Border Protection, US Census data, UN port information, as well as data manually collected by PIERS staff. The data include the quantities and types of each commodity being shipped, the carriers, vessel identification codes, departure and arrival ports and dates, and various other data for every shipment imported to or exported from the US via maritime ports from January 2006 through March 2024. Representing more than 247 million shipments, these data allow us to inspect many aspects of the maritime freight economy.

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[2] Wang (2012) analyzed rate data from Drewery and found that the fall of the conference system in 1998 shifted the structure of the economy from cartel price-fixing to a competitive market. Notably, their analysis supported healthy competition through at least Q4 2009, well into the era of OCAs.

[3] For every shipment, the shipper and carrier sign a "bill of lading," which serves both as the title for the goods as well as the service contract between the two parties. The bill of lading accompanies the shipment at all times while in transit.

To the PIERS data we add vessel specifications such as total capacity along with port entry and exit dates for each vessel from the US Army Corp of Engineers Foreign Traffic Vessel Entrances and Clearances database. Due to the private nature of contract pricing discussed above, we do not have price information for each BOL in the PIERS database. We do, however, analyze rate indexes for each lane and month from Drewery's Container Freight Rate Insight (CFRI) reports in order to inspect the impacts of OCA activities and other variables on average monthly rates. Drewery CFRI reports list lanes at a much more aggregated/regional level than PIERS; we find the best match from Drewery for each PIERS lane based on the geographic locations of the origins and destinations listed in each source. The regional nature of Drewery lanes limits our ability to investigate an important aspect of maritime shipping, namely the substitutionary nature of nearby ports. Intuition dictates that shippers facing rate increases (or quality decreases) on one lane would substitute for a nearby lane, especially in the case when either shipper or final buyer (or both) are located away from the port city itself.

Almost all variables used in this study are identical to those in the original sources mentioned above, with two notable exceptions. First, arrival and departure dates in the PIERS BOL data sometimes vary from the actual arrival and departure dates of the vessel[4]. Where possible, we use the port entry dates from the Corp of Engineers database to resolve discrepancies, and otherwise cluster nearby dates into a single arrival or departure date using a machine learning algorithm. Second, in order to analyze the dynamics of cargo slot sharing between carriers, we infer the vessel's owner (i.e., the carrier operating that vessel at any given time, whether by owning the vessel outright, chartering it, or any of the other various means by which carriers control vessels) from the carrier and vessel on each BOL in the PIERS data. The carrier representing the plurality of containers carried on a given vessel during a given month is taken to be that vessel's owner. Containers carried on that vessel from carriers other than the vessel's owner are thus deemed shared cargo.

Data sources and variables descriptions for the main database are presented in Table 1.

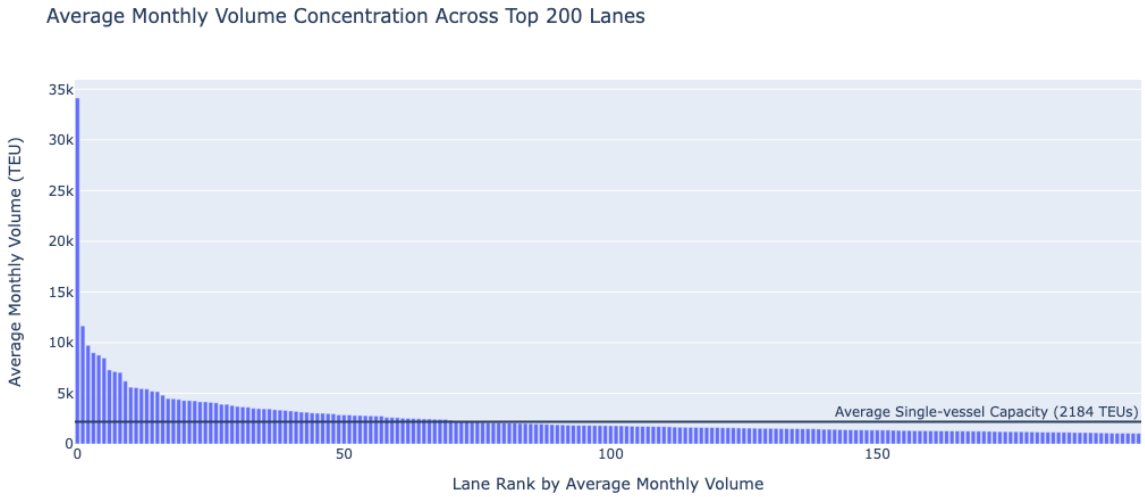
[4] E.g., Even though container vessels rarely spend more than a few hours in port, one bill may be dated as arriving January 3rd and another, from the same vessel and port, may be dated January 5th. When a round trip between the relevant ports takes weeks, we consider those two bills to have arrived on the same date, and assume the difference in dates is due to when the bill was processed rather than when the cargo actually arrived.

Table 1

Variable	Type	Source	Obs	Description
Bill of Lading (BOL) characteristics				
BOL ID	*categorical*	*PIERS*	63,737,454	Alphanumeric code uniquely identifying each BOL
Date	*categorical*	*PIERS*	63,737,455	Arrival (imports) or departure (exports) date for each BOL
Volume (TEU)	*numerical*	*PIERS*	63,737,455	The Twenty-foot Equivalent Unit (TEU) volume for each BOL
Commodity Code(s)	*categorical*	*PIERS*	63,736,118	HS codes for the commodities included in the BOL
Lane ID	*categorical*	*PIERS*	63,737,455	Unique identifier for the lane on which the cargo was carried
Origin Port Name	*categorical*	*PIERS*	63,737,455	Name of US port of origin
Origin Port Code	*categorical*	*PIERS*	63,737,455	US Customs code of port of origin
Coast Region	*categorical*	*PIERS*	63,762,870	US coast of origin
Destination Port Name	*categorical*	*PIERS*	63,737,455	Name of foreign destination port
Destination Port Code	*categorical*	*PIERS*	63,737,455	US Customs code of foreign destination port
Destination Territory	*categorical*	*PIERS*	63,760,578	Country of destination
Destination Region	*categorical*	*PIERS*	63,760,578	Region of destination port
Carrier Name	*categorical*	*PIERS*	63,737,455	Name of carrier for each BOL
Carrier SCAC	*categorical*	*PIERS*	63,737,455	The carrier's Standard Carrier Alpha Code
Carrier Alliance	*categorical*	*FMC*	63,737,455	The Ocean Carrier Alliance to which the carrier belonged when the shipment was carried
Vessel ID	*categorical*	*PIERS*	63,737,455	IMO code uniquely identifying the vessel on which the cargo was carried
Vessel Owner	*categorical*	*PIERS*	63,737,455	Indicates whether the cargo was carried by the vessel's owner or primary carrier
Lane Characteristics				
Lane ID	*categorical*	*PIERS*	22,510	Unique identifier for the PIERS origin-destination port pair
Drewery Lane	*categorical*	*Drewery*	102	Origin-destination region pairs (Drewery uses "Los Angeles", for example, to indicate all SW US ports)
Within Alliance Region	*categorical*	*PIERS/FMC*	4,592,040	Indicates whether the Lane ID falls within the geographic scope of the Carrier Alliance (indexed monthly)
Rate (40ft Dry, USD)	*numerical*	*Drewery*	7,403	Drewery monthly rate index for 40ft containers on each Drewery Lane
Rate (20ft Dry, USD)	*numerical*	*Drewery*	7,403	Drewery monthly rate index for 20ft containers on each Drewery Lane
Vessel Characteristics				
Vessel ID	*categorical*	*PIERS*	18,993	IMO code uniquely identifying the vessel
Vessel Capacity	*numerical*	*US Corp of Eng.*	14,874	Total TEUs able to be carried by vessel (assuming 13.6 NRT per TEU)
Vessel Owner	*categorical*	*PIERS*	3,874,572	Indicates whether the cargo was carried by the vessel's owner or primary carrier
Owner Alliance	*categorical*	*FMC*	3,874,572	The Ocean Carrier Alliance to which the Primary Carrier belonged when the shipment was carried

This study is concerned with the impacts of OCAs on US agricultural producers; we thus limit the data to exports only. As we see in the figure below, export volumes are highly concentrated into the major shipping lanes, with only the top 75 out of 22,400 total lanes seeing more than a single vessel's worth of cargo in a given month. Given that large lanes typically see hundreds of vessels and many different carriers, and smaller lanes often see only a handful of vessels (on which they fill small percentages of the vessel's capacity) and 1 or 2 carriers, it is natural to suspect that OCA activity would have potentially very different effects on large lanes than on small ones. Smaller lanes, however, still collectively represent the vast majority of lanes and a substantial percentage (XX%) of total volumes, and their inclusion in the calculations of average treatment effects may hide (or inflate) certain effects. For the purposes of this study, we restrict the data to only the top 500 lanes by volume[5].

[5] Determining the best cutoff and/or accounting for lane size are opportunities for future analyses.



As described in the Methodology section below, we inspect OCA impacts at several different levels of aggregation, each organized into monthly panels. At the highest level of aggregation, we inspect lane characteristics over time such as carrier concentration, number of vessels in service, etc. We then inspect individual carrier characteristics on each lane over time, such as the capacity offered by each carrier on that lane. Our aggregations get more specific with each model, ending with a panel consisting of carriers carrying specific commodities on specific vessels on each lane over time. Summary statistics and descriptions for the variables of interest are presented in Tables 2.1–2.5.

Table 2.1 – Lane Panel

Variable	Total Obs	Unique Obs	Mean	SD	Min	Max	Description
Lane ID	102,000	500	-	-	-	-	Unique lane identifier for each PIERS origin-destination pair
Month	102,000	204	-	-	Jan-07	Dec-23	Month
HHI	97,065		0.449	0.280	0.064	1.000	Herfindahl-Hirshman Index of carrier concentration on the lane during the month
Volume (TEU)	102,000		1,406	2,378	0	48,794	Total cargo (TEUs) carried on the lane during the month
Capacity (TEU)	102,000						Sum total capacity of all ships active
Vessels	102,000		3.49	2.02	0.0	14.0	Number of unique vessels in service on the lane during the month
Carriers	102,000		6.41	4.32	0.0	23.0	Number of unique carriers servicing the lane during the month
Alliances	102,000		2.73	1.33	0.0	7.0	Number of unique Alliances servicing the lane during the month
Ports	102,000		34.26	18.20	0.0	65.0	Number of unique foreign ports accessible from the origin port during the month
Countries	102,000		21.25	12.30	0.0	44.0	Number of unique foreign countries accessible from the origin port during the month
Regions	102,000		6.73	3.76	0.0	11.0	Number of unique foreign regions accessible from the origin port during the month
Drewery Lane	97,065	76	-	-	-	-	Drewery (regional) lane corresponding to the Lane ID
Rate (40ft Dry, USD)	49,736		1603.67	760.80	400.00	8250.00	Drewery monthly rate index for 40ft containers on each Drewery Lane
Rate (20ft Dry, USD)	49,736		1237.06	528.16	310.00	5070.00	Drewery monthly rate index for 20ft containers on each Drewery Lane

Table 2.2 – Carrier-Lane Panel

Variable	Total Obs	Unique Obs	Mean	SD	Min	Max	Description
Lane ID	80,988,000	500	-	-	-	-	Unique lane identifier for each PIERS origin-destination pair
Month	80,988,000	204	-	-	Jan-07	Dec-23	Month
Carrier	80,988,000	793	-	-	-	-	Carrier
Alliance	653,571	12	-	-	-	-	The OCA to which the carrier belonged during the month
Carrier Market Share	653,571		0.149	0.211	0.000	1.000	Percentage of total volume on the lane during the month sold by each carrier
HHI	653,571		0.449	0.280	0.064	1.000	Herfindahl-Hirshman Index of carrier concentration on the lane during the month
Volume (TEU)	80,988,000		1.77	57.60	0	25,915	Total cargo (TEUs) carried on the lane during the month
Capacity (TEU)	80,988,000						Sum total capacity of vessels on the lane during the month from the carrier
Vessels	80,988,000		0.02	0.25	0.0	17.0	Number of unique vessels in service from the carrier on the lane during the month
Carriers	80,988,000		0.08				Number of unique carriers servicing the lane during the month
Alliances	80,988,000		Need to re-think coersing all 793 scacs across				Number of unique Alliances servicing the lane during the month
Ports	80,988,000		month and lane				Number of unique foreign ports accessible from the origin port during the month
Countries	80,988,000						Number of unique foreign countries accessible from the origin port during the month
Regions	80,988,000						Number of unique foreign regions accessible from the origin port during the month
Drewery Lane	653,571	76	-	-	-	-	Drewery (regional) lane corresponding to the Lane ID
Rate (40ft Dry, USD)	345,480						Drewery monthly rate index for 40ft containers on each Drewery Lane
Rate (20ft Dry, USD)	345,480						Drewery monthly rate index for 20ft containers on each Drewery Lane

Methodology & Results

The impacts of alliances are evaluated at the vessel-, alliance-, and lane-level. At the vessel-level, we evaluate operational differences in alliance-operated and non-alliance-operated vessels. Do alliance-operated vessels serve more volumes, visit more export destinations, make more turns, or have more capacity?

Alliance agreements typically specify vessel contribution, with alliance members sharing vessel capacity on each vessel proportional to their volume contribution of capacity to the alliance. Most non-alliance operated vessels carry cargo from only one carrier. In contrast, vessels operated by an alliance carry volumes among alliance member carriers. Vessels contributed to each alliance are not identified within alliance agreements (i.e., the agreements do not specify vessel identification codes, or vessel names). For our purposes, a vessel is identified as alliance-operated within if over 90% of cargo is from an alliance, and the vessel is carrying cargo for at least two alliance members (the vessel owner, and at least one other alliance member).

Then, for each lane-month-alliance-vessel, differences in vessel operations between alliance- and non-alliance-operated vessels can be identified using a panel fixed effect model:

$$Y_{vaijt} = b_0 + V_v + A_a + L_{ij} + d_t + a_1 A_{aijt} + a_2 A_{vaijt} + e_{vaijt},$$

where V_v is a vessel fixed effect, A_a is an alliance fixed effect, L_{ij} is a lane fixed effect, d_t is a time period fixed effect, A_{aijt} is an indicator =1 if alliance a has an alliance-operated vessel active on lane ij in period t, and A_{vaijt} is an indicator =1 if vessel v is an alliance-operated vessel operating on lane ij in period t. A_{aijt} controls for alliance-lane-time-specific unobservables that may cause an alliance to operate an alliance-operated vessel on lane ij in period t. The control group is non-alliance-operated vessels operated by an alliance member carrier from the same alliance on the same lane in the same time period. The parameter of interest is a_2 which measures the marginal affect of a vessel being alliance-operated.

The impact of a vessel being alliance-operated is measured across 5 outcome variables: total volumes carried (TEUs), vessel capacity, and the number of foreign ports, number of foreign countries, and the number of foreign regions serviced by the vessel.

	TEUs	# Foreign Ports	# Foreign Countries	# Foreign Regions	Cap From Vessel	Turns
Intercept	6.59***	0.131***	0.00516	-0.0266***	-0.0127***	-0.26
vessel of alliance a is alliance operated on lane ij in time t	6.98***	0.404***	0.25***	-0.0589***	-0.0146***	1.86***
vessel v on lane ij is alliance operated in time t	6.59***	0.131***	0.00516	-0.0266***	-0.0127***	-0.26
N	1,038,069	1,038,069	1,038,069	1,038,069	1,038,069	1,038,069
DF Resid	1,034,530	1,034,530	1,034,530	1,034,530	1,034,530	1,034,530
R2	0.104	0.357	0.311	0.306	0.217	0.992

Alliance activity is a significant predictor of vessel-specific service levels, however these impacts are economically insignificant accounting for online marginal differences in service levels.

At the lane-level, we evaluate impacts of increased alliance-level concentration, as measured by the Herfindahl-Hirschman Index (HHI) on lane- and port-level quality metrics, including: the number of vessel calls, lane capacity, container rates, and the number of foreign ports, number of foreign countries, and the number of foreign regions serviced by each U.S. port.

To measure the impact of market concentration on port and lane-quality metrics, a panel fixed effects model is specified:

$$Y_{ijt} = \alpha C_{ijt} + \gamma V_{ijt} + \beta_{ij} + \delta_{it} + \delta_{jt} + \epsilon_{ijt} \quad (1)$$

where Y_{ijt} is the lane-level quality metric of interest on lane *ij* in time *t*, C_{ijt} is the market concentration (HHI) on lane *ij* in time *t*, V_{ijt} is the volume of exports on lane *ij* in time *t*, β_{ij} is a lane-level fixed effect, δ_{it} is a U.S. origin port-time fixed effect, δ_{jt} destination foreign port-time fixed effect, and ϵ_{ijt} is a normally distributed error. This specification allows for

causal identification of the impact of market concentration on lane-level quality metrics, so long as there are not time variant lane-level unobservables correlated with market concentration and the lane-level quality metric. This specification is immune to lane-level time invariant unobservables, U.S. port-level time variant unobservables, and foreign port-level time variant unobservables.

	# Vessels	Lane Capacity	# Foreign Ports	# Foreign Countries	# Foreign Regions
TEUs	0.000781***	3.66***	6.81e-05***	9.95e-06***	-6.02e-07***
HHI on lane ij	-0.000871***	-2.52***	8.25e-06**	-1.52E-06	-1.68e-06***
HHI at origin port i	0.000182***	1.77***	1.23E-05	-1.03e-05***	1.41e-05***
HHI at dest port j	-0.000268***	-0.0371	-2.07e-05***	2.05e-05***	9.77e-07**
HHI on substitute lanes -ij	9.09E-06	0.496***	1.99e-05***	3.18e-06*	1.17E-08
HHI on substitute origin ports -i	4.91e-05***	-0.391***	4.35e-05***	-1.16e-05***	3.56e-07*
HHI on substitute dest ports -j	0.000288***	1.11***	-5.17E-06	1.49e-05***	-1.71e-06***
N	37,368	37,368	37,368	37,368	37,368
DF Resid	36,958	36,958	36,958	36,958	36,958
R2	0.777	0.815	0.993	0.997	0.999

	Rate	Rate
TEUs	0.00404	-
HHI on lane ij	-0.00488	-0.00516
HHI on substitute lanes -ij	0.0251***	0.0249***
HHI at origin port i	0.0358	0.0349*
HHI at dest port j	0.0139	0.0140*
HHI on substitute origin ports -i	-0.00577*	-0.0056*
HHI on substitute dest ports -j	-0.0193**	-0.0195**
N	3,491	3,491
DF Resid	3,340	3,341
R2	0.839	0.839

Market concentration is a statistically significant predictor of lane-level quality attributes, however, these impacts are in most cases economically insignificant. Concentrated lanes remain sufficiently competitive preventing carriers from exerting market power.

Discussion

While market concentration among ocean carrier alliances has been the center of much discussion and concern, we find relatively little evidence that alliance concentration is to the detriment of shippers. We also, however, find little evidence as carriers would suggest that alliance utilization improves service quality.

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