Implications of COVID-19 on the US container port distribution system: import cargo routing by Walmart and Nike

Authors: P. Cariou & T. Notteboom

A modified version of this work had been published:
International Journal of Logistics Research and Applications
DOI: 10.1080/13675567.2022.2088708

To cite this article:
Pierre Cariou & Theo Notteboom (2022): Implications of COVID-19 on the US container port distribution system: import cargo routing by Walmart and Nike, International Journal of Logistics Research and Applications, DOI: 10.1080/13675567.2022.2088708

To link to this article: https://doi.org/10.1080/13675567.2022.2088708

Implications of COVID-19 on the US container port distribution system: import cargo routing by Walmart and Nike

Pierre Cariou

The Centre of Excellence in Supply Chain (CESIT), Kedge Business School, France

pierre.cariou@kedgebs.com

Theo Notteboom

Maritime Institute, Faculty of Law and Criminology, Ghent University, Belgium

Faculty of Sciences, Antwerp Maritime Academy, Belgium

Faculty of Business and Economics, University of Antwerp, Belgium

theo.notteboom@ugent.be

Abstract

The purpose of this paper is to discuss the implications of COVID-19 on container import flows via the US port distribution system. We employ statistics collected for more than 21 US ports and for more than 550 000 container shipments by Walmart and Nike to identify trends and potential shifts in the US port distribution system. Results unveil different changes in distribution channels during the pandemic era, between aggregated port level and industry level. These differences are specific to firms and could be explained by the origin of flows, carrier selection to transport cargos and US port/inland distribution systems. Our study contributes to a better understanding of the different role played by ports for industries (retailers, Footwear & Apparel) and shows that the ability to adapt supply chains to a major disruption remains subject to the initial choices on the location of production, on carrier choices and on port/inland distribution networks.

Keywords: COVID-19, port system, inland distribution, sourcing, disruption, retailer

1. Introduction

The implications of COVID-19 on US manufacturing and international supply chains are more profound than any other disruptions ever experienced (Butt 2021). Some goods are lacking on retailers' shelves and lead times are skyrocketing due to a low schedule integrity of container liner services, port congestion in major US ports, and severe equipment, dockworker and trucker shortages (HBR 2020; Bloomberg 2021; CNN 2021). The pandemic confirms how port distribution systems are critical for a nation's economic well-being as they affect the delivery of inputs for production and of final goods to end-users (Arnold et al. 2006; Wei et al. 2020).

With such large implications, shippers have set in place many countermeasures. Butt (2021) mentioned actions on inventory management, suppliers' relationships, inbound routes, suppliers risk evaluation, the identification of new suppliers, securing stocks, and alternative outbound routes. For US import flows, we could then expect that the outbreak of the pandemic has led to large shifts in global sourcing strategies and in the spatial distribution and routing of US container imports. However, there are limited studies on the impact for the port-related distribution network (Blackhurst et al. 2011; Ali and Golgeci 2019).

This study investigates the implications of COVID-19 on the US port distribution system at a global scale and for two specific sectors: the Retailing and Footwear & Apparel (F&A) industries. These two sectors heavily rely (more than 80% of production and sourcing is in Asia, Market Watch 2021; Walmart 2021) on international supply chains and ports and the objective of this research is to answer two research questions:

RQ1: How did the COVID-19 impact import container flows via US container ports?

RQ2: What can explain differences in the reaction of US Retailing and F&A shippers to the COVID-19 disruption in terms of their use of the US port distribution system?

To do so, the paper first assesses whether major shifts in cargo distribution patterns in the US port system have occurred in 2020 and during the first semester of 2021, by using both global US port container statistics (21 ports) and disaggregated data on more than 550,000 individual import shipments by Walmart and Nike. Retailers account for more than 50% of all US container imports (Piers Journal of Commerce, 2019) and Walmart is the largest US and worldwide importer. Nike is representative of an industry (F&A) that also heavily depends on international supply chains (ranked 12th as US importer).

We expect that COVID-19 triggered a shift in the spatial distribution of import cargoes in US ports and for these individual shippers. In line with Trepte and Rice (2014), we analyze whether the disruption in a large port/set of ports in the US west coast led to a substitution to US eastern ports or, in line with Ducruet and Notteboom (2012), the global network remained quite stable with only small shifts. We identify and discuss three reasons to explain the divergence in supply chain reaction. First the initial sourcing strategies, second, the link to specific maritime service providers (carriers) and third, the initial US ports of entry and inland distribution system. Our findings confirm the full complexity of inter-organizational relationships in supply chains (Fan and Stevenson 2018) that plays on supply chain resilience of US import cargo flows.

This study is organized as follows. Section 2 is a literature review on the impact of disruption on port distribution and Section 3 presents our dataset and research design. Section 4 presents the changes in the US port system as well as Walmart and Nike port distribution networks. Section 5 discusses three main reasons for differences observed in Section 4. Finally, Section 6 provides some managerial implications and concludes.

2. Literature review on port distribution systems

Our literature review is on the main drivers of changes in port distribution systems and provides insights on the US port distribution system.

2.1. Drivers of changes in port distribution systems

A port system is a system of two or more ports, located in proximity within a given area (Ducruet and Notteboom 2022). Many factors affect the cargo distribution patterns and hierarchies in port systems (Pallis et al. 2011; Ng et al. 2014). Empirical studies highlight that over time, some port systems are getting more spatially concentrated while others are evolving to a more evenly distributed system. Recent empirical studies include applications to China (Wang et al. 2017; Zhang et al. 2021), Latin America (Wilmsmeier et al. 2014), Europe (Wilmsmeier and Monios 2013; López-Bermúdez et al. 2020), Africa (Notteboom and Fraser 2020) and to the world (Guerrero and Rodrigue 2014; Rodrigue 2022; de Oliveira et al. 2021; Ducruet and Notteboom 2022).

The implications of a disruption on a specific port distribution system are hard to predict. On the one hand, as ports have extended their hinterland towards inland logistics, ports should be more vulnerable to disruptions along the supply chains (Achurra-Gonzales et al. 2017) and we could then expect a high traffic volatility and large cargo shifts between ports (Svanberg et al. 2021). On the other hand, as ports are embedded in supply chains and carriers with links to hinterland connections, we could expect that port substitution is rather limited (Wendler-Bosco and Nicholson 2019). COVID-19 had different effects on ports. In terms of port operations, sanitary protocols, social distancing, longer shift changeover, cleaning equipment, and a lower number of dockworkers per shift reduced port productivity (UNCTAD 2020; Notteboom and Pallis 2021). Furthermore, some goods are more affected such as food and household items while luxury & fashion supply chains are more resilient (UNCTAD 2020).

Disparities also exist as the pandemic has followed different phases. In early 2020, lockdown measures in China led to a global slowdown or resulted in a shortage (pharmaceuticals and medical equipment) of production. In mid-March 2020 a (global) demand shock with backpropagation along supply chains led to a decline in global (derived) demand and limited retail activity. Last-mile vulnerabilities for distribution became visible due to lower availability of the workforce (e.g., absenteeism in trucking). Since September 2020, new distribution networks emerged as several regions of the world (such as North America) are restocking inventories at distribution centers and stores to cope with a sharp rise in the demand for (durable) goods, with nearshoring and reshoring strategies implemented to reduce the dependence on overseas production (Notteboom and Haralambides 2020).

2.2. Disruption in the US port system `

The US port system is a complex network of ports supporting over 90% of the volume of overseas trade and more than 13 million jobs (MARAD 2017). They are also important links to deliver products and raw materials to US consumers (Touzinsky et al. 2018). The transport and logistics network in the US has very specific attributes with a large concentration of economic activities in coastal states. It relies heavily on long-distance rail land bridges, large interior rail hubs and significant transloading activity near major gateway ports.

In the long run, Hayuth (1988) observed a modest trend towards cargo deconcentration in the US container port system between 1970 and 1985. Notteboom (2006) stressed that the inequality in the North American container port system slightly rose in the late 1990s and early 2000s with the southwest coast (LA-Long Beach) dominating the whole system. Rodrigue and Guan (2009) suggest that divergences exist along the North American east coast and that they are mostly driven by hinterland access, shipping line networks and supply chain designs. More recent studies point to concentration patterns emerging in the US port system (Guerrero and Rodrigue 2014; Rodrigue 2022).

Fan et al. (2012) highlights that congestion is a common feature of most US ports leading to higher costs and traffic diversion to other routes. Justice et al. (2016) study on the resilience of the US container port system stresses that it is particularly challenged by regional container supply chain dynamics and distribution logics. Touzinsky et al. (2018) study on the impact of Hurricane Matthew (October 2016) on three southeastern stresses that it had a particularly high impact on the Port of Savannah, an effect which is mostly explained by differences in port layout, traffic volume and efficiency. Friedt (2021) analysis on the dynamics and spatial distribution of Hurricane Katrina's trade effects across US infrastructure finds that ports subject to disruption experience a trade reduction, with a rerouting persistent for 8 years.

Park et al. (2008) estimate the economic impact of the 11-day labor strike shutdown at the LA/LB ports in 2002 and show that although the ports lockout occurred on the entire West Coast, severe economic losses were only found in Los Angeles and San Francisco and were affecting more exports than imports. Rose and Wei (2013) investigate the economic consequences of a 90-day disruption at the twin seaports of Beaumont and Port Arthur, Texas and show a limited effect as large ports such as Houston, New Orleans and Louisiana in their direct vicinity can take over most of the traffics. According to Wei et al. (2020), a major port disruption scenario with a one-year disruption at the ports of Los Angeles and Long Beach, would result in a $569 billion GDP loss at the national level. Achurra-Gonzalez et al. (2017; 2019) focus on the possibility for re-routing and Trepte and Rice (2014) describe the port capacity bottlenecks at a large-scale system level.

Various actions exist to mitigate disruptions (Berle et al. 2011; Vonck and Notteboom 2016; Chen et al. 2017a, 2017b; Rose 2004) and to improve resilience (Holling, 1973; Pimm 1984). For shippers and suppliers (Wei et al. 2020), the mitigation options are to mobilize unused capacity, prioritize most valuable cargo (imports over exports), re-route vessels, improve operational capabilities or reschedule for production capture (extra-shift and over-time for instance). In re-routing, vessel operators may face cost "penalties" for longer shipping distances, as well as the use of land routes, to deliver the cargo to the original destination (Trepte and Rice 2014; Xing and Zhong 2017).

From a logistics point of view, the most prominent strategies (Verchuur et al. 2020) aim at production recapture (i.e. ports can make up for disruption by shifting more cargo once they become operational again) and port substitution (i.e. part of cargo can be diverted to other port/ports). Ports with a high utilization rate and with large congestion problems (e.g. ports of Los Angeles and Long Beach) will face difficulties in recapturing cargo, whereas ports with lower utilization rates (e.g. Baltimore, Charleston) will be more likely to do so (Fan et al., 2012). Chlomoudis and Styliadis (2019) studied the US West and East Coast port ranges from 2005 to 2015 and demonstrate, using a Shift-Share Analysis, that changes in the West Coast are the result of successive shifts in traffic from the port of Los Angeles (2005-2008) to Seattle (2008 to 2012) and finally to Long Beach and Tacoma during the last period. It however remains limited when considering a major shift to the East coast ports.

A main conclusion from these studies is that a distinction exists between short-term and longer-term disruptions for which cargo is structurally diverted to competitive ports (Verschuur et al. 2020). Major shifts can be related to investment in large infrastructure, such as the opening of larger Panama Canal locks in 2016 (Medina et al., 2021). Man-made disruptions would exert the most negative influence (Lam and Su 2015) as they impair normal routine of port operations, productivity and customer relationships (Galvao et al. 2016; Porterfield et al. 2012). In the longer term, they influence port choice, port costs and revenues as well as the national or regional socio-economic welfare (Hall 2004; Notteboom 2010; Zhang and Lam 2015, 2016). With more disruptions occurring over time, the deconcentration in favor of smaller ports predicted in earlier literature could be stimulated. Slack and Wang (2002) pointed out that larger container ships along with concerns over routing are in favor of relatively small ports. Wilmsmeier and Monios (2013) also consider that relatively small ports will become more important as port systems change due to the deployment of larger vessels.

3. Research design and data

Our research design is reported in Figure 1. The main objective of the descriptive analysis is to identify changes in the cargo concentration patterns in the US port distribution system, and then to compare these general trends with evolutions for Walmart and Nike (section 4). From this comparative analysis, a series of explanatory factors (section 5) are analyzed to better understand the observed patterns and differences.

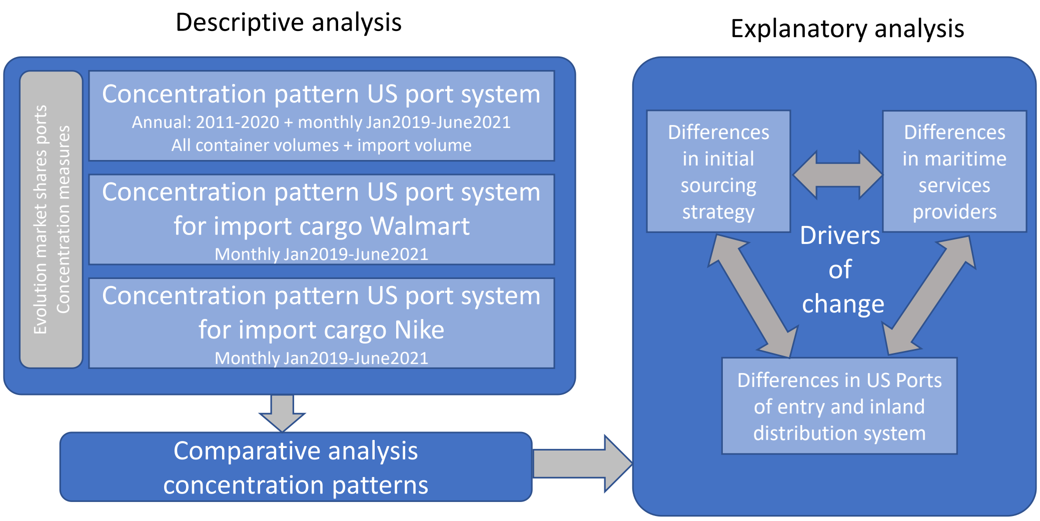


Figure 1. Research design

In our analysis, we consider that the choice on the port of entry is the result of two types of choices (Moya and Valero 2017). As highlighted by Ng et al. (2013) "A shipping line chooses its ports of call for each of its liner route to form its liner network. Based on the liner networks of shipping lines, a shipper chooses its port of origin and port of destination (port of O/D) for its shipments." Talley and Ng (2021) also consider that "cargo port choice should really be examined from both perspectives, simultaneously, as cargo port choice is made by both users and providers of cargo port services." Other authors have particularly focused on identifying and evaluating the main port choice criteria used by shippers (e.g. Cabellé et al. 2020; Onwuegbuchunam 2013) and shipping lines (e.g. Chang et al. 2008; Lirn et al. 2004; Saeed and Aaby 2013; Yang et al. 2016; Notteboom et al. 2017). These studies suggest that carriers focus strongly on nautical criteria (location vis-à-vis the main shipping routes, draft conditions, etc.), terminal productivity, cost and ownership considerations, and inland access to the cargo bases in the hinterland. Shippers are more likely to follow a supply chain perspective when choosing ports, thereby considering the impact of a specific port of call on the integrated logistics cost (both out-of-pocket cost and time costs) and the performance of the entire chain. However, differences exist among regions and shippers. For example, in their analysis of containerized imports into the US, Steven and Corsi (2012) found that large shippers emphasize the factors affecting speed of delivery more than the freight charges compared to small shippers.

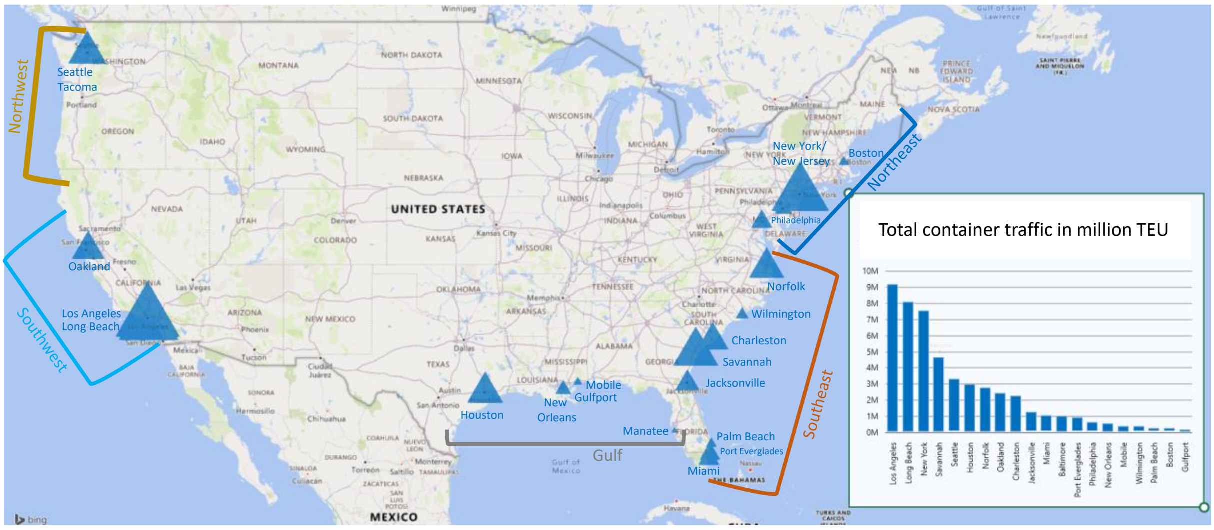


Figure 2. The US container port system – TEU traffic in 2020

Source: authors' compilation based on port authority data

At an industry level, we use import shipments in number of containers for Walmart and Nike. The selection of Walmart is motivated by the fact four of the top-five US importers (Walmart, Target, Home Depot and Lowe's) are from the retail industry (Table 1) and that retailers account for more than 50% of all US container imports (Piers Journal of Commerce 2019). Walmart is by far the largest importer and it operates approximately 10,500 stores and clubs under 48 banners in 24 countries and eCommerce websites, but the US is still considered as its home market.

The US Footwear and Apparel is also a large industry for the container industry with Nike importing approximatively 120,000 TEU by year (12th largest US importer). Nike was founded in 1972 in Oregon and evolved from being an importer and distributor of Japanese specialty running shoes to becoming one of the world-leading companies in the design, distribution, and marketing of athletic footwear and apparel. Table 1 presents a list of the top-15 US importers in 2017.

Table 1. Top-15 US importers in TEU in 2017

Rank	Company	'000 TEU	%	Sector
1	**Walmart**	**875**	**13%**	**Retail**
2	Target	590	9%	Retail
3	Home Depot	388	6%	Retail
4	Lowe's	287	4%	Retail

5	Dole Food	220	3%	Fruit and vegetables
6	Samsung America	185	3%	Conglomerate
7	Family Dollar Stores/Dollar Tree	168	2%	Retail
8	LG Group	163	2%	Conglomerate
9	Philips Electronics North Am.	142	2%	Electronics
10	IKEA International	121	2%	Retail
11	Chiquita Brands International	118	2%	Fresh fruit and vegetables
12	**Nike**	**116**	**2%**	**Footwear and apparel**
13	Newell Brands	115	2%	Outdoor and home goods
14	Costco Wholesale	112	2%	Retail
15	Sears Holdings	103	2%	Retail-consumer goods
	Top-100	6 760		

Source: Journal of Commerce (2019)

Information for Walmart and Nike shipments are gathered from US customs data and are contained in the bill of lading. It is collected at a shipment level (one shipment can correspond to one or several containers). For each shipment, information is available on the foreign port/country of origin, the number of containers shipped, the carrier and the US port of entry. Data frequency is for daily records. As in Holmes and Singer (2017), there is a difference between the total number of TEU reported in Journal of Commerce (approximatively 900,000 TEU imported per year for Walmart) and the number reported in the US customs extract. These differences can be explained by the fact that imports can use other modes of transport and/or enter into the US from Mexican or Canadian ports, and by import cargo with a bill of lading mentioning other consignees than Walmart or Nike[i].

Assuming as in Holmes and Singer (2017) that each import container is a 40 feet container, our sample includes 522,358 TEU imported in 2019 and 299,077 TEU in 2020 by Walmart. For Nike, the number of TEU for 2019 is equal to 21,520 TEUs and 31,382 TEU in 2020[ii]. We can here assume that air transport is, at least before COVID-19, taking a modest share of imports as an alternative to maritime transportation.

4. Descriptive analysis

Our analysis on changes in the spatial distribution of import cargo (in TEU) in the US port system is measured through the share of ports in total imports (Figure 3) and by the share of port regions in total import (Figure 4). Cargo concentration in the port system is captured in using the normalized Herfindhal-Hirschman Index (Cracau and Duran Lima 2016). The HHI-normalized ranges from 0 (equal distribution) to 1 (unique point of entry). For a market share of x_i over x the $HHI =$

$\sum_{i=1}^{n}\left(\frac{x_i}{x}\right)^2$ and the normalized HHI is $HHI^N = \frac{HHI - 1/n}{1 - 1/n}$.

4.1. Changes in spatial cargo distribution in the US container port system

Total container traffic handled by the US container port system increased gradually from 38.6 million TEU in 2011 to 51.2 million TEU in 2019. COVID-19 brought a small volume decline of 0.98% to 50.7 million TEU in 2020. The SW coast (LA/Long Beach) is the first US port region of entry. Its overall share in US container traffic declined from 42.3% in 2011 to 38% in 2019, followed by a modest recovery in 2020 and the first half of 2021. The NW coast has lost market share, while the US East Coast has consistently improved its relative position.

The changes during the COVID-19 era reveal strong volatility in traffic within and between the observed years (January 2019 to June 2021). Chinese New Year (January-February) brings a drop in handled volumes particularly at US West Coast ports as industrial and logistics activity in China is halted for a few weeks. However, with the global spread of COVID-19 and associated lockdowns in early 2020, this volume drop was much more pronounced in 2020 and lasted till the Summer of 2020.

The drop in consumer demand in Q2 2020 in the US was stronger than in most European or Asian countries. However, also the subsequent rise in demand in the US was much stronger. From late Summer 2020 onwards, TEU traffic in the US port system saw strong growth, fueled by a shift in consumer spending from services to products, and a rather unexpected fast economic recovery supported by an extensive stimulus package implemented by the US government. By early 2021, total as well as import volumes already reached levels far above 2019. Throughout the period of observation, the share of loaded imports in the total container traffic fluctuated between 42 and 48%, with figures for late 2020-early 2021 reaching the upper side of this percentage range.

4.2. Spatial distribution of Nike and Walmart import cargo

Walmart and Nike rely on a large number of US port gateways. In 2020, Walmart transited most of its import cargo flows via Savannah (23%; SE coast), Houston (19%; Gulf) and Norfolk (16%; SE coast), followed by Seattle/Tacoma (NW coast) and Mobile (Gulf) each representing about a tenth of the import volumes, and LA/Long Beach (SW coast) each handling about 6-7%. Nike strongly relied on five gateway ports for its US imports, i.e. Seattle/Tacoma (24%), Los Angeles (21%), Long Beach (15.1%), Port Everglades (15.2%) and Savannah (14.9%).

The spatial distribution of Walmart and Nike flows strongly deviates from the total import volume handled by the US port system (left part of Figure 3). Despite their significant import volumes, Walmart and Nike hardly ever represent a significant share of the total loaded import TEU of the ports considered (right part of Figure 3). The only outliers are some smaller container ports, such as Mobile for Walmart and Port Everglades for Nike.

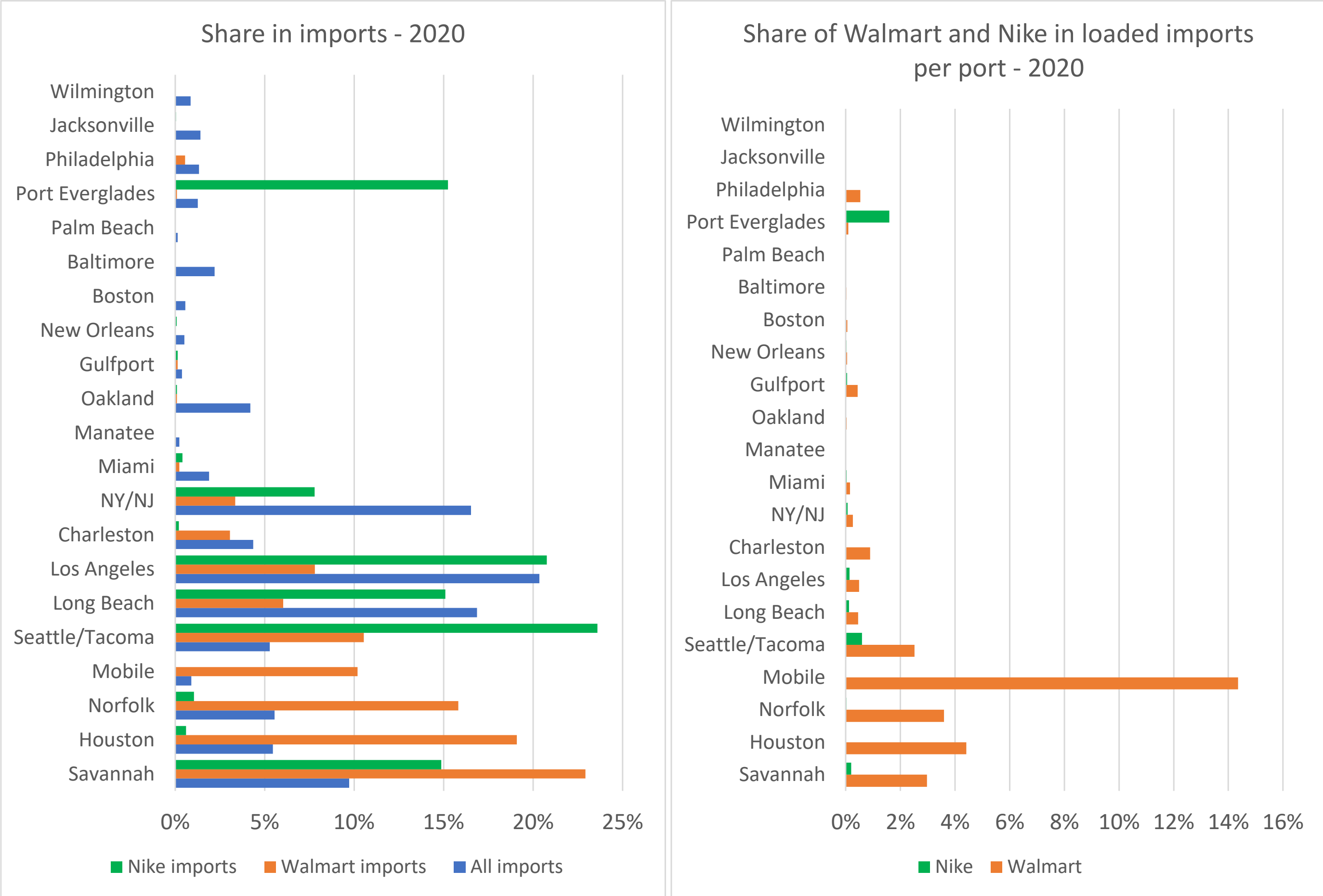


Figure 3. (Left) Share of ports in total imports and Walmart and Nike imports in 2020 (%, basis = TEU), and (Right) share of Walmart and Nike imports in total loaded imports per US port
Source: authors' elaboration

During the first six months of the pandemic (Figure 4), Walmart strongly declined its relative reliance on the Gulf of Mexico port region, while increasing the gateway position of the southeast coast (Savannah and Norfolk in particular) for its imports. In contrast, Nike saw a strong increase in the imports share of the southeast coast region in the second half of 2020, followed by a sharp decline in 2021, compensated by a growing reliance on LA and Long Beach despite serious port congestion in this SW coast port region. The Seattle/Tacoma port cluster acted as a prime US entry point for Nike imports in 2019, but its market position gradually declined during the pandemic to only 4.5% by June 2021.

Estimates on the HHI at individual port level for Nike (around 0.17) and for Walmart (around 0.12) confirm that the majority of their imports is passing via a limited number of gateway ports, compared to the aggregated HHI of the US port system (0.07). The regional HHIs, which focus on the five port regions as units of analysis, show a lower concentration level than the aggregated volumes in quite a few months. For Walmart, both the port level HHI and region level HHI slightly increased after the outbreak of COVID-19 followed by a mild decentration tendency since the start of the demand peak in early Autumn 2020. On the contrary, Nike imports witnessed a dip in port level and region level concentration in late 2020 (to about 0.11), followed by a strong rise in the first half of 2021 (i.e. HHI at individual port level of 0.25) caused by a sudden strong reliance on LA and Long Beach.

To conclude, there are three sticking elements when examining the change in US ports and individual companies traffics:

• First, the supply shock related to COVID-19 (February-May 2020) negatively affected all import volumes.

• Second, the second supply shock related to US port congestion affected the distribution of volume amongst US ports.

• Third, there are large disparities between the reactions of Walmart and Nike to the COVID-19 crisis, both in terms of volume and cargo distribution (US ports of entry).

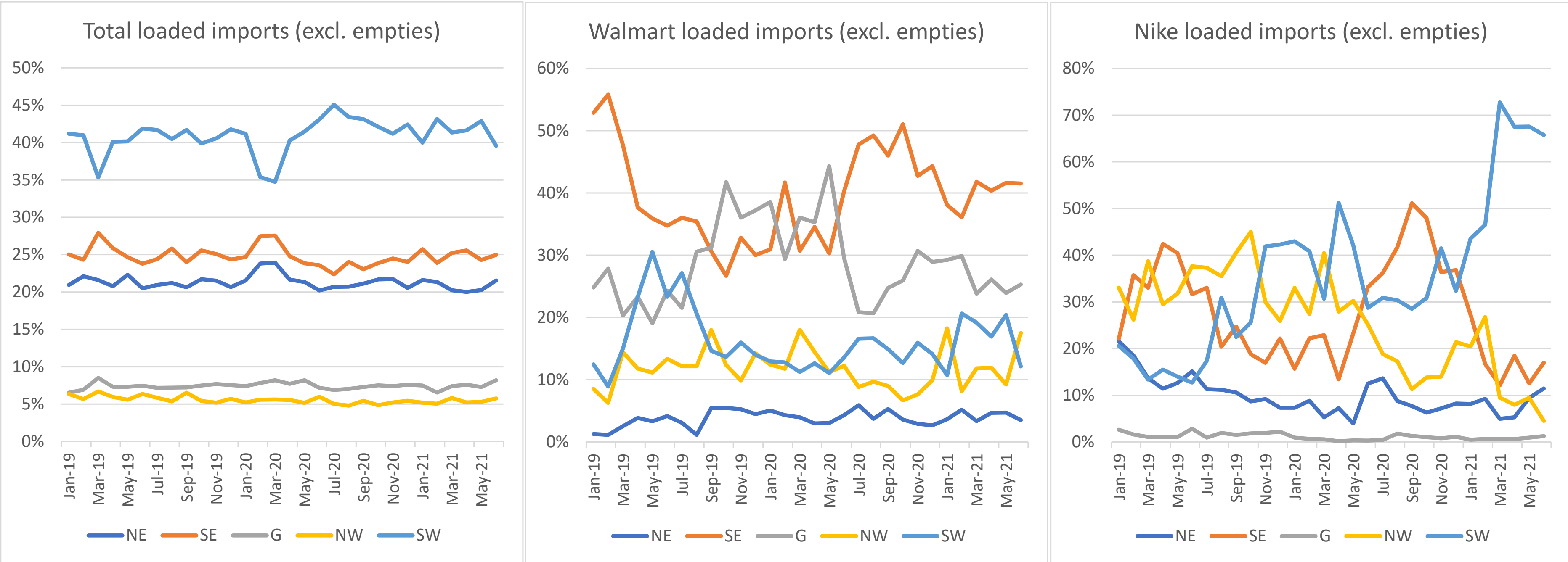


Figure 4. Shares of port regions in total loaded imports, Walmart imports and Nike imports, Jan 2019-June 2021, basis = TEU

Source: authors' elaboration

5. Explanatory analysis

We are offering three main explanations of the observed disparities provided in Section 4: at the origin due to differences in initial sourcing strategy; during transportation, due to the reaction by container carriers and US ports of entry, and at US destination, due to differences in the US port inland distribution systems.

5.1. Differences in initial sourcing strategy

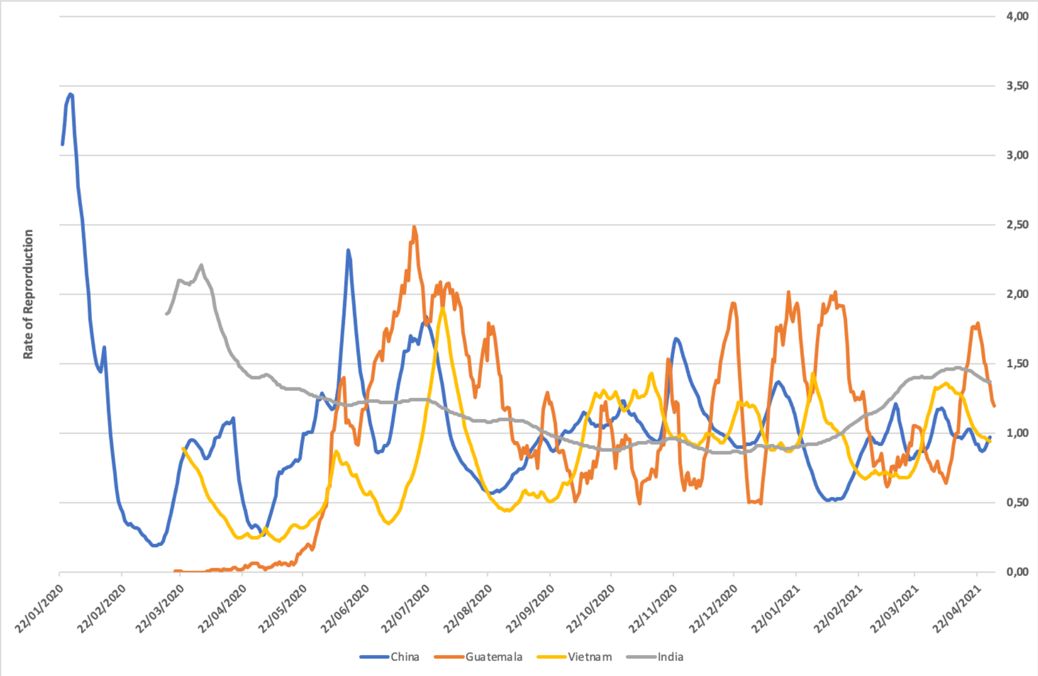
Following the surge in COVID-19 cases during the first half of 2020 (Figure 5), Walmart's import container volume went down by 50% during the first semester of 2020 compared to the last semester of 2019. During the same period, there was almost no change in import volumes for Nike. These disparities could be attributed to the initial sourcing strategy (Table 2) and on how/when the various sourcing facilities were affected by the pandemic.

Table 2. Changes in imported volumes by countries of origin (no. of containers)

	S1-2019	S2-2019	S1-2020	S2-2020	S1-2021
	Walmart				
China	105 981	80 168	36 326	48 109	62 102
India	11 896	11 042	7 670	13 922	14 974
Singapore	6 527	4 164	1 496	4 053	3 213
South korea	2 755	5 306	2 216	2 124	2 805
Other	16 141	17 199	12 769	20 850	18 492
	Nike				
Vietnam	349	2268	3040	2118	6606
China	543	1421	1507	1365	4923
Guatemala	712	931	743	1515	1018
Israel	366	502	398	580	648
Other	1649	2019	2208	2217	3852

Source: authors' elaboration

Figure 5. COVID-19 reproduction rate in selected countries (January 2020-Arpil 2021)



Source: authors' elaboration

Walmart's import volume is heavily dependent on China which accounts for 80% of origin of imports in 2019. This share has been reduced in Q1-2020 to 60%, with most of the reduction being compensated by a rise in imports from India. If volume went up afterwards, the levels are not comparable to 2019 volumes. Walmart tried to maintain the low prices business model by (re)negotiating with suppliers and finding new sources of manufacturing outside of China[iii]. Overall, COVID-19 has brought more uncertainties to China's logistics demand growth (Liu et al. 2022).

Nike's sourcing for their finished products (i.e. footwear & apparel) relies on 458 factories across 36 countries, mainly located in Asia (manufacturingmap.nikeinc.com). Judd et al. (2021) stresses that Nike's sourcing has been reduced to a relative handful of strategic suppliers during the last decade. In 2019, 93% of Nike's footwear output came from three countries: Vietnam (49%), China (23) and Indonesia (21), and a mere four suppliers produced 61% of its shoes. Longtime reliance on mainland Chinese production is ending, accelerated since 2017 by US-China trade disputes and in 2020 by trade sanctions for forced labor among Uyghurs in Western China (Turrillo 2020; Alam et al. 2019). At the beginning of the pandemic, four countries accounted for about 10-20% of Nike's maritime sourcing: Vietnam (10%), China (15%), Guatemala (20%) and Israel (10%). An interesting feature is that by the end of the period, Nike sourcing is re-concentrating in two locations (Vietnam with 39% and China with 29%). This could be explained by the increase in the COVID reproduction rate in Guatemala (Figure 5). While the rate was low during the first semester of 2020, it reached similar levels than in Asia since then.

5.2. Differences in maritime services providers

Table 3 reports the number of containers transported by ocean carriers for Walmart and Nike over the entire period.

Table 3. Imported volume by carriers (no. of containers) – period January 2019 – June 2021

	WALMART		NIKE
CMA CGM	236 346	HAPAG LLOYD A G	8814
MSC	64 172	CROWLEY	5450
ORATEL NETWORKS	56 318	ORATEL NETWORKS	4927
MAERSK LINE	52 434	CMA CGM	4405
ZIM ISRAEL NAVIGATION CO LTD	22 515	MAERSK LINE	4061
HAPAG LLOYD A G	20 762	BLUE ANCHOR LINE	2859
CHINA OCEAN SHIPPING COMPANY	16 982	APL	2062
HYUNDAI MERCHANT MARINE	13 474	MSC	1925
EVERGREEN LINE	9 235	EVERGREEN LINE	1573
Other	16 297	Other	7422

Source: authors' elaboration

The reaction of maritime carriers to COVID-19 has been different. In general, the COVID-19 has incentivized shipping lines to implement various contingency measures resulting in: vessel repositioning from other trade routes to the Pacific; shifts in US port calls; the deployment of larger vessels on the trans-Pacific trade; and higher call sizes per port call[iv]. Overall, these measures negatively affect the maritime network connectivity of the US port system starting from Q2 2021. Indeed, UNCTAD's Liner Shipping Connectivity Index (LSCI)[v] for the US dropped from 95.6 in Q4 2019 to 93.3 in Q1 2020, then gradually increased to 105.6 in Q1 2021, after which it fell sharply to 92.2 in Q2 2021 and 96.7 in Q3 2021.

The reaction was triggered by different elements. First, the sharp decline in demand, in particular due to the supply shock in China in early 2020, led shipping lines and alliances (i.e. 2M, Ocean Alliance, The Alliance) to resort to blanked sailings (Notteboom et al. 2021). The temporary rationalization in liner service capacity supply was particularly visible on the Pacific route from Asia to the US West Coast. Carriers usually resort to blank sailings at the start of each year due to lower exports during the Chinese New Year holiday. Blank sailings on the Pacific reached exceptionally high levels in the first half of 2020. The peak was reached in mid February 2020 with 41% of available vessel capacity blanked (data SeaIntelligence).

By mid-March, the supply side had built back up in Asia, but a demand shock in the US emerged as a result to the semi-lockdown measures. This led to a renewed wave in blank sailings with carriers idling more than 2.7 million TEU of fleet capacity on a global scale (data Alphaliner). Between April and June 2020, the blanked capacity share on the trans-Pacific trade fluctuated between 12% and 24%. With the sharp rise in demand by late Summer 2020, the blanked capacity share rapidly moved to zero. Blank sailings on the Transatlantic trade developed quite differently from the Pacific, as the former trade route was hardly affected by COVID-19 related problems in Asia. There was a spike in blank sailings in March-April 2020, as the Coronavirus spread from Europe to North America. There was another significant spike in blank sailings towards the end of 2020.

The number of trans-Pacific blanked sailings started to increase again in early 2021, due to port congestion in China (i.e. temporary terminal closures due to COVID-19 infections in ports of Tianjin, Ningbo and Shenzhen) and along the US West coast, LA and Long Beach in particular. In mid-November 2021, a record of 86 container ships were at anchor in the San Pedro bay area (data of Marine Exchange of Southern California), while Asia's largest ports showed signs that congestion was easing. The average waiting time at the US southwest ports amounted to 18 days, up from 8 days in April 2021. The blanked sailings no longer were blanks to pull out vessel capacity, but blanks caused by container vessels not being able to make the return journey in time due to long port delays. Carriers could not resort to recovery vessels to keep weekly services operational as the fleets were fully deployed and stretched beyond capacity. The number of port calls then reduces, but the call sizes at major container ports in North America increased, creating peaks in ship-to-ship operations and yard activity, gate congestion, and other operational challenges for terminals (Notteboom et al. 2021).

However, not all shipping lines were impacted in the same way. An analysis of Alphaliner (2021) based on November 2021 data revealed that carriers which own terminal capacity along West Coast ports faced far less vessel delays. For example, the ships of American niche carrier Matson are handled at its own SSA Marine Terminal in Long Beach while Evergreen also benefits from the fact that it has its own terminal with Everport. Evergreen's partners CMA CGM and COSCO/OOCL of the Ocean Alliance benefited from relatively short transit times given their terminal connections. Although COSCO had to sell OOCL's shares in the Long Beach Container Terminal (LBCT) to Macquarie in March 2019, it still has a priority arrangement. Controlling a terminal is no guarantee to avoid congestion. Maersk's ships took an average of 34 days from Asia to reach its own APMT terminal at Pier 400. The terminal yard is clogged as shippers cannot pick up the import cargo in time given the lack of truckers and equipment. In November 2021, Hapag-Lloyd, Yang Ming and Zim even faced an average transit time of more than 40 days. The longest port waiting times are observed for the newcomers on the trade (such as Transfar Shipping) leaving Asia using newly chartered ships without having already signed a terminal contract.

Faced with the challenge of keeping stores stocked amid a global supply chain crisis, some major retailers like Walmart went so far as to charter their own container ships. Walmart's out-of-stock levels are higher than normal due to high sales levels and supply chain constraints, while Walmart's suppliers are facing longer lead times to their orders. Walmart secured chartered capacity for Q3 and Q4 2021 (Leonard 2021).

The supply chain problems for Nike began in Q4 2020 when Nike was slow to ship collections to its wholesale partners despite growing consumer demand and the re-opening of economies. Consequently, Nike's sales drop in North America in Q1 2021 was not caused by a lower consumer demand, but rather a shortage of shipping containers and congestion at US ports that delayed shipments in that quarter by more than three weeks (Adegeest 2021). Nike's inventory in North America was up 31% year-on-year during Q1 2021, but much of this was in-transit inventory. Comparatively, the inventory in its distribution centers was down 20% year-on-year for Q1.

Shippers have also to deal with very high freight rate levels, despite poor schedule reliability and port congestion. Spot freight rates on the trans-Pacific route (eastbound) remained rather flat fluctuating around $1,500 per forty-foot equivalent unit (FEU) at the start of the pandemic. By September 2020, spot rates to reach around $4,000. A major rate surge occurred after April 2021 to reach record high rates in September 2021, followed by modest rate cuts by the end of 2021 (data Xeneta and Shanghai Containerized Freight Index). Shippers also pay additional costs such port congestion surcharges and dwell time charges at the terminals.

Large shippers typically rely on long-term contracts with preferred carriers, and are however less exposed to short-term rate fluctuations on the spot market. Still, they had to implement initiatives to deal with high freight rate levels. For instance, Walmart controls the final price on the shelf which means that when suppliers raise the cost of a product, Walmart can decide on whether to absorb some or all of that increase, or simply pass it to consumers, which could hurt sales if they choose to shop elsewhere for the same product.

During the China-US trade war in 2019, Walmart updated its Retail Link System, the information network used daily by its suppliers to let them submit cost increases that are directly attributable to higher US import tariffs on Chinese goods. This update proved its usefulness also to translate the high container freight rates since late Summer 2020 into day-to-day operations.

5.3. Differences in US ports of entry and inland distribution system

In the context of the pandemic, another disruption arises from the congestion at the major US seaports. When it comes to cargo re-routing, recent empirical work (Friedt 2021; Sytsma 2017) has stressed limited evidence on the impact of COVID-19 on port substitution (Notteboom et al. 2021).

Although some container vessels have been diverted to other US gateway ports, overall cargo diversion remained rather modest at the San Pedro Bay (Berger 2021). This was confirmed in the overall shares of the five port regions in Figure 4. Asian import flows remained strongly aligned to the LA/Long Beach inland distribution network, despite shortages in the availability of trucks, warehouse space and labor.

Although other US West Coast ports have a much smaller container handling level (i.e. 2.46 million TEU for Oakland in 2020 and 3.32 million TEU for Seattle/Tacoma, compared to 17.33 million TEU for LA/Long Beach), they also face capacity shortages at the terminals and inland, reducing their capability to efficiently accommodate a TEU overflow from LA/Long Beach. Despite COVID-related cargo diversion among ports overall being quite modest, the situation for individual shippers proved to be very different.

Figure 4 stressed that a new shift amongst US port ranges took place during the first six months of 2021. For Walmart, the main changes are the decrease in the share of Los Angeles (32%) and Long Beach (11%) to 23% and 6% for the first semester of 2021. The main winner is located on the East Coast and is the Port of Savannah that grew from 15% to 21%. Walmart's chartered ships primarily call at small container ports such as Mobile, Texas, thereby avoiding the most congested hubs.

However, these alternatives not only imply a transit through the Panama Canal and much longer transit times from Asia, ports such as Savannah also started to face serious port congestion problems since the Summer of 2021 (North American Shippers Association, 2021), with some carriers such as Hapag-Lloyd and CMA-CGM suspending calls.

Notwithstanding the congestion problems in LA/Long Beach, Nike became more committed to these ports in 2021. The share of imports using the southwest coast port region saw a steep increase in S1 2021 at the expense of the southeast coast (Table 4 - Nike), despite the fact some of its preferred carriers such as Hapag-Lloyd (Table 3), according to Alphaliner (2021), faced the longest transit times of all carriers to enter the San Pedro bay gateways.

The main increase in Nike imports is mostly through Los Angeles with a market share that increased from 15% to 37% (from S2-2019 to S1-2021) and for Long Beach, from 15% to 24%. This is to the detriment of Seattle (from 36% to 11%) and New York/New Jersey (from 14% to 7%). As stressed in Section 5.1, Nike re-located its production in Asia due to the vulnerability of South/Central American countries to COVID-19 and West Coast ports are a more direct option for Asian import.

Table 4. Change in US Port of entry (no. of containers)

	S1-2019	S2-2019	S1-2020	S2-2020	S1-2021
	Walmart				
Savannah, Georgia	34 991	17 892	10 905	23 364	21 473
Houston, Texas	23 106	20 916	12 803	15 732	17 596
Norfolk, Virginia	30 974	18 282	7 789	15 860	14 680
Seattle/Tacoma	14 054	15 047	8 139	7 609	13 103
Los Angeles, California	6 335	8 584	3 632	8 038	11 405
Other	33 840	37 158	17 209	18 455	23 329
	Nike				
Los Angeles, California	344	1063	1561	1696	6378
Long Beach, California	197	1069	1559	810	4170
Seattle/Tacoma	1208	2552	2476	1225	1827
New York/New Jersey	548	693	567	655	1421
Port Everglades, Florida	775	1029	801	1590	1194
Other	547	735	932	1819	2057

Source: own compilation

The above findings illustrate how shippers in the retail and footwear & apparel industries have had some fundamental differences in the way they adjusted their port of entry strategies. Shippers' initial inland distribution systems also play an important role to understand the evolution in the US port distribution system. Jula and Leachman (2011) and Leachman and Jula (2011) stress that a typical large US importer/retailer operates through Regional Distribution Centers (RDCs). The containers may be directly shipped inland to the RDCs, called "direct shipment"; or they may be unloaded at transload or import warehouse facilities and the contents sorted and re-shipped in domestic vehicles to multiple RDCs.

This leads to two alternative supply chain channels: (1) shipping marine containers directly from Asia to RDC destinations, and (2) shipping marine containers to transloading warehouses in the hinterlands of the ports of entry. For medium-value goods, it is more efficient (Jula and Leachman 2011) to practice a "four corners" or "five corners" policy with RDCs located in hinterlands of the ports of New York–New Jersey, Savannah, Los Angeles – Long Beach, and Seattle – Tacoma or those ports plus Houston. Leachman and Davidson (2012) study for the year 2006 and using US Customs data imported from Asian origins observed a difference according to the retailer's size. Between 55,000 and 300,000 TEU per year, the retailer should split their goods such that the cheapest goods are shipped using a direct strategy, while the most expensive goods are transloaded through LA and Seattle. For a retailer at "super-Walmart" levels of volume splitting goods such that four separate strategies are applied is the best option, with the most expensive goods being shipped through LA only.

The sale of products to wholesalers is the biggest distribution channel of Nike. Direct-to-consumer (or DTC) sales, which include online and factory retail outlets (300 Nike stores across the US) and e-commerce sales through its website, forms another main distribution activity for Nike. All these destinations are supplied through a limited number of distribution centers:

• Mid-South: Memphis, TN (open since 2015) and Byhalia, MS (since 2020). The North America Logistics Campus in Memphis is Nike's largest distribution center worldwide at 2.8 million square foot. Nike also leases two other facilities in the same city and one in Dayton, TN;

• West: Foothill Ranch, CA (leased facility for apparel and equipment) and Ontario, CA (for Converse only);

• East and mid-North: Bethlehem, PA is a 1 million square foot facility open since 2021 to support its e-commerce fulfillment on the East Coast. Another distribution center in Indianapolis, IN is leased and operated by a third-party logistics provider.

Nike does not practice a four or five corners distribution strategy, but follows a "three corners" approach with some major DCs even located in non-coastal states such as Tennessee and Indiana. There are other smaller distribution facilities located in various parts of the United States, some of which are leased or operated by third-parties. The location of the DCs partly explains Nike's choices in terms of ports of entry. LA/Long Beach are ideally located to connect to the Californian DCs and for routing a big part of the Asian cargo to all DCs. Savannah and Port Everglades are the main gateways for Nike in proximity of the mid-South DCs. New York plays a key role for the East and mid-North.

Walmart's distribution network is vast with 144 million square foot of warehousing space (Table 5). The import DCs, RDCs, food distribution centers and E-commerce fulfilment centers take up most of this square footage. The import DCs are particularly important for channeling overseas import flows to other DCs. In 2021, Walmart had 11 import distribution centers across the US: 5 in California, 4 in the mid-South (one in South Carolina, two in Georgia and one in Alabama), 2 in the mid-North (Kansas which opened in 2021 and Illinois) and one in the east (Virginia). This pattern points to a "four corners" distribution strategy with only the northwest coast not having an import DC in close proximity. In mid-2022, Walmart will open the new Walmart Ridgeville Import Distribution Center in Dorchester County, South Carolina, near the port of Charleston. The new facility will supply several RDCs, which will support approximately 850 Walmart and Sam's Club stores across South Carolina and beyond. Once fully operational, the distribution center is expected to increase volumes at the Port of Charleston by 70,000 FEU or about 5% (South Carolina Ports, 2020). This facility is likely to further increase the high share of the southeast coast in Walmart's port distribution system (see earlier Figure 4).

Table 5. Active Facilities in Walmart's distribution network, status at the end of 2021

Facility type	Number of facilities	1000 square foot
Import DC	12	19,000
Regional DC	42	50,115
E-commerce fulfilment center	27	21,288
Food DC	45	35,803
Fashion DC	7	8,045
Specialty DC	23	4,001
Sam's Club dark store	6	827
Sam's DC	23	3,778
Centerpoint	11	1,650
Total for US market	**196**	**143.907**

Source: updated from MWPVL (2020)

6. Discussion and conclusions

We contribute to literature on the impact of supply chain disruptions in investigating two initial research questions.

First, how did the COVID-19 impact import container flows via US container ports? This question was raised as while many studies consider US supply chain disruptions from natural disruptions such as hurricanes, terrorism and cyber-attacks (Friedt 2021; Sytsma 2017; Rose and Wei 2013; Rose et al. 2018) to conclude on a limited substitution amongst ports, we lack similar research when a disruption occurs during a longer period of time and is associated with major port lockdowns and slowdowns. We therefore place a major disruption (i.e. the COVID-19 pandemic) as the central element in the analysis of port system dynamics. Our main conclusion is that COVID-19 in the early stage (February-May 2020) negatively affected the total container volume transiting the US port distribution system, followed by a combination of a demand peak and severe supply issues resulting in US port congestion affecting the cargo distribution amongst US ports. The SW coast (LA/Long Beach) remains the most important US port region. Its overall share in US container traffic declined from 42.3% in 2011 to 38% in 2019, followed by a modest recovery in 2020 and the first half of 2021. The NW coast has lost market share, while the US East Coast has consistently improved its relative position in the national port system. The cargo concentration level in the US port system decreased between 2011 and 2019 (both at port regional level and individual port level) with a sharp rebound since 2020. Thus, the COVID-19 pandemic presents a trend break in the concentration dynamics in the US port system.

Second, what can explain differences in the reaction of US Retailing and F&A shippers to the COVID-19 disruption in terms of their use of the US port distribution system? In order to answer this question, we investigated the reaction of US shippers to the pandemic, using the specific case of US port of entry. This second research question was motivated by the fact that while many studies focus on the port level, a disaggregate perspective on shippers' port system dynamics is lacking. This leads us to stress that analysis based on aggregated container volumes per port might hide underlying dynamics and logics at the level of (1) specific cargo segments (import, export and transshipment cargo) and, (2) the cargo routing behavior of market actors such as specific shipping lines and shippers. Our analysis highlights some large disparities between the reactions of Walmart and Nike to the COVID-19 crisis, both in terms of volume and cargo distribution (US port of entry) and stresses that these disparities could be related to the initial choices on the location of production, on carrier choices and on port/inland distribution networks. Thus, the analysis of Walmart and Nike shows that some similarities and divergences exist in the strategies set by the main importers and that, similar to other short-term disruptions (hurricanes, strikes…), different mitigation options were used by shippers: new suppliers' relationships, changes in inbound routes and new sourcing.

However, the management of the disruption related to the pandemic appears to be more complex than other disruptions as it affects the sourcing of products by countries, the international transportation and the port or inland connections within the US. As mentioned by Sharma et al. (2022), the global cost of pandemic depends on the number of affected countries and then on the required duration of lockdowns policies It means for instance, and contrary to Trepte and Rice (2014) who analyze a labor disruption in a single port/set of ports in the US west coast or to Touzinsky et al. (2018) or Friedt (2021) that study the impact of a Hurricane happening in a specific US region, that the sources of disruption are multiple, and that the management of the risk associated are more complex.

Nike provides an example of an unexpected impact from the pandemic. The fact that, following Asia, South America was largely impacted by the pandemic means that contrary to expectation, the sourcing was relocated in Asia, and the importance of US West Coast ports for Nike grew by the end of the period. Therefore, and contrary to expectations for a long-lasting supply chain disruption, a major re-routing of US flows is not observed, despite a persistent congestion on the US West Coast ports. Another difficult element is related to the fact that the congestion is nation-wide and that it does not limit to a specific geographic area which means that a major re-routing strategy can prove to be risky. A possible rerouting away from LA/Long Beach is challenging as other US ports and their inland transport systems at present lack the scale and capacity to efficiently create a path disruption in the observed longer-term cargo concentration patterns in the US port system.

It therefore means that ways to manage the current port-related pandemic disruptions are challenging. In the short to medium term, it requires closer collaboration between supply chain actors to optimize the use of existing resources and capacity in the sea-port-inland distribution system. Large retailers such as Walmart and Nike can take part in data sharing and management initiatives with other parties in the chain. Such initiatives should contribute to a greater transparency and visibility in cargo flows, a better equipment availability/utilization and unlock opportunities for joint cargo bundling through horizontal collaboration among shippers.

Asset managers and transport operators can more effectively use pricing and operational tools to tackle existing supply chain inefficiencies, such as the late return of empty containers, late bookings, no shows, etc. The transition to a truly 24/7 logistics landscape, for example by implementing night operations at terminals' truck gates and distribution facilities, is another step towards a better use of existing capacity. In the longer term, additional capacity at the level of seaport terminals, truck chassis, and warehousing capacity and additional human resources might be needed to cope with increased cargo volatility brought by disruptions. Creating capacity buffers in supply chains comes at a cost, but also brings cost savings linked to a higher reliability and shorter transit times. The COVID-19 crisis has demonstrated that combining just-in-time logistics with a lack of buffers and poor resilience brings capacity shortages and major supply chain disruptions resulting in high logistics costs and inflationary pressures.

The volatile market conditions caused by the pandemic have made supply chain management a more important cornerstone in corporate strategy formulation and implementation of companies such as Walmart and Nike. Logistics decisions on cargo routing, inventory levels, the number and location of distribution centers, logistics cost allocations and the direct involvement in logistics operations are more than ever taken at the highest corporate decision level. The same applies to rate and capacity negotiations with carriers and other logistics service providers.

While our study contributes to a better understanding of the critical role played by ports for many US industries and on the ability of different industries to adapt their supply chains to a major port disruption, there are some limitations and pending research questions. The first limitation relates to the timing of the research. In line with similar work on the impact of COVID-19 on supply chains (Shi et al. 2021), the supply chain crisis was still unfolding during the time of writing, which implies that port congestion and other supply chain issues continued also after the observed period of analysis (ending in June 2021). The available historic dataset does not allow to draw empirically verified conclusions on how Walmart and Nike will redesign their supply chains in the longer term.

This study was therefore primarily aimed at analyzing the short-term and immediate reactions of both companies in terms of the use of the US port distribution system. Second, the paper contained a multiple-case study of only two large shippers. Third, our study is limited to maritime imports via the US port system. We did not consider other transport modes (such as air freight) or alternative ports in Canada (such as Vancouver and Prince Rupert on the west coast and Halifax and Montreal on the east coast).

This paper opens windows to further research. First of all, and as mentioned by Butt (2021), there are many other ways to adjust to a disruption than to consider a re-routing in distribution flows. In particular, it could make sense to further investigate the potential impact on modal split (air, rail, road transport) consecutive to the pandemic. Second, it would be interesting to further investigate the reaction of other shippers and in particular, those with more time sensitive cargos such as in the Agri-food business (Shanker et al. 2020; Khumar et al. 2021), to better understand how the increase in end-to-end lead time associated to the pandemic affected the US logistic distribution systems (Montoya-Torres et al. 2020). An extension of the analysis to other shippers, including also smaller and medium-sized companies, might result in a much richer pallet of possible port of entry shifts by cargo owners in reaction to the pandemic.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

References

ACHURRA-GONZALEZ, P.E. ANGELOUDIS, P. ZAVITSAS, K. NIKNEJAD A, and D.J. GRAHAM D.J., 2017, Attacker-defender assessment of vulnerability in maritime logistics corridors. In: Ducruet C (ed) Advances in shipping data analysis and modeling. Tracking and mapping maritime flows in the age of big data. Abingdon: Routledge, 297-315.

ACHURRA-GONZALEZ, P.E. ANGELOUDIS, P. GOLDBECK, N. GRAHAM D. J. ZAVITSAS, K., and M.E.J. STETTLER M.E.J., 2019, Evaluation of port disruption impacts in the global liner shipping network. Journal of Shipping and trade 4:3. https://link.springer.com/article/10.1186/s41072-019-0043-8

ADEGEEST, D.A., 2021, Nike's sales affected by shortage of shipping containers, Fashion United, 19 March 2021.

ALAM, M. S. SELVANATHAN, E.A. SELVANATHAN, S. and M. HOSSAIN, M., 2019, The apparel industry in the post-Multifiber Arrangement environment: A review". Review of Development Economics, 23(1), 454–474._

ALI, I. and I. GÖLGECI., 2019, Where is supply chain resilience research heading? A systematic and co-occurrence analysis. International Journal of Physical Distribution & Logistics Management, 49(8), 793-815.

ALPHALINERn 2021, California congestion surprisingly no big issue for some carriers, Alphaliner Weekly Newsletter, 30 November 2021

ARNOLD, B. CAMMARATA, C. FARMER, D. KOWALEWSKI, K. LADIPO, F. LASKY, M. and D. MOORE D., 2006, The Economic Costs of Disruptions in Container Shipments. Homeland Security and Governmental Affairs United States Senate.

BERGER, P., 2021, Why Container Ships Can't Sail Around the California Ports Bottleneck. The Wall Street Journal, 21 September 2021

BERLE, Ø. ASBJØRNSLETT, B.E. and J.B. RICE., 2011, Formal vulnerability assessment of a maritime transportation system, Reliable Engineering System and Safety, 96, 696–705.

BLACKHURST, J. DUNN, K.S. and C.W. CRAIGHEAD, 2011, An Empirically Derived Framework of Global Supply Resiliency, Journal of Business Logistics, 32(4), 374-391.

BLOOMBERG, 2021, The world economy's supply chain problem keeps getting worse. Retrieved at https://www.bloomberg.com/news/articles/2021-08-25/the-world-economy-s-supply-chain-problem-keeps-getting-worse.

BUTT, A.S., 2021, Understanding the implications of pandemic outbreaks on supply chains: an exploratory study of the effects caused by the COVID-19 across four South Asian countries and steps taken by firms to address the disruptions, International Journal of Physical Distribution & Logistics Management, 52 (4), 370-392.

CABALLÉ VALLS, J., DE LANGEN, P.W., GARCÍA ALONSO, L. AND VALLEJO PINTO, J.Á., 2020, Understanding port choice determinants and port hinterlands: findings from an empirical analysis of Spain. Maritime Economics & Logistics, 22(1), 53-67.

CHANG, Y.T., LEE, S.Y. AND TONGZON, J.L., 2008, Port selection factors by shipping lines: Different perspectives between trunk liners and feeder service providers. Marine Policy, 32(6), 877-885.

CHEN, L. ZHAO, X. TANG, O. PRICE, L. ZHANG, S. and W. ZHU., 2017, Supply chain collaboration for sustainability: A literature review and future research agenda, International Journal of Production Economics, 194, 73-87.

CHEN, H. CULLINANE, K.P.B. and N. LIU, 2017, Developing a Model for Measuring the Resilience of a Port-Hinterland Container Transportation Network, Transportation Research Part E Logistic and Transportation Review, 97, 282-301.

CHLOMOUDIS, C. and T. STYLIADIS., 2019, Concentration of container flows in the port phase: the case of the U.S West and East Coast port ranges, Issues in Business Management and Economics, 7(1), 1-13.

CNN, 2021, Global supply chains nightmare, Retrieved (28 October 2021). https://www.cnn.com/2021/10/12/business/global-supply-chain-nightmare/index.html

CRACAU, D. and J.E. DURAN LIMA., 2016, On the Normalized Herfindahl-Hirschman Index: A Technical Note, International. Journal of Food System Dynamics 7(4), 382-386.

DE OLIVEIRA, G.F. SCHAFFAR, A. CARIOU, P. and J. MONIOS., 2021, Convergence and growth traps in container ports, Transport Policy, 110, 170-180.

DUCRUET, C. and T. NOTTEBOOM., 2012, The worldwide maritime network of container shipping: spatial structure and regional dynamics, Global Networks, 12(3), 395-423.

DUCRUET, C. and T. NOTTEBOOM., 2022, Revisiting port system delineation through an analysis of maritime interdependencies among seaports, GeoJournal, 87, 1831–1859.

EDELSON, S. 2021, Walmart Gets Behind U.S. Manufacturing With 10-Year, $350 Billion Investment, Forbes, 3 March 2021.

FAN, L. WILSON, W.W. and B. DAHL., 2012, Congestion, port expansion and spatial competition for US container imports. Transportation Research Part E Logistic and Transportation Review, 48, 1121-1136.

FAN, Y. and M. STEVENSON, M., 2018., A review of supply chain risk management: definition, theory, and research agenda. International Journal of Physical Distribution & Logistics Management, 48(3), 205-230.

FRIEDT F.L., 2021, Natural disasters, aggregate trade resilience, and local disruptions: Evidence from Hurricane Katrina, Review of International Economics, 29(5), 1081-1120.

GALVAO, C.B. WANG, G.W. and J. MILESKI., 2016, Public-private interests and conflicts in ports: A content analysis approach. Asian Journal of Shipping and Logistics, 32, 13-22.

GUERRERO, D. and J.P. RODRIGUE., 2014, The waves of containerization: shifts in global maritime transportation. Journal of Transport Geography, 34, 151-164.

HALL, P.V., 2004, We'd have to sink the ships: Impact studies and the 2002 west coast port lockout. Economic Development Quarterly, 18, 354-367.

HAYUTH, Y., 1988, Rationalization and deconcentration of the US container port system. The Professional Geographer, 40(3, 279-288.

HBR, 2020, Global supply chains in a port-pandemic world. Retrieved (28 October 2021) at: https://hbr.org/2020/09/global-supply-chains-in-a-post-pandemic-world

HOLLING, C.S., 1973, Resilience and stability of ecological systems." Annual review of ecology and systematics, 4(1), 1-23.

HOLMES, T.J. and E. SINGER., 2017, Indivisibilities in Distribution. Reserve Federal Bank of

Minneapolis, Working paper 737.

JOURNAL OF COMMERCE, (2019), https://www.joc.com/.

JUDD, J. and J. LOWEL JACKSON., 2021, Repeat, Repair or Renegotiate? The Post-COVID Future of the Apparel Industry. Discussion Paper 43, International Labor Organization.

JULA, P. and R.C. LEACHMAN, 2011, A supply-chain optimization model of the allocation of containerized imports from Asia to the United States. Transportation Research Part E Logistic and Transportation Review, E(47), 609-622

JUSTICE, V. BHASKAR, P. PATEMAN, H. CAIN, P. and S. CAHOON, 2016, US container port resilience in a complex and dynamic world. Maritime Policy and Management, 43(2), 179-191.

KUMAR, P., and R. K. SINGH., 2021, Strategic Framework for Developing Resilience in Agri-Food Supply Chains During COVID 19 Pandemic. International Journal of Logistics Research and Applications, Early Access.

LAM, J.S.L. and S. SU., 2015, Disruption risks and mitigation strategies: An analysis of Asian ports." Maritime Policy and Management, 42, 415-435.

LEACHMAN, R.C. and E.T. DAVIDSON., 2012, Policy Analysis of Supply Chains for Asia – USA Containerized Imports. Proceedings of the 2012 Industry Studies Association Annual Conference, Industry Studies Association, Univ. of Pittsburgh, Pittsburgh, PA, May 30-June 1, 2012.

LEACHMAN, R.C. and P. JULIA, 2011, Congestion analysis of waterborne, containerized imports from Asia to the United States. Transportation Research Part E Logistic and Transportation Review, E47, 992-1004.

LEONARD, M., 2021, Walmart charters ships to ensure freight capacity, inventory for peak season. Supply Chain Dive, 18 August 2021.

LIU, W.Y. LIANG, X. BAO, J. QIN, and M. K. LIM, 2022, China's Logistics Development Trends in the Post COVID-19 era. International Journal of Logistics Research and Applications, 25(6), 965-976

LIRN, T.C., THANOPOULOU, H.A., BEYNON, M.J. AND BERESFORD, A.K.C., 2004, An application of AHP on transhipment port selection: a global perspective. Maritime Economics & Logistics, 6(1), 70-91.

LÓPEZ-BERMÚDEZ, B. FREIRE-SEOANE, M.J. and E. LESTA-CASAL., 2020, Core and comprehensive ports: The new challenge for the development of the Spanish port system. Transportation Research Interdisciplinary Perspectives, 8, 100243.

MARAD, 2017, Marine transportation system (MTS). Maritime Administration Office of Intermodal System Development hwww.marad.dot.gov/ports/marine-transportation-system-mts/

MARKET WATCH, 2021, Nike manufacturing in Vietnam grinds to a halt due to Covid-19. Retrieved

(28 October 2021) at: https://www.marketwatch.com/story/nike-manufacturing-in-vietnam-grinds-to-a-halt-due-to-covid-19-11626714516

MEDINA J. KIM J-H. and E.S. LEE., 2021, Did the Panama Canal expansion benefit small U.S. ports? Maritime Transport Research 2:100013.

MOYA, J.-M. and M.F. VALERO., 2017, Port choice in container market: a literature review. Transport Reviews, (37)3, 300-321.

MONTOYA-TORRES, J.R. MUÑOZ-VILLAMIZAR, A. and C. MEJIA-ARGUETA., 2020, Mapping research in logistics and supply chain management during COVID-19 pandemic. International Journal of Logistics: Research and Applications, Early Access.

MWPVL, 2020, The Walmart Distribution Center Network in the United States, retrieved from www.mwpvl.com

NG, A.S.-F. SUN, D. and J. BHATTACHARJYA, 2013, Port choice of shipping lines and shippers in Australia. Asian Geographer, 30(2), 143-168.

NG, A. K. DUCRUET, C. JACOBS, W. MONIOS, J. NOTTEBOOM, T. RODRIGUE, J. P. and G. WILMSMEIER, 2014, Port geography at the crossroads with human geography: between flows and spaces. Journal of Transport Geography, 41, 84-96.

NORTH AMERICAN SHIPPERS ASSOCIATION, 2021, Savannah Port Congestion – carriers drop service or increase congestion surcharges. www.nasaships.com, October 21, 2021

NOTTEBOOM, T. and D. FRASER, 2020, The Development of the Container Port System in Southern Africa." In: OLUKOJU A., CASTILLO HIDALGO D. (eds) African Seaports and Maritime Economics in Historical Perspective. (Palgrave Studies in Maritime Economics, Palgrave Macmillan). https://doi.org/10.1007/978-3-030-41399-6_7

NOTTEBOOM, T.E., PAROLA, F., SATTA, G. AND PALLIS, A.A., 2017, The relationship between port choice and terminal involvement of alliance members in container shipping. Journal of Transport Geography, 64, 158-173.

NOTTEBOOM, T. PALLIS, T. and J-P. RODRIGUE., 2021, Disruptions and resilience in global container shipping and ports: the COVID-19 pandemic versus the 2008–2009 financial crisis. Maritime Economics and Logistics, 23, 179-210

NOTTEBOOM, T., 2006, Traffic inequality in seaport systems revisited. Journal of Transport Geography, 14(2), 95-108.

NOTTEBOOM, T. 2010, Concentration and the formation of multi-port Gateway regions in the European container port system: An update. Journal of Transport Geography, 18, 567-583.

NOTTEBOOM, T. and H.E. HARALAMBIDES, 2020, Port Management and Governance in a Post-COVID-19 Era: Quo Vadis? Maritime Economics and Logistics, 22, 329-352.

NOTTEBOOM, T. and T. PALLIS. 2021, IAPH-WPSP Port Economic Impact Barometer One Year Report: A survey-based analysis of the impact of COVID-19 on world ports in the period April 2020 to April 2021. International Association of Ports and Harbors (IAPH)

ONWUEGBUCHUNAM, D.E., 2013, Port selection criteria by shippers in Nigeria: A Discrete Choice Analysis. International Journal of Shipping and Transport Logistics, 5(4-5), 532-550.

PALLIS, A.A. VITSOUNIS, T.K. DE LANGEN, P.W. and T. NOTTEBOOM, 2011, Port economics, policy and management: Content classification and survey, Transport Reviews, 31(4), 445-471.

PARK, J. GORDON, P. MOORE, J. and H. RICHARDSON, 2008, The state-by-state economic impacts of the 2002 shutdown of the Los Angeles–Long Beach ports. Growth and Change, 39(4), 548-572.

PIMM, S.L., 1984, The complexity and stability of ecosystems. Nature, 307(5949), 321-326.

PORTERFIELD, T.E. MACDONALD, J.R. and S.E. GRIFFIS, 2012., An exploration of the relational effects of supply chain disruptions. Transportation Journal, 51, 399-427.

RODRIGUE, J.P., 2022, The geography of maritime ranges: interfacing global maritime shipping networks with Hinterlands. GeoJournal, 87, 1231–1244.

RODRIGUE, J.P. and C. GUAN, 2009, Port hinterland divergence along the North American Eastern seaboard. In NOTTEBOOM, T., DE LANGEN, P., and C. DUCRUET (2009), Ports in Proximity: Essays on Competition and Coordination among Adjacent Seaports. (London, Ashgate: 131-160).

ROSE, A., 2004, Defining and measuring economic resilience to disasters. Disaster Prevention and Management: An International Journal, 13(4), 307-314.

ROSE, A. and D. WEI, 2013, Estimating the economic consequences of a port shutdown: the special role of resilience, Economic Systems Research, 25(2), 212-232.

ROSE, A. WEI, D. and D. PAUL, 2018, Economic consequences of and resilience to a disruption of petroleum trade: the role of seaports in US energy security. Energy Policy, 115, 584-615.

SAEED, N. AND AABY, B.C., 2013, An analysis of factors contributing as selection criteria for users of European container terminals. TRB 2013 Annual Meeting..

SHANKER, S.A. BARVE, K. MUDULI, A. KUMAR, J. A. GARZA-REYES, and S. JOSHI, 2021, Enhancing Resiliency of Perishable Product Supply Chains in the Context of the COVID-19 Outbreak. International Journal of Logistics Research and Applications, Early Access.

SHARMA, M., S. LUTHRA, S. JOSHI, and A. KUMAR, 2022, Developing a Framework for Enhancing Survivability of Sustainable Supply Chains During and Post-COVID-19 Pandemic. International Journal of Logistics Research and Applications, 25 (4-5), 433-453.

SHI X., LIU W., and J. ZHANG, 2021, Present and future trends of supply chain management in the presence of COVID-19: a structured literature review. International Journal of Logistics: Research and

Applications, Early Access.

SLACK, B. and J.J. WANG, 2002, The challenge of peripheral ports: an Asian perspective. GeoJournal, 56(2), 159-166.

STEVEN, A.B. AND CORSI, T.M., 2012, Choosing a port: An analysis of containerized imports into the US. Transportation Research Part E: Logistics and Transportation Review, 48(4), 881-895..

SOUTH CAROLINA PORTS, 2021, Walmart breaks ground on distribution center in South Carolina.3 3 December 2021, retrieved from http://scspa.com/news/walmart-breaks-ground-on-distribution-center-in-sc/

SVANBERG, M. HOLM, H. and K. CULLINANE, 2021, Assessing the Impact of Disruptive Events on Port Performance and Choice: The Case of Gothenburg. Journal of Marine Science and Engineering, 9(2), 145 https://doi.org/10.3390/jmse9020145.

SYTSMA, T., 2017 The impact of climatic disasters on trade: evidence from hurricanes and U.S. ports. SSRN Electron. J. https://doi.org/10.2139/ssrn.3067531.

TALLEY W.K. and N.W. NG., 2021, Cargo port choice equilibrium: A multi-perspective look at shippers' port choice." Transportation Research Part E: Logistics and Transportation Review, E154, 102454.

TOUZINSKY K.F. SCULLY, B.M. MITCHELL K.N. and M.M. KRESS, 2018, Using Empirical Data to Quantify Port Resilience: Hurricane Matthew and the Southeastern Seaboard. Journal of Waterway, Port, Coastal and Ocean Engineering, 144(4).

TREPTE, K. and J.B. RICE, 2014, An initial exploration of port capacity bottlenecks in the USA port system and the implications on resilience. International Journal of Shipping and Transport Logistic, 6, 339-355.

TURRILLO, H., 2020, Global Textile Industry Overview: China, The U.S. And Europe Dominates The Market. https://www.fashionabc.org/global-textileindustry- overview-china-u-s-europe-dominates-market/

UNCTAD, 2020, The Impact of the COVID-19 Pandemic on Trade and Development: Transitioning to a New Normal UNCTAD/OSG/2020/1.

UNCTAD, 2021, Liner shipping connectivity index (LSCI database available at https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=92

VERSCHUUR, J. KOKS, E.E. and J.W. HALL, 2020, Port disruptions due to natural disasters: Insights into port and logistics resilience, Transportation Research Part D, 85, Early Access.

VONCK, I. and T. NOTTEBOOM, T., 2016, Panarchy within a port setting. Journal of Transport Geography, 51, 308-315.

WALMART, 2021, How Walmart is navigating the supply chain to deliver this holiday season.

Retrieved (28 October 2021) at: https://corporate.walmart.com/newsroom/2021/10/08/how-walmart-is-navigating-the-supply-chain-to-deliver-this-holiday-season

WANG, L. NOTTEBOOM, T. LAU, Y.Y. and A.K. NG, 2017, Functional differentiation and sustainability: A new stage of development in the Chinese container port system. Sustainability, 9(3), 328.

WEI, D. CHEN, Z. and A. ROSE, A., 2020, Evaluating the role of resilience in reducing economic losses from disasters: A multi-regional analysis of a seaport disruption. Paper Regional Science, 99, 1691-1722.

WENDLER-BOSCO, V. and C. NICHOLSON, C., 2019, Port disruption impact on the maritime supply chain: a literature review. Sustainable Resilient Infrastructure, 5(17), 1-17.

WILMSMEIER, G. and J. MONIOS, 2013, Counterbalancing peripherality and concentration: an analysis of the UK container port system. Maritime Policy and Management, 40(2), 116-132.

WilmSMEIER, G. MONIOS, J. and G. PÉREZ-SALAS, 2014., Port system evolution–the case of Latin America and the Caribbean. Journal of Transport Geography, 39, 208-221.

XING, J. and M. ZHONG, 2017, A reactive container rerouting model for container flow recovery in a hub-and-spoke liner shipping network. Maritime Policy & Management, 44(6), 744-760.

YANG, J., WANG, G.W. AND LI, K.X., 2016. Port choice strategies for container carriers in China: a case study of the Bohai Bay Rim port cluster. International Journal of Shipping and Transport Logistics, 8(2), 129-152..

ZHANG, Q. YAN, K. and D. YANG, 2021, Port system evolution in Chinese coastal regions: A provincial perspective. Journal of Transport Geography 92, Early Access.

ZHANG, Y. and J.S.L. LAM, 2015, Estimating the economic losses of port disruption due to extreme wind events. Ocean Coastal Management, 116, 300-310.

ZHANG, Y. and J.S.L. LAM, 2016, Estimating economic losses of industry clusters due to port disruptions. Transportation Research Part A Policy and Practice, 91: 17-33.

[i] International import cargoes moving into the US via air, rail or truck are not included. The container import data used in this research is restricted to Walmart and Nike as shippers or beneficial owners of containerized cargo that entered US ports by ocean vessels. Statistics do not include containers shipped using a bill of lading for non-vessel-operating common carriers, forwarders or brokers, and third-party logistics providers.

[ii] Most US containers are forty-feet containers or FEU, so one container equals two TEU (Holmes and Singer, 2017).

[iii] In March 2021, Walmart announced that it will be investing $350 billion over the next decade on products made, grown or assembled in the US in six priority categories, including plastics, textiles, small electrical appliances, food processing, pharmaceutical and medical supplies. The most competitive products for reshoring are those made of raw materials available in the US, such as cotton, plastics and metals, items with highly automated product processes, and products that are inefficient to ship. This local sourcing strategy could cut imports by 20% over the next decade (Edelson, 2021).

[iv] For example, the MSC Isabella with a nominal capacity of some 23,000 TEU broke earlier records when the Pier 400 terminal moved 34,263 TEU on her in the port of Los Angeles in June 2020.

[v] The Liner Shipping Connectivity Index (LSCI) by UNCTAD is based on five components of the maritime transport sector: number of ships, their container-carrying capacity, maximum vessel size, number of services, and number of companies that deploy container ships in a country's ports (with index 100 equal to the highest value of all countries in 2006) (UNCTAD, 2021).