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# Ship Turnaround Times in Port: Comparative Analysis of Ocean Container Carriers

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**Abstract.** There is general recognition that port turnaround times of container ships vary considerably. Recent efforts to explain the differences have employed factors involving port efficiency and the numbers of containers transferred, with only limited success. In this paper the role of the shipping lines is considered. Eighteen global carriers are selected and their average turnaround times (ATTs) in 20 ports on three East-West and one North-South trade route are obtained. By comparing the ATT of each carrier in each port with the overall ATT of that port provides a measure of relative carrier performance, thereby identifying a standard of performance independent of overall port activity. A wide range of scores are indicated, with several carriers recording much longer relative ATT scores overall, including CMA-GGM, APL and UASC while Evergreen, Yang Ming and Maersk record the lowest (and best) scores. The results suggest that carriers have a role to play in in port turnaround times. Two factors are examined: on-time arrivals and ship stowage plans. The results of the analysis are used to assess the recent round of restructuring of the global shipping alliances and the extent to which the partnerships reflect differences in ATTs. Suggestions for further research are presented.

**Keywords.** Times in port, differences between carriers, container carrier strategies.

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## 1 Introduction

Time is one of the most important factors shaping container shipping. The imperative of providing weekly services helps determine the number of vessels deployed and the selection of ports of call (Agarwal and Ergom 2008). For shippers, supply chains are shaped by arrival and departure times of vessels, and their choice of port is often made on the basis of accessibility and proximity, both of which have a time dimension (Tongzon 2009). From the perspective of the shipping line there are two constituents of time: time at sea and time in port. In the academic literature most attention has been given to the former, partly because transit times between ports are usually the longest components of shipping services (Brouer et al 2013). Another reason arises out of the recent adoption of slow steaming, precipitated by high fuel costs, that has required adjustments in service configurations as well as the number of vessels deployed (Cariou and Notteboom 2011). In this paper the focus is on time in port. An individual port call may be of little more than 24 hours duration, but since most container services involve many port calls, between 10 and 18 on most complete runs involving outbound and return legs, the cumulative total of times in port represent a quite significant component of service duration.

The time consumed in each port call comprises several components: the process of attaching mooring lines and securing the vessel at the berth, providing ship supplies and bunkering, but most time consuming operation is that of unloading and loading containers between ship and shore. The amount of time taken up with cargo handling depends upon the relative efficiency of port operations, not just the ship-to-shore gantry cranes, but also the operations in the terminal area from container stacks to berth-side and the patterns of arrival and departure of containers through entry gates. Recent attempts to quantify the relationships between average terminal turnaround times (ATTs) and port terminal efficiency variables at a global level (Ducruet et al. 2014; Slack et al 2018) the correlations have been found to be weak at best.

Slack et al (2018) observed that ATTs are differentiated regionally, with East and North Asian ports having the shortest ATTs and the West Coast US and African ports generating the longest ATTs. When ATTs were disaggregated regionally much higher levels of associations with efficiency measures were obtained. Other research has revealed that transshipment ports turnaround ships faster than others (Cullinane et al 2006) and mega ships require longer terminal times than smaller vessels (Merk 2015), thus indicating that types of vessels or port functions may influence ATTs.

The present paper seeks to extend and deepen understanding of ships time in port by considering additional factors that influence ATTs. The length of time ships spend in port tends to be seen as an outcome of port operational problems, but the shipping lines themselves may play a role in explaining in ATTs. As confirmed in the following literature review different carriers have different service orientations and approaches to service performance. It is suggested here that these differences may impact on times in port, which leads to the first set of research questions: to what extent do the ATTs of carriers differ? Are there differences between specific ports of call or across the spectrum of service calls? After providing empirical evidence of differences in ATTs of the container shipping lines the paper goes on to consider the principal carrier-induced factors that give rise to slower ship turnarounds.

## 2 Literature Review

There is considerable evidence in the literature that individual container shipping lines engage in different practices and strategies to serve customers and operate their fleet of ships. These differences are in evidence in a range of situations, including the design of shipping networks where there are contrasts in the use of transshipment hubs (Fremont 2007), in the extent of slot sharing (Lam et al 2007), and in round the world services (Lim 1996). Differences have been demonstrated in the form of ownership structures (Slack and Fremont 2009) and the timing of involvement in strategic alliances (Panayedes and Weidmer 2011). The participation of carriers in vertical integration with terminal operations (Olivier 2005; Soppe 2009) and their investments in inland connections (Cariou 2008; Franc et al 2010) have been shown to be highly differentiated among the global container shipping lines.

In a study comparing the relative levels of efficiency of major container shipping lines Wiegmans et al (2013) revealed persistent differences between carriers on ranked input and output performance criteria, such as average ship capacity, throughput per ships and profits per throughput. The diversity was repeated in the Data Envelopment Analysis (DEA) scores which led the authors to draw the following conclusions:

*first, the differences between the respective container carriers are considerable; and, secondly, there is no 'clear' efficient carrier in terms of cost minimisation or sales maximisation. (Wiegmans et al 2013 p.71).*

Regarding the issue of time differences among carriers the focus in the academic literature has been on the issue of punctuality of vessel arrivals rather than the length of time spent in port. One important corpus of research has employed mathematical programming and systems analysis to analyse case study data drawn from a carrier or a terminal operator with the goal of improving operational performance (Agarwal and Ergom 2008; Brouer et al 2012; Pani et al 2014; Song et al 2015; Reinhardt et al 2016). In most cases the data sources remain confidential. Broader in scope are a number of studies that draw on data published annually by Drewry Shipping Consultants. In 2006 Drewry began monitoring arrival times for 350 port pairs and comparing them with published schedules. It provides quarterly reports on the punctuality scores of all the major shipping lines and along major trade routes. Apart from some initial use of the results by academic researchers, the reports appear to be mainly employed by industry, no doubt because of their high subscription costs. Notteboom (2006) contrasted the strategies Maersk and MSC concerning scheduled reliability, suggesting that the former goes out of its way to adhere to published arrival and departure times, but charges higher rates, while the latter is less strict but by “*seemingly random skipping of one or more ports of call during a round voyage*” (Notteboom 2006 p.33) adjusts to disruptions and temporal dislocations. Other techniques to ensure schedule reliability adopted by some carriers include the management of their own terminals, where they may have greater control over vessel turnarounds rather than waiting in a multi-user facility (Verminnen et al 2007).

While the literature on punctuality agrees that poor performance may be precipitated by unavoidable issues such as mechanical breakdowns and weather conditions as well as issues in the ports themselves including lack of berth availability due to congestion or labour disruptions, it is still unclear what is the role of the carriers themselves.

Comprehensive differences between carriers regarding the length of times in port have been difficult to analyse in part because of the lack of specific time metrics. In the mid-2000s two different research teams headed by Saldanha in the USA and Ducruet in France began to use data on shipping arrival and departures drawn from Lloyds Maritime Intelligence Unit (LMIU) Shipping Movements Database. This source tracks commercial shipping movements and was continuously updated by movement data delivered by Lloyds’ agents, Coastguards, Customs, Port Authorities, and other trusted market sources. The subsequent studies published by Ducruet (2010, 2012) focused on transit times for container shipping between for 1050 ports in the world for one month in each of 1996, and 2006 and analysed the resultant network topological

structures, but did not differentiate between carriers on these networks. However, Saldanha et al (2006) revealed differences in the transit times of different carriers between Busan and Los Angeles, with COSCO exhibiting the worst transit time performance and Hyundai the best. In a subsequent paper (Saldanha et al 2009) combined the ocean transit time data with inland distribution times to markets and estimates of logistics costs. The results provided evidence that ocean transit time and transit-time reliability have substantial influence on the overall door-to-door process time and reliability:

*Thus, the shippers who select ocean carriers' services primarily for cost and convenience are missing important opportunities to cut logistics costs by not making transit time a priority in their selection process. (Saldanha et al 2009, p. 30).*

This review of the literature reveals that while the differences between shipping lines are numerous and multi-dimensional there has been very little comprehensive examination of carrier differences with regards ship's time in port. Notteboom (2006) provides only a couple of cases as examples, and Saldanha et al (2006) compared only the services of carriers between Busan and Los Angeles. Part of the reason for this has been the difficulty of obtaining actual time measurements at a comprehensive scale. Such opportunities are now available. In 2002 the World Maritime Organisation required mandatory reporting of the real time positions of ships, but was not until the end of the decade that commercial companies such Lloyds Intelligence Unit began to assemble the data and make it available in comprehensive outputs. It was this data source that was used in recent papers focusing on ships time in port (Ducruet et al (2014; and Slack et al (2018)). These papers focus exclusively on vessel turnaround times by port and explain differences by examining port efficiency criteria.

### **3 Methodology**

The Lloyds Intelligence Unit data is organised by individual vessel movements, including the times of arrival and departure at ports of call. A wide range of vessel characteristics are displayed, including vessel dimensions, registration, and ownership. In our original data collection ship movements on three major East-West and one North-South trade routes were extracted (Trans-Pacific, Trans-Atlantic, Asia-NW Europe, and NW Europe - East Coast of South America) four months during 2013 (January, May, September and November). All movements on these trade routes involving 20 selected ports were obtained. The time elapsed between arrival and departure for each vessel call was calculated for each of the base ports and

50 other intermediate ports of call were calculated. The overall ATT for the 70 ports was 25.53 hrs. (Slack et al 2018).

Unfortunately the Lloyds data only identifies the ship owner of each vessel rather than the ship operator. There are many vessels listed in the master file we created that belong to companies that are involved in ship chartering such as Offen and E.R. Schiffahrt. Their ship portfolios are large and many of their vessels are leased to major shipping lines. It is very complicated to follow the vessel charters of the independent ship owners and for this reason only the vessels under the ownership of major ship operating companies were selected. Even here some data manipulation was required since many carriers possess vessels under different subsidiaries, and thus a merging of details was required.

The 20 base ports were selected for analysis (see Table 1). To have considered all the intermediate ports of call as well would have been unwieldy and would have included many cases where only one carrier was providing service. The matrix of ATTs for the 20 ports contains involving 18 carriers of the top 20 global container carriers' average times of are displayed in Table 1.

#### **4 Analysis**

The results reveal a picture of complexity, with differences in ATTs between carriers across all the ports identified. This observation provides a clear answer to the first research question. It is already established that there are important differences between the ATTs of individual ports (Ducruet 2014), but the evidence presented in Table 1 provides indisputable evidence of differences between the carriers as well. While some of this difference may be due to varying numbers of containers discharged and loaded by each carrier, for which there are no data available, the ATT scores are too differentiated between ports for this to provide a full explanation. In order to further analyse the ATTs of the carriers an examination of the relative scores of ATTs is undertaken, in which the ATT of each carrier in each port is compared with the overall port ATT:

(1)  $A_j - a_{ij}$ , where  $A_j$  is the ATT of port  $j$ , and  $a_{ij}$  is the ATT of carrier  $i$  in port  $j$

The results of such a comparison produces either a positive or negative score, with a positive value indicating that the carrier spends less time in the port than is average for the port (Table 2)

**Table 1** Carrier ATTs in the 20 base ports

	APL	CMA CGM	COSCO	CSCL	Evergreen	Hamburg Sud	Hanjin	Hapag-Lloyd	HMM	K Line	Maersk	MOL	MSC	NYK	OOCL	UASC	Yang Ming	Zim	Mean ATT
Antwerp	61.43		30.65	22.40	24.63	21.52	40.27	28.39		26.93	16.69	18.11	42.28	34.46	23.56		26.63	25.29	29.69
Buenos Aires				47.48		34.98	58.37				38.51		33.77						42.61
Busan	11.98	18.06		9.74	9.95		16.67	16.22	15.25	9.94	12.74	25.05	11.91	12.60	23.71		10.55	17.67	14.86
Halifax								12.92			11.49							21.33	15.24
Hamburg	44.65	44.45	45.41	38.90	30.96	31.06	41.75	42.27	54.40	38.66	24.62	45.71	23.07	35.58	45.30	37.81	31.40	36.42	39.05
Hong Kong	22.12	21.05	15.56	19.83	17.64		14.35	17.02	20.04	16.90	14.74	17.85	10.82	20.77	14.05	19.64	14.86	14.33	18.37
Le Havre	20.88	20.56		37.81	18.70	18.64	13.52	17.52			20.78	17.23	19.91		18.31	41.94			23.09
Long Beach		72.22	61.76				68.06			71.84			78.51		87.09			22.37	60.24
Los Angeles	47.45			67.82	49.43		73.94	19.85	71.32	42.72	59.97	64.69	57.56	72.78			59.69		65.45
Montreal								68.60			54.58		67.98		62.01				63.29
New York		50.00			24.01	31.39		23.79			19.36	29.69	27.86					26.00	29.57
Norfolk		23.33			13.47	21.21		15.61			14.97	12.43	10.72						15.96
Prince Rupert			30.03				24.00								17.06		30.32		25.35
Rotterdam	49.54	25.18	34.12	31.85	38.10	24.49	33.58	27.71	41.58	26.63	22.65	29.91	28.69	41.34	37.61	33.01	28.09	37.86	34.58
Santos				24.02		27.80	32.30				24.15		18.09						25.28
Seattle	61.53	48.86	28.91	35.99			21.55		36.44	37.09	55.63	17.14					31.53		37.37
Shanghai	21.31	24.10	24.44	23.11	14.90		21.35	17.52	18.61	20.25	18.42	13.50	20.40	14.19	19.45	24.25	19.37	19.18	19.67
Singapore	37.80	25.25	22.83	18.90			25.79	30.70	25.67	23.67	28.80	26.67	37.53	30.04	32.69		18.79	35.06	28.15
Tacoma					28.76			32.21	45.17	65.67					34.17		42.98	37.20	40.45
Vancouver	21.07	63.09	28.61	49.89	37.00		22.77	55.29	36.16	37.99	56.13	23.84			80.08		34.38	73.16	44.25

Source: own calculations



**Table 2** Relative Carrier performance: comparing carrier ATTs with port mean ATTs

	APL	CMA CGM	COSCO	CSCCL	Evergreen	Hamburg Sud	Hanjin	Hapag-Lloyd	HMM	K Line	Maersk	MOL	MSC	NYK	OOCL	UASC	Yang Ming	Zim
Antwerp	-31.74		-0.96	7.29	5.06	8.17	-10.58	1.30		2.76	13.00	11.58	-12.59		6.13		3.06	4.40
Buenos Aires				-4.87		7.63	-15.76				4.10		8.84	-4.77				
Busan	2.88	-3.20		5.12	4.91		-1.81	-1.36	-0.39	4.92	2.12	-10.19	2.95		-8.85		4.31	-2.81
Halifax								2.32			3.75			2.26				-6.09
Hamburg	-5.60	-5.40	-6.36	0.15	8.09	7.99	-2.70	-3.22	-15.35	0.39	14.43	-6.66	15.98		-6.25	1.24	7.65	2.63
Hong Kong	-3.75	-2.68	2.81	-1.46	0.73		4.02	1.35	-1.67	1.47	3.63	0.52	7.55	3.47	4.32	-1.27	3.51	4.04
Le Havre	2.21	2.53		-14.72	4.39	4.45	9.57	5.57	23.09		2.31	5.86	3.18	-2.40	4.78	-18.85		
Long Beach		-11.98	-1.52				-7.82			-11.60			-18.27		-26.85			37.87
Los Angeles	18.00			-2.37	16.02		-8.49	45.60	-5.87	22.73	5.48	0.76	7.89				5.76	
Montreal								-5.31			8.71		-4.69	-7.33	1.28			
New York		-20.43			5.56	-1.82		5.78			10.21	-0.12	1.71					3.57
Norfolk		-7.37			2.49	-5.25		0.35			0.99	3.53	5.24					
Prince Rupert			-4.68				1.35											25.35
Rotterdam	-14.96	9.40	0.46	2.73	-3.52	10.09	1.00	6.87	-7.00	7.95	11.93	4.67	5.89		-3.03	1.57	6.49	-3.28
Santos				1.26		-2.52	-7.02				1.13		7.19	-6.76				
Seattle	-24.16	-11.49	8.46	1.38			15.82	0.93	0.28	0.28	-18.26	20.23					5.84	
Shanghai	-1.64	-4.43	-4.77	-3.44	4.77		-1.68	2.15	1.06	-0.58	1.25	6.17	-0.73	5.48	0.22	-4.58	0.30	0.49
Singapore	-9.65	2.90	5.32	9.25			2.36	-2.55	2.48	4.48	-0.65	1.48	-9.38	-1.89	-4.54		9.36	-6.91
Tacoma					11.69			8.24	-4.72	-25.22					6.28		-2.53	3.25
Vancouver	23.18		15.64	-5.64	7.25	21.48		-11.04		6.26	-11.88	20.40			-35.83		9.87	-28.91
<b>TOTAL</b>	<b>-45.25</b>	<b>-52.15</b>	<b>14.40</b>	<b>-5.32</b>	<b>67.44</b>	<b>28.75</b>	<b>-0.26</b>	<b>56.06</b>	<b>-7.44</b>	<b>13.83</b>	<b>52.25</b>	<b>58.24</b>	<b>20.76</b>	<b>-11.94</b>	<b>-54.06</b>	<b>-21.89</b>	<b>48.64</b>	<b>33.59</b>

These relative scores are examined in two different ways. The first is a measure that is the sum of the differences for carrier  $i$  in port  $j$ . There are thus positive and negative scores:

(2)  $\Sigma(A_j - a_{ij})$ , where  $A_j$  is the average ATT port  $j$ , and  $a_{ij}$  is the ATT of each carrier  $i$  in port  $j$

The results reveal that there are important differences between the shipping lines (Tables 2 and 3). The best performer is Evergreen while OOCL is the worst, representing a mean relative time difference of 120 hours. There appear to be several classes of performance, with OOCL, CMA-CGM, and APL representing a group with the negative mean time differences in excess of 45 hours. Four other carriers recorded negative values: CSCL, Hanjin, HMM and NYK, but their performance is not as poor as the previously-mentioned carriers. Ten of the 18 carriers recorded positive levels of performance, but here again there are differences, with COSCO, Hamburg Sud, K-Line, MSC and Zim all recording positive values, but less than 35 hours above average. Evergreen, Hapag Lloyd, Maersk, MOL and Yang Ming are revealed as a group with the best performance.

One difficulty with this measure is that a high or low relative score in a few ports of call only could influence the total relative score. Examples include that of Hapag Lloyd where nearly all the total +56.06 hours is due to a relative shorter than normal score at Los Angeles of +45.60 hours, and, at the other extreme, OOCL, with a relative total score of -54.06 hours is influenced by the longer than average of -35.83 hours recorded at Vancouver.

A different set of results are obtained when an ordinal-based score is calculated. In this approach the number of times a carrier's port call is negative or positive (longer or shorter than the average for that port) is counted. For each carrier the number of positive cases is expressed as a percentage of the total number of cases (see Table 3):

(3)  $n/N * 100$  where  $n$  = number of cases where  $a_{ij} > A_i$ , where  $A_i$  is the ATT of port  $i$ , and  $a_{ij}$  is the ATT of carrier  $j$  in port  $i$ ; and  $N$  = number of ports  $i$  served by carrier  $j$

Table 3 indicates that the ordinal-based results contain there are fewer carriers performing poorly than when the sum of the differences (in hours) is calculated per formula (2). This is indicative of the way a few longer than average calls in a few ports can influence the results. The percentage values result completely remove OOCL as the worst performer, with that dubious honour being conferred on CGM-CMA. APL, HMM, NYK and USAC are other carriers with more port service times that are longer than the port means. COSCO and Hanjin reveal a neutral performance with an equal number of shorter

and longer calls. CSCL which is identified as a poor performer in the sum of difference scoring is now slightly positive.

**Table 3** Relative port performance of carriers

CARRIER	□ diff (hours)	□ of calls positive
APL	-45.25	36.36
CMA-CGM	-52.15	27.27
COSCO	14.4	50.00
CSCL	-5.32	53.84
Evergreen	67.44	91.67
Hamburg-Sud	28.78	62.50
Hanjin	-0.26	46.67
Hapag Lloyd	56.06	66.67
HMM	-7.44	40.00
K-Line	13.83	75.00
Maersk	52.25	82.35
MOL	58.24	76.92
MSC	20.76	66.67
NYK	-11.94	37.50
OOCL	-54.06	53.84
UASC	-21.89	40.00
Yang Ming	48.64	83.33
ZIM	33.59	61.54

Three carriers with the best percentage positive results are Evergreen, Yang Ming and Maersk. Evergreen emerges as the leader with only one of the 12 ports of call whose times below the port average. Yang Ming is in second place with 10 of its 12 port calls being shorter than the port averages. Maersk is in third place with 14 out of 17 port calls being better than the port averages. Other carriers revealing overall high performance include MOL, K-Line, MSC and Hapag-Lloyd.

Both measures of carrier turnaround times in port take into account the differences in port ATTs, so that a carrier calling at a port with high ATTs is compared equally with all others calling at that port. The fact that carriers such as Evergreen and Maersk call at ports who's ATTs may be high and yet consistently score faster turnarounds than other carriers is clear evidence of carrier performance differentiation. We suggest that the ordinal-based score is the better indicator because it can dampen strong negative or positive values that can occur. It emphasises the level of performance across the full range of ports served. It is a metric that more clearly reveals the differences that exist between carriers,

with several achieving consistently shorter port turnarounds, while others appear to take spend longer times to clear ports.

## 5 Interpretations

Explaining the differences between carriers represents a challenge. Most of the research on ships time in port suggests that port inefficiencies are to blame. The evidence presented here, where some carriers consistently achieve faster turnarounds even in ports where average ATTs are high, suggest that carriers themselves may be a factor to be taken into account. Here, we consider two elements, based on published research and discussions with four terminal operators on the West Coast of North America, two in Western Europe and two in China, as well as with shipping company officials in the head offices of two European carriers and one Chinese shipping line. First is the issue of transit time delays, where there is academic research on carrier response differences with regards to service disruptions. Second is that of container stowage plans, an issue that was raised in our industry interviews.

### 5.1 *Transit time delays*

It is widely claimed extended ships time in port may be affected by that transit time delays (Slack and Comtois 2013; Song et al 2015; Reinhardt et al 2016). Transit delays are caused a range of factors, including weather, tidal conditions, mechanical failings and congestion in the previous port of call (Pani et al 2014). Late arrival of a vessel due any one of these issues may result in the terminal being unprepared to discharge and load containers in an optimal fashion: the berth may be already allocated to another ship and cranes may have been deployed elsewhere. As discussed in the literature review these factors may be largely beyond the direct control of the carriers, but both academic studies (Notteboom 2006) and professional sources (Bonney 2015) suggest that some carriers pay particular attention to service reliability while for others punctuality is less important than filling ships, and accordingly may extend the times of departure to wait for more cargo with consequent impacts on the subsequent ports of call.

Drewry Carrier Performance Reports are a source of carrier punctuality data. Unfortunately, its high subscription cost has prohibited its use here. Many trade journals report the results of Drewry's latest survey. A search of trade journals reporting Drewry carrier scores for 2013 indicate that Maersk, Evergreen and Yang Ming were the top three with regards punctuality (Journal of Commerce 2013). This is a result that closely matches the ATT ranking obtained in this paper. Apart from listing the best

performers the trade magazines usually do not indicate the ranking of the other carriers. One of the few times that a trade journal reported a poor performer was Maritime Executive (2013) revealing that MSC and CSAV had the worst punctuality scores in 2013, a result that does not accord with ATT rankings produced here.

Unfortunately, there are no means to test the relationship between punctuality and ATTs of all the carriers from our data. It would have required a compilation of published schedules of all the carriers in 2013 in order to compare expected arrival times with the actual times. This has been impossible *ex post facto*. Thus, comparing carrier punctuality and ATT scores requires further research.

## 5.2 *Stowage Plans*

A common complaint levelled against most carriers by terminal operators is that on-board container stowage plans do not consider operational conditions in the terminals. Stowage plans must consider two issues. First, they must ensure that the loaded container ship is seaworthy. This requires the vessel to have transversal stability when sailing, and its draft and trim must be within limits, and the weight distribution must satisfy the stress limits of the structure (Delgado 2013; Pacino 2013). The positioning of containers by bay, row and tier is critical to ensuring seaworthiness. The stowage of containers must also consider the weight of individual containers, ensure the safe positioning of 20 and 40 foot containers, and position refrigerated containers (*reefers*) near power plugs. Second, the stowage plans must consider the order in which containers will be exchanged at each port of call. It will seek to ensure that slot allocations minimise the amount of repositioning of containers as the ship sails from one port to another and as containers are sequentially discharged and added during the voyage.

The range of considerations that have to be taken into account makes stowage planning very challenging. In the past the plans were prepared by a designated officer on each ship, but with the growth of the size of vessels and the complexity of voyages it became necessary to utilize software and now stowage planning a head office activity. Because of the critical importance of the first set of stowage considerations for the safety and security of the vessel these tend to be the primary determinants in the software algorithms in allocating containers to slots. Even the goal of minimising repositioning of containers may not take into account discharging and loading from a terminal operator's perspective. Our interviews revealed that STS cranes are called upon to make frequent lateral moves in order to position themselves alongside the required container slots, moves that are time consuming and reduce terminal efficiency.

While the general factors affecting stowage plans are known and measured, how individual plans of different carriers are not. There is a need for a survey and comparative analysis of stowage plans in order for their differences to be identified and evaluated. At a conference in London organised by the Journal of Commerce on Port Productivity one paper provided a useful case study (Brant and Lambers 2014). The authors describe how the OOCL team involved in producing stowage plans in China were brought to the British port of Southampton to meet with the terminal operator in order to understand the particular issues it faced. The stowage planners were able to adjust existing configurations to help improve terminal efficiency. At the same time the carrier met with the dock worker's union to try to coordinate vessel arrivals with the start of shifts in order to avoid situations that occurred previously when vessel arrivals came in the middle of a shift, with resultant down time when the changes of shift occurred during operations.

## 6 Perspectives on the restructuring of alliances

The results of the analysis provide an interesting perspective on the recent and ongoing restructuring of the container shipping business. Since 2016 the former alliance structures have unravelled, and new carrier groupings have been formed (Table 4).

**Table 4** Container shipping alliances 2017

Alliances	Members
2M	Maersk (+Hamburg Sud), MSC
Ocean Alliance	CMA-CGM, COSCO, Evergreen, OOCL
The Alliance	Hapag Lloyd (+ UASC), K-Line, MOL, NYK, Yang Ming
(No name)	HMM, Sinokor Merchant Marine, Heung-A Shipping

The 2M alliance comprises Maersk and MSC (two of the better performers in ATTs, and two European carriers under complete or historic family ownership). Initially these carriers had formed an alliance called Oceans 3 with the other major European carrier, CMA-CGM. Given the differences between the time performance of CMA-CGM, which is among the worst, and Maersk and MSC which are among the best, it was somewhat of a strange association in light of the results of this study. However, that alliance was rejected by Chinese regulators, and when CMA-CGM purchased the Singaporean carrier APL a decision was made to link CMA-CGM with the Chinese carriers COSCO (which had merged with CSCL), OOCL and Evergreen. This alliance is now called the Ocean Alliance. It may be

noted that in July 2017 COSCO made an offer to purchase OOCL, that if approved would make COSCO the third largest global container carrier by capacity, thereby replacing its alliance partner CMA-CGM. These developments forced many of the remaining carriers that were in the G6 and CKYHE alliances to come together as 'The Alliance' whose members were to have included Hapag-Lloyd (that subsequently merged with UASC), K-Line, MOL, NYK, and Hanjin, but even this new structure had to be reformed with the financial collapse of Hanjin. HMM, having subsequently failed to join the 2M alliance, has established an alliance with two smaller regional carriers: Sinokor Merchant Marine and Heung-A Shipping. In late 2016 2M increased its capacity further with Maersk's purchase of Hamburg Sud, a former privately owned carrier involved in North-South trades, whose ATT performance is close to those of Maersk and MSC.

The Ocean Alliance combines many of the worst performing carriers in terms of the duration of port calls, but it also includes Evergreen, the best performing carrier according to our data and a company that historically was reluctant to join alliances. Undoubtedly, the change in control of the carrier, with the handing over of management of the company to professional executives by its founding owner is a factor. Evergreen has moved closer to actions of other major carriers recently, by ordering super post panamax vessels for example. The third alliance, 'The Alliance', is dominated to a greater degree than the others by one carrier, Hapag-Lloyd, which after its merger with UASC in 2016 has the largest fleet in the alliance by far, but with the exception of UASC and NYK all members had positive port time performances. The remaining carrier, Zim, lies outside the proposed alliances, although it operates with many of the other carriers in slot sharing agreements on specific trades. Zim tends to avoid competition on the main routes, but has strength in specific regional markets.

## 7 Conclusions

The research confirms that there exist important differences in ATTs between carriers. While all container shipping lines experience longer than average turnaround times in ports on occasion, it is demonstrated that certain carriers exhibit consistently longer turnarounds across the spectrum of ports of call. Others, in contrast, manage to achieve better than average turnarounds, even in ports where overall ATTs are longest.

The results suggest that long ATTs are not due entirely to problems in the port: lower STS crane efficiencies, labour issues, congestion in the terminals and at the gate entrances etc. If this were the case there would be narrower differences overall between carrier performance across the spectrum of

ports. It must be concluded that carriers themselves are partly responsible for the differences. For example, while it is known that weather and delays in a previous port of call affect the punctuality of vessel arrivals, there are differences between the carriers in their responses to these service interruptions. Similarly, differences in vessel slot storage plans are identified as constraints on terminal operations. Some carriers are evidently more oriented towards service regularity and reliability, while others appear to be more tolerant of delays and adopt more flexible schedules that may result in longer port stays.

The range of ATTs between carriers indicates that time and performance levels in the container shipping industry must take into account internal operational and policy differences between the companies. In this paper several factors have been put forward to account for the differences. Clearly there is a need to explore further the relationships with quantitative testing and other forms of analysis. Several lines of enquiry are suggested. Costing of different strategies employed to respond to service disruptions would be very important. Achieving on-time arrivals may result in lower faster turnarounds and therefore lower port costs, but it may require higher fuel costs as vessels have to catch up on inevitable delays *en route*. Conversely, carriers operating in less rigid schedules with lower fuel costs but experiencing longer ATTs must be facing higher terminal charges. Finally, because the significance between propriety systems. To what extent are operational issues in the different ports of call factored into the software?

Finally, we note that while AIS affords a comprehensive and accurate way to measure transits and time in port it provides academic researchers with a new set of issues to explore and explain.

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