Container ship fleet forecast and maritime economic assessment

Prepared for:

INFRASTRUCTURE VICTORIA

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PRIVATE & CONFIDENTIAL

Drewry Maritime Advisors

Drewry background and scope discussion

Drewry Background

- Founded in 1970.
- Drewry is an independent research and advisory organisation for the maritime sector.
- Our research and advisory business units provide an industry-leading, unrivalled knowledge base. We use our continuing research, specialist knowledge and global offices to constantly analyse and decipher the shipping and ports sector globally.
- We combine and focus our resources for each project and each client, building trusted relationships where our advice is at the core of commercial decision-making.
- Drewry has previously carried out similar exercises on ship size projections for port planning and development, both globally and in Australia. These include
  - Shipping Line Investigations and Fleet Forecast study – Port of Hastings Development Corporation (2013)
  - Port of Melbourne Corporation – Structure of ship fleet study (2011)
  - Port of Durban dig out plan – Ship size forecast (2014)
  - World fleets: trades, trends and forecasts – container and bulk trades – Various conference presentations

Scope of Drewry engagement

- Infrastructure Victoria (IV) has commissioned Drewry to analyse the global container ship fleet, its likely development and implications for Australia. This work is to be part of the IV port assessment and will be used to discuss the size credible to visit Southeast Australia in future. How responsive does Australia need to be in accepting larger ships to cascade implications and the fact that there is limited competition between ports and most cargo goes to the port that is closest to the capital city where most of the freight will be consumed?
- Following are the specific items of scope to cover:
  - Review the current and future container fleet
  - Historic evolution of demand and supply issues in the container market
  - Review the impact of vessel upsizing on container freight rates
  - Demonstrate the cost savings that can be made through vessel upsizing
  - Determine factors that can impact decisions of vessel upsizing
  - Recommend a reasonable planning ship size for a future port servicing Victoria and detail why this was selected and what timeframe it covers

Contents

Executive summary

Current and future container fleet

The container fleet has grown relentlessly since 2001, from 5.3 million TEU in 2001 to 20 million TEU in 2016, at a CAGR (2001-2016) of 9.2%, with ships of over 8,000 TEU currently accounting for 45.3% (9.1 million TEU) of the world cellular container fleet. A combined nominal capacity of 3.2 million TEU, corresponding to about 16% of the existing fleet in capacity terms, is currently on order, with 78% of this orderbook comprising ships of 10,000 TEU and above. This figure also includes ships of up to 21,100 TEU currently on order. The 249 vessels on order that are under 8,000 TEU account for 17.3% of the capacity, while the 175 vessels on order that are over 8,000 TEU account for 82.7% of the capacity.

There have been step changes in ship dimensions, mainly because of upscaling of the conventional design of container ships. The current global container fleet has an average LOA of less than 300 mtrs for ships under 7,000 TEU, which quickly increases to 400m for ships of 18,000 TEU plus. For all container ship size ranges there is a spread around the average dimensions, which can be significant even in smaller ship sizes. Future dimensions of container ships would be influenced by various factors, with the addition of an extra row of containers that would influence the vessel's beam. DNV GL has worked typical dimensions of future container ships, which in theory could reach 26,300 TEU. However, this size would not be suitable to transit the Suez Canal and would also require a new structural design that would act as a natural constraint and a deterrent of ship size growth.

Historic evolution of demand and supply issues in the container market

Global supply growth has far outpaced demand growth, mainly driven by economies of scale, resulting in increasing supply-demand imbalance. More recently, container ship scrapping has picked up pace because of various factors. As a major industry modifier, this scrapping momentum is most likely to continue. New industry regulatory requirements to be enforced in the next few years will also hugely affect ship owners and could be additional drivers for more demolitions. The historical balance between global fleet growth (after adjustments) and Drewry's measurement of global container traffic growth after deducting empties and transhipment volumes indicates that the industry has remained oversupplied for container capacity. Such is the scale of the drive for bigger ships that the Drewry global supply-demand index is heading lower and is unlikely to near the balancing number of 100 until 2019.

Impact of vessel upsizing

The increasing size of container ships is affecting all trade routes. There is a heavy bias towards the largest ships for the Asia-Europe trade where average vessel size is 14,936 TEU and the largest operational ship is *MSC Oscar* of 19,244 TEU. Transpacific trade has increased significantly in terms of the size of vessels transiting the Panama Canal to US East Coast ports from Asia. The average size of these vessels has increased by 46% to 6,600 TEU, and this trend will continue throughout 2017 as operators take advantage of the opportunities offered by the widened Panama Canal.

Executive summary

Australian container trade is served by 27 deep-sea loops through a complex mix of joint services, consortia and multi-area coverage. North East Asia and Japan is a key trade lane with 10 services as is South East Asia with 8 services. Europe and North America are served by 3 services each. On the Australian trades, average vessels of 5,700 TEU are currently operating on the NE Asia-Australia route. The largest ship deployed on the Australian trade is the 7,455 TEU E.R. Long Beach on the Europe-Australia trade followed by the 6,350 TEU *MOL Prestige* deployed on the NE Asia-Australia trade. While Sydney can handle ships of 10,000 TEU, Melbourne, with its 300 metre length swing basin constraint and the other limits imposed by the Yarra Channel, limits the Australian service to ships of less than 7,500 TEU (what is now considered a relatively small size for deep-sea trades). Even some of these relatively small vessels are restricted by tide, daylight time arrivals, height of the West Gate Bridge and weather conditions, constraints that combine to make ship owners cautious about testing the official port limits with vessels that may be delayed from time to time. This is particularly important for the container trades that have to match schedules to windows in other ports.

An assessment of the 169 vessels deployed in servicing Australian ports by vessel length overall (LOA) shows the fleet limited by Melbourne's 300 metre length swing basin constraint. In July 2016, Maersk announced that it would deploy 9,500 TEU vessels into Auckland. This is typical of the trend in North-South routes. While Australia has 2 ports in the top 100 container ports of the world (Melbourne at 60 and Sydney at 72), smaller ports attract larger ships.

Impact of vessel upsizing on container freight rates

There is a negative correlation between freight rates and ship sizes over the medium term. Looking at 6 Australian and global routes over the last 6 years shows that approximately 1% increase in average ship size has resulted in a 1% fall in freight rates – resulting from unit cost economies from ship size. However, there are big variations between trade routes. On routes where vessel upsizing has been sudden, like Asia-Brazil and to a lesser extent US West Coast-Australia, freight rates have also decreased sharply, although the 2 trends do not occur at the same time. Freight rates are subject to more swings than ship sizes. The 4 other trade routes indicate the same overall negative relationship between changes in ship sizes and freight rates, with variations and temporary dislocations along the trend lines. Overall, we do not see a strong correlation between the times when average ship sizes increase faster (significant upsizing) and when freight rates fall faster. All we see is that rates move down most years, as ship sizes generally go up, and that the two trends are correlated over the medium term.

The global shipping supply-demand balance has a strong influence on freight rates. This has always been the case in container shipping. In the last 5 years, growing overcapacity has triggered a price war on most trade routes. The correlation coefficient between the average rates on the 6 routes and the global supply-demand balance is 0.89 Behind the supply-demand balance is the marine bunker price, a less important driver of freight rates. The correlation coefficient between the average rates on the 6 routes and marine bunker prices is 0.58.

There are many dislocations in freight rates that cannot be explained by changes in ship sizes, by supply-demand or by bunker costs. It is generally believed that the explanation for these is the 'carrier behaviour' factor – when major carriers change their competition behaviour.

Factors that can impact decisions of vessel upsizing

Shipping lines will nearly always choose the largest vessel that they can fill with cargo on a weekly rotation. The cost savings to Australia of upgrading from a 5,000 TEU to 11,000 TEU ship would be significant.

Executive summary

Carriers have been forced to create new alliances to deploy their largest ships in the best services, remain competitive on slot costs and absorb the new tonnage being delivered. A similar result would be seen on the non-East West as well as Australian trades as bigger ships cascade onto these routes and alliance networks spread beyond the usual key trades.

The allocation of capacity and ship size selection is driven by trade factors and strategic carrier behaviour such as routing and transhipment initiatives. This network is further shaped by global fleet availability for cascading and by trade lane competition. This ever-changing market results in alliances, consortia and vessel-sharing arrangements.

Currently the trade volume and market share between alliances sets the limit on the use of vessels in Australia to 7,500 TEU. However, it is the existence of the port constraints that makes it difficult for an aggressive shipowner to take market share by stepping up a class size and deploying larger and lower per TEU cost vessels. Drewry considers that without the constraints, there would currently be demand for larger ships, as already seen in ports smaller than Melbourne. Indeed, the Harbour Master in Melbourne has had numerous inquiries by shipowners to berth vessels of over 300 m LOA.

Despite being the largest container port by volume in Australia, Melbourne is also the port that limits ship size along the East Coast route. Melbourne's turning circle is the governing constraint on ship upsizing for all Australian East Coast ports. The 300 m LOA for Melbourne constrains vessels to under 7,500 TEU from the general fleet. Given that this LOA limit was adopted for the design vessel by PoMC for Webb Dock and the capacity upgrade, it is possible that Webb Dock may not be permitted to take larger vessels, even though it could physically handle them.

A future port in Victoria could lift the limits allowing ships of over 7,500 TEU to service Australia.

Key considerations and implications for design ship for a future port servicing Victoria

Container ship sizes depend on Australia-wide volumes, consolidation of alliances and the choice between transhipment and direct service. In addition, the volume to adjacent markets such as New Zealand would influence the ship size. Indeed, reports from New Zealand indicate that vessels on the swing trade are constrained by Australian limits.

Ships tend to be 90% utilised on the head-haul trade with all alliance operators using similar-sized vessels within a service. However, competing alliances on the same trade route can deploy a group of vessels as much as 50% smaller than the vessel sizes used by the more aggressive alliances.

Our projection of future ship size is based on the Drewry density index, a measure indicating the propensity to use larger vessels on a route; furthermore, our assumptions include alliance consolidation and the incidence of transhipment.

Forecast ship size – scenario 1:

Container vessels calling Australian ports are limited by ship sizes due to restrictions in channel depth and basin width. Scenario 1 assumes these constraints exist in the future and ship sizes are constrained at 7,500 TEU resulting in a greater number of vessel calls to handle the projected volume.

Executive summary

Forecast ship size – scenario 2:

Scenario 2 assumes that a new Victorian Hub port is established and there are no constraints on vessel size. Trades are served as per their current routing (4 trade lanes - Europe, North America, SE Asia and N Asia) with some rationalisation of services on North Asian and South Asian trades, but no change in European and North American trades.

Average ship size increases to 18,000 TEU by 2030 and maximum ship size increases to 20,000 TEU.

Forecast ship size – scenario 3:

Scenario 3 assumes that a new Victorian Hub port is established and there are no constraints on vessel size. Trade from Europe is served entirely via transhipment at Singapore with no direct services until 2025. Trade from North America is also served entirely via transhipment with 70% being transhipped via Hong Kong and 30% via Singapore. There is also some rationalisation in the number of services on North Asian and South Asian routes.

Forecast design ship recommendation:

Investment in channel width, depth and infrastructure depends on the selection of the design vessel. Drewry selects a typical vessel within the size band for the design vessel rather than one at the extreme end of the range.

Drewry had previously presented a generic container ship design vessel *Honolulu Bridge* of 8,614 TEU for the medium term. Although the Yarra Basin turning circle in Melbourne limits ships of this size, the opening of Webb Dock in 2Q2017 may overcome this constraint. As the life of a container terminal is about 40 years, and assuming the government wishes to match the port infrastructure with the market, the new facility should at least consider a design vessel of 18,000 TEU.

Drewry realises that this size may seem difficult to appreciate starting from the current Australian shipping profile. Nonetheless, further liner grouping and consolidation along with the continued trend towards transhipment suggest that this design vessel is the most probable requirement for the long term. Indeed, the alternatives are either the opportunity cost borne nationally by sub-optimal port infrastructure in Melbourne, or a lower trade forecast which implies lower GDP growth.

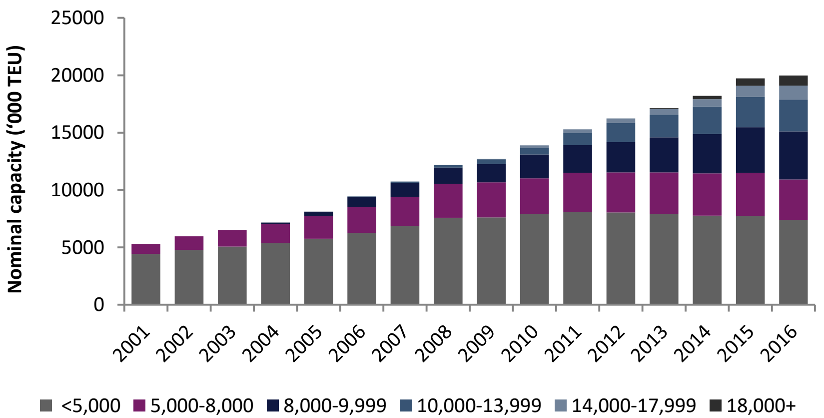
Review of global containership fleet

The container fleet has grown relentlessly since 2001 from 5.3 million TEU in 2001 to 20 million TEU in 2016, at a CAGR (2001-2016) of 9.2% with ships of over 8,000 TEU currently accounting for 45.3% (9.1 million TEU) of the world cellular container fleet.

As of 01 January 2017, the cellular fleet comprised 5,154 vessels at a nominal capacity of 20 million TEU, with ships of more than 8,000 teu driving capacity growth. This being driven by the need to have the competitive advantage of lowest operating slot cost. It is now evident that the share of total capacity represented by ships of over 8,000 TEU has continued to rise for some time now with capacity from ships of over 8,000 TEU at 45.3% (9.1 million TEU) of world cellular container fleet, although this group only includes 836 vessels, 16.2% of the number of cellular container fleet worldwide.

The composition of the current container fleet indicates definite trends with ships of 10,000-13,999 TEU, new Panamax size vessels, capable of transiting the expanded Panama Canal, constituting 13.9% of global container ship capacity. However container ship size has continued to grow beyond the expanded Panama Canal dimensions i.e. 'Post New Panamax' category with ships of 18,062 TEU being the largest currently in service.

Development of world cellular container fleet by size range



World cellular containership fleet by size range (1 January 2017)

Size range TEU	Number of vessels	Share %	Capacity '000teu	Share %	Average age
<500	329	6.4%	98	0.5%	21.5
500-999	705	13.7%	531	2.7%	14.3
1,000-1,499	700	13.6%	814	4.1%	12.7
1,500-1,999	546	10.6%	937	4.7%	12.3
2,000-2,499	260	5.0%	603	3.0%	14.2
2,500-2,999	358	6.9%	961	4.8%	10.9
3,000-3,999	249	4.8%	861	4.3%	10.8
4,000-4,999	583	11.3%	2,578	12.9%	9.7
5,000-5,999	308	6.0%	1,670	8.4%	11.3
6,000-6,999	230	4.5%	1,507	7.5%	9.9
7,000-7,999	50	1.0%	365	1.8%	10.3
8,000-9,999	478	9.3%	4,185	20.9%	6.7
10,000-13,999	228	4.4%	2,768	13.9%	4.4
14,000-17,999	83	1.6%	1,227	6.1%	3.3
18,000+	47	0.9%	881	4.4%	1.6
Grand Total	**5,154**	**100.0%**	**19,985**	**100.0%**	**11.6**

Global ship development trends - orderbook analysis

Combined nominal capacity of 3.2 million TEU, corresponding to about 16% of the existing fleet in terms of capacity, is currently on order. About 78% of the order book is accounted for by ships of 10,000 TEU and above, and up to 21,100 TEU.

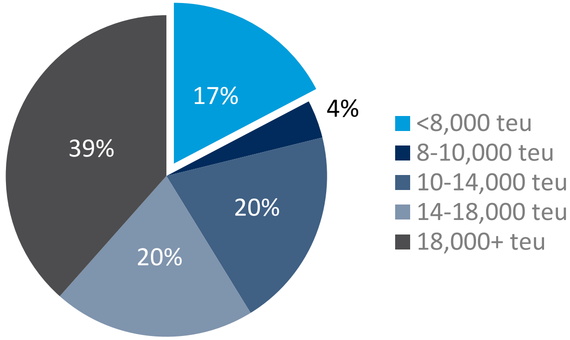
At the beginning of January 2017, the order book accounted for 424 container ships, with a combined nominal capacity of 3.2 million TEU, corresponding to about 16% of the existing fleet in capacity terms. A large proportion of the orderbook comprises ships ordered before 2015. So much has been made of the orderbook and its impact in recent years, but it has virtually stopped and only about 200,000 TEU was contracted during 2016 – a complete reversal of the 2 million TEU ordered in 2015. This is by far the lowest amount of new tonnage ordered in any given year in the six-year period since the orderbook came back on stream after the 2008-09 recession. The annual average over this six-year period is 1.19 million TEU.

The graph below shows the distribution of standing capacity of container ships on order for different size segments. In terms of standing capacity, the impact of the largest ships on order is seen with 78% of the order book being accounted for by ships of 10,000 TEU and above.

Carriers' fleet composition has entered a new era with the 10,000 TEU vessel now very much smaller than the largest ships of 19,200 TEU in operation and of 21,100 TEU on the orderbook.

The top 20 carriers are firmly locked into the theory that big ships are eco ships and will save on slot costs, and that the 13,000 TEU vessels currently in operation are simply not big enough to generate the required economies of scale and fuel savings.

Order book by size range (% of TEU capacity), 1st January 2017



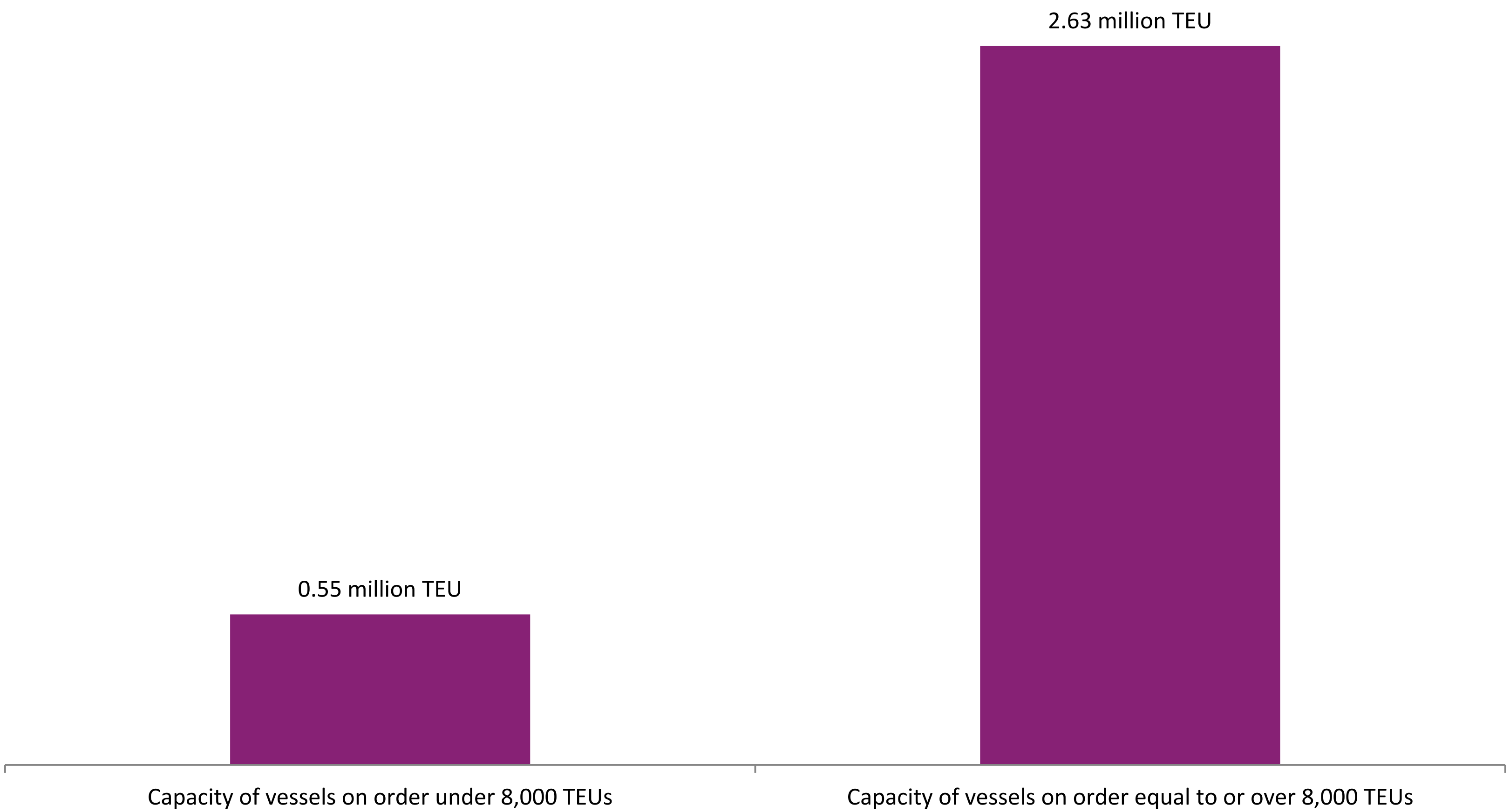
Order book by size range compared to current fleet, 1st Jan 2017

	Current OB	Current fleet	% of current fleet
<1,000	3	628	0.5%
1,000-2,000	169	1751	9.7%
2,000-3,000	216	1564	13.8%
3,000-5,000	119	3439	3.5%
5,000-8,000	44	3542	1.2%
8,000-9,999	122	4185	2.9%
10,000-13,999	639	2768	23.1%
14,000-17,999	648	1227	52.8%
18,000+	1225	881	139.0%
Grand Total	**3186**	**19985**	**15.9%**

Order book by vessel capacity - under 8,000 TEU and over 8,000 TEU

The 249 vessels on order that are under 8,000 TEU account for 17.3% of the capacity. The 175 vessels on order that are over 8,000 TEU account for 82.7% of the capacity

Capacity of vessels on order split by vessels under 8,000 TEU and over 8,000 TEU



Typical ship dimensions (existing fleet)

Step changes in ship dimensions have mainly been achieved by upscaling the conventional design of container ships. The current container fleet has an average LOA of less than 300 m for ships under 7,000 TEU, which quickly increases to 400m for ships of 18,000 TEU plus. All container ship size ranges are spread around the average dimensions. This spread can be significant even in smaller size ranges.

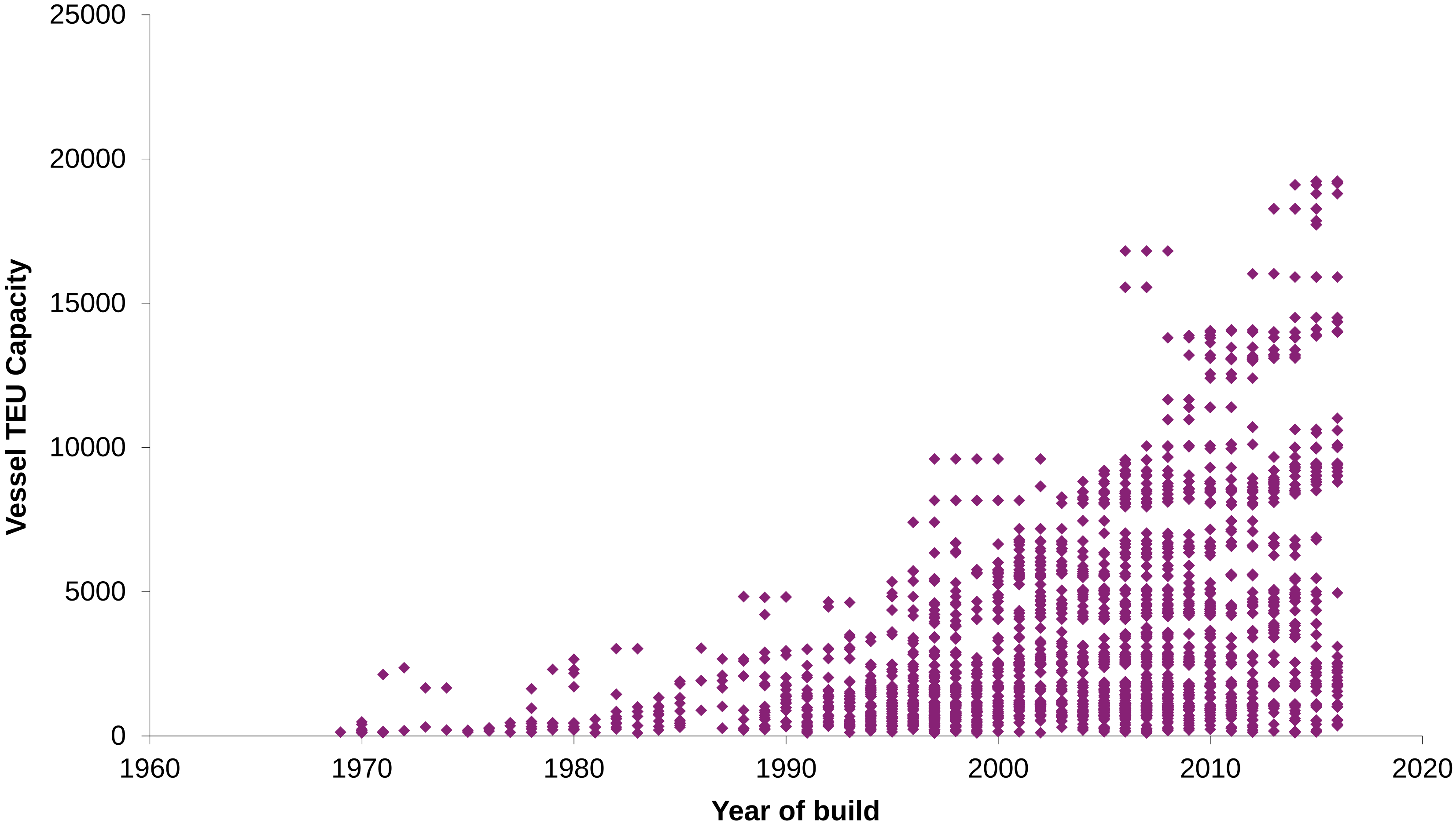
Average ship dimensions of existing containership fleet, 01 January 2017

Ship size band nominal capacity	Average of LOA (m)	Max of LOA (m)	StdDev of LOA (m)	Average of Beam (m)	Max of Beam (m)	StdDev of Beam (m)	Average of Draught (m)	Max of Draught (m)	StdDev of Draught (m)
<500	99.6	137.3	13.3	16.5	21.5	2.0	5.6	8.0	1.0
500-999	132.3	179.0	12.2	21.0	27.1	1.8	7.6	10.1	0.9
1,000-1,499	155.9	217.1	11.9	24.3	28.4	1.6	8.8	11.3	0.7
1,500-1,999	178.9	219.6	9.5	27.2	31.0	1.2	10.0	11.5	0.8
2,000-2,499	199.9	272.3	13.1	30.2	32.3	1.4	11.0	12.5	0.7
2,500-2,999	213.5	272.3	10.8	30.7	35.2	1.1	11.6	14.0	0.5
3,000-3,999	235.9	288.0	14.7	33.0	37.3	1.8	11.9	13.2	0.7
4,000-4,999	268.9	300.0	14.3	33.2	40.0	2.0	12.7	14.0	0.8
5,000-5,999	281.3	294.2	10.9	37.5	43.5	3.6	13.5	14.5	0.7
6,000-6,999	298.1	318.4	9.9	40.5	43.4	1.1	14.1	24.6	1.1
7,000-7,999	304.5	320.4	8.2	43.2	45.2	0.9	14.0	14.5	0.5
8,000-9,999	326.1	366.9	17.9	45.0	48.4	2.3	14.4	15.5	0.5
10,000-13,999	356.6	368.5	15.3	48.3	51.2	1.7	15.0	16.0	0.8
14,000-17,999	375.8	399.2	13.8	52.1	56.4	1.8	15.6	16.0	0.5
18,000+	399.0	400.0	1.6	58.8	59.1	0.2	15.6	16.0	0.7
Grand Total	**220.1**	**400.0**	**79.4**	**31.3**	**59.1**	**9.6**	**11.0**	**24.6**	**2.9**

Containership size evolution and different ‘generations’ of ships

Ship Type	Period	TEU Capacities	Example of Vessel	TEU Capacity	Length (m)	Beam (m)	Maximum Draft (m)	Deadweight	Built
First Generation	1968-	1,200-1,400	Horizon Discovery	1,404	213.5	27.5	9.8	20,585	1968
Second Generation	1970-80	2,000-3,000	Horizon Reliance	2,653	272.3	30.5	12.4	45,805	1980
Panamax	1980-90	3,000-5,000	SSgt Edward A Carter Jr	4,614	289.5	32.3	12.7	58,869	1985
Post-Panamax	1988-	4,000-12,000	President Truman	4,300	274.9	39.3	12.5	52,769	1988
Post-Panamax (variation)			OOCL Hong Kong	5,344	276.0	40.0	14.0	67,625	1995
Post-Panamax (variation)			Maersk Kure	7,403	318.2	42.8	14.5	90,456	1996
Post-Panamax (variation)			Susan Maersk	9,600	347.0	42.8	14.5	104,696	1997
New (Neo) Panamaxes	2010-	12,000-13,000	MSC Beryl	12,400	365.8	48.4	15.0	139,419	2010
Super Post-Panamax	2006-	13,000-18,000	Emma Maersk	15,550	397.7	56.4	15.5	156,907	2006
Super Post-Panamax (variation)			CSCL Venus	14,074	366.1	51.2	15.5	155,470	2011
Super Post-Panamax (variation)			CMA CGM Marco Polo	16,020	395.0	53.6	16.0	186,470	2012
18,000TEU (Maersk Triple Es and variations)	2013-	18,000-21,000	Maersk Mc-Kinney Moller	18,270	399.9	59.0	16.0	194,153	2013
	2015-		CSCL Arctic Ocean	19,000	400.0	58.6	16.0	186,000	2015
	2015		MSC Oscar	19,244	395.4	58.6	16.0	196,000	2015
	2017-		OOCL TBN	21,100	400.0	58.8	n.a.	246,051	On order
Wide beam WafMax	2011-	4,500	Maersk Cabinda	4,496	249.1	37.4	13.5	61,547	2012
Wide beam for South America	2011-	9,000-10,000	Cap San Antonio	9,669	333.2	48.2	14	124,424	2014

Global container fleet TEU vs year of build, 01 January 2017



Typical ship dimensions (future ships)

Future dimensions of container ships would be influenced by various factors, and the most important factor is the addition of an extra row of containers that would widen the vessel's beam. DNV GL has worked typical dimensions of future container ships that in theory could reach 26,300 TEU, although this size would be unsuitable to transit the Suez Canal. It would also require a new structural design that will constrain and deter ship size growth.

ULCV concept design options and principal dimensions

Bays	Rows	Tiers	TEU nominal	LOA (m)	Lpp (m)	B (m)	T (m)	DWT
24	23	12	20,332	400.00	383.00	58.60	15.00	178,895
24	23	12	20,332	400.00	383.00	58.60	16.00	198,592
24	23	12	20,332	400.00	383.00	58.60	17.00	218,756
24	24	12	21,325	400.00	383.00	61.10	15.00	186,599
24	24	12	21,325	400.00	383.00	61.10	16.00	207,131
24	24	12	21,325	400.00	383.00	61.10	17.00	228,149
24	25	12	22,228	400.00	383.00	63.60	15.00	194,581
24	25	12	22,228	400.00	383.00	63.60	16.00	215,947
24	25	12	22,228	400.00	383.00	63.60	17.00	237,819
26	23	12	22,212	430.00	413.00	58.60	15.00	192,420
26	23	12	22,212	430.00	413.00	58.60	16.00	213,669
26	23	12	22,212	430.00	413.00	58.60	17.00	235,468
26	24	12	23,301	430.00	413.00	61.10	15.00	200,719
26	24	12	23,301	430.00	413.00	61.10	16.00	222,900
26	24	12	23,301	430.00	413.00	61.10	17.00	245,592
26	25	12	24,264	430.00	413.00	63.60	15.00	208,940
26	25	12	24,264	430.00	413.00	63.60	16.00	232,022
26	25	12	24,264	430.00	413.00	63.60	17.00	255,636
28	25	12	26,316	460.00	443.00	63.60	15.00	222,849
28	25	12	26,316	460.00	443.00	63.60	16.00	247,652
28	25	12	26,316	460.00	443.00	63.60	17.00	273,014

Source: DNV GL – ULCS - The next generation will be Suezmax

- Future dimensions of container ships would be influenced by various factors, with the most critical being additional capacity by introducing an extra row of containers that would influence the vessel's beam (or width).
- The key dimensions of a 20,000 TEU ULCV currently being built are outlined below:
  - DWT – 250,000 tonnes
  - LOA – 400 metres
  - Beam – 59 metres
  - Containers across weather deck – 23 rows
  - Draft – 16 metres
  - Service speed – 21 knots
- In a study carried out by DNV GL the firm has concluded that by increasing the beam to 25 rows and length to 28 bays, the capacity of a ULCV could reach 26,300 TEU. These would be ships of LOA 460.0m, beam 63.6m and draft 17.0m. Such supersize ships would be too big to sail through the new, expanded Suez Canal in a fully laden state. This would also require a new structural design concept, introducing "strength coaming" on top of the sheer strake, and therefore it is unlikely that such a ship will be ordered in the near future, even though it would reduce the fuel cost per TEU.

Container ship demolition and fleet renewal cycle

Container ship scrapping has picked up pace because of a number of factors and, as a major industry modifier, the scrapping momentum is likely to continue. New industry regulations that will come into force over the next few years could also increase scrapping, affecting ship owners to a large extent.

The pace of scrapping has picked up because of various factors and, as a major industry modifier, the scrapping momentum is likely to continue. Such has been the pace of scrapping in the container sector last year that of the total capacity scrapped in 2016, ships of more than 4,000 TEU accounted for 66%. Until 2012, the scrapping of a 4,000 TEU vessel was virtually unheard of, and the average operational life of container vessels was still around 25 to 30 years. However, more recently ships as young as 10 years (*YM Los Angeles* 4,923 TEU, built in 2006) are being scrapped and replaced by even younger, bigger and more efficient ships. These younger ships being scrapped are mainly in the in sub-8,000 TEU category. New regulatory requirements to be enforced over the next few years will also hugely affect ship owners and could be additional drivers for scrapping.

Since the orderbook for intermediate and smaller size categories (<4,000teu) is small, and these ships will also not be competitive in the global fleet outside the feeder trades, their fleet will be much less important than it is today.

The age and renewal of containerships will result in intermediate and smaller size categories (<4,000teu) becoming scarce globally over the next 20 years. This is likely to affect many North-South trade routes including those of Australia.

Container ship sales for demolition, 2010-16 (TEU)

Range (TEU)	<500	500-999	1,000-1,499	1,500-1,999	2,000-2,999	3,000-3,999	4,000+	Total	Share of 4000+ TEU scrapped	Avg age	Avg TEU	No. of ships scrapped
2010	5,104	14,391	19,033	10,932	31,906	35,452	13,879	130,697	11%	29.9	1,504	83
2011	7,902	3,376	15,295	9,511	31,224	10,474	-	77,782	0%	30.1	1,325	61
2012	5,283	17,570	38,051	57,445	107,086	100,445	8,493	334,373	3%	23.4	1,867	182
2013	5,328	15,878	37,408	59,995	54,231	188,333	83,168	444,341	19%	22.5	2,283	199
2014	6,893	23,566	32,500	16,216	59,912	73,163	169,128	381,378	44%	23.4	2,230	171
2015	2,746	14,507	6,974	25,601	42,700	30,475	71,172	194,175	37%	22.9	2,158	90
2016	1,017	9,377	17,131	18,773	115,181	57,397	439,198	658,074	67%	19.0	3,392	194

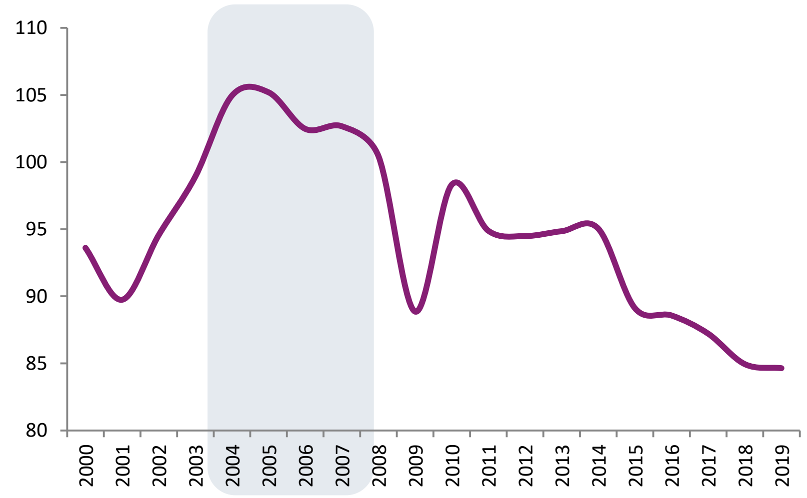
Drewry's global supply-demand balance

The historical balance between global fleet growth (after adjustments) and Drewry's measurement of global container traffic growth after deducting empties and transhipment volumes indicates that the industry has remained oversupplied. Such is the scale of the drive for bigger ships has led the Drewry global supply-demand index is heading lower and is and likely to remain below 100 beyond 2019

The historical balance between global fleet growth (after adjustments) and Drewry's measurement of global container traffic growth after deducting empties and transhipment volumes indicates that the industry has remained in a trough since the Drewry global supply-demand index (100 = equilibrium) fell in 2008. A reading of 100 represents equilibrium and conditions that support rate increases.

An analysis of the container market since 2000 suggests that the industry has been oversupplied except during 2003-2008 when the Drewry global supply-demand index increased to above 100. Carrier action to withdraw capacity, combined with an unexpected rise in demand, improved the balance in 2010, but thereafter the market deteriorated because of low demand and overcapacity. In an effort to exploit economies of scale carriers introduced large ships into their networks resulting in a cascading of larger ships on all trade routes. Demand growth has been very weak in 2015 and 2016 which, coupled with an overhang of excess capacity, has impacted the balance. As illustrated in the graph alongside, the supply-demand balance is heading towards an unhealthy, southerly direction with the Drewry global supply-demand index is heading lower and is and likely to remain below 100 beyond 2019

Drewry global supply-demand index (100 = equilibrium)



Global ship development trends by trade route

The increasing size of container ships is affecting all trade routes, with a heavy bias towards the largest ships for the Asia-Europe trade where the average vessel size is 14,936 TEU (the largest operating ship is *MSC Oscar* of 19,244 TEU). Vessel sizes on the transpacific trade transiting the Panama Canal to US East Coast ports from Asia have also increased significantly (the average has gone up by 46% to 6,600 TEU), a trend that will continue in 2017 as operators take advantage of the opportunities offered by the widened canal.

The scale of changes in the structure of the container fleet and the continuing trend for even larger ships on order will have repercussions on all trade routes. This trend will gather momentum with the opening of the widened Panama Canal.

There is a heavy bias towards the largest ships for the Asia–Europe trade. The average size deployed on this trade lane is 14,936 TEU and the largest operating ship is *MSC Oscar* (19,244 TEU). The average vessel size on the two Asia-Europe trades has increased by 9.7% in the past 12 months. Even in the Mediterranean, where there are some port restrictions in the East, the average size has reached 10,000 TEU. The Asia-Europe trade will be unable to absorb the additional capacity without cascading the existing ships on to other trade routes.

The key change on the transpacific trade has been the significant increase in the size of vessels transiting the Panama Canal to US East Coast ports from Asia. The average size of these vessels has increased by 46% to 6,600 TEU, and this trend will continue throughout 2017 as operators take advantage of the opportunities offered by the widened Panama Canal.

Summary of selected major East-West trade routes

	Number of Weekly Services (OCT 1)		Average Vessel Size per Weekly String (TEU)		No. of Vessels of 8,000-9,999 TEU	No. of vessels of 10,000 TEU+	% Change in Average Vessel Size
	4Q15	4Q16	4Q15	4Q16	4Q16	4Q16	4Q16/4Q15
Far East/Europe headhaul							
Far East/N Europe	19	16	14,076	14,936	6	175	6.1%
Far East/Mediterranean (direct)	15	14	9,303	10,071	37	77	8.3%
Total	**34**	**30**	**11,659**	**12,789**	**43**	**252**	**9.7%**
Transpacific headhaul							
Far East/USEC - Panama	15	10	4,537	6,637	29	10	46.3%
Far East/USEC - Panama/Suez		2		8,690	21		
Far East/USEC - Suez	7	4	7,762	7,673	18	4	-1.2%
Far East/USWC	41	36	7,638	7,890	105	42	3.3%
Far East/USWC and USEC	3	4	7,453	7,996	38	13	7.3%
Total	**66**	**56**	**6,856**	**7,661**	**211**	**69**	**11.7%**
Transatlantic headhaul							
Eur/N Atlantic	12	8	4,467	4,843	5		8.4%
Eur/S Atl, USGulf, Mex	5	5	5,030	4,985			-0.9%
Eur/Montreal (Canada)	3	3	3,573	3,605			0.9%
Total	**20**	**16**	**4,277**	**4,720**	**5**	**0**	**10.4%**

Notes: Note: Services sailing via Panama/Cape of Good Hope and Suez/Cape of Good Hope have been included under 'Far East/USEC - Panama' and 'Far East/USEC - Suez' respectively

Source: Drewry Maritime Research

Australian liner services (01 January 2017)

Australian container trade is served by 27 deep-sea services through a complex mix of joint services, consortia and multi-area coverage. North East Asia and Japan is a key trade lane with 10 services as is South East Asia with 8 services. Europe and North America are serviced by 3 services each.

Alliance/Carrier	Service	Trade Route	Australia Ports of call	Maximum ship TEU
MSC	Australia Express	Europe/Med-Oceania	Sydney, Melbourne, Adelaide, Fremantle	7,455
CMA CGM/Hapag-Lloyd/ANL	EAX/New NEMO	Europe/Med-Oceania, SE Asia-Oceania	Fremantle, Melbourne, Sydney, Adelaide	5,928
APL/HMM/Hamburg-Sud/Hapag-Lloyd	FA2/CAS/AAS	NE Asia-Oceania	Melbourne, Sydney, Brisbane	5,466
ANL/Hapag-Lloyd/Hamburg-Sud	Loop A (PSW)/WAS	North America-Oceania	Melbourne, Sydney	3,884
Hamburg-Sud/Hapag-Lloyd	PNW/WAN	North America-Oceania	Sydney, Melbourne, Adelaide	2,741
Hamburg-Sud/Maersk	Trident/Oceania	North America-Central America/Caribbean, North America-Oceania	Sydney, Melbourne	4,250
COSCON/OOCL/ANL	Central loop/A3C	NE Asia-Oceania	Sydney, Melbourne, Brisbane	5,762
Hamburg-Sud/MOL/COSCON/NYK	JKN/ANZL/CNZ/NZJ	NE Asia-Oceania	Brisbane	4,538
Maersk/MSC/Safmarine	Boomerang/New Wallaby Service	NE Asia-Oceania	Brisbane, Sydney, Melbourne, Fremantle, Adelaide	6,350
OOCL/ANL/COSCON	Northern Express/A3N	NE Asia-Oceania	Melbourne, Sydney, Brisbane	5,301
OOCL/MOL/K-Line/Evergreen	AU2/NAX/ESACO/AEA3/NEAX	NE Asia-Oceania	Melbourne, Sydney, Brisbane	5,090
A3 Consortium (COSCON/OOCL/ANL)	Southern Express/A3S	NE Asia-Oceania	Sydney, Melbourne, Brisbane	5,888
Evergreen/TS Line/Yang Ming/Sinotrans	CAT/CAT/STA	NE Asia-Oceania	Sydney, Melbourne, Brisbane	4,620
MEL	ANA	NE Asia-Oceania	Darwin	1,808
MOL/OOCL/PIL	Bight loop (AAA2/AAT/FA2)	SE Asia-Oceania	Fremantle, Melbourne, Adelaide	5,087
OOCL/PIL/Yang Ming/MOL	Torres loop (AAA1/AAB/AA1/FA1)	SE Asia-Oceania	Brisbane, Sydney, Melbourne, Fremantle	5,087
APL/CMA CGM/COSCON	AAX	SE Asia-Oceania	Fremantle, Sydney, Melbourne, Adelaide, Fremantle	5,506
Hapag-Lloyd/OOCL/COSCON/UASC	AUS/AAC1/AOS/SAL/ASA	SE Asia-Oceania	Brisbane, Sydney, Melbourne, Adelaide	4,771
K-Line	WASCO	SE Asia-Oceania	Fremantle	1,708
MSC	Capricorn Service	SE Asia-Oceania	Fremantle, Adelaide, Melbourne, Sydney, Brisbane	3,534
Maersk	Southern Star	SE Asia-Oceania	Brisbane	4,258
PIL/ANL/OOCL/APL/NYK	NZS/NZE/NZX/NZS/KIX	SE Asia-Oceania	Brisbane	5,047
Swire Shipping	West Coast North America/Oceania	North America-Oceania	Brisbane, Geelong, Port Kembla, Brisbane	2,082
AAL/Swire	Australia East Coast/New Zealand MPC	NE Asia-Oceania	Brisbane, Melbourne	2,029
Maersk	Northern Star	SE Asia-Oceania	Sydney	3,003
CMA CGM/Marfret	PDL/NASP	North Europe-North America	Brisbane, Sydney, Melbourne	2,826
PIL/OOCL/CMA CGM/ANL/COSCON	ANZEX/CNS/ANS/NCS	NE Asia-Oceania	Brisbane	4,578

Overview of container ship development trends in Australia

On the Australian trades, the average vessel size of 5,700 TEU is currently operating on the NE Asia-Australia route. The largest ship currently deployed on the Australian trade is the 7,455 TEU *E.R. Long Beach* on the Europe-Australia trade followed by the 6,350 TEU *MOL Prestige* deployed on the NE Asia-Australia trade.

Even on the Australian trades, average vessel sizes have increased significantly on nearly all trade routes in the past 10 years. On the NE Asian and European trades there was a noticeable upsizing in 2016 whilst in the USEC the average ship size has remained stable at 3,690 TEU over the past three years.

The largest ship currently deployed on the Australian trade is the 7,455 TEU *E.R. Long Beach* on the Europe-Australia trade followed by the 6,350 TEU *MOL Prestige* deployed on the NE Asia-Australia trade.

Maximum ship size (TEU) per weekly string in Australia trades 01 Jan 2017

	Largest Vessel on Trade	Nominal TEU	Operator
Eur/Australia	E.R. Long Beach	7,455	MSC
USWC/Australia	Cap Capricorn	3,884	Hamburg Süd
USEC/Australia	Bernhard-S	4,250	Maersk
NE Asia/Australia	MOL Prestige	6,350	Maersk
SE Asia/Australia	APL England	5,506	APL

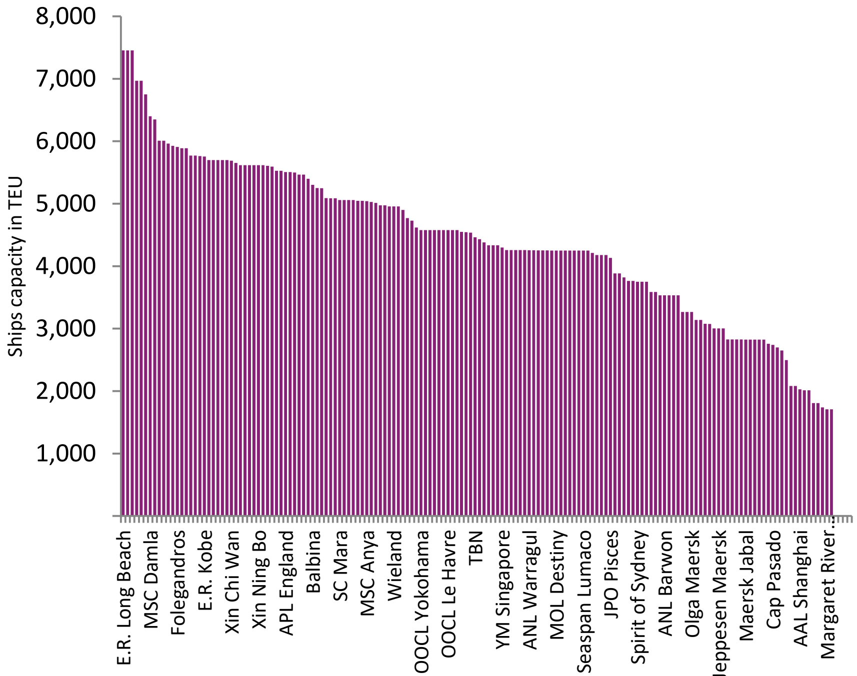
Development of average ship size (TEU) per weekly string in Australia trades 2006-2016

Trade lane	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	% Change in Average Vessel Size 2006/2016
Europe - Australia	4115	3162	3075	3583	3193	3157	4220	4272	4691	4590	5696	**38%**
NAM-Australia	4115	2486	2525	2824	2824	3298	3449	3488	3692	3673	3690	**-10%**
NE Asia - Australia	2973	4251	4353	4579	4652	4922	4812	5349	5594	5417	5706	**92%**
SE Asia - Australia	3799	4176	4239	4579	4652	4710	4812	4810	5009	5199	5,506	**50%**

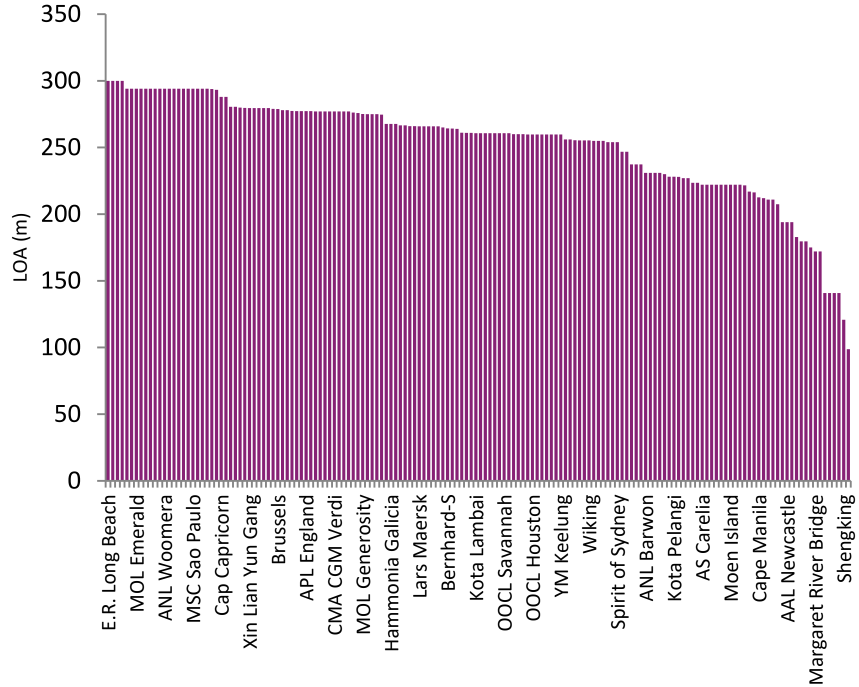
Australian service vessel profile

While Sydney can handle 10,000 TEU vessels, Melbourne, with its 300 metre length swing basin constraint, limits the Australian service to ships of less than 7,500 TEU (what is now considered a relatively small size for deep-sea trades). Some of these relatively small vessels are restricted by tide, daylight time arrivals, height of the West Gate Bridge and weather conditions, constraints that combine to make ship owners cautious about testing the official port limits. An assessment of the 169 vessels deployed in servicing Australian ports by vessel length overall (LOA) shows the fleet limited by Melbourne’s 300 metre length swing basin constraint.

Australian container service vessel list by size - Jan 2017



LOA of Australian container vessels - Jan 2017



Deployment of 8,000 TEU vessels on secondary trade lanes

In July 2016, Maersk announced that it would deploy 9,500 TEU vessels into Auckland. This is typical of the trend in North-South routes. Even though Australia has 2 ports in the top 100 container ports of the world (Melbourne at 60 and Sydney at 72), smaller ports attract larger ships.

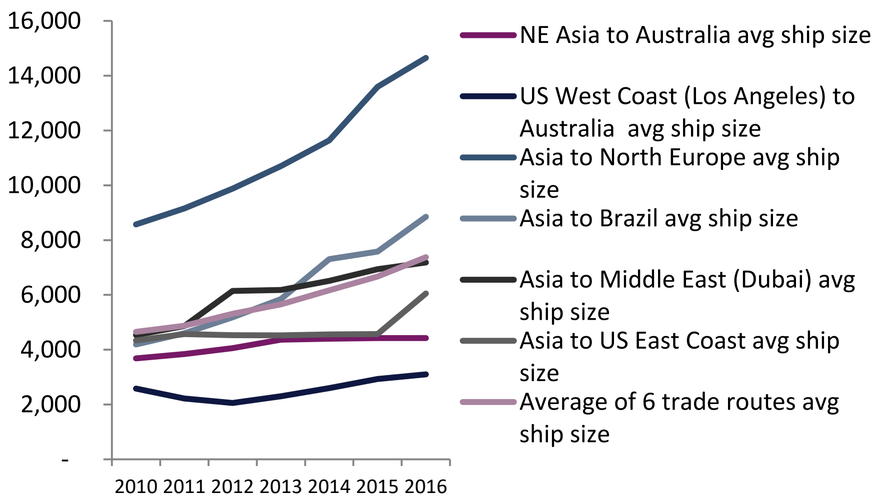
Ports smaller than Melbourne servicing 8,000 to 10,000 TEU vessels

Region	Country	Port	Throughput2015	Max Vessel Size
South America/ Latin Region				
East Coast South America	Argentina	Buenos Aires	1,433,053	10,500
East Coast South America	Brazil	Itajai	983,646	10,500
East Coast South America	Brazil	Itapoa	535,225	10,500
East Coast South America	Brazil	Paranagua	775,877	10,500
East Coast South America	Brazil	Rio Grande	725,721	10,500
West Coast South America	Chile	Coronel	449,000	13,102
West Coast South America	Chile	Puerto Angamos	193,000	13,102
West Coast South America	Chile	San Antonia	1,077,478	13,102
West Coast South America	Chile	San Vicente	456,156	9,600
West Coast South America	Colombia	Buena Ventura	677,059	13,102
West Coast South America	Peru	Callao	1,900,444	13,102
East Coast South America	Uruguay	Montevideo	810,106	10,500
Mediterranean Region				
East Mediterranean & Black Sea	Croatia	Rijeka	200,102	9,074
East Mediterranean & Black Sea	Romania	Constanza	689,012	10,622
East Mediterranean & Black Sea	Slovenia	Koper	790,736	9,074
East Mediterranean & Black Sea	Ukraine	Odessa	372,297	10,622
Africa Region				
East Africa	Mauritius	Port Louis	467,237	11,660
Southern Africa	South Africa	Coega	636,663	11,660
Southern Africa	South Africa	Port Elizabeth	212,576	9,400
West Africa	Ivory coast	Abidjan	610,200	11,660
West Africa	Ivory coast	San Pedro	209,000	11,660
West Africa	Togo	Lome	905,700	11,660

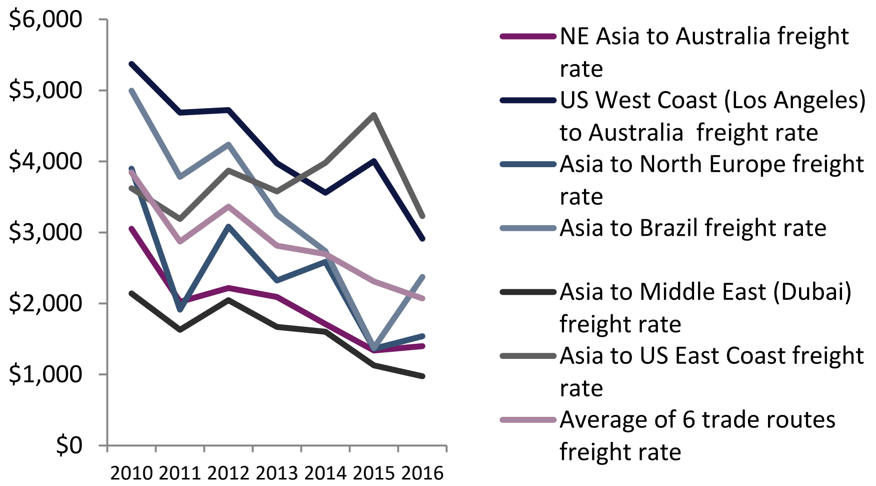
Comparison of freight rates before and after vessel upsizing

There is a negative correlation between freight rates and ship sizes over the medium term. Considering 6 Australian and global routes over the last 6 years indicates that about 1% increase in average ship size has resulted in a 1% fall in freight rates – resulting from unit cost economies from ship size. However, there are big variations between trade routes.

Average ship size by trade route (TEU)



Freight rate by trade route (all-inclusive, in US$/40ft container)



Medium-term development of changes in freight rate and in average ship sizes on several trade routes (2010-16)

	% Increase in average ship size 2016/2010 (B)	% Decrease in average rate 2016/2010 (A)	Ratio (A)/(B)
NE Asia to Australia	20%	-54%	-2.7
US West Coast (Los Angeles) to Australia	20%	-46%	-2.3
Asia to North Europe	71%	-61%	-0.9
Asia to Brazil	111%	-52%	-0.5
Asia to Middle East (Dubai)	58%	-54%	-0.9
Asia to US East Coast	40%	-11%	-0.3
Average	53%	-46%	-0.9

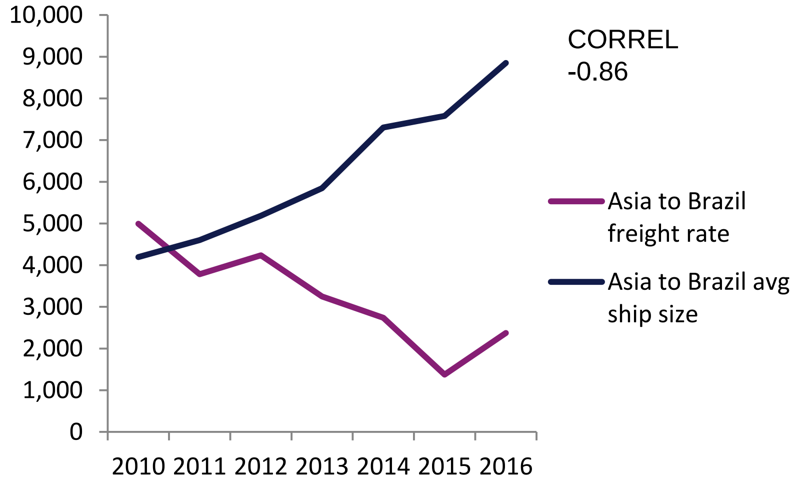
Notes: Freight rates are in US$/40ft container; ship sizes are in TEU

Source: Drewry Maritime Research

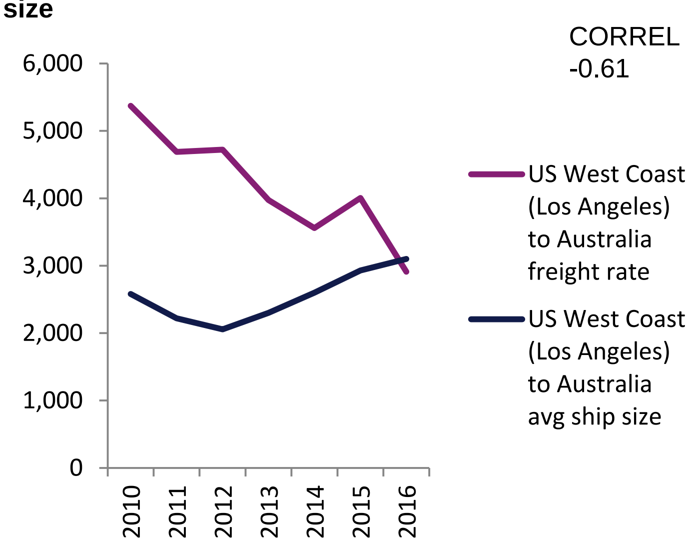
Comparison of freight rates before and after vessel upsizing

On routes where vessel upsizing has been sudden, like Asia-Brazil and to a lesser extent US West Coast-Australia, freight rates have also decreased sharply, although the 2 trends have not occurred at the same time. Freight rates are subject to more swings than ship sizes.

Asia to Brazil freight rate vs ship size



US West Coast (Los Angeles) to Australia freight rate vs ship size



Notes: Freight rates are in US$/40ft container; ship sizes are in TEU

Source: Drewry Maritime Research

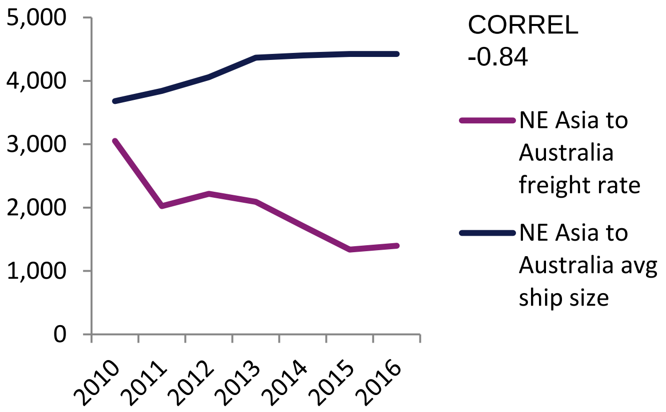
On the Asia-Brazil trade freight rates are highly correlated with ship size, with a coefficient of correlation of -0.86. In 2016, though, there was a counter-intuitive combination of increasing rates and increasing ship sizes. In Drewry's opinion, the 2016 rate increase was caused by a complete change in the behaviour of carriers on this particular trade route (explained later on separate factor of rates).

On the US-Australia route, freight rates are correlated with ship sizes, but only with a coefficient of -0.61. Rates on this route fell by 46% over 2010-16 as the average ship size rose by 'only' 20%. Rates had started to fall in 2010-12 even though the ship sizes at that time were not increasing. This suggests that factors other than changes in ship sizes also affect freight rates.

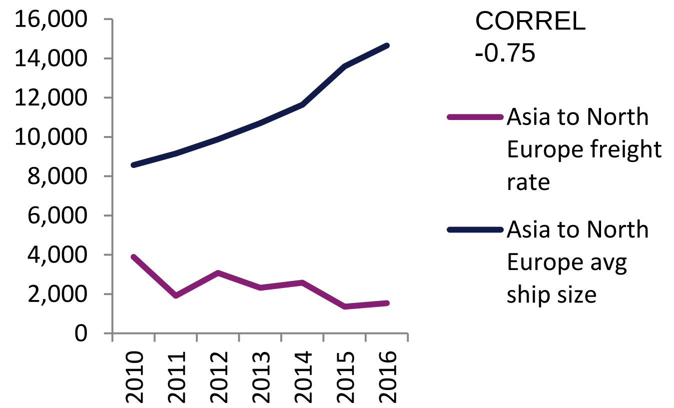
Comparison of freight rates before and after vessel upsizing

The analysis of 4 other trade routes also shows the same overall negative relationship between changes in ship size and changes in freight rates, with variations and temporary blips along the trend lines.

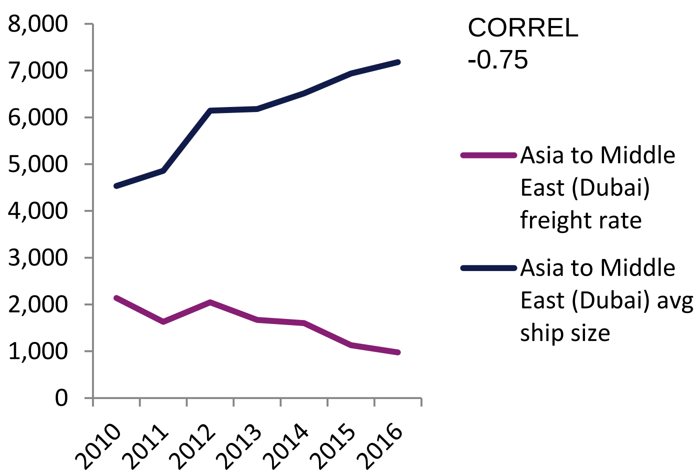
NE Asia to Australia freight rate vs ship size



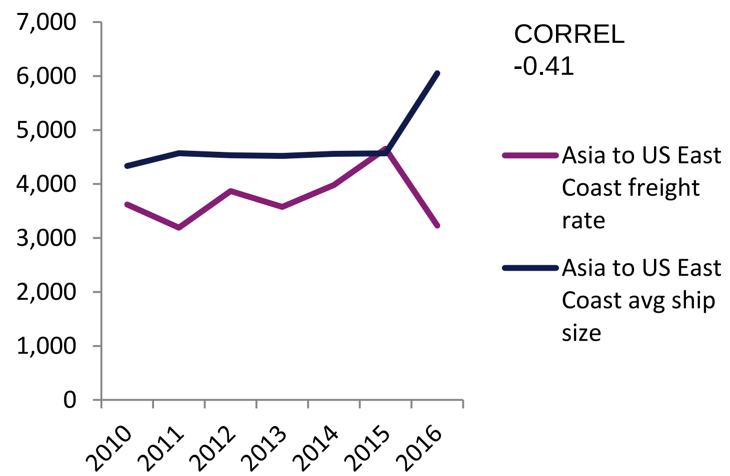
Asia to North Europe freight rate vs ship size



Asia to Middle East (Dubai) freight rate vs ship size



Asia to US East Coast freight rate vs ship size



Notes: Freight rates are in US$/40ft container; ship sizes are in TEU

Source: Drewry Maritime Research

Comparison of freight rates before and after vessel upsizing

Overall we do not see a strong synchronisation between the times when average ship sizes increase faster (significant upsizing) and when freight rates fall faster. All we see is that rates move down most years as ship sizes generally go up, and that the two trends are correlated over the medium term.

The strongest example of a very big increase in the ship size and a corresponding fall in rates was in 2016 on the Asia-US East Coast trade route, where the opening of the new Panama Canal enabled carriers to introduce larger, more cost-effective ships. The reduction in rates was amplified by the fact that, in 2015, rates were inflated due to volume diversions from the Asia-US West Coast route (caused by US West Coast port strikes).

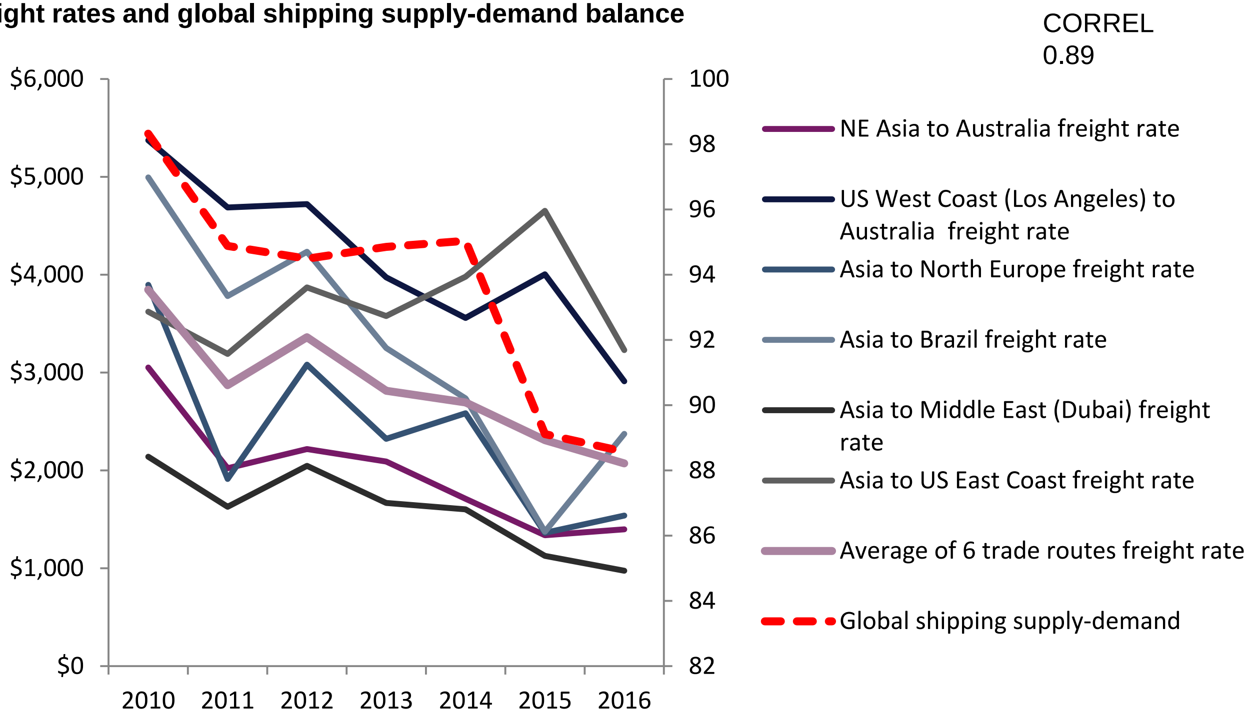
However, there are many instances on other trade routes reviewed here where, comparing rates and ship sizes form one year to the next, the relationship is not as you would expect it to be,

The next slides examine other drivers of freight rates that are not related to ship sizes.

Factors that influence freight rates

The global shipping supply-demand balance has a strong influence on freight rates, which has always been the case for container shipping. In the last 5 years, growing overcapacity has triggered a price war on most trade routes. The correlation coefficient between the average rates on the 6 routes and the global supply-demand balance is 0.89.

Freight rates and global shipping supply-demand balance



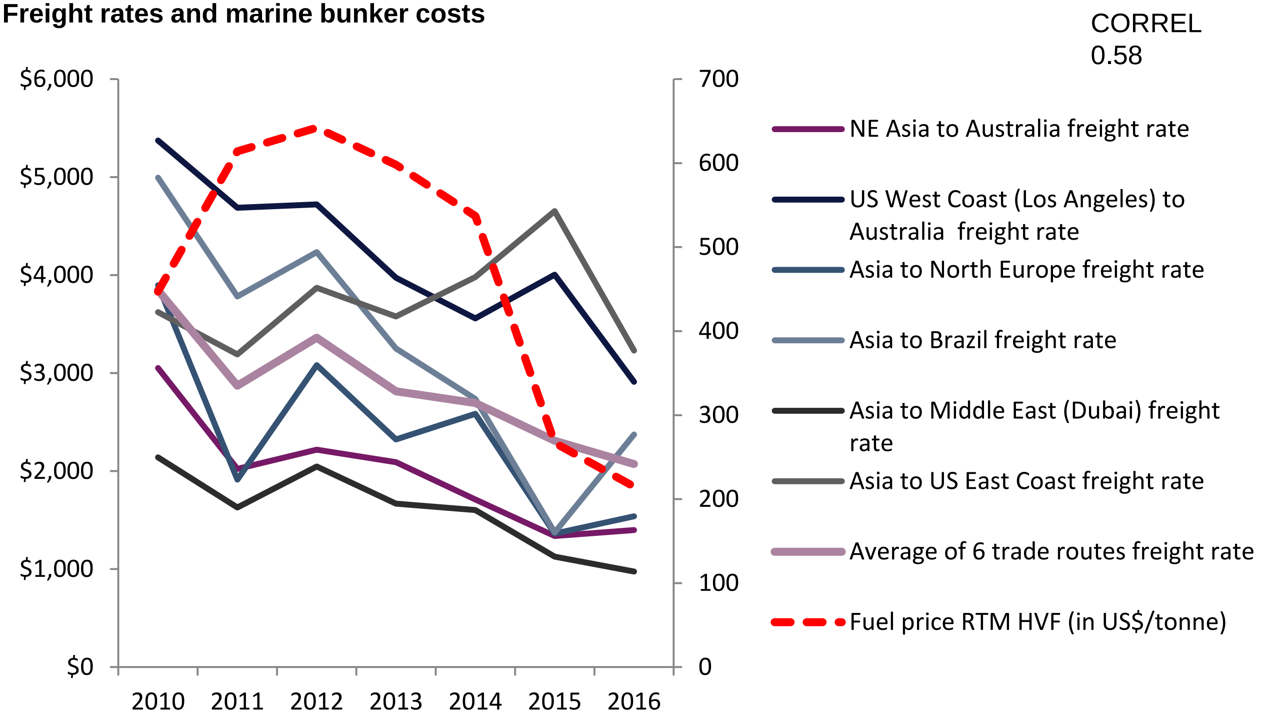
Source: Drewry Maritime Research

On the Asia-Brazil trade route, rates increased sharply in 2016 despite the worsening global supply-demand balance. This shows that not all trade routes are subject to the global supply and demand balance

Factors that influence freight rates

A less important factor (after supply-demand balance) is the bunker price. The correlation coefficient between the average rates on the 6 routes and bunker prices is 0.58.

Freight rates and marine bunker costs



Source: Drewry Maritime Research

The fall in marine bunker costs (or fuel price shown here for the port of Rotterdam in US$/tonne) in 2015 contributed to the sharp fall in freight rates on most trade routes in 2015.

However, as this drop in rates coincided with a major deterioration in the supply-demand balance, it is not easy to say which factors contributed to what change in freight rates.

Identify what factors can influence freight rates

There are many blips in freight rates that cannot be explained by changes in ship sizes, by supply-demand balance and bunker costs. It is generally believed that the explanation for these is the “carrier behaviour” factor – when major carriers change their competition behaviour.

Factors that influence rates

Factors	Influence
Supply-demand	Biggest cyclical factor
Cost factor 1: increasing ship sizes	Also a major factor. Correlated with rates with levels varying between -0.4 to -0.9.
Cost factor 2: bunker prices	A secondary factor. Correlated with rates with a coefficient of 0.6 (on average); in 2015, bunker costs accounted for only 13% of shipping lines’ total costs.
Carrier behaviour	A hard to gauge temporary factor that can push freight rates up or down if major carriers change their competitive behaviour.

Source: Drewry Maritime Research

In 2016, rates on the Asia-to-Brazil trade rose (despite worsening overcapacity) because several major carriers decided to cut capacity by over 30% and to merge services with competitors, even at the risk of losing market share. The “behaviour” of these carriers changed suddenly, causing a sharp rise in rates.

Similar situations have been seen in the past with rate decreases caused by the decision of a few carriers to go after a bigger market share by under-cutting prices. When additional ship capacity is used by a carrier to enter a particular trade route, this can cause rates to fall.

These changes in carrier behaviour are more at the trade route level and are not linked to the global conditions of the shipping market.

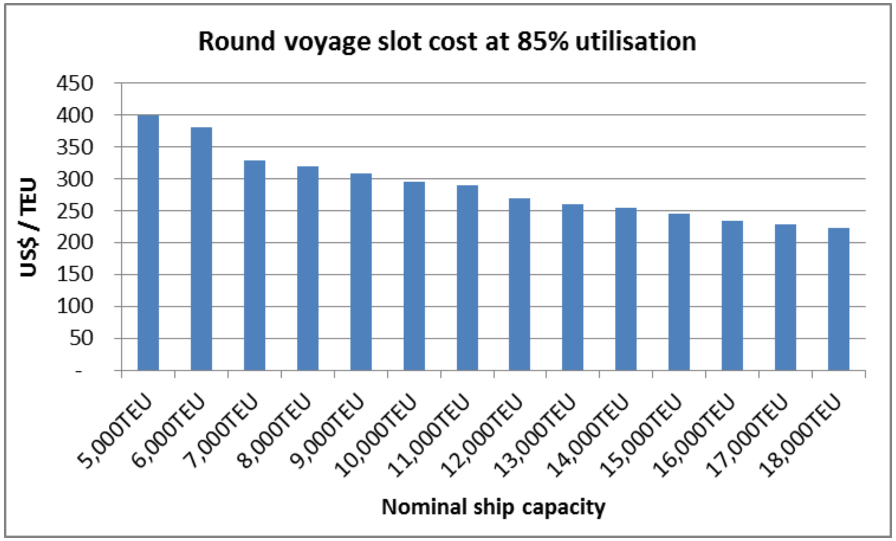
Cost savings that can be made through vessel upsizing

Shipping lines will nearly always choose the largest vessel that they can fill with cargo on a weekly rotation. The cost savings to Australia of upgrading from a 5,000 TEU to 11,000 TEU ship would be significant.

- Shipping lines will nearly always choose the largest vessel that they can fill (85% utilisation as a benchmark) with cargo on a weekly rotation. Economies of scale, derived from spreading costs over more containers, means fewer ships to carry the same cargo, reducing the overall cost to service the route. Conversely, shipping lines will not use vessels that are too large for the trade and incur additional costs for no additional freight income.

- To estimate the potential savings from larger ships, Drewry has made a high-level estimate of the cost savings based on a 28-day round voyage at an average speed of 17 knots. This provides an order of magnitude of the cost savings.

- The cost savings to Australia of upgrading from a 5,000 TEU vessel to an 11,000 TEU ship is about US$110 per TEU, depending on load factors and bunkering costs. This differential of US$110 per TEU could increase significantly as more scrapping of ships of 5,000 TEU and higher bunker costs would considerably increase the charter rates and operating expenses of the 5,000 TEU ship category in comparison to an 11,000 TEU ship.



Impact of vessel upsizing – alliance development

Carriers have been forced to form new alliances to deploy their largest ships in the best services, to remain competitive on slot costs and to absorb the new tonnage being delivered. A similar result would be seen on the non-East West trades and on Australian trades as bigger ships cascade onto these routes and alliance networks spread beyond the usual key trades.

Shipping lines provide regular calls with the largest vessel that they can fill with cargo. Lines trade-off frequency and vessel size; an average of 85% utilisation once a week provides a guide to the vessel size.

The increasing size of the average container ship has had multiple effects on the market. First, it has helped reduce unit costs for the carriers with the largest vessels that have the ability to fill them. Second, it has spurred even more lines to invest in larger vessels, resulting in severe overcapacity. As a consequence, many lines are unable to compete on their own resulting in the formation of alliances that offer frequent services to retain market share, compete effectively as well as benefit from lower transport costs.

The table below compares the number of weekly services and the average vessel size development in the past 5 years (2011-2016) highlighting the consolidation of carrier services on the Far East-Europe trade as a consequence of ship size development

	Number of Weekly Services (OCT 1)		% Change in Weekly services	Average Vessel Size per Weekly String (TEU)		% Change in Average Vessel Size
	4Q11	4Q16	4Q16/4Q11	4Q11	4Q16	4Q16/4Q11
Far East/Europe headhaul						
Far East/N Europe	29	16	- 45%	9,401	14,936	59%
Far East/Mediterranean (direct)	20	14	- 30%	6,711	10,071	50%
Total	**49**	**30**	**- 39%**	**8,300**	**12,789**	**54%**

Despite the relatively slow global fleet growth, many ships of at least 10,000 TEU are scheduled to be delivered in 2017. Most of these vessels will be deployed on the East-West trades and the cascade will be perpetuated into the minor East-West and North-South trades.

Only three alliances (2M, Ocean Alliance and THE Alliance) will be in operation on key East-West trade routes from April 2017.

A similar result of consolidation of services would be seen on the non-East West trades and on Australian trades as bigger ships cascade onto these routes and alliance networks spread beyond the usual key trades.

Factors affecting deployment of ship capacity

The allocation of capacity and selection of ship size are driven by trade factors and strategic carrier behaviour such as routing and transhipment initiatives. This network is further shaped by global fleet availability for cascading and by trade lane competition. This ever-changing market results in alliances, consortia and vessel-sharing arrangements.

The market determines ship size selection on each trade route. Trade route development depends on factors such as trading volumes, regional market distribution and balance of container flows. Carrier behaviour such as routing and transhipment initiatives; global fleet availability and cascading; market infrastructure constraints (port draft, quay length, handling equipment); operational constraints (operating costs, bunker prices); and trade lane competition result in either collaborative initiatives such as consortia and VSA or competition.

Australian container trade is served by 27 deep-sea services through a complex mix of joint services, consortia and multi-area coverage. The most important trading regions are North East Asia and Japan with 10 services and South East Asia with 8 services. The US and Europe are served with a mixture of transhipment services and direct services (3 x US and 3 x Europe). The Australia/New Zealand trade is served by a mixture of regional cabotage movements on other services covering both markets and two dedicated services that are effectively short sea. All other areas are served by transhipment due to the lack of cargo volume to support direct services. New Zealand is an adjacent market for additional deep-sea volume and due to its export dominance, it offsets Australia's import dominance on many links. New Zealand's importance has declined with increased dependency on Asian transhipment links. With shared services, developments in Melbourne must be consistent with capabilities in Sydney, Brisbane and to a lesser extent with main New Zealand ports that are in the process of being upgraded. The attractiveness of different trade routes varies. The very competitive Asia to Europe head-haul lane offers high volumes, but the back-haul has much lower vessel utilisation, typically around 50-70%. Dominant leg cargo flows drive capacity trade route requirements.

There is a growing battle for market share among carriers and a push to reduce unit operating costs by deploying the largest possible vessels commensurate with filling the ships. For many carriers it will be dangerous for competitiveness in operating costs to be left behind in the rush to larger ships. This is a function of the extreme cyclicality of the industry and needs to have the lowest costs to survive down cycles. The global fleet of containerships of 8,000 TEU+ has been replacing capacity of the intermediate and smaller size categories (<8,000teu) and, as a result, bigger ship size would cascade onto other trade routes including the Australian trades. Previous interviews undertaken in 2013 indicated that the North Asia services would introduce 6,500 TEU vessels if there were no constraints on vessel size in Australian ports. This has been superseded, and ports smaller than Melbourne located on the North-South are handling vessels of over 10,000 TEU; for example, Maersk in Port of Auckland. On Asian trades it is suggested that bigger ships will result from consolidation of services and additional transhipment volume as East-West services have more capacity because of the introduction of larger ships by new building or cascading. The North East Asian/Japan trade is most likely to push the operational envelope on ship size. The North American and European direct services are both under threat from transhipment operations as larger ships are introduced on the East-West routes and Australia-Asia routes. This will be accentuated by the widening of the Panama Canal and the deployment of the 18,000 TEU vessels on the Asia-Europe trade route. Loss of volume share to Asian transhipment has a marked effect given the lack of growth in these trades. There is not much scope for further rationalising the number of direct services to achieve economies of scale, except in the European trade if the competition authorities allow. Maersk believes they will move to transhipment operations in time.

Technology advancement; limitation on size & capacity of ships

Upscaling the conventional design of container ships has led to step changes in ship dimensions. The focus more recently has been on economies of scale within physical and technological constraints. Lloyd's Register research shows that a 24,415 TEU ship is likely to have a beam of 64 metres and a length of 479 metres, a slight increase from those of an 18,000 TEU ship.

There have been step changes in ship dimensions in the mid-1990s from 4,500 TEU to 7,000 TEU, then in the mid-2000s to 13,000-14,400 TEU and more recently to 21,100 TEU. Each step change has mainly been achieved by an upscaling of the conventional design of container ships. Increasing capacity on container ships has therefore come from extending length, draft, beam as well as the addition of cylinders to the conventional single engine of conventional ships. However, the focus more recently has been on economies of scale within the boundaries of physical and technological constraints suggesting limitations on size and capacity of container ships. Some of the key technological factors constraining ship size upscaling are as follows:

Ship's draft – In practice ship's draft has been limited by the weight of containers aboard. This in turn has been limited by the stacking height of containers one above the other. The current strength of containers limits stacking height (ISO standard and classification society rules limit any increase in container stacking). This limits any increase in the number of tiers (height of containers stacked one above the other). This is also reflected in practice where we observe maximum draft has been reached although container strength can be handled by advanced engineering and could result in an increase in stacking height. Ship's draft increases with size but there is resistance to going over 15/16 metres as the number of ports available for service falls rapidly

Ship's beam - The newest large ships have maximised beam rather than draft. Vessel lengths have been shortened on the new largest vessels in favour of beam as a means of increasing capacity. The largest capacity vessels (over 10,000 TEU) are becoming beamier as they seek to add capacity within tighter draft constraints. For example the number of rows has increased from 18 on a 10,000 TEU ship to 19 rows on the new Panamax ship of 12,500 TEU, to 22 rows on the *Emma Maersk* and to 23 rows on the Maersk EEE 18,000 TEU vessel. Broader ships can be taller but also have limitations in relation to crane outreach and lock dimensions. There are certain infrastructure restrictions that are relevant, such as Panama and Suez canals, port drafts, availability of berth length and container stack weights.

Ship's length - The 15,000 TEU and above vessel size demonstrates a reluctance to go over 400 metre in length. Longer, thinner ships are faster or more fuel efficient than those with a wider beam but are restricted by available berth, turning circle and lock lengths as well as torsional stress that the ship may be subject to. Achieving sufficient torsional strength in ships with large hatch opening is a key challenge in container ship design that constraints increases in ship length. The more recent ship designs have relocated the accommodation block and bridge of very large container ships to a more forward position, compared to a conventional design. This has helped in overcoming some of the torsional stresses associated with increased vessel length.

Propulsion – The power requirements of increasing container ship size were mainly achieved by the addition of cylinders to the single engine design. This is possible due to the reduction in design speed allowing retention of single screw operation and reducing the relative extra cost of operation. Engine design has been pushed to the limit by the ever growing size of vessels with recent vessel designs now having outgrown the range of readily available diesel engines

The more recent ship designs indicate that limits on upsizing conventional design ships have been reached and further increase in size and capacity of container ships would require both technological advancement and innovation. All the ship builders and classification societies are currently researching further growth in container ship size. Lloyd's Register research shows that a 24,415 TEU ship is likely to have a beam of 64 metres and length of 479 metres, a slight increase in the length and beam of the 18,000 TEU design ship.

Key considerations and implications for a future port servicing Victoria

Currently the trade volume and market share between alliances sets the limit on the use of vessels in Australia to 7,500 TEU. But as trade grows, or the lines consolidate, there will be demand for larger ships. Currently, the infrastructure capacity in Melbourne would be the governing constraint along the coast. These constraints would limit even mid sized vessels in the world fleet from operating in Australia

The constraints are as follows:

- Approach channels are limited to 14 m and 0.6 m tidal assistance;
- the Harbour Master's instructions limit vessels to 300 m LOA;
- beam restrictions within Swanson Dock depending on conditions;
- swinging basin for Swanson 342 m;
- Westgate Bridge 50 m plus 2 m exclusion zone;
- Webb Dock could possibly handle larger vessels but the design vessel for the capacity upgrade has been limited to ships of 300 m LOA (some 7,500 TEU);
- Port Phillip Heads, while having a 17m draft, is difficult due to variable currents and wave patterns. This means on some weekly calls container ships of over 6,000 TEU would be restricted. Since container ship owners need reliability, they tend to be conservative and are likely to restrict vessels above 6,000 to 6,500 TEU range even if the market demands larger vessels; and
- lack of rail at Webb Dock.

Constraints on the Australian East Coast

Despite being the largest container port by volume in Australia, Melbourne is also the port that limits ship size along the East Coast. Melbourne's turning circle is the governing constraint on ship upsizing for all Australian East Coast ports. The 300 m LOA for Melbourne constrains vessels to under 7,500 teu. Given that this LOA limit was adopted for the design vessel by PoMC for Webb Dock and the capacity upgrade, it is probable that Webb Dock would not be permitted to take larger vessels

Despite being the largest container port by volume in Australia, Melbourne is also the port that limits ship sizes along the East Coast. Melbourne is constrained by a 14 m draft at the Heads, Length Over All (LOA) of 300 m in the Yarra turning circle and by air-draft of 50.1 m under the West Gate Bridge. Moreover, the 250 m width within the Swanson Dock Basin makes it difficult to manoeuvre wide beam vessels.

Sydney, with its short channel, 15.6 m draft limit and no length constraints would be able to handle ships of over 10,000 TEU capacity.

Brisbane currently has a 14 m draft which limits vessel size to about 8,000 TEU capacity. Nevertheless, according to Russel Smith, ex-CEO of the port, Brisbane plans to increase the draft to 15 m. This investment, however, would wait until Victoria commits to extra depth, as there would be little demand for this draft in Brisbane until shipowners could service the entire route with larger vessels.

The 300 m LOA for Melbourne constrains vessels to under 7,500 teus. Given that this LOA limit was adopted for the design vessel by PoMC for Webb Dock and the capacity upgrade, it is possible that Webb Dock will not be permitted to take larger vessels.

Key considerations and implications of a future port servicing Victoria

The PAN Australia stevedoring arrangements are unique to Australia and dominate the relationship between shipping lines and stevedores.

i. Relationship between shipping lines and stevedores

Interviews with shipping lines did not reveal an overriding dissatisfaction with either stevedore. There was however a certain resignation that until recently there was only a choice of two and the stevedores were in a strong position as long as they steered clear of the ACCC.

All Australian stevedores are common user and without joint shareholdings in shipping lines, and so, the relationships are based on liner trades' agreements. Stevedores and lines negotiate agreements generally for a 2 or 3 year term and, for the same service, use the same stevedore in all Australian ports. This is because favourable rates are offered for volume as well as a view, real or imagined, that this model allows the lines to gain better berthing windows. Although lines will not discuss their intent to re-sign contracts, in the absence of considerable dissatisfaction or a compelling alternative, they tend to re-sign rather than change.

One line did see the rates offered by HPH in Brisbane as compelling enough to move one service to the stevedore. During the interviews it emerged that this was a trial with the possibility of further services being transferred to HPH. This raised the issue of whether there had been any reaction from DP World to this move away from their Brisbane terminal. However, the line confirmed that there had been no reaction, and indeed, a reaction would attract the attention of the ACCC.

Another compelling reason to move would be the change of groupings in a service or an alliance. Allied lines tend to use the same stevedore because of collateral service movements. Should one of the lines form a new alliance with a company using another stevedore, the choice of stevedore would be based on consensus. As lines and stevedores are almost always aware of competitors' stevedoring prices, there tends to be limited variation for similar commercial conditions. This transparency is further reinforced by the ACCC Stevedoring Monitoring Reports.

Opinions differed on whether HPH could succeed in Australia without a Victorian terminal. HPH would find it more difficult to operate in Australia if there were no independent operators in Melbourne. It is probable that a new completely independent operator in Melbourne could help change the PAN Australia stevedoring model and allow HPH to operate effectively in the other two ports.

To put this in context, Australian stevedores have a unique relationship with shipping lines. While some form of liner trade contract is common around the world, there is a unique element in Australia – the PAN Australia contract – a model where stevedoring costs are averaged over several ports.

The opponents of PAN Australia stevedoring rates claim it is an anticompetitive restrictive practice as shown by the failure of CSX in Brisbane. On the other hand, the defenders argue the economies of scale make it a lower cost alternative. These issues were brought into focus on 11 September 2013 when the Group Managing Director of HPH, Dr John Meredith said: "HPH has established bases in Brisbane and Sydney and is attempting to gain access to the stevedoring market in Melbourne", and Dr Meredith continued: "The company feels there is room for new operations, expanded facilities and new technology".

He acknowledged that the competitive position was made complex for incumbents but equally so for a new stevedore, due to the prevalence of "PAN Australia" contracts with shipping lines. These cover operations across Australia, with stevedores packaging their services on the premise of working for carriers in several ports.

Key considerations and implications for a future port servicing Victoria

Melbourne's infrastructure would be the governing constraint in container ship upscaling in Australia. A future port in Victoria could lift the limits allowing ships of over 7,500 TEU to service the country.

ii. Constraints/pinch points that may arise with existing operations

The new developments in Brisbane and Sydney mean that Melbourne would be the port closest to quay line capacity. With 1,800 m of quay, Melbourne should be able to handle throughput approaching 3 million teus per annum before suffering significant quay line congestion. With Webb Dock coming on stream in 2Q 2017, adding another 661 m of quay line, berth availability will not be an issue for shipping lines in any Australian port. On the other hand, PoMC has adopted a 300 m long, 42.9 m beam design vessel for planning purposes. This is a small design vessel by modern port standards to meet the constraint limiting the deployment of larger ships along the Australian coast.

In Australia, the governing constraints to container ship upscaling are in Melbourne. While draft limits exist in Brisbane, there are plans to dredge the approach channel to 15 m when market demands. Sydney has more draft than the other capital city ports and unlikely to be the governing constraint along the coast. Melbourne's major navigational constraints are located at the following:

1. Port Phillip Heads;
2. Williamstown Channel and Webb Dock; and
3. Yarra Channel and Swanson Dock.

The critical constraints at the mid-term are assumed as

1. Swanson Dock – the West Gate Bridge has a limit of 50.1 m air-draft clearance at all tides.
2. The restriction for Melbourne is 300 m LOA.
3. At Webb Dock, the 14 m draft would apply. There are, however, no air-draft or swing basin limits. It is understood that the 300 m LOA would apply.

Vessels can be loaded to their weight capacity or volume capacity. Vessels loaded to their weight capacity sail to the design draft. Since Australian container exports have a significant agricultural component, the boxes are heavy, and are therefore at times governed by draft. This however can be mitigated by tide, and many of the newer largest vessels have a 14.5 m maximum draft.

Air-draft - The air-draft restriction has been singled out for Melbourne as a special concern; because of the West Gate Bridge restrictions, height or air-draft is an issue for Swanson Dock. The West Gate Bridge, which has a safe clearance of 50.1 m at all tides, allows a safety margin of 2 metres (corresponding to the height of the maintenance cradle) from the physical clearance of 53.5 m. By way of comparison, a modern 8,000 TEU vessel would expect to have a keel to mast height of between 58 m and 63 m from which the draft of between 13 m to 13.5 m would be subtracted to arrive at the air-draft clearance. As the West Gate Bridge is lower than some of the other major bridges overseas, naval architects have modified the design (for example mast tilting) to take these restrictions into account. Consequently, ship-owners may be able to select ships with this feature for deployment into Melbourne. Drewry considers that the 300 m vessel length and 14 m draft limits would govern ship upsizing rather than air-draft.

In conclusion, the 300 m LOA for Melbourne constrains vessels to under 7,500 teus. Given that this LOA limit was adopted for the design vessel by PoMC for Webb Dock and the capacity upgrade, it is probable that Webb Dock would not be permitted to take larger vessels.

Rail at Webb Dock - Webb Dock would not have a rail connection and would be at a competitive disadvantage on the landside. Shipping line interviews revealed that the rail option was "nice to have", but "not essential" to its success.

Ship size forecast; approach and methodology – cargo flows

Container ship sizes depend on Australia-wide volumes, consolidation of alliances as well as the choice of transhipment or direct service. In addition, the volume to adjacent markets such as New Zealand also influences the ship size.

Ship size would be driven by a combination of (i) the overall Australian volume (not Victorian volume alone), (ii) volumes served direct and volumes served via transhipment, (iii) associated New Zealand volumes on trade routes where lines operate a joint Australia-New Zealand service.

An assessment of liner services to/from Australia indicates Melbourne, the key port in Victoria, is part of a larger liner network that serves a wider Australian market and on some services also serves adjacent markets, Pacific islands and New Zealand. Containership sizes are therefore influenced by Australia-wide volumes including those from adjacent markets. The Deloitte container trade volume forecast was for Victoria only. It was therefore necessary for Drewry to build on this volume forecast to make it useable for forecasting the fleet structure. Drewry has estimated Australian container volume based on historical relationships between Victorian container traffic and Australian volume.

Our assessment of liner services to/from Australia indicates Australia is served via 4 trade routes: (i) North America, (ii) North and East Asia including Japan, (iii) South East Asia, and (iv) Europe. This means that trade to/from Africa, South America, the Middle East, South Asia among others are served via transhipment. Also, our assessment of trade routes indicates that volumes from Europe and the US are served via transhipment. We assume 90% of trade from Europe is via direct services and 10% is transhipped, all of which at Singapore. We also assume that 75% of the trade from the US is via direct services and 10% is transhipped, all of which at Singapore. Singapore is a key transhipment hub for Australian trades serving Africa and other Asian trades. While the choice of direct or transhipment significantly alters ship sizes, the choice of transhipment hub is not a material one in the context.

Since some of the services calling at Australian ports also call at New Zealand ports, we assessed associated New Zealand volumes based on capacity deployed on joint Australian and New Zealand trades and estimated capacity for New Zealand trades. We are able to estimate the volumes for each trade lane, based on a combination of the above, to assess the container ship size.

Container ship size therefore depends to a large extent on liner ship operating strategy to serve a particular market via direct call or transhipment.

Trade capacity deployment and existing ship size spread

Ships tend to be 90% utilised on the head-haul trade with all alliance operators using similar-sized vessels within a service. However, competing alliances on the same trade route can deploy a group of vessels as much as 50% smaller than the vessel sizes used by the more aggressive alliances.

Existing liner services operating to/from Australia cover four trade lanes (i) North America, (ii) North and East Asia including Japan, (iii) South East Asia, and (iv) Europe. Each of these trade lanes is served by a number of services that carriers operate either as an independent service or on an alliance with a number of operators. Operators in an alliance generally tend to use similar size ships within a service; however, ship sizes vary on different services. In practice there is therefore a spread of vessel sizes on different services within a trade lane. Within this spread, the smallest vessels within one alliance could be 50% less than the average maximum size used by a less aggressive alliance. As is evident from the current spread of average vessel size on a particular trade route, there is a tendency for one operator or alliance to push the ship size up on a trade lane and a spread of vessel size below the maximum vessel size.

Of all the trade lanes serving Australia, the US-Australia trade lane is the only one with 81% of the capacity coming from maximum ship sizes and up to 85% of this maximum ship size. On other routes this ship size band (maximum and up to 85% of maximum ship size) is made up of less than 50% capacity. This suggests that on trade routes excluding US-Australia, operators aggressively chase market share with bigger ships and therefore lower operating costs per TEU. Consequently, port upgrading will favour the more aggressive operators deploying larger vessels with lower per TEU operating costs.

We reviewed each service (ship size, frequency, ports of call, capacity) on key trade routes to/from Australia and compared it with 2016 throughput for Australia. Our assessment suggests that ships are around 88% utilised on the Australian head-haul trades and have assumed this is the case for services that are operated on joint adjacent markets such as New Zealand. This in our view is a fair representation of the liner trade and is what we would expect to see on these trade routes.

Current spread in vessel size on Australian trades

	Average Max			Share of capacity (other size bands)		
	Ship size	Number of services	Share of capacity	Max < 85%	85% < 70%	> 70%
Europe/Australia	7,455	1	47.9%	0.0%	37.1%	15.0%
NE Asia/Australia	5,888	1	14.2%	26.3%	44.1%	15.4%
SE Asia/Australia	5,506	1	14.5%	13.4%	44.9%	27.2%
US (EC&WC) /Australia	4,250	1	42.2%	39.1%	0.0%	18.7%

Drewry route density index and potential service rationalisation

Our projection of future ship size is based on the Drewry route density index, a measure indicating the propensity to use larger vessels on a route; furthermore, our assumptions include alliance consolidation and the incidence of transhipment.

Our projection of future ship size is based on the Drewry density index and our assumption on the potential rationalisation of liner network services.

Drewry route density index: The Drewry route density concept is a subjective tool for assessing the potential for a route to support larger ships than those currently deployed. It is not a micro econometric model calculating the optimum size of a ship. The results must be assessed against existing physical restraints such as port drafts, technological maximum ship capacities and commercial considerations like competition policy. The route density Index model can be used to assist the evaluation and quantification of the various factors affecting current service routes and to simulate future alternative conditions and sensitivities in forecasts of future trade volumes and environments.

Essentially the index reflects that a route with high density has the propensity to deploy (or in the future adopt) larger ships than the less dense routes. The size of these ships may be increased further on longer routes where the economies of scale of ship operation become enhanced with the higher proportion of steaming time within a round voyage. In our assessment of route density we use the South East Asia-Australia trade lane (shortest route) as a benchmark to calculate route length index and use US-Australia as a benchmark to calibrate the average ship size as we believe this trade lane reflects what we would expect in an ideal situation where operators tend to operate close to maximum ship size on a particular trade lane.

Drewry route density index

Trade route	Miles	Route Length Index
North and Central America	8,000	2.00
North & East Asia Japan	5,000	1.25
South East Asia	4,000	1.00
Europe	12,200	3.05

Potential rationalisation of liner network services: In addition to the route density and trade length factors, there is a trade-off between the number of active competing services and vessel size within a route of any given density or length. That is, the greater the number of services, the smaller the average size of ships. In a dense route with multiple services (such as North Asia-Australia and South Asia-Australia trade routes) there is the potential to move to larger ships with their economies of operation by means of consortia or service rationalisation. The number of competing services on a route is not a given over time and rationalisation through consortia membership, acquisition or withdrawal are factors to be considered in the pursuit of competitive operating costs. To a large extent, this depends on operating strategies of liner companies.

In our assessment of existing liner services on Australian trades there is a mix of weekly, fortnightly and monthly services. This equates to 2.5 services to/from Europe, 2.7 services to/from North America, 9.0 services to/from South East Asia and 8.7 services to/from North East Asia. These are operated as a combination of either independent services, joint services or alliances/consortia. We take an objective view to rationalisation of services on North East Asia and South East Asia to/from Australia trade lanes based on existing services and alliance arrangements. Whilst there could potentially be considerable rationalisation, we have taken a view on rationalisation based on existing operating conditions ignoring the formation of large consortia or M&A that may result in a change in existing arrangements, among others.

Liner network services potential rationalisation

Trade route	Existing number of weekly Services	Minimum number of rationalised weekly services
North and Central America	2.7	
North & East Asia Japan	8.7	4
South East Asia	9.0	4
Europe	2.5	

Forecast maximum ship size – scenario 1

Container vessels calling Australian ports have constrained growth in ship sizes due to restrictions in channel depths and berth size. Scenario 1 assumes these constraints continue into the future – ship size constrained at 7,500 TEU resulting in greater number of vessel calls to handle the projected volume.

Maximum Ship size (Scenario 1)

- Liner network - Trades are served as per their current routing (4 trade lanes - Europe, North America, SE Asia and N Asia) with no service rationalisation

Case 1 - Melbourne Constraint		2017	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065
Total Victorian container trade	TEU	2,862,300	3,057,040	3,616,080	4,194,106	4,862,804	5,568,871	6,337,339	7,197,296	8,167,833	9,278,131	10,531,514
Implied Australian dominant leg trade		4,402,304	4,736,777	5,665,944	6,625,416	7,732,495	8,900,398	10,170,457	11,590,706	13,192,860	15,024,934	17,092,581
Average vessel size	TEU	4,323	4,967	5,734	5,769	5,790	5,804	5,813	5,821	5,801	5,782	5,769
Number of ship calls		1,245	1,224	1,262	1,464	1,701	1,952	2,229	2,542	2,911	3,333	3,794
Implied Australian capacity		5,382,948	6,081,878	7,234,623	8,445,545	9,847,571	11,329,512	12,956,104	14,797,713	16,886,948	19,274,734	21,887,964

Liner network - Trades are served as per their current routing (4 trade lanes - Europe, North America, SE Asia and N Asia) with no rationalisation of services

Number of Ship calls											
Europe	111	112	124	137	150	161	173	187	205	227	261
NE Asia	536	535	560	647	746	852	962	1,078	1,206	1,352	1,533
SE Asia	453	452	454	555	680	814	969	1,153	1,364	1,604	1,828
North America	125	125	124	125	125	125	125	125	136	150	173
Max vessel size projections											
Europe	7,455	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
NE Asia	5,888	6,450	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
SE Asia	5,506	6,050	7,450	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
North America	4,250	4,300	4,700	5,150	5,700	6,250	6,800	7,450	7,500	7,500	7,500
Number of weekly services											
Europe	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NE Asia	8.7	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
SE Asia	9.0	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
North America	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7

Forecast maximum ship size – scenario 2

Scenario 2 assumes that a new Victorian Hub port is established and Port of Melbourne ceases operations; there are no constraints on vessel size. Trades are served as per their current routing (4 trade lanes - Europe, North America, SE Asia and N Asia) with some rationalisation of services on North Asian and South Asian trades; no change in European and North American trades

Average ship size increases to 18,000 TEU by 2030 and maximum ship size increases to 20,000 TEU.

Maximum Ship size (Scenario 2)

- No Melbourne Constraint, some rationalisation of services on NE Asia and SE Asia routes

Case 1 – No Melbourne Constraint		2017	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065
Total Victorian container trade	TEU	2,862,300	3,057,040	3,616,080	4,194,106	4,862,804	5,568,871	6,337,339	7,197,296	8,167,833	9,278,131	10,531,514
Implied Australian dominant leg trade		4,402,304	4,736,777	5,665,944	6,625,416	7,732,495	8,900,398	10,170,457	11,590,706	13,192,860	15,024,934	17,092,581
Average vessel size	TEU	4,323	8,596	10,227	11,727	12,769	13,148	13,487	13,789	14,067	14,326	14,624
Number of ship calls		1,245	708	707	720	771	862	961	1,073	1,201	1,345	1,497
Implied Australian capacity		5,382,948	6,081,878	7,234,623	8,445,545	9,847,571	11,329,512	12,956,104	14,797,713	16,886,948	19,274,734	21,887,964

Liner network - Trades are served as per their current routing (4 trade lanes - Europe, North America, SE Asia and N Asia) with some rationalisation of services on NE Asia and SE Asia routes

	2017	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065
Number of Ship calls											
Europe	111	111	111	111	111	111	111	111	111	111	111
NE Asia	536	254	254	266	303	343	384	428	475	530	598
SE Asia	453	230	229	230	243	294	352	421	500	590	674
North America	125	114	114	114	114	114	114	114	114	114	114
Max vessel size projections											
Europe	7,455	7,600	8,250	9,000	9,750	10,400	11,050	11,900	12,900	14,200	16,150
NE Asia	5,888	14,850	18,100	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
SE Asia	5,506	11,450	14,200	17,350	20,000	20,000	20,000	20,000	20,000	20,000	20,000
North America	4,250	4,700	5,100	5,600	6,200	6,750	7,400	8,050	8,800	9,600	10,950
Number of weekly services											
Europe	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
NE Asia	8.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
SE Asia	9.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
North America	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7

Forecast maximum ship size – scenario 3

Scenario 3 assumes that a new Victorian Hub port is established and Port of Melbourne ceases operations; no constraints on vessel size. Trade from Europe is served entirely via transhipment at Singapore with no direct services from 2025 and trade from North America is served entirely via transhipment with 70% being transhipped via Hong Kong and 30% via Singapore. There is also some rationalisation in number of services on North Asian and South Asian routes.

Maximum Ship size (Scenario 3)

- Liner network - Trades are served by two major trade routes with cargo from Europe and America served via transhipment

Case 3 – No Melbourne Constraint		2017	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065
Total Victorian container trade	TEU	2,862,300	3,057,040	3,616,080	4,194,106	4,862,804	5,568,871	6,337,339	7,197,296	8,167,833	9,278,131	10,531,514
Implied Australian dominant leg trade		4,402,304	4,736,777	5,665,944	6,625,416	7,732,495	8,900,398	10,170,457	11,590,706	13,192,860	15,024,934	17,092,581
Average vessel size	TEU	4,323	8,596	10,227	15,153	15,148	15,144	15,138	15,131	15,123	15,116	15,116
Number of ship calls		1,245	708	707	557	650	748	856	978	1,117	1,275	1,448
Implied Australian capacity		5,382,948	6,081,878	7,234,623	8,445,545	9,847,571	11,329,512	12,956,104	14,797,713	16,886,948	19,274,734	21,887,964

Liner network - Trades are served as per their current routing (4 trade lanes - Europe, North America, SE Asia and N Asia) with no rationalisation of services

	2017	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065
Number of Ship calls											
Europe	111	111	111	-	-	-	-	-	-	-	-
NE Asia	536	254	254	291	331	374	418	464	516	574	648
SE Asia	453	230	229	266	319	375	438	514	601	701	800
North America	125	114	114	-	-	-	-	-	-	-	-
Max vessel size projections											
Europe	7,455	7,600	8,250	-	-	-	-	-	-	-	-
NE Asia	5,888	14,850	18,100	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
SE Asia	5,506	11,450	14,200	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
North America	4,250	4,700	5,100	-	-	-	-	-	-	-	-
Number of weekly services											
Europe	2.5	2.5	2.5	-	-	-	-	-	-	-	-
NE Asia	8.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
SE Asia	9.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
North America	2.7	2.5	2.5	-	-	-	-	-	-	-	-

Factors influencing planning ship size for a future port servicing Victoria

Investment in channel width, depth and infrastructure depends on the selection of the design vessels. Drewry chooses a more typical vessel within the size band for the design vessel rather than one at the extreme end of the range.

Maximum ship size definition is useful for bulk ports with a particular ship class to service, but it is less useful for container terminals. Since container terminals handle a range of ship sizes, a few maximum size vessels may arrive in any one year, and therefore, investing to handle this maximum peak load may not be cost effective.

Whereas port planners often choose the largest possible vessel within a class size or cluster for the design vessel, Drewry takes a different view for container ports. To begin with, Drewry chooses a more typical vessel within the size band rather than one at the extreme end of the range. This avoids specialised vessels that are less likely to redeploy onto the Australian route. Following that, the choice of the appropriate period is important for the Business Case and the need to build some infrastructure ahead of demand. For example, berth footings should be built to match the forecast design vessel for the long term, and channel depth could be phased to match demand, mitigating the need to overcapitalise in the early years.

Investment in channel width, depth and infrastructure depends on the selection of the design vessels.

Channel width - Optimum channel design is a complex task taking into account currents, wave height, bends, wind strength, the type of bottom and dredging costs. Once known, the Port Authority factors these into the Business Case and recovers the investment from Harbour Dues. That said it is possible to use simple benchmarks as working estimates until further details are known.

The US Army Corps of Engineers (USACE), which supervises dredging for all North American ports, provided the following benchmark for channel width.

“For one-way ship traffic, values for channel width vary from 2 to 7 times the design ship beam. Typically a range of 2.5 to 5 is used as design criteria. For straight one-way channels with low currents, widths of 2 or 2.5 times the design ship beam should generally be conservative. Recommending a similar criteria for two-way ship traffic is difficult due to lack of data” (USACE 1984, 1995, 1999).

Channel depth - The USACE offers the following guidance on channel draft.

“Vessels rarely sail at their full design draft. To do so would entail a full load of loaded containers, which is uncommon. The USACE guidance suggests that maximum effective cargo capacity is typically about 95% of DWT. Applying this ratio to design draft *versus* sailing draft suggests that a vessel designed for 15.2 m draft would, for example, usually sail at a maximum of 14.5 m. While not a precise relationship, this guideline is often adopted for initial analysis.”

The USACE also suggests a minimum of 3 feet under keel clearance. Drewry, however, suggests 10% of the working draft as a benchmark for under keel clearance of the design vessel. This provides an additional tolerance that would allow for wave action and a variable that recognises the newer wide beam vessels may need a larger tolerance in the event of a beam-on sea.

National benefits from deeper draft vessels

Drewry notes that in addition to Victoria enjoying the cost savings from larger vessel sizes, both Sydney and Brisbane would gain the cost savings offered by larger vessels currently not yet available because of the Melbourne limits. If the Business Case were to be considered on a national basis, the benefits of lifting Melbourne’s constraints would be multiplied by a factor of over two.

Previous choice of design vessel for Australia

Drewry had previously presented a generic container ship design vessel *Honolulu Bridge* of 8,614 TEU capacity for the medium term. Although the Yarra Basin turning circle in Melbourne limits ships of this size, the opening of Webb dock in 2Q2017 may help overcome this constraint.

Based on studies during 2010 and 2011, Drewry presented a generic container ship design vessel at the Ports Australia Biennial Conference in 2012. The vessel chosen was *Honolulu Bridge*.

Even though the medium-term trade growth would support ships of this capacity, and although they would be able to call into Sydney and probably Brisbane (given a 93% load factor), they would be constrained in Melbourne. The Yarra Basin turning circle limits ships to 300 m LOA, which are generally under 6,000 TEU. In 2Q 2017, however, the opening of Webb Dock would lift this length constraint.

Channel width and depth based on the previous design vessel

Assuming *Honolulu Bridge* as the initial design vessel and the USACE default benchmarks, the 45.8 m beam and 13.5 m maximum draft would result in the following channel requirements:

Design vessel x 2.5 x beam would result in a 115 m channel width at the base of the channel.

Design vessel maximum ship draft of 13.5 m x 95% load factor = utilised draft of 12.9 m allowing for a 10% under keel clearance of 1.3 m would result in a required channel depth of 14.15 m.

Please note the choice of design ship is likely to be changed as part of this review.

Vessel	Honolulu Bridge
Year built	2012
Length m	336
Beam m	45.8
Dead weight tonnage	96,980
Gross tonnage	96,790
TEU Capacity	8,614
Draft	13.54

Forecast design ship - recommendation

Shipping lines have expressed their desire to deploy bigger ships on Australian trades, but are unable to do so because of port restrictions. However, the projected container traffic growth supports the use of larger container ships. While the recent dredging at Melbourne and development of Webb Dock meet the requirements of the current trade, they are insignificant developments for the long term.

Shipping lines have expressed their desire to deploy bigger ships on Australian trades if there were no restrictions at the port. However, the ship size is currently constrained due to draft and available turning circle at Swanson dock in Melbourne and this restricts overall ship size deployed in Australian trades. Our model suggests that the Europe, North Asia and South Asia-Australia trades would reach this ship size of 7,500 TEU as early as 2025 resulting in greater number of vessel calls to handle any projected volume growth. If trades are served as per their current routing (4 trade lanes - Europe, North America, SE Asia and N Asia) with some rationalisation of services on North Asian and South Asian trades, ship size increases to 18,000 TEU by 2030. In addition if trade from Europe is served entirely via transhipment at Singapore with no direct services from 2025 and trade from North America is served entirely via transhipment with 70% being transhipped via Hong Kong and 30% via Singapore ships of up to 18,100 TEU would be required by 2025.

Port of Melbourne has recently been dredged to accommodate deeper draft vessels and the turning circle expanded to accommodate bigger ships. Further Webb Dock is being developed and may be able to handle ships of up to 8,100 TEU by 2Q2017. Whilst this would meet the needs of the trade at that point in time, it is unlikely to meet the requirements for bigger container ships that are likely to call Australian ports based on the long-term growth forecast of container traffic.

For the other Australian ports, the key constraining factor is the depth as neither Brisbane nor Sydney are limited for turning the ship around in port. Length of the vessel is therefore unlikely to pose any constraint. Brisbane currently has a depth of 14 m although it is understood that PBPL has earmarked A$200 million to increase the depth to 15 metres, but no details about the timing are available. Port Botany at Sydney has a natural depth of 15 metres. It is therefore unlikely that either Sydney or Brisbane would be a constraint on the Australian East Coast trade.

Conclusions

Since the life of a container terminal is about 40 years, the new facility should at least consider a design vessel of 18,000 TEU capacity.

Drewry realises that this size may seem difficult to appreciate starting from the current Australian shipping profile. Nonetheless, further liner grouping and consolidation along with the continued trend towards transhipment suggest this design vessel as the most probable requirement for the long term. Indeed, the alternative implies a lower GDP growth rate; consequently, a lower trade forecast.

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