FUTURE OF CONTAINERIZATION: RAPID GROWTH OR MATURATION?

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Introduction

International trade has expanded the world economy and transformed supply chains in ways that defy the imagination. More liberal trading regimes, since the World War II, expanded opportunities for countries to "do what they can do best, and to import the rest." Freer trade was achieved through successive rounds of trade negotiations under the auspices of the GATT (General Agreement on Tariffs and Trade) which morphed into the World Trade Organization in 1995. The sum of exports and imports now represents more than 50% of global production compared to less than 10% at the turn of the 20th century. Much of this trade is in components and materials that feed global supply chains. When the gradual reduction of trade barriers is combined with reductions in the cost of communications and transportation the growth of international trade can be dramatic.

Transportation and communications are usually described as derived demands. They exist only to serve the needs of users and to expand as required. In general, this is true. The exceptions are when technological advances occur that change the economics of trade. Kindleberger[i] describes the double stimulus for trade that is created by developments in transportation technology. "As has been discovered many times, a reduction in transport costs may increase profits for the producer at the same time that it lowers the price to the consumer, thereby doubly stimulating the exchange." (p.24) As much as the liberalization of the international trading regime increased opportunities for trade, it is the development of digital communications and the containerized shipping system that stimulated export-led growth over the last 50 years. It is impossible to envision how the economies of Southeast Asia could have grown to match those of Europe and North America, without the development of ISO containers and computers.

After 45 years of continuous growth, the expansion of container transport paused during the "great recession" of 2008 to 2016. While container traffic is now picking up, as trade grows again, the question arises whether the prior pace of growth will return, or as Havenga et al[ii] suggest that containerization has reached a stage of maturity. "Across the board, the factors that caused global container volumes to grow at a more rapid rate than global GDP are diminishing, which will flatten out the rate of global container growth." (p. 99) The purpose of this article is to examine the growth of containerization and consider its future direction. The next section presents a model of technology growth and the significant changes that have propelled containerization. The supply-side drivers are examined with respect to the growth of containerization. The paper ends by weighing some evidence of industry maturation and thoughts on the further evolution of container shipping.

The growth of container traffic and container ports

Until the 1950s, international trade was carried as either bulk, or break-bulk cargoes. Bulk commodities, like grain, are loaded mechanically without packaging using conveyors and other handling systems. Break-bulk cargoes are goods packaged in barrels, crates, etc. and loaded individually onto the ship. The introduction of containerized shipping, by entrepreneur Malcom McLean, transformed international trade. Gisela Rua states "Containerization is one of the most important innovations affecting international trade in the second half of the twentieth century. First used in 1956, it quickly became the central piece of

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today's global economy."[iii] Mclean would likely disagree with how "quickly" containerization gained success, but not its importance.

As with many innovations, the introduction of containers was resisted by vested interests in labour and shipping. Although containers greatly reduced the cost of transhipping, and losses due to theft, for the first ten years progress was slow. The event that helped create the tipping point was the Vietnam War. The unloading of ships at the Vietnam ports became a key bottleneck in the supply chain. By November 1965, 122 fully loaded ships were waiting at anchor off Saigon and nearby holding areas. Inadequate port facilities were compounded by the lack of ground transport. McLean went to Vietnam and lobbied in Washington that containers could help in the war effort. After substantial resistance, the idea was embraced and championed from within. The first container ship to reach Vietnam was in November 1967.

The impact of containerization was so great that by the end of the conflict 10 percent of all freight was carried in containers.[iv] With the $450 million that McLean earned during this period, containerization made it past the tipping point and began a prolonged period of rapid growth. The expansion of international seaborne trade by container ships since 1970 is shown in Table 1. The volume of cargoes carried in containers has more than doubled every ten years, rising by 5,000% from 1970 to 2015. During this period, the market share of containers rose from 1% of total trade to 17%. Given that bulk commodities, like grain, are included, this growth is even more significant. If the measure of size were in terms of value shipped, the growth of containerized transport would be even more impressive

Table 2 - International seaborne trade carried by container ships from 1980 to 2015 (in million tons loaded)

Year	**1970**		**1980**		**1900**		**2000**		**2010**		**2015**	
	30-36*	.01375#	102	.0275#	234	.0584#	598	.0999#	1,280	.1522#	1,687	.1679#

Source: *Statista, World Seaborne Trade* *Estimated. # % of Total trade.

The linkage between the introduction of containerization and the economic development of Southeast Asia is illustrated in the growth of container traffic at the ports. Table 2 presents the top 10 container ports for selected years after 1985. It is striking that the ports in Japan, Europe and USA that accounted for seven of the top 10 up to 1995 no longer appear in the top-10 list by 2016. China now accounts for 7 of the 10 top ports. (Note: Los Angles and Long Beach, if combined, would be number 6).

Table 2 - Top Ten Container Ports (1985-2016) – TEUs (millions)

1985				**1995**				**2001**				**2016**			
R	**Port**	**Count**	**TEUs**	**R**	**Port**	**Count**	**TEUs**	**R**	**Port**	**Count**	**TEUs**	**R**	**Port**	**Count**	**TEUs**
1	Rott.	Neth.	2.65	**1**	HK	China	12.55	**1**	HK	China	17.83	**1**	Shan.	China	37.13
2	NY	USA	2.37	**2**	Sing.	Sing.	11.85	**2**	Sing.	Sing.	15.57	**2**	Sing.	Sing.	30.90
3	HK	China	2.29	**3**	Kao.	Taiwan	5.05	**3**	Busan	Korea	8 .07	**3**	Shen.	China	24.0
4	Kao.	Taiwan	1.90	**4**	Rott.	Neth.	4.79	**4**	Kao.	China	7.54	**4**	Nig.Z.	China	21.56
5	Kobe	Japan	1.86	**5**	Hamb.	Ger.	2.89	**5**	Shan.	China	6.34	**5**	HK	China	19.81
6	Sing.	Sing.	1.70	**6**	L.B.	USA	2.84	**6**	Rott.	Neth.	6.12	**6**	Busan	Korea	19.45
7	Yoko.	Japan	1.33	**7**	Yoko.	Japan	2.73	**7**	LA	USA	5.18	**7**	Guang	China	18.85
8	Antw.	Bel.	1.24	**8**	LA	USA	2.56	**8**	Shen.	China	5.08	**8**	Qingdao	China	18.05
9	Hamb.	Ger.	1.16	**9**	Antw.	Bel.	2.33	**9**	Hamb.	Ger.	4.69	**9**	Dubai	UAE	14.77
10	Busan	Korea	1.16	**10**	NY	USA	2.22	**10**	LB	USA	4.46	**10**	Tianjin	China	14.52
T	**17.66**			**49.81**				**80.88**				**219.04**			

Source: The data for 1985 and 1995 see Container Shipping and Ports: An Overview, THEO E. NOTTEBOOM, Review of Network Economics Vol.3, Issue 2 – June 2004 and for the period 2001 and 2016. R=Rank. T=Total. Count=Country.

Supply-side Drivers

Many technological changes were required to create the modern containerized transportation system. Changes are described in the following areas: ship, cranes and container terminal systems. Important innovations on the landside of containerization contributed to its growth, specifically the development of double-stacked trains, however only the marine sector is considered here.

Economies of size in container shipping have had a significant impact on transportation costs and the development at the ports[v]. This can be seen in the statistics shown in Table 3. The average container ship size, over the last four decades, has increased from 975(TEUs) in 1980 to 2,191(TEUs) in 2006 and to 3,801 (TEUs) in 2017, an increase of 290% with the largest container ship rising from 3,057 TEU in 1980 to 21, 413 TEUs in 2017 or 600%. *The Journal of Commerce* in 2015 reports that "The largest container vessels on order have more than sextupled since 1975 and is set to expand by at least 13 percent by 2020, according to an IHS Maritime & Trade analysis of the order book. …. The competition between carriers to amass fleets of larger ships is so intense it has been likened to an "arms race."[vi]

Table 3- Container Ship Size

Year	Average Ship Size (TEU)	Largest ship in world fleet (TEU + Max. draft)
1980	975	3,057 - 11.6m
1990	1,355	4,409 - 14.0m
2000	1,741	7,200 -14.5m
2007	2,191	13,500 - 15.5m
2017	3,801*	21,413 – 30+m

Source: *Drewry - World container cargo prospects, 2007. *July 2016, Review of Maritime Transport 2016, p. 41.*

Research studies provide evidence of the economies of size in container ships. Samsung calculated that a vessel of 12,000 TEU on the Europe – Far East route would generate a 11 per cent cost saving per container slot compared to an 8,000 TEU vessel, and a 23 per cent reduction compared to a 4,000 TEU unit. Similar calculations made by Drewry for the trans-Pacific route estimate a potential cost difference of around 50 per cent between a Panamax unit of 4,000 TEU and a mega Post-Panamax unit of 10,000 TEU[vii]. Driven by an increase in globalization of supply chains, the shift to containerization of bulk commodities (e.g. lumber) and perishables,[viii] and competition within the liner trade, the costs of containerization have fallen while the scope of containerized shipments has expanded.

Table 4 presents the change in the profile of the container fleet since 2010. The trend to larger sizes is clear. As larger ships are introduced, the mid-sized are not being replaced. Some sources see the size going to 24,000 TEU, but the depth of key shipping routes, like the Straits of Malacca and Suez Canal will likely put a cap on the ultimate size of container ships.[ix]

Table 4 Composition of the International Container Fleet, 2010-2017

Fleet as at December 31	2010	2011	2012	2013	2014	2015	2016	2017
TEU nominal	Ships	Ships	Ships	Ships	Ships	Ships	Ships	Ships
18000-21000						35	47	72
10000-17999	71	118	162	198	255	302	341	407
7500-9999	264	289	326	377	429	454	475	482
5100-7499	431	462	475	495	509	518	471	476
4000-5099	680	710	739	775	794	735	679	667
3000-3999	322	328	296	288	298	262	249	264
2000-2999	718	723	677	674	691	648	621	661
1500-1999	586	596	572	580	594	581	590	625
1000-1499	702	717	702	687	700	696	699	719
500-999	807	804	785	770	778	748	753	758
100-499	268	244	226	221	221	182	187	194
Total	4849	4991	4960	5065	5267	5153	5112	5325

Source: Adapted from Alphaliner, various years

Container Cranes

Shipping cargo in containers would not have gained momentum without the invention of container cranes. Table 5 presents the progression of the crane technology by year of introduction. In 1959, the first container crane was built by PACECO (Pacific Coast Engineering Company) for Matson Shipping using the RTT (rope towed trolley). Ten years later, concerns about the RTT led to the invention of the MOT (machine on trolley) container crane by Kochs in 1968, and then by Noell, a German manufacturer. The possibility of human error by a crane operator led to automation of STS (ship to shore) container cranes to minimize the danger. As container ships grew in size, increasing the dimensions of the crane (after the first generation (1967-1974)) became the most pressing need. One authority describes it as 'Increasing Crane Dimensions: A Vessel's Dictate.'[x] Increasing the dimensions gained momentum in 1984, when the Port of Rotterdam (ECT) commissioned the first Post-Panamax crane.

As the size of the ships increased with shipping companies ordering Post-Panamax vessels (1988-2006) so did the size of the cranes. Within a few years, 20 ports installed new cranes with a larger outreach to remain competitive, while many ports introduced extensive crane raise and boom expansion programs. The arrival of ultra large container ships (i.e. ULCS – 10,000+ TEUs) after 2006, led terminal operators to invest in even larger cranes or to modify existing cranes to accommodate these larger ships, improve their service (berth performance) and to reduce their costs. Table 5 shows the developments of major crane characteristics during the period 1959 to 2010, where "The load movement went up more than 11-fold (from 576 ton-metres to more than 6,500 ton-metres) and the crane dead weight increased more than 6-fold (from 325 tons to more than 2,000 tons)" according to Ham and Rijsenbrij.[xi]

Table 5 – Developments of major crane characteristics

Type of Crane: Year of Introduction						
Characteristic	**Matson 1959**	**Panamax 1972**	**Post max 1977**	**Post max 1990**	**Super Post max 2006**	**State of the Art 2011**

Source: Development of Containerization, Success through Vision, Drive and Technology, Hans Van Ham and Joan Rijsenbrij, 2012, p. 132.

Container Terminal Systems

The introduction of containers changed cargo handling at ports. The development of container terminals has been divided into several stages: 1. early development 1955-1966. 2. turbulent development 1966-1976. 3. partial automation1976-2016. The first stage witnessed the development of the first terminal in the US by Matson, Sea-Land and Alaska Steam. They were mainly stevedoring areas converted into parking spaces for wheeled boxes.

The second stage witnessed the development of massive port expansion programs as the ports could not provide the needed capacity. The pattern of development in the US varied at different ports. For example, at NY/NJ many terminals were converted into container facilities, Long Beach developed plans to reclaim from the sea 1000 hectares, etc. In addition, many facilities in the US were modified or newly designed for higher density stacking (Straddle carrier, RTG (rubber-tired gantries), and RMG (rail mounted gantries).

The third stage of partial automation1976-2016 saw the emergence where one or more components of the container terminal was partially automated (automation is defined where no human reaction is needed). Partial automation occurred in various segments of port terminal activities. Examples of such activities are moving containers using ship to shore cranes, shuttle carriers (using automatic guided vehicles i.e. AGVs), automated stacking of cranes, automated gate facilities, etc.

Partial automation has now evolved into a fully automated container terminal system. In September, 2017, Kalmar and Navis (parts of Cargotec), delivered the first OneTerminal automation solution to International Container Terminal Services Incorporated at the Port of Melbourne, Australia. This has made Victoria International Container Terminal (VICT) the world's first fully automated international container handling facility. It includes the Navis N4 Terminal System and software integration. "The N4 Terminal System will allow VICT to optimise operations, speed turnaround times deliver a new level of unprecedented efficiency in key areas of the terminal," said M. Welles.[xii]

The magnitude and complexity of operations at a container terminal involve berth planning, stowage planning, quay crane scheduling, loading/unload sequencing, and space planning. The high level of performance demanded by shipping lines led to the evolution of Terminal Operating Systems (TOS). The TOS tracks and directs the movement and storage of various types of cargo in and around a container terminal or Port. It is composed of sub-systems for administration, planning, scheduling, executing and reporting. Communications technologies used include the internet, EDI processing, mobile computers, wireless LANs (local area networks) and Radio-frequency identification (RFID). Without the advances in computers and communications, it would be impossible to obtain the levels of efficiency in the use of assets, labour and equipment.

Continued Rapid Growth or Maturity?

An economic model of the product life-cycle as illustrated in Figure 1. The x-axis represents time and the y-axis is a measure of output, like revenues or tonnes. The pattern of development proceeds through stages of introduction, growth, maturity and eventually decline. Only a few innovations ever reach the tipping point where rapid growth begins. During the growth phase, the expansion rate exceeds the growth rate of the general economy. When the product reaches maturity, its increase slows and in the case of transport grows as a derived demand of trade expansion.

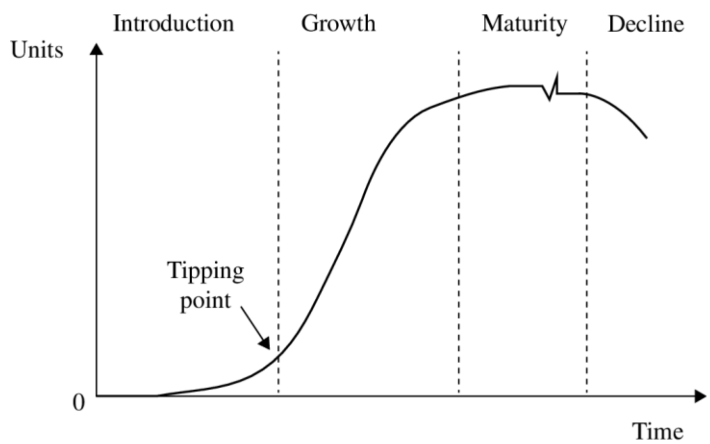

Figure 1 Product Life-cycle of Containerization

Whether the container industry is entering a stage of maturity, or simply taking a pause from its impressive growth rate is difficult to confirm. The signs that one might expect to see are changes in the rates of growth and technological improvement. Also, maturing markets tend to exhibit increasing industry concentration and ownership consolidation. These indicators are examined briefly.

A perspective on the growth rate of containerization was offered recently by World Marine News:

> "The cellular containership fleet has reached a new high of 21 million TEU in November, according to Alphaliner. However, the fleet growth was somewhat slower than expected over the past two years as it took 22 months for the fleet to pass the 20 million TEU threshold. As disclosed, this is the slowest growth rate since 2000, taking into account that the average growth rate over the past 15 years came at 1 million TEU every 12-13 months. Alphaliner ascribed the slowdown to the increased scrapping of ships which removed 501,000 TEU from the fleet as vessel deliveries brought in 413,000 TEU resulting in marginal shrinking of the fleet."[xiii]

It is also worth noting that the shipping lines have been practicing "slow steaming" to deal with excess supply that occurred following the "Great Recession" after 2008. This reduces fuel consumption costs, but it also allows more container ships to continue operating which inflates the appearance of activity.

The shipping lines achieved internal growth through investing in larger more efficient ships, optimizing services and increasing productivity. Physical constraints make the drive for ever larger container ships unlikely. Ships over 14,000 TEUs already exceed the size of the new Panama Canal locks. Forecasts of container ship deliveries are becoming bifurcated between ships carrying more than 10,000 TEUs and those carrying fewer that 4,000 TEUs. The Alphaliner[xiv] forecast of cellular fleet deliveries to 2020 is reproduced in Table 6. As can be observed, no new ships in the 4,000 to 9,999 TEU-category are expected in the next two years, while the other size categories remain active. An inference from these data is that continuous growth in ship size is unlikely to be direction of the future. Instead, the industry could be expanding its hub and spoke networks, with the mid-sized ships slowly phased out over time.

Table 6 Expected Deliveries of Cellular Ships, 2018-2020

	2017 deliveries		2018 deliveries		2019 deliveries		2020 deliveries	
TEU nominal	Ships	TEUs	Ships	TEUs	Ships	TEUs	Ships	TEUs
18000-21000	25	504289	28	541598	5	90000		
13300-17999	23	334460	15	210798	9	125740		
10000-13299	43	489333	23	294900	2	23600		
7500-9999	7	64592						
5100-7499	5	28062						
4000-5099	4	16022						
3000-3999	15	54539	12	41300	2	7100	1	3500
2000-2999	42	107473	30	80236	2	5600		
1500-1999	38	67720	16	29400	5	9122		
1000-1499	20	22902	23	28338	1	1162		
500-999	5	3303	1	600				
100-499	7	2278	2	720				
Total	234	1694973	150	1227890	26	262324	1	3500

Source: adapted from Alphaliner - Fleet Forecast-2017-01.pdf

External growth in the shipping lines was obtained through horizontal acquisitions and mergers, agreements, combinations, and alliances. Between 1996 and 2005, thirteen major mergers and acquisitions occurred. Drewry lists four major reasons for mergers: economies of scale, strategic advantage, complementary geographic coverage and market power. After a lull of nearly ten years, another round of mergers occurred largely in response to financial pressures. The latest increase in mergers is attributed more for survival (low rates and overcapacity in 2016) than for growth.[xv] One source states “By all accounts the liner shipping industry has witnessed the most significant restructuring in its history…” when in the last 3 years 7 of the biggest 20 container lines merged or were acquired.[xvi]

The early structural changes paved the way for the evolution of alliance partnerships.[xvii] The first global alliance in shipping was formed in 1994 between American President Lines, Orient Overseas Container Lines, and Mitsui-OSK Lines. By 1998, five major alliances were formed with 61.03% of the market. Twenty years later (in 2017), continued mergers and acquisitions, bankruptcies and strategic developments changed the alliance structure to three: 2M alliance, Ocean Alliance and THE Alliance. These alliances represent a total fleet of 15,862,742 TEUs or 76.6% of operational capacity. By comparison, the top 30 carriers and alliances in 2001 held less than 50% of the operational capacity.[xviii] The substantial increase in concentration is consistent with a maturing industry.

Prior to the 1970s, most port facilities, especially in non-Western countries were owned or controlled by governments, municipalities and other public parties. The port terminals were run by two types of operators: a. stevedores (e.g. PSA) and b. shipping companies (e.g. Sealand and APL). The increasing need for specialized services, the growing demand for container facilities and the growing need to keep up with developments in international business led to the gradual rise of specialized “global” port operators. This process was facilitated by deregulation and privatization of ports in some countries. The structure of port terminal ownership is shown in Table 7, which indicates a gradual increase of ownership by ocean carrier terminal operators and a rapid increase in global terminal operators.

Table 7 - Terminal ownership structure (1991-2001)

Year	Others	Global	Ocean Carriers
1991	69%	20%	11%
1996	61%	27%	12%
2001	46%	35%	19%

Source: Drewry Shipping Consultants Ltd., 2001.

As in the case of the shipping lines, the terminal operators have gone through a maturation process of concentration. By the 21st century, two distinct types of container terminal operators began to attract attention: ocean carrier terminal operators[xix] and specialised terminal operators.[xx] A few years later, a third type of global container terminal owner began to emerge - financial institutions i.e., banks, hedge funds, private equity groups, and investors.[xxi] Table 8 presents the current structure that illustrates a significant gap between the top operators and the rest which continued to increase after 2001.

Table 8 - Global/international terminal operators' total throughput (2001-2018) (Million teus)

		2001		2005		2015		2018
Ranking	Operator	M. teu	(%) share	M. teu	(%) share	M. teu	(%) share	Ranking
1/1/1	HPH	29.3	11.8%	51.8	13%	81.0	11.8%	4th
3/2/2	APM Term.	13.5	5.5%	40.4	10.1%	69.3	10.1%	2nd
2/3/3	PSA Int.	19.5	7.9%	40.3	10.1%	63.8	9.3%	3rd
8/5/4	Cosco Group	4.4	1.8%	14.7	3.7%	62.8	9.2%	1st
7/6/5	DP World	4.7	1.9%	12.9	3.2%	60.5	8.8%	5th
4/4/?	P&O**	10.0	4.0%	23.8	6%			
5/7	Eurogate	8.6	3.5%	12.1	3%			

Source: Drewry Shipping Consultants (2003, 2006)

Further automation of container terminals, and possibly the operations of container ships, will help control costs, but there is nothing on the horizon that will create the economies that have been experienced by increasing ship sizes. Concentration is reducing competition and incentives to pass on the economic benefits of productivity improvement to shippers. The characteristics of a maturing industry are visible on the supply-side. If rapid growth is to return to the container industry, it must come from the demand-side of the market.

Demand Side Drivers

The two most important forces that drove the demand for containerization were the conversion of breakbulk and some bulk commodities to containerization, and the growth of export-led economies in developing countries. Most of the breakbulk cargoes that will fit into a container have already shifted. Some commodities, like grain, could still move from bulk to containers, but these volumes are only likely to be large in circumstances where backhaul rates are available.[xxii]

Population growth and higher disposable incomes have a direct impact on trade. This could lead to increased container demand, but a closer look at these trends presents mixed messages. Global population is expected to reach around 9.5 billion in 2050 from 7.6 billion in 2017, but the majority this growth is expected to occur in the cities of the developing world that do not have high incomes. The rich countries have the wealth to import more, but their population is stabilizing, aging and in some countries, it is even in decline (parts of Europe and Japan). It is far from clear that imports of containerized goods will grow significantly in the rich countries.

One should never assume that the populations in Southeast Asia have reached average incomes equal to North America or Europe. Certainly, more people are enjoying high incomes, but parts of China and Indochina remain very poor. Besides economic growth rates in Southeast Asia are slowing, and domestic growth is likely to be more important than export-related growth in the coming decades. The "wildcard" is the region that surrounds the Indian Ocean. The populations of Pakistan, India, Bangladesh and Indonesia, Kenya and South Africa could certainly generate the output to expand the demand for containerized trade. These countries are industrializing, but whether they will be able to find export markets like Southeast Asia did, is unclear.

Conclusion

It is always difficult to identify changes in trends, especially when they are so well-established. An historical parallel with the advances in railway technology (telegraph signalling, steel rails and compound steam locomotives) might be instructive in considering the future of containerization. The rapid growth of global railway networks (1855-1915) extended low cost transportation into the grassland plains of North America, Australia, Argentina, etc. Suddenly, it became economic to grow wheat for sale abroad. Before the end of the 19th century, the resulting surge in exportable wheat was already overwhelming the demand in Europe, which was the only import market. After WW1, grain prices fell dramatically and remained at depressed levels for much of the remainder of the 20th century.

The rapid growth of container technology (1968-2008) enabled a surge of manufactured goods to be produced and exported from low labour-cost countries of Southeast Asia. The major importers are North America and Europe, as evidenced by the Wal-Mart shelves filled with goods from this region. Can and will the rich countries continue to absorb ever larger volumes of manufactured goods from low-labour cost countries? Not only is there political push-back in the US, which is the largest market, but a full out drive towards robotics and automation is underway to compete with workers in developing countries. While continued growth of containerization will occur, the authors of this article agree with Havenga, et al. that this industry is maturing. The future expansion of container shipping is more likely to follow the growth of the world economy, rather than to lead it.

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[i] Kindleberger, Charles P. *Foreign Trade and the National Economy*. New Haven, Conn: Yale University Press, 1962.

[ii] Havenga, Jan H. , Anneke de Bod and Zane P. Simpson (Stellenbosch. "Deconstructing Container Forecasting: Commodity-Based Supply Chain Analysis for South Africa." *Canadian Transportation Research Forum*. Proceedings Issue: 49th Annual Meeting (2014): 96-110. ISBN 978-0-9867070-5-6

[iii] *Diffusion of Containerization, Gisela Rua, October 2014, p. 27, www.federalreserve.gov*

[iv] Mercogliano, Salvatore R. Fourth Arm of Defense. Washington Navy Yard, D.C: Naval History & Heritage Command, 2017.

[v] *Container Traffic Forecast Study – Port of Vancouver*, Ocean Shipping Consultants, 2016, pp. 124-153

[vi] *Largest container ships on order to rise 13 percent by 2020*, JOC, July 7, 2015

[vii] See Container Shipping and Ports: An Overview, THEO E. NOTTEBOOM, Review of Network Economics, Vol.3, Issue 2 – June 2004.

[viii] Transportation Technology and the Rising Share of US Perishable Food Trade, Economic Research Service, USDA, pp.31-39.

[ix] Levinson, M. *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton, NJ: Princeton University Press, 2006.

[x] Development of Containerization, Success through Vision, Drive and Technology, Hans Van Ham and Joan Rijsenbrij, 2012, p. 132.

[xi] *Id.*

[xii] VCIT world's first fully automated container terminal: Cargotec, September 12, 2017, www.ctl.ca

[xiii] *World Maritime News.* "Alphaliner: Containership Fleet Breaks 21Mn TEU Mark" Posted on November 29, 2017

[xiv] Alphaliner - Fleet Forecast – various years

[xv] Consolidation in the Liner Industry, White Paper, March 2016, pp. 1-25. (www.drewry.co.uk)

[xvi] A dramatic restructuring, Food Logistics, August 2017, pp. 64-67.

[xvii] PortGraphic: dynamics in alliance formation in container shipping, Theo Notteboom, Port Economics, June 1, 2016, p. 1.

[xviii] The puzzle of shipping alliances in April 2017, 20 April 2017, www.porteconomics.eu

[xix] For example, Maersk; APL; Evergreen; Hanjin; P&O Nedlloyd; NYK; MSC; and OOCL.

[xx] For example, HPH; APT; PSA, P&O, COSCO; Eurogate; and DP World.

[xxi] For example (Babcock and Brown, DPW (Sovereign Wealth Fund), Ports America (A1G; Fund), RREEF (Deutsche Bank; Fund), Macquarie Infrastructure (Fund), Morgan Stanley Infrastructure (Fund), SSA Marine (Goldman Sachs).

[xxii] Prentice, Barry E. and Mark Hemmes. (2015) "Containerization of Grain: Emergence of a New Supply Chain Market". *Journal of Transportation Technologies*. **5**, 55-68.