Is the Drive For Ever Bigger Containerships Irresistible?

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1. Introduction

Good morning ladies and gentlemen. Over the last year the debate on containership size has become highly controversial. Big containerships were championed in the excellent study "Malacca Max: the Ultimate Container Carrier" which argues that:-

"The driving force is the creation of a competitive advantage through economies of scale. The Malacca-max design has an overall lower cost level of approximately 16% over the current largest container ships of 8000 TEU. In a world of cut-throat competition, 16% can make a decisive difference"[1].

No wonder this fascinating study stirred up so much debate. Its predictions that the ship size race will escalate to 18,000 teu have struck terror into the hearts of terminal operators and liner companies who, if the study is right, must prepare for yet another round of investment.

But not everyone agrees that mega-ships are what the industry needs. Several academic studies take a very different view.[2] So who is right? I have no doubt that it is technically feasible to build an 18,000 TEU containership and given present circumstances in world shipbuilding it would not be difficult to find a shipyard willing to undertake such a task. But is the liner industry really moving towards a world of hubs, with mega-containerships shuttling between them? I cannot answer such a fundamental question in a short paper, but I can at least try to clarify the issues, which I will do under the following headings:-

1. **Trade outlook**; ship size depends partly on volume, so we must establish how much trade will carried in future, to put the commercial discussion in context.
2. **Economies of scale in shipping**; the container business is not the only part of the shipping industry to be confronted with the size issue. How do other parts of the industry deal with it?
3. **Trends in containership size**; how has the container business tackled the size issue to date?
4. **The economics of containership size**. How much would unit transport costs be reduced by taking another step up in ship size?
5. **Implications of ship size for the global transport system**; some thoughts about how the transport system could develop and the systemic implications for ship size.

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[1] Wijnolst, Scholtens, Waals (1999) Malacca-Max The Ultimate Container Carrier Delft University Press, page 7

[2] Seok-Mia Lin (1994) *Economies of Containership Size: a New Evaluation* concludes that "the benefits of size economics are not strikingly apparent". Sidney Gilman (1998) in *Size Economics and Network Efficiency in large Containerships* concludes "the savings in initial capital costs, which represent a large component of size economies, are rather weak".

2. The Future of the Container Trade

The challenge of sustaining growth

We start with trade. In the last 50 years seaborne trade has grown steadily at 2-3% per annum, and, crisis and wars apart, most analysts assume that this will continue over the next 20 years (Figure 1). But the container business has been far more dynamic. Whilst the bulk trade has grown at only 1-2% per annum, container movements have expanded at 6-8% per annum (figure 2). This rapid growth did not happen spontaneously, it had to be earned in three ways:-

1. **Widening market share**: Containerships pushed out the less efficient traditional vessels, as can be seen in Figure 3, increasing their market share. More recently it has targeted specialist markets such as refrigerated cargoes. This transitional phase will soon end, and the growth rate of the mature container trade will fall.
2. **Price Reduction**: Transport costs have fallen remarkably. The cost of shipping 15,500 bottles of scotch whiskey from the UK to Japan fell from $1,560 in 1991 to $675in 2001. The cost of shipping 14,500 pairs of trainers from the Far East to UK is about 18 cents a pair[i]. Today it is cheaper to move a container by sea from distant parts of the world than by land from a local town.
3. **Generating new trades**: Containerisation has been successful in creating new trades. Figure 4 illustrates the transport model with its many stages of manufacture, assembly, packaging, wholesale and retail. Manufacturers scan the world for cheaper manufacturing and assembly locations and new markets. By opening up *maritime highways* to new areas of opportunity, the container industry stimulated a "virtuous cycle" of expansion for global business and created new cargoes for itself.

This past growth was hard earned, but as the industry matures future growth will become even tougher to win. The 6% per annum growth forecast which most analysts seem to take for granted (see Figure 5) will not happen spontaneously. So the container business is "under the gun" to find ways of generating additional cargo. Are 18,000 teu ships the answer? I suspect that if they have a part to play it will be a modest one and that making those *maritime highways* faster and more comprehensive may prove more important.

3. Economies of Scale in Shipping

Containerships are much bigger today than they were thirty years ago. The age profile of the containership fleet in Figure 6 shows that the average size of ship delivered trebled from 900 teu in the early 1970s to 3100 teu in the 2003 orderbook. Clearly there has been a good deal of variation around the trend line. There were periods in the late 1960s, the late 1980s and the late 1990s when sizes jumped by 30-50% in just a few years, only to fall back again. The most extreme case was in the late 1980s when the average size shot up to 2,200 teu in 1988, then fell back to 1,800 in 1992. Deliveries did

not average 2,200 teu again until 1998. There was another surge 1999-2003 when the average reached 3,300 teu. The trend forecast suggests that this will prove to be an overshoot and the average size will creep up to about 3300 teu in ten years time, which is not much bigger than the orderbook today. So if past trends continue the recent surge in containership size should ease off for a spell as carriers take stock of recent increases. All we have to do is decide whether this rather simplistic forecast is right.

Average ship sizes do not always increase

Although the sort of “size creep” shown in Figure 6 is a pervasive part of shipping economics, it can take many forms. The average size trends for three other shipping segments, tankers, bulk carriers and gas tankers in Figure 7 show some different patterns (note that this graph shows the average size of the whole fleet, not of deliveries in each year). For example the average size of crude oil tanker shot up in the 1970s, but is smaller today than it was twenty five years. The same is true of gas tankers. These trades are even better suited to exploiting economies of scale than containerships, so what happened?

The explanation is that the commercial environment changed. Until the 1970s the seaborne oil trade was tightly controlled by the 7 major oil companies who planned and orchestrated every aspect of sea transport. Oil was cheap and transport accounted for half the CIF cost, so they used the biggest tankers possible, eventually building the 440,000 dwt “ULCCs”. Then in the 1970s the trade changed and control of transport passed into the hands of oil traders[3] who were less interested in size than flexibility. Because the oil parcels they traded were repeatedly bought and sold during transport, ships that could only access a few discharge ports were a problem and the ULCCs became white elephants. Just to make matters worse the balance of the oil trade moved from long haul to short haul suppliers and tanker sizes fell by almost 30% during the 1980s.

Bulk carriers behaved quite differently from tankers. There was no spectacular increase in size. Rather the average size crept steadily upwards, increasing by 60% between 1975 and 2002, an average of 2.2% per annum. Today the standard Capesize bulker, the biggest vessel, is 175,000 dwt, compared with 120,000 dwt twenty years ago, a 46% increase. There are a handful of 300,000 dwt bulk carriers but these are used in specialist trades and you will not find investors losing much sleep over the possibility that the standard Capesize will jump to 300,000 dwt. Until recently the containership fleet followed a very similar pattern to bulk carriers, as can be seen in Figure 7. However in the last five years the containership size index has drawn ahead of the bulk carrier index. So in general sizes tend to creep up over time. Perhaps there is a lesson for containers in the experience of the oil business with traders.

Shipping market portfolio economics

One final point. Economies of scale are not restricted to adding big ships at the top of the size range and scrapping the small old ships[4]. In practice shipping markets use a portfolio of sizes to meet the wide ranging demands of cargo transport. Figure 8, which

3 For example Shell had control of a fleet of 283 ships in 1978, but by the late 1990s they owned less than 20 tankers

4 Note that tankers and bulk carriers have a group of "deep draught" vessels which so far the containership fleet does not. That certainly suggests that it would be possible for a fleet of very big container ships to develop for deep-sea routes.

Fig 7

Size Trends In Merchant Ships

- Average size of merchant ships can change
- Tankers, bulk carriers and gas tankers all followed different size trends
- It is all a matter of economics

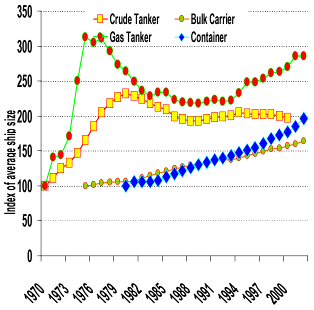


Fig 8

Economies of Scale - Draft

- The chart shows the draft distribution of the tanker, bulk and container fleets
- The average is
  - Tankers 10.6
  - Bulk 11.6
  - Container 9.7

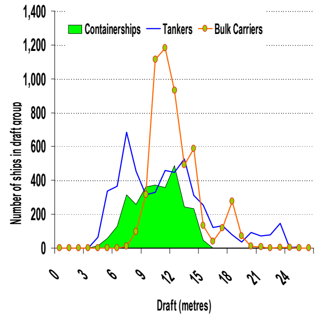


Fig 9

Container Fleet by Size

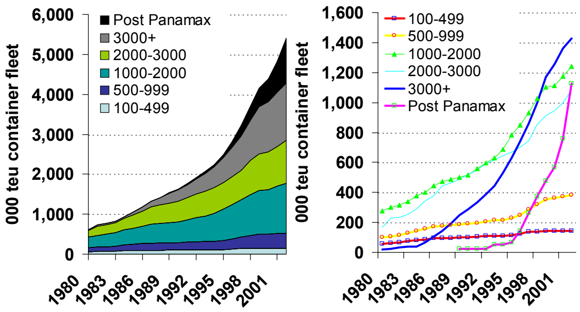


Fig 10

Container Transport Costs

- Door to door transport costs depend on the cost of
  - The ship
  - The containers
  - Terminals
  - Inland transport
- Economies of scale apply differently in each case

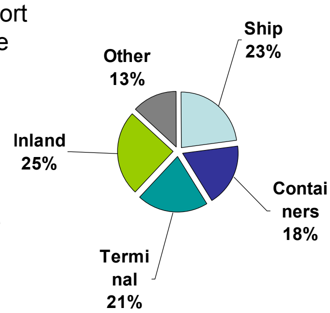


Fig 11

The Container Transport Model

- The ship accounts for about 23% of the through transport cost –OPEX, capital, bunkers & port costs
- Containers about 18% and container handling and inland costs about 54%

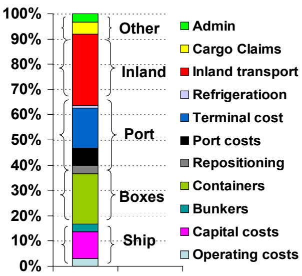
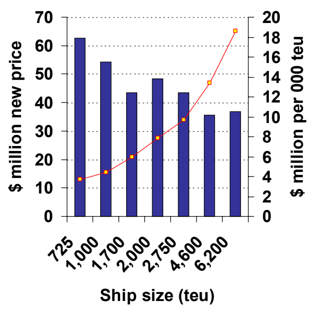


Fig 12

Economies of Scale – Capital Cost

- The line shows the price of ships ranging from 750 teu to 6,200 teu
- The bars show the cost per 000 teu
- Above 2000 teu the cost saving/000 teu is very small



compares the size/draft distribution of the tanker, bulk carrier and containership fleets, demonstrates that they all use a wide range of different ship sizes[5].

Over the last decade size segments within the bulk fleets have become well identified, with much of the size increase taking the form of upgrading sizes within these segments. For example in the tanker fleet the main segments are Products tankers, Aframaxes, Suezmaxes, and VLCCs. A typical Aframax tanker was 79,999 dwt twenty years ago, but today it is 110,000 dwt. That is a 37% increase, which is very significant. Similarly Suezmaxes have increased from 120,000 dwt to 160,000 dwt. Ironically the smallest increase has been in the VLCC sector which has increased from 280,000 dwt to 300,000 dwt for the latest generation of ships.

Exactly the same thing has been happening in the container fleet (Figure 9). A handy containership used to be 1000 teu and today it is 1700 teu. So economies of scale are not just an issue for the deep sea routes, for which 8000 TEU ships have been ordered recently. The continuing process of squeezing the short and medium distance trades into bigger ships is probably the most important application of scale economies in the container business today. As we will see when we examine economies of scale, these are the sizes where the economic benefits of bigger ships are the greatest.

4. The Economics of Size in Container Shipping

What drives container economics?

To progress matters further we need to look more closely at the economics of scale. Since the Malacca-Max lobby places so much emphasis on this justification for investing in bigger ships, we should look closely at where the gains come from. When we examine the broad transport operation we find that ship related costs account for less than a quarter of the door to door delivery cost. The components, shown graphically in Figure 10[6] are:

1. **The ship** which includes OPEX, capital and bunkers(23%); this share diminishes as the ship gets bigger
2. **The containers** including maintenance(18%); this cost is not directly influenced by ship size but there might be congestion driven diseconomies
3. **Ports and terminals**, including stevedoring (21%); This sector certainly faces significant diseconomies of scale due to the cost of dredging as draft is deepened[7]
4. **Inland transport** (25%); these costs are not directly related to the size of ship, but there are logistics issues which do not necessarily favour big ships.
5. **Other costs**, including container repositioning (13%); not ship's size related, except possibly some small saving in administration

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[5] The average draft is 9.7 metres for containerships; 10.6 metres for tankers and 11.6 metres for bulk carriers

[6] The calculation in this section are based on a model from Stopford, Martin (1997) *Maritime Economics* Routledge, London Chapter 10 The model is based on a simple transatlantic round voyage, and provides a framework for illustrating the impact of economies of scale on the total transport cost.

[7] Gillman (1998) expresses the view that there are probably diseconomies of scale in port operations

Viewed from this perspective we should be aware that any savings achieved by using bigger ships may be heavily diluted by the time they reach the shipper, especially if there are diseconomies in other parts of the system.

Economies of scale in ship costs

Beyond 5,000 teu, economies of scale diminish very rapidly. The reason is obvious when we examine the three key elements in the economies of scale calculation, capital costs; operating expenses; and bunker costs (see figure 11).

- **Capital costs:** Surprisingly investors do not save very much capital by building super ships, as Figure 12 demonstrates[8]. The cost of the ship increases from $12 million for a 725 TEU ship to $64 million for a 6000 TEU ship. The bars show that the average cost per 1000 TEU falls from the $18 million for a 725 TEU ship to $12 million for a 1700 TEU ship, but beyond that there is little further reduction and a 6200 TEU ship still costs $10.3 million per 1000 TEU. So the capital saving per 1000 TEU by building a 6000 TEU ship, as compared with four 1700 TEU vessels is quite small. For Mega ships the same principle seems to apply. The Malacca Max study estimates a construction cost of $10 million per 000 teu for an 18,000 teu vessel, so there are no further economies. At a cost of $181.5 million for the 18,000 teu vessel[9], one 18,000 teu ship costs only 5% less than three 6,200 teu vessels!
- **Operating costs (OPEX)**; Operating costs, which include crew, insurance, stores, maintenance and admin, also offer less opportunity for economies of scale than appears at first sight. Figure 13 plots the main components of operating expenses, over a range of ship sizes stretching from 1000 TEU to 18,000 TEU. Administration, stores and manning do not increase significantly, so there are scale economies here. However insurance and maintenance costs are likely to increase in line with the capital cost of the ship, offering little scale economy. The bigger the ship, the more important they become.
- **Bunkers:** Finally there is fuel consumption. Figure 14 plots bunker consumption against TEU capacity for a sample of 2500 containerships[10]. The regression equation suggests that increasing a ship's capacity by 1000 TEU increases the bunker consumption by 31.8 tonnes per day (though in a more thorough analysis would take account of the faster speed of bigger ships). The intercept is only 4.3 tonnes, so there are almost no economies of scale in bunker consumption, at least over such a wide TEU range.

The container economies of scale curve & the sector multiplier

My estimate of the container economies of scale curve, shown in Figure 15, confirms the tendency for returns to diminish. Increasing ship size from 1000 TEU to 2000 TEU saves 20% in the unit cost of transport; from 2000 to 4000 TEU saves 7%; and from 4000 TEU to 6000 TEU saves only 4%. Beyond 8000 TEU the economies are hard

[8] These prices are from the January 2002 issue of *Container Intelligence Monthly*, published by Clarkson Research. They are cash costs, and some additional delivery expenses would be incurred.
[9] Malacca-Max study 1999 page 61, and Clarkson Container Intelligence Monthly
[10] The fit is quite good, and could doubtless be improved further by including vessel speed in the calculation.

to detect. Interestingly the Malacca Max reports reached a similar conclusion. According to statistics quoted in the Planco Report[11], prepared for the Port of Hamburg, and illustrated in Figure 16, the savings in moving from an 8000 TEU ship to a 12,000 TEU ship is only 2% ($4 per teu). A negligible benefit from increasing ship size by 50%.

So there are economies of scale, but because they diminish with size the biggest benefits will be derived by upsizing cargoes in the smaller segments of the container fleet, not by building super ships.

Diseconomies of scale

Finally we should mention the diseconomies of scale. Using very big ships requires deep dredging of hub ports and necessitates feeder services to ports which cannot accommodate them. These feeder costs dwarf the savings on using bigger ships, on the deep sea leg, as Figure 17 illustrates. This graph shows the feeder cost superimposed on the economies of scale curve. The small feeder vessels are highly inefficient and there is an extra set of port costs to consider.

These economics simply do not make sense to me. You could avoid feeder services by deepening all the ports, but this incurs additional costs, and when dealing with drafts in excess of 18 metres, dredging costs increase exponentially. This does not matter to containership operators who do not have to pay these massive capital costs. No doubt governments will put up the funds and somewhere along the line the capital will be written off. However as economists and analysts, we have a responsibility to identify the shipping system which is most appropriate for the global economy, not the one which suits a particular segment.

5. Customer service & ship size

Which brings us to the central issue. It is the efficiency of the transport system we should be concerned with. This point was brought home very forcibly when I re-read the McKinsey report on containerisation[12]. This report, written in 1967, was uncannily accurate in predicting how the liner industry would change after containerisation, so its analysis of the fundamental processes deserve attention. It viewed containerisation as the automation of liner transport:-

"basically automation is the desire to reduce per unit costs, which can be accomplished in two ways – expensive labour can be replaced with cheaper capital equipment - e.g. replacement of clerical staff with offers machines. Material resources can be better utilised through improved process control - e.g. automated gauge controls on a rolling mill. Most applications of automation involve both these elements.

In these terms the best way of improving productivity and reducing unit costs is to make the whole transport system work more efficiently at higher volumes of throughput and there are still many opportunities to apply these principles.

The new *maritime highways*

One of the reasons the containerisation has been so successful is that it has

[11] Planco Consulting GmbH, Essen *Analysis of the Need for a Deep Water Port in the German Bay*, October 2000 Anlage 3 tab

[12] McKinsey & Company (1967) "*Containerisation: The Key to Low-cost Transport*" for British Transport Docks Board June 1967.

allowed industry to migrate its manufacturing activities to those parts of the world which offer the best economic advantage. In a very real sense this has allowed the industry to specialise in a way which Adam Smith would have thought highly appropriate. In principle there is no limit to the volume of trade in raw materials and components which can be shuttled around the world during modern manufacturing, provided doing so shaves a few cents off the bottom line.

This is a great escalator for the container business to be on, but like all escalators, you have to keep moving. For the container industry the challenge is to provide fast, cheap transport to the right places. Today the global economy is continuing to develop, with a new areas of industrial activity in South America, China, Eastern Europe (see Figure 18). These areas of new activity have one thing in common. They do not lie at either end of the major arterial routes between North America, Europe and Japan. At least one way to look at the container trade over the next 20 years is as a "filling out" of the trade matrix. That would growth focus growth on the mid size ships, and it is here that the benefits of economies of scale are greatest. Squeezing a 1200 teu trade into a 2000 teu ship gives a massive benefit. It is a universal approach followed by all shipping markets and we should not allow the newsworthiness of super ships to cloud our vision. This is where economics will drive the container business.

Finally we are moving into an era driven by intermodal logistics servicers. I suspect that their focus, like the oil traders, will be on flexibility. The ability to switch ships from port to port is invaluable, and it is in the tightening up of the distribution service, using all sizes of vessels, that the really big gains are to be made in future. Another reason for keeping size in perspective.

6. Conclusions

So let me pull my conclusions together. Marcel Proust commented "the real discovery consists not of finding new land, but in seeing with new eyes". Big ships are fascinating, especially really big ships like the Malacca-Maxes. Just look at the love affair tanker owners have with VLCCs! But we need to keep a sense of balance.

My five points are as follows. *Firstly*, economies of scale diminish beyond 3000 teu and over 8000 TEU the savings become immeasurably small. *Secondly* there are significant diseconomies due to the cost of dredging, congestion, distributing cargo from hubs and associated logistic difficulties. *Thirdly* there are massive economies to be made by upgrading ship sizes in the small and mid size trades. *Fourthly* the trading world is broadening and this will favour mid size ships. *Fifthly*, a business dominated by logistics operators is likely to value the flexibility offered by smaller ships.

So I believe the drive for bigger container ships is irresistible but the "bigger" I have in mind is not an 18,000 TEU ship replacing a 5000 teu vessel. It is more likely to be an 1800 TEU ship replacing 500 TEU ship. Now that gives a real saving.

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[i] The Far East Freight Conference (FEFC) provided these figures. They are undiscounted, so a big shipper would expect to pay much less. The Whiskey is based on 15,500 bottles in a 20-foot container at a rate of $1,660 in 1991 and $675 in September 2000. The trainer example is 14,500 pairs of trainers in a 40-foot container at a tariff of about $2,750.