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Economies of container ship size: a new evaluation

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Based on recent operation performance data, the earnings and costs of container service have been investigated in the context of two indices developed by the Japanese and used elsewhere in East Asian shipping: *charter base* and *hire base*. Although the average size of container ships on the world's main trade routes has increased over the past two decades it is dangerous to generalize about the economies of scale derived from larger ship size. The effects of ship's size on voyage results vary in accordance with such factors as ship's purchase price, level of running costs, level of freight rates, voyage length, achieved load factors and accounting methods used for allocating fixed costs. The question of optimum vessel size, therefore, has no generally applicable answer. Shipowners must compromise.

1. Introduction

The size of container ships has been increased continuously. Why have the ships gotten bigger? Because of the economies of scale. The larger ship is cheaper per ton to build, and running costs per ton also fall as size of the vessel is increased. As major container operators have been putting newer and bigger ships in the water, they have reduced the operating cost per container-mile by nearly half in the last decade [1]. It is a reasonable hypothesis that there are economies of container ship size at work.

Cost economies are particularly important where and when fierce competition exists. Price wars among the container lines have led to bankruptcy for several high cost operators; the low cost firms are left; and a few others 'bailed out' or subsidized by their governments. This 'survival of the fittest' phenomenon is especially apparent on the world's highest volume trade routes: East Asia–North America, East Asia–Europe and North America–Europe. It is in these main corridors of container trade that there has been the most attention given to reduction of unit costs of container carriage and the most experimentation with larger capacity ships.

To the shipowner and to the shipbuilder the utility of 'megacarriers' is an important issue today. In this study the effects of ship's size economies will be examined and a number of other factors influencing these scale economies in container shipping will be reviewed. The 'economies of size' will be measured by comparing unit earnings and unit costs for different vessel sizes. The basic unit in this study for measuring vessel capacity and cargo lift will be the TEU (twenty-foot equivalent unit).

One purpose of this paper is to provide a quantitative test of the hypothesis that larger vessels are more economical in producing a unit of transport services—e.g. carrying one container from A to B. To achieve this purpose the relationship between unit voyage income, unit costs and size of vessel will be examined, testing the validity of the common assumption of increasing income and decreasing cost for vessels of increasing sizes. Another aim is to examine the distortions of the hypothesis that 'larger is better' by certain other factors such as vessel's purchase price, average freight rate level, average voyage lengths for the trade, achieved load factors, accounting procedures including methods of allocating shore overhead, etc. All of these factors have relevance to optimum vessel size for the most cost-effective *and* the highest income-producing container service.

The literature on ocean shipping contains several articles on ship's size economies. However, many of those studies utilize a 'macro' approach, building quantitative models from somewhat limited empirical data and a great deal of 'generalization' [2–6]. This paper will examine the earnings derived from and costs of container service with respect to the voyage operations of individual vessels but in terms of a general accounting model. The accounting model cuts across all facets of the operation although it has some deficiencies. The economies of vessel size will be converted to the language and measurement of revenue indices and expense indices that have been widely used in Japanese and East Asian shipping circles.

It is hoped that this paper will provide a methodology and insights that will be useful in planning and controlling routine operations as well as in making non-routine decisions and in formulating longer term plans and policies in the field of shipping.

The database obtained from East Asian shipping lines reflects the operation performances of ten container ships. Admittedly this is not a perfectly comprehensive platform for analysis, but at least a representative sample from which general implications can be drawn.

2. The conceptual framework

In conformance with the premise of scale economies it is commonly supposed that unit costs of transport service decrease with increments of vessel size. A corollary or additional proposition is that earnings per unit of transport service increase with increments of vessel size.

This paper will test the validity of these suppositions and propositions using the concepts and concomitant calculations of *Charter base* and *Hire base*. This terminology and these systems of calculation might be unfamiliar to the Westerners. Charter base (CB) and hire base (HB) are terms not to be found in English dictionaries. They were devised in Japanese shipping circles in the 1920s [7]. The CB may be thought of as a revenue index and the HB an expense index. Originally these concepts were intended for tramp voyage calculations; however, they have also been applied to liner shipping because they are simple and they reflect the efficiency of a vessel quite effectively. They are currently popular with Japanese and East Asian ship managers needing to make quick comparisons and decisions on vessel employment.

Charter base (CB) is the contribution margin (or marginal income) of a vessel per day when she is employed on a specific voyage. The contribution margin, an accounting terminology, is equal to revenue minus variable expenses [8]. The charter base is calculated by subtracting variable operation costs [9] from freight revenues and dividing the remainder by operation days. Charter base is usually calculated before and after every voyage.

CB: Freight Revenue – Variable Operation Costs (cargo related expenses + navigation expenses) = Contribution Margin ÷ Operation Day

Symbolically, it can be presented as follows: FR = freight revenue of a ship for a specific period of time; VOC = variable operation costs of a ship for a specific period of time; OD = operation days of a ship for a specific period of time (e.g. the duration of the voyage). Then, it can be represented as

$$CB = (FR - VOC) \div OD \tag{1}$$

In this paper a further calculation of CB per TEU (CB/TEU) of selected vessels will be made to measure the effects of ship's size economies to test the hypothesis that CB/TEU (unit contribution margin) increases as ship size increases. The CB/TEU for vessels of various capacities will be compared.

Hire base (HB) reflects the daily costs allocated to the fully-manned ship whether in revenue-earning operation or not (as long as the ship is not laid up). The expense items are crew and vessel expenses, and various overheads such as administrative, facility and equipment, and various non-operation expenses borne by the shipowner whether the ship is in revenue-earning operation or not.

The HB may be calculated by dividing total fixed costs (running costs + capital costs + overhead) by operation days. It is derived from the operation performance of a vessel over a specific period of time (e.g. a voyage of specific duration). It can be used also as a target figure for the ship's next period of operation.

There is more than one way of defining and allocating costs that make up HB. For liner operations of container ships the most comprehensive depiction of fixed costs (including overhead allocations to the vessel) is appropriate [10].

HB: Fixed Costs [= (ship expenses + crew expenses + insurance + depreciation + overhead)] ÷ Operation Days

Symbolically, if FC = various fixed costs of a ship during a specific period of time; and OD = operation days of a ship during a specific period of time. Then,

$$HB = FC \div OD \qquad (2)$$

The hire base which includes all but the variable costs of vessel operation should correspond quite closely to the time-charter rates on container ships. If CB is higher than HB, the operation will be profitable. Hire base per TEU is a unit cost measurement that is used as a guideline in space sharing arrangements between steamship lines. Having factored out the voyage-specific variable costs we intend to use HB per TEU for various size vessels to measure the effects of ship's size economies on the fixed and ongoing costs of vessel operations. Our hypothesis is that HB/TEU decreases with increments of vessel size.

3. Analyses of operation performance statements

3.1. *Different sizes on different routes*

The summary of operation performance of five ocean container ships of various sizes are shown in table 1. More detailed operation performance statements and additional informations are presented in Appendix A.

Ships A-1 and A-2 were employed on the route between East Asia and the US Pacific Northwest. The trade route of ship A-3 was between East Asia and the US East Coast. Ship A-4 was employed in a pendulum service which has vessels swinging back and forth through the three continents—Europe, North America and Asia—with Asia as the pendulum fulcrum.

The operation performance statement of ship A-5 is an estimated one predicting the performance of a fourth generation 4000-TEU container ship, a size that has been an object of much attention in current container trades.

Ships, A-1 and A-2 are different in size but operated on the same route. The comparison of these vessels' performance should illustrate explicitly the effects of economies of ship's size. Ships A-3 and A-4 are sister ships employed on different routes. These ships should illustrate the effects of other factors besides size influencing the voyage results. Ship A-5 is included as the predicted performance of a 4000-TEU vessel, which will be operated on the route between East Asia and the U.S. South Pacific.

Table 1. Operation performance of different sizes on different routes: 1991.

	Vessel type				
	A-1	A-2	A-3	A-4	A-5
Capacity[1]	1150	1662	2668	2678	3730
Miles[2]	120 010	120 010	134 528	135 812	137 880
Operation days	350	350	358	364	350
Supplied[3]	23 000	33 240	30 322	42 848	74 600
Carried[4]	19 114	27 556	23 294	34 610	59 012
Load factor[5]	83·1%	82·9%	78·9%	80·8%	78·3%
Freight revenue[6]	22 322	32 260	30 500	42 540	68 261
Cargo expense[6]	14 535	21 006	14 560	22 419	39 493
Navigation expense[6]	2066	2194	3336	4919	4965
Ship expense[6]	2539	3077	4813	5481	10 692
Overhead[6]	2041	2839	5863	5708	23 947

Revenues and expenses in thousands of U.S. dollars.
Source: Data supplied by East Asian shipping interests.
[1] The figure listed is the maximum carrying capacity of a one-way voyage represented by TEU.
[2] Reflects the total distances the ship navigated for the year, as calculated by multiplying the distance of a round-voyage leg by the number of round-voyages a ship performed for a year in 1991.
[3] Reflects the total amount of transport service produced by the ship for 1991, which is the product of the ship's TEU carrying capacity and the number of round-voyages (counted as two voyage legs) the ship performed in 1991.
[4] Reflects the total amount of transport service consumed for the year which is the product of the number of TEUs the ship actually carried and the number of round-voyages the ship performed for the year in 1991.
[5] Load factor is the percentage of total carrying capacity actually used. It is also called the performance ratio or the utilization ratio of a ship, and is calculated by dividing the carried quantity by the supplied quantity.
[6] The details of freight revenue, cargo expenses, navigation expenses, ship expenses, overhead are presented in Appendix B.

To investigate the effects of ship's size, we can compare unit income and unit cost per TEU for each of these ships and draw general inferences from these values. Unit income and unit cost will be affected by achieved load factors but the range of difference of the load factors among the five vessels is small—less than 5% between lowest and highest.

Table 2 shows that ship A-1's daily contribution margin were $16 346 in 1991, and A-2: US$25 886, A-3: US$35 207, A-4: $41 764, and ship A-5 will be US$68 011 (in 1993) as shown in row 1 of table 2.

The CB/TEU for each of these vessels is shown in row 2 of table 2. At a glance, it appears that CB/TEU increased with increments of ship size, as postulated previously. The main reason for the anomaly of A-3 is that the number of voyages completed in 1991 was less than those of the other vessels. A-3's average voyage length was 11 837-miles compared with 6000-miles for A-1 and A-2, 8488-miles for A-4, and 6894-miles for A-5. The ratio of containers carried to mileage steamed is unfavourable for A-3.

Table 2 indicates that the HB has increased consistently with ship size increases. Higher daily costs for larger vessels are to be expected. However, the HB/TEU data in Table 2 do not support the hypothesis that unit costs (in this case unit fixed costs) necessarily decrease with increments of vessel size. This implies that there are other components bearing upon the unit cost equation. Ship size is only one possible explanatory factor.

A-1 and A-2, however, were ships of different capacity that operated on the same route. It is apparent that the larger vessel A-2 is more economical than A-1 on this route. The unit contribution margin (CB/TEU) of A-2 is larger than that of A-1, and the unit fixed costs (HB/TEU) of A-2 were lower than those of A-1, which does support the hypothesis that unit income increases and unit cost decreases as ship's size increases. It should be added that this one comparison of ships of different sizes on the same route is not really enough to prove the point.

Table 2. CB and HB comparison of different sizes on different routes: 1992 (Unit: US$).

	Vessel type				
	A-1	A-2	A-3	A-4	A-5
CB	16 346	25 886	35 207	41 764	68 011
CB/TEU	14·214	15·275	13·196	15·595	18·185
HB	13 086	16 903	29 821	33 214	98 969
HB/TEU	11·379	10·170	11·177	12·403	26·533

Charter Base

The CBs for each of these vessels are derived as discussed in the previous section:

CB = (FR − VOC) ÷ OD –(1)

To illustrate, using the data from table 1 for ship A-1:

CB = ($22 322 000 − $16 601 000) ÷ 350 days = US$16 346/day

FR = total freight revenue for 1991 = US$22 322 000;

VOC = total variable operation costs for 1991 = US$16 601 000 = $14 535 000 (cargo related expenses) + $2 066 000 (navigation expenses)

OD = total operation days for 1991 = 350-days.

CB/TEU = US$16 346/1 150 TEU = US$14 214

Hire Base

The HBs for each of these vessels are derived as follows.

Using the data from table 1 for vessel A-1 to illustrate:

HB: US$4 580 000 ÷ 350 days = US$13 086/day

FC = fixed cost for 1991 = US$4 580 000.

=$627 000 (crew expenses) + $769 000 (ship expenses) + $199 000 (insurance) + $944 000 (depreciation) + 2 041 000 (overhead)

HB/TEU = US$13 086 ÷ 1150 TEU = US$11·379

A-3 and A-4 were sister ships employed on different routes. The CB/TEU of A-4 is higher than that of A-3. The A-3 supplied 15 161 TEUs, earning US$30 500 000 and A-4 supplied 21 424 TEUs earning US$42 540 000 for a year in 1991. The average freight rates for A-3 were US$1275/TEU which compares unfavourably with A-4's US$1229, when we consider extra distances and voyage durations on A-3's route.

Meanwhile, A-4's pendulum service consisted of four voyage legs: from East Asia to Europe, from Europe to East Asia, from East Asia to the U.S. Northwest and from the U.S. Northwest to East Asia. Therefore, although A-4 had only four round-voyages, her actual total voyage legs become sixteen while the voyage legs of A-3 are twelve. Consequently, the freight revenues earned by A-4 were more than those of A-3 and her CB/TEU is higher than that of A-3.

However, the HB/TEU of A-4 is higher than that of A-3. The main reason is that the purchase price of A-4 is substantially higher than that of A-3 (see Appendix A). The price difference was as much as US$3 575 000 per whole ship and US$1295 per TEU, although A-4 was purchased just one and a half years later. The effects of this extend through the vessel's whole life and inflate her hire base.

Vessel A-5's CB and CB/TEU are the highest, but the HB/TEU is also the highest, which is incompatible with one of our original hypotheses. The CB/TEU is higher because her running costs per day per container are lower than those of the other vessels. The HB/TEU, however, is higher due to high fixed costs such as hull insurance and especially depreciation and overhead.

This vessel was purchased at US$73 900 000 in January 1993. The unit price per TEU was US$19 812 which is US$7889 higher than that of A-4's US$11 913 (see Appendix A). A-5 is a state-of-the-art vessel and the purchase price more than reflects it.

Depreciation, overhead (administrative and non-operation expenses) of A-5 are far higher than those of other vessels. Overhead expenses such as administrative and non-operation expenses are as much as 20·9% and 9·3% of the total costs respectively, which makes one wonder about the allocation system used [11]. The high HB/TEU ratio for A-5 and exceptionally high overhead costs (see table 1) suggest that the allocation practice has strong effects on the ship's operating cost structure.

We can assume that the HB will always be affected by the exact accounting methods used. Accountants frequently debate the methods of allocating overhead and the differences between historical value, present real value and replacement value of assets. 'In house' accounting procedures can, of course, be tailored to give shipping managers the most realistic picture of what's going on. Accounting must be honest but accountants need to have more than one method since there is more than one facet to the real picture [12].

The HB/TEU ranged from $10·170 to $26·533. As discussed previously, the HB corresponds closely to a ship's minimum necessary time-charter rate and the HB/TEU is equivalent to minimum necessary TEU slottage. The recent time-charter rates on various size container ships and the TEU slottage rates have been compared with the HB and HB/TEU of table 2. There is a rough equivalence. For instance, the average going rate of a TEU slot for a 1200-TEU vessel in 1992 was US$11·70 which was compatible with the 1991 HB/TEU of A-1's US$11·379. This implies also that A-1 would be competitive in the container tramp charter markets.

3.2. *Two sets of sister ships on the same route*

Table 3 summarizes operation performance of five container ships, each for just one round-voyage between East Asia and the US West coast in 1992. The ships, B-1 and B-2—sister ships—were built in 1992 with a 4411-TEU capacity and a speed of 25·1 knots. The ships, B-3, B-4 and B-5—sister ships—were built in 1986 with a 2641-TEU capacity and a speed of 20·0 knots. The data for B-1 and B-2 in table 3 record their maiden voyage performances. Detailed information of fixed costs were not available; only aggregated amounts were available for these vessels.

Table 3. Operation performance of sister ships on the same route: 1992 (Unit: US$).

	Sister ships		Sister ships		
	B-1	B-2	B-3	B-4	B-5
Navigated miles	14 414	14 414	14 414	14 414	14 414
Voyage days	42	42	42	42	42
Supplied TEU	8822	8822	5282	5282	5282
Carried TEU	6035	6410	4950	4988	4994
Load factor	68·4%	72·7%	93·7%	94·4%	94·5%
Freight revenue	7 681 815	8 294 107	6 553 052	6 643 023	6 622 980
/TEU	(1273)	(1294)	(1324)	(1332)	(1326)
Cargo expense	5 295 298	6 088 509	4 507 958	4 515 809	4 515 284
Navigation expense	615 210	632 869	379 658	389 490	398 788
Fixed cost	1 788 407	1 788 526	875 746	876 036	875 978

Source: Data supplied by East Asian shipping interests.

There are substantial differences between the CB/TEU of B-1 and B-2 despite their being the same size. Although the load factors and freight revenues were more favourable for B-2, this advantage was more than cancelled out by higher cargo costs.

At a glance, the smaller ships (2641-TEU vessels) were far more economical than the larger ones (4411-TEU vessels). The CBs/TEU of smaller vessels are far higher and HBs/TEU are substantially lower than those of larger vessels.

The main reason for this is that the carrying capacities of 4411-TEU ships are temporarily lowered to 3522-TEU for the operation's sake, i.e. in order to keep pace with the schedules of smaller vessels which permitted a fixed schedule at each calling port on a specific weekday. However, it seems that the fundamental reason for lowering the lift is the limits imposed by market share. The routes were currently in excess capacity and freight rates were relatively low. From the beginning it was not easy to fill large vessels.

The implications of the above are that it is desirable to use container ships of uniform size on particular routes. Also, the choice of optimal size is significant. The vessels of 2641-TEU capacity were more appropriate for the present route than 4411-TEU vessels. The CBs/TEU are higher and HBs/TEU are lower for the smaller ships because of the lost capacity on B-1 and B-2.

Another indicator often used by transportation economists is the cost per TEU per mile carried. The cost per TEU-mile can be calculated by dividing total costs by total amount of transport service produced during a specific period of time. The total amount of transport service is calculated by multiplying total navigated miles by the total number of containers a ship carried (or if planning a voyage, carriable) for a specific period of time.

However, neither a ton-mile nor a TEU-mile are all-revealing measuring units of transport service [13]. If we compare the unit costs of the same type of vessel being operated on the trade routes of various distances, the unit cost of the vessel employed on longer route is far less than that of the vessel on the shorter route. Ton-mile or TEU-mile costs are very dependent on the distances of voyage legs [14].

Nevertheless, in certain shipping circles, the TEU-mile is currently being used as a measuring unit or a guideline. For instance, an American observer noted: 'By replacing smaller and less efficient ships, C-10s will help APL (American President Line) reduce ocean transportation costs on a per TEU per mile basis to just over 5 cents, 50% lower than 1984 levels. APL's Panamax size vessels are operated at a cost of about 10 cents per TEU per mile [15].'

It is best to use cost or income per TEU-mile for comparisons of vessel performance on the same route or routes of equivalent length. However table 4 reveals no startling variations in TEU-mile costs. The empty slots—i.e. low load factors—for B-1 and B-2 cloud the picture.

Table 4. CB and HB comparison of sister ships on the same route: 1992 (Unit: US$).

	Sister ships		Sister ships		
	B-1	B-2	B-3	B-4	B-5
CB	42 174	37 446	39 653	41 374	40 688
CB/TEU	9·561	8·489	15·014	15·666	15·406
HB	42 581	42 583	20 851	20 858	20 856
HB/TEU	9·6539	9·6538	7·8951	7·8977	7·8972
U.S.¢/TM†	7·9777	8·4939	7·9675	7·9432	7·9471

†U.S. cents per TEU per mile (based on the 14 414-mile voyage length).

Table 5. Proportions of various expenses to total expenses (Unit: %).

	Vessel type				
	A-1	A-2	A-3	A-4	A-5
Cargo expense	68·6	72·1	51·0	58·2	49·9
Navigation expense	9·8	7·5	11·7	12·8	6·3
Ship expense	12·0	10·6	16·8	14·2	13·5
Administration expense	7·0	7·6	12·4	8·1	20·9
Non-operational expenses	2·6	2·2	8·1	6·7	9·3
	100·0	100·0	100·0	100·0	100·0
(Crew expense)	3·0	2·2	2·1	1·6	0·9

Source: Drawn from table 1 and Appendix A.

We have no empirical evidence here that TEU-mile cost decreases as ship size increases although it is clear that vessels B-1 and B-2 were not performing up to their true potential.

4. Implications and conclusions

The rapid growth of container ship sizes during the last decade stimulates an interest in the effects of ship's size economies. In investigating the latter other factors influencing ship's economies in container shipping spring to the surface.

In this study we examined the income and costs of container services using the concepts of charter base (an income index) and hire base (a cost index) with respect to the operation performances of individual vessels of different sizes.

Generally it is assumed that the use of larger vessels significantly reduces unit costs due to high proportion of fixed costs to total costs. However, the benefits of ship's size economies are not strikingly apparent if one uses unit cost and income measurements as in this study [16].

Table 5 illustrates the general cost structure for the container ship services previously examined.

On the whole, it is evident the economies of container ship voyages depend on many factors unrelated to size; for instance, on route characteristics, accounting practices, prevailing level of freight rates, load factors, operation days and on the ups and downs of the shipbuilding market.

Especially, the unit cost of a vessel may be strongly biased by the ship's purchase price. The effects of a high purchase price may extend over the vessel's whole life. It is well known that the prices of ships are flexible and variable within a short period of time. Thus, it is important for a shipping line to seize the best time to purchase a vessel. The competitiveness of a shipping line is much affected by their fleet purchase prices.

Route characteristics such as distances and calling ports also affect unit costs. Major voyage cost components such as bunker expenses, port charges and terminal charges are dependent on distances, calling ports and number of annual voyages of a vessel. Accounting methods also have substantial effects on unit costs.

Nobody doubts and denies the existence of scale economies in container shipping even though its magnitude can be a question. The evidence of scale economies in the bulk trades, especially the tanker trades, is much more dramatic and convincing than in the container trades.

Shipping lines that have survived have been beset with concerns about excess capacity, a traditional problem in the maritime industry. Over-tonnaging is a serious problem and brings downward pressure on freight rates. Pessimists might agree that, 'The industry may never make an adequate return if everyone continues reinvesting in new ships to drive costs down while simultaneously pushing rates down [17].'

Perhaps, in order to overcome such difficulties, there is no other choice but to rely on the conferences for the tailoring of supply to fit demand; otherwise, the low rates will continue to reduce the number of shipping lines and this leads to oligopoly (if not worse). In the end, this could be quite harmful to consumers of container service.

Appendix A

Operation performance statements of different size vessels **(revenues and expenses in thousands of U.S. dollars).**

	Vessel type				
	A-1	A-2	A-3	A-4	A-5
Type (TEU)	1200	1700	2700	2700	4000
Capacity (TEU)	1150	1662	2668	2678	3730
Built	79·08	81·03	87·06	88·12	93·01
Purchase price	19 377	25 607	28 356	31 931	73 900
/TEU	(16 580)	(15 063)	(10 628)	(11 923)	(19 812)
Speed (knots)	17	18·6	22	22	24
Bunker (MT/day)	45·1	145·6	97	97	140
Crew number	20	22	17	18	18
Distance (mile)	12 001	12 001	23 674	33 953	13 788
Duration (days)	35	35	63	91	35
Operation days	350	350	358	364	350
Voyages (O/I)	10/10	10/10	6/6	4/4	10/10
Navigated miles	120 010	120 010	134 528	135 812	137 880
Supplied (TEU)	23 000	33 240	30 322	42 848	74 600
Carried (TEU)	19 114	27 556	23 924	34 610	59 012
Load factor	83·1%	82·9%	78·9%	80·8%	78·3%
Freight revenue	22 322	32 260	30 500	42 540	68 261
/TEU	(1168)	(1170)	(1275)	(1229)	(1157)
Cargo related expense	14 535	21 006	14 560	22 419	39 493
Cargo expense	829	1 197	1 704	1 794	2 765
Stevedorage	4 724	6 827	8 226	10 828	19 273
Haulage	8 445	12 204	3 669	8 250	15 560
Agency fee	538	777	961	1 524	1 777
Navigation expense	2 066	2 194	3 336	4 919	4 965
Port charge	612	649	1 451	2 563	1 609
Bunker expense	1 444	1 534	1 871	2 341	3 336
Ship expense	2 539	3 077	4 813	5 481	10 692
Crew expense	627	632	593	613	718
Ship expense	769	966	2 569	3 181	5 735
Insurance	199	236	205	227	544
Depreciation	944	1 243	1 446	1 460	3 695
Administrative expense	1 491	2 207	3 537	3 131	16 560
Non-operation expense[†]	550	632	2 326	3 469	7 387

Source: Data supplied by East Asian shipping interests.

[†]Non-operation expenses are aggregated amount of interest paid, exchange loss, donation and miscellaneous loss, etc. The figures shown in this table are the differences between the non-operation gains such as interest income, exchange gains and miscellaneous gains. It is generally not classified into fixed costs, but classified into fixed costs in this paper because the majority of them are fixed except the exchange loss.

Appendix B

Cost structure of container shipping

B.1. *Variable costs*

Cargo-related expenses

(*a*) Cargo expenses: CFS charges (stuffing, stripping), measuring/weighing, tallying, cargo inspection, customs examination, documentation, non-containerized/overheight/overwidth/dangerous cargo surcharge, reefer cargo expenses (pre-trip inspection, pre-cooling, monitoring, storage), etc.

(*b*) Terminal Handling Charges (THS): loading/unloading/receiving/delivery (lift onto chassis for empty despatch, lift off from chassis for receiving outbound load, load into vessel from stacking area for outbound cargo and discharge from vessel into stacking area, lift onto chassis for delivery, lift off from chassis for empty return for outbound cargo), shifting (from cell to cell, unload on the terminal and reload on the same vessel), transshipment (unload on the terminal and reload on another vessel on the same terminal), storage of full and empty container, stevedorers or equipments stand-by charge, overtime surcharge, etc.

(*c*) Haulages: railroad charge, rail ramp fee, inland depot charge, inland transportation, local drayage, port equalization, port shuttle, feeder charge, etc.

(*d*) One-way short-term lease for container, chassis and trailer.

Navigation expenses

(*a*) Port charges: pilotage, towage, dockage, wharfage, harbour/tonnage/light/buoy/anchorage dues, mooring/unmooring and running lines, customs/quarantine fee, watchman/agency/canal fee, etc.

(*b*) Bunker expenses: fuel and marine diesel oil.

B.2. *Fixed costs (running costs and capital costs)*

(*a*) Crew expenses: wages, overtime, pensions, accident/sickness insurance, travelling/repatriation, provisions, victualling and cabin stores, etc.

(*b*) Vessel expenses: stores/spares, lubricants, maintenance/minor repair, annual survey, fresh water, communication charge, etc.

(*c*) Insurance: hull/machinery, war risks, freight/demurrage defence, P&I, other marine-risks, etc.

(*d*) Depreciations: ship, container, chassis, trailer and other container related equipment, terminal property and equipment, etc.

(*e*) Amortization for long-term terminal, container, chassis and trailer leaseholds and leaseholds improvements, etc.

B.3. *Overhead*

(*a*) Administrative expenses: compensation of officers and directors, salaries and wages of employees, fringe benefits, rental expenses, office expenses, communication expenses, dues and subscription, travel expenses, advertising, entertainment and solicitation, legal fees, taxes, etc.

(*b*) Non-operating revenues: interest income, dividend income, revenue from non-shipping operations, foreign exchange gains, income from affiliated companies, etc.

(*c*) Non-operating expenses: interest expenses, foreign exchange losses, donations and contributions, miscellaneous losses, etc.

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8. HORNGREN, C. T. and FOSTER, G. (1982), *Cost Accounting*, (Englewood Cliffs, NJ: Prentice-Hall), p. 48.
9. Variable operation costs are 'voyage specific' and the sum of cargo-related expenses and navigation expenses only; ongoing vessel operating costs such as crew costs are considered 'fixed' and are not included in charter base calculations.
10. Several separate HBs can be derived in accordance with the requirements and the levels of costs included. For instance, three stages of HBs can be derived as below. These HBs may be flexibly used as an operation guideline in terms of the market situations. When the market situations are good, the higher stages of HB will be used as an operation index, and vice versa. In this study of liner shipping we are using HB(III).
    (*a*) HB(I): Fixed Costs(I) { = (ship expenses + crew expenses + insurance)} ÷ OD
    (*b*) HB(II): Fixed Costs(II) { = (fixed costs(I) + depreciation)} ÷ OD
    (*c*) HB(III): Fixed Costs(III) { = (fixed costs(II) + overhead)} ÷ OD
11. The overhead costs listed in table 1 are allocated as follows.
    (*a*) Administrative expenses: the direct expenses paid out to a particular vessel are directly allocated to the vessel unadjusted. The indirect expenses are allocated based on the manpower employed on the various routes; allocations are made to the vessels on the same route based on each vessel's carrying capacity.
    (*b*) Non-operation expenses: Interest payments on a vessel purchase are allocated based on the actual amount paid for each vessel. Joint costs such as interest on working capital, foreign exchange losses and donations are allocated according to the same formula as administrative expenses.
    (*c*) Amortization for facility lease: Allocations are based on the amount of containers carried, calculated by multiplying the vessel's carrying capacity by the estimated load factor.
12. Accrual basis accounting requires that revenues and expenses be correctly measured and necessitates a cut-off point at each accounting period. This cut-off is done by applying the matching principle which focuses on the measurement of expenses and the matching of them with the periodic revenues earned during the period. Accrual basis accounting means that all completed transactions are recorded when they occur, regardless of when any related cash receipts or payments occur.
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14. Originally this paper aimed to analyse the data in the context of costs and revenues per TEU-mile in addition to CB and HB; but, after further consideration the TEU-mile costs appeared to be too voyage-specific to illuminate the question of scale economies. TEU-mile costs are listed in table 4 for academic interest.

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