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A GROUPING ANALYSIS FOR THE SIMILARITY OF SHIP FLEET COMPOSITION AMONG LEADING CONTAINER CARRIERS

Hua-An Lu

Key words: fleet composition, scatter analysis, cluster analysis.

ABSTRACT

Tonnage supply of the liner shipping industry is highly concentrated and continuously growing. Carriers provide ship capacities by various fleet composition strategies for coping with their service networks. This paper explores the similarity of fleet supply among the top 20 global liner carriers in terms of data gathered at the beginning of 2008. A scatter analysis is applied to simply show the difference in two-dimensional elements. This research also attempts to group these carriers with cluster analysis by appending more attributes concerned with fleet composition. Results reveal that MSC, Evergreen, COSCO, CSCL, and Yang Ming always form a firm cluster with using larger ships and keeping relatively aged fleet. CMA CGM, Hamburg Süd, and ZIM have higher ratios on capacities contributed from medium size ships. Except PIL and Wan Hai operating smaller size of ships on their service scopes, other carriers own more large-sized and younger ship fleet. Their decision depends somewhat on the steps of alliance partners.

I. INTRODUCTION

Container liner shipping has played an indispensable role among modern marine transport industries; the ratio of container freights delivered through seaborne logistics systems rapidly grows year by year [17]. A primary reason for this growth stemmed from the emergence of the industrial globalization that has made a dramatic change in the global supply chains of shippers. To confront the reformation of service requirements, container liner carriers must be able to adjust from managing strategies to practical operations.

Cariou [3] highlighted three directions for development in the liner industry during the last 15 years: horizontal integration among carriers, vertical integration of carriage processes, and investment in bigger vessels. The integration of carriage processes can be considered as a complementary strategy to the other developments. Alliance cooperation is not new in liner shipping [4], but strategic alliances among carriers resulted in the increase in the size of firms and the emergence of global carriers. This formation indeed altered carrier service networks and fleet deployments [15] even beyond vessel operations toward more extensive cooperative dimensions [16]. Strategic alliances were also considered as one way of rationalizing fleet development [6]. Some members affiliated with the same strategic alliance, such as Yang Ming Line (YML) and "K" Line, even took the step of joint-ordering for the same type of vessels to deploy their alliance routes with fleet sharing (http://www.yml.com.tw/). A potential investment risk is thus reduced by addressing mutual concerns and collaborating with each other.

The technological revolution of shipbuilding by enlarging the size of vessels encouraged liner companies to order several larger ships with capacities above 5,000 twenty-foot equivalent units (TEU). Although the capital investment for maintaining a super fleet of this scale is huge, the motivations for shipping companies to maintain large ship investments were mainly focused on the beneficial economies of scale regarding ship size [5, 6, 9].

Some carriers sought to reshape their fleet tonnages, but a few companies remained cautious. The conservative countermeasure may be the result of several conditions. First, the capacity supply is always more excessive than the demand of market and is fixed in the short term, which is especially obvious in terms of the main lanes like transoceanic routes [7, 8, 11]. Carriers have to sufficiently assess the future development of demand markets and the countermeasures of competitors. Second, the liner shipping industry is one of the most capital-intensive industries [7]. Larger vessel investment involves a much greater degree of financial consideration. Third, the service network structure may have to transform into a new arrangement with economies of scope following the large expansion of a ship fleet. The deployment viability in the main markets requires coping with other conditions, such as freight rate and feeder costs [10]. In particular, ports with

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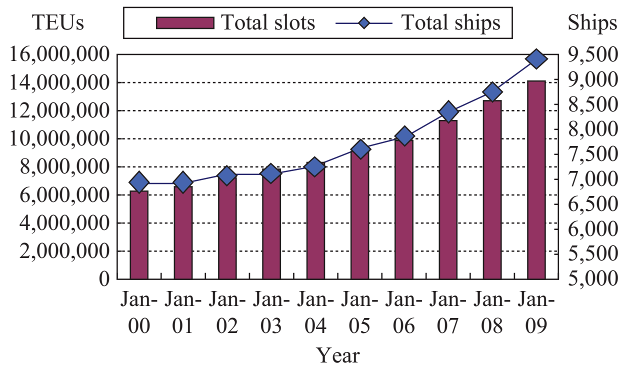

Fig. 1. Development in capacity and number of container ships. (*Source*: Compiled for this paper based on the data of CI-online.)

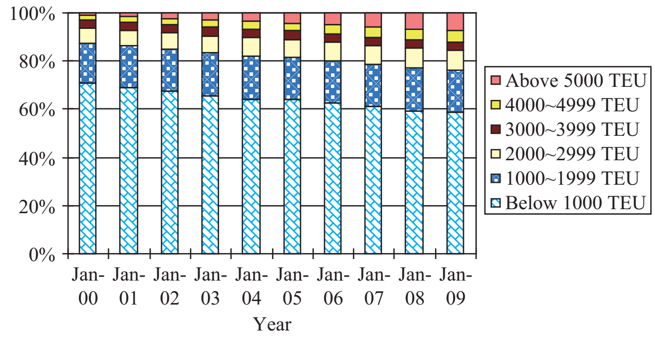

Fig. 2. Ratios of ship number for various size sectors. (*Source*: Compiled for this paper based on the data of CI-online.)

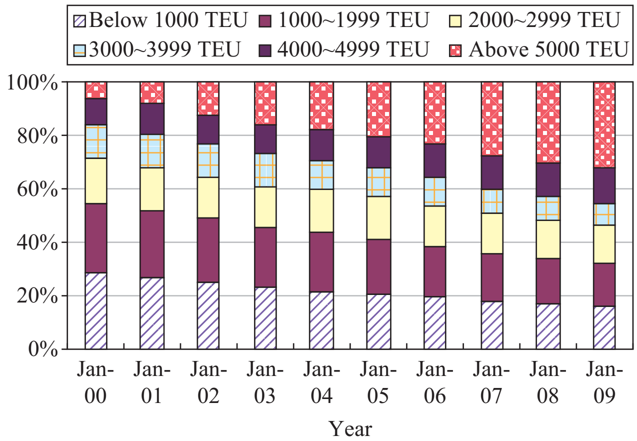

Fig. 3. Ratios of slot capacities for various size sectors. (*Source*: Compiled for this paper based on the data of CI-online.)

the qualified physical infrastructure, facilities and equipment to accommodate the operations of larger vessels are required [12, 13]. Finally, larger ships represent that more slot capacities need to be filled for enjoying the benefits of economies of scale [6]. It is a whole new challenge to the carrier's marketing abilities.

Every shipping company has its own fleet development strategy. It, however, is influenced by some factors, such as company scale, service deployment, considerations in ship ownerships, and commitments to strategic alliance members. This research aims to deeply explore the similarity of fleet composition and the critical grouping criteria by means of clustering methodologies. Therefore, attributes relative to the mentioned factor categories will be involved with the contents of fleet composition, while criteria of fleet composition consist of ship age, size, and type. The analysis entities were focused on the top 20 carriers because the decisional behaviors of leading carriers have always dominated or influenced the tendency of the industry and the learned roles of others. This study assumes that the decisional behaviors of the discussed carriers maintained consistency throughout recent years. The relative data has been collected for the fleet composition of 2008. Main sources for these data are the database of Containerisation International (CI) online and its monthly reports, as well as Alphaliner.

II. TONNAGES SUPPLY STATUS

Ship tonnage supply of the liner shipping industry for container deliveries is continuing to grow since the beginning of the new century. As shown in Fig. 1, the total number of slot capacities going into 2007 has been over 10 million TEU, while the supply was just over 6 million TEU in 2000. This increase yields the slot supply at above 14 million TEU, 11.76 percent of the growing rate at the beginning of 2009. At the same time, fleet supply of the whole industry also increased to 9,413 ships at the beginning of 2009 from 6,918 ships in 2000. The average annual growth rate of capacities is 9.65 percent, but the rate of ship numbers is merely around 3.48 percent. The increase in the size of container ships brought about a dramatic alteration during these years.

Viewing the number of ships, the whole tonnage is classified into six levels of ship sizes in the CI-online database. Ships below 1,000 TEU had 12.95 percent of the average growth rate, standing for the most part of all sectors, but the shared percentage fell from 70.6 percent to 58.6 percent during these years. Except ship sizes between 1,000 to 1,999 TEU, other ships sized between 2,000 to 4,999 TEU and above 5,000 TEU all shared in the percentage below 10 percent, as shown in Fig. 2. However, the average growth rate between 4,000 TEU to 4,999 TEU reached 207 percent, while that of a ship above 5,000 TEU experienced more than 868 percent growth. Orders for new building and/or replacing ships in carriers have moved towards the large-size sectors year by year. Counting the total slots for all size levels, the total number attributed to the ship size above 5,000 TEU has increased to 32.5 percent in 2009 from a shared percentage of 6.0 percent at the beginning of 2000. This sector owns the majority of capacities at present. The shared percentages of other size levels were gradually squeezed to less than 17 percent by the increment of larger ships as shown in Fig. 3.

Table 1. Tonnages of top 20 container carriers at the beginning of 2008.

Rank	Carrier	Code (for this paper)	Country	Total		Owned		Chartered	
				TEU	Ships	TEU	Ships	TEU	Ships
1	Maersk	MK	Denmark	1,932,033	535	1,009,056	187	922,977	348
2	MSC	MS	Switzerland	1,234,739	374	710,606	214	524,133	160
3	CMA CGM	CC	France	895,494	377	268,839	88	626,655	289
4	Evergreen	EV	Taiwan	625,274	177	363,425	102	261,849	75
5	Hapag-Lloyd	HL	German	496,709	139	256,581	61	240,128	78
7	CSCL	CL	China	434,170	140	251,192	87	182,978	53
6	COSCO	CO	China	430,952	141	232,499	94	198,453	47
8	APL	AP	Singapore	402,857	125	134,798	37	268,059	88
9	NYK	NY	Japan	385,613	118	251,358	51	134,255	67
10	OOCL	OO	Hong Kong	350,793	82	204,915	36	145,878	46
11	Hanjin	HJ	South Korea	349,952	84	122,546	23	227,406	61
12	MOL	MO	Japan	346,870	111	165,038	38	181,832	73
13	“K” Line	KL	Japan	308,194	93	169,306	34	138,888	59
14	ZIM	ZM	Israel	289,899	113	136,009	42	153,890	71
15	YML	YM	Taiwan	274,281	83	172,825	51	101,456	32
16	CSAV	CV	Chile	265,064	89	21,208	4	243,856	85
17	Hamburg Süd	HS	German	284,097	123	110,309	37	173,788	86
18	Hyundai	HY	South Korea	209,277	48	59,341	12	149,936	36
19	PIL	PI	Singapore	178,777	113	104,192	73	74,585	40
20	Wan Hai	WH	Taiwan	140,750	82	98,591	51	42,159	31

Source: Alphaliner (Feb. 2008)

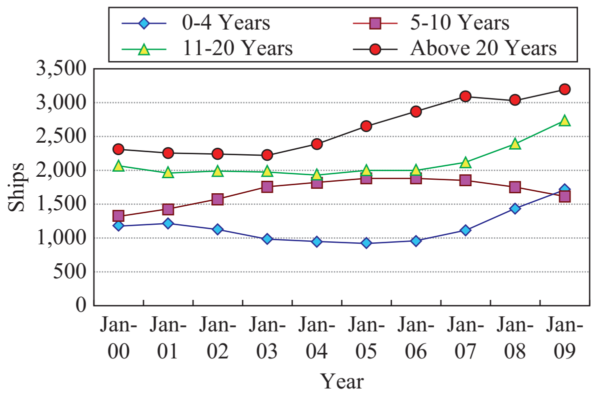

Fig. 4. Ship numbers for various age sectors. (*Source*: Compiled for this paper based on the data of CI-online.)

Between 2000 and 2009, container ships greater than 20 years of age were the most prolific. The number of ships of this age began to increase from 2004 and reached over 3,000 in the last three years. As we know, a peak on the marine container market appeared during 2005 to 2007. One of the intuitive acts for carriers is to satisfy the imperative requirement of ship supply by postponing retirement for older ships because orders for building new ships cannot meet the current increase in market demand. As depicted in Fig. 4, the net increments for ships between 5 to 10 years of age and 11 to 20 years of age have developed in different ways. The former sector shows an incremental decline and the latter sector maintained a stable path with incremental growth in the last three years.

III. DIFFERING WAYS TO PROCURE TONNAGES

Carriers acquire their ships in two ways: purchase and leasing. Purchase is a long-term investment for productivity tools in order to help the development of lines. Carriers can order new tonnages to ship manufacturers or purchase the second-hand ones from other owners. Leasing represents a relatively short-term supplement although carriers can choose long-term or short-term chartering according to their needs. These kinds of choices present not only the carrier’s outlook for the future market but also the financial level of the company to support its required operations.

1. Ownership Analysis

Among top 20 operators at the beginning of 2008, most were European or Asian carriers, except for the CSAV group, a resident of South America. Table 1 ranks operators according to their total slot capacities in TEU. Maersk Line and Mediterranean Shipping Company (MSC), with over one million TEU, led other carriers, especially the former (reaching almost two million TEU), from a total consideration of more than 500 ships. Because two important players [i.e., P&O Nedlloyd and Canadian Pacific (CP)] have been merged by Maersk and Hapag-Lloyd respectively, Pacific International Lines (PIL)

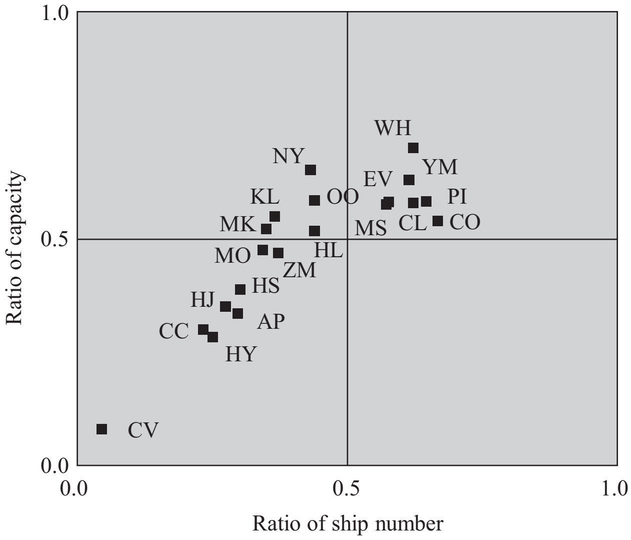

Fig. 5. Scatter analysis by ratios of ship number and capacity for owned fleet.

and Wan Hai Lines were listed in the top 20 since 2006. Other carriers were frequently listed in the leading group within these recorded years, expended their tonnages through different procurement ways in order to maintain their competitive level within this leading group.

Applying the ratios of ship numbers and slot capacities of owned fleet as the unit of measurement, these carriers can be clearly divided into three categories, which are scattered on the two-dimensional diagram shown in Fig. 5. The top three carriers represent different typical roles, respectively. Seven carriers in this leading group have higher ratios, over 50 percent both in ships and capacities, of owned fleet versus that of chartering. They include MSC, Evergreen Marine Company, China Shipping Container Lines (CSCL), China Ocean Shipping Company (COSCO), YML, PIL, and Wan Hai. This group, located within the upper-right square, can be regarded as the set of companies that prefer to operate owned fleet and spend more capital on the long-term tonnage investment.

There are totally 60 percent carriers with over half slot capacities contributed from their owned fleets besides the aforementioned seven companies. Another set located within the upper-left square absolutely tends to invest ownership in larger ships and prefer to charter smaller ships. They are Maersk, Hapag-Lloyd, NYK Line, Orient Overseas Container Line (OOCL) and “K” Line.

An additional eight carriers [i.e., CMA CGM, American President Lines (APL), Hanjin Shipping, Mitsui O.S.K. Lines (MOL), ZIM, CSAV, Hamburg Süd, and Hyundai Merchant Marine] prefer to acquire more capacities and ships from the leasing market. CSAV appears to be an isolated case for constructing its tonnages almost solely through chartering. This set represents the group of carriers that favor handling the relatively short-term investment of chartering for their tonnage expansion.

Table 2. Average sizes of owned and chartered ships for top 20 carriers in 2008.

Carrier	Average Capacity of Total Fleet (TEU/ship)	Average Size (TEU/ship)	
		Owned	Chartered
Hyundai	4,359.9	4,945.1	4,164.9
OOCL	4,278.0	5,692.1	3,171.3
Hanjin	4,166.1	5,328.1	3,728.0
Maersk	3,611.3	5,396.0	2,652.2
Hapag-Lloyd	3,573.4	4,206.2	3,078.6
Evergreen	3,532.6	3,563.0	3,491.3
K Line	3,313.9	4,979.6	2,354.0
YML	3,304.6	3,388.7	3,170.5
MSC	3,301.4	3,320.6	3,275.8
NYK	3,267.9	4,928.6	2,003.8
APL	3,222.9	3,643.2	3,046.1
MOL	3,125.0	4,343.1	2,490.8
CSCL	3,101.2	2,887.3	3,452.4
COSCO	3,056.4	2,473.4	4,222.4
CSAV	2,978.2	5,302.0	2,868.9
ZIM	2,565.5	3,238.3	2,167.5
CMA CGM	2,375.3	3,055.0	2,168.4
Hamburg Süd	2,309.7	2,981.3	2,020.8
Wan Hai	1,716.5	1,933.2	1,360.0
PIL	1,582.1	1,427.2	1,864.6
Total Average	3,137.1	3,851.6	2,837.6

2. Average Size

Operating tonnages of liner companies are more concerned with service scopes and deployed sizes of ships on every line. The average sizes in TEU for every carrier may just represent the rough relationships between the adopted ship sizes, the number of serviced loops, and the characteristics of these services. As shown in Table 2, Hyundai, OOCL, and Hanjin had the highest average sizes with more than 4,000 TEU. Nine other carriers, such as Maersk, Hapag-Lloyd, Evergreen, and so forth, all fall between 3,000 and 3,999 TEU. Except for Wan Hai and PIL, which represent less than 2,000 TEU in the average ship size, the average size of the other four carriers (i.e., CSAV, ZIM, CMA CGM, and Hamburg Süd), is between 2,000 and 2,999 TEU.

In addition, the average size of owned and chartered ships can roughly distinguish ship sizes acquired from these two sources. Except for CSCL, COSCO and PIL, the other 17 companies maintain larger average sizes of owned ships than chartered vessels, especially OOCL, which holds the largest slot supply of the owned fleet. The average sizes of owned fleet are certainly larger than the average sizes of the total fleets for these 17 carriers.

Moreover, if one exploits the average sizes of owned and chartered ships for comparison with one another, these carriers can be separated into distinct groups. This result can reveal

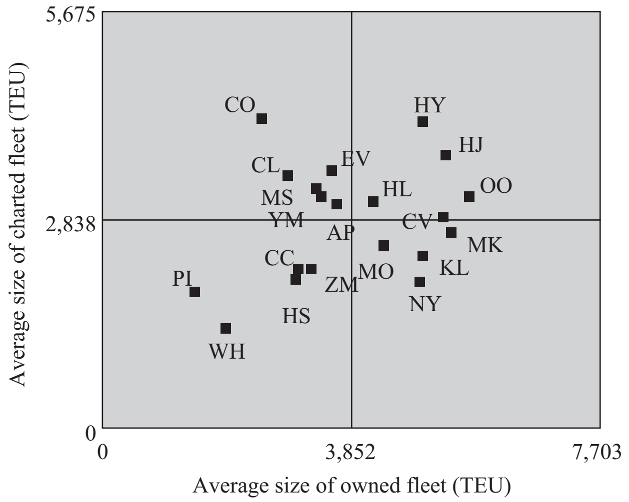

Fig. 6. Scatter analysis for average sizes of owned and chartered fleets.

the relative positions among carriers. Its separation standards are the total average sizes for all top 20 carriers in owned and chartered fleet, i.e. 3,852 and 2,838 TEU. As shown in Fig. 6, carriers partitioned in the upper-right area hold relatively larger owned and charted fleets, while the lower-left sector reflects just the opposite. As similar as the other two areas are, the average size of owned and chartered ships greatly differ. This approach is somewhat concerned with the fleet scale of carriers. PIL and Wan Hai, for example, are relatively smaller than other carriers.

IV. CLUSTER ANALYSIS

This section will take into account fleet composition and other attributes relative to tonnage supply to conduct the cluster analysis for the top 20 carriers. In general, cluster analysis studies have five basic steps [1] that need to be followed:

(1) Select a sample to be clustered
(2) Define a set of variables with which to measure the entities in the sample
(3) Compute the similarities among the entities
(4) Use a cluster analysis method to create groups of similar entities
(5) Validate the resulting cluster solution

1. Cluster Sample and Measurements

The top 20 carriers are the sample for clustering in this research, and, their data at the beginning of 2008 are collected in order to be able to calculate the variable definition. Factors affecting carrier tonnage supply are classified into five categories: company scale, service deployment, ship ownership, fleet composition, and relationships with strategic alliances. By combining consideration for the availability of data collection, some measurements from each group are selected to conduct this analysis. Meanwhile, all defined variables are standardized into the interval values within 0 and 1.0 for reducing the influence of different scales in original data.

Company scale represents the possible level of capital invested into ship purchase and leasing. Shares of ships (V1) and capacity (V2) for the whole industry of a specific carrier can suitably express the scale position of this carrier in the whole industry. As for service deployment, the ratio of the average size of fleet for a specific carrier to that of the largest one among the top 20 carriers (V3) can present the similarity for general considerations in ship deployment coupled with a service network. Moreover, the number of services can somewhat reflect the span and intensity of a carrier's service in geographic scope. Average lines per ship served (V4) and average lines per 1,000 TEU provided (V5) are used to measure a carrier's resource deployment in operations. In the section for ship ownerships, the ratios of owned ships and capacities to that of the whole company (V6 and V7), as mentioned in the section for procurement methods, are included as well as the ratios of average capacities for owned and chartered fleet to that of the largest one among the top 20 carriers (V8 and V9).

The main parts for added variables in the fleet composition consist of fleet age, size, and type. The status of fleet age reveals the investment and operation of new and older ships. Considering the availability of data collection from CI-online, ratios of numbers and capacities provided from ships with ages below 4 years, 5 to 10 years, 11 to 20 years, and above 21 years to the whole fleet are involved, respectively (V10 to V17). The variables of fleet size are calculated with the ratios of numbers and capacities of various ship scales to the whole fleet. The levels of the classification in the database of CI-online are noted for the following categories: below 1,000 TEU, 1,000 to 1,999 TEU, 2,000 to 2,999 TEU, 3,000 to 3,999 TEU, 4,000 to 4,999 TEU, and above 5,000 TEU (V18 to V29). Because the full container ships are the majority in contemporary liner companies, the ratios of ship numbers and capacities for this type to the whole fleet (V30 and V31) are also considered.

Carriers which participated in the strategic alliances need to fit the cooperative operations with appropriate ship tonnages, so their decisions on fleet composition are somewhat influenced by that of their partners. Ratios of ships and capacities to the whole numbers of the affiliated alliances (V32 and V33) may be suitable to measure the influences. The ratio is, of course, 0 when the carrier did not join any strategic alliance. Table 3 lists the clustering variables discussed above.

Before implementing the cluster analysis, the Pearson correlation analysis was conducted for every pair of variables to exclude variables with the higher and significant linear relationships; this aims to avoid an over-emphasis of certain dimensions that may bias the clustering results. As shown in Table 4, the higher coefficients mainly appear between ship number and capacities in each category, such as V20 and V21, V1 and V2, and V32 and V33, besides between average size of

Table 3. Selected measurements for cluster analysis.

Category	Selected Measurements	Variable
Company Scale	Share of ships for the whole industry	V1
	Share of capacities for the whole industry	V2
Service Deployment	Ratio of average size of fleet to that of the largest one	V3
	Average lines per ship served	V4
	Average lines per unit capacity (thousand TEU) provided	V5
Ship Ownerships	Ratio of owned ships to the whole company's fleet	V6
	Ratio of owned capacities to the whole company's supply	V7
	Ratio of average capacity of owned fleet to that of the largest one	V8
	Ratio of average capacity of chartered fleet to that of the largest one	V9
Fleet Composition	Ratio of ships with ages below 4 years	V10
	Ratio of capacities offered from ships with ages below 4 years	V11
	Ratio of ships with ages between 5 to 10 years	V12
	Ratio of capacities offered from ships with ages between 5 to 10 years	V13
	Ratio of ships with ages between 11 to 20 years	V14
	Ratio of capacities offered from ships with ages between 11 to 20 years	V15
	Ratio of ships with ages above 21 years	V16
	Ratio of capacities offered from ships with ages above 21 years	V17
	Ratio of ships with capacities below 1000 TEU	V18
	Ratio of capacities provided from ships with capacities below 1000 TEU	V19
	Ratio of ships with capacities between 1000 to 1999 TEU	V20
	Ratio of capacities provided from ships with capacities between 1000 to 1999 TEU	V21
	Ratio of ships with capacities between 2000 to 2999 TEU	V22
	Ratio of capacities provided from ships with capacities between 2000 to 2999 TEU	V23
	Ratio of ships with capacities between 3000 to 3999 TEU	V24
	Ratio of capacities provided from ships with capacities between 3000 to 3999 TEU	V25
	Ratio of ships with capacities between 4000 to 4999 TEU	V26
	Ratio of capacities provided from ships with capacities between 4000 to 4999 TEU	V27
	Ratio of ships with capacities above 5000 TEU	V28
	Ratio of capacities provided from ships with capacities above 5000 TEU	V29
	Ratio of full container ships to the whole company's fleet	V30
	Ratio of capacities provided from full container ships to the whole company's fleet	V31
Relationships with Strategic Alliances	Ratio of ships to the whole number of the affiliated strategic alliance	V32
	Ratio of capacities to the whole number of the affiliated strategic alliance	V33

fleet (V3) and large ship size as well as capacity (V28, V29). In this study, if the Pearson correlation coefficient for every pair of variables is larger than 0.8 and it reaches the significance level of 5 percent, one of these variables will be deleted. The final selected variables maintain the most numbers without the relationships of the above correlations. Therefore, variables V1, V3, V4, V6, V10, V12, V14, V16, V18, V20, V22, V24, V26, V28, V30, and V32 were excluded. Most of these are the fleet composition variables, while variables relative to fleet capacities were preserved. The remaining 17 measures still have at least one variable belonging to each category.

2. Clustering Method and Results

A rough but widely agreed frame is to classify clustering techniques as hierarchical clustering and partition clustering, based on the properties of clusters generated [18]. Because the purpose of this research is to distinguish carriers into meaningful groups, partition clustering techniques are more appropriate to the analysis. K-means is a traditional and popular partition method. The central idea of this method is to choose some initial partition of data units and then alter cluster memberships so as to obtain a better partition [2]. Therefore, this approach requires users to indicate the number of clustering groups before implementation. Users also need to choose how to define a measure of similarity when clustering data units. This research adopts Euclidean distances calculated by citied variables as the proximity of individual carriers. Because the involved data in this research are not too large to spend much time solving, trying more alternative groupings is allowable. The results may provide other helpful information among such distinction. SPSS 12.0 Windows was employed

Table 4. Correlation analysis for all measures.

	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25	V26	V27	V28	V29	V30	V31	V32	V33
V1	.966(**)	-.021	-.536(*)	-.648(**)	-.022	.031	.023	-.067	-.081	.104	-.091	-.102	-.159	-.211	.305	.309	.152	.098	-.019	-.093	.152	.097	-.033	-.039	-.172	-.193	-.053	.113	-.257	-.281	-.384	-.388
V2	1	.187	-.399	-.608(**)	-.027	.061	.198	.074	-.124	.016	-.016	-.007	-.187	-.207	.310	.333	.078	.000	-.125	-.215	.062	-.044	-.039	-.083	-.058	-.119	.101	.253	-.169	-.173	-.276	-.274
V3		1	.648(**)	.095	-.247	-.146	.799(**)	.740(**)	-.080	-.251	.205	.272	-.119	.012	.011	.063	-.263	-.475(*)	-.671(**)	-.750(**)	-.255	-.563(**)	-.100	-.263	.407	.142	.858(**)	.847(**)	.172	.293	.476(*)	.532(*)
V4			1	.805(**)	-.103	-.069	.423	.554(*)	-.236	-.436	.196	.220	.279	.403	-.163	-.132	.021	-.046	-.313	-.354	-.387	-.478(*)	-.022	-.080	.202	.121	.510(*)	.450(*)	.329	.391	.684(**)	.742(**)
V5				1	.107	.107	-.044	.142	-.296	-.413	.110	.115	.455(*)	.503(*)	-.178	-.181	.268	.376	.125	.131	-.353	-.229	.040	.071	-.032	.086	-.009	-.070	.321	.320	.538(*)	.564(**)
V6					1	.864(**)	-.621(**)	.043	-.461(*)	-.097	-.224	-.186	.082	-.009	.616(**)	.522(*)	.389	.408	.606(**)	.520(*)	-.255	-.079	-.072	.018	-.414	-.207	-.372	-.236	-.251	-.328	-.147	-.140
V7						1	-.335	-.213	-.493(*)	-.215	.071	.115	-.008	-.120	.472(*)	.472(*)	.244	.333	.585(**)	.471(*)	-.110	.016	-.103	-.028	-.500(*)	-.285	-.307	-.191	-.086	-.100	-.011	-.094
V8							1	.292	.191	-.100	.417	.405	-.237	-.133	-.361	-.222	-.443	-.536(*)	-.686(**)	-.706(**)	-.055	-.353	-.046	-.235	.420	.142	.786(**)	.705(**)	.362	.519(*)	.410	.373
V9								1	-.082	-.083	-.225	-.157	.023	.153	.264	.167	.048	-.237	-.549(*)	-.597(**)	-.411	-.611(**)	-.023	-.134	.404	.176	.636(**)	.686(**)	-.075	-.031	.266	.425
V10									1	.852(**)	-.226	-.325	-.578(**)	-.510(*)	-.366	-.388	-.204	-.286	-.377	-.266	.285	.208	.193	.147	.097	-.114	.153	.096	.010	.210	-.424	-.430
V11										1	-.423	-.520(*)	-.597(**)	-.638(**)	-.020	-.163	.114	-.008	-.185	-.087	.215	.205	.031	.023	-.056	-.191	-.008	.039	-.338	-.156	-.665(**)	-.665(**)
V12											1	.932(**)	-.108	-.146	-.536(*)	-.380	-.279	-.217	.039	.018	.109	.093	-.356	-.359	.059	.028	.153	.076	.203	.305	.484(*)	.414
V13												1	-.091	-.152	-.385	-.273	-.247	-.229	-.034	-.079	.077	.031	-.342	-.358	.149	.134	.171	.119	.078	.180	.577(**)	.494(*)
V14													1	.930(**)	-.162	-.189	.174	.342	.340	.337	-.454(*)	-.321	-.158	-.088	.086	.270	-.102	-.188	.153	-.084	.246	.308
V15														1	-.141	-.123	.091	.220	.186	.181	-.424	-.334	.092	.135	.098	.239	-.031	-.135	.336	.098	.337	.429
V16															1	.911(**)	.310	.196	.073	-.026	-.002	-.023	.242	.234	-.230	-.139	-.208	-.004	-.322	-.417	-.185	-.171
V17																1	.009	.014	.125	.003	.148	.090	.335	.305	-.294	-.227	-.210	-.045	.007	-.132	-.119	-.141
V18																	1	.859(**)	.078	.114	-.385	-.206	.004	.050	-.253	-.097	-.183	-.015	-.544(*)	-.502(*)	-.033	.011
V19																		1	.393	.467(*)	-.302	-.031	-.043	.018	-.391	-.162	-.399	-.303	-.226	-.309	-.087	-.063
V20																			1	.968(**)	-.043	.272	-.238	-.066	-.420	-.101	-.717(**)	-.731(**)	.016	-.182	-.264	-.299
V21																				1	-.034	.309	-.253	-.092	-.390	-.088	-.722(**)	-.775(**)	.031	-.178	-.324	-.340
V22																					1	.916(**)	.169	.271	-.447(*)	-.502(*)	-.293	-.270	.129	.157	-.262	-.338
V23																						1	.134	.302	-.572(**)	-.508(*)	-.575(**)	-.569(**)	.088	.070	-.379	-.445(*)
V24																							1	.956(**)	-.140	-.137	-.231	-.179	.384	.375	.111	.075
V25																								1	-.289	-.224	-.405	-.349	.319	.293	.019	-.014
V26																									1	.908(**)	.338	.231	-.059	.030	.182	.253
V27																										1	.003	-.090	-.124	-.086	.150	.204
V28																											1	.950(**)	.059	.173	.342	.383
V29																												1	-.098	.045	.332	.360
V30																													1	.897(**)	.275	.256
V31																														1	.278	.245
V32																															1	.966(**)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Table 5. Clustering results for various partitions.

Clustering for 3 Groups			Clustering for 4 Groups				Clustering for 5 Groups				
G1	G2	G3	G1	G2	G3	G4	G1	G2	G3	G4	G5
MK	MS	ZM	MK	MS	CC	PI	MK	MS	CC	CV	PI
NY	CC	HS	HL	EV	ZM	WH	HL	EV	ZM		WH
OO	EV	PI	AP	CO	HS		AP	CO	HS		
HJ	HL	WH	NY	CL			NY	CL			
KL	CO		OO	YM			OO	YM			
CV	CL		HJ				HJ				
HY	AP		MO				MO				
	MO		KL				KL				
	YM		CV				HY				
			HY								

Clustering for 6 Groups						Clustering for 7 Groups						
G1	G2	G3	G4	G5	G6	G1	G2	G3	G4	G5	G6	G7
MK	MS	CC	HL	CV	PI	MK	MS	CC	HL	AP	CV	PI
NY	EV	HS	AP		WH	NY	EV	HS	MO	HJ		WH
OO	CO		MO			OO	CO		ZM	HY		
HJ	CL		ZM			KL	CL					
KL	YM						YM					
HY												

to conduct the whole procedure. Table 5 displays the conducted results for partition groups from 3 to 7.

From the perspective of clustering techniques, it was decided that one of the techniques should be the final grouping alternative. Rand [14] offered an approach in which the focus of attention is on the joint membership of pairs of data units for evaluating two partitions. Two data units which are assigned to the same cluster or to different clusters both in the two partitioning results are called a similar pair. The similarity between two partitions is then computed as the ratio of the number of similar pairs to the number of all paired combinations. By applying this concept to assess the grouping results in Table 5, it is easy to determine that the comparisons of the second and third clustering results have a higher similarity with 189 similar pairs from 190 paired combinations. Therefore, the result of clustering four groups is more stable than that of the other partition methods.

According to the most stable result, half of the top 20 carriers are grouped into the first set, which includes Maresk, Hapag-Lloyd, APL, NYK, OOCL, Hanjin, MOL, “K” Line, CSAV, and Hyuandai. The second set includes MSC, Evergreen, COSCO, CSCL, and YML. Members of the third group include CMA CGM, ZIM, and Hamburg Süd, while the last group only contains PIL and Wan Hai. This classification mainly reflects some variables with general significance levels. Table 6 lists the centers of four groups for every clustering variable. Average capacities of owned and chartered fleets (V8, V9), fleet ages between 5 to 10 years and over 20 years (V13, V17), fleet sizes with 1,000 to 3,000 TEU and over 5,000 TEU (V21, V23, V29), and the influence from the strategic alliance (V33) reach the statistic significance of at least 5 percent.

From the relative scores in significant variables, shown in Table 6, these four groups are primarily classified by the fleet sizes that carriers hold. Group 1 has more capacities contributed from owned large-size ships (V8 and V29) and more ships with ages ranging from 5 to 10 years (V13). The influence of the strategic alliances to fleet composition is greater than others (V33). Group 2 also holds more capacities contributed from large-size fleets, but these come from leasing market (V9). They also preferred to keep ships for a longer period of time (V17). Capacities of Group 3 are contributed by the middle-size ships between 2,000 to 2,999 TEU (V23). Three carriers belonging to this group did not join any strategic alliance. The members of Group 4 are relatively small-scale companies. They owned more capacities as small-size fleets between 1,000 to 1,999 TEU (V21). Fig. 7 displays the spread on significant attributes for these four groups respectively.

Aside from separating four groups, one can identify some interesting things from other partitions in Table 6. First, CSAV is always isolated when partitions are larger than five groups. Second, Group 2, which consists of MSC, Evergreen, COSCO, CSCL, and YML, is a firm collection because they are always put together when partitions are larger than four groups. Moreover, PIL and Wan Hai also gather close because their scales and service scopes seem not to be able to catch up to other traditional leading carriers temporarily. Finally, the connection of other carriers appears not to be strong enough to form a firm group. However, CMA CGM and Hamburg Süd

Table 6. Center of clusters and their statistical significance.

Measure Category	Selected Variable	Group				*F* Significance
		G1	G2	G3	G4	
Company Scale	V2	0.04	0.05	0.04	0.01	0.478
Service Deployment	V5	0.17	0.15	0.14	0.18	0.299
Ship Ownerships	V7	0.43	0.58	0.39	0.64	2.756
	V8	***0.86***	0.55	0.54	0.30	28.559***
	V9	0.70	***0.83***	0.50	0.38	8.278***
Fleet Composition	V11	0.37	0.45	0.49	0.39	1.267
	V13	***0.35***	0.23	0.24	0.28	3.785*
	V15	0.24	0.20	0.22	0.29	0.439
	V17	0.04	***0.12***	0.05	0.04	3.262*
	V19	0.01	0.02	0.02	0.04	1.906
	V21	0.07	0.11	0.12	***0.49***	78.018***
	V23	0.12	0.12	***0.32***	0.22	5.565***
	V25	0.09	0.12	0.19	0.06	2.202
	V27	0.22	0.16	0.13	0.19	0.716
	V29	***0.49***	0.46	0.21	0.00	11.343***
	V31	1.00	0.99	0.99	0.99	1.345
Relationships with Strategic Alliances	V33	***0.11***	0.04	0.00	0.00	4.061**

***: *P* < .001, **: *P* < .001, *: *P* < 0.05.

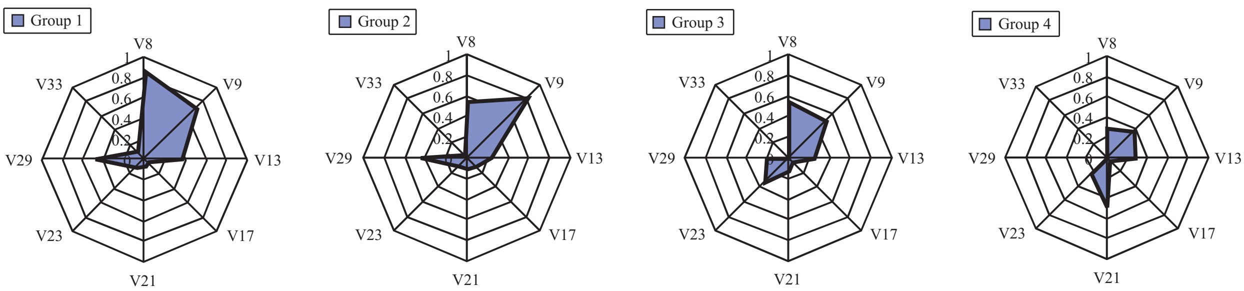

Fig. 7. Spread results on significant attributes for every group.

may be closer than ZIM with these two carriers in this group. Maersk, NYK, OOCL, and "K" Line seem be the core members in Group 1 because they are always found together no matter how many groups are divided.

3. Discussion

It is found, from analysis results, that ship sizes, ages, ownerships, and following partners' steps are main factors to set leading carriers apart different groups. To maintain a large-size fleet can provide potential shippers the higher slot availabilities in the competitive markets. Shipping lines are able to develop a consolidation function with ease to concentrate freight flows, in terms of own feeder services and consignments from alliance partners, for enjoying the economies of scale from large equipment. However, the pressure to sufficiently utilize slot capacities is still existed. To own a lot of larger ships means higher investment costs. Besides expenses on the ship procurement, sometimes it may bring more additional investments on landside operations, such as port and inland transports and storages, to yield huge financial burdens to carriers. How to schedule a variety of ships with different sizes for the transshipment function to form an effective service network is quite complicated.

To maintain a medium or small ship fleet can afford less financial and marketing pressures and put these tonnages into the niche trades. Conservative strategies can avoid to loss too much in a rapidly economic decline that might even become a worldwide fluctuation. However, these lines will confront the huge competitive pressures from those who have marched a step in ship tonnages. They must utilize other effective methods to reflect the advanced and wider requirements from their potential customers and wait a suitable chance for their expansion.

Ship ages and ownerships mainly concern with the financial leverage of shipping lines. Using aged ships seems able to sufficiently use their procuring values, but to keep the suitable

Table 7. Pros and cons of different groups based on the distinguishing features.

Group	Carriers	Distinguishing features	Pros	Cons
1	Maersk Hapag-Lloyd APL NYK OOCL Hanjin MOS "K" Line	1. Maintain a large-size ship fleet Owned ships have a larger average capacity 2. Ships between 5 to 10 years contribute a higher percentage of capacities 3. Step with strategic alliance development	• Higher slot availabilities for customers • Consolidation of freight flows for enjoying economies of scale • Controlling more tonnages for a long term • Better seaworthiness and engine propulsion • Stable schedule reliability • Benefit from a cooperative brand • Step by step to penetrate undiscovered markets • A bargain power in building new tonnages	• The pressure to concentrate enough freights still existed • Costly in ship fleet procurement and other additional investments • Complicated service network planning • Financial burdens on ship replacement • Considering partners' steps in tonnage development at any time • Lengthy decision-making process in discussing cooperation alternatives
2	MSC Evergreen COSCO CSCL Yang Ming	1. Maintain a large-size ship fleet 2. Chartering ships have a larger average capacity 3. Ships above 21 years contribute a higher percentage of capacities	• Higher slot availabilities for customers • Consolidation of freight flows for enjoying economies of scale • Sufficiently usage of ship's procuring value	• The pressure to concentrate enough freights still existed • Costly in ship fleet procurement and other additional investments • Complicated service network planning • More expenses for ship surveys and maintenance • Paying more attention on schedule reliability
3	CMA CGM ZIM Hamburg Süd	Ships between 2000 to 2999 TEU contribute main slot capacities	• Less financial and marketing pressures • To focus on their own niche markets	• To confront the huge competitive pressure • Necessity of effective methods to response customers wider requirements
4	PIL Wan Hai	Ships between 1000 to 1999 TEU contribute main slot capacities	• Less financial and marketing pressures • Focus on their own niche markets	• To confront the huge competitive pressure • Necessity of effective methods to response customers wider requirements

seaworthiness all the time is also costly. Especially, many international safety regulations have enforced carriers to follow a series of scheduled inspections for certificating ships sailing safety. Otherwise, the violated ships might be detained by the port state control to make schedule delay, and then these disturbances will impact shipping lines' operations. To maintain younger ship fleet can ensure a better performance on ship's seaworthiness and engine propulsion. Too fast to replace ship tonnages will also make a lot of financial burdens. This program normally relies on the short-term chartering market. It is noted that the number as well as age of large ships are less than those of the medium and the small ones in container liner shipping. Some companies sold large ships to other owners and chartered them back to control tonnages and reduced the pressure of cash flow at the mean time.

The alliance co-operation between shipping lines is much going on. Members of strategic alliances seem not to go back to the independent running in the near of future because they still benefit from the joint brand as mentioned as the discussion in the first section. They can penetrate some undiscovered markets step by step and appropriately control investment budgets for a long term. Partners with the joint venture plan for building the new tonnages may have a competitive price than ordering by single one alone. However, the individual company must consider the development of partners' tonnages at any time in planning own future requirements. The self willingness in ship fleet composition is somewhat affected. In particular, the decision-making process in strategic alliances is supposed to be sufficiently discussed in lengthy. Table 7 summarizes the pros and cons of four groups mentioned above, based on their distinct characteristics.

There are many differences among shipping lines in the existed resources, management concepts, and financial conditions. There is no optimal module of ship fleet composition for all carriers, but a suitable one for the specified company. The most important thing is to quickly response the requirements of potential customers due to a complicated environment that shipping lines confront in the contemporary liner industry and container transport. These requirements may come from the inner competitive of this industry as well as the shift from other transport modes.

V. SUMMARY

Based on the data at the beginning of 2008, this research attempted to find the similarities between the top 20 carriers in their contents of ship fleet composition. A simple scatter analysis focused on ship number and capacity acquired from different sources, i.e., owned or chartered, and average sizes of each. A more sophisticated clustering procedure was applied by using a variety of measures including attributes of company scale, service deployment, ship ownership, fleet composition and relationships with strategic alliances. The last three categories had critical attributes to be able to distinguish different groups. Some consistent findings could be found from these analysis results.

1. The top three carriers, i.e., Maresk, MSC, and CMA CGM, adopted totally different perspectives to extend their fleet tonnages. Maersk held more capacities from owned ships of larger sizes and chartered more ships of smaller sizes. MSC primarily maintained owned capacities and ship number, but it chartered ships of larger sizes. CMA CGM preferred to acquire more capacities and ships from the chartering market.
2. MSC, Evergreen, COSCO, CSCL, and YML form a solid cluster with more capacities contributed from large-size fleets derived from leasing to the market. Their capacities contribute from ships with older ages were relative higher than other groups.
3. CMA CGM, Hamburg Süd, and ZIM have more capacities contributed from the middle-size ships between 2000 to 2999 TEU. These three carriers also maintained lower average size both on owned and chartered fleet. Their tonnages contributed from the chartering channel were larger than that from owned fleet.
4. PIL and Wan Hai Line are new to the top 20 carrier list, which accounts for why their scales and tonnages are smaller than others.
5. Other leading carriers were grouped into another set with more capacities contributed by large-size ships and more ships aged between 5 to 10 years. In particular, Hyundai, OOCL and Hanjin maintain the highest average size in total fleet with more than 4,000 TEU.

Ship investment is a long-term issue of fleet planning and management. It becomes more complicated for carriers especially when they confront a competitive and cooperative environment. This research has provided an assessment based on the distinguishing features from our clustering analysis. Further studies can exploit multi-period data to devote to investigating the decisional behavior analysis of ship investment for carriers.

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