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Cluster Analysis on the Management Performance of Major Shipping Companies in the World

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Abstract

In the modern economic context, it is apparent that there is a strong focus on the importance of global shipping industry. Recently, the world economic crisis has negatively influenced the industry with regard to both supply and demand, which has seen almost no sign of recovery. The fact that the entire industry is operating with low efficiency and at a low profit state has made all stakeholders anxious. This research examines the financial performance of the world' s major shipping lines in order to give maritime stakeholders a closer look into the industry behind the ranking. Besides, the research evaluates the competitiveness of shipping companies in terms of financial ability and suggestions for strategic actions to stakeholders are provided. For these purposes, Fuzzy-C Means is used to cluster the selected lines into different groups based on their financial indices, namely liquidity, asset management, debt management and profitability. Levene' s tests which are then followed by ANOVA tests are also utilized to assess the robustness of the clustering outcomes. The results indicate that liquidity, solvency and profitability act as the main criteria in the classification problem.

Key words: Major Shipping Lines, Financial Performance, Clustering, Fuzzy-C Means

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Ⅰ. Introduction

The liner shipping industry transports products which account for one third of global trade. It benefits from globalization more than any other industry and also faces strong headwinds resulting from the world financial crisis. Many research findings show that competition in the shipping market increased over the 2000-2008 period. In such boom market situation, ocean carriers compete in price and the competition is described as monopolistic with high level of entry barrier (Sys, 2010). Sys also pointed out that a liner carrier with a one percentage point average costs higher than another would have a 16.7 percent lower profit (2010). Therefore, the strategy "bigger is better" was applied by shipping lines in order to grab more market share as well as to be cost effective. Before 2008, a large number of ship orders were placed so as to expand capacity and to enhance liners' competitiveness. However, according to Dustin (2016), instead of double digit growth in demand with respect to GDP growth, the actual multiplier was only 1.1 with average year growth of 2.9% which used to be 4.4% from 2000 to 2008. As a result, the capacity of the industry has considerably surpassed demand and demand is expected to be between 8.2 percent and 13.8 percent higher by the end of 2020, when compared to the 7 percent excess of supply over demand in 2015 (Hugh, 2016). Moreover, it was mentioned in the Maersk Group Annual Report 2015 that in the five-year period, between 2011 and 2015, this biggest carrier reported the falling price of bunker by 52%, which in turn put more pressure on the freight rate which was already at historical lows due to intense competition (2016). The slowdown in global trade, the oversupply of ships and the plunging freight rate have altogether driven the shipping market into a drastically prolonged slump. Consequently, shipping lines have been operating within a low and negative margin, and even major shipping lines have announced bankruptcy or are on the verge of it.

In literature, a lot of research has been carried out analyzing the performance of world ocean carriers. However, most of the previous studies focused on searching for tools to measure financial performance without taking into account the actual situation of many companies at the same time. This research supplements previous work, which classifies selected major shipping lines into groups based on their actual financial results using Fuzzy-C Means (FCM) and draws meaningful conclusions from the clustering outcomes.

The methodology of this study is as follows. Firstly, important financial ratios of liquidity, asset management, debt management and profitability are selected to evaluate the operational efficiency of the shipping companies. Within its scope, twelve companies with public annual reports from 2012 to 2015 were chosen for research purposes. Secondly, the data collected from the financial reports of the designated shipping lines are summarized for eleven ratio calculations and used as input data for FCM clustering. The clustering is carried out using GA – Fuzzy Clustering software. Besides, a series of Levene's test and ANOVA tests were also

implemented in order to examine the accuracy of the clustering results. Therefore, the efficiency of the outcomes were enhanced. The results from the study evoke meaningful recommendations regarding the strategic actions of stakeholders.

Following the above method, the aim of this research is firstly to classify world major shipping lines into clusters based on their financial performance and to help stakeholders such as investors and cargo owners to have a closer look into the industry before a strategic decision is made. Secondly, via financial performance, an evaluation of the competitiveness among selected companies can be drawn. Thirdly, via the characteristics of cluster members, induction and forecasts are created using the information provided about a member in the cluster.

Ⅱ. Literature Review

2.1 Research on financial performance evaluation of shipping lines

With respect to performance evaluation, Chiang analyzed the situation of the top three container shipping companies in Taiwan by using financial ratios and intellectual capital based on data from 2003 to 2005 (2007). Half of the report focused on selecting the indicators using grey relation analysis and the other part applied TOPSIS to rank performance. There were a total of three companies, eight properties of financial indicators and twelve intellectual capital indicators formed the matrix of a relatively small data field. Besides, each property is separately used as criteria to evaluate the selected firms' performance instead of taking into account all factors at the same time. Moreover, within the same topic of discussing the financial ability of Taiwanese container shipping companies, Wang also used grey relation analysis to cluster financial ratios and decide the most typical ones, and then a fuzzy multiple-criteria decision-making method was proposed to rank the selected three carriers (2010). The study aggregates the strength and weakness indices into performance indices to easily rank the alternatives. Moreover, Konsta examined the applicability and usefulness of performance indicators in shipping management performance and evaluation (2012). A questionnaire was taken across tanker shipping firms in Greece to investigate the importance of KPIs from the view of the companies.

This research resembles the above recent studies by stating the need to measure financial performance among shipping companies, especially in such a plunging market. However, in applying Fuzzy C-means, this study clusters the twelve carriers into groups with eleven data properties at the same time so that an overall evaluation can be easily exposed to maritime stakeholders. Also, the most updated data from the world major carriers was collected and summarized as input for the research.

2.2 Research on evaluating the competitiveness of shipping lines

Various studies have been performed regarding the competitiveness of liner shipping. Lee et al. analyzed the local and global factors and the changing situations which influence the shipping

markets (2010). In approaching to these factors, the Analytical Hierachy Process (AHP) was applied to evaluate the competitiveness factors of ship management companies. The results suggested that human resources, shipboard and land management were the main factors determining the shipping company's competitiveness.

Ha et al. adopted a panel data model to nine shipping companies from 2009 to 2015 to determine the effect of the freight rate, bunker fuel prices, scale economies and the chartered vessel ratios on the profits of selected lines. The results showed that the freight rate had a positive impact while bunker fuel price exerted a negative effect on the profits (2017).

Investing in the shipping field has been proven to yield high profits in an economic upturn. However, even in a downturn, investors keep their interest in this industry in the hope for market recovery. From the investors' perspective, financial performance is an important tool when considering an investment decision. Therefore, the financial health of a company directly influences their competitiveness in winning investors' deals. This research adds another approach to recognizing the competitiveness of a group of ocean carriers by separating safe companies from the risky ones.

2.3 Research on economic problems using FCM

Regarding the financial market, in 2011, Zhou attempted to analyze the influential factors of financial market for all lines. In applying FCM, the study indicated that effective compartmentalizing clustering measured standard of good and bad clustering. Following data on the Shanghai Stock Exchange, it was found that a stock market exited positive, negative and zero action; and all listed firms had a different reaction to the rate fluctuation. In 2013, Yin studied the clustering of the supply chain, focusing on organizing supply chain units, transportation modes and work orders into different unit-transportation-work order families. A Fuzzy C-means based hybrid evolutionary approach was proposed so that various data could be organized dynamically into different order clusters. Outside of this, Ansari, investigated the classification of a large database of 120 customer profiles (2016). A combination of Fuzzy C-means and Genetic algorithm were utilized to cluster the list of customers based on four criteria: length of relationship, recency of trade, frequency of trade and monetary value. Customers were clustered into two groups as desired and meaningful conclusions were also drawn.

The above literature proved that Fuzzy C-means is a good tool to cluster data especially with high dimensional data sets and a large number of prototypes (Winkler, 2012). In real life, the population is usually large which makes it hard for interested parties to have an insight into it. When such a population is classified into groups of similar data members, stakeholders can easily understand and better evaluate as well as make decisions using useful clustered results. Therefore, this research supplements the previous literature in the field of commercial shipping industry, which also generates meaningful results and recommendations.

III. Methodology

3.1 Introduction of Fuzzy C-means

Cluster analysis is a powerful tool in various applications for discovering groups and identifying key properties in the underlying data. The fundamental steps for clustering is to select data features and make a decision on the appropriate clustering algorithm. After that, the validation of the results should be tested and an interpretation of the results is made. The application of clustering is data reduction, hypothesis generation, hypothesis testing and prediction based on groups.

In classical clustering or K-means clustering, each data point can only belong to one cluster or clusters cannot overlap one another. Therefore, this method of clustering shows good results when datasets are discrete or well separated. However, in dealing with overlapping clusters in which data points have characteristics similar to more than one cluster, K-means clustering may not be successful. Besides, K-means also fails to recognize the noisy data which makes the clustering results less accurate.

In order to overcome such problems, Fuzzy C-means was developed by Dunn in 1973 and improved by Bezdek in 1981 (Bezdek, 1984). In FCM, data points can belong to more than one cluster with varying degrees of membership. By means of this method, it is not compulsory for data located around the boundaries of clusters to belong to a certain cluster. In comparing the performance of the K-means algorithm and FCM Algorithm, the research by Sivarathri et al. proved that although FCM takes more iterations towards the clustering results, the accuracy and quality of the clusters is more comparative (2014).

3.2 FCM Algorithm

Similar to K-means clustering, FCM determines the number of clusters beforehand. Let $X = \{x_1, x_2, ..., x_n\}$ be the set of data and $V = \{v_1, v_2, ..., v_c\}$ be the set of clusters' centers in a p dimensional space where n is the number of data, p is the number of data properties and c is the number of clusters. Centroids are used as centers in describing the clusters.

Conditions for a fuzzy partition matrix are given by:

$$u_i \in [0,1], 1 \le i \le c, 1 \le j \le N, \quad (1)$$

$$\sum_{i=1}^{c} u_{ij} = 1, 1 \le j \le N, \quad (2)$$

$$0 \le \sum_{j=1}^{N} u_{ij} < N, 1 \le i \le c, \quad (3)$$

FCM algorithm minimizes the objective function as follows:

$$J_m(X, U, V) = \sum_{j=1}^{N} \sum_{i=1}^{c} (u_{ij})^m d^2(x_i, v_j) \quad (4)$$

Where x_i is the j^{th} data point, v_i is the centroid of i^{th} cluster, u_{ij} is the membership of each data to a cluster, $d^2(x_j, v_i)$ is the squared Euclidean distance between x_j and v_i and m is

the fuzzier factor.

FCM is implemented using the following process.

The relative membership function of each data towards the centroid is calculated as follows:

$$U_{ij} = \frac{(1/d^2(x_{i,}v_j)^{\frac{1}{m-1}}}{\sum_{k=1}^{c}(1/d^2(x_i,v_d)^{\frac{1}{m-1}}} \quad (5)$$

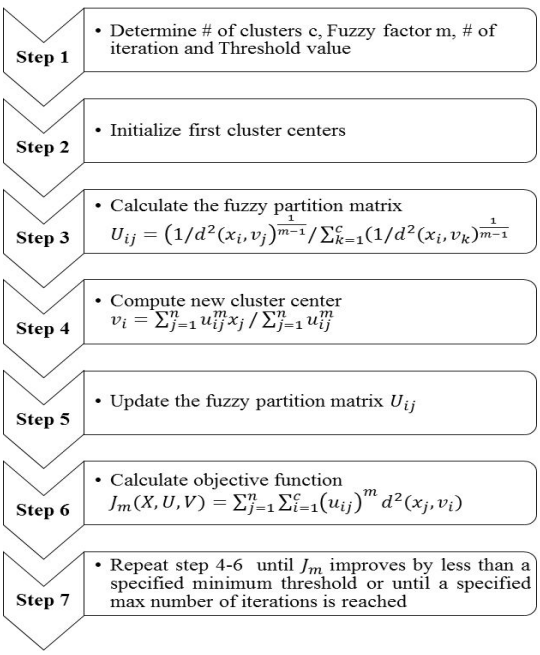

Fig 1. FCM Step-by-step flow chart

Cluster centers are computed using the formula:

$$v_i = \sum_{j=1}^{n} u_{ij}^m x_j / \sum_{j-1}^{n} u_{ij}^m \quad (6)$$

The algorithm stops when the improvement of error is below the defined threshold or a maximum number of iterations is reached.

IV. Data Analysis and Results

4.1 Input data

An initial sample of the top twenty shipping lines in the world in 2016 with public financial statements from 2009 to 2016 were targeted for research purposes. However, given the fact that in a market downturn, many companies are reluctant to publicly announce their annual reports, the collection of data for research purposes was implemented with difficulty. Besides, the requirement for FCM clustering is that no single value should be missed in the input data file. Therefore, in order to perform the clustering, we eliminate the firms and firm-years that do not satisfy the clustering requirements. As a result, twelve world major shipping lines with public financial statements within a four-year period (2012-2015) were selected. The chosen research period is considered appropriate since the information is most up to date. Moreover, the shipping industry is cyclical when the performances of all companies swing together with the economy and the selected period is consistent with the current state of the industry recession to be considered within the scope of the research.

The list of companies includes CMA CGM, COSCO, Evergreen Line, Hapag Lloyd, Hanjin Shipping, Yang Ming Marine, OOCL, MOL, NYK Line, Hyundai M.M., K Line and Wan Hai Lines. These companies were listed in the top 20 shipping lines in the world in 2016, ranked by how many twenty-foot equivalent units (TEUs) shipping containers a company can carry at any

given time according to Infographic. In terms of geographical location, five companies are located in China, three are in Europe, three are in Japan and two belong to South Korea. All of them are the most important regions for shipping industry. According to the ranking, the top three shipping lines CMA CGM, COSCO, and Evergreen Line move the majority of the container cargo in the world. Besides this, among the companies of interest, CMA CGM has the highest market segment of 11.1% and Wan Hai Lines has the lowest proportion of 1.1% among the selected carriers. Due to severe market fluctuation, the companies implemented reorganization as well as forming alliances in responding to the strategy of getting bigger. The benefits of alliance are increased service frequency, reduced cost and increased geographical coverage. In 2016, the world' s shipping alliances include the 2M alliance (Maersk and MSC), the Ocean Three alliance (CMA CGM, UASC, China Shipping), the G6 alliance (NYK Line, OOCL, APL, MOL, Hapag Lloyd and Hyundai M.M.) and the CKYHE alliance (K Line, COSCO, Hanjin, Evergreen, Yang Ming).

The shipping industry is characterized by cyclicality; therefore, all the companies follow a general trend of growth and decline. In a peak period, the demand for ships surges together with freight rate, assets value and liquidity level. This leads to an increase in ship orders. The fact has proved that global economic growth and the expansion of fleet capacity by an individual shipping line significantly contribute to profit of shipping lines. Thus, it is seen that during the economic plateau, the selected companies witnessed high profit, high liquidity and a large number of ship orders as well as time chartering contracts. However, during a trough, there are clearly signs of overcapacity as a result of plunging freight rate below operating costs, decrease in liquidity, falling in assets value and increase in debt.

Within the distress period, it is observed that the revenues of all the selected carriers are low and fluctuating. Besides, the profit margins are also low and negative in some cases because revenues cannot cover expenses which include operating expenses, financial expenses and taxes. Moreover, since shipping industry is mainly financed by debt capital to promote the development of fleets, all companies are shown to be highly leveraged, especially Hyundai M.M.. Within the peak period, various orders of ships were made, which had been financed by bank loans. When the crisis came with decreasing freight rates, short-term and long-term obligations were yet to be fulfilled, which led to high credit risks. Furthermore, some carriers such as CMG CGM, Hanjin and Hyundai M.M. operated the fleets with high chartered vessel ratios compared to other lines such as Evergreen.

Table 1. Selected financial ratios with reference from other studies

No	Type	Ratio Name	Referred References
1	Liquidity	Current Ratio	Maro, Chiang, Wang, Chen, Ding, Lin, Ko
2		Acid Test Ratio	Maro, Chiang, Wang, Chen, Ding, Ko
3		Cash Ratio	Maro, Chiang, Wang, Chen, Ding, Lin, Ko
4	Asset Management	Fixed Assets Turnover	Maro, Chiang, Wang, Ding, Ko
5		Total Assets Turnover	Maro, Chiang, Wang, Ding, Lin, Ko
6	Debt Management	Debt Ratio	Maro, Chiang, Wang, Ding, Lin, Ko
7		LT Debt Ratio	Maro, Ding, Ko
8		E/D Ratio	Maro, Wang, Chen, Lin, Ko
9	Profitability	Profit Margin	Maro, Chiang, Wang, Ding, Ko
10		Return on Equity	Maro, Chiang, Chen, Ding, Ko
11		Return on Assets	Maro, Chiang, Wang, Chen, Ding, Lin, Ko

The liner shipping companies are described by eleven properties which are categorized by the following ratios: liquidity (three ratios), asset management (two ratios), debt management (three ratios) and profitability (three ratios). These are key performance indicators for measuring shipping companies' financial performance. The selected ratios are frequently used in many research works regarding the evaluation of companies' financial performance as well as the prediction of financial distress. Table 7 lists some of the recently published papers that were referenced in this research.

The rationale that these ratios are chosen can be described as below.

Firstly, liquidity ratios measure a shipping line's ability to pay its short-term debt obligations through the calculation of the current ratio, acid test ratio and cash ratio. Liquidity ratio analysis is effective when looking within industries of identical financial structures and similar sizes. Healthy firms are supposed to retain adequate liquidity and experience financial distress when they are in an illiquid situation. With the current state of weak demand in shipping, the probability of having low profit and low liquidity is higher, which increases the chance of default. More to the point, banks are also reluctant to finance low liquidity companies or may tighten the loan activities. In a highly cyclical industry like commercial shipping, maintaining an adequate liquidity is crucial. Therefore, companies with sufficient liquidity stay healthier, more competitive and lure away anxieties from their stakeholders. The calculation of key liquidity ratios are as follows.

$$Current\ Ratio = \frac{Current\ Assets}{Current\ Liabilities} \quad (7)$$

$$Acid\ Test\ Ratio = \frac{Current\ Assets - Inventory}{Current\ Liabilities} \quad (8)$$

$$Cash\ Ratio = \frac{Cash + Cash\ Equivalents}{Current\ Liabilities} \quad (9)$$

Secondly, asset management ratios include fixed assets ratio and total asset ratios as below.

$$Fixed\ Assets\ Ratios = \frac{Revenue}{Fixed\ Assets} \quad (10)$$

$$Total\ Assets\ Ratio = \frac{Revenue}{Total\ Assets} \quad (11)$$

The above ratios attempt to measure firms' efficiency in generating sales from assets. Since the shipping industry is capital intensive, the way companies utilize their assets plays an important role. With regard to unpredictable conditions, future market swings may have negative effect on shipping revenue as well as asset value. Badly timed of ship orders has led to an over-capacity in the whole market while the demand has seen no recovery. Thus, from asset management ratios, stakeholders are open to how asset-intensive the firm is and the efficiency of the firm's assets are employed. In the fixed assets ratio, net fixed assets is applied instead of fixed assets data as it better reflects the real value of the companies' properties.

Thirdly, debt management ratios include the following ratios.

$$Debt\ Ratios = \frac{Total\ Debts}{Total\ Assets} \quad (12)$$

$$LTDebt\ Ratios = \frac{LTDebts}{Total\ Equity} \quad (13)$$

$$E/D\ Ratio = \frac{Equity}{Total\ Debts} \quad (14)$$

These ratios measure the degree of financial leverage used by the company. Debt management ratios are crucial in evaluating the performance of a shipping company because capital intensive industry usually relies on debt to expand its capacity. Shipping lines compete for market share and capacity; as a result, the market supply is topped up with megaships from the boom in the market and even in a market downturn. The irrational decision increases the debt level as well as the default rate of shipping lines. Therefore, through these ratios, stakeholders are exposed to the real financial capability of the firms they are interested in.

Fourthly, the profitability ratio consists of the followings:

$$Profit\ Margin\ Ratio = \frac{Net\ \ Income}{Revenue} \quad (15)$$

$$Return\ on\ Equity\ Ratio = \frac{Net\ \ Income}{Equity} \quad (16)$$

$$Return\ on\ Assets\ Ratio = \frac{Net\ \ Income}{Total\ Assets} \quad (17)$$

Since stakeholders are most concerned with profitability, this ratio is widely used in all industries. Profitability ratios attempt to assess the ability and overall efficiency of a firm to generate earnings from its operation, from assets and for the shareholders when compared to expenditure. In the financial distress, most shipping lines struggle to keep a sustain profitability situation. Accordingly, companies with

better profitability ratios even in the plunging market stay healthier and more efficient.

4.2 FCM Clustering

Table 2. Parameters of Fuzzy C-means

No	Parameters	Value
1	Number of clusters	3
2	Fuzzy Coefficient	1.5,2,3
3	Max number of iteration	100
4	Threshold Value	0.1

In order to implement fuzzy clustering, GA-Fuzzy Clustering Software was used. The clustering was implemented four times using computed data from four fiscal years from 2012 to 2015. The chosen parameters of FCM are default values for a typical clustering problem with fuzzier factor *m=2*, maximum number of iteration of *100* and threshold value equals *0.1*. However, two cases of *m=1.5* and *m=3* were also implemented to have an insight into the fuzziness of the selected data and comparison is also made in the upcoming section.

After running the software, the twelve shipping lines are divided into three desirable groups. The clustered results in year 2012 are illustrated in table 3. Cluster 1 includes Hanjin and Hyundai M.M. Cluster 2 includes NYK, MOL, K Line, Hapag Lloyd, Yang Ming, CMA CGM and COSCO. Cluster 3 includes OOCL, Evergreen and Wan Hai.

Table 3. Clustering results in year 2012 (m=2)

No	Shipping Lines	Cluster 1	Cluster 2	Cluster 3	Result
1	Hanjin	0.9420	0.0378	0.0200	Cluster1
2	HMM	0.9283	0.0422	0.0294	
3	NYK	0.0131	0.9500	0.0368	
4	MOL	0.0103	0.9505	0.0390	
5	K Line	0.1011	0.7536	0.1452	
6	Hapag Lloyd	0.0448	0.7402	0.2148	Cluster2
7	Yang Ming	0.1352	0.6741	0.1906	
8	CMA CGM	0.0866	0.6694	0.2439	
9	COSCO	0.0526	0.4998	0.4474	
10	OOCL	0.0129	0.0649	0.9221	
11	Evergreen	0.0110	0.0906	0.8983	Cluster3
12	Wan Hai	0.0659	0.1711	0.7629	

Except for COSCO, the membership of all other shipping lines toward their relative clusters are considerably high, which shows the higher level of homogeneity among members in the same group. As seen in the result table, COSCO does not belong to a well-defined cluster. As per the algorithm' s rule, a datum shall belong to a group with higher degree of membership or lower level heterogeneity towards other clusters. However, this company is seen to be placed in a middle space between group 2 and group 3 with an almost similar membership degree. This is also a strong point of FCM when compared with classical clustering in the way that the characteristics of data and clusters are clearly described.

Table 4. Clustering results in year 2013 (m=2)

No	Shipping Lines	Cluster 1	Cluster 2	Cluster 3	Result
1	Hanjin	0.9765	0.0137	0.0096	Cluster1
2	HMM	0.9754	0.0141	0.0104	
3	NYK	0.0238	0.6269	0.3491	
4	MOL	0.0095	0.9186	0.0718	
5	K Line	0.0227	0.5757	0.4015	
6	Hapag Lloyd	0.0196	0.8159	0.1644	Cluster2
7	Yang Ming	0.0485	0.7934	0.1579	
8	CMA CGM	0.0258	0.7134	0.2606	
9	COSCO	0.0563	0.6946	0.2490	
10	OOCL	0.0275	0.1659	0.8064	
11	Evergreen	0.0067	0.1497	0.8434	Cluster3
12	Wan Hai	0.0191	0.1202	0.8606	

Table 4 displays the clustering outcomes in the year 2013. As illustrated, the results agree that in the year 2012 or it can be said that the performance of twelve selected major carriers are consistent during a 2-year period. In 2013, COSCO moves toward the group 2 as membership degree of it to group 2 surges.

Clustering results in year 2014 are demonstrated in table 5. As seen, cluster 1 consistently comprises of Hanjin and Hyundai M.M while there is movement among members between cluster 2 and 3.

Table 5. Clustering results in year 2014 (m=2)

No	Shipping Lines	Cluster 1	Cluster 2	Cluster 3	Result
1	Hanjin	0.9601	0.0236	0.0162	Cluster1
2	HMM	0.9691	0.0177	0.0130	
3	MOL	0.0182	0.9286	0.0531	
4	Evergreen	0.0173	0.8945	0.0881	
5	COSCO	0.1270	0.6939	0.1790	Cluster2
6	Hapag Lloyd	0.0755	0.6438	0.2806	
7	Yang Ming	0.1629	0.4992	0.3378	
8	K Line	0.0090	0.0508	0.9400	
9	CMA CGM	0.0457	0.3016	0.6526	
10	NYK	0.0487	0.3165	0.6347	Cluster3
11	OOCL	0.0886	0.3584	0.5529	
12	Wan Hai	0.0811	0.2126	0.7062	

Whereas Wan Hai and OOCL are constantly included in group 3, Evergreen moves towards group 2. Besides, K Line, CMA CGM and NYK are transferred to group 3 with relatively high level of association. Also in this year, Yang Ming is considered a middle datum between group 2 and group 3 since the membership is not sufficiently high toward either groups.

Table 6 shows the outcomes from the clustering performed in year 2015. As the table describes, the result in year 2015 absolutely coincides with that of 2014. In other words, the performance of selected shipping lines are consistent within this 2-year time period.

Table 6. Clustering results in year 2015 (m=2)

No	Shipping Lines	Cluster 1	Cluster 2	Cluster 3	Result
1	Hanjin	0.6436	0.2348	0.1214	Cluster1
2	HMM	0.8019	0.1074	0.0906	
3	MOL	0.0054	0.9708	0.0236	
4	Evergreen	0.0229	0.8428	0.1342	
5	COSCO	0.0489	0.8234	0.1275	Cluster2
6	Hapag Lloyd	0.0381	0.7733	0.1885	
7	Yang Ming	0.2087	0.5141	0.2771	
8	K Line	0.0343	0.1220	0.8435	
9	CMA CGM	0.0291	0.3998	0.5710	
10	NYK	0.0127	0.0873	0.8998	Cluster3
11	OOCL	0.0721	0.3441	0.5836	
12	Wan Hai	0.0132	0.0796	0.9071	

In the case of coefficient *m=3* which means the higher fuzziness of data regarding the three clusters, the results almost resemble that of *m=2* except for the case of COSCO which is included in group 3 instead of group 2 in 2012. When m is set to be *1.5* or the clusters are more discrete rather than fuzzy, the clustering outcomes are also consistent with the results drawn under the default value of m. However, in year 2015, Hanjin Shipping moves to group 2 and there is only one member of Hyundai M.M. in group 1. The reasons for these differences are explained in the next part.

4.3 Cluster validity assessment

One of the most important issues in the clustering process is to test the validity of the clustering results. In other words, the outcomes should show a high degree of heterogeneity between clusters or that the groups are well separated. It is only if the clusters exhibit significant different means in the variables that are they distinguishable. In order to assess the quality of the clustering results, a one-way ANOVA test is applied. ANOVA was developed by Sir Ronald A. Fisher and introduced in 1925. It is used to identify whether a significant difference exists among the means of two or more groups. Since ANOVA stands for "analysis of variance ", the question of the test is "Is there variance between the group means or are they similar?"

The null hypothesis is that all population means are equal and the alternative hypothesis is they are different. The decision of the test is made upon the comparison of the test statistics F and the critical value or reject H_0 if $F \geq$ critical value. Otherwise, the test is concluded by comparing p value and significance level α. If $p \leq \alpha$, we reject the null hypothesis and if $p > \alpha$, we fail to reject the null hypothesis.

Normally, before carrying out the one-way ANOVA test, the Levene' s test for equality of variances is to be performed. The test hypothesis is that groups variances are equal and the alternative hypothesis is not all of them are equal. If the Levene test is positive or p value 〉 significance level, then the variances in the different groups are homogeneous. This acts as the priori condition for ANOVA.

In this paper, we conducted a series of Levene' s tests and a one-way analysis of the

variance tests on cluster variates to assess the validity of the three clusters based on eleven clustering criterion in four years. Significance level α is chosen to be 0.05. The tests are performed using SPSS. The following table shows the results of p values of Levene's tests and ANOVA tests in which $p \leq 0.05$ means there is not enough evidence to reject the null hypothesis and vice versa. Our preferred outcome is that clusters' means are significantly different with homogeneity-of-variance among clusters; or the p value of Levene's test is greater than 0.05 and that of ANOVA test is smaller than 0.05. Since Levene's test result is the condition for ANOVA test, the latter is performed only when the former produces positive results.

Table 7. Results of Levene's Tests and one-way ANOVA's tests

Year	Test	Current Ratio	Acid Test Ratio	Cash Ratio	Fixed Assets Turnover	Total Assets Turnover	Debt Ratio	LT Debt Ratio	E/D	Profit Margin	ROA	ROE
2012	Levene's	0.44	0.87	0.11	0.40	0.34	0.19	0.10	0.22	0.80	0.90	0.03
	ANOVA	0.00	0.00	0.00	0.62	0.20	0.02	0.00	0.01	0.02	0.00	-
2013	Levene's	0.50	0.44	0.02	0.72	0.16	0.31	0.14	0.13	0.15	0.11	0.08
	ANOVA	0.00	0.00	-	0.51	0.62	0.01	0.00	0.01	0.07	0.05	0.00
2014	Levene's	0.40	0.25	0.01	0.74	0.36	0.18	0.25	0.11	0.55	0.46	0.00
	ANOVA	0.00	0.00	-	0.06	0.11	0.00	0.00	0.01	0.18	0.10	-
2015	Levene's	0.45	0.35	0.09	0.59	0.44	0.57	0.00	0.35	0.01	0.01	0.00
	ANOVA	0.00	0.00	0.07	0.04	0.10	0.00	-	0.01	-	-	-

Table 7 shows that liquidity ratios, especially current ratio and acid test ratios, and debt management ratios are the strongest criterion in determining the formation of clusters. While profitability ratios illustrates relatively weak relations when trying to decide the partitioning, it is hard to cluster the selected twelve companies using asset management ratios.

Since the majority of the above test results support the hypothesis that the clusters are well partitioned, we can come to confirm the validity of Fuzzy C-means outcomes.

4.4 Clustering Results Interpretation

In order to title the three clusters, cluster centers are considered and compared among groups. The results show that members in cluster

1 possess low liquidity and low profitability while the debt ratio is high. Most of the ratios in cluster 2 are in the middle when compared with the other two groups. Cluster 3 has lowest debt ratio and highest liquidity as well as the best profitability when compared to the average values of these criteria for all shipping lines. As interpreted from the results, asset management ratios fluctuate and are not consistently different among clusters. These results coincide with those of the ANOVA tests in which asset management does not act as the main criteria in the clustering outcomes. Therefore, the three clusters are given the following meaning. Cluster 1 includes shipping lines with Not Good financial performance, Cluster 2 consists of shipping lines with Average financial performance and the companies in Cluster 3 comparatively, sustain a good financial performance.

Stakeholders, especially cargo owners do not only care about the service quality in choosing shipping carriers but also carefully consider the financial security of such companies before making strategic decisions. In a difficult market situation, the problem of cost competitiveness is strongly focused. The companies that stay competitive in terms of costs are supposed to have positive bottom lines. Moreover, when a carrier aims at strengthening its competitiveness by developing the fleet, it is required to have a competitive capital structure. Furthermore, in assuring a competitive daily operation, the shipping companies are to maintain a good liquidity level. Therefore, the competitive advantage among shipping lines with respect to financial health can also be evaluated based on the clustering results. The competitiveness of companies in the three clusters are; thus, high, average and low respectively.

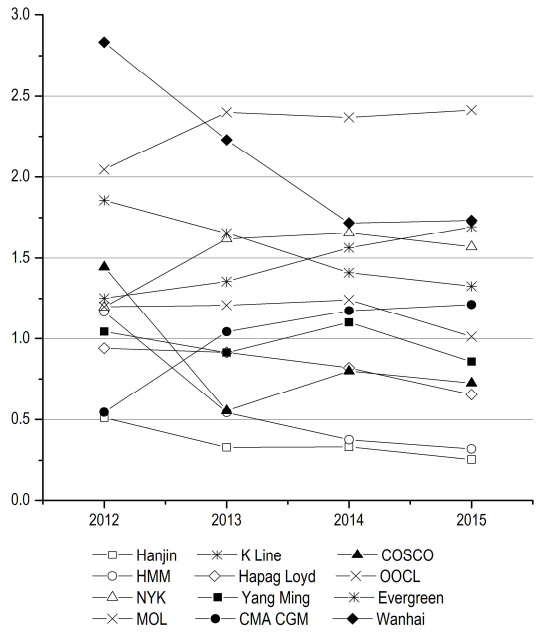

Fig 2. Liquidity ratio of selected shipping lines from 2012 to 2015

Figure 2 shows the liquidity situation of the selected twelves lines during the 4-year period. It is clearly seen that Hanjin and Hyundai M.M. are at the lowest level and have plunging liquidity while those of Wai Hai, Evergreen and OOCL are consistently the highest. In terms of ability to fulfill short-term obligations, COSCO's performance is improving and stays closer to the three good shipping lines in the recent years, the reason for which it has a similar membership function towards cluster 2 and 3; and when the clusters are defined to be fuzzier, COSCO was clustered in the good performance group. Other shipping lines that have comparatively average performance can be seen from the graph.

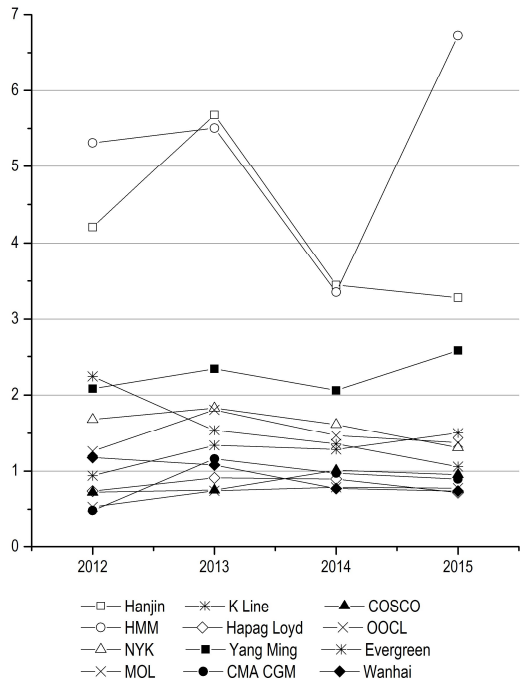

Fig 3. Debt ratio of selected shipping lines from 2012 to 2015

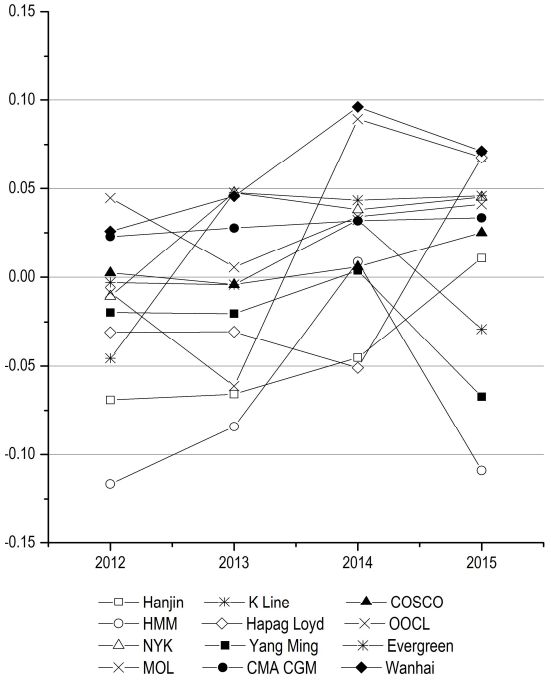

Fig 4. Profitability ratio of selected shipping lines from 2012 to 2015

Figure 3 explains the debt ratios of the shipping companies under research. This shows that Hanjin and Hyundai M.M have the highest leverage, especially Huyndai M.M which raised its debt level to almost 7 times that of owners' equity in 2015. Wan Hai, Evergreen, OOCL, K Line, CMA CGM, MOL, Hapag Lloyd, COSCO and NYK all have adequate level of debt to equity of below 2, which keeps these companies' situation relatively safe in terms of long-term obligation management.

Figure 4 designates the profitability situation of the twelve companies. The most obvious thing to be seen is that during the 4 years, the profit margin of these major world carriers are low and fluctuating. Many companies have bottom lines below zero. This fact can be understood since commercial shipping industry strictly cycles with the economy. The trade growth recently is much lower than predictions made before 2010 and there is no exception made for the slump of profit among large or small size of shipping companies. However, a point to be noted is that Wan Hai stays profitable during the period and has best profit margin among all the container lines. Although Wan Hai ranks the lowest in the list according to TEUs carried, it shows that scale is not the factor that explains it outperforming other carriers. Besides, Hyundai M.M and Hanjin Shipping have lowest profitability although Hanjin improves its performance in 2015 with slightly

positive returns. This point explains the difference in the clustering results when fuzzier coefficient is set to be 3, Hanjin moves towards cluster 2 in year 2015 although debt ratio and liquidity ratio are in an alarming situation.

The world economic crisis in 2008 left its marks on the whole shipping industry; however, different companies bear different burdens. In 2009, it was estimated that Hanjin lost more than US$1 billion while the total loss of the industry was US$15 billion (BHS1Global, 2017). By 2016, the debt topped up US$5 billion whereas a paltry profit of $6 million was posted (Braden, 2016). The orders of ship by Hanjin placed until 2015 grew nearly 100 percent year over year despite the impact of overcapacity and the container ship fleet hits the record of 20 million TEUs. Moreover, until 2016, Hanjin had 62 chartered vessels of which many were time charter agreements, which generated a high debt ratio (Braden, 2016). Apart from the bank loans, Hanjin issued bonds to quickly access to financing, but as they had short maturity period, the company faced serious liquidity problems. Therefore, although returned to profitability in 2015, this could not solve such liquidity and solvency problems. After the refusal of its liquidity plan by Korea Development Bank, Hanjin Shipping announced bankrupt in 2016. The other Korean carrier, Hyundai M.M., by 2016, also operated a fleet of 55 containerships, of which 33 were chartered (Wackett, 2016). The ratio of debt to equity at more than 700 percent and the loss of US$500 million in 2015 pushed the company to the verge of bankruptcy with severe cashflow pressure, default on charter hire payments and ships which were subject to being arrested by creditors. These facts explain the reasons for which the two Korean carriers are clustered in such a not good group for consecutive four years.

The reasons for the success of Wanhai was explained in its Annual Report 2015 that facing a severe market situation, the company adopted a "stable and sustainable" business philosophy and committed to effective cost management and efficiency improvements (2016). In response to market difficulties, the services and ship deployments were restructured to be fully ulitized together with tight control of operation so that the ship schedule is reliable and the service quality is sustainable.

In attempt to track carriers' financial health, Drewy's Z-score test was also carried out by Szakonyi, which revealed that NYK, Wanhai, OOCL, K Line, Hapag-Lloyd, MOL, COSCO, CMA CGM, Evergreen and Yang Ming possessed a considerably higher score than Hyundai M.M. and Hanjin, especially that of Hanjin turned negative (2016). With regard to this test, a higher score means a lower risk of bankruptcy. Comparing such scores of the top ocean carriers, the results totally agree with the clustered outcomes yielded from this research.

V. Conclusion

In this study, we conducted research on the top twelve world shipping lines using the Fuzzy C-means clustering method. In detail, information from public annual reports from 2012 to 2015 of the twelve selected carriers were collected and

used as input for the clustering implementation. The population was classified based on four groups of criteria namely liquidity, asset management, debt management and profitability. A series of Levene' s and ANOVA tests were carried out to assess the validity of the clustering results. The outcomes from this research are presented as below.

Firstly, according to the cluster outputs, the three main criteria for classification problems are liquidity, solvency and profitability. This result is reasonable in the way that in a market downturn, companies' bottom lines plunge together with market demand, so a firm that maintains profitable result is considered to be healthier when compared with rivals. Besides, shipping companies that rely heavily on leverage in ship investment have a worse finance situation and take higher default risk. Furthermore, due to low demand and heavy long-term obligations, firms also meet difficulties in using current assets to pay for present finance costs and other operational expenses. As a result, liquidity becomes crucial to all carriers.

Secondly, the clustering results also revealed that Wan Hai which is the world twentieth carrier, outperformed all other larger rivals to be the most profitable shipping company in the world for the chosen period. Although shipping companies compete with each other with regard to scale and market share, it is clear that size does not play the only role in deciding the strong performance of a shipping company.

Thirdly, the two Korean carriers including Hanjin Shipping and Hyundai M.M are consistently clustered in the group of low performance during the 4-year period. These companies have lower liquidity and lower profits while the debt level is significantly higher than their rivals. In August 2016, Hanjin – the world' s seventh largest container shipper filed for bankruptcy after years of losing money, struggling in raising liquidity and restructuring debt. The fall of Hanjin was concluded by its biggest creditor of Korea bank' s refusal to prop it up. As mentioned in the introduction of FCM algorithm, members in the same cluster have high level of homogeneity. Therefore, it can be forecasted from the clustering result that Hyundai M.M is also on the verge of bankruptcy since there has also been a lot of news released about the creditors of Hyundai M.M. rejecting pleas to reschedule its debts. Without government support, bankruptcy may close in on Hyundai M.M.. Therefore, stakeholders should be better prepared for such a circumstance.

Forthly, the results shown in this research is meaningful to maritime stakeholders in the way that it recommends the stakeholders to reconsider the investment portfolios or shipping service decision. Big carriers may be mistaken with healthy ones. The market has proved that "too big to fail" theory does not hold with the collapse of Hanjin Shipping. As a result, investors interested in shipping market may be subject to portfolios revision and shippers are to choose the carriers in the safe financial situation cluster.

Through the above research results, maritime stakeholders are receptive to this useful source of information, about the efficiently operating cluster of shipping lines and those which are at

risk. Proper strategic decision can be made in order to improve the efficient commercial shipping industry. However, the limitation of this research is the small number of shipping companies. Besides, although the ANOVA tests show the positive results of well partitioned clusters, the subjectivity in choosing the number of clusters may lead to local optimum. In order to search for global obtimum results, further research is needed.

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세계 주요선사의 경영성과에 대한 군집분석

도티밍황 · 최경훈 · 박계각

국문요약

현재 경제 상황에서 세계 해운산업의 중요성은 매우 강조되고 있다. 최근 세계 경제 위기로 인해 전체 산업은 공급과 수요 측면에서 어려움에 직면에 하였으며 저효율 및 저수익 상황이라는 사실은 모든 이해 관계자들에게 불안감을 안겨주었다. 따라서 본 연구에서는 해운산업의 이해 관계자에게 세계 주요 해운회사의 재무성과를 자세히 살펴볼 수 있도록 주요 해운회사의 재무성과를 클러스터로 분류하였다. Fuzzy-C Means 기법을 활용하였으며 Levene 테스트와 ANOVA 테스트를 통하여 클러스터링 결과의 견고성을 평가하였다. 그 결과 유동성, 지급 여력 및 수익성이 분류 상 중요한 기준 되는 것으로 도출되었으며 이러한 결과는 선별 된 운송 회사의 경쟁력 수준을 제시하고 있으며 클러스터에 속한 기업은 동일한 특성을 갖고 있으므로 클러스터 내 한 기업 특성을 파악하면 나머지 기업의 특성도 파악할 수 있어서 투자 결정함에 있어서 중요한 판단 기준으로 활용할 수 있다.

주제어: 주요 해운회사, 재무성과, 분류, Fuzzy-C Means