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Measuring the Efficiency of Maritime Transport Companies*

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Abstract

Purpose - This paper evaluated the efficiency performance of the three major maritime transport markets and examined the determinants of the performance. The firms' revenue fluctuates with the changes of the economic cycle; hence it is important for them to set up business strategies to improve efficiencies. A lack of efficiency measurements for shipping firms leads to a significant gap in determining their overall performance.
Research design, data, and methodology - Each of DEA scores was adopted for the evaluation and panel regression was used to examine the impact of determinants on the performance. The analysis included 50 shipping firms from three maritime transport markets as follows; 15 firms of container liners, 18 firms of bulk carrier and 17 firms of tanker carriers, and its period was from 2010 to 2016.
Results - In the CCR model, container liners were the highest, tanker carriers were the second, and bulk carriers were the lowest in operation efficiency and financial efficiency. By region, operation efficiency and financial efficiency was high in the order of America, Asia, and Europe.
Conclusions - This study suggests business strategies for maritime transport companies based on the analytical results of determinants of operational and financial efficiency.

Keywords: Maritime Transport, Data Envelopment Analysis, Container Liners, Bulk Carriers, Tanker Carriers.

JEL Classifications: C33, L91, L10, L25, R40.

1. Introduction

Recently, some studies have focused on analyzing, evaluating and improving business efficiency, which are considered as an important approach to endure global competition. Performance measurement is the process of collecting, analyzing and/or reporting information regarding the performance of an individual, group, organization, system or component(Upadhaya et al., 2014). Measuring the performance can relate to research business strategies within companies or organizations whether the output is in the objectives what they had expected or should have been achieved.

Under the trend of the global production and consumption patterns, maritime transport companies(MTCs) have been challenged to extend their geographical coverage and to meet complicated customers' requirements with reasonable freight rates. Therefore, MTCs should use their resources efficiently to offer more value to their shippers, which indicate an efficiency in operations. Indeed, maritime transportation industry heavily relies on capital investment highly capital-intensive and MTCs are, in turn, quickly exposed to the financial risks. Thus, not only the generating more financial outcomes with the restricted resources, but also the neutralizing financial risks should maintain the efficiency in the financial management is a crucial task.

MTCs would be significantly influenced by the business cycle of economic expansion and contraction. When the business cycle is improving, the MTCs have a high demand for their transport services. On the other hand, when the business cycle is declining, the shipping companies experience the difficulties due to the reduced need for

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transport. Therefore, the revenue of MTCs fluctuates with the changes of the business cycle; Hence, it is essential for them to set up strategies to improve the efficiency. Today's world is rapidly changing due to the swift changes in organization's infrastructures such as their assets(Liao, 2014; Ishaq et al., 2012).

Hence, most companies have been traditionally evaluated their business performance using an indicator or a set of indicators including financial ratios, more sophisticated methods are being used to assess its overall productivity and efficiency such as frontier analysis of productivity, inter alia, Stochastic Frontier Analysis(SFA) and Data Envelopment Analysis(DEA) are two representative techniques in frontier analysis. DEA has drawn more researchers' attention due to its advantages of being a non-parametric method and its ability to consider multiple inputs and outputs in an analysis simultaneously. DEA has been extensively employed in various industry such as logistics and distribution(Kim, 2016; Zhatkanbaev et al., 2015; Wu et al., 2012; Li, 2012; You & Kim, 2011; Hawawini et al., 2003; Cullinane & Gong, 2002; Beamon, 1999; Kaplan & Norton, 1992), banking industry(Shadkam & Mehdi, 2015; Banna et al., 2015; Salehi et al., 2014; Fethi & Pasiouras, 2010; Chen et al., 2005; Asmild et al., 2004; Luo, 2003), information technology industry(Chang et al., 2012, Chen & Iqbai, 2004), agriculture(Davidova & Latruffe, 2007), telecommunication(Tsai et al., 2006), electronic industry(Liu & Wang, 2008; Estache et al., 2008), hospital (Bates et al., 2006); airport(Chow et al., 2010; Chiou et al., 2006), port and maritime shipping(Noorizadeh et al., 2013; Wiegmans et al., 2013; Carvalho & Marques, 2012; Woo et al., 2011; Bichou, 2011; Lun & Marlow, 2011; Merikas et al., 2010; Lun et al., 2010; Wu & Liang, 2009; Yang et al., 2009; Lambertides & Louca, 2008; Lam et al., 2007; Jenssen & Randøy, 2006; Randoy et al., 2003; Grammenos & Arkoulis, 2002).

Performance studies adopting DEA are relatively rare in maritime transport industry compared to other sectors and other transport modes(Bang et al., 2012; Panayides & Lambertides, 2011). Several works were recently published for evaluating the efficiency and business performance of shipping companies using frontier analysis. Panayides and Lambertides(2011) evaluated the operational and financial efficiency in shipping firms' containers, bulk, and tanker sectors. They used both SFA and DEA, and also showed the results of these two techniques were significantly correlated. Bang et al.(2012) assessed operational and financial efficiencies of 14 liner shipping companies and examined the impact of operational strategies on the efficiencies adopting two-stage DEA approach. However, the analyses of these studies are limited to a specific year and not able to capture the performance changes of shipping companies over the past few years. Besides, it is crucial to identify and assess the factors that influence determinants of performance to provide managerial implications for improving business performance.

In the DEA studies of other industries, the impact of factors about financial management and structure on efficiency has been examined(Fethi & Pasiouras, 2010). These factors are profitability, capitalization, indebtedness (Casu & Molyneux, 2003; Yeh, 1996; Davidova & Latruffe, 2007). The performance of MTCs may be more related to financial management tools such as profitability, liquidity, growth indicators, and the rigorous examination of their impact on efficiency would provide significant implications to financial managers of shipping firms.

Thus, to evaluate and measure a business efficiency and performance of MTCs with the accurate financial data is attracting research theme. But, little is researched in respect of the efficiency using financial indicators and focused on the listed enterprise at the securities market. Therefore, this study aims to evaluate the efficiency of maritime transport companies adopting a dynamic approach during seven years and examining the impact of financial management on their efficiency.

In this study, we finally chose 50 MTCs from the Thomson Reuters which were classified by the Industry Classification Benchmark(ICB), that is used globally to divide the market into increasingly specific categories, allowing investors to compare industry trends between well-defined sub-sectors. Our 50 MTCs were also listed in the Marine Transportation as the Subsector of the Industrial Transportation as one of the Sector. To analyze the more useful efficiency of MTCs, we separated three main shipping sectors which have the container liners(15 companies), bulk carriers(18 companies), and tanker carriers(17 companies). In this analysis, raw data derived from their financial statement, including balance sheet, cash flow, statement and ratio analysis and the time-span was from 2010 to 2016 and two dimensions of efficiency are applied to this analysis across the three sectors, which are an operational efficiency(OE) and a financial efficiency(FE). Subsequently, the determinants of the two efficiencies are analyzed using a panel analysis.

2. Methodology and Data Collection

DEA is used as a primary analysis tool in this study. DEA is a non-parametric method that measures the relative efficiency of a Decision-Making Unit(DMU) within a group. It does so in estimating an empirical production frontier given that units within the group may have various inputs and/or outputs. This technique allows efficiency to be measured without the production function or the weights used for the inputs and outputs in advance. Two DEA models that are widely used are the Charnes, Cooper, and Rhodes(CCR) model and the Banker, Charnes, and Cooper(BCC) model. They have difference in that the former assumes constant returns to scale of activities, whereas the latter considers variable returns to scale of activities, which mitigates the impact of economies of scale(Zhou et al., 2008). An output-oriented model and an input-oriented model can be considered in both DEA-CCR and DEA–BCC models. The output-oriented model seeks to maximize the proportional increase in output while keeping the level of inputs constant, whereas input-oriented model focuses on how much inputs can be reduced while maintaining the same level of output. This study adopts the output-oriented model to assess the relative efficiency of shipping companies.

Following the previous literature(Cullinane et al., 2006), the DEA model can be mathematically expressed as follows. Formally, let inputs be

$$x_k = (x_{1k}, x_{2k}, x_{3k}, ..., x_{Mk}) \in R_+^M$$

to produce outputs

$$y_k = (y_{1k}, y_{2k}, y_{3k}, ..., y_{Nk}) \in R_+^N.$$

The row vectors x_k and y_k form the kth rows of the data matrices X and Y, respectively. Let the following be a non-negative vector, which forms the linear combination of the k firms.

$$\lambda = (\lambda_1, \lambda_2, \lambda_3, ..., \lambda_K) \in R_+^K$$

Finally, let

$$e = (1, 1, ..., 1)$$

be a suitably dimensioned vector of unity values. An output-oriented efficient measurement problem can be written as a series of K linear programming envelopment problems, with the constraints differentiating between the DEA-CCR and DEA-BBC models, as shown in equations (1)-(5) below. The combination of equation (1)-(4) and (1)-(5) respectively form the DEA-CCR and DEA-BCC models.

$$\max_{U,\lambda} \quad U \qquad (1)$$

$$\text{s.t.} \quad Uy'_k - Y'\lambda \le 0 \qquad (2)$$

$$X'\lambda - x'_k \le 0 \qquad (3)$$

$$\lambda \ge 0 \; (DEA-CCR) \qquad (4)$$

$$e\lambda' = 1 \; (DEA-BCC) \qquad (5)$$

The output oriented measure of technical efficiency of the kth DMU TE_k can be computed by equation (6).

$$TE_k = \frac{1}{U_k} \qquad (6)$$

In this study, we collected the data from Thomson Reuters Advanced Analytics. They have an industry classification taxonomy, for instance, the ICB was launched by Dow Jones in 2005. It is used to segregate markets into sectors within the macro-economy. The ICB uses a system of 10 industries, partitioned into 19 super-sectors, which are further divided into 41 sectors, which then contain 114 sub-sectors. Entirely MTCs were listed on the Marine Transportation(SUBSECTOR) of the Industrial Transportation (SECTOR). The initial data were 54 MTCs, however, after filtering out those with missing data, they were subsequently reduced to 50 MTCs. Among the 50 MTCs, 15 companies are listed in the market of Container Liners, 18 in the market of Bulk Carriers and 17 in the Tanker Carriers. Relying on the reputation of Thomson Reuters Advanced Analytics, we can assume that the sample is a good proxy for the maritime transport industry with the three major market segments. The dataset also has the advantage of having MTCs that is globally dispersed, all of the companies are publicly traded in various stock markets across the world. The geographical distribution of MTCs breaks down as follows: 24 listed in Asia, 16 registered in Europe and ten contained in America. Therefore, the financial statements of the MTCs were in the standardized from the Thomson Reuters with local currencies converted to US dollars. The target period is from the fiscal year of 2010 through fiscal 2016. Detained information on the major markets and regions is shown in <Table 1>.

<Table 1> shows the input and output variables employed in operational efficiency model(Model 1: OE) and financial efficiency model(Model 2: FE). Moreover, it shows significant markets and regions of MTCs.

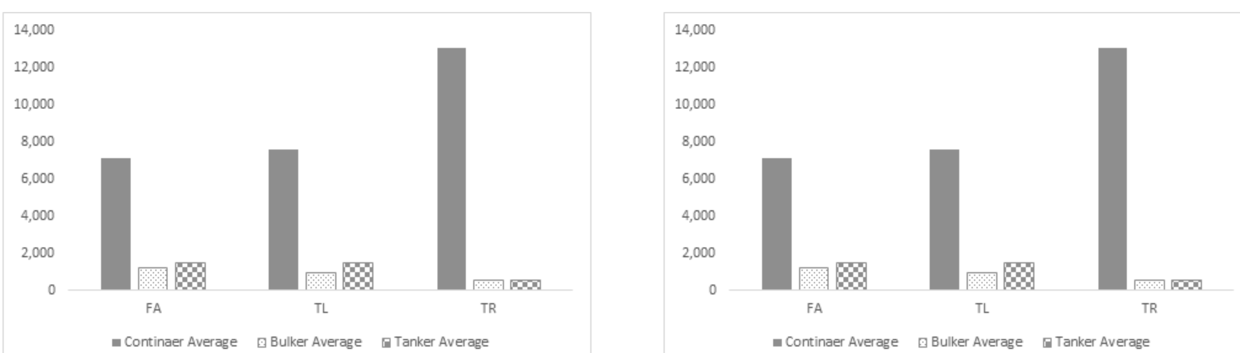
The Asia region is composed of 24 companies(COSCO, OOCL, HMM, EVERGREEN, YANGMING, WANHAI, SAMUDERA, MOL, NYK, KLINE, SITC, SINOTRANS, UMING, PACIFIC BASIN, PRECIOUS, SINCERE, THORESEN, NSUNITED, JINHUI, ARPENI, GESC, BERLIAN, KYOEI and QATAR) of 11 countries(China, Hongkong, Korea, Taiwan, Singapore, Japan, Thailand, Indonesia, India And Qatar). This area is more focused on container liners because there are the head office of 12 companies among 15 container liners.

The Europe region is made up of 8 countries which are northern and western european countries(Denmark, Germany, Greece, Norway, U.K., Belgium, Italy and Sweden) and 18 firms which are 2 container liners, 6 bulk carriers and 8 tanker carriers(MAERSK, HAPAG, NORDEN, DRYSHIPS, DIANA, NAVIOS, EUROSEAS, BELSHIPS, STOLT, JAMES, EURONAV, TSAKOS, PREMUDA, CONCORDIA, TOPSHIPS and NEWLEAD).

The America region also covers Bermuda which is a British island territory in the North Atlantic Ocean and South Africa, and includes Chile and United States and consist of 9 companies(CSAV, GRINDROD, GOLDEN, GENCO, EAGLE, TEEKAY, NATANKER, OSG, FRONTLINE and DHT).

<Table 1> Summary statistics of inputs and output

Major markets and Regions of Maritime Transport		Model 1: Operational Efficiency (OE)			Model 2: Financial Efficiency (FE)		
		input		output	Input		output
		Fixed Assets (FA, m$)	Total Liabilities (TL, m$)	Total Revenue (TR, m$)	Cash Flow, Operating/ Total Assets (CFOTA, %)	Total Liabilities/ Total Assets (TLTA, %)	Total Revenue/ Total Assets (TRTA, %)
Container Liners	Mean	7,106.72	7,590.19	13,108.64	54.08	57.29	94.46
	Std. dev.	10,438.46	8,773.98	19,239.89	7.25	21.74	62.33
	Min.	2.89	37.86	127.13	19.83	1.71	5.86
	Max.	44,671.00	35,549.62	80,627.52	70.24	95.98	387.88
Bulk Carriers	Mean	1,209.30	945.61	561.16	24.02	61.56	34.07
	Std. dev.	1,493.47	1,205.19	653.31	6.41	65.46	36.45
	Min.	72.93	45.00	18.37	3.34	11.22	6.85
	Max.	9,025.35	7,510.06	2,812.32	65.32	531.48	211.57
Tanker Carriers	Mean	1,498.70	1,502.03	521.05	25.08	71.51	28.68
	Std. dev.	1,883.36	2,395.57	618.38	5.75	46.16	29.15
	Min.	1.47	13.07	3.60	2.07	8.32	1.50
	Max.	9,366.59	12,142.22	2,450.38	51.91	284.89	250.41
Total (All carriers)	Mean	3,076.92	3,128.16	4,311.77	33.40	63.66	50.35
	Std. dev.	6,439.13	5,832.02	11,993.83	15.02	49.30	52.55
	Min.	1.47	13.07	3.60	2.07	1.71	1.50
	Max.	44,671.00	35,549.62	80,627.52	70.24	531.48	387.88
Asian Carriers	Mean	2,604.94	2,980.41	6,324.80	41.51	49.71	54.71
	Std. dev.	3,412.44	4,412.65	16,503.26	16.66	21.22	44.13
	Min.	193.13	37.94	88.68	16.61	1.75	1.50
	Max.	11,516.39	15,823.68	80,627.52	65.43	80.04	169.42
European Carriers	Mean	4,192.15	3,247.26	4,435.61	33.01	85.16	81.57
	Std. dev.	10,648.68	8,472.40	13,899.40	16.92	121.02	123.26
	Min.	111.14	82.54	7.27	16.25	25.83	7.53
	Max.	43,744.57	34,678.65	56,108.38	70.24	531.48	387.88
American Carriers	Mean	2,080.55	1,971.74	1,303.28	31.26	62.18	41.66
	Std. dev.	1,981.77	2,332.03	1,672.90	13.79	11.46	30.57
	Min.	357.70	90.13	40.83	23.71	48.32	12.31
	Max.	6,771.38	7,933.90	5,452.26	70.24	82.04	84.40



Model 1: OE　　　　Model 2: FE

<Figure 1> Variables comparison of the three sectors

<Table 2> shows the correlations of each model. Model 1 indicates statistical significance and a correlation between total liabilities and fixed assets($r = 0.937,\ p < 0.01$). There is a statistically significant relationship between total revenue and fixed assets($r = 0.728,\ p < 0.01$) but the correlation is weak as it is between total revenue and total liabilities ($r = 0.847,\ p < 0.01$). According to Model 2, the Pearson correlation coefficient between CFOTA and TLTA is -0.184; between CFOTA and TRTA is 0.524. But the correlation coefficient($r = 0.034,\ p > 0.1$) between TLTA and TRTA did not turn out to be statistically significant.

Performance efficiency was measured using CCR and BCC efficiency analysis. Recall that CCR efficiency is a model assuming constant returns to scale, where an increase of inputs leads a corresponding increase output. While the BCC efficiency model shows variable returns to scale, the meaning of input increase does not necessarily result in a corresponding increase in output.

<Table 2> Correlation between the variables

	Model 1: Operational Efficiency			Model 2: Financial Efficiency		
	FA (Fixed Assets)	TL (Total Liabilities)	TR (Total Revenue)	CFOTA (Cash Flow, Operating/ Total Assets)	TLTA (TL/TA)	TRTA (Revenue/ TA)
FA	1	0.937**	0.728**			
TL		1	0.847**			
TR			1			
CFOTA				1	-0.184**	0.524**
TLTA					1	0.034
TRTA						1

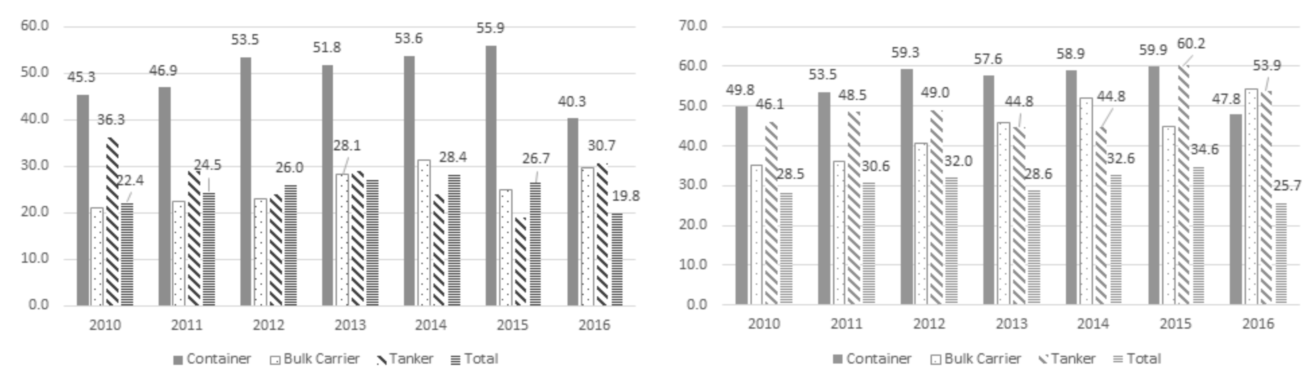
Note: ***,** and * indicate significance at the 1%, 5% and 10% respectively.

3. Analysis Results

3.1. DEA model

DEA scores of the operational and financial efficiency of 50 maritime firms from 2010 to 2016 are presented in <Table 5> and <Table 6> respectively. These maritime businesses include 15 container shipping firms (DMU 1-15), 18 bulk firms (DMU 16-33) and 17 tanker firms (DMU 33-50). According to the CCR model, which assumes a constant return to scale, it was reported that the average of operational efficiency of all the maritime firms was 22.4% in 2010 and slightly increased until 2014. On the other hand, according to the BCC model, which assumes a variable return to scale, the average was 28.5% in 2010 and decreased over time to 25.7% in 2016. <Figure 2> shows that the operational efficiency was relatively higher for container shipping firms. Their CCR efficiency was 45.3% in 2010, and it increased to 40.3% in 2016. Bulk firms were reported to have 21.2% of CCR efficiency in 2007, whose value slightly increased in 2016 to 29.7%. However, it decreased in 2015 (24.9%). Tanker firms show the lowest operational efficiency out of all the maritime companies that the models assessed. They report having only 8.8% of operational efficiency in 2010 which is relatively much lower than both container liners and bulk carriers. The results of the BCC efficiency model are shown in <Figure 2>. In this model, container firms were reported to have the highest BCC operational efficiency and bulk carriers were the second and tanker were the lowest until 2014. This rank is the same as the CCR model result. The BCC average efficiency of container liners firms was almost identical as tanker firms between 2015 and 2016. Average efficiency of container firms in 2010 was 49.8%, in the meantime, that of bulk companies and tanker firms were 35.2% and 46.1%, respectively. In the case of the most recent year, 2010, container liners recorded 47.8% of BCC efficiency which is slightly lower than in 2015. In 2016, bulk firms' BCC efficiency was 54.5%, which increased by 19.3%p from 2010 and that of tanker firms' was 53.9%, which increased by 7.8% from 2010.

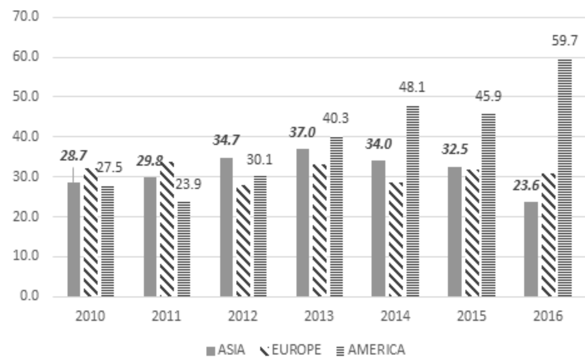
<Figure 3> indicates the results of operational efficiency in each region where maritime firms are listed. Asia-listed maritime companies have 3.3% of the difference in CCR operational efficiency from Europe-listed ones, but the difference from America-listed ones was as high as 1.2% in 2010. In 2013, the CCR efficiency of Asia-listed firms was 37.0%, Europe 33.1%, and America 40.3%. Europe-listed companies were reported to have 30.7% of CCR efficiency in 2016. In the meantime, America-listed ones had 59.7%, and Asia-listed ones had 23.6%; hence we can say that



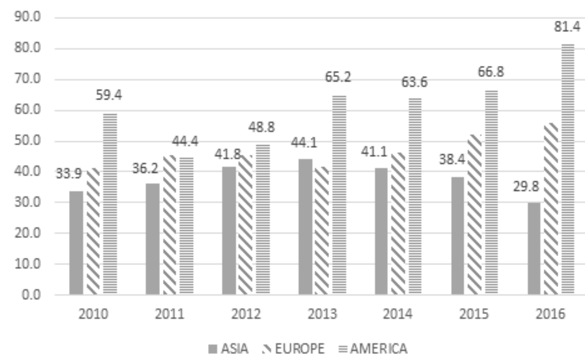
Operational Efficiency(CCR) Operational Efficiency(BCC)

<Figure 2> Operational Efficiency of Shipping Firms

CCR efficiency was relatively improved for Europe-listed firms. And <Figure 3> reports the BCC average efficiency from maritime companies segmented based on the region where the firms were listed. In this term, America-listed companies had relatively higher BCC efficiency compared to other regional companies. The result of the BCC efficiency model shows a distinct difference from the CCR model. For example, Europe-listed firms had 9.1% of the difference from the CCR efficiency result in 2010. Asian and European maritime companies exhibit an increase in outputs as a result of an increase in inputs using CCR analysis. American firms show a relatively massive difference in CCR efficiency and BCC efficiency. Besides, CCR and BCC efficiency of these companies are higher than that of Asian and European-listed one's efficiency since 2014.



Operational Efficiency(CCR)



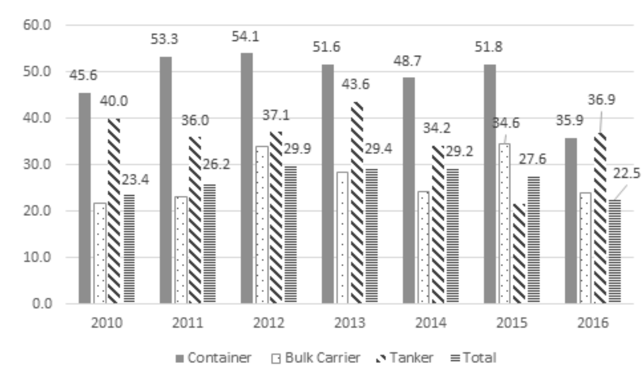
Operational Efficiency(BCC)

<Figure 3> Operational Efficiency by region

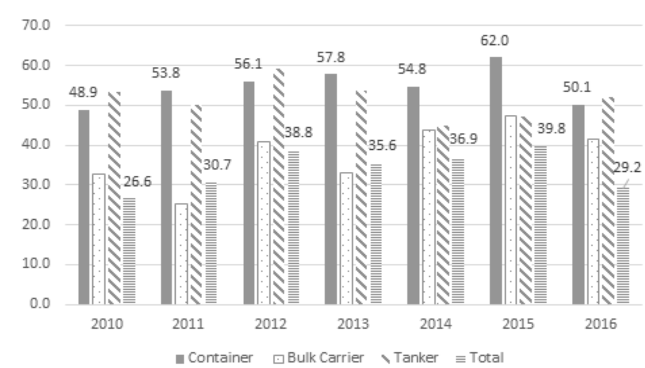
<Table 3> Operational Efficiency of all firms

DMU	Market	Company	Country	Region	CCR							BCC						
					10	11	12	13	14	15	16	10	11	12	13	14	15	16
1	Container	MAERSK	Denmark	EUROPE	31.4	34.0	40.8	46.3	51.6	45.9	25.9	69.6	87.4	68.7	76.5	73.9	62.0	49.8
2	Container	COSCO	China	ASIA	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3	Container	OOCL	Hongkong	ASIA	33.6	34.3	50.4	46.7	38.7	37.5	23.7	33.7	46.2	51.0	46.9	38.8	37.6	23.9
4	Container	HMM	Korea	ASIA	26.4	29.1	32.1	32.7	29.2	33.3	29.3	26.9	29.6	33.8	34.2	29.6	33.6	29.9
5	Container	CSAV	Chille	AMERICA	57.7	50.0	62.5	100	100	100	100	59.4	51.8	63.5	10.4	100	100	100
6	Container	EVERGREEN	Taiwan	ASIA	33.6	33.0	42.8	40.2	33.4	30.9	19.6	33.9	36.4	43.1	40.4	33.6	31.0	19.8
7	Container	YANGMING	Taiwan	ASIA	27.8	28.1	35.4	36.9	34.7	32.0	21.0	27.9	31.2	35.4	36.9	35.1	32.3	21.3
8	Container	WANHAI	Taiwan	ASIA	38.8	38.2	38.9	42.6	40.0	44.7	29.7	39.7	39.0	39.6	43.8	41.4	45.6	31.2
9	Container	SAMUDERA	Singapore	ASIA	33.7	32.9	54.3	59.7	57.8	64.8	43.0	40.4	35.1	100	100	100	100	100
10	Container	MOL	Japan	ASIA	25.0	24.2	27.5	35.0	29.3	31.8	20.0	25.1	29.9	27.6	35.0	29.3	31.8	20.0
11	Container	NYK	Japan	ASIA	26.2	28.9	31.7	41.6	40.5	48.0	27.6	26.3	32.0	31.8	41.7	40.5	48.1	27.6
12	Container	KLINE	Japan	ASIA	26.0	29.4	40.0	48.1	51.3	50.9	27.2	26.1	32.0	40.2	48.2	51.3	51.0	27.4
13	Container	HAPAG	Germany	EUROPE	38.7	41.1	53.9	55.2	34.0	45.5	26.9	38.8	51.3	54.3	55.4	34.1	45.6	27.1
14	Container	SITC	Hongkong	ASIA	80.9	100	91.8	81.6	68.1	75.5	46.1	100	100	100	94.6	76.7	80.3	52.8
15	Container	SINOTRANS	Hongkong	ASIA	100	100	100	100	96.0	97.8	64.3	100	100	100	100	10	100	87.0
16	Bulk	UMING	Taiwan	ASIA	15.9	12.8	13.2	16.6	17.6	8.0	12.7	16.4	13.1	13.3	16.8	18.0	15.9	17.3
17	Bulk	NORDEN	Denmark	EUROPE	100	100	100	100	100	80.8	100	100	100	100	100	100	100	100
18	Bulk	GRINDROD	South Africa	AFRICA	100	100	100	100	100	21.5	100	100	100	100	100	100	57.8	100
19	Bulk	DRYSHIPS	Greece	EUROPE	5.1	5.1	5.9	8.9	14.0	100	32.5	37.3	38.3	56.6	69.5	100	100	100
20	Bulk	PACIFIC BASIN	Hongkong	ASIA	27.0	34.0	39.8	55.6	62.5	39.2	40.7	55.1	46.7	67.5	79.6	84.0	76.2	86.9
21	Bulk	DIANA	Greece	EUROPE	10.3	12.8	8.9	7.8	10.9	9.3	7.5	12.2	13.2	10.5	7.8	11.1	11.1	9.1
22	Bulk	PRECIOUS	Thailand	ASIA	12.7	10.7	9.2	10.6	11.4	9.8	7.9	21.6	14.2	10.3	11.4	12.0	10.8	8.9
23	Bulk	SINCERE	Taiwan	ASIA	10.6	9.5	9.9	10.3	12.1	14.3	16.3	10.8	9.8	10.1	10.7	12.7	14.5	17.6
24	Bulk	THORESEN	Thailand	ASIA	18.3	21.1	23.5	43.9	45.7	33.0	48.7	23.5	21.3	23.6	45.1	46.2	48.0	50.3
25	Bulk	NAVIOS	Greece	EUROPE	6.3	10.4	11.8	14.7	17.0	9.2	13.5	29.5	24.5	29.1	24.2	28.4	30.1	35.3
26	Bulk	GOLDEN	Bermuda	AMERICA	4.1	7.0	6.5	7.8	8.0	6.9	9.2	5.4	9.5	9.6	12.4	8.4	11.5	20.6
27	Bulk	GENCO	Usa	AMERICA	4.9	5.1	3.4	4.5	9.8	9.3	10.0	19.5	14.0	10.6	10.6	10.8	10.9	10.8

DMU	Market	Company	Country	Region	CCR							BCC						
					10	11	12	13	14	15	16	10	11	12	13	14	15	16
28	Bulk	NSUNITED	Japan	ASIA	28.8	29.2	33.9	50.1	58.7	35.3	45.0	50.9	44.3	56.7	66.0	71.2	76.5	92.3
29	Bulk	JINHUI	Hongkong	ASIA	11.4	11.2	8.7	11.2	9.6	9.1	10.4	15.1	11.9	11.0	11.2	9.9	9.1	12.2
30	Bulk	EUROSEAS	Greece	EUROPE	9.0	14.5	13.2	20.4	21.5	30.6	20.4	19.1	72.4	92.6	100	100	100	100
31	Bulk	EAGLE	Usa	AMERICA	5.0	6.6	4.4	6.6	19.4	14.2	17.4	11.5	11.1	8.9	9.4	21.8	14.6	18.8
32	Bulk	BELSHIPS	Norway	EUROPE	5.0	8.8	10.4	13.8	13.9	11.7	15.9	100	100	100	100	100	20.1	100
33	Bulk	ARPENI	Indonesia	ASIA	5.7	5.8	10.4	23.9	31.3	5.8	26.8	6.0	7.6	19.4	51.8	100	100	100
34	Tanker	TEEKAY	Bermuda	AMERICA	20.1	13.9	11.0	9.2	9.7	5.1	12.5	100	97.4	95.6	87.2	93.3	100	100
35	Tanker	STOLT	U.K.	EUROPE	94.8	68.3	48.1	47.1	44.5	19.6	39.6	100	100	100	100	100	100	100
36	Tanker	GESC	India	ASIA	28.2	26.4	20.0	21.2	22.4	13.1	24.7	30.0	36.7	37.4	39.3	42.9	55.5	47.4
37	Tanker	NATANKER	Bermuda	AMERICA	100	25.1	25.5	45.2	63.4	31.6	47.8	100	31.3	26.6	45.2	63.8	80.6	54.8
38	Tanker	JAMES	U.K.	EUROPE	100	100	100	100	100	39.7	100	100	100	100	100	100	100	100
39	Tanker	OSG	U.S.	AMERICA	32.6	23.9	17.5	14.3	10.6	7.2	38.1	56.8	51.7	54.9	55.0	24.8	49.8	58.2
40	Tanker	FRONTLINE	Bermuda	AMERICA	29.0	33.7	23.0	5.0	9.1	8.1	32.9	62.8	67.0	59.0	12.8	21.5	36.6	67.0
41	Tanker	EURONAV	Belgium	EUROPE	25.7	18.6	14.8	14.2	15.1	18.9	37.8	29.5	26.5	28.6	25.8	31.1	79.8	69.9
42	Tanker	BERLIAN	Indomesia	ASIA	23.2	18.4	16.6	9.7	14.0	100	24.3	36.3	51.0	52.0	39.4	37.7	100	100
43	Tanker	TSAKOS	Greece	EUROPE	18.3	16.7	13.9	14.6	16.9	10.0	16.5	22.6	24.0	27.0	28.5	34.4	45.6	36.5
44	Tanker	PREMUDA	Italy	EUROPE	24.7	27.3	19.1	16.3	11.5	4.3	10.0	25.4	31.4	25.8	21.4	14.9	12.9	10.4
45	Tanker	CONCORDIA	Sweden	EUROPE	22.2	19.3	13.6	11.6	11.5	11.1	30.7	22.3	27.4	14.1	11.6	11.6	27.0	32.6
46	Tanker	DHT	Bermuda	AMERICA	23.9	22.9	23.9	28.1	11.1	13.5	31.7	24.1	23.6	51.8	28.3	17.4	47.3	46.4
47	Tanker	KYOEI	Japan	ASIA	21.0	20.5	13.8	12.8	12.8	5.9	15.5	21.4	22.6	17.3	17.0	16.6	17.8	18.3
48	Tanker	TOPSHIPS	Greece	EUROPE	18.8	25.0	8.5	100	5.6	8.3	18.9	19.2	100	100	100	100	100	30.0
49	Tanker	QATAR	Qatar	ASIA	32.1	30.5	36.8	41.4	45.1	25.5	34.6	32.1	31.9	40.7	43.5	45.8	68.3	36.5
50	Tanker	NEWLEAD	Greece	EUROPE	1.7	1.8	1.3	3.1	2.9	1.1	7.0	1.7	2.7	2.2	5.8	5.3	2.5	7.8
Average Efficiency by each market and region		Container Liners		15 companies	45.3	46.9	53.5	51.8	53.6	55.9	40.3	49.8	53.5	59.3	57.6	58.9	59.9	47.8
		Bulk Carriers		18 companies	21.1	22.5	23.0	28.1	31.3	24.9	29.7	35.2	36.2	40.5	45.9	51.9	44.8	54.5
		Tanker Carriers		17 companies	36.3	28.9	24.0	29.0	23.9	19.0	30.7	46.1	48.5	49.0	44.8	44.8	60.2	53.9
		Total		50 companies	22.4	24.5	26.0	27.1	28.4	26.7	19.8	28.5	30.6	32.0	28.6	32.6	34.6	25.7
		Asia		24 companies	28.7	29.8	34.7	37.0	34.0	32.5	23.6	33.9	36.2	41.8	44.1	41.1	38.4	29.8
		Europe		16 companies	32.0	33.6	27.9	33.1	28.7	31.9	30.7	41.1	45.6	45.4	41.5	46.1	52.2	55.8
		America(included S.Africa)		10 companies	27.5	23.9	30.1	40.3	48.1	45.9	59.7	59.4	44.4	48.8	65.2	63.6	66.8	81.4



Financial efficiency(CCR)



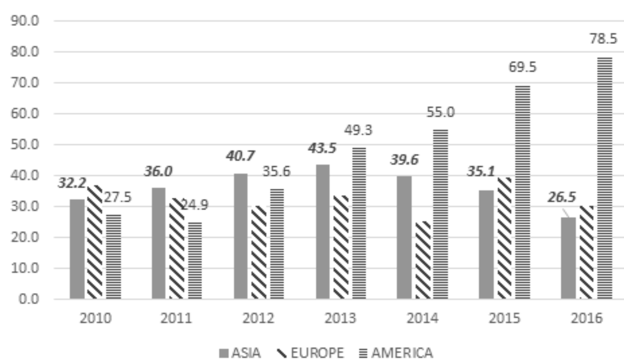
Financial efficiency(BCC)

<Figure 4> Financial efficiency of Shipping Firms

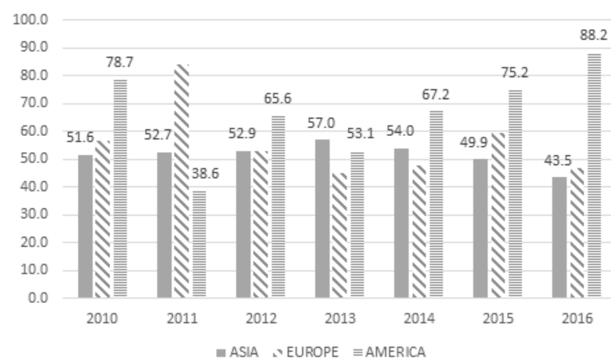
Maritime firms exhibit a total average of financial efficiency of 23.4% in 2010 using the CCR model, which assumes a constant return to scale. The percentage of the companies that are considered to be efficient DMUs is only 6.0% in the same year. The total average BCC efficiency was 26.6% in 2010 and 29.2% in 2016. The overall trend of a variance in CCR and BCC efficiency was reported to be similar. <Figure 4>, below, shows an average of the CCR financial efficiency of maritime firms. Container firms have the highest average efficiency of 45.6% in 2010, whereas bulk carriers have 21.7% of average efficiency. Tanker firms recorded 40.0% of average efficiency; this is 5.6%p lower than container firms.

In <Figure 4> below we see the BCC financial efficiency of maritime firms, assuming a variable return to scale. All maritime firms have the highest BCC efficiency in 2015 except for tanker carriers. Container firms have BCC efficiency of 62.0%. The BCC efficiency for bulk firms is 47.4%, and tanker firms have 47.2% BCC efficiency. Container firms had the highest market BCC efficiency in 2015, and it decreased by almost 7.9%p in 2016. Bulk carriers have 32.8% of average financial efficiency in 2010 and tanker firms report 53.3%, which is higher than the average of other maritime companies. In 2016, bulk businesses have 41.6% of efficiency, which is a little lower than the average efficiency of other carriers. Tanker firms are found to have 44.8% in 2014 which is 8.9%p lower than the previous year.

The CCR financial efficiency is shown in <Figure 5> based on the region the firms are listed. Asia-listed companies have 36.0% of average financial efficiency in 2011. This figure rose to 3.8%p the following year. However, the financial efficiency of these firms decreased to 26.5% in 2016. This 11.3%p compared to 3 years ago decline is due to the global economic recession. Europe-listed companies are shown to have 36.9% in 2010. The CCR financial efficiency for America-listed firms is found to be 27.5% in 2010, 49.3% in 2013 and 78.5% in 2016. Compared to Asia and Europe-listed firms, they show much more variance in financial efficiency. It is noticeable that the reason why American-listed companies are prone to raise capital from stock market than other markets. And <Figure 5> indicates the BCC financial efficiency for Asia, Europe, and America-listed firms. Since 2013, the overall trend of variance is not much different from the CCR financial efficiency. Europe-listed companies recorded the highest BCC financial efficiency of 39.3% in 2015, but this fell to 30.4% in 2016. They are more prone to be affected by the market impact. Asia-listed firms don't show much variation in the figure. But they have relatively lower BCC financial efficiency.



Financial efficiency(CCR)



Financial efficiency(BCC)

<Figure 5> Financial efficiency by region

<Table 4> Financial Efficiency of all firms

DMU	Market	Company	Country	Region	CCR							BCC						
					10	11	12	13	14	15	16	10	11	12	13	14	15	16
1	Container	MAERSK	Denmark	EUROPE	31.6	41.4	40.9	46.3	51.6	45.9	25.9	31.6	42.5	41.1	46.4	52.1	46.1	27.3
2	Container	COSCO	China	ASIA	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3	Container	OOCL	Hongkong	ASIA	33.5	41.8	50.5	46.8	38.7	37.5	23.7	33.5	43.7	50.7	46.8	38.9	37.6	24.8
4	Container	HMM	Korea	ASIA	28.3	28.4	31.5	30.1	34.0	41.3	38.8	32.2	29.5	31.5	32.0	39.7	100	100
5	Container	CSAV	Chille	AMERICA	60.5	100	71.8	10.0	21.8	28.3	17.2	100	100	100	100	100	100	100
6	Container	EVERGREEN	Taiwan	ASIA	33.4	35.4	42.7	40.2	33.4	30.9	19.6	33.5	37.1	42.8	40.2	33.5	34.6	21.2
7	Container	YANGMING	Taiwan	ASIA	27.9	31.9	35.5	36.9	34.7	33.3	26.7	28.0	32.3	35.6	36.9	34.7	49.5	38.1
8	Container	WANHAI	Taiwan	ASIA	38.7	38.6	38.8	42.6	40.0	44.7	29.7	38.8	39.1	38.9	42.7	40.2	44.7	30.8
9	Container	SAMUDERA	Singapore	ASIA	34.0	42.8	54.8	59.9	57.8	64.8	43.0	38.2	42.8	55.0	60.0	58.3	65.1	47.6
10	Container	MOL	Japan	ASIA	25.1	29.1	27.5	35.0	29.3	31.8	20.0	25.1	29.1	27.6	35.0	29.4	31.8	20.4
11	Container	NYK	Japan	ASIA	26.3	31.3	31.6	41.6	40.5	48.0	27.6	26.3	31.6	31.7	41.6	40.5	48.1	27.9
12	Container	KLINE	Japan	ASIA	27.0	31.9	40.1	48.1	51.3	50.9	28.4	27.4	32.2	40.2	48.1	51.4	51.3	35.8
13	Container	HAPAG	Germany	EUROPE	38.7	47.0	54.0	55.3	34.0	45.5	26.9	38.7	47.8	54.1	55.3	34.1	45.6	27.9
14	Container	SITC	Hongkong	ASIA	79.2	100	91.2	81.5	68.1	75.5	46.1	79.7	100	91.8	81.7	68.7	75.9	50.1
15	Container	SINOTRANS	Hongkong	ASIA	100	100	100	100	96.0	97.8	64.3	100	100	100	100	100	100	100
16	Bulk	UMING	Taiwan	ASIA	12.5	11.1	14.6	11.0	8.5	11.8	7.8	14.4	12.2	15.0	13.8	12.6	11.9	11.7

DMU	Market	Company	Country	Region	CCR							BCC						
					10	11	12	13	14	15	16	10	11	12	13	14	15	16
17	Bulk	NORDEN	Denmark	EUROPE	100	100	100	100	100	100	100	100	100	100	100	100	100	100
18	Bulk	GRINDROD	South Africa	AFRICA	100	100	100	34.5	29.7	25.7	17.7	100	100	100	52.9	36.9	26.4	26.0
19	Bulk	DRYSHIPS	Greece	EUROPE	5.7	5.8	12.9	11.9	13.0	100	56.0	6.1	7.2	13.5	14.2	18.4	100	100
20	Bulk	PACIFIC BASIN	Hongkong	ASIA	28.2	33.7	50.0	52.2	47.0	57.5	40.7	29.8	37.7	50.8	64.7	65.0	58.0	53.7
21	Bulk	DIANA	Greece	EUROPE	11.7	12.2	11.4	7.8	10.9	10.8	7.5	12.4	13.9	11.6	9.3	35.9	16.6	11.2
22	Bulk	PRECIOUS	Thailand	ASIA	11.1	9.6	14.1	11.8	11.4	13.6	7.9	100	10.2	17.7	14.6	14.3	14.7	11.9
23	Bulk	SINCERE	Taiwan	ASIA	10.8	9.8	13.0	9.4	10.7	15.0	16.3	12.8	11.8	15.5	14.4	13.4	20.5	100
24	Bulk	THORESEN	Thailand	ASIA	19.2	22.3	35.0	34.5	25.8	53.4	26.3	19.8	23.4	36.3	41.0	37.0	65.1	34.1
25	Bulk	NAVIOS	Greece	EUROPE	6.9	11.0	16.6	14.7	13.0	18.8	10.8	8.7	13.5	17.1	17.1	16.3	22.6	16.7
26	Bulk	GOLDEN	Bermuda	AMERICA	4.9	7.4	7.7	7.8	8.0	10.9	9.2	5.2	8.3	8.4	8.8	16.3	15.8	11.4
27	Bulk	GENCO	Usa	AMERICA	5.5	5.8	8.8	7.0	11.6	12.9	10.0	6.7	7.2	33.2	7.4	100	29.9	100
28	Bulk	NSUNITED	Japan	ASIA	31.1	31.7	65.1	48.7	34.2	52.0	32.0	35.6	40.5	65.5	65.8	60.4	55.4	55.9
29	Bulk	JINHUI	Hongkong	ASIA	12.7	11.7	14.5	13.1	9.6	11.1	10.2	13.9	13.5	15.4	14.8	10.0	11.5	13.6
30	Bulk	EUROSEAS	Greece	EUROPE	11.3	15.7	19.5	20.7	21.2	33.6	20.4	100	16.9	100	24.0	33.5	100	20.6
31	Bulk	EAGLE	Usa	AMERICA	5.6	7.8	11.3	10.6	19.4	22.0	19.6	6.6	9.6	13.6	11.3	100	100	19.9
32	Bulk	BELSHIPS	Norway	EUROPE	5.8	9.6	19.1	15.7	13.9	18.9	13.7	6.3	11.7	19.6	20.9	16.8	19.6	25.0
33	Bulk	ARPENI	Indonesia	ASIA	8.3	10.6	100	100	46.5	53.9	23.8	11.9	17.4	100	100	100	85.5	37.6
34	Tanker	TEEKAY	Bermuda	AMERICA	30.2	26.3	26.3	22.1	21.8	10.5	24.3	38.7	41.2	39.3	24.8	23.1	15.6	27.6
35	Tanker	STOLT	U.K.	EUROPE	95.2	68.3	71.9	69.6	62.2	26.6	51.8	99.0	74.1	99.3	79.7	64.1	36.2	52.9
36	Tanker	GESC	India	ASIA	28.3	26.4	23.9	23.5	25.2	13.1	24.7	28.3	31.1	28.1	24.9	25.3	14.7	24.9
37	Tanker	NATANKER	Bermuda	AMERICA	100	25.1	25.5	45.2	63.4	31.6	47.8	100	100	100	100	100	89.8	58.3
38	Tanker	JAMES	U.K.	EUROPE	100	100	100	100	100	47.5	100	100	100	100	100	100	73.0	100
39	Tanker	OSG	U.S.	AMERICA	44.0	44.2	48.4	36.7	49.1	7.3	38.1	100	100	100	38.6	100	12.0	53.5
40	Tanker	FRONTLINE	Bermuda	AMERICA	37.4	59.2	54.3	14.1	13.3	8.5	32.9	38.1	76.7	74.3	15.7	14.8	15.7	33.9
41	Tanker	EURONAV	Belgium	EUROPE	27.9	22.7	24.6	25.8	22.9	18.9	37.8	35.1	33.9	39.1	35.8	29.0	30.6	44.2
42	Tanker	BERLIAN	Indomesia	ASIA	39.1	48.0	62.7	59.6	57.3	100	36.9	73.6	66.4	100	61.9	60.2	100	100
43	Tanker	TSAKOS	Greece	EUROPE	22.6	22.2	23.6	21.7	23.7	10.5	19.4	31.5	33.8	40.8	25.0	25.1	17.3	22.0
44	Tanker	PREMUDA	Italy	EUROPE	26.3	28.9	30.6	27.8	24.6	10.5	24.3	27.8	33.7	46.1	31.5	27.2	47.7	42.3
45	Tanker	CONCORDIA	Sweden	EUROPE	22.3	19.3	20.8	20.7	17.5	12.6	30.7	22.4	20.8	29.5	26.5	18.9	17.3	35.7
46	Tanker	DHT	Bermuda	AMERICA	24.0	22.9	31.7	28.1	15.1	13.5	31.7	26.6	23.3	45.5	36.4	18.7	16.5	32.2
47	Tanker	KYOEI	Japan	ASIA	28.3	30.4	26.4	24.8	23.0	11.0	21.6	29.7	33.1	31.4	25.4	23.5	16.4	24.6
48	Tanker	TOPSHIPS	Greece	EUROPE	19.6	33.3	18.1	80.2	9.0	14.1	26.7	23.5	37.6	21.5	86.4	22.7	100	31.1
49	Tanker	QATAR	Qatar	ASIA	32.0	30.5	36.8	41.4	45.1	25.5	34.6	32.0	36.4	100	100	100	100	100
50	Tanker	NEWLEAD	Greece	EUROPE	3.1	3.8	5.3	100	8.2	5.5	43.9	100	8.2	10.9	100	9.4	100	100
Average Efficiency by each market and region		Container Liners	15 companies		45.6	53.3	54.1	51.6	48.7	51.8	35.9	48.9	53.8	56.1	57.8	54.8	62.0	50.1
		Bulk Carriers	18 companies		21.7	23.1	34.1	28.4	24.1	34.6	23.9	32.8	25.3	40.7	33.0	43.7	47.4	41.6
		Tanker Carriers	17 companies		40.0	36.0	37.1	43.6	34.2	21.6	36.9	53.3	50.0	59.2	53.7	44.8	47.2	51.9
		Total	50 companies		23.4	26.2	29.9	29.4	29.2	27.6	22.5	26.6	30.7	38.8	35.6	36.9	39.8	29.2
		Asia	24 companies		32.2	36.0	40.7	43.5	39.6	35.1	26.5	51.6	52.7	52.9	57.0	54.0	49.9	43.5
		Europe	16 companies		36.9	32.7	30.3	33.4	25.4	39.3	30.4	56.7	83.9	52.9	45.2	47.9	59.5	47.1
		America(included S.Africa)	10 companies		27.5	24.9	35.6	49.3	55.0	69.5	78.5	78.7	38.6	65.6	53.1	67.2	75.2	88.2

3.2 Determinants of Efficiency

3.2.1 Panel Analysis of Operational Efficiency

Financial management indicators are used in this panel analysis as independent variables, and dependent variables are operational efficiency and financial efficiency. The equation below was used to examine the impact of financial management of maritime firms on operational efficiency.

$$OE_{et-t'} = \beta_0 + \beta_1 ROE_{et'} + \beta_2 FAG_{et'} + \beta_3 CAG_{et'} + \beta_4 ER_{et'} + \beta_5 ATO_{et'} + \beta_6 CR_{et'} + \epsilon_{et'} \quad (7)$$

Where $OE_{et'}$ is the dependent variable for operational efficiency which is an efficiency for a firm(j) during the time period of $t \sim t'$. Independent variables are Return on equity $ROE_{et'}$, as an indicator for profitability; Fixed Asset Growth $FAG_{et'}$ and Current Asset Growth $CAG_{et'}$ as a growth indicator; Equity Ratio $ER_{et'}$ as business operation safety; Asset Turnover $ATO_{et'}$ as a business activity measure; Current Ratio $CR_{et'}$ as a liquidity indicator.

<Table 5> Determinants of Operational Efficiency Analysis (Model 1)

Independent Variables	Dependent Variable : Model 1					
	Container		Bulk Carrier		Tanker	
	Fixed Effects	Random Effects	Fixed Effects	Random Effects	Fixed Effects	Random Effects
ROE	-0.139 (-3.569)***	-0.114 (-2.693)***	0.005 (0.143)	-0.013 (-0.383)	-0.016 (-1.093)	-0.014 (-1.050)
FAG	-0.003 (-0.062)	-0.049 (-1.064)	-0.032 (-1.123)	-0.021 (-0.766)	-0.006 (-1.304)	-0.004 (-0.840)
CAG	-0.016 (-0.669)	-0.034 (-1.169)	-0.021 (-1.062)	-0.005 (-0.244)	-0.023 (-1.448)	-0.018 (-1.039)
ER	1.312 (12.047)***	1.156 (11.768)***	-0.003 (-0.121)	0.029 (1.598)	0.518 (4.156)***	0.432 (4.818)***
ATO	0.218 (6.134)***	0.280 (9.353)***	0.333 (9.123)***	0.534 (17.638)***	1.107 (8.044)***	0.941 (14.689)***
CR	0.323 (1.282)	0.479 (1.649)	0.583 (1.011)	-0.081 (-0.612)	0.399 (0.833)	0.547 (1.029)
cons.	-28.518 (-4.246)***	-27.706 (-4.332)***	13.266 (5.599)***	6.946 (2.933)***	-19.956 (-3.546)***	-14.987 (-4.085)***
F stat	58.797***	33.762***	41.698***	28.912***	26.611***	50.497***
R^2	0.951	0.673	0.927	0.595	0.913	0.787
Adj.R^2	0.935	0.653	0.904	0.574	0.879	0.771
Hausman Test	30.878***		111.830***		2.946	

*** ,** and * indicate significance at the 1%, 5% and 10% respectively.

<Table 5> reports the result of the panel analysis for operational efficiency. Asset Turnover $ATO_{et'}$ positively impacts operational efficiency in most maritime transport markets and this is statistically significant. In panel data, Hausman test also can be used to differentiate between Fixed Effects and Random Effects. This result is shown to be statistically significant in container liners and bulk carriers after the Hausman test, and random-effects model is analyzed to be appropriate.

Container liners have 0.673 of R-square and F value is 33.762($p < 0.01$). This is statistically significant. $ROE_{et'}$ ($p < 0.05$), $ER_{et'}(p < 0.01)$ and $ATO_{et'}(p < 0.01)$ are statistically significant and have a positive impact on the dependent variable, whereas $ROE_{et'}(p < 0.01)$ only negatively affects the dependent variable. Thus, the expansion of the equity negatively affects operational performance.

The result of analysis for bulk carriers reports an R-squared of 0.595 and an F value of 28.912($p < 0.01$) It shows that independent variables are statistically associated with the dependent variable and it is a strong model fit. In case, Asset Turnover $ATO_{et'}$ is not a statistically significant variable but has a consistently positive impact on the dependent variable.

As the result of Hausman test, tanker should choose fixed effects model. The analysis for tanker firms shows a statistically significant result with an R-squared of 0.913 and an F value of 26.611($p < 0.01$). $ER_{et'}(p < 0.01)$ and $ATO_{et'}$ ($p < 0.01$) have statistical significance. They give positive effects on the operational efficiency. If $FAG_{et'}(p > 0.1)$ is not statistically significant but it has a negative sign on the efficiency.

3.2.2 Panel Analysis for Financial Efficiency

The equation below is used to analyze the determinants of financial efficiency.

$$FE_{et-t'} = \beta_0 + \beta_1 ROE_{et'} + \beta_2 FAG_{et'} + \beta_3 CAG_{et'} + \beta_4 ER_{et'} + \beta_5 ATO_{et'} + \beta_6 CR_{et'} + \epsilon_{et'} \quad (8)$$

$FE_{et'}$ is the dependent variable for financial efficiency, which is an efficiency for a firm(j) during the time period of $t \sim t'$. The independent variables are Return on Equity $ROE_{et'}$, as an indicator for profitability; Fixed Asset Growth $FAG_{et'}$ and Current Asset Growth $CAG_{et'}$ as a growth indicator; Equity Ratio $ER_{et'}$ as business operation safety; Asset Turnover $ATO_{et'}$ as a business activity measure; Current Ratio $CR_{et'}$ as a liquidity indicator.

<Table 6> Determinants of Financial Efficiency Analysis (Model 2)

Independent Variables	Dependent Variable : Model 2					
	Container		Bulk Carrier		Tanker	
	Fixed Effects	Random Effects	Fixed Effects	Random Effects	Fixed Effects	Random Effects
ROE	-0.015 (-2.654)**	-0.201 (-4.526)***	-0.095 (2.346)***	-0.109 (-2.919)***	-0.021 (-1.324)	-0.024 (-1.610)
FAG	0.068 (1.337)	-0.248 (4.853)***	-0.043 (1.333)	-0.003 (-0.108)	-0.004 (-0.791)	-0.003 (-0.565)
CAG	0.009 (0.368)	-0.038 (-1.085)	0.000 (-0.019)	-0.010 (-0.418)	-0.006 (-0.371)	-0.019 (-1.010)
ER	0.302 (2.710)***	0.788 (9.842)***	0.026 (0.907)	-0.022 (-1.001)	0.245 (1.905)**	0.169 (1.555)
ATO	0.368 (10.119)***	0.341 (16.061)***	0.494 (11.999)***	0.577 (16.405)***	0.879 (6.742)***	0.914 (11.010)***
CR	1.040 (4.043)***	1.541 (4.733)***	0.842 (1.296)	0.146 (0.258)	0.620 (1.254)	0.866 (1.498)
cons.	-2.157 (-0.314)	-22.463 (-4.792)***	6.137 (2.301)***	6.484 (2.604)***	-0.199 (-0.034)	-1.209 (0.258)
F stat	51.826***	63.148***	30.883***	42.006***	22.254***	25.994***
R^2	0.945	0.792	0.904	0.681	0.898	0.655
Adj.R^2	0.927	0.781	0.874	0.664	0.857	0.630
Hausman Test	52.386***		28.638***		1.061	

***,** and * indicate significance at the 1%, 5% and 10% respectively.

<Table 6> shows the result of the panel analysis for the financial efficiency. R-square is sufficient to explain this Model 2. Consequently, only two equations such as tanker and total can be explained with the statistically significant model fit. Hausman Test generates that random-effects model is appropriate to analyze two equations to get the statistically significant result. Analysis of container firms results in an R-squared of 0.792 and an F stat of 63.148 ($p < 0.01$). Model fit is robust, and it does produce a statistically significant result. Adjusted R-square is also positive direction. This model is suited to analyze the determinants of financial efficiency for container firms.

The outcome of Bulk carrier's case is similar to analysis on container firms. It does show a statistically significant result, with R-square being 0.681 and F stat 42.006 ($p < 0.01$). As a result of Hausman test, fixed effects model is statistically better fit for tanker firms ($p < 0.01$) than the random-effects model. Statistical analysis for tanker firms shows that the R-square is 0.898 and F stat is 22.254 ($p < 0.01$). This result indicates that the equation explanation is not strong but the overall effect of two independent variables is statistically significant. $ROE_{et'}$ and $ATO_{et'}$ ($p < 0.01$) have a positive impact on the financial efficiency.

4. Conclusion and Discussion

This study evaluated the economic performance of 50 international shipping firms using DEA from 2010 to 2016 and investigated the impact of corporate financial management on their business performance. Maritime companies are significantly affected by the business cycle. When the business cycle is good, the maritime firms have been strongly requested for freight services from their shippers because of the overflowing demand. When the business cycle is low, however, they experience difficulties in earning operational costs for their fixed assets. The firms' revenue fluctuates with the changes of the business cycle; hence it is essential for them to set up business strategies to improve efficiencies. A lack of efficiency measurements for shipping firms leads to a significant gap in determining their overall performance. So, this study aims to contribute to the efficiency measurement of maritime transport companies using financial accounting variables for DEA analysis.

The results of this analysis are as follows. Firstly in the CCR and BCC model, container liners were the highest, tanker carriers were the second, and bulk carriers were the lowest in the operation efficiency and financial efficiency. Secondly, by region, operation and financial efficiency were high in the order of America, Asia, and Europe. Lastly, to present the result of the panel analysis with regards to the operational and financial efficiency as dependent variables, six financial indicators are used as independent variables. Hausman test was also used to differentiate between fixed effects and random effects, but most equations were chosen into the random-effects. In the operational efficiency, container liner's the expansion of the return on equity negatively affects operational performance with statistical significance. But the current ratio of the bulk carriers is positively associated with the dependent variable. Asset turnover of tanker carriers shows a statistically significant result. Each independent variables give positive effects on the operational efficiency except the fixed assets growth.

This study suggests business strategies for companies' practice based on the analytical results of determinants of operational and financial efficiency. These strategies differ depending on the type of maritime transport companies. Container liners typically experience fluctuating revenues as the business cycle changes. These companies need to develop long-term strategies that intend to increase their Equity Ratio. To improve their operational performance, they need to raise their equity from the selling stocks and increasing profits. Since 2010, Bulk carriers have experienced difficulties from an excess of freight space due to the consistent supply of new ships and the downward trend of freight charges. The firms need to take measures to improve their performance results. Since freight costs for bulk ships are decided through long-term shipping contracts, they don't usually get affected by exogenous variables. However, that's not always the case. Bulk carriers need to suppress the growth rate of fixed assets by selling them off. Variable assets increase by holding funds. It is a desirable business strategy for these firms to contain fixed asset and current asset growth to increase their equity ratio so they may enjoy the benefits from good business cycles, as container firms do.

Tanker carriers carry crude oil, heavy oil, bunker oil, naphtha, and LNG. The revenue has been stable over that period, and the stocks of these firms are considered safe to invest. They need to set up strategies for their long-term operations and to improve efficiencies. They need to maximize their profits by raising their equity when the business cycle is good and focus on increasing the efficiency of their ships.

The empirical results of this study contribute to the existing academic research as well as have practical applications for shipping firms. Firstly though there has been active research in the efficiency of companies in specific industries, it is rare to find studies aiming at the improvement for the entire shipping industry. This study contributes to the development of an efficiency model for shipping industry as a whole. Secondly, the assessment of the determinants of efficiency for shipping firms provides a firm basis for further research in the distribution industry by studying details of maritime transport companies' efficiency measures. However, this study has limitations as follows. First, this study is limited to use financial accounting data as variables. Further research can contribute to this gap by using non-financial indicators with the comprehensive measurement of performance. Second, data for analysis is limited to 50 shipping firms. Further research should obtain more data to represent the industry better and determine industry-specific characteristics of companies. This may provide more distinct performance measurements through an increase in sample size.

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