The impact of capacity on firm performance: a study of the liner shipping industry

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Abstract: In liner shipping operations, shipping capacity and firm performance are associated closely. This study aims to evaluate the effect of scale operations by conducting a data envelopment analysis (DEA) using empirical data. The DEA model of this study consists of two input variables (i.e., shipping capacity and operating cost) and two output variables (profit and revenue). Based on the empirical data collected in 2008, K Line and RCL are found to be efficient firms in the liner shipping industry. The results suggest that non-mega operators, with market share of 5% or below, can operate their firms efficiently.

Keywords: firm capacity; firm performance; liner shipping; container shipping; empirical research.

Reference to this paper should be made as follows: Lun, V.Y.H. and Marlow, P. (2011) 'The impact of capacity on firm performance: a study of the liner shipping industry', *Int. J. Shipping and Transport Logistics*, Vol. 3, No. 1, pp.57–71.

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1 Introduction

Shipping has evolved from its original relationship concerning ships and seaborne trade to imply the transport of cargoes between two geographical points. Shipping is a 'global industry' and is closely related with trade volume (Lun et al., 2010a; Lun and Quaddus, 2009). Without shipping, much international trade would cease to function; and without international trade, shipping would not be in such high demand. Shipping carries more than 90% of international trade in the world (Hensher and Button, 2000) and liner shipping is one of the major modes of transport facilitating international trade (Lun and Browne, 2009). It acts as an economical means of transporting large volumes of cargoes across oceans (Lun et al., 2009). Liner shipping firms, as suppliers of sea-transportation services (Bohme, 1984), carry a large volume of cargoes comprising manufactured or partly manufactured goods consolidated from different consignments by different shippers into standardised containers (Sys, 2009). Liner shipping companies (LSCs) operate as carriers and invest in such items as containers, ships and advanced information systems with the aim to fully satisfy the customer demand for regular freight transport (Lun and Browne, 2009).

In liner shipping operations, capacity management is a crucial factor influencing the performance of shipping firms. The recent concentration effect of container carriers contributes to scale economies in shipping operations and generates revenue for shipping lines. There are a number of reasons to link capacity with shipping firm performance. One of the size-based strategies is low operating cost derived from scale economy as a key source of competitive advantage (Porter, 2004). Scale operation is also a useful tool for LSCs to expand by enlarging their fleets and allocating more ships to serve wider markets. As a result, scale operations and firm performance are closely and positively associated in liner shipping operations (Lun et al., 2010b).

From the strategic management perspective, organisational capability is a key component for firms to succeed (Makadok, 2001). In liner shipping, capabilities can be regarded as the ability of firms to perform a coordinated set of tasks and utilise resources to achieve superior performance (Teece et al., 1997; Helfat and Peteraf, 2003; Wang and Zajac, 2007; Lun et al., 2009; Yip and Lun, 2009). Capacity management can be seen as a source of organisational capability. LSCs may engage in collaboration with other shipping firms by forming alliances to attain continuous growth in the industry (Smart and Vertinsky, 1984; Mason et al., 2007). Vessel sharing agreements including slot sharing and sailing arrangements are a common type of collaboration for LSCs to optimise vessel capacity utilisation and reap scale economies by deploying larger-sized container ships (Alix et al., 1999; Cullinane and Khanna, 2000; Verstrepen et al., 2009). The LSCs have strategic interdependence to consolidate their resources, with the aim to maximise market share, and minimise operating costs in the shipping market (McKelvey and Aldrich, 1983; Dyer and Nobeoka, 2000; Zineldin, 2004). Consequently, collaboration can be a suitable approach to achieve cost advantage and service integration in liner shipping operations (Alix et al., 1999; Groothedde et al., 2005; Kulmala and Rauva, 2005; Mason et al., 2007). Alternatively, LSCs are expected to acquire their competitors as such action can be regarded as a 'natural' path to attain scale economy, increase operational efficiencies, and develop synergies (Alix et al., 1999).

To seek growth opportunities, a firm may consider diversification. Vertical integration or development of the logistics service business can be another growth opportunity (e.g., NYK Logistics and OOCL Logistics diversify their operations to integrate into the supply chain of their customers). An important question about growth opportunities is: how LSCs firms plan to grow? According to Lun et al. (2010a), the structural options include organic growth, acquisition, joint venture, alliance and network:

- *Organic growth:* a company is considered to be growing organically when it is increasing the turnover of its existing business, but not by acquiring other companies. Organic growth offers the greatest control without meshing organisational cultures. It is an excellent alternative for firms like OOCL logistics when the opportunity and resources exist.
- *Acquisition:* buying an existing firm can be an alternative way for firms to grow in a short time. Acquisition may also lead to market power and create economies of scale (Brouthers et al., 1998). However, the control of business operations without meshing organisational cultures may be a concern.
- *Joint venture:* a joint venture has a greater alignment of incentives that motivates partners to adapt to a changing environment than is the case in a contractual agreement (Kogut, 1988). For instance, CMA CGM formed a joint venture with Jardine Shipping in 2000 to create the CMA CGM shipping agency in Hong Kong at the time of developing its agency business.
- *Alliance:* the term alliance, or strategic alliance, can be used to describe a wide range of organisational structures in which two or more shipping lines cooperate for mutual benefit and share common goals. A strategic alliance in the liner shipping industry is driven by the need to accomplish the organisational objective of achieving operational gains. Cosco, K Line, Yang Ming, and Hanjin Shipping focused on strengthening their strategic CKYH alliance and service offerings in 2006.
- *Network:* network can be considered as "a transformation process of independent actors and resources into a more closely knit configuration of a network". The transformation process of a liner shipping network can be classified into a creation process and an operations process. The former refers to the formation of relationships among actors to deliver liner shipping services, while the latter refers to continuous efforts to maintain and improve the relationships.

Liner shipping firms collaborate beyond organisational boundaries to attain cost and service improvements (Dyer and Nobeoka, 2000). Firms depend on each other to obtain resources for organisational growth and performance improvements. Strategic interdependence can be defined as 'a situation in which one firm has resources or capabilities beneficial to but not possessed by the others' (Gulati and Gargiulo, 1999). Strategic interdependence and concentration of the liner shipping industry are closely associated. For instance, the largest liner shipping company (e.g., Maersk) or shipping alliance (e.g., Grand Alliance members: Hapag-Lloyd, NYK and OOCL) possess the power to influence other operators in the industry.

The emergence of globalisation leads to widely diffused production sites and decreases in transport cost (Scholte, 2008; Lun and Browne, 2009). The LSC is no longer isolated and independent from challenges and liner shipping operations shift towards cost minimisation and value maximisation (Sahay et al., 2006; Bergqvist, 2008). Overall shipping capacity is expected to increase because of the growth in seaborne trade volume.

To remain competitive, the LSC's business strategy focuses on growth and large scale operations (Cheng and Choy, 2007). Although liner shipping plays an important role in facilitating international trade and supporting global economic development, research studies dedicated to scale operations in liner container shipping remain scanty. These prior studies were either largely descriptive (Alix et al., 1999; Fremont, 2009; Verstrepen et al., 2009) or predominantly conceptual (Lu, 2007). Nevertheless, empirical study on the operational efficiency of liner shipping is seriously lacking. This paper endeavours to conduct an empirical study to evaluate the efficiency of liner shipping from the perspective of scale operations. The purpose of this study is to fill this important but under-explored research gap by using data envelopment analysis (DEA) as a tool to compare relative efficiency among LSCs.

2 Business strategy in shipping

A strategy is a fundamental pattern of present and planned objectives, resource deployment, and interactions of an organisation with its market, competitors and other environmental factors. A well-developed shipping strategy should contain five key components (Lun et al., 2010a):

- *Scope:* scope refers to the breadth of a firm's strategic domain - the type of industry (e.g., a third-party logistics provider, a liner shipping company, or a container terminal operator), and market segments it competes in or plans to go in.
- *Goals and objectives:* strategy states the desired levels of accomplishments such as growth rate over a specific time period.
- *Resource deployment:* resource deployment refers to the availability of resources that a firm requires to achieve its goals and objectives. For example, LSCs order new shipping capacity to launch new container shipping services calling at ports in the emerging countries.
- *Competitive advantage:* an important part of a strategy is to specify how the firm competes in the market. For example, LSCs may increase their shipping capacity to enhance their competitiveness through maintaining a high efficiency level.
- *Synergy:* synergy can be defined as "the degree to which the deployment of various resources complements and reinforces one another". The formation of alliances in the liner shipping industry is a typical example of the creation of synergy among the allied members.

Nowadays, shippers expect a higher level of service quality than ever before since they have more choices and possess better knowledge about service offerings in the liner shipping market. The challenge for LCSs to stay competitive is to determine what their customers want and whether they are satisfied with their services. Market orientation can be defined as the "organisation-wide generation of market intelligence across departments, and organisation-wide responsiveness to it" (Kohli and Jaworski, 1990). This concept of market orientation suggests that the long-term organisation goal is to satisfy customer needs for the purpose of maximising corporate profits. In doing so, firms are required to take a proactive attitude in running their business and be responsive to customer needs. A key advantage for a firm to become market-oriented is to get close to the market and understand how it is likely to change in the dynamic business environment (Lun et al. 2010a).

To be market-oriented, LSCs need to acquire market intelligence about customers, competitors and the market to decide how to deliver superior customer values, and take actions to deliver value to customers. It is desirable for these LSCs to develop customer focus, generate competitor intelligence, and nurture cross-functional coordination:

- *Customer focus:* it is essential for market-oriented firms to understand customers' preferences and requirements, and effectively deploy the required resources and skills to satisfy customer expectation. Shippers' decisions to support a LSC are based on the attributes and features of the shipping services they value. For example, it is mentioned in K Line's website that it is 'dedicated to providing the finest ocean cargo carrier transportation services available'. K Line is a customer focused operator.

- *Competitor intelligence:* it is essential for LSCs to identify competitive threats and develop strategies to cope with adverse business environment. RCL can be used as an example to illustrate competitor intelligence. According to RCL's website: 'RCL will increasingly expand its feeder services and container liner business in Asia through the provision of high quality containership services with reliable fixed day sailings, fast transit, the deployment of modern and high specification containerships and customer service information technology'.

- *Cross-functional coordination:* LSCs need to be effective in coordinating business functions to provide superior customer value. For instance, K Line's far reaching infrastructure of vessels, terminals, double-stack trains and containers are all dedicated to providing a full range of ocean carrier, rail, truck transportation and LCL and warehousing services (source: http://www.kline.com)

One goal of LSCs is to outperform their competitors. Both operational effectiveness and competitive strategy are essential to attain superior performance. Operational effectiveness means performing similar activities better than competitors. It refers to any practices that allow a LSC to better utilise its resources, such as delivering services cost effectively. Differences in operational effectiveness may affect firm performance because they directly influence relative cost positions. Constant improvement in operational effectiveness is necessary to achieve better firm performance. On the other hand, strategic positioning means performing activities different from rivals or performing similar activities in different ways. Strategic positions can be attained from variety-based positioning and needs-based positioning:

- *Variety-based positioning:* it is based on the choice of product or service variety rather than customer segments. Variety-based positioning makes economic sense when a company can best produce particular products or services using distinctive sets of activities. For example, K Line deploys the resources of vessels, terminals, trains and containers to provide a full range of container transport services to its customers.

- *Needs-based positioning:* a second basis for positioning is that of serving most or all the needs of a particular group of customers. Needs-based positioning arises when the same customer has different needs for different types of transactions. For instance, RCL expands its container shipping businesses through the provision of high quality liner services to offer a variety of liner shipping services to meet the various transport needs of the shippers in this shipping market segment.

Liner shipping plays an important role to foster global trade (Lai and Cheng, 2004). Nowadays, the majority of liner cargoes are containerised. According to Fremont (2009), containerisation helped to create the impressive growth of liner traffic over the past two decades which is the result of a combination of the following factors:

1 the improved operating efficiency of port handling

2 the continuous increase in the containership's size which contributes to a significant reduction in unit transport cost

3 the rise of intermodalism which allows door-to-door transport

4 the development of value-added services in transport logistics.

Increasingly, container shipping is recognised as a core component of contemporary logistics systems To a large extent, customer satisfaction (i.e., delivering products of the right condition at the right time to the right place) and cost reduction (i.e., deploying bigger container vessels on the trading routes to reap scale economies) are goals for LSCs to achieve (Cullinane and Khanna, 2000; Lai and Cheng, 2004; Lun and Browne, 2009). Furthermore, many shippers have a focus on supply chain management and increasingly expect their LSCs to provide a wider scope of shipping services (Lai and Cheng, 2004; Fremont, 2009; Lun and Browne, 2009). In order to satisfy the expectations of shippers and accelerate their growth in global markets, many LSCs have started to provide a deeper and wider scope of services. LSCs have offered deeper services such as increasing the number of ports of call and sailing with greater frequency to meet the market needs. To widen the service scope, LSCs offer a wide range of services such as consolidation, trucking, and other logistics related services.

Indeed, LSCs operate under competitive pressures such as high customer expectation and competition from other firms in the industry. Increasing competition may force LSCs to change continuously so as to survive and grow (Lai and Cheng, 2004). It is logical to speculate that LSCs will seek to enlarge their fleets and deploy more ships to achieve cost economies and rationalise their services (Lun and Browne, 2009). The largest LSCs significantly increase their carrying capacity and this action leads to a high concentration ratio in the liner shipping industry. For instance, the four leading LSCs, namely Maersk Line, MSC, CMA CGM, and Evergreen, had collectively increased their global market share to 37.6% in 2010 in terms of TEU carrying capacity (source: http://www.axsliner.com). Under such circumstance, the effect of increased shipping capacity on efficiency is an important consideration that deserves research attention.

3 Research design

The main objective of this study is to evaluate the efficiency of liner shipping due to scale operations. To evaluate the level of efficiency of LSCs, data on shipping capacity (in terms of TEU), revenue, profit (i.e., firm earning), and operating cost (i.e., the difference between total revenue and total earning) were collected from a report published by *Containerisation International* in 2008. Source data are shown in Table 1.

Table 1 Source data for evaluating the efficiency of LSCs

Operator	*Capacity**	*Operating cost***	*Profit***	*Revenue***
CCNI	40,716	747	–14	733
Horizon	43,760	1,085	122	1,207
RCL	52,046	464	107	571
MISC	70,575	1,379	95	1,474
Wan Hai	125,393	1,622	252	1,874
Hyundai	194,350	5,113	336	5,449
CSAV	235,430	4,057	93	4,150
Yang Ming	276,016	3,930	187	4,117
Zim	284,572	3, 658	151	3,809
K Line	293,321	10,434	1,426	11,860
MOL	325,030	6,792	150	6,942
Hanjin	326,014	5,938	118	6,056
OOCL	351,542	4,884.5	731.5	5,616
NYK	370,224	6,441	211	6,652
APL	394,804	5,994	659	6,653
CSCL	418,818	4,559	764	5,323
COSCO	426,814	5,902	374	6,276
Hapag Lloyd	491,954	8,381	483	8,864
CMA	790,812	10,500	1,300	11,800
Maersk	1,726,265	24,262	2,408	26,670

Notes: *in TEU (i.e., 20-foot equivalent unit)
**in million USD

This paper uses several quantitative statistical tools for evaluating the relationship between shipping capacity and efficiency level. In the first stage, we use correlation analysis to empirically test the relationship among the variables to illustrate how they influence operational efficiency. In the second stage, we use a DEA approach to evaluate the efficiency of LSCs. In this study, we use a 'two-input and two-output' DEA model to determine the efficiency level of each decision making unit (DMU). A DMU is 'the entity responsible for converting input and output and its performance is to be evaluated'. In this study, the inputs of the DEA model are shipping capacity and operating cost while the outputs of the DEA model are revenue and profit. To examine the efficiency in terms of these two inputs and two outputs, we use the DEA model which was initially proposed by Charnes, Cooper and Rodes (CCR) in 1978. To deal with multiple inputs and outputs, we simplify the calculation of efficiency score by weighting the various outputs and inputs. To evaluate DMU's efficiency, DEA uses variable weights to measure the inputs and outputs. In the CCR model, linear programming is used to determine the weight so as to maximise the ratio of outputs/inputs. The optimal weights generally vary from one DMU to another DMU. Thus, the weights in DEA are derived from the data instead of being fixed in advance. Each DMU is assigned a set of weights with values.

The CCR model consists of CCR input-orient (CCR-I) model and CCR output-orient (CCR-O) model. The CCR input-orient model aims to minimise the input while satisfying the output levels. On the other hand, the CCR output-orient model attempts to maximise outputs without requiring more input values. In this study, we use the DEA-Solver software to run the CCR-I model.

4 Results of the empirical analysis

Efficiency can be defined as the ratio of output to input in any system. In a DEA model, DMU's efficiency level can be illustrated by its DEA score. When the inputs can be transformed into outputs in an efficient way, the DEA score of this DMU will obtain a score of 1.00 (i.e., 100%). In this study, we use DEA as the tool since it allows the examination of LSCs with multiple inputs and multiple outputs simultaneously (Adler and Berechman, 2001). The DEA score indicates the degree of efficiency in converting inputs into outputs. Hence, we conduct DEA to determine which DMUs operate efficiently in the liner shipping industry (Wu and Liang, 2009). According to Dias et al. (2009), DEA has gained increasing popularity as an analytical tool for measuring efficiency because of the following features:

1 it is a standardised, robust, and transparent methodology

2 it is a powerful analytical tool for measuring and evaluating the relative efficiency of DMUs when multiple performance measures are present

3 it is not necessary to assess the value of variables before conducting computation

4 it utilises the concept of an efficient frontier for evaluating firm performance.

Before conducting the DEA, descriptive statistics on the two input variables and the two output variables are examined. The results are shown in Table 2. In this study, data concerning 20 DMUs are collected from *Containerisation International.* The shipping capacity of these DMUs ranges from 40,716 TEUs to 1,726,265 TEUS. Profit level is between –14 million USD and + 2,408 million USD. Hence, there are significant differences in terms of scale of operations and profitability among these DMUs.

Table 2 Descriptive statistics on input and output variables

	N	*Input*		*Output*	
		TEU	*Operating cost**	*Profit**	*Revenue**
Max	20	1,726,265	242,62	2,408	26,670
Min	20	40,716	464	–14	571
Average	20	361,923	5,807.13	497.675	6,304.8
SD	20	358,960	5,097.76	585.401	5,629.24

Note: *in million US dollars

To understand how the shipping capacity, operating cost, profit and revenue are associated, we conducted a correlation analysis to examine the direction, strength, and significance of the relationships of these variables. The results of correlation analysis are illustrated in Table 3. These results suggest that there is a positive correlation between shipping capacity and operating cost with a correlation coefficient (r) of 0.952 at a significance level of $p = 0.000$. Our findings also suggest a positive correlation between shipping capacity and profit with a correlation coefficient (*r*) of 0.864 at a significance level of $p = 0.000$. Furthermore, the results indicate that the relationship between shipping capacity and revenue is positively associated with a correlation coefficient (*r*) of 0.952 at $p = 0.000$ level. These results indicate that both of the output variables (i.e., revenue and profit) are positively correlated with shipping capacity and market share of DMUs.

In addition, our findings demonstrate that profit and revenue is positively correlated with a correlation coefficient (*r*) of 0.917 at a significance level of $p = 0.000$. On the other hand, the operating cost is positively correlated with profit with the correlation coefficient (*r*) of 0.898 at a significance level of $p = 0.000$. The operating cost is also positively associated with revenue with the correlation coefficient (*r*) of 0.999 at a significance level of $p = 0.000$. These results indicate that both of the outputs of profit and revenue are highly associated with operating cost.

Table 3 Correlation matrix

		TEU	*Operating cost*	*Profit*	*Revenue*
Shipping capacity	Pearson correlation	1.000			
	Sig. (two-tailed)				
Operating cost	Pearson correlation	.952**	1.000		
	Sig. (two-tailed)	0.000			
Profit	Pearson correlation	.864**	.898**	1.000	
	Sig. (two-tailed)	0.000	0.000		
Revenue	Pearson correlation	.952**	.999**	.917**	1.000
	Sig. (two-tailed)	0.000	0.000	0.000	

Notes: **significant at the 0.01 level (two-tailed)

To evaluate the efficiency level of DMUs in converting the inputs to outputs, we use the tool of DEA. The CCR model measures the efficiency of input-output proportions (Lam et al., 2009) by generalising the single output/single input ratio efficiency measure for each DMU to multiple outputs/multiple inputs situations (Yun et al., 2004). To develop the efficiency ratio of two inputs (i.e., TEU and operating cost) and two outputs (i.e., profit and revenue), we use the CCR input-oriented model (Chandra et al., 1998; Po et al., 2009) which aims to minimise the input so that a desired level of output is attained. We use the DEA-Solver software to run the CCR-I model and the computational results are reported in Table 4.

This study is intended not only for measuring the efficiency of DMUs in the liner shipping industry but also examining the relationship between shipping capacity and efficiency level. To understand how the shipping capacity affects DMU's efficiency level, we use linear regression analysis to examine the relationship market share and DEA score. The results of the regression analysis are summarised in Table 5. The results indicate that market share is not a good indicator to influence the DEA score with $R^2 = 0.000$ and the relationship is not significant at the $p = 0.986$ level. The regression equation of the relationship between these two variables is: $3.512 - 0.327\ \beta$. The negative value of β indicates the negative relationship between market share and DEA score but this relationship is not significantly supported. The results suggest that the relationship between market share and firm efficiency does not exist in the liner shipping industry.

Table 4 CCR-I results

DMU		*Capacity (in TEU)*	*Market share*	*Score*
1	K Line	293,321	2.6%	1.000000
2	RCL	52,046	0.4%	1.000000
3		351,542	2.7%	0.969703
4		125,393	1.1%	0.969553
5		43,760	0.4%	0.967068
6		418,818	3.8%	0.966608
7		790,812	6.5%	0.944839
8		394,804	3.2%	0.941539
9		194,350	1.6%	0.928541
10		1,726,265	16.8%	0.927820
11		70,575	0.6%	0.919519
12		491,954	4.4%	0.903301
13		426,814	3.7%	0.896549
14		276,016	2.3%	0.884977
15		370,224	3.1%	0.883087
16		325,030	2.7%	0.882072
17		326,014	3.3%	0.874220
18		235,430	2.4%	0.874216
19		284,572	2.3%	0.873417
20		40,716	0.3%	0.841441

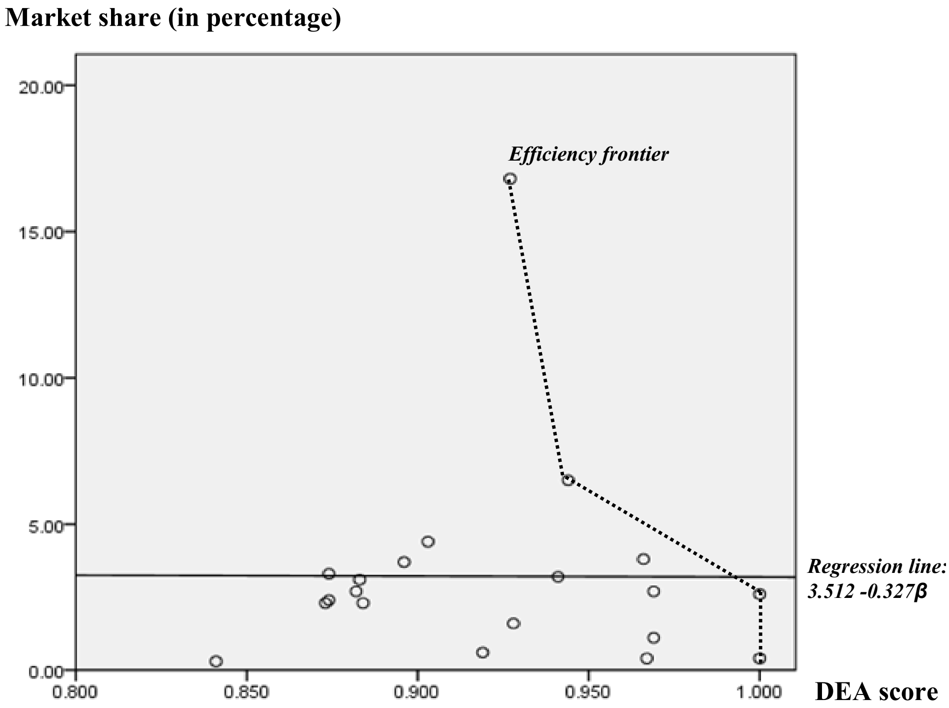
Table 5 Results of regression analysis

Equation	*Model summary*				*Parameter estimates*	
	R square	*df1*	*df2*	*Sig.*	*Constant*	*B*
Linear	.000	1	18	.986	3.512	–.327

Notes: Dependent variable: market share (MS); independent variable: efficiency level in DEA score (EL)

On the other hand, the DEA result can be used as a tool to develop the efficiency frontier for evaluating DMU's efficiency level. An efficiency frontier consists of the optimal points plotted along the curve that have the highest expected efficiency level for the given operating capacity. Figure 1 demonstrates the relationship between these two variables (i.e., market share and DEA score). The findings of this study suggests that a DMU with market share of 5% or below is able to achieve the DEA score of 1.00, a DMU with market share between 5% and 15% can reach the DEA score of 0.945, and a DMU with market share of 15% or above can attain the DEA score of 0.928. The efficiency frontier of the liner shipping industry is shown in Figure 1. According to the efficiency frontier, the DEA score of DMU decreases when market share increases.

Figure 1 Regression line and efficiency frontier to illustrate the association between market share and DEA score



5 Discussion and conclusions

The findings from this study suggest that operating cost is strongly associated with profit and revenue. In liner shipping operations, firms need to undertake capital investment on vessels, containers, and other operational facilities that can affect the performance of shipping firms in term of profit. On the other hand, the correlation analysis of our study shows that shipping capacity is associated with profitability and revenue in the liner shipping industry. As the volume of trade tends to grow, it is logical for firms to increase their shipping capacity and hence enjoy scale operations.

Although our findings indicate a strong relationship between the input variables (i.e., shipping capacity and operating cost) and output variables (i.e., revenue and profit), it is essential to evaluate the efficiency of converting these inputs to outputs. Hence, DEA was used as a tool for examining the efficiency level of firms in the liner shipping industry. In this study, two DMUs (i.e., K Line and RCL) receive the efficiency score of 1.0. Which shows that these two DMUs are operated efficiently. The carrying capacities of these two DMUs are 293,321 and 52,046 TEUs, respectively. The findings indicate that small operators, with a market share of 5% or less, can operate their firms efficiently. The results indicate that carrying capacity in term of TEUs is not a key determinant affecting a shipping firm's efficiency level. Strategic positions may be important for shipping firms to succeed. Accordingly, firms in the shipping industry may focus their strategic positions on variety-based positioning and needs-based positioning. Variety-based positioning is based on the choice of shipping service variety. Variety-based positioning enhances firm performance when these firms can best produce particular shipping services using distinctive sets of activities. For example, K Line deploys the ships, trains, and containers for delivering a full range of global container transport services to meet its customer's requirements. On the other hand, needs-based positioning emphasises serving most of the needs of a particular group of customers. For instance, RCL offers container shipping services to meet the various transport needs of the shippers in Asia, Australasia, and the Middle East. In addition to the strategic position, productivity and operational efficiency are also important factors influencing shipping firms. Operational efficiency means performing similar activities better than competitors. Productivity refers to the ratio of output to input (Gunasekaran et al., 1994) which calculates output from production processes per unit of input (Lun and Cariou, 2009). From the LSC's point of view, efficient liner shipping operations can be defined in terms of how the inputs have been utilised to generate a high level of profitability.

The implications of this study are two-fold and can be drawn from the perspectives of both researchers and managers. From the research perspective, our DEA model is able to identify 'best practice' in the liner shipping industry (Saen, 2009). The findings suggest that LSCs tend to adopt a growth strategy by enlarging their carrying capacity, but the majority of LSCs fail to achieve a high operational efficiency level. Hence, we suggest that the LSCs may need to revamp their business operations through developing positioning strategies. From the management perspective, our findings indicate that efficient liner shipping operations aim to minimise the input while maximising the output levels to strive for high operating efficiency. Although the correlation between market share and profitability exist (with $r = 0.864$), enlarging market share implies extra investment on ships and other related facilities. Investment is linked with business risk and the return on investment relies on the growth in trade volume. In addition to growth in market share, the findings of this study provide an alternative solution for firms to make effective business decisions to improve their operational performance and enhance their competitiveness in the liner shipping industry.

A potential limitation of this paper is related to methodological issues. The data collected were mainly based on secondary sources. The drawback of using secondary data is that there is insufficient information to validate the collected data reliability and accuracy. Moreover, we used empirical data of 20 DMUs in 2008 to determine the efficiency level (i.e., DEA score) and develop the efficiency frontier. There is a lack of information to triangulate the findings. It is desirable to collect longitudinal evidence in the liner shipping industry to validate and generalise the results.

Acknowledgements

This research was supported in part by the research project G-U587 funded by the Hong Kong Polytechnic University. The authors are grateful to Mr. Joseph Lau (Research Assistant of the Hong Kong Polytechnic University) for his assistance in preparing part of the materials of this paper.

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