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Measuring the Technical Efficiency for the Shipping Banks

—An Approach Using Data Envelopment Analysis

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Abstract

The international transportation industry involves various sectors, shipping being one with particular characteristics which differentiates it from others especially as relevant capital risk is concerned. Within this scope, shipping banks are required to assess a number of factors in order to limit the risk from loans, considering the investment capital required. The efficiency of shipping banks is particularly important as it may affect the borrowing level and consequently the financial situation and investment activity in shipping market. This paper examines the Technical Efficiency (TE) of 71 banks operating worldwide in the maritime sector from 2005 to 2010, which is the period that the shipping industry reached its peak and one of its lowest point, making extremely difficult to secure debt finance in shipping, by using Data Envelopment Analysis (DEA) and presents the factors which may affect their technical efficiency, through the application of Regression Analysis. Based on the paper results, most banks during the study period are technically inefficient, whereas TE is proved to be higher under the assumption of variable returns to scale (VRS DEA model) when comparing to constant returns (CRS DEA model). Statistically significant variables are total deposits and total assets for both TE-CRS and TE-VRS and ROE (Return On Equity) for TE-VRS, providing significant information regarding factors on which management should further focus, in order to maintain and reinforce technical efficiency with respect to their strategy for financing shipping sector.

Keywords

Technical Efficiency, Shipping Banks, DEA, Shipping Finance, Profitability

1. Introduction

Shipping sector bears special characteristics that render it considerably different from all other international transport industries, forming a particularly dynamic environment with equally high risks of investment capital losses. In this context, the commercial banks, as the primary source of financing a market characterized by high capital and operating costs, play a leading role. At the same time, they are required to evaluate a broad range of different factors in order to limit the relevant risk and finally reach an efficient risk-yield balance. This becomes even more important when seen in the context of the latest international developments following the implementation of the Rules of Basel III in combination with the capital lost due to one of the most prolonged downturns in the shipping market.

Considering the aforementioned, the level of ship finance available remains low while the banks seek ways to shrink their balance sheets, as a result of both regulatory and commercial restraints. Thus, the shipping banks, *i.e.* commercial banks that provide loans to shipping sector, have become more selective and tighter with the relevant lending volumes and terms, whereas leverage has become shorter with respect to efficiency. Efficiency of commercial banks involved in the shipping industry is crucial for their sustainability, which in turn depends on funding and effective management of operating costs. Thus, bank efficiency plays a significant role in the shipping industry, affecting financial growth or causing systematic risks.

The purpose of this paper is to assess the technical efficiency of banks involved in the shipping industry and to test independent variables that affect shipping banks' TE for the time period from 2005 to 2010, which is the period that the shipping industry reached its peak and one of its lowest point, making extremely difficult to secure debt finance in shipping. Data Envelopment Analysis is used in order to extract efficiency scores for shipping banks worldwide. The model applied is based on the intermediate approach of banking operation with orientation in outputs (output oriented), while models are executed both with constant and variable returns to scale (CRS and VRS approaches) in order to detect any differences in banks' TE in terms of technology. Furthermore, Regression Analysis is used, in order to test independent variables that affect shipping banks' TE.For the purpose of this paper, technical efficiency measures the ability of a bank to produce optimal output from a given set of inputs.

This paper reveals for the first time the most important factors arising from shipping bank's internal environment based on DEA and implicitly contributes to the development of a specific methodological tool for measuring technical efficiency with respect to bank ability to produce optimal output from a given set of inputs. Essentially, it might be considered as a decision support tool, taking into account certain bank specific factors from its internal operational environment, in order to define the level of its efficiency in the market as a whole.

The paper is structured as follows; Section 2 sets a literature review of DEA approaches for estimating bank efficiency. Section 3 presents the methodology applied, while Section 4 presents the empirical analysis and relevant results. Section 5 concludes the paper along with implications for further research.

2. Literature Review

Bank efficiency has been an important issue for analysts [1] [2] [3], practitioners and policymakers being expressed as a function of bank-specific, *i.e.* operating expenses, management, asset quality, bank size and non-interest income and operating environment factors, i.e. interest rate, economic growth, regulatory requirements. In order to model bank efficiency properly, two basic approaches are usually used; the intermediation and the production approach. While in production approach a bank's resources produce services to customers, under intermediation approach, banks are viewed as mediators between depositors and borrowers, accepting deposits from customers and transforming them into loans to clients [1] [4]. Moreover, estimating bank efficiency involves both parametric and non-parametric methods. The most frequently used non-parametric method is Data Envelopment Analysis (DEA), rooted in the work of Farell [5] and first introduced by Charnes *et al.* [6], who applied mathematical programming in order to locate a frontier used to evaluate efficiency of Decision Making Units (DMUs. DEA is become substantially popular in estimating efficiency of the banking industry. In addition, Charnes *et al.* [6] suggest a constant returns to scale (CRS) approach while Banker *et al.* [7] a variable returns to scale (VRS) approach, which splits overall technical efficiency into two products, i.e. pure technical efficiency and scale efficiency.

Both approaches are used in previous literature, since some researchers estimate bank efficiency by CRS approach [8] [9] [10] while others use both CRS and VRS approach [11] [12]. Most DEA models regarding bank efficiency are input-oriented, mainly due to the general belief that bank managers are in control mostly of their inputs in relation to the outputs, although there are several studies using DEA models that are output-oriented [13] [14] or both output- and input-oriented [12] [15]. It should be noted, though, that input-oriented or output-oriented DEA models under CRS approach do not show different results in terms of technical efficiency [16] [17].

DEA models for estimating bank efficiency have been widely used in previous years for several banking industries [4] [18] [19] [20] [21] [22], based on different approaches and input-output variables. Siems [23] uses as input variables the number of employees, fixed assets, interest expenses, other non-interest expenses and the number of loans, and as output variables deposits and interest income. Miller & Noulas [24], examining technical efficiency of US banks, use both CRS and VRS output-oriented DEA method, using as inputs total transactions deposits, total non-transactions deposits, total interest expense and total non-interest, and as outputs total interest income, total non-interest income and loans. Casu & Molyneux [12] use a VRS output-oriented approach of DEA, including as outputs total loans and other earning assets and as inputs total costs and total deposits. Ataulla & Le [14] apply a VRS DEA method both input- and output-oriented, consisting of interest expenses and operating expenses as inputs and loans, advances and investments as outputs. Roberta *et al.* [25] apply an input-oriented DEA method using staff costs, capital (operating expenses excluding staff costs), funds and interest expenses as input variables, and deposits, loans and investments as output variables. Tyrone *et al.* [26] use the number of employees, interest expenses, deposits and current amount of deposits as input variables, and loans, interest income, operating income and earnings as output ones. Suffian [27] applies an input-oriented VRS DEA approach, with deposits, wages, interest expenses and non-interest expenses as inputs, while Shiang-Tai Liu [28] uses a CRS output-oriented DEA method, including demand deposits short-term loans and medium-term loans as outputs. In addition, Akhtar *et al.* [29] applies an input-oriented CRS approach, with operating expense, advances and capital as inputs, whereas Varias and Sofianopoulou [30] applied an input oriented model to estimate technical efficiency of 19 biggest Greek commercial banks by using interest expenses/deposits, other overhead expenses/fixed assets and personnel expenses/total assets as inputs. Rahim *et al.* [31] examined the technical efficiency of Islamic banks by applying DEA method based in the intermediation approach, proving that the main source of technical efficiency was the scale of operation. Nandkumar and Singh [32] used DEA approach to estimate the technical efficiency of commercial banks in India over the years 2006-2010 by applying CCR DEA model, showing that major factors resulting in the poor performance of banks is their huge amount of deposits and operating expenses, as well as the excess number of employees.

Either CRS or VRS DEA methods for estimating bank efficiency aim to detect the most and least efficient banks, but questions often arise about the identification of those ways that improve technical efficiency. In this frame, it is essential to identify those factors that impact overall bank efficiency.

3. Methodology

DEA method is selected as the most suitable for the measurement of technical efficiency of a group of banks, as can process models with many inputs and outputs in different measures, enables comparisons, allows the use of input and output vectors and requires lesser degrees of freedom. Application of DEA in the banking sector refers to the estimation of the relative efficiency of each bank in a current sample in comparison with the relative efficiency of the rest of the banks comprising the total sample [33]. This is achieved by maximizing the ratio of the weighted sum of outputs to the weighted sum of inputs for each DMU (bank) as follows [6]:

$$\begin{aligned} &\max_{v_i, u_r}\left(h_o\right), h_o = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \\ &\text{subjected to } \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \quad \forall j = 1,\cdots,n \\ &u_r, v_i \ge \varepsilon, \quad i = 1,\cdots,m, \qquad r = 1,\cdots,s \end{aligned} \tag{1}$$

where h_0 = the relative efficiency of bank *o*, *o* = the bank assessed by $j = 1,\cdots,n$ banks of the sample, *j* = the number $j = 1,\cdots,n$ of banks of the sample, *r* = the number $r = 1,\cdots,s$ of outputs, *i* = the number $i = 1,\cdots,m$ of inputs, $y_{rj} > 0$

= the amount of output r of bank j ($r=1,\cdots,s$), $x_{ij}>0$ = the amount of input i of bank j ($i=1,\cdots,m$), and v_i, u_r = the coefficients of input i and output r, respectively, which maximize the objective function of the bank examined each time.

This linear fractional programming model described above is easily converted in a linear programming model as follows [7]:

$$\max_{v_i,u_r}(h_0), h_0=\sum_{r=1}^{s}u_r y_{ro}$$

$$\text{subjected to} \begin{cases} \sum_{i=1}^{m} v_i x_{io} = 1 \\ \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \\ u_r, v_i \ge 0 \quad i=1,\cdots,m \quad j=1,\cdots,n \end{cases} \tag{2}$$

In conclusion, the model is applied once for each bank in the sample looking for the combination of inputs and outputs (u_r, v_i) that gives the higher degree of the bank's efficiency (h_0), without leading to a input-output ratio greater than 1 (100%) when applied to other banks in the sample. For each bank, the relative efficiency is estimated as follows:

1) h_0 = 1, indicating that the bank is relatively efficient, or

2) h_0 < 1, indicating that the bank is relatively inefficient.

DEA can be applied assuming either constant returns to scale (CRS) or variable returns to scale (VRS). Consequently, most researchers after having applied DEA methods to estimate technical efficiency, they estimate its determinants, assessing in the same time the degree and the nature (positive or negative) of their impacts on technical efficiency through multiple regression [34] [35]. Formally,

$$TE_j = c + a_1 Z_1 + a_2 Z_2 + \cdots + a_j Z_j + \varepsilon_j \tag{3}$$

where, TE = Technical Efficiency, $Z_1, Z_2, \cdots, Z_j$ = are the independent variables affecting TE, a_1, a_2, a_j = their coefficients and ε = error term. This model is estimated either by Time Series Ordinary Least Squares—OLS or by Panel Data Models. The regression model applied for estimating the factors affecting shipping banks' efficiency is as follows:

$$\begin{aligned} te = {} & c + a_1 ROA + a_2 ROE + a_3 LLP\_TL + a_4 LNTTLDEP \\ & + a_5 LNS\_TA + a_6 LN\_TA + a_7 t + \varepsilon \end{aligned} \tag{4}$$

where te = the technical efficiency of bank, ROA = Return On Assets, ROE = Return On Equity, LLP_TL = Total Loan Loss Provision/Total Loans, $LNTTDEP$ = the natural logarithm of Total Deposits, LNS_TA = Total Loans/Total Assets, and $LNTA$ = the natural logarithm of Total Assets.

4. Empirical Approach and Data

The sample of present analysis consists of seventy-one (71) banks worldwide involved in shipping finance for the time period of 2005-2010, which is the period that the shipping industry reached its peak and one of its lowest point, making extremely difficult to secure debt finance in shipping. All banks (Table 1) are numbered consequently $(1,2,3,\cdots,71)$ and 60.5% of selected banks are

Table 1. List of banks.

No	Bank	No	Bank
1	Aegean Baltic Bank	37	Goldman, Sachs & Co., oHg
2	Alpha Bank AE	38	HSH Nordbank AG
3	Aozora Bank	39	ICICI Bank Limited
4	AS DnB NORD Banka	40	Industrial Bank of Korea
5	Bank Danamon Indonesia Tbk	41	ING Bank N.V.
6	Bank of China Limited	42	Intesa Sanpaolo
7	Bank of Fukuoka Ltd.	43	Kansai Urban Banking Corporation
8	Bank of Tokyo-Mitsubishi UFJ Ltd (The)-Kabushiki Kaisha Mitsubishi Tokyo UFJ Ginko	44	Kookmin Bank
9	BNP Paribas	45	Korea Development Bank
10	Bremer Landesbank Kreditanstalt Oldenburg-Girozentrale	46	Landesbank Hessen-Thueringen Girozentrale-HELABA
11	Capital One Bank (USA) National Association	47	Macquarie Bank Ltd
12	China Development Industrial Bank	48	Malayan Banking Berhad-Maybank
13	China Merchants Bank Co Ltd	49	Marfin Egnatia Bank SA
14	Citibank International Plc	50	National Australia Bank Limited
15	Commerzbank AG	51	National Bank of Greece SA
16	Corner Banca S.A.	52	National Federation of Fisheries Cooperatives-Suhyup Bank
17	Credit Agricole Corporate and Investment Bank-Credit Agricole CIB	53	Natixis
18	Crédit Industriel et Commercial—CIC	54	Nordea Bank AB (publ)
19	Credit Suisse Group AG	55	Piraeus Bank SA
20	Danske Bank A/S	56	Proton Bank S.A.
21	DBS Bank Ltd	57	Shinhan Bank
22	DekaBank Deutsche Girozentrale	58	Shinkin Central Bank
23	Deutsche Bank AG	59	Shinsei Bank Limited
24	Deutsche Schiffsbank AG	60	Skandinaviska Enskilda Banken AB
25	Dexia Bank Belgium-Dexia Bank	61	SpareBank 1 SR-Bank
26	DnB NOR Bank ASA	62	Sumitomo Mitsui Banking Corporation
27	Dresdner Bank AG	63	Swedbank AB
28	Dresdner Kleinwort Limited	64	T Bank S.A
29	DVB Bank SE	65	Tokyo Star Bank Ltd.
30	DZ Privatbank S.A.	66	Turkiye Garanti Bankasi A.S.
31	Efibanca SpA-Gruppo Bipielle	67	UBS AG
32	Emporiki Bank of Greece SA	68	UniCredit Bank AG
33	FBB First Business Bank SA	69	UniCredit SpA
34	Finansbank A.S.	70	WestLB AG
35	Fortis Bank SA/NV-BNP Paribas Fortis	71	Woori Bank

located in Europe and mostly Germany, 36.61% in Asia and 2.8% in USA. All data were derived from Bloomberg professional data base and Bank scope data base provided by Bureau van Dijk.

Shipping banks' TE is estimated by the non-parametric DEA method, both in terms of CRS and VRS, in order to test if results are verified by different production and technology circumstances, taking into account the fact that CRS models usually refer to long-term period while VRS models to short-term (Siriopoulos & Tziogkidis, 2009). Additionally, DEA method is consistent with the intermediary approach, according to Berger & Humphrey (1997) belief that this approach is best suited for the estimation of efficiency in the banking sector, since it includes interest expenses which usually are of 1/2 to 3/4 of total bank expenses. Moreover, both CRS and VRS DEA methods applied are output-oriented. Regarding input and output variables, total expenses excluding staff cost, staff cost and deposits are used as inputs, while net shipping loans are used as the only output, since it best reflects banks' profitability. In the subsequent stage of this analysis, A regression model is used in order to test for potential variables that affect technical efficiency.

In Figures 1-6, TE of all 71 shipping banks is presented using both CRS and

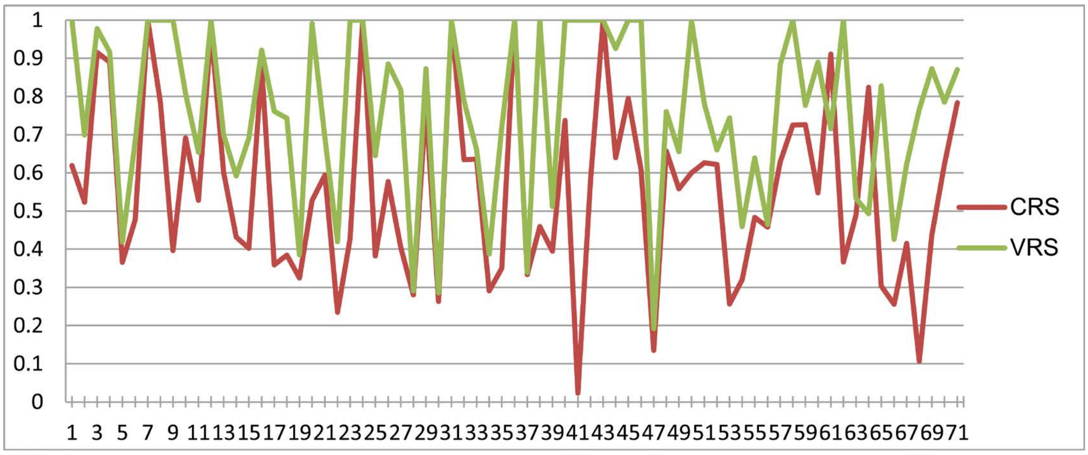

Figure 1. TE of all 71 banks (CRS-VRS comparison, 2005).

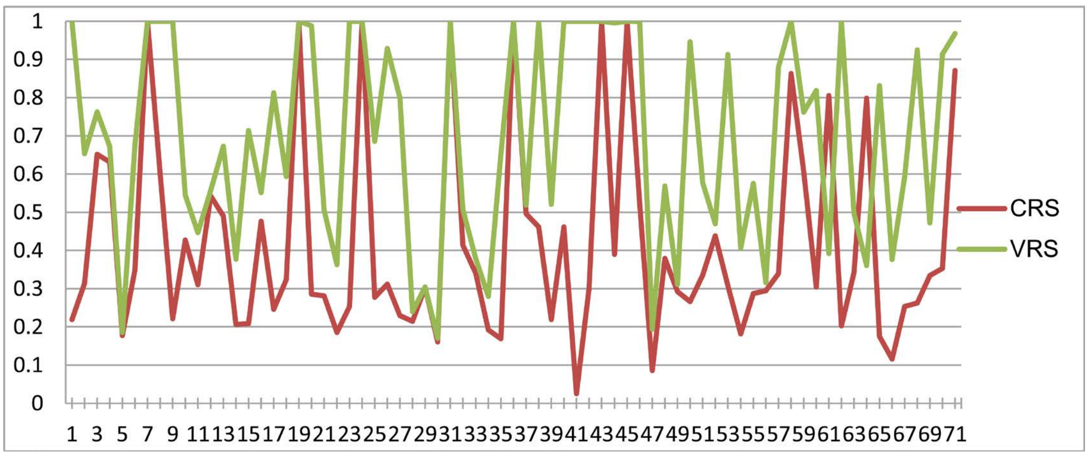

Figure 2. TE of all 71 banks (CRS-VRS comparison, 2006).

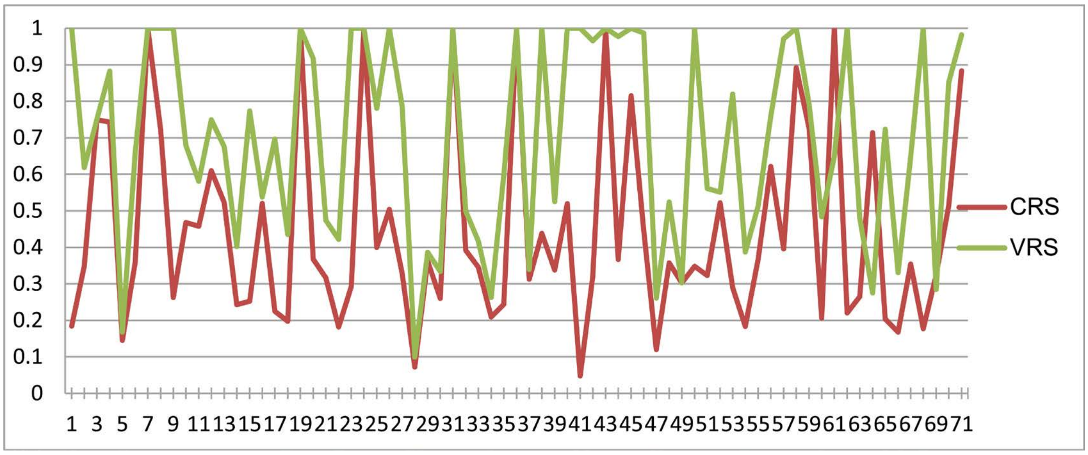

Figure 3. TE of all 71 banks (CRS-VRS comparison, 2007).

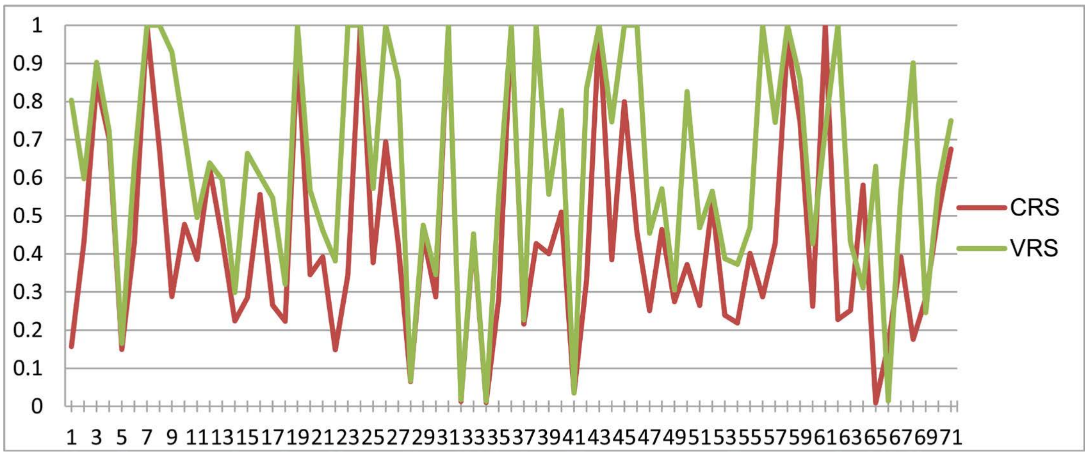

Figure 4. TE of all 71 banks (CRS-VRS comparison, 2008).

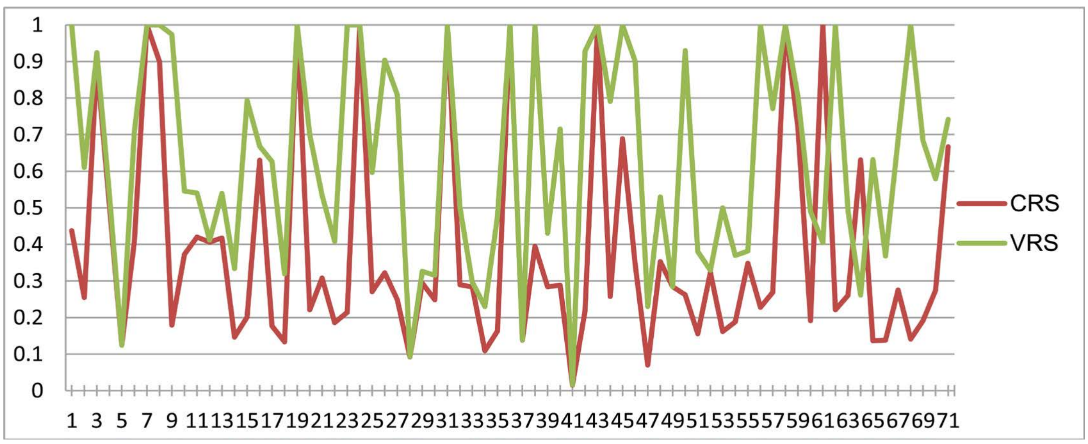

Figure 5. TE of all 71 banks (CRS-VRS comparison, 2009).

VRS DEA methods, respectively. Firstly, it is proved that TE assessed under VRS hypothesis seems to be more effective in relation to CRS assumption. This is also evidenced through the box plots (Figure 7 & Figure 8), where the mean of TE determined by VRS is higher compared to TE determined by CRS. Additionally TE of shipping banks is observed to show a significantly high degree of variabil-

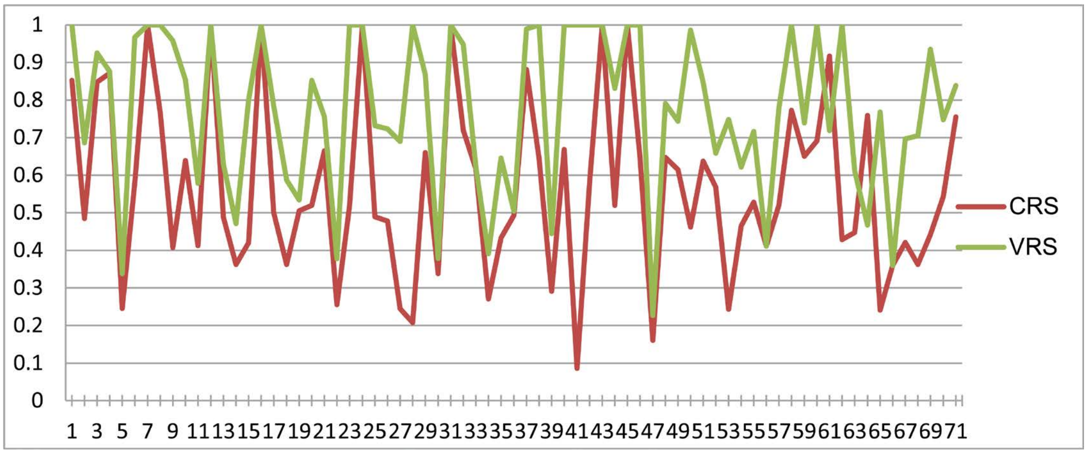

Figure 6. TE of all 71 banks (CRS-VRS comparison, 2010).

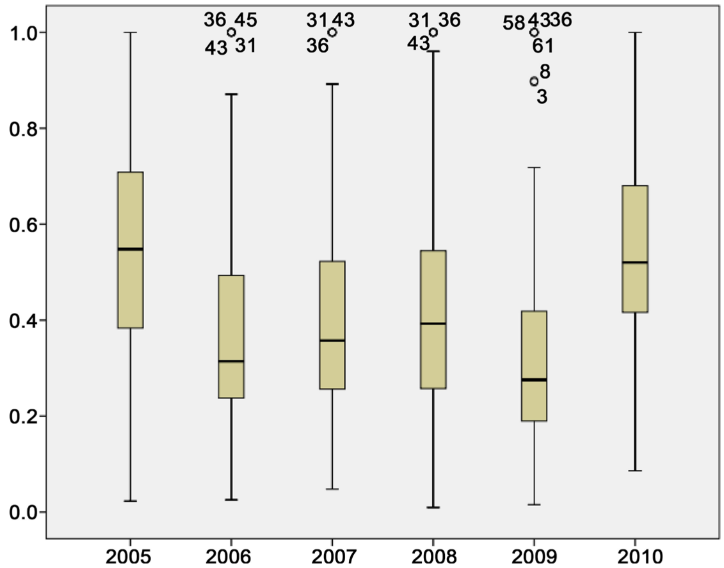

Figure 7. CRS-TE box plots (2006-2010).

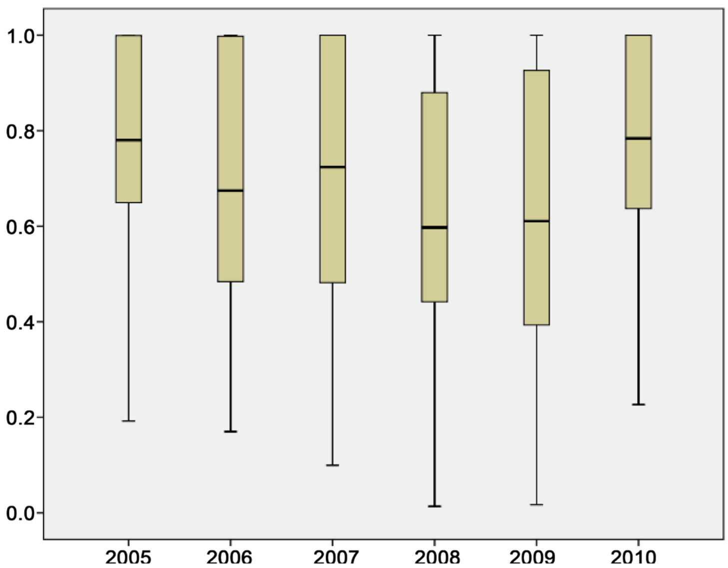

Figure 8. VRS-TE box plots (2006-2010).

ity, especially in the case of CRS. Summarized results of TE under the CRS and VRS approaches are presented in Table 2, including the number and percentage of banks having TE for all years. The vast majority of banks are technical inefficient over the years, although the VRS approach gives a higher number of technical efficient banks when compared to CRS approach, denoting probably that VRS approach is influenced by the bank size.

By presenting the descriptive statistics of the data (Table 3) to summarize the central tendency and spread characteristics of banks, it is observed that the mean of *ROA*(Return on Assets)is equal to 0.816 suggesting that net income of banks is on average slightly lower than the total assets and demonstrating high ability in investment activities of banks. The aforementioned is confirmed by the high-mean value of *ROE* (*Return on Equity*, 8.341), showing high profitability for the banks by comparing their net income to their average shareholders' equity. At the same time, the mean of *LLP_TL* (*Loan Loss Provision to Total Loans*) shows the very low ratio of total loan loss provision compared to total loans, while the means of the variables *LNTTDEP* (*Natural Logarithm Total Deposits*), *LNS_TA* (*Loans to Total Assets*) and *LNTA* (*Natural Logarithm Total Assets*) are relatively high and equal to 16.895/50.518 and 17.957 respectively.

Table 4 presents the summary results the best model results under CRS and VRS approaches, where statistically significant variables are *total deposits* and *total assets* for both TE-CRS and TE-VRS and *ROE*) for TE-VRS.

The regression models applied or estimating the factors affecting shipping banks' efficiency based on CRS and VRS approach are respectively as follows:

Table 2. Summarized results of TE banks under CRS and VRS approach.

Year	Number of TE banks under CRS approach	Percentage (%)	Number of TE banks under VRS approach	Percentage (%)
2005	5	7.04%	18	25.35%
2006	5	7.04%	19	26.76%
2007	7	9.86%	19	26.76%
2008	6	8.45%	15	21.13%
2009	8	11.27%	15	21.13%
2010	7	9.86%	19	26.76%

Table 3. Descriptive statistics for independent variables used in regression models.

Variables	Minimum	Maximum	Mean	Std. Dev.
ROA	−7.239	21.791	0.816	2.027
ROE	−130.100	355.700	8.341	31.286
LLP_TL	−1.21E−07	2.13E−04	3.18E−06	2.09E−05
LNTTLDEP	9.590	20.832	16.895	2.205
LNS_TA	6.810	94.750	50.518	20.648
LNTA	11.651	21.863	17.957	2.007

Table 4. Best model summarized results under CRS and VRS approach.

CRS	*b*	*se*(*b*)	*t*	*p*	*VRS*	*B*	*se*(*b*)	*t*	*p*
(*Constant*)	−0.092	0.146	−0.632	0.528	(*Constant*)	−0.275	0.150	−1.835	0.068
LN_TA	0.005	0.001	6.207	0.000	*LNTTLDEP*	0.052	0.008	6.414	0.000
LNTTLDEP	0.018	0.008	2.317	0.021	*LN_TA*	0.002	0.001	2.155	0.032
					ROE	−0.001	< 0.001	−2.580	0.011
$R^2 = 0.139$. $R^2_{adj} = 0.132$. $s = 0.242$. $F = 21$. $p(F) < 0.001$					$R^2 = 0.145$. $R^2_{adj} = 0.138$. $s = 0.249$. $F = 21.98$. $p(F) < 0.001$				

$$te(CRS) = -0.092 + 0.018 \cdot LNTTLDEP + 0.005 \cdot LN\_TA \quad (5)$$

and

$$te(VRS) = -0.275 - 0.001 \cdot ROE + 0.052 \cdot LNTTLDEP + 0.002 \cdot LN\_TA \quad (6)$$

LNTTLDEP (Total Deposits) is positively correlated to TE under CRS and VRS approaches, meaning that more efficient banks have higher market shares. Specifically, a 1% increase in Total Deposits drives to 0.018% and 0.052% increase of technical efficiency score under CRS and VRS approach respectively. Total Assets (LN_TA) is also positively correlated with TE under both CRS and VRS approaches with the technical efficiency score to increase by 0.005% and 0.002% respectively, when Total Assets increase by 1% and vice versa, as confirmed by Hauner [36], who suggests that the bank size has a positive impact on its efficiency. Larger banks are expected to pay less for their inputs and simultaneously they may face increased returns to scale which increases the relevant efficiency. *ROE* is negatively correlated with TE only under VRS approach, with an increase in *ROE* affecting negatively but slightly the technical efficiency scores. TE is not affected by *LNS_TA* (Total Loans/Total Assets), *ROA* and *LLP/TL* (Total Loans Provision/Total Loans), *ROA* seems to be positively correlated with TE, whereas *LLP/TL* seems to be negatively correlated with TE, as shown by previous research [37] [38] [39], where banks facing difficulties in collecting loans are usually driven to bankruptcy [40] [41] [42].

5. Conclusions

According to results, banks during the study period are technically inefficient, suggesting that market factors may influence the operation of shipping banks. Additionally, TE is proved to be higher under the assumption of variable returns to scale (VRS DEA model) when comparing to constant returns (CRS DEA model). Results obtained by the application of CRS and VRS models, respectively, seem to differ significantly, mainly due to the choices and combinations of inputs and outputs and because of the substantially high levels of TE detected in banks under review. Regarding the factors that affect TE under both CRS and VRS approach, ROA, statistically significant variables are total deposits and total assets for both te-CRS, te-VRS and ROE (Return On Equity) for *te*-VRS. Total Assets and Total Deposits are positively correlated with TE, denoting that profitability and market power, reflected on the bank's size, are favorable for obtaining higher levels of TE in the banking sector. In contrast and as expected, ROE is negatively correlated with TE.

Overall, the results of this research indicate banks involved in shipping finance are not technical efficient over the time period examined. Additionally, regression models applied provided useful information to be considered by management regarding factors that affect TE. However, the research focused on shipping market as a whole, whereas the study period was specific. It would be of interest regarding future research to apply the proposed methodology in order to examine if the certain sub sector to be financed, *i.e.* dry bulk, tankers, container shipping, or the country of origin, the period to be examined, or even ownership structure of shipping banks affect their TE. It would be also interesting to define the internal factors of the operational environment of banks in combination with the external factors associated with shipping market that may affect the amount of loans for the shipping industry based on previous years' experience. In general, the existence of non-technical efficiency in shipping banks raises questions about their decision to continue financing such a risky and heterogeneous market, despite the regulations set by the Basel Convention.

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