# Technical Efficiency of Shipping Banks: A DEA Approach

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19 January 2015

# TECHNICAL EFFICIENCY OF SHIPPING BANKS: A DEA APPROACH

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**ABSTRACT**

The international transportation Industry involves various sectors, shipping being one with particular characteristics which differentiates it from others. Within this scope, commercial banks are one of the main entities that may offer the required funding in a market that is characterized by the need for large amounts of capital and high operating costs. Banks play a significant role and are required to assess a number of factors in order to limit the risk from loans as well as to establish an accurate risk-return ratio. The efficiency of banks involved in the shipping industry is particularly important since it may, on one hand, affect financial growth, and on the other, create systemic crisis that may affect the economy as a whole as it directly affects the borrowing and consequently the financial situation and investment activity the shipping companies. This paper presents an effort to assess the shipping banks' efficiency, and the determination of those factors which affect their technical efficiency, through the application of Data Envelopment Analysis. The results of this research indicate the factors that affect the efficiency of the shipping banks such as ROA, ROE, total loan loss provision to total loans ratio, total deposits and total assets, providing significant information to be considered by management regarding factors on which they should further focus in order to maintain and/or reinforce technical efficiency.

*JEL classification: G21, D2, C14*

*Keywords: Technical efficiency, shipping banks, DEA, finance, profitability.*

## 1. INTRODUCTION

Efficiency of commercial banks involved in the shipping industry is crucial for its 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 its financial growth or causing systematic risks. The aim of this paper is the assessment of the technical efficiency of banks involved in the shipping industry through DEA analysis and the determination of those factors that affect their technical efficiency through a regression model (fixed effects). For the purpose of this paper, technical efficiency measures the ability of a bank to produce optimal output from a given set of inputs (Farrell, 1957).

## 2. LITERATURE REVIEW

Bank efficiency has been an important issue for analysts (Berger & Humphrey, 1992; **Bergendahl, 1998;** Meryem & Pasiouras 2009), practitioners and policymakers. In order to model properly bank efficiency, 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, known also as asset approach, banks are viewed as mediators between depositors and borrowers, accepting deposits from customers and transforming them into loans to clients (Berg et al, 1993; Berger & Humphrey, 1992). 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 (1957) and first introduced by Charnes et al (1978), 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. 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 (Ray, 2004). 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 (Charnes, Cooper & Rhodes, 1978):

$$
\begin{aligned}
&\underset{v_i,u_r}{Max} \quad h_o = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{i_o}} \\
&\text{s.t.} \quad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \quad \forall j = 1,\dots,n \\
&\qquad u_r, v_i \ge \varepsilon \\
&i = 1,..,m, r = 1,..,s
\end{aligned} \tag{1}
$$

where $h_0$ = the relative efficiency of bank 0, 0 = the bank assessed by j = 1,….,n banks of the sample, j = the number j = 1,….,n of banks of the sample, r = the number r = 1,….,s of outputs, i = the number i = 1,….,m of inputs, $y_{rj}>0$ = the amount of output r of bank j (r = 1,2,…,s), $\chi_{ij}>0$ = the amount of input i of bank j (i = 1,…,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 (Banker, Charnes & Cooper, 1984):

$$
\begin{aligned}
&\underset{v_i,u_r}{Max} \quad h_o = \sum_{r=1}^{s} u_r y_{ro} \\
&s.t. \qquad \sum_{i=1}^{m} v_i x_{io} = 1 \\
&\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \\
&v_i, u_r \ge 0
\end{aligned} \tag{2}
$$

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.

In addition, DEA can be applied assuming either constant returns to scale (CRS) or variable returns to scale (VRS). Charnes et al (1978) suggest a CRS approach while Banker et al (1984) a VRS approach, which splits overall technical efficiency into two products, i.e. pure technical efficiency and scale efficiency. This is the key differentiation between the two methods as the first (CRS) is related to the ability of managers to use some particular resources of enterprises, while the second (VRS) refers to the exploitation of economies of scale in the limit indicated by the constant returns to scale. Both approaches are detected in previous literature, since some researchers estimate bank efficiency by CRS approach (Noulas, 1997; Avkiran, 1999; Soteriou & Zenios, 1999) while others use both CRS and VRS approach (Canhoto & Dermine, 2003; Casu & Molyneux, 2003). 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 (Ataullah et al, 2004; Ataullah & Le, 2006) or both output- and input-oriented (Casu & Molyneux, 2003; Beccalli et al, 2006). 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 (Coelli et al, 2005; Coelli & Perelman, 1996).

Regarding this previous analysis, various DEA models for estimating bank efficiency have been used in previous years for several banking industries (Sherman & Gold, 1985; Ferrier & Lovell, 1990; Aly et al, 1990; Elyasianin & Medhian, 1990; Berg et al, 1993; Brockett et al, 1997; Leibenstein & Maital, 1992). Roberta et al (2009) 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. Siems (1991) 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. Tyrone et al (2009) 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. Miller & Noulas (1996), 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. Suffian (2009) applies an input-oriented VRS DEA approach, with deposits, wages, interest expenses and non-interest expenses as inputs, while Shiang-Tai Liu (2010) uses a CRS output-oriented DEA method, including demand deposits short-term loans and medium-term loans as outputs. Ataulla & Le (2006) 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. Lastly, Casu & Molyneyx (2003) 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.

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, regarding several financial, social or political variables that affect the business environment in which a bank operates but are not considered as inputs or outputs. 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 (Siriopoulos & Tziogkidis, 2009; Berger & Humphrey, 1997). Formally,

$$\mathrm{TE}_j = c + \alpha_1 Z_1 + \alpha_2 Z_2 + .... + a_j Z_j + \varepsilon_j \qquad (3)$$

where, TE = Technical Efficiency, $Z_1$, $Z_2$,….,$Z_j$ = 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.

## 3. METHODOLOGY

Both total technical efficiency (TTE) and pure technical efficiency (PTE) are 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). It should also be noted that CRS method is mostly applicable in samples with both big and smaller banks (Berg et al, 1991). 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 ½ to ¾ of total bank expenses. Moreover, both CRS and VRS DEA methods applied are output-oriented. Regarding input and output variables, total expenses excluding staff expenses, staff expenses 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 (fixed effects) in order to test for potential exogenous variables that affect technical efficiency. The regression model applied is as follows:

$$te_{jt} = c + a_1 ROA + a_2 ROE + a_3 LLP\_TL + a_4 LNTTLDEP + a_5 LNS\_TA + a_6 LNTA + \varepsilon_j \qquad (4)$$

where $te_{ji}$ = the technical efficiency of bank *j* at time *t*, 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.

The sample of present analysis consists of seventy-one (71) banks involved in the maritime sector that operate worldwide and the collected yearly data concern the time period of 2005-2010. All banks (Appendix, Table V) are numbered consequently (1,2,3,…,71) and 60,5% of selected banks are located in Europe and mostly Germany, 36,61% in Asia and 2,8% in USA. All data were derived from Bloomberg and Bankscope databases.

## 4. RESULTS

In Figures I-VI (see Appendix) TE of all 71 banks is presented for all 6 years using both CRS and VRS DEA methods, respectively. Firstly, it is detected that banking TE assessed under VRS hypothesis seem to be more effective in relation to CRS assumption. This is also evidenced through the box plots (see Appendix, Figures VII&VIII), where the mean of TE determined by VRS is higher compared to TE determined by CRS. Additionally TE of banks is observed to show a significantly high degree of variability, especially in the case of CRS. Summarized results of TE under the CRS and VRS approaches are presented in Table I, including the number and percentage of banks having TE for all years using the two models, respectively. The vast majority of banks have high values of TE 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.

Table I – 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% |

By presenting the descriptive statistics of the data (Table II) to summarize the central tendency and spread characretistics of banks, it is observed that the mean of ROA is equal to PGA 0.816 suggesting that net income of banks is on average slightly lower than the total assets, demonstrating high ability in investment activities of banks. The above is confirmed by the high mean value of ROE which is equal to 8.341 and shows high profitability for the banks by comparing their net income to their average shareholders' equity. At the same time, the mean of LLP_TL shows the very low ratio of total loan loss provision compared to total loans, while the means of the variables LNTTDEP, LNS_TA and LNTA are relatively high and equal to 16.895, 50.518 and 17.957 respectively.

Table II– Descriptive statistics for independent variables used in OLS 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 III presents the summary results under CRS and VRS approaches.

Table III – OLS model summarized res Table III – OLS model summarized results under CRS and VRS approach

| | **CRS approach** | | **VRS approach** | |
|---|---|---|---|---|
| **Variables** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| **Constant** | -1.4553 | 0.0177** | -1.0058 | 0.1525 |
| **ROA** | 0.0114 | 0.2890 | 0.0414 | 0.0009*** |
| **ROE** | -0.0003 | 0.5111 | -0.0014 | 0.0135** |
| **LLP_TL** | -879.4470 | 0.2463 | -2477.2700 | 0.0048*** |
| **LNTTLDEP** | 0.0962 | 0.0002*** | 0.0343 | 0.2488 |
| **LNS_TA** | 0.0000 | 0.9951 | -0.0015 | 0.4440 |
| **LNTA** | 0.0147 | 0.6303 | 0.0659 | 0.0628* |
| | No. of observations: 266<br>R-squared: 0.164<br>Adjusted R-squared: 0.144 | | No. of observations: 266<br>R-squared: 0.242<br>Adjusted R-squared: 0.224 | |

***, **, * denote statistical significance under 1%, 5% and 10% significance level, respectively

Summarizing the results of Table III, ROA is positively correlated with TE under VRS approach, denoting that profitability is positively linked to TE, as confirmed by previous studies (Isik & Hasan, 2002; Hasan & Marton, 2003; Miller & Noulas, 1996). Banks with higher profitability ratios are usually preferred by customers and therefore attract larger shares of deposits and more creditworthy borrowers. This in turn forms a favorable environment regarding intermediary banking activities. Furthermore, TE is not affected by LNS_TA (Total Loans/Total Assets). In contrast, Total Assets (LNTA) is positively correlated with TE under VRS approach, as confirmed by Hauner (2005), who suggests that the bank size has a positive impact on its efficiency, since larger banks are expected to pay less for their inputs and simultaneously they may face increased returns to scale through sharing of fixed costs which increases efficiency taking into account the high volume of services provided.

As expected, LLP/TL (Total Loans Provision/Total Loans) is negatively correlated with TE under VRS approach, as verified by previous research (Kwan & Eisenbeis, 1995; Resti, 1997; Barr et al, 2002). Furthermore, most research conducted to explain causes of banks' failure have proved that banks facing difficulties in collecting loans usually are driven to bankruptcy (Dermiguc-Kunt, 1989; Whalen, 1991; Barr & Siems, 1994). Lastly, LNTTLDEP (Total Deposits) is positively correlated to TE under CRS approach, since more efficient banks have higher market shares.

## 5. CONCLUSIONS

This paper examined Technical Efficiency (TE) of 71 banks operating worldwide in the maritime sector for the time period from 2005 to 2010 by using DEA method. This model applied was based on the intermediate approach of banking operation with orientation in outputs (output oriented), while models were 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. In the second level of previous analysis, two fixed-effects OLS models were applied, in order to test exogenous independent variables that affect banking TE.

According to results, the majority of banks operating in the maritime industry maintain a high level of TE over the years, whereas some of them show fluctuations. 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). Furthermore, 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, 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, Total Loans Provision/Total Loans is negatively correlated with TE, since efficiency in the banking sector is strongly linked to creditworthiness of borrowers.

Overall, the results of this research indicate banks involved in the maritime sector are of high TE over the time period examined. Additionally, OLS models applied provided useful information to be considered by management regarding factors that affect TE. In would be of interest regarding future research to apply the proposed methodology in order to examine if the country of origin or even ownership structure of banks affect their TE operating within the maritime sector.

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**APPENDIX**

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

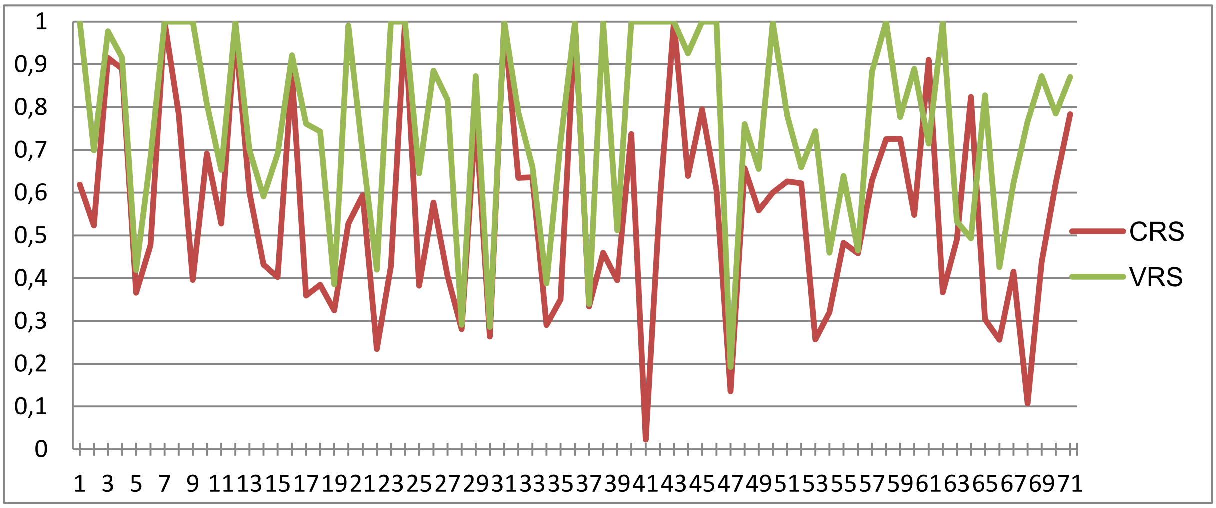


Figure II-TE of all 71 banks (CRS-VRS comparison, 2006)

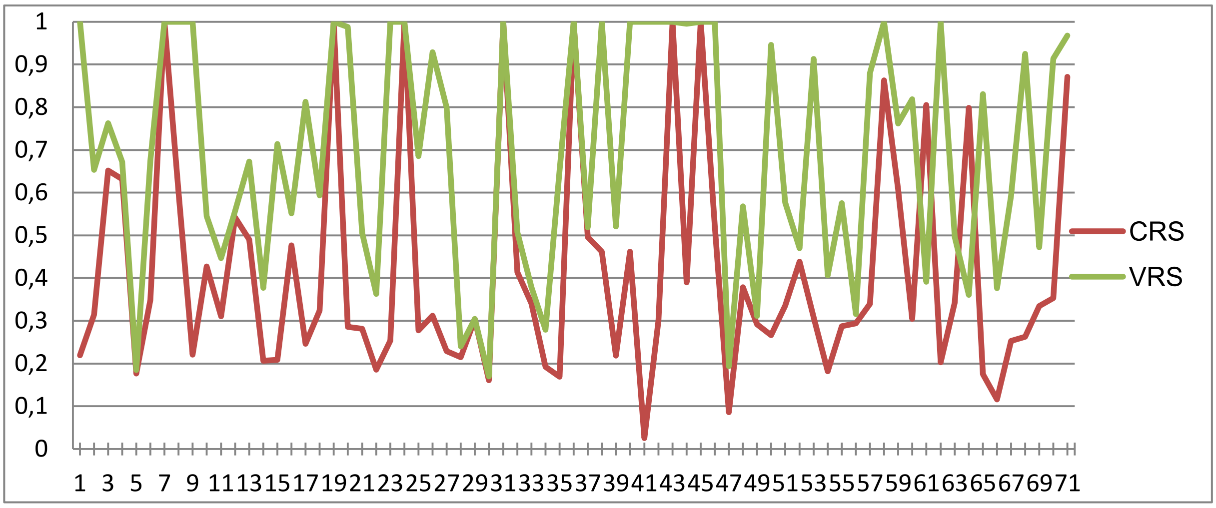


Figure III-TE of all 71 banks (CRS-VRS comparison, 2007)

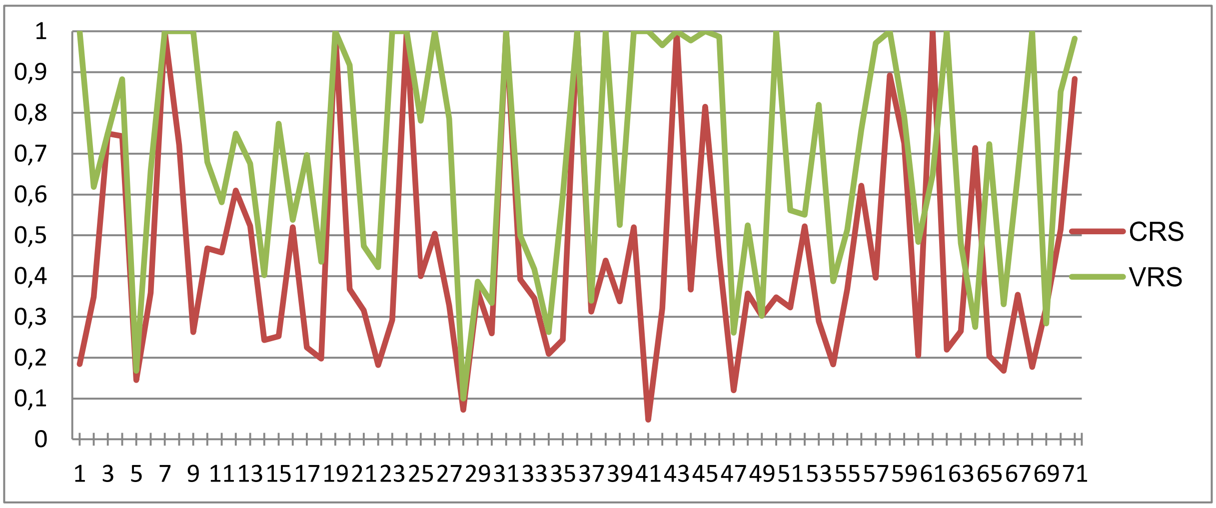

Figure IV-TE of all 71 banks (CRS-VRS comparison, 2008)

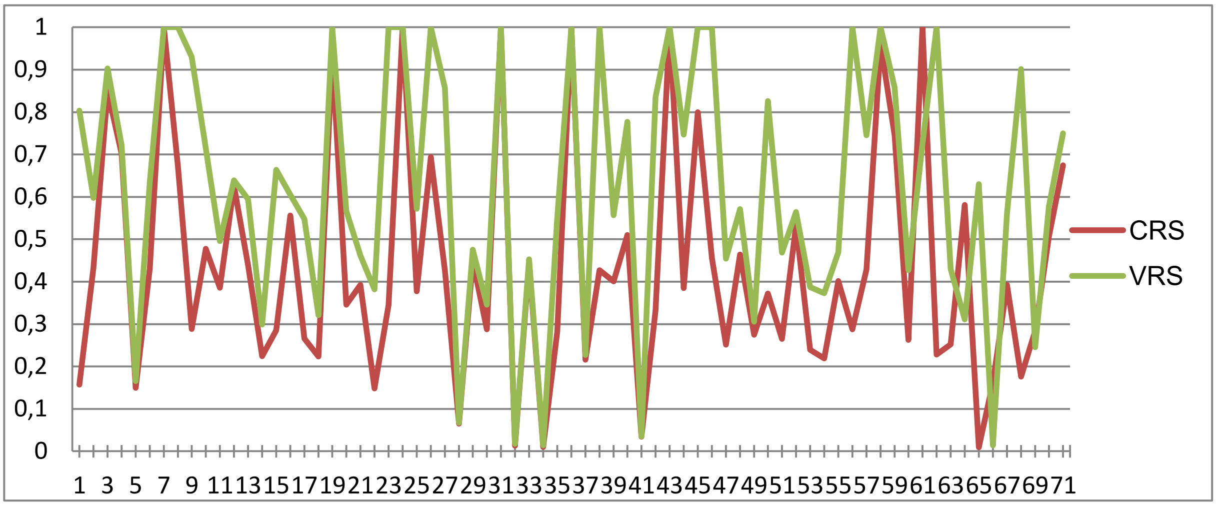


Figure V-TE of all 71 banks (CRS-VRS comparison, 2009)

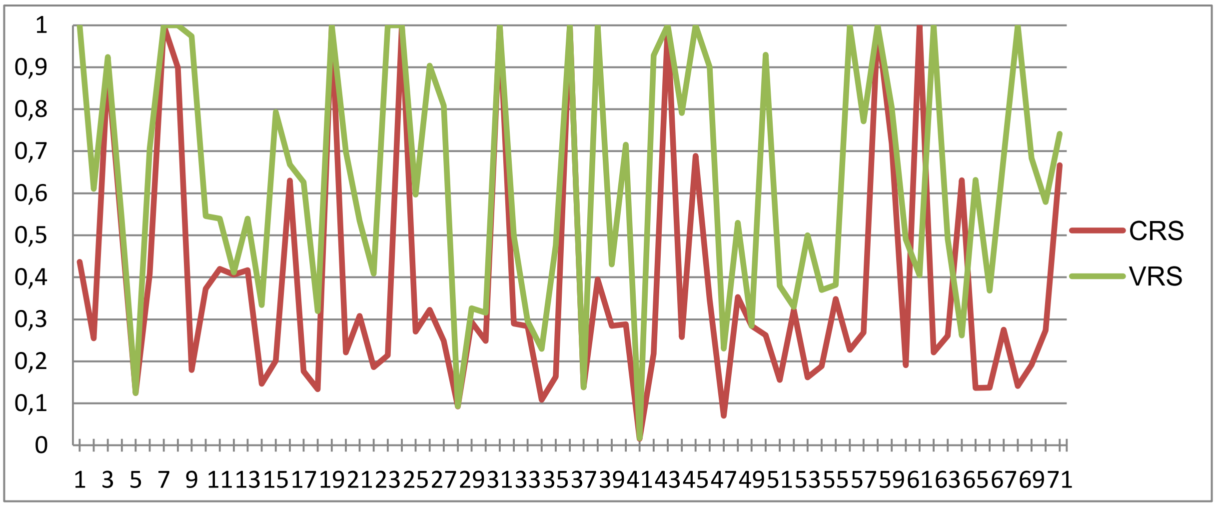


Figure VI-TE of all 71 banks (CRS-VRS comparison, 2010)

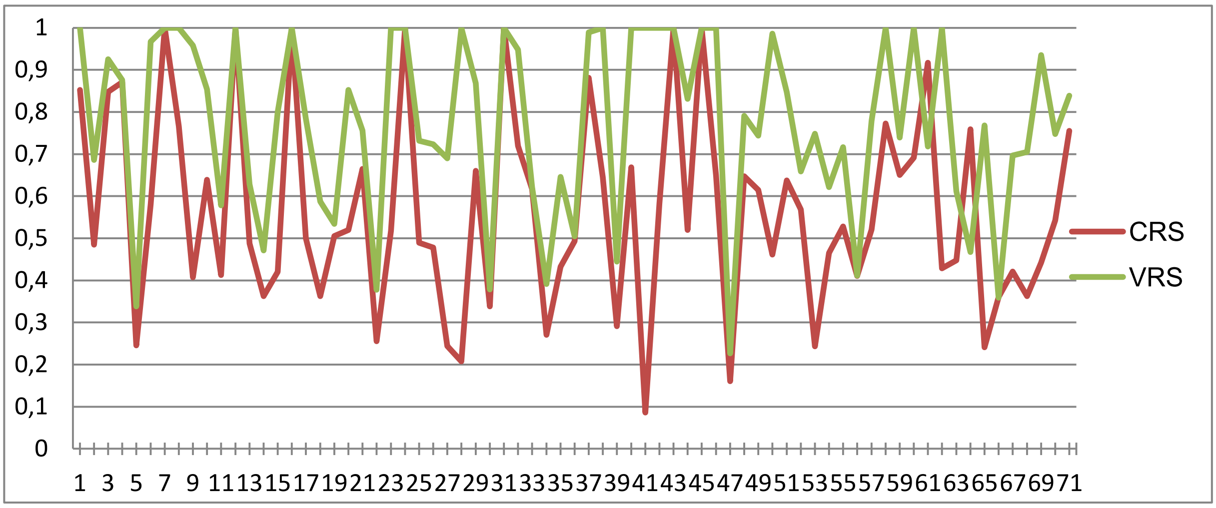

Figure VII- CRS-TE box plots (2006-2010)

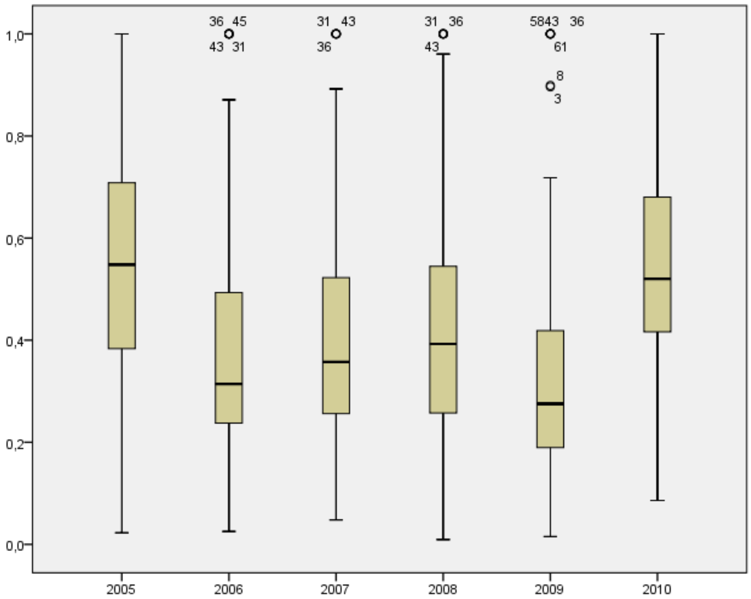


Figure VIII- VRS-TE box plots (2006-2010)

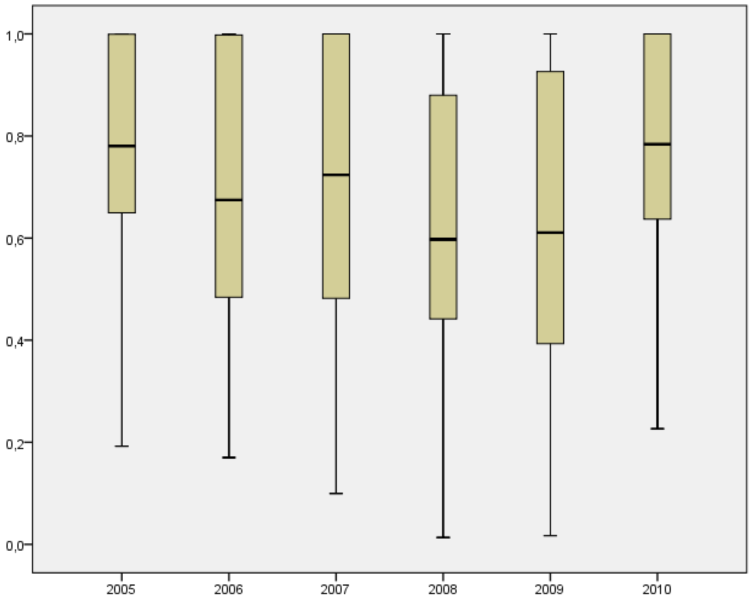

Table V – List of banks

| 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 |

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| 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 |