The influence of banks' internal performance on market performance: a non-parametric approach

M. Oberholzer, G. van der Westhuizen &
S. van Rooyen

ABSTRACT

The purpose of the study is to determine the degree to which banks' market performance, as measured by market value ratios, is affected by their internal performance. Annual financial statement reports were used to determine the internal and market performance of listed banks on the JSE Limited over a ten-year period. The internal performance measures used are the profitability ratios in the Du Pont analysis and two Data Envelopment Analysis (DEA) models to estimate efficiency. Income statement data were included as the output of the first model to determine banks' operating efficiency, and balance sheet data were included as the output of the second model to determine banks' finance and investment efficiency. The study concluded that market value ratios correlate better with profitability ratios than the income statement output-based and balance sheet output-based efficiencies. This study is the first to compare two DEA models and profitability ratios with market value ratios. The value of the study is therefore that it indicates that profitability ratios should be used as a proxy for market value ratios rather than efficiency measures that focus separately on income statement data and balance sheet data.

Key words: allocative efficiency, cost efficiency, Data Envelopment Analysis, Du Pont analysis, market value ratios, technical efficiency

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Profs M. Oberholzer and S. van Rooyen are at the WorkWell Research Unit for Economic and Management Sciences, North-West University, Potchefstroom. Prof. G. van der Westhuizen is at the Unit for Business Mathematics and Informatics, Vaal Triangle Campus of the North-West University, Vanderbijlpark. E-mail: Merwe.Oberholzer@nwu.ac.za

Introduction

In measuring the performance of an organisation, there are several tools that can be used, one of which is financial ratio analysis. Different financial ratios provide different answers in relation to organisational performance, and no single ratio provides an adequate indication of a bank's performance (Halkos & Dimitrios 2004: 201–224). Therefore, the components of the Du Pont analysis, which combine several financial ratios in three profitability ratios, are used since this analysis measures profit relative to the sales, assets and equity of each bank (Brigham & Ehrhardt 2006: 458).

Another tool for measuring performance is efficiency estimates. The two most widely used quantitative techniques for measuring relative productivity (or relative efficiency) are Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) (Coelli, Rao, O'Donnell & Battese 2005: 161). DEA is used in this study as an efficiency measurement because it lends itself more easily to the analysis of multiple-output firms. Banks can be regarded as multiple-output firms since different outputs can be identified (for example, interest income, non-interest income and deposits, loans) (Cronje 2002: 34–37). DEA is a technique for combining all the input (for example, Rand value of equity, assets and interest expenditure) (Cronje 2002: 34–37) and output data of the bank into a single measure of productive efficiency, which lies between zero (meaning the firm is altogether inefficient) and one (which signals that the firm is fully efficient).

Market value ratios are the third performance measure in this study. These are an indication of investors' opinion with regard to firms' past performance and future prospects (Dunis & Reilly 2004: 231). There are many different market value ratios, also known as multiples, that are similar to the profitability ratio indications of relative performances, and different authors suggest using different ratios (Park & Lee 2003; Dunis & Reilly 2004). In this study, five ratios are selected, which all have the market share price as a common component.

The first two measures, namely profitability analysis and DEA efficiency estimates, indicate performance from an internal point of view, while the market value ratios indicate the performance from an external point of view. This study will compare the results of the two internal performance measures with the external performance measure for South African listed banks.

Literature review and statement of the problem

The results of profitability ratios and market value ratios are easy to calculate and readily available from financial and market reports, while DEA is more complex and not readily available.

DEA was developed by Charnes, Cooper and Rhodes (1978) as a linear programming technique for evaluating the relative efficiency of public sector non-profit organisations. Sherman and Gold (1985) were the first to apply DEA to banking. DEA has previously been used to study the performance of banks, since it is suitable for multiple-input–multiple-output firms such as banks, at both corporate level (for example, Halkos & Dimitrios 2004; Devaney & Weber 2000; Berger & Humphrey 1997; Resti 1997; Cronje 2002) and at the branch level (for example, Sherman & Ladino 1995; Sherman & Gold 1985; Oral & Yolalan 1990; O'Donnell & Van der Westhuizen 2002; Van der Westhuizen 2008).

These studies used different variables in their DEA models, including a combination of income statement data, balance sheet data and other non-financial data, for example the number of staff (Cronje 2002: 34–36). Other studies, such as Halkos and Dimitrios (2004) and Chen (2002), used financial ratio output variables without input variables, while Zhu (2004) used a combination of financial statement data and financial ratios in his DEA model.

The study by Halkos and Dimitrios (2004), which compared the DEA efficiency estimates with financial ratios, concluded that DEA is superior to financial ratios as a performance measure, since there is only a low correlation between the DEA results and the individual ratios. Therefore, they suggest that DEA and financial ratios should be used to complement each other. This corresponds with the conclusions of Oberholzer and Van der Westhuizen (2004) and Yeh (1996). The study by Oberholzer and Van der Westhuizen (2004) found mixed results with regard to the correlation between DEA and a number of financial ratios. Hassan Al-Tamimi and Lootah (2007: 333) found that financial ratios fail to consider multiple outputs that are provided by multiple inputs. In their study, they used two separate DEA models, one focused on the profitability efficiency and the other on the operational efficiency, and financial ratios. With both DEA models, they could identify top and poor performers, since the results were consistent over time, which was not the case with the financial ratios.

However, in spite of widespread adoption of ratio analysis and DEA in banks, the problem has been identified that there has been no empirical linkage between the market value ratios and the efficiency of banks' operating activity, finance/investment activity and profitability ratios. This study also measures DEA efficiency using two separate DEA models. The first model focuses on the efficiency of banks' operating activity, as measured mainly by the income statement, and the second model focuses on the efficiency of banks' finance/investment activity, as measured mainly by the balance sheet. (To simplify references, these two models will be indicated as (1) income statement output-based and (2) balance sheet output-based). Where previous

studies compared DEA efficiency estimates with (internal) financial ratios, this study is the first to take it further and compare DEA efficiency estimates and profitability ratios with (external) market value ratios.

With reference to the problem identified, the research question is: To what extent are market value ratios affected by profitability ratios and DEA efficiency estimates? The results will therefore indicate the change in market value ratios when there is a change in the profitability ratios, the operating activity (measured by the income statement output-based model), and finance/investment activity (measured by the balance sheet output-based model). Accordingly, the study aims to investigate the strength of the monotonic relationship between the three profitability ratios, the two DEA models and five market value ratios.

Objectives

With reference to the research question, the objectives of this paper are as follows:

- To measure performance by using the profitability ratios of profit margin, return on assets and return on equity
- To measure performance by using the market value ratios, namely price/book value, price/cash flow, price/earnings, price/net asset value, and price/EBITDA (earnings before interest, taxes, depreciation and amortisation)
- To measure performance by using two DEA models – one that is income statement output-based and another that is balance sheet output-based – in order to estimate technical, allocative and cost efficiency
- To determine the relationship between the profitability and the two DEA model estimates with the market value ratios.

Hypotheses

The conceptual framework of the study is that profitability ratios, EVA efficiency estimates and market value ratios are all performance measurements. A positive relationship between them is therefore expected. The profitability ratios return on equity and return on assets is a combination of income statement and balance sheet data, while the profit margin is calculated from income statement data alone. The income statement output-based model mainly uses income statement data, with some balance sheet data, while the balance sheet output-based model mainly uses balance sheet data and some income statement data. Therefore, only an empirical investigation will indicate the different extent to which market value ratios are affected by the three measures of performance. With this in mind, and also with

reference to the objective of the study, the following null hypotheses for each bank under review, as well as all the banks together, will be tested:

1. H_0: There is no significant relationship between the profitability ratios and market value ratios.
2. H_0: There is no significant relationship between the DEA income statement output-based efficiency estimates and market value ratios.
3. H_0: There is no significant relationship between the DEA balance sheet output-based efficiency estimates and market value ratios.

DEA methodology

DEA involves the use of linear programming methods to construct a non-parametric piecewise surface (or frontier) over the data. This means that efficiency measures are then calculated relative to this surface (Coelli et al. 2005: 162) and it does not try to associate a unit, such as a bank, with statistical averages that may not be applicable to that bank (Avkiran 1999: 207). DEA thus measures the efficiency of a bank relative to its peers, which are the other banks included in the study, and not in relation to a theoretical maximum. DEA can be used to estimate four main types of efficiency: technical, allocative, cost and scale efficiency. In practice, the measurement of these efficiencies involves estimation of production frontiers. DEA effectively estimates the frontier by finding a set of linear segments that envelop the observed data. For example, assume the observed data comprise two-input, single-output firms M, R and A, the DEA estimate of the production frontier will be the piecewise linear surface VMRV' depicted in Figure 1.

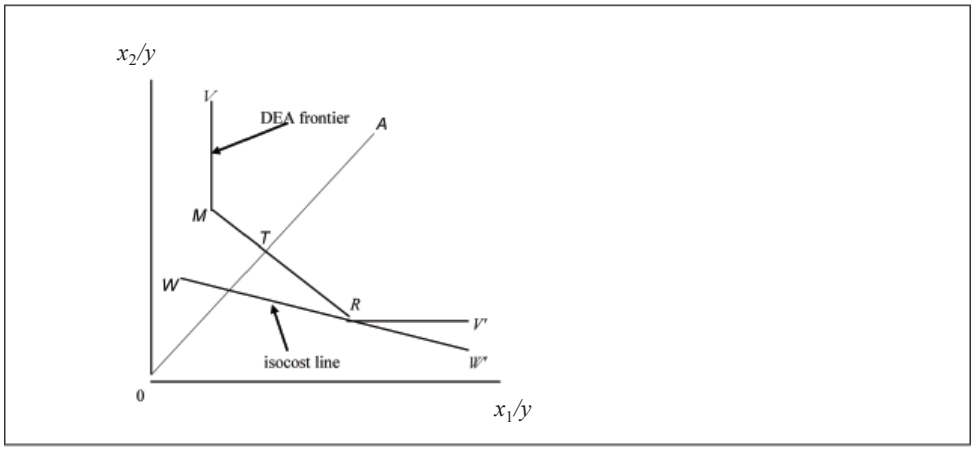

Figure 1: Two-input single-output DEA frontier

A firm is said to be technically efficient if it produces a given set of outputs using the smallest possible amount of inputs. Allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices (Avkiran 1999: 206–207). A firm is cost efficient if it is both technically and allocatively efficient. The firm is said to be scale efficient if it operates on a scale that maximises productivity (Avkiran 1999: 211).

It is important to note that in Figure 1, MV and RV' are parallel to the respective axes. A firm producing on this part of the frontier does not represent an efficient point, because the use of the respective inputs can be reduced without any reduction in output (Coelli et al. 2005: 164).

The original model proposed by Charnes et al. (1978: 430) and adopted by Sherman and Gold (1985: 312) is formulated as follows:

Objective function

$$\max E_o = \frac{\sum_{i=1}^{k} u_i \psi_{io}}{\sum_{j=1}^{m} v_j x_{jo}}, \qquad \text{(i.e. maximise } \frac{output\ index}{input\ index}\text{)} \qquad (1)$$

where

o = the branch being assessed from the set of $r = 1, 2, ..., n$ bank branches;
k = the number of outputs at the branches;
m = the number of inputs at the branches;
ψ_{ir} = observed output i at branch r;
χ_{jr} = observed input j at branch r.

Constraints

$$\frac{\sum_{i=1}^{k} u_i \psi_{io}}{\sum_{j=1}^{m} v_j x_{jo}} \leq 1 \text{ for all } r = 1, ..., n \quad \text{(boundary constraints)} \qquad (2)$$

$$u_i, v_j \geq 0, \text{ for all } i = 1, ..., k \text{ and } j = 1, ..., m \text{ (non-negativity constraints)} \qquad (3)$$

This analysis is performed repetitively, with each bank branch in the objective function, producing efficiency ratings for each of the 'n' branches. The solution sought is the set of (u_i, v_i) values that maximise the efficiency ratio E_o of the bank branch being rated, without resulting in an output/input ratio of 1 when applied to each of the other branches in the dataset. (For a more detailed discussion of the DEA methodology, refer to Cronje [2002], Avkiran [1999] and Coelli et al. [2005].)

Data sources and method

Financial statement data at year-end from 1998 to 2007 were obtained from the McGregor database. At the time of data extraction, 2007 was the latest year for which all the banks in the sample had complete data. The reason for including data for ten years (1998 to 2007) was to ensure that the application of regression analysis is scientific. Eight banks were listed on the JSE Limited. Only five of the banks are included in the study: ABSA, Nedcor, First National Bank, Standard Bank and Mercantile Bank. The banks that are excluded are Saambou, which ceased operations in 2005, Rand Holdings BM, for which only incomplete data are available, and Capitec, which has been operational only since 2002. The total assets of the five banks included in the study represent 85.28 per cent of all 35 banks that were operating in South Africa at the end of 2007 (SARB 2009).

In order to achieve the first and the second objectives, namely to measure performance by using profitability and market value ratios, data were taken from the McGregor database. The third objective was to calculate the DEA efficiency estimates. The income statement and balance sheet data were also provided by the McGregor database. In total, 50 data points are available (5 banks x 10 periods). This is sufficient according to Avkiran (1999: 208), who states that the sample size should be three times as large as the sum of the chosen variables in the DEA models. Each of the models defined uses two input and two output variables (refer to DEA models).

The fourth objective was to determine the relationship between the profitability and market value, and DEA efficiency estimates and market value. The rank order correlation coefficient of Spearman may be used to determine whether there is a monotone dependence between the profitability ratios, the DEA efficiencies in the two models, and the market value ratios of each bank. Rank order correlation is a non-parametric technique for determining the strength of the relationship between two variables. Non-parametric means that the correlation statistics are not affected by the type of mathematical relationship between variables, unlike the least square regression analysis, which requires the relationship to be linear (Vose 1996: 33). The Spearman rank order correlation coefficient is a more general measure

of any kind of monotonic relationship between x and y. This measure is based on ranks and is therefore not as sensitive for outliers (Millard & Neerchal 2001: 534). Regression analysis with a single independent variable requires a sample of at least ten observations (Sekaran 2006: 294–297; Hanke, Wichern & Reitsch 2001: 73). Each bank provides ten data points over the ten-year period.

In order to test the hypotheses, the p-values are calculated to determine the extent to which they are rejected or not rejected.

Profitability ratios, DEA model and market value ratios

Profitability ratios

The Du Pont analysis indicates how return on equity is affected by the profit margin (which is net profit/total income), return on assets (which is the profit margin x total income/assets) and leverage (assets/equity) (Brigham & Ehrhardt 2006: 457; Correia, Flynn, Uliana & Wormald 2007: 5–21).

DEA model

Two main approaches to define inputs and outputs in banking are used, namely the intermediation and the production approach. According to Berger and Humphrey (1997: 197), under the production approach, banks produce accounts of various sizes by processing deposits and loans, incurring capital and labour costs. Under the intermediation approach, banks intermediate deposited and purchased funds into loans and other assets. Favero and Papi (1995: 388–389) identify another three approaches to the input and output specifications, namely: (1) the asset approach, (2) the user cost approach and (3) the value added approach.

In this paper, a combination of approaches was used. Stavarek (2002) used equity as an input with a number of other inputs. Fixed assets, or physical capital, was used as an input by various authors, *inter alia*, Wheelock and Wilson (1995), Favero and Papi (1995) and Elyasiani and Mehdian (1990, 1992). To some extent, the approach used by Rangan, Grabowsky, Aly and Pasurka (1988) is adopted. The main reason for using this approach in Model 2 is that only balance sheet data were used in the case of outputs. Loans and deposits were also used as outputs by, *inter alia*, Aly, Grabowsky, Pasurka and Rangan (1990) and Berger and Humphrey (1997). Equity and fixed assets were used in various combinations as inputs by Rangan et al. (1988), Berger and Humphrey (1997), Aly et al. (1990) and Favero and Papi (1995). In the case of Model 1, only income statement data were used for the outputs, which corresponds

with the models used by Hassan Al-Tamimi and Lootah (2007), Charnes, Cooper and Haung (1990) and Chen (1998). There are many possible variables to include in a DEA model. It is important to emphasise that the variables included could impact the correlation results. It was decided to use two models, which are specified as follows:

Model 1 (income statement-based outputs)

Outputs:	y_1	=	Rand value of interest income
	y_2	=	Rand value of non-interest income
Inputs:	x_1	=	Rand value of deposits
	x_2	=	Rand value of staff and operating costs
Input prices:	w_1	=	(Rand volume of interest expenses)/x_1
	W_2	=	Production price index (StatsSA 2009)

Model 2 (balance sheet-based outputs)

Outputs:	y_1	=	Rand value of deposits
	y_2	=	Rand value of loans
Inputs:	x_1	=	Rand value of equity
	x_2	=	Rand value of fixed assets
Input prices:	W_1	=	Production price index (StatsSA 2009)
	w_2	=	(Rand value of depreciation)/x_2

The inputs and outputs in Model 1 are not taken from the income statement alone. The input (Rand value of deposits) is a balance sheet item, but the input price (Rand volume of interest expenses) is an income statement item. If the income statement item (Rand volume of interest expenses) were used as the input, then deposits would have been the input price, which does not make any sense. All the inputs and outputs in Model 2 are balance sheet items, but the input price depreciation is an income statement item.

The International Accounting Standards (IAS 30: §10) (IASB 2005) requires that banks should report specific amounts (for example, interest income, interest expenses, dividend income). The interest income, deposits and loans used in the models are the amounts that are based on banking operations. For example, investment income does not form part of the interest income, and investments do not form part of loans.

Market value ratios

The first market value ratio is the price/earnings ratio, which is the current share price divided by annual earnings per share. The ratio provides an indication of how much investors would be willing to pay per Rand of profit. The price/earnings ratio is often linked to an organisation's growth prospects. The price/earnings ratio for a firm with higher growth prospects would be higher than for an organisation with lower growth prospects, because the investor would be willing to pay more for a higher expected growth in earnings (Fairfield & Harris 1993: 591; Brigham & Ehrhardt 2006: 452).

The price/EBITDA is a variation of the price/earnings ratio. Because the accounting of these expenses may differ between firms, the price/EBITDA ratio adjusts for the accounting of these expenses. EBITDA omits depreciation and taxes and will therefore be relevant for companies with large capital investments that result in large depreciation charges (Penman 2007: 49).

The value of any organisation is the present value of the future free cash flows, and the price/cash flow ratio is therefore useful, especially where the price of a share is more related to cash flows than net income (Park & Lee 2003: 335; Brigham & Ehrhardt 2006: 452).

The price/book value ratio is a market value ratio that provides an indication of expectations of future performance by relating the market price of a share to the book value of the share (Dunis & Reilly 2004: 231). Accordingly, a high price/book value ratio can be linked to higher rates of return on equity. A variation of the price/book value ratio is the price/net asset value ratio, which compares the market price per share to the net asset value per share. According to the formula Equity = Assets – Liabilities, the net asset value, which is Assets – Liabilities, is the same as the book value of equity. However, the McGregor database calculates net asset value as Tangible Assets – Current and Long-term Liabilities.

Empirical results

Profitability ratios and market value ratios

Table 1 indicates the results of the profitability ratios included in the Du Pont analysis (objective 1). It seems that Bank 1 and Bank 2 are the most profitable. Bank 2 is the most profitable according to the profit margin (PM) ratio, with an average of 15.4 per cent, while Bank 1 is the most profitable according to the return on equity (ROE) ratio, with an average of 19.7 per cent, and the return on assets (ROA) ratio of Banks 1, 2, and 5 are the same with an average of 1.3 per cent. The average profit margin,

Table 1: Annual results from 1998 to 2007 per bank (n = 10) and in total (n = 50) of financial ratio analysis and market ratio analysis

Bank	Profitability ratios			Market value ratios				
	PM	ROA	ROE	P/ book	P/cash	P/E	P/NAV	P/ EBITDA
1	0.147	0.016	0.233	2.08	5.51	8.27	1.62	153.22
	0.163	0.016	0.232	2.49	8.50	9.97	1.95	222.73
	0.179	0.029	0.452	2.50	5.85	10.73	2.07	140.89
	0.125	0.015	0.225	1.53	4.11	6.64	1.19	113.57
	0.092	0.013	0.193	1.21	4.57	5.93	0.99	76.54
	0.040	0.005	0.080	1.13	2.63	9.15	0.91	93.99
	0.090	0.013	0.175	1.52	6.65	8.44	1.21	108.83
	0.034	0.005	0.075	1.32	10.26	7.80	1.07	83.67
	0.060	0.011	0.157	1.73	8.07	10.04	1.43	80.23
	0.061	0.010	0.146	2.63	12.10	15.04	2.16	129.45
Average	0.099	0.013	0.197	1.81	6.83	9.20	1.46	120.31
2	0.180	0.016	0.217	3.03	9.24	11.29	0.60	269.48
	0.193	0.015	0.222	2.76	8.93	10.81	0.54	292.45
	0.195	0.017	0.225	2.72	4.28	9.64	0.44	273.66
	0.167	0.013	0.195	2.22	7.62	9.20	0.35	230.26
	0.125	0.012	0.189	1.88	7.64	8.55	0.28	167.46
	0.159	0.012	0.199	2.08	8.21	8.95	0.28	217.98
	0.162	0.014	0.199	2.69	10.99	12.36	0.41	298.16
	0.154	0.014	0.210	2.79	10.64	13.05	0.42	268.39
	0.095	0.013	0.224	3.31	11.54	14.21	0.55	184.81
	0.110	0.004	0.073	5.64	60.10	33.73	0.83	1134.12
Average	0.154	0.013	0.195	2.91	13.92	13.18	0.47	333.68
3	0.229	0.035	0.193	1.59	7.43	8.29	1.64	310.27
	0.205	0.022	0.149	1.53	9.11	10.00	1.56	333.89
	0.186	0.020	0.121	2.50	13.45	20.59	2.53	682.62
	−0.746	−0.079	−0.427	1.18	−47.88	−1.28	1.19	−668.38
	−0.193	−0.027	−0.371	0.78	−2.91	−2.27	0.85	106.25
	−0.608	−0.221	−2.599	0.51	−0.23	−0.16	0.56	−218.12
	−0.142	−0.023	−0.164	0.22	−2.12	−2.48	0.25	47.29
	−0.326	−0.054	−0.374	0.55	−1.98	11.74	0.55	202.82
	0.097	0.019	0.087	0.95	8.72	10.15	0.95	162.79
	0.012	0.003	0.027	0.95	8.72	10.15	0.95	162.79
Average	−0.129	−0.031	−0.336	1.08	−0.77	6.47	1.10	112.22

Bank	Profitability ratios			Market value ratios				
	PM	ROA	ROE	P/ book	P/cash	P/E	P/NAV	P/ EBITDA
4	0.127	0.013	0.182	1.77	6.04	8.95	1.39	1.77
	0.132	0.012	0.161	2.00	7.51	11.44	1.52	2.00
	0.134	0.012	0.155	1.68	8.10	11.80	1.37	1.68
	0.039	0.004	0.054	1.66	8.97	19.03	1.43	1.66
	–0.043	–0.005	–0.096	1.51	–36.24	319.90	1.00	1.51
	0.038	0.004	0.057	1.83	9.79	11.27	1.33	1.83
	0.000	0.000	0.000	1.92	7.28	7.49	1.91	1.92
	0.338	0.040	0.376	2.46	5.46	12.56	2.27	2.46
	0.050	0.007	0.069	3.04	22.71	12.23	2.76	3.04
	0.094	0.019	0.239	2.53	9.13	12.58	2.36	2.53
Average	0.091	0.011	0.120	2.04	4.88	42.73	1.73	2.04
5	0.188	0.014	0.248	2.41	5.99	10.13	0.51	194.43
	0.166	0.012	0.208	2.53	7.53	10.68	0.48	204.18
	0.166	0.012	0.225	2.94	10.36	10.20	0.53	233.65
	0.196	0.015	0.230	2.83	5.66	10.54	0.58	218.69
	0.160	0.013	0.207	1.78	6.98	8.15	0.38	136.21
	0.133	0.015	0.176	1.56	3.39	7.71	0.38	134.31
	0.159	0.014	0.176	1.46	7.37	8.51	0.34	152.08
	0.168	0.015	0.191	2.18	9.25	10.24	0.44	186.61
	0.064	0.007	0.090	2.16	23.69	9.75	0.38	140.13
	0.071	0.011	0.128	1.49	7.40	9.10	1.30	99.64
Average	0.147	0.013	0.188	2.13	8.76	9.50	0.53	169.99
Total Average	0.072	0.004	0.073	2.00	6.72	16.22	1.06	147.65

return on assets and return on equity for all the banks together are 7.3 per cent, 0.4 per cent and 7.3 per cent, respectively. (The averages were used merely as an explanation of the data. Note that the median could also be suitable as an aggregation to explain the data.)

Table 1 also indicates the market value ratios (objective 2). It seems as if Bank 2 has outperformed the other banks with regard to their market ratios. Bank 4 has an extremely high average price/earnings ratio (P/E) in comparison with the other banks; however, it would seem that this figure has been distorted by the unusually high price/earnings ratio of 319.90 in one quarter. If this period's price/earnings ratio is omitted, the average for the remaining nine periods is 11.93. This figure seems more in line with the other banks, in which case Bank 2 has the highest average

price/earnings ratio (13.18). Bank 2 also has the highest average price/book ratio (2.91), price/cash flow ratio (13.92) and price/EBITDA ratio, but the lowest ratio of price to net asset value (P/NAV) (0.47). These figures suggest that investors might expect higher future performance from Bank 2 than from the other banks. Bank 3 has the lowest price/book value (1.08), price/cash flow (-0.77) and price/earnings (6.47) ratios, which could indicate that investors have lower expectations of future performance than for the other banks.

DEA results

The third objective is to measure performance by using DEA models that are income statement output-based and balance sheet output-based. The software package DEAP version 2.1 by Coelli (1996) is purpose-built to solve the DEA problem and has been used in this paper to generate estimates of technical, allocative and cost efficiency for each observation in the data set (in other words, for each bank in each year).

Table 2 presents the necessary results of the DEA efficiency estimates. According to Model 1, Bank 3 is, on average, the most technically efficient (TE), with an estimate of 93.5 per cent, which means that the bank can increase its output by 6.5 per cent without increasing its input. According to Model 2, Bank 1 is the most technically efficient, with an estimate of 91.8 per cent, which means it can increase its output by 8.2 per cent without increasing its input. According to the two models, the average technical efficiency of all the banks together is 89.5 per cent and 79.0 per cent, respectively. Bank 4 and Bank 2 are the most allocative efficient (AE) banks according to Model 1 and Model 2 respectively. The estimates are 99.7 per cent and 99.9 per cent respectively, which means that Bank 4 can increase its output by 0.3 per cent, and Bank 2 can increase its output by 0.1 per cent, just by altering their input mixes. According to the two models, the average allocative efficiency of all the banks together is 98.5 per cent and 89.3 per cent respectively. Technical and allocative efficiency combined provide cost efficiency (CE). According to Model 1, Bank 3 is the most cost efficient, while Bank 1 is the most cost efficient according to Model 2, with estimates of 91.3 per cent and 90.4 per cent respectively. According to the two models, the average cost efficiency for all the banks together is 88.4 per cent and 69.7 per cent respectively.

The technical efficiency of all the banks, except Bank 1, is higher in Model 1 than it is in Model 2. The overall technical efficiency estimate for Model 1 (89.5 per cent) is also higher than the estimate of Model 2 (79.0 per cent). Allocative efficiency, however, has mixed results with regard to the two models. The difference between the allocative efficiency of Model 1 and Model 2 is marginal for Bank 1, higher for

Banks 2, 4 and 5 for Model 2, and higher for Bank 3 for Model 1. The overall averages are misleading with regard to allocative efficiency because of the distortion of the estimate of Bank 3, which is extremely low for Model 2. Another distortion problem experienced in Table 1 is that in Model 1, 27 out of 50 allocative efficiency estimates are the maximum of 100 per cent. That means that the ranking is from 1 to 23, and 27 estimates are ranked together at 24th place. There is a similar problem in Model 2, in that 26 out of 50 allocative efficiency estimates are 100 per cent, which means that the ranking is from 1 to 24, and 26 estimates are ranked together at 25th place.

Table 2: Annual results from 1998 to 2007 per bank (n = 10) of DEA efficiencies of Model 1 and Model 2

Bank	DEA results					
	Model 1			Model 2		
	TE	AE	CE	TE	AE	CE
1	0.917	0.942	0.864	0.864	1.000	0.864
	1.000	1.000	1.000	0.847	1.000	0.847
	0.818	0.933	0.763	0.894	1.000	0.894
	0.746	0.966	0.721	0.812	1.000	0.812
	0.791	1.000	0.791	0.942	1.000	0.942
	0.883	1.000	0.883	0.895	0.946	0.847
	0.903	1.000	0.903	0.925	0.906	0.838
	0.886	1.000	0.886	1.000	1.000	1.000
	0.921	1.000	0.921	1.000	1.000	1.000
	1.000	1.000	1.000	1.000	1.000	1.000
Average	0.887	0.984	0.873	0.918	0.985	0.904
2	0.382	0.891	0.340	0.789	1.000	0.789
	0.865	1.000	0.865	0.675	1.000	0.675
	1.000	1.000	1.000	0.517	1.000	0.517
	0.867	0.985	0.854	0.490	1.000	0.490
	0.945	1.000	0.945	0.594	1.000	0.594
	0.820	0.965	0.791	0.573	1.000	0.573
	0.821	1.000	0.821	0.541	1.000	0.541
	0.943	1.000	0.943	0.488	1.000	0.488
	0.915	1.000	0.915	0.630	1.000	0.630
	0.842	1.000	0.842	0.694	0.994	0.690
Average	0.840	0.984	0.832	0.599	0.999	0.599
3	0.994	1.000	0.994	0.760	0.960	0.730
	0.966	0.999	0.965	0.589	0.530	0.312
	0.956	0.991	0.947	0.538	0.811	0.436
	0.841	0.949	0.798	0.772	0.683	0.527

Bank	DEA results					
	Model 1			Model 2		
	0.651	0.797	0.519	0.958	0.987	0.946
	0.939	1.000	0.939	1.000	1.000	1.000
	1.000	1.000	1.000	1.000	0.349	0.349
	1.000	0.968	0.968	0.971	0.393	0.382
	1.000	1.000	1.000	1.000	0.405	0.405
	1.000	1.000	1.000	1.000	0.339	0.339
Average	0.935	0.970	0.913	0.859	0.646	0.543
4	0.982	1.000	0.982	0.779	1.000	0.779
	1.000	1.000	1.000	0.684	0.839	0.574
	0.933	0.983	0.917	0.752	0.751	0.565
	1.000	1.000	1.000	0.875	0.838	0.733
	0.957	1.000	0.957	0.873	0.890	0.777
	0.843	1.000	0.843	1.000	1.000	1.000
	0.722	1.000	0.722	0.932	0.875	0.816
	0.774	1.000	0.774	0.796	0.896	0.713
	0.807	1.000	0.807	0.888	0.948	0.842
	0.986	0.989	0.975	0.931	0.991	0.923
Average	0.900	0.997	0.898	0.851	0.903	0.772
5	0.838	0.944	0.791	0.656	1.000	0.656
	0.786	0.990	0.778	0.556	0.916	0.509
	0.826	0.984	0.813	0.513	1.000	0.513
	0.888	0.994	0.883	0.518	1.000	0.518
	0.895	1.000	0.895	0.499	1.000	0.499
	0.943	1.000	0.943	0.750	0.755	0.566
	0.971	1.000	0.971	0.892	0.713	0.636
	0.981	1.000	0.981	0.946	0.934	0.884
	1.000	0.996	0.996	0.913	1.000	0.913
	1.000	1.000	1.000	1.000	1.000	1.000
Average	0.913	0.991	0.905	0.724	0.932	0.669
Total	0.895	0.985	0.884	0.790	0.893	0.697

Relationship between the variables

Tables 3, 4 and 5 will be helpful in determining the degree to which market value ratios are affected by profitability and DEA efficiency estimates.

Table 3 presents the Spearman's correlation coefficient (r) between the profitability ratios and the market value ratios. The p-value, for testing the null hypothesis, is also

Table 3: Correlation coefficient (r) between profitability ratios and market value ratios, and testing of the hypothesis (p)

Bank	Profit ratio	r & p	Market value ratio				
			P/book	P/cash	P/E	P/NAV	P/EBITDA
1	PM	r	0.552	−0.176	0.079	0.527	0.697
		p	0.099*	0.596	0.810	0.114	0.037**
	ROA	r	0.552	−0.079	0.067	0.539	0.673
		p	0.099*	0.810	0.841	0.105	0.043**
	ROE	r	0.491	−0.261	0.018	0.467	0.624
		p	0.142	0.435	0.960	0.162	0.061*
2	PM	r	−0.236	−0.624	−0.394	−0.012	0.358
		p	0.239	0.061*	0.234	0.976	0.285
	ROA	r	0.115	−0.333	−0.018	0.243	0.285
		p	0.726	0.317	0.960	0.465	0.395
	ROE	r	0.285	−0.115	0.152	0.336	0.030
		p	0.395	0.726	0.653	0.317	0.928
3	PM	r	0.619	0.758	0.361	0.606	0.800
		p	0.063*	0.023**	0.280	0.069*	0.015**
	ROA	r	0.679	0.709	0.348	0.655	0.788
		p	0.041**	0.033**	0.298	0.050**	0.018**
	ROE	r	0.679	0.709	0.348	0.655	0.788
		p	0.041**	0.033**	0.298	0.050**	0.018**
4	PM	r	0.345	−0.067	−0.079	0.309	0.345
		p	0.298	0.841	0.810	0.352	0.298
	ROA	r	0.515	0.018	−0.055	0.430	0.515
		p	0.121	0.960	0.873	0.197	0.121
	ROE	r	0.564	0.006	−0.067	0.467	0.564
		p	0.091*	0.984	0.841	0.162	0.091*
5	PM	r	0.663	−0.307	0.626	0.431	0.724
		p	0.047**	0.358	0.060*	0.197	0.030**
	ROA	r	0.055	−0.576	−0.006	−0.100	0.139
		p	0.101	0.084*	0.984	0.764	0.674
	ROE	r	0.758	−0.345	0.515	0.457	0.745
		p	0.023**	0.298	0.121	0.171	0.025**
Total	PM	r	0.565	0.190	0.209	−0.064	0.665
		p	0.000***	0.184	0.144	0.653	0.000***
	ROA	r	0.420	0.153	0.147	0.151	0.515
		p	0.003***	0.285	0.303	0.289	0.000***
	ROE	r	0.610	0.089	0.139	−0.042	0.435
		p	0.000***	0.535	0.327	0.772	0.002***

*** Significant at a 1 per cent level (two-tailed)
** Significant at a 5 per cent level (two-tailed)
* Significant at a 10 per cent level (two-tailed)

shown. The null hypothesis is rejected at a significance level of one, five and ten percent respectively if $p < \alpha = 0.01$, $= 0.05$ and $= 0.1$, respectively (two-tailed). There are 26 (24 positive and 2 negative) significant relationships (where the null-hypothesis is rejected) out of a possible 75 (three DEA estimates x five financial ratios x five banks). The profitability ratios correlate best to the price/EBITDA and price/book value ratios. For all the banks together, a significant relationship exists at a 99 per cent confidence level between all three profitability ratios and the price/book value and the price/EBITDA ratios. The profit margin and return on equity have the highest correlation with the market value ratios, since with both of them, there are nine positive significant relationships. This is followed by return on assets where there are only six positive significant relationships.

Table 4 presents the Spearman's correlation coefficient (r) between the income statement output-based DEA estimates (Model 1) and the market value ratios. There are ten significant relationships out of a possible 75, of which only four are positive. The DEA efficiency estimates (Model 1) correlate best to the price/cash flow ratio, with two positive correlation coefficients where the relationship is significant. This is also the only ratio that is significant for all the banks together. Technical efficiency has the highest correlation with the market value ratios (with three significant relationships).

Table 5 presents the Spearman's correlation coefficient (r) between the balance sheet output-based DEA estimates (Model 2) and the market value ratios. There are 16 significant relationships out of a possible 75, nine of which are positive. The DEA efficiency estimates (Model 2) correlate best, firstly, to the price/net asset value ratio and, secondly, to the price/book value ratio. For all the banks together, there are positive significant relationships with the price/net asset value and price/book value ratios. Allocative efficiency has the highest correlation with the market value ratios, with seven positive significant relationships.

Conclusion

This study investigated the performance of five listed banks on the JSE Limited over a ten-year period. The performance is measured by means of profitability ratios, two DEA models (one of which is income statement output-based and the other of which is balance sheet output-based) and market value ratios. The research question is to determine to the extent to which market value ratios are affected by a change in profitability ratios and DEA efficiency estimates. Spearman's correlation coefficient is used to determine the relevant relationships.

Table 4: Correlation coefficient (r) between DEA estimates (Model 1) and market value ratios, and testing of the hypothesis (p)

Bank	DEA	r & p	Market value ratio				
	Model 1		P/book	P/cash	P/E	P/NAV	P/EBITDA
1	TE	r	0.523	0.728	0.613	0.587	0.357
		p	0.116	0.029**	0.066*	0.078*	0.284
	AE	r	−0.444	0.273	−0.137	−0.410	−0.512
		p	0.183	0.413	0.682	0.219	0.124
	CE	r	0.268	0.753	0.536	0.345	0.077
		p	0.421	0.024**	0.108	0.301	0.818
2	TE	r	−0.152	−0.382	−0.152	−0.185	−0.321
		p	0.649	0.252	0.649	0.578	0.335
	AE	r	0.068	0.171	0.273	0.013	0.171
		p	0.838	0.609	0.413	0.969	0.609
	CE	r	−0.115	−0.345	−0.127	−0.139	−0.273
		p	0.730	0.300	0.703	0.677	0.413
3	TE	r	−0.138	0.369	0.386	−0.203	0.328
		p	0.678	0.268	0.247	0.543	0.325
	AE	r	−0.077	0.515	0.119	−0.019	0.135
		p	0.817	0.122	0.721	0.954	0.685
	CE	r	−0.109	0.363	0.262	−0.152	0.255
		p	0.743	0.277	0.432	0.649	0.443
4	TE	r	−0.294	0.077	0.357	−0.204	−0.294
		p	0.378	0.818	0.284	0.540	0.378
	AE	r	0.082	−0.190	−0.082	0.082	0.082
		p	0.807	0.568	0.807	0.807	0.807
	CE	r	−0.357	0.013	0.281	−0.268	−0.357
		p	0.284	0.969	0.400	0.421	0.284
5	TE	r	−0.715	0.179	−0.472	−0.291	−0.728
		p	0.032**	0.592	0.157	0.383	0.029**
	AE	r	−0.763	−0.068	−0.550	−0.479	−0.744
		p	0.022**	0.839	0.099*	0.150	0.026**
	CE	r	−0.685	0.248	−0.455	−0.212	−0.709
		p	0.040**	0.456	0.173	0.525	0.033**
Total	TE	r	−0.252	0.083	0.115	0.017	−0.010
		p	0.077*	0.560	0.420	0.906	0.942
	AE	r	−0.041	0.248	0.120	−0.004	−0.094
		p	0.772	0.083*	0.402	0.976	0.512
	CE	r	−0.234	0.011	0.123	0.011	−0.018
		p	0.101	0.936	0.390	0.936	0.898

*** Significant at a 1 per cent level (two-tailed)

** Significant at a 5 per cent level (two-tailed)

* Significant at a 10 per cent level (two-tailed)

Table 5: Correlation coefficient (r) between DEA estimates (Model 2) and market value ratios, and testing of the hypothesis (p)

Bank	DEA Model 2	r & p	Market value ratio				
			P/book	P/cash	P/E	P/NAV	P/EBITDA
1	TE	r	−0.182	0.477	0.182	−0.112	−0.673
		p	0.584	0.152	0.584	0.736	0.043**
	AE	r	0.029	−0.608	−0.299	−0.010	0.492
		p	0.931	0.068*	0.369	0.977	0.140
	CE	r	−0.018	−0.491	−0.212	−0.006	0.285
		p	0.957	0.141	0.525	0.985	0.393
2	TE	r	0.467	0.418	0.248	0.591	0.200
		p	0.162	0.210	0.456	0.076*	0.549
	AE	r	0.168	−0.196	−0.126	0.244	0.070
		p	0.614	0.556	0.705	0.464	0.833
	CE	r	0.321	0.042	0.018	0.405	0.091
		p	0.335	0.899	0.957	0.224	0.785
3	TE	r	−0.621	−0.663	−0.558	−0.608	−0.455
		p	0.063*	0.047**	0.094*	0.068*	0.173
	AE	r	0.643	−0.037	−0.037	0.606	0.364
		p	0.054*	0.911	0.911	0.069*	0.275
	CE	r	0.388	−0.373	−0.199	0.327	0.158
		p	0.244	0.263	0.551	0.326	0.636
4	TE	r	0.212	0.467	−0.067	0.164	0.212
		p	0.525	0.162	0.841	0.623	0.525
	AE	r	0.612	0.079	0.515	0.697	0.612
		p	0.066*	0.813	0.122	0.037**	0.066*
	CE	r	0.430	0.212	0.455	0.624	0.430
		p	0.197	0.525	0.173	0.061*	0.197
5	TE	r	−0.127	0.200	0.055	−0.557	0.030
		p	0.703	0.549	0.870	0.095*	0.928
	AE	r	0.724	0.145	0.377	0.018	0.570
		p	0.030**	0.664	0.259	0.958	0.087*
	CE	r	0.018	0.188	0.067	−0.412	0.127
		p	0.957	0.573	0.841	0.216	0.703
Total	TE	r	−0.315	−0.189	−0.181	0.276	−0.532
		p	0.027**	0.185	0.206	0.054*	0.000***
	AE	r	0.238	−0.083	−0.040	0.032	0.202
		p	0.096*	0.559	0.777	0.823	0.157
	CE	r	0.047	0.240	−0.070	0.240	−0.114
		p	0.740	0.094*	0.622	0.094*	0.424

*** Significant at a 1 per cent level (two-tailed).
** Significant at a 5 per cent level (two-tailed).
* Significant at a 10 per cent level (two-tailed).

The following six specific findings were made, and the conclusions are as follows (note that since cost efficiency is a function of both technical and allocative efficiency, specific comments will only be made with respect to the latter two):

- Since profitability ratios have the strongest relationship with the two market value ratios, namely price/EBITDA and price/book value, the profitability ratios could probably be regarded as the most significant drivers of the two market value ratios.
- In the same regard, the profit margin and return on equity would probably be the most important profitability ratios to drive the market value ratios positively, followed by return on assets.

The conclusion is that profitability is significant with regard to what investors expect from future performances. It is also significant with regard to accounting differences of depreciation and/or differences between the relative sizes of depreciation amounts. Other factors, such as market sentiment, investor rationality and speculation, are more important than profitability with regard to (1) how much investors are willing to pay per Rand profit, (2) cash flow and (3) the over- or undervaluation of shares.

- Since the income statement output-based DEA model (1) has the strongest relationship with the market value ratio price/cash flow, the income statement output-based DEA model could probably be regarded as the most significant driver of the price/cash flow ratio.
- In the same regard, technical efficiency will probably be the most important DEA estimate in the income statement output-based model (1) to drive the market value ratios positively.

The conclusion is that the efficiency measured by the model in which the inputs are deposits, staff and operating costs and the outputs are interest and non-interest income is more significant for future cash flows than other variables in the market value ratios. In this model, changes in the input-output ratio (technical efficiency) are probably a more important driver than changes in the input mix (allocated efficiency) for changes in market value ratios.

- Since the balance sheet output-based DEA model (2) has the strongest relationship with the two market value ratios, namely price/net asset value and price/book value, the balance sheet output-based DEA model could probably be regarded as the most significant driver of the two market value ratios.
- In the same regard, allocative efficiency will probably be the most important DEA estimate in the balance sheet output-based model (2) to drive the market value ratios.

The conclusion is that the efficiency measured by the model in which the inputs are equity and fixed assets and the outputs are deposits and loans are more significant for the over- or undervaluation of shares and the Rand per profit that investors are willing to pay than other variables in the market value ratios. In this model, changes in input mix are more important than changes in the input-output ratio when there are changes in the market value ratios.

The study also found that there is a higher degree of positive relationship between the profitability ratios and market value ratios than in the case of DEA efficiency estimates and market value ratios. The balance sheet output-based DEA efficiencies also correlate more highly to market value ratios than the income statement-based efficiency estimates. The study therefore concludes that changes in profitability are probably the most significant driver for changes in market value ratios, followed by the efficiency to generate balance sheet outputs (deposits and loans) and finally the efficiency to generate income statement outputs (interest income and non-interest income).

The technical efficiency of the banks' operating activity, as indicated by the income statement output-based DEA model, is more significant as a probable driver for market value ratios than the technical efficiency of their finance/investment activity, as indicated by the balance sheet output-based DEA model, while the latter is more significant with regard to the allocative efficiency. This means that a change in deposits and loans to equity and fixed assets ratio affects market value ratios more than a change in interest income and non-interest income to deposits and staff and operating costs ratio. However, the input mix ratio of deposits and staff and operating costs affects market value ratios more than the input mix of equity and fixed assets.

The study is the first to measure the extent to which market value ratios are affected when there are changes in the profitability ratios, the efficiency of the operating activity and the efficiency of the finance/investment activity. The main conclusion is that market value ratios are more likely to be affected by changes in profitability ratios, which combine performances of the operating activity and the finance/investment activity, than in the case of separate efficiency measurements of the finance/investment activity and operating activity. Therefore, profitability ratios should be used as a proxy for market value ratios rather than separate measures of balance sheet output-based and income statement output-based efficiencies.

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