

Performance Evaluation of Banks in Pakistan Based on Market Value Ratios –An Application of Data Envelopment Analysis

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Abstract

Performance and efficiency evaluation in organizations has gained considerable importance in the past three decades. Different techniques and tools have emerged including the Data Envelopment Analysis (DEA) model. This paper analyses the performance efficiency of listed Pakistani commercial banks based on their market value ratios, namely the Market Price/Earnings (P/E) ratio and the Market Price/Book Value (P/B) ratio and then develop a ranking. The DEA technique is a linear programming methodology which measures the relative performance of similar firms using a variety of identical inputs and a variety of similar outputs. All of the 20 commercial banks that are listed on the Pakistan Stock Exchange are included in the study. The data pertains to 2018. As per the findings, the top five banks that are exhibiting the highest level of relative efficiency based on their market value ratios are Faysal Bank Limited, Bank Islami Pakistan Limited, Habib Metropolitan Bank Limited, Meezan Bank Limited and Habib Bank Limited.

Keywords: Banks, Performance Evaluation, Efficiency, Data Envelopment Analysis (DEA), Financial Ratios.

1. INTRODUCTION

The 4th Pakistan Banking Awards Ceremony was held in Karachi on 10th of January, 2020. In this event Bank Alfalah was declared as the best bank for the year 2019. This idea of evaluating and recognizing performance of banks in Pakistan has been jointly sponsored by the Institute of Bankers Pakistan, DAWN Media Group and A. F. Ferguson & Co (a member firm of the Price Waterhouse Coopers Network). In the earlier first three events of the Pakistan Banking Awards, the best performing banks were; United Bank Limited (2016), Bank Alfalah (2017), and Meezan Bank (2018). As per the media reports an impartial and transparent evaluation process was adopted by the distinguished jury consisting of five experts from economic, banking and financial sectors. Details of the evaluation process are however not publicly available.

Banks provide multifaceted products and services. As such performance evaluation of banks also needs to be multi-dimensional. This is the reason that the Pakistan Banking Awards are granted in several other categories also. The other categories include; best consumer franchise, best investment bank, best bank for SME, best bank for agriculture, and best bank for microfinance. This research evaluates bank performance in Pakistan on selected dimensions based on market value information publicly available. The linear programming mathematical technique known as “Data Envelopment Analysis (DEA)” has been utilized to overcome the problems associated with the multidimensional evaluation.

1.1. History of Banking in Pakistan

The banking sector has witnessed distinct phases in Pakistan. The first spans from 1947 to 1974 and can be termed as the ‘Pre Nationalization’ period. The second could be referred to as the tenure of ‘Nationalized’ time period stretching from 1974 to the late 1980s. The period of ‘Privatization and Deregulation’ started in later part of 1980s and continued till 2004. Current period can be referred to as the period of consolidation.

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During all these years the total number of banks including the foreign banks in Pakistan peaked to 53 in 1996. Because of mergers and acquisitions, this number has gradually declined and as on December 31, 2019 their strength

stands at 34. The total number of foreign banks operating in Pakistan also peaked to 28 in 1996 and has since then shrunk to just 5 by the end of 2019. The State Bank of Pakistan (SBP) uses the term “Scheduled Banks” to collectively refer to all of the different categories of banks. SBP has grouped the banks in four clusters. The name of the clusters and the total strength in each are; Public Sector Banks (5), Domestic Private Banks (20), Specialized Banks (4) and Foreign Banks (5). Out of the five public sector banks, only two are listed on the Pakistan Stock Exchange (PSX). Out of the twenty domestic private banks seventeen are listed on the PSX. None of the specialized banks and none of the foreign banks are listed on the PSX. Thus out of a total 34 banks, currently 20 are listed on the PSX. As the focus of this research is on the market value ratios, the non-listed banks have been excluded from the study.

1.2. Importance of Performance Evaluation

The system of modern banking has evolved and grown to a level whereby it is viewed as playing the most significant role in facilitating economic development and prosperity by channelizing money from the ones who save to the ones who invest to set up and expand businesses (Shyu et al., 2015). This role is referred to as intermediation. Efficient intermediation (performance) is expected to be translated into more rational and effective allocation of scarce resources, which in turn is likely to lead to macroeconomic stability and growth, thereby creating more employment opportunities in a country. Evaluation of bank performance is an on-going activity undertaken by all the stakeholders including; founding shareholders, managers, creditors, public investors, regulators, market analysts and rating agencies.

Performance and efficiency evaluation requires numerical measures of inputs and outputs and their comparison which is called the ‘production function’. In case of manufacturing firms, the inputs and outputs are easily conceptualized (Fletcher and Snee, 1985). In case of firms providing services such as commercial banks, there is multiplicity of outputs as well as inputs. Impounding the figures of these multiple inputs and outputs into a single measure of performance evaluation has always been the challenge (Bos and Bikker, 2008). Evaluation of the performance of banks and financial institutions is regarded as difficult and challenging because of the non-availability of explicit public information for individual banks on interest rates on different inputs such as deposits and outputs such as loans. Terms such as profitability, productivity, efficiency, competition, concentration value creation are used to specify and measure bank performance (Bos and Bikker, 2008).

1.3. Current Performance Evaluation Scenario of Banks in Pakistan

Formal performance evaluation of Banks is undertaken by all of the institutional stakeholders in Pakistan. Such efforts result in production of reports in which information is generated across the board and there is no singular top performer identified. Public access to such evaluation reports is available in at least three instances. The first is generated by the State Bank of Pakistan, second issued by the two rating agencies namely Pakistan Credit Rating Agency (PACRA) and Vital Information Services (VIS), and the third by the Corporate Brokerage Houses. In the following section, brief outline of the dimensions of evaluation adopted by these three categories are presented.

1.3.1. State Bank of Pakistan

Though there are several publications by the Central Bank, however the most comprehensive is the “Financial Statement Analysis of the Financial Sector” published annually covering the entire financial sector based on past five year data (FSA, SBP, 2019). In context of commercial banks, the FSA covers the following five dimensions of performance; i) Efficiency and Profitability, ii) Liquidity, iii) Asset Quality, and iv) Leverage. A total of 28 different financial ratios are computed and reported under the foregoing categories.

1.3.2. Credit Rating Agencies

A detailed “Rating Report” is published by Pakistan Credit Rating Agency every six months on the selected banks included in its scope of entity rating. This report covers the following areas, Profitability, Capital Adequacy, Funding and Liquidity, and Credit Risk. A total of around ten financial ratios are computed and reported under the foregoing categories. Pakistan’s second rating agency Vital Information Services also issues its Rating Report on each of the bank included in its scope of rating portfolio. There is a mix of ratios utilized for the evaluation which cover Capital adequacy, Profitability, and Funding.

1.3.3. Corporate Brokerage Houses

Corporate Brokerage Houses also periodically publish short equity research reports on banks. In several cases, such reports are released via their web portal for public consumption. These reports are focused more on valuation ratios such as P/E ratio and the P/B ratio rather than the ones described above for SBP and credit rating agencies.

2. LITERATURE REVIEW

It is often stated that “If you can measure it, you can manage it”. The question arises what needs to be measured in context of business organizations? The first such answer appears to have been provided by (Drucker, 1954) who proposed a mix of measures which included both objective and subjective items such as productivity and innovation as a possible solution to issues in performance measurement. Since then interest in Performance Evaluation grew significantly and a number of journals came up on the subject of Productivity and Performance Evaluation. An overview of the discipline of Performance Evaluation (Taticchi et al., 2010) for a 40 year period spanning from 1970 to 2008 spells out 24 different models and frameworks for performance evaluation. Another extensive overview by (Keong Choong, 2014) has referred to a vast body of literature on Performance Evaluation. Before 1980s, the conventional evaluation techniques were based on ROI, ROE, ROCE and their derivatives (Simons, 2000). Attraction to develop Performance Evaluation Systems started in 1980s. The ‘Economic Value Added (EVA) Model’ (Stewart, 2007), the ‘Activity Based Costing (ABC) Model’ and the ‘Activity Based Management (ABM) Model’ came up during this time period (Cooper and Kaplan, 1988). During the period 1990 to 2007, twenty additional frameworks were developed (Taticchi et al., 2010) including the Balanced Scorecard (BSC) (Kaplan and Norton, 1992). Successful application of the Balanced Scorecard Model in several industries has been reported during the years following its development.

2.1. The DEA Model

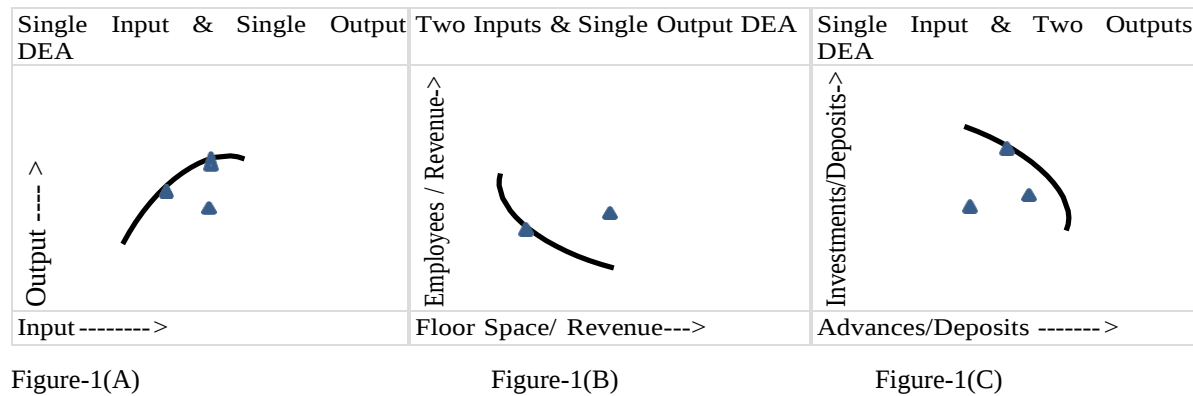
Under the domain of Operations Research, DEA methodology was pioneered in 1978 by a team of three researchers; Charnes, Cooper and Rhodes (Charnes et al., 1978). The model created by them was abbreviated after their names as CCR. The application of this model was restricted to manufacturing scenarios in which technology characterized constant returns to scale. The scope of the model was later enlarged by Banker, Charnes and Cooper to cover situations where the technology involved variable returns to scale (Banker et al., 1984). Their methodology has also been abbreviated with the first letters of their names as the ‘BCC DEA Model’. Mathematically, DEA is described as a linear programming technique which can be applied to the observed data in such a manner that enables discovery of relationship amongst inputs and outputs. These steps translate into discoveries of efficient production possibility surfaces which are considered to be building blocks of modern economic theories. The analytical capability of DEA was quickly picked up by the researchers so that it has become a commanding tool for measuring and evaluating performance (Cooper, 2011).

The DEA model builds up on the concept of efficiency, which is described as the ratio of output to input. The four situations that emerge in this context are; (i) single input and single output, (ii) two inputs

and single output, (iii) single input with two outputs, and (iv) multiple inputs and multiple outputs. Besides a mathematical solution, the first three situations can also be solved graphically. In the first situation a simple graph is derived as shown in Figure-1(A) representing the conventional production function with the single input plotted on the horizontal axis and the single output on the vertical axis. The shape of the curve exhibits the three phases; increasing returns to scale, constant returns to scale and decreasing returns to scale. Plotted data points may lie on the curve (efficient) and below the curve (inefficient).

For the second situation involving dual inputs and solo output, two ratios are computed. The first ratio is obtained by dividing the single output such as interest revenue by one of the two inputs such as branch floor space. The second ratio is obtained by dividing the same solo output that is interest revenue by the second input such as number of employees. Because of the reasons explained in the later section, the inverse of the two computed ratios are plotted, one on the horizontal axis and the other on the vertical axis as shown in Figure-1(B). The conceptual 'Envelopment Surface' takes the shape of curve which is convex to the origin. The data points closest to the origin are most efficient as opposed to the data points lying farthest from the origin are considered to be comparatively less efficient.

For the third case, the single input and two outputs can be conceptualized considering deposits as the single input with advances (loans) and investments as the two outputs. Ratio of advances/deposits can be charted on the horizontal axis and the ratio of investments/deposits can be plotted on the vertical axis. The resulting envelopment surface takes the shape of a curve concave to the origin as shown in Figure- 1(C). Data points lying on the curve are considered to be more efficient than those lying under the curve.



As regards the fourth category of multiple inputs and multiple outputs, graphical analysis is not possible due to multi-dimensionality of the outputs and the inputs. Thus the analysis is done based on linear programming. Under the Linear Programming methodology efficiency is determined on the basis of weights of the different inputs and the weights of the different outputs. It may be noted that the unit of measurement of various inputs and outputs need not be alike (Cooper et al., 2007). For example consider that there are several different inputs and outputs of any particular bank. Each output is denoted by the symbol 'k' and each input is denoted by the symbol 'i'. The examples of inputs could be taken as Number of Employees, Capital, ATMs, Deposits, and so on. Examples of outputs can be considered as Loans, Investments, Customer-Satisfaction etc. For computing the conventional measure of efficiency of any one bank, the following equation would be applicable in which $w_1, w_2, w_3 \dots w_n$ denote weights of the first to the n^{th} output, whereas $v_1, v_2, v_3, \dots v_n$ denote weights of the first to the n^{th} input. The formulation for efficiency would be as under:

$$E = \frac{k_1w_1 + k_2w_2 + k_3w_3 \dots \dots + k_nw_n}{i_1v_1 + i_2v_2 + i_3v_3 \dots \dots + i_nv_n}$$

The DEA methodology evaluates the actual data on the inputs and outputs of the firm and then through mathematical linear programming determines optimal values of weights for both the inputs and outputs with the condition that the outcome is equal to or less than one and with the additional condition that the value of the weights computed is non-negative which means that it is either greater than zero or equal to zero. The result of the applied procedure results in efficiency score for all of the firms which ranges from a smaller fraction such as 0.012 to 1.0. Those banks with a score of 1.0 are considered to be 100% efficient and lie on the envelopment frontier. Those banks with a score of less than 1.0 lie below the efficiency frontier and are therefore considered inefficient (Cooper, 2011).

When efficiency is analyzed through input and output orientation, the result is obtained in a single measure which simultaneously captures all of the considered inputs as well as the outputs. It is therefore possible for an analyst to investigate the efficiency of a bank taking into account its loan portfolio, deposits, investments, and even bad loans. If the analyst undertakes the efficiency analysis through the use of financial ratios, then there might be conflicting results. For example Bank-A has the best efficiency in terms of ROA, but it is Bank-B which is more efficient in terms of ROE. As such the input-output efficiency analysis technique seems to offer an advantage over the conventional analysis undertaken through financial ratio analysis (Pasiouras, 2013). It is also accepted in the literature (Berger et al., 1997) that efficiency measures derived both from parametric and non-parametric approaches have advantages over accounting ratios.

As described in the previous section, banking performance needs to be evaluated from many different dimensions. Each dimension has its own significance as well as importance. No particular dimension can be ignored or substituted for another. Evaluation of a bank's performance can be accomplished through accounting as well as market measures. For example, Return on Assets (ROA), Return on Equity (ROE) and Net Interest Margin (NIM) are the accounting based measures. These measures are molded in accordance with accounting principles. The accounting principles conform to legal and regulatory compliance framework (Combs et al., 2005). Market measures include the Price/Earnings Ratio and the Price/Book Ratio. The market based ratios are shaped by sentiments of the investors (Haslam et al., 2010). They can also be impacted by behaviors and beliefs and also be affected by views of analysts on future earnings potential of the firms. Accounting variables take into account the past data so they are not considered to be forward looking as compared to market based ratios which are inherently forward looking (Brinkhuis and Scholtens, 2018).

3. Methodology

For the purpose of this study, the focus is on the creation of value and specifically the market value. In this context the two market value ratios are intended to be applied. The first is the Price/Earnings Ratio and the second is the Price/Book Ratio. The P/E ratio is computed by dividing the market price per share with the earnings per share. The P/E ratio measures the amount that investors are willing to pay for each unit of currency (Rupee, Dollar, Euro, etc.) earned by the firm. The level of this ratio indicates the degree of confidence that investors have in the company's future performance. It is generally considered that higher the P/E ratio, the greater the investor confidence (Gitman, 2014).

The Price/Book ratio is computed by dividing the market price with the book value per share. A higher P/B ratio is attributed to firms that are expected to perform well. Typically, firms that are expected to earn high returns relative to their risk are also expected to have a higher P/B ratio. If the ratio exceeds one (1.0) then this means that investors are willing to pay more for the firm's accounting book value. A company's book value of its share is culmination of its past performance. The book value also indicates the amassed amount that stock holders have invested on per share basis. This could have been a direct investment by way of purchase of shares or an indirect manner by way of the retention of earnings by the company (Brigham and Ehrhardt, 2017).

The following Table-1 presents three separate rankings of the 19 listed commercial banks; on the basis of Earnings Per Share (EPS), on the basis of Book Value Per Share (BVPS) and then finally on the basis of market price. The data pertains for the year ended 2018.

TABLE-1
RANKING OF LISTED COMMERCIAL BANKS IN PAKISTAN
EARNINGS PER SHARE, BOOK VALUE PER SHARE & MARKET PRICE

RANKING - EPS			RANKING – BVPS			RANKING - MKT. PRICE		
	Bank	EPS		Bank	BVPS		Bank	MP
1	MCB	18.02	1	MCB	117.74	1	MCB	195.67
2	UBL	12.44	2	HBL	112.14	2	UBL	145.81
3	ABL	11.25	3	UBL	110.02	3	HBL	143.45
4	NBP	9.41	4	ABL	73.56	4	ABL	105.31
5	HBL	8.04	5	NBP	69.04	5	MEZN	87.06
6	MEZN	7.67	6	BAHL	41.64	6	BAHL	73.81
7	BAHL	7.57	7	ALFB	38.47	7	ALFB	46.44
8	ALFB	5.72	8	MEZN	34.54	8	NBP	44.70
9	ASKRI	3.52	9	ASKRI	25.28	9	HMBL	44.58
10	SCBPL	2.90	10	JSBL	16.46	10	FAYSL	25.04
11	BOP	2.89	11	SCBPL	15.94	11	SCBPL	24.05
12	SONR	1.62	12	BOK	13.81	12	ASKRI	22.90
13	HMBL	1.20	13	BOP	13.17	13	BOK	13.30
14	SAMBA	0.68	14	SAMBA	13.06	14	SONR	12.82
15	SILK	0.57	15	BISPL	12.66	15	BOP	12.02
16	JSBL	0.56	16	SONR	12.41	16	BISPL	11.98
17	FAYSL	0.49	17	HMBL	8.29	17	JSBL	7.86
18	BOK	0.47	18	SILK	6.17	18	SAMBA	7.85
19	BISPL	0.21	19	FAYSL	3.90	19	SUMIT	1.49
20	SUMIT	(0.43)	20	SUMIT	3.62	20	SILK	1.31

Source: Author's tabulation based on public data for the year ended 2018

4. Results and Findings

As can be seen, that in all of the three categories, the top five positions are shared by the big five banks of the country. These banks in terms of their decreasing order of market share in total assets are; Habib Bank (HBL), National Bank of Pakistan (NBP), United Bank (UBL), MCB Bank (MCB) and Allied Bank (ABL). In the third category (market price) however, NBP has slipped to the 8th position.

The following Table-2 presents the ranking of the 19 listed commercial banks on the two market value ratios, that is, the P/E Ratio and the P/B Ratio. The two rankings indicate different hierarchy when compared with one another and when compared with the rankings in Table-1 above. Since the focus of this research is on Market Value Ratios, an attempt is being made to uncover the combined effect of these two ratios and develop a ranking accordingly. The table also shows the computed reciprocal of the P/E Ratio and reciprocal of the P/B Ratio designated as 'X' and 'Y' respectively. The reason for computation of the reciprocals is provided in the next section.

TABLE-2
RANKING OF LISTED COMMERCIAL BANKS IN PAKISTAN
MARKET PRICE/EARNINGS PER SHARE AND MARKET PRICE/BOOK VALUE PER SHARE

RANKING: PRICE / EARNINGS				RANKING PRICE / BOOK			
	Bank	MP/EPS	X		Bank	MP/BVPS	Y
1	BISPL	57.048	0.018	1	FAYSL	6.421	0.156
2	FAYSL	51.102	0.020	2	HMBL	5.378	0.186
3	HMBL	37.15	0.027	3	MEZN	2.521	0.397
4	HBL	17.842	0.056	4	BAHL	1.773	0.564
5	JSBL	14.036	0.071	5	MCB	1.662	0.602
6	UBL	11.721	0.085	6	SCBPL	1.509	0.663
7	SAMBA	11.544	0.087	7	ABL	1.432	0.699
8	MEZN	11.351	0.088	8	UBL	1.325	0.755
9	MCB	10.858	0.092	9	HBL	1.279	0.782
10	BAHL	9.7503	0.103	10	ALFB	1.207	0.828
11	ABL	9.3609	0.107	11	SONR	1.033	0.968
12	SCBPL	8.2931	0.121	12	BISPL	0.946	1.057
13	ALFB	8.1189	0.123	13	BOP	0.913	1.096
14	SONR	7.9136	0.126	14	ASKRI	0.906	1.104
15	ASKRI	6.5057	0.154	15	NBP	0.647	1.545
16	NBP	4.7503	0.211	16	SAMBA	0.601	1.664
17	BOP	4.1592	0.24	17	JSBL	0.478	2.094
18	SILK	2.2982	0.435	18	SUMIT	0.412	2.43
19	SUMIT	-3.465	-0.29	19	SILK	0.212	4.71

Source: Author's Tabulation based on public data

4.1. Application of the DEA Model on the Market Value Ratios – Graphical Solution

The DEA model is based on the concepts of inputs and outputs. There are several versions of the model; single input and single output, two inputs and single output, single input and two outputs, and multiple inputs and multiple outputs. In the present case, EPS and BVPS would be considered as inputs and the market price would be considered as output. Hence this research would fall in the category of two inputs and single output. The efficiency is computed as output divided by input. The P/E Ratio is therefore a measure of efficiency as the market price (output) is being divided by the earnings per share (input). The second ratio P/B is also a measure of efficiency as market price (output) is being divided by the book value (input).

The inverse of the two ratios are also referred to in the finance literature. The inverse of the P/E Ratio is written as EPS/P and is technically referred to as earnings yield. Similarly the inverse of the P/B Ratio is written as BVPS/P and is technically referred to as a variant to the valuation methodology. The inversion of the two ratios provides a common comparison ground in terms of one unit of the common denominator which is one unit of the currency in which the market price is being considered. Thus the inversion of the P/E Ratio results in a figure per single unit of Rupee (PKR) and the inversion of the P/B Ratio also results in a figure per one unit of the denominator which is again per single unit of PKR (Saeed et al., 2017).

The reciprocal of the two ratios have already been computed in Table-2 above. As the two ratios have a common denominator, they can easily be plotted, and meaningful inferences can be drawn from the

graph. The inverse of the P/E Ratio is plotted on the X-axis, and the inverse of the P/B Ratio is plotted on the Y-axis. The resulting graph is shown in the following figure-1.

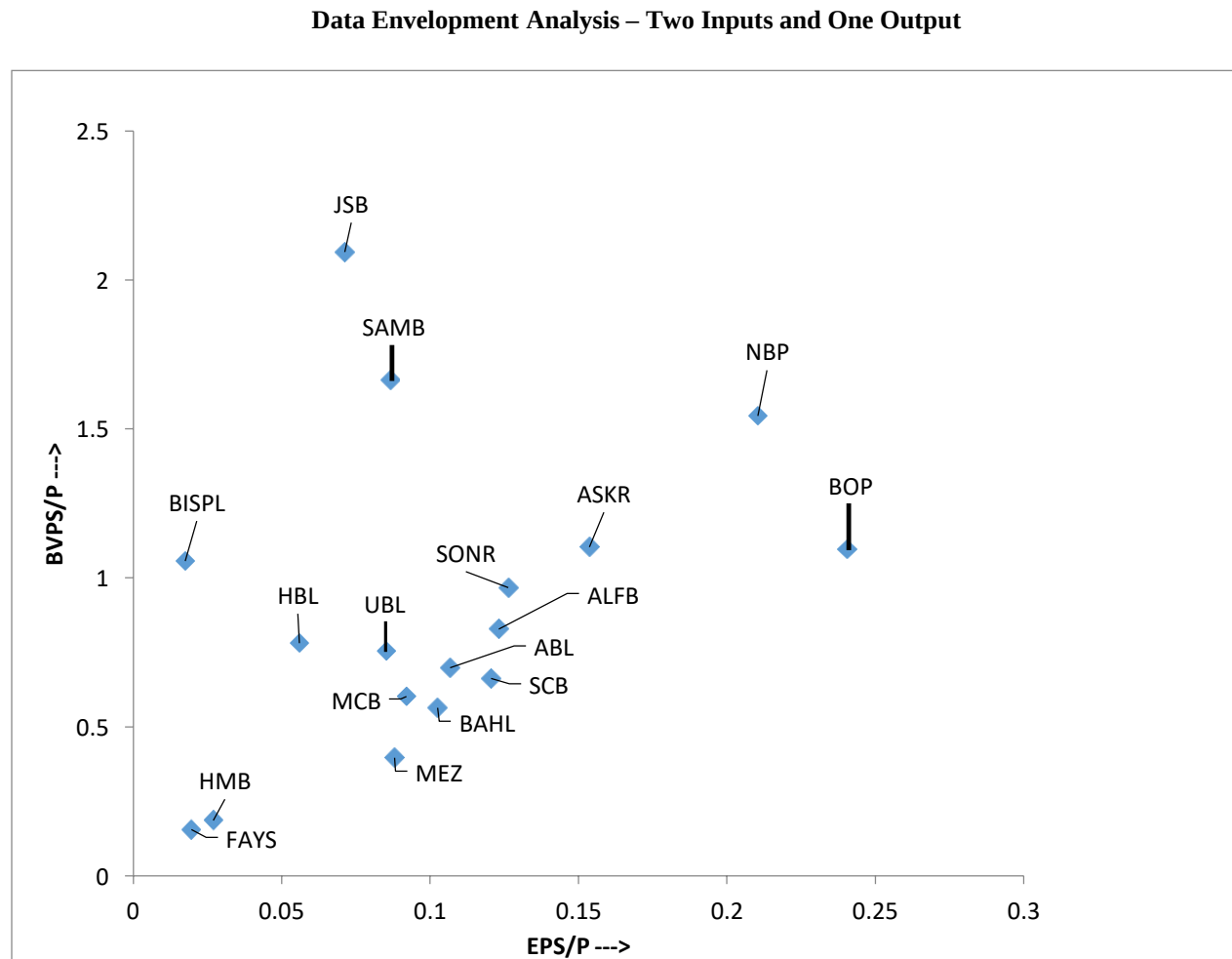


Figure-1
Source: Author's estimation using Microsoft Excel

In the above graph, a conceptual efficiency frontier results which is convex to the origin. The data points represent the relevant positions of each of the banks with reference to each other. Points which lie on the frontier and are also close to the origin are considered to be more efficient than the points which are farther from the origin which are comparatively less efficient. The data points lying on the conceptual curve convex to the origin represent Faysal Bank and Bank Islami Pakistan placing them in the first second positions respectively in context of highest relative efficiency among the 19 listed banks in Pakistan. Due to their outlier effect, two banks were excluded from the above graph namely Summit Bank and Silk Bank. More precise efficiency ranking for the remaining banks is presented in the next section

4.2. Application of the DEA Model on the Market Value Ratios – Linear Programming Solution

Spread sheet software as well as dedicated DEA software are available to undertake the efficiency calculations for any of the four scenarios described earlier. In the present case the DEA Solver software

(LV 8.0) written by Cooper, Seiford and Tone has been used. The efficiency scores and the ranking as derived through the software are as under:

TABLE-3
Efficiency Ranking of Listed Banks in Pakistan

Rank	1	1	3	4	5	6	7	8	9
Bank	FAYSL	BISPL	HMBL	MEZN	HBL	BAHL	JSBL	MCB	SCBPL
Score	1	1	0.838	0.393	0.345	0.276	0.262	0.259	0.235

Rank	10	11	12	13	14	15	16	17	18
Bank	UBL	ABL	SAMBA	ALFB	SONR	BOP	ASKRI	NBP	SILK
Score	0.229	0.223	0.22	0.188	0.161	0.142	0.141	0.101	0.045

Source: DEA Solver LV 8.0 Estimation (CCR Input Oriented Model)

The software generated ranking has placed Faysal Bank and Bank Islami in the top category with equal ranking and 100% efficiency score followed by Habib Metropolitan Bank, Meezan Bank and Habib Bank in the 3rd, 4th and 5th places respectively. Technically, Summit bank is in the last position because of having a negative EPS. It has been excluded from the above table because of distortions created by the negative value of EPS.

5. Conclusions

Performance evaluation of organizations such as banks is both important as well as challenging. It is important because banks provide a number of different products and services. Nearly all of these products and services have a critical role in the economic development and financial stability of the economy. The challenge lies in the public access to sensitive data. This study has determined the performance ranking of the 20 listed commercial banks in Pakistan based on their market value ratios. Two ratios were used, Price/Earnings and Price/Book. The data pertained to the year ended 2018. These ratios were used because they are considered to be forward looking. Data Envelopment Analysis (DEA) methodology was used to overcome the problems associated with multidimensional analysis. DEA employs linear programming to identify the best performance from among a group of similar firms which are using identical inputs and identical outputs. Over the last few decades DEA has become a popular tool for performance and efficiency analysis. A graphical analysis was undertaken together with a mathematical solution through DEA Solver LV 8.0 software. Based on the findings, Faysal Bank Limited and Bank Islami Pakistan Limited were determined to be in the top position. Whereas Habib Metropolitan Bank Limited, Meezan Bank Limited, and Habib Bank Limited were found to be in the 3rd, 4th and 5th positions respectively.

Banking performance can be evaluated from many different dimensions. This study focused on two dimensions to facilitate graphical representation of the DEA methodology. More detailed multidimensional evaluation can be undertaken with the help of DEA Solver software. Such efforts would also open up a newspectrum of the challenges that are associated with multidimensional analysis.

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