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Relationship Between Cost Efficiency and Stock Price: Evidence from Bangladeshi Commercial Banks

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Abstract

This paper employs Stochastic Frontier Approach (SFA) and Data Envelopment Analysis (DEA) to measure cost efficiency score of 30 listed private commercial banks in Dhaka Stock Exchange (DSE) and finds its influence on stock prices. Results suggest that, there is a significant positive impact of changes in share prices on the cost efficiency score. This suggests, those banks are most cost efficient, they are able to generate more return for their stockholder than those of inefficient banks.

Keywords: cost efficiency, DEA, SFA, stock performance, Bangladeshi banks

1. Introduction

Developments in the environment have increased banking sector efficiency around the world. Deregulations, globalization, financial innovation and technological progress all have gradually reduced the costs of information processing and transmission and have been major forces impacting on the performance of the banking sector (Girardone et al., 2004). However, performance in developing nations has been poor because of government control and intervention. Therefore, studying banking efficiency can help management to take necessary actions to improve their performance.

According to literature, efficient market reflects all available information. In a semi-strong market, stock performance represents the best measure to estimate the creation of value for shareholders and positive relationship exists (Brealey & Myers, 1991). Other things being equal, cost-efficient banks are able to raise capital at a lower cost; therefore, they should bring more profit for their shareholders. Hence, there should be a positive relationship between cost efficiency and stock performance. This paper will investigate whether higher cost efficiency reflects in better stock performance.

There are number of studies available on ratio analysis and bank efficiency, but very few are available on cost efficiency and stock performance and to author's knowledge no study has been done for Bangladeshi banks.

The microeconomic theory of firm is the source of economic efficiency theory. Debreu (1951) and Farrell (1957) developed the concept of productive efficiency framework. Economic efficiency can be divided into technical efficiency, allocative efficiency, scale efficiency and scope efficiency. A firm is considered to be fully efficient when it maximizes profit and minimizes cost. Farrell (1957) first measured productive efficiency using efficient isoquant. He assumed production function to be homothetic. According to Farrell (1957), a homothetic function is a monotonic transformation of a homogeneous function in which the marginal rate of technical substitution is constant along a ray drawn from the origin. Let $f(x_1, x_2)$ is a homogeneous production function and isoquant of this production function is efficient isoquant. Transformation of a homothetic production function is $F(X) = g[f(x_1, x_{2)}]$, where g represent the increasing monotonic transformation. Series of isoquant can be obtained from scaling up series of efficient isoquants.

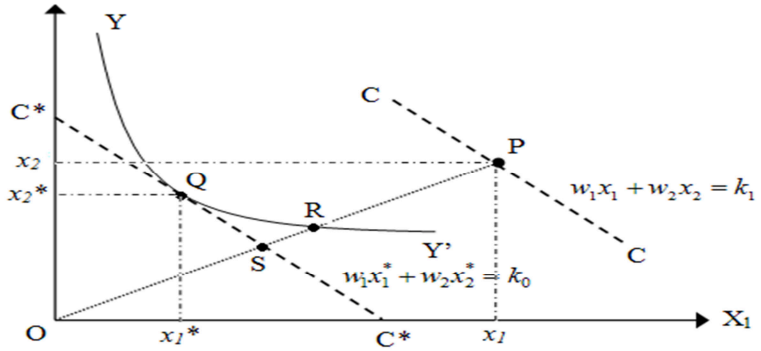

Figure 1. Technical, allocative and cost efficiency

Source: Cooper et al., 2007.

Farrell (1957) assumed constant return to scale (CRS) correspond to the efficient production function. In Figure 1, YY' represent unit isoquant, $(X_{1,}X_2)$ is the inputs combination, by which a firm is able to produce certain output when the firm is perfectly efficient. It can also be said, YY' represents minimum combination of inputs in order to produce a unit of output. In Figure 1, combination of inputs along with the isoquant unit is considered as technically efficient and any point to the right or above is considered to be inefficient. For example, at point P, a unit of input is enough to produce a unit of output. RP indicates producer's technical inefficiency, means inputs can be decreased without changing output amount. Therefore, technical efficiency term is OR/OP. value ranging from 0 to 1. Value of 1 indicates firms to be perfectly technically efficient.

Allocative efficiency is the process of selecting input mix that allocates factors to the highest values and gives opportunity cost input factors in productive efficiency measurement. In Figure 1, input's market price $(w_{1,}w_2)$, CC is the iso-cost line thorough P is associated with $w_1x_1 + w_2x_2 = k_1$ and slope of line is input price ratio. Cost can be reduced further by moving the line in parallel until it is to the isoquant at Q. $w_1x_1^* + w_2x_2^* = k_o$ provides minimal cost at the given level of output. To measure the ratio of OS/OR, relative distance of S and R is calculated. The ratio of OS/OR indicates, cost can be reduced if it moves from point R to a both allocatively and technically efficient point Q. Therefore, at the point P, Allocative efficiency is the ratio of OS/OR.

Another cost efficiency measurement found in the existing literatures. Cost efficiency is the ratio of minimal cost (wx^*) to actual cost (wx_o), and it can be presented as $wx^*/\ wx_o$ = OS/OP. by choosing inputs mix accordingly, a firm can minimize its total cost. Therefore, Overall cost efficiency = Allocative efficiency* Technical efficiency= OS/OR* OR/OP= OS/OP.

2. Review of Literature

Studies show stock price accommodate publicly available information related to earnings. In

this study, earnings will be replaced by cost efficiency. As cost efficiency is estimated based on available accounting information, cost efficiency should be reflected in stock price.

As DEA and SFA allows taking multiple inputs and outputs variables, and their results are more all inclusive, these approaches have advantages over ratio analysis (Berger & Humphery, 1997).

Beccali et al. (2006) used both SFA and DEA in their study and found cost efficient banks earn more profit and cost efficiency is strong determinants for stock returns. They argued '*ceteris paribus*', cost efficient banks raise capital at lower cost of capital, which reflects in stock price. Liadaki and Gaganis (2010) on the other hand found no relationship between cost efficiency and stock price. One possible reason for this difference could be Liadaki and Gaganis (2010) used only SFA and they investigated both cost and profit efficiency.

Ioannidis et al. (2008) also did not observe any effect cost efficiency on stock return. They found profit efficiency is better explanation of variation in stock return. Sufian and Mazid (2007) found cost efficient banks outperform cost inefficient banks to some extend when it comes to stock performance.

Adenso-Diez (1997) included production cost, systematic risk and branch network distribution when studied Spanish banking sector and observed link between partial efficiency and stock returns. Eisenbeis et al. (1999) derived X-efficiency using SFA and found cost efficient bank outperform inefficient banks.

While Pasiouras et al. (2008) did not find any relationship between efficiency and stock performance for Greek banks, Majid et al. (2008) claimed to find significant relationship in the Asian stock exchanges.

Eisenbeis et al. (1999), suggested weight should be put more on SFA measurement because risk taking behavior, managerial competence and stock returns can be well explained through informative efficiency score obtained from SFA.

3. Methodology and Data

This study follows following steps:

First: Calculate cost efficiency score (DEA and SFA)

Second: Calculate annual stock returns

Third: Regression analysis of bank's stock performance and relate to efficiency score

3.1 Methodology

Data Envelopment Analysis (DEA)

DEA is first introduced by Charnes et al. (1978) is a non-parametric approach to measure efficiency. This basis of this approach is constant return to scale and technical efficiency. This method is linear convex frontier which envelops decision making units (DMUs). DEA model can be expressed following fare et al. (1985) as:

$$\frac{min}{\lambda, x_i} \qquad w_{i0}\ x_{i0}^*$$

$$subject\ to$$

$$\sum_{j=1}^{n} \lambda_i y_{ri} - y_{r0} \geq 0, \qquad r = 1,2, \ldots\ldots, s$$

$$\sum_{j=1}^{n} \lambda_i x_{ij} - x_{i0}^* \leq 0, \qquad i = 1,2, \ldots\ldots, m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, \quad j = 1,2, \ldots\ldots n$$

Here, $j = 1,2,3, \ldots\ldots, n$ represents the number of banks, vector of input pricesw_{jo}, output levely_{r0}, and vector of input quantities for selected banksx_{j0}^*. In the DEA model, it is presumed that all the input prices are same for all decision-making units. But in reality, markets are not always perfect. Tone (2002) identified this model has limitation as this model does not take into consideration that cost can also be reduced by reducing input prices. He then proposed a new model.

$$\frac{min}{\lambda, \bar{x}} \qquad e\overrightarrow{x_{\iota 0}}$$

$$subject\ to$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - y_{r0} \geq 0, \qquad r = 1,2, \ldots\ldots, s$$

$$\sum_{j=1}^{n} \lambda_j \bar{x}_{ij} - e\overrightarrow{x_{\iota 0}} \leq 0, \qquad i = 1,2, \ldots\ldots, m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, \quad j = 1,2, \ldots\ldots n$$

Here, $e \in R^m$ is a row vector with all elements equal to 1 and $\bar{x}_{ij}$=$(w_{1j}x_{1j,\ldots,}w_{ij}x_{ij})^T$. Tone (2002) stated elements of $\bar{x}_{ij}$ in monetary terms and denominated in homogeneous units. Therefore, elements of vector $\bar{x}_{ij}$ have a meaning. Unit cost is fixed at w_{i0} and optimal input mix is searched in the traditional model. In the new model of DEA, optimal input mix $\overrightarrow{x_0}$ is found independently. Therefore, new cost efficiency is defined as NCE=$e\overrightarrow{x_0}/\ e\bar{x}$.

Stochastic Frontier Approach (SFA)

Stochastic frontier approach was first proposed by Aigner et al. (1977) and Van Den Broeck (1977). Even though proposed year is same, the proposed separately. The original function is production function and it is specified for cross sectional data. Original function has two components and an error term. One component is for technical inefficiency and other is for random effects. Aigner et al. (1977) assumed error has normal distribution and inefficieny term has half normal non-negative distribution. Later, many researchers made adjustments to this original model. Greene (1990) defined inefficiency term has two parameter gamma. Stevenson (1980) identified inefficiency is truncated normal. Another significant study by Pitt and Lee (1981) accommodated panel data to the original model. The estimated inefficiency is taken as the conditional mean or mode of the distribution of the inefficiency term, given the observation of the composed error term (Berger & Humphrey 1997).

Cost efficiency is measured in this study. Cost efficiency measures how well a firm performs relative to 'best' firm producing same output in the same environmental condition (Berger et al., 2009).

Following Coelli et al. (2005, p. 242) SFA model can be expressed as:

$$lnTC_{it} = c\,(x_{it};\beta) + v_{it} + u_{it} \quad (1)$$

Where, TC_{it} denotes observed total costs at the t-th observation (t=1, 2 ...T) for the i-th firm (i=1, 2 ...N),

x_{it} is a (1×k) vector of output quantities and input price,

β is a (k×1) vector of unknown parameters to be estimated,

C ( ) is a suitable function form.

v_{it} Is stochastic error capturing the effect of noise and measurement errors which are assumed to be iid. $\mathcal{N}$ (0, σ_v^2), and independent of the u_{it}; u_{it} is non negative inefficiency term.

Aigner et al. (1997) stated, v_{it} have normal distribution and u_{it} have half normal distribution. It is also known as half normal model. Berger and Young (1997) mentioned more general truncated distribution for inefficiency is more flexible. Greene (1990) found gamma distribution is more appropriate compare to half-normal distribution. In contrast, Berger and Humphrey (1997) argue that, assumption of half normal is not correct as most firms are not clustered near full efficiency. Since the truncated normal and gamma distributions may be close to the symmetric normal distribution assumed for the random error, it makes difficult to separate inefficiency from random error in a composite framework (Berger & Humphrey, 1997). Despite of criticism of being inflexible, half-normal assumptions of inefficiency is widely refereed in literature. Bauer et al. (1998) stated when estimating efficiency for individual firms, error can occur due to imposing distributional assumptions. Cobb-Douglas frontier function is applied in this study.

The frontier cost function following (Berger et al., 2009; Coelli et al., 2005, p. 266):

$$\ln(\frac{TC_{it}}{w_{3it}}) = \alpha_0 + \sum_{j=1}^{2} \alpha_j \ln(\frac{w_{jit}}{w_{3it}}) + \sum_{k=1}^{3} \beta_k \ln(y_{kit}) + year\ dummy_t + v_{it} + u_{it} \quad (2)$$

TC_{it}= total cost at the t-th observation, y_{kit} is the k-th output at the t-th observation, w_{jit} is the j-th input price at the t-th observation, $year\ dummy_t$ are the dummies where t=1, 2, 3...T, v_{it} is the stochastic error and measurement errors and u_{it} is half normal non-negative inefficiency term.

Following Berger et al. (2009), total cost and input price terms are normalized by input price w_3 in order to avoid estimation biases.

Regression Model of Bank Efficiency and Stock Performance

Stock daily returns were collected for calculating stock performance. Stock returns are then regressed against cost efficiency to understand their relationship. The estimated model:

$$R_{it} = \beta_o + \beta_1 E_{it} + \varepsilon_i \quad (3)$$

Where,

R_{it} = return on bank i's stock for the period end t

E_{it}= bank i's annual percentage change in efficiency scores (DEA, SFA)

3.2 Data

Sample for this study consists of 30 private commercial banks listed in Dhaka stock exchange (DSE). Data collected for the period of July 2018 to June 2019. Information regarding stock prices was collected from Dhaka stock exchange (DSE). Descriptive statistics presented in the table below.

Table 1. Descriptive Statistics

	Mean		Median		Stdev		Min		Max	
	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018
Total Assets	314292	289831	293901	275531	207259	183585	67142.9	57529.4	997429.6	899959.8
Profit before tax	4611.2	4176.5	3938.0	4057.0	3248.5	2965.8	556.0	158.0	13701.0	12113.3
Interest Income	33803.9	16726.5	17743.8	14842.7	53269.8	13490.2	1910.0	2670.0	210457.9	57141.6
Commission Income	3222.7	3437.8	2573.0	2876.0	1747.7	1913.0	702.6	695.8	5633.0	6656.0
Return on Average Assets	0.94%	0.92%	0.82%	0.87%	0.45%	0.51%	0.01%	0.01%	1.87%	2.02%
Return on Average Equity	11.61%	10.88%	11.34%	10.74%	4.91%	5.68%	0.08%	0.13%	19.70%	22.14%
Cost/ Income ratio	53.47%	53.05%	52.16%	52.93%	11.36%	10.85%	34.61%	34.96%	74.00%	75.00%
Equity/ Total Assets	7.37%	7.84%	7.76%	7.61%	2.70%	1.89%	0.82%	5.44%	11.42%	11.39%

Source: author's calculation.

Inputs and Outputs definitions

In this study, dependent variable is total cost. Output prices are total loans and other earning assets. Input prices are price of borrowed funds, labour price and price of physical capitals. Details of calculation are given in Table 2.

Table 2. Inputs and Outputs

Variable	Symbol	Name	Description
Dependent variable	TC	Total cost	total of interest expenses, personal expenses and noninterest expenses
Output price	y_1	Total loans	Total loans
	y_2	Other earning assets	Total earnings assets less loans and securities
Input price	w_1	Price of borrowed funds	Interest expense over total deposits
	w_2	Labour price	Personal expense over total assets
	w_3	Physical capital price	Other non-interest expense over fixed assets

Source: author's estimation.

Table 3. Summary statistics of cost, inputs and outputs

	Mean	Median	Stdev	Min	Max
Total cost	29370.7	21683.7	19358.8	16457.5	72265.0
Total loans	251790.5	196456.0	173810.0	116098.2	764360.2
Other earning assets	37320.5	11565.0	78047.2	5357.0	271706.0
Borrowed funds	0.0540	0.0617	0.0217	0.0046	0.0746
Labour price	0.0075	0.0081	0.0042	0.0029	0.0137
Physical capital	0.8222	0.8054	0.3924	0.3434	0.9456

Source: author's calculation.

4. Results and Discussion

Table 4. Efficiency scores and change

	2018	2019	% change
DEA Input Score	78.6	80.71	2.68%
DEA Output Score	80.44	82.78	2.91%
SFA Cost Efficiency Score	77.56	78.87	1.69%

Source: author's calculation.

Efficiency estimations from two methodologies (DEA, SFA) are shown in Table 4. Scores range between 77.56 and 82.78. To better understand, changes in efficiency scores from 2018 to 2019 were also calculated. For all cases positive changes have been observed which indicates a "good performance" in terms of cost efficiency. A positive stock price trend suggests there is a positive relationship between cost efficiency and stock price performance.

Table 5. Correlation

		Average	Change DEA Input	Change DEA Output	Change SFA
Average	Pearson Cor.	1	.392**	.401**	.142
	Sig. level	.	.000	.000	.168
Change DEA Input	Pearson Cor.	.392**	1	.920**	.342**
	Sig. level	.000	.	.000	.001
Change DEA Output	Pearson Cor.	.401**	.992**	1	.336**
	Sig. level	.000	.000	.	.001
Change SFA	Pearson Cor.	.142	.342**	.336**	1
	Sig. level	.168	.001	.001	.

Source: author's calculation.

To further validate, correlation analysis was done. Results (Table 5) show,

- There is a positive and statistically significant relationship between changes in DEA and SFA cost efficiency scores.
- Correlations between changes in average stock prices and changes in DEA scores are positive and statistically significant.
- Correlation between changes in average stock prices and changes in SFA score are positive but statistically insignificant.

Table 6. Regression

DEA	**Coefficient**
Constant	0.0322***
Change DEA	0.333***
Adjusted R2	0.112
SFA	
Constant	0.0321**
Change Cost	0.152*
Adjusted R2	0.032

Note. * denotes 10%, ** denotes 5%, *** denotes 1%.

Source: author's calculation.

Regression analysis (Table 6) of changes in efficiency scores (both DEA and SFA) and change in stock price shows positive and significant coefficients estimation, which is in line with the result obtained above (Table 5).

5. Conclusion

Traditionally banks try to minimize cost to income ratio to maximize cost efficiency score. However, researcher (Berger & Humphrey, 1997) stresses that SFA and DEA are better approaches than accounting method in estimating cost efficiency. Therefore, his paper investigated existence of relationship between cost efficiency and banks' stock price change using SFA and DEA approaches. The findings indicate that stock prices changes with the changes in cost efficiency score. And in estimation of efficiency score, DEA method provides better explanation than SFA. In practical it implies that banks should concentrate on reducing cost to maximize shareholders return.

This study is limited in terms of the sample size, variables. Future research can include more variables and banks to obtain more robust result. Future study can also compare another country's banking industry to get clearer picture of Bangladesh banking sector.

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