Stock Market Technical Efficiency for Half Normal Distribution

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Abstract

This paper analyzes the technical efficiency of selected groups of companies of Bangladesh Stock Market using a stochastic frontier production function approach for half normal distribution. This research considers Cobb-Douglas Stochastic frontier model and both the time-variant and time-invariant inefficiency effects are estimated. The studied input variables-market return, market capitalization, book to market ratio and market value show significant relationship with the stock returns. The estimated average technical efficiency for the selected 94 companies of the stock market over the period 2000-2008 is 94.48% of potential output for the half normal distribution. The results show that technical efficiency gradually decreases over the reference period. The value of technical efficiency is high for investment group and low for bank group in time-variant situation whereas the value of technical efficiency is high for investment group also but low for ceramic group in time-invariant situation.

Keywords*: Technical efficiency; Cobb-Douglas stochastic frontier; Half normal distribution; Time-variant; Time-invariant.*

INTRODUCTION

Many researchers, who, investigated technical efficiency of financial institutions used, either, parametric stochastic frontier approach (SFA) or non-parametric data envelopment analysis (DEA) (Berger and Humphrey 1997). In addition, there had been a number of studies that had compared parametric and non-parametric techniques to examine efficiency of financial institutions, for example for banking industry (Ferrier and Lovell, Pastor et al., Resti, Bauer et al., Altunbas et al., Maudos et al., Weill 1990, 1997, 1997, 1998, 2001, 2002, 2004) and for the insurance industry (Fecher et al., Cummins and Zi 1993, 1998). Since the deterministic DEA and

SFA differ both in structure and in implementation, empirical evidence showed that both methods provide significantly different efficiency scores. This study considered the SFA to measure the technical efficiencies of selected companies in DSE market in Bangladesh instead of DEA; because of the advantage of SFA which deals with stochastic noise and also allows statistical tests of hypotheses concerning production structure and degree of inefficiency. DEA does not impose any assumptions about production functional form and does not take into account random error (Kasman and Turgutlu 2008). SFA employed a composed error model in which inefficiencies are assumed to be following an asymmetric distribution. Most past studies used the half-normal and truncated normal distribution as assumption on the inefficiency effects model because of the ease of estimation and interpretation (Kirkley et al. 1995). In this empirical study of SFA, half-normal assumption was used, as this is the most common assumption in the literature.

Dhaka Stock Exchange (DSE) has significant implications on the performance of the financial sector as well as the entire economy (Uddin 2009) and it is the main stock exchange of Bangladesh. This paper concentrated on the DSE, as this is the country's oldest stock exchange, and according to Standard and Poor's Emerging Stock Markets Fact Book 2000, the DSE is one of the frontier emerging markets of South Asia. The market efficiency of the DSE studies found available in (Alam et al., Hassan and Maroney, Rahman et al., Rahman et al., Uddin and Alam 1999, 2004, 2006a, 2006b, 2007).The way of applying SFA on measuring the technical efficiency of DSE market, DSE can play the desired role in the process of economic development of the country.

The goal of this paper was to identify the determinants which influence the share prices in DSE and the level of influential. This study seek evidence on whether factors such as market return, market capitalization, book-to-market ratio and market value are significantly related to stock returns. This study was important, because it would examine not only the capital market behavior of Bangladesh over the period 2000-2008 but also predict the technical efficiencies for the selected groups of companies.

MATERIALS AND METHODS

Stochastic frontier model with technical efficiency effects

This paper consider the stochastic frontier model for the technical inefficiency effects in stochastic frontier production function proposed by Battese and Coelli(1992). This model was used because in this study there were no explanatory variables associated with the technical inefficiency effects and also the model was proposed for the analysis of panel data. The stochastic frontier model for panel data can be written as:

$$Y_u = \exp(x_u\beta + V_u - U_u) \quad i = 1,2,\ldots\ldots,N \quad t = 1,2,\ldots\ldots,T \quad (1)$$

where, Y_u denotes the output for the i-th company in the t-th time period; x_u denotes the (1×*k*) vector whose values are functions of inputs for the i-th company in the t-th time period; β is a (1×*k*) vector of unknown parameters to be estimated; V_u s is the error components of random disturbances, distributed i.i.d. *N* $(0, \sigma_v^2)$ and independent from U_u. U_u s is non-negative random variables associated with the technical inefficiency of production and it can be expressed following Battese and Coelli (1992) as

$$U_{it} = \{\exp[-\eta(t-T)]\}U_i \qquad (2)$$

where η is an unknown scalar parameter to be estimated, which determines whether inefficiencies are time-varying or time invariant; and U_i s are assumed to be i.i.d. and truncated at zero of the *N* (μ, σ_u^2) distribution.

If η is positive, then $-\eta(t-T)=\eta(T-t)$ is positive for *t*<*T* and so, $\exp[-\eta(t-T)]>1$, which implies that the technical inefficiencies of companies decline over time. If η is zero, then the technical inefficiencies of industries remain constant. However, if η is negative, then and thus the technical inefficiencies of companies increase over time.

The stochastic frontier model (1) was considered here to measure the technical efficiency of Dhaka Stock Market companies in Bangladesh. The maximum likelihood estimation (MLE) method used to estimate the parameters of the stochastic frontier model. Using the composed error terms of the stochastic frontier model (1), the total variation in output from the frontier level of output attributed to technical efficiency is defined by $\gamma = \sigma_u^2/(\sigma_u^2+\sigma_v^2)$.In the truncated and half-normal distribution, the ratio of industry specific variability to total variability, *γ*, is positive and significant, implying that company specific technical efficiency is important in explaining the total variability of output produced. This is done with the calculation of the maximum likelihood estimates for the parameters of the stochastic frontier model by using the computer program FRONTIER Version 4.1 (Coelli 1996).

Data sources and variables construction

Data set

The data collected from Dhaka Stock Exchange (DSE) market consisting 94 companies in Bangladesh for the period of 2000-2008. In DSE markets there are 22 types of category of company exist and this study covered 13 types of category of company as: Banks, Investment, Food & Allied Products, Fuel & Power, Textile, Pharmaceuticals & Chemicals, Service & Real Estate, Cement, Tannery Industries,

Ceramic Industry, Insurance and Miscellaneous. Out of 94 companies the data represents both financial and non financial company. In this study, 58 companies are come out from non financial sector and 36 companies are come out from financial sector. In short, we can say that, the data represents the overall market.

Dependent variable

Individual Return (Y**):** In this study, we take individual company's return as a dependent variable.DSE prepares individual company's daily closing price. Using the closing price of individual company we calculate the return of individual company as follows:

Individual Company's Return = In (P_t) –In (P_{t-1})

where, P_t = closing price at period t; P_{t-1}= closing price at period t-1 and ln = natural log.

In order to obtain the individual company's return, we are not adjusted company's dividend, bonus and right issues since many researchers confirmed that their conclusions remained unchanged whether they adjusted their data for dividend, bonus and right issues or not (Lakonishok and Smidt, Fishe et al. 1988, 1993). The reasons to take logarithm returns are justified by both theoretically and empirically. Theoretically, logarithmic returns are analytically more tractable when linking returns over longer intervals. Empirically, logarithmic returns are more likely to be normally distributed which is a prior condition of standard statistical techniques (Strong 1992).

Independent variables

Market Return(X_1): DSE prepares daily price index from daily weighted-average price of daily transaction of each stock. The name of the index is "All Share Price Index". Market return is calculated as follows:

Market return = In (P_t) –In (P_{t-1})

where, P_t = price index at period t; P_{t-1}= price index at period t-1 and ln = natural log.

Market Capitalization(X_2): Market Capitalization is the total value of a company's issued share capital as determined by its share price in the stock market. It is calculated as the number of ordinary shares in issue multiplied by the previous day's closing share price and is expressed in millions. The formula is the following:

Market Capitalization = (Previous day's closing share price * Shares in issue)

Book to Market Ratio(X_3): The book value of a company is total assets minus intangible assets and liabilities. Here we took the company's net asset value per share as a book value of that company. The market value is the share value in the current

market price. After establishing the book value and the market value of a company simply dividing the book value by the market value we got the book to market ratio as:

Book to Market Ratio = (Book value/Market value)

Market Value(X_4): The total money value of securities traded in a specific period is called the market value of that period. We calculated the market value by multiplying share price by the number of securities traded as:

Market Value = (Share price * number of securities traded)

Empirical stochastic frontier model

Since the panel data is used in this study and the sample number is not very high, we select the Cobb-Douglas stochastic frontier production with the distributional assumption to assess the technical efficiency of companies in DSE market. Furthermore, the Cobb-Douglas production function is looked as a simple tool which can be handled easily and can handle multiple inputs in its generalized form (Murthy 2002). The empirical version of stochastic frontier model (1) with the specification of Cobb-Douglas functional form can be expressed with the decomposed errors:

$$\ln Y_{it} = \beta_0 + \beta_1 \ln X_{1it} + \beta_2 \ln X_{2it} + \beta_3 \ln X_{3it} + \beta_4 \ln X_{4it} + (V_{it} - U_{it}) \quad (3)$$

Where, the subscripts i and t represent the i-th company and the t-th year of observation, respectively; i=1,2,…,94; t=1,2,….,9;Y_{it} represents the individual return; X_{1it} represents the market return; X_{2it} represents market capitalization; X_{3it} represents book to market ratio; X_{4it} represents market value. “ln” refers to the natural logarithm; the β_i's are unknown parameters to be estimated; V_{it} follows $N(0, \sigma_v^2)$ and U_{it} follows a half-normal distribution at zero and guarantees inefficiency to be positive only.

The technical efficiency can be defined for the i-th company in the t-th year following (Battese and Coelli 1988) in the context of stochastic frontier model (1) as follows:

$$TE_{it} = \exp(-U_{it}) \quad (4)$$

U_{it} denotes the specifications of the inefficiency model in equation (2).

RESULTS AND DISCUSSION

Ordinary least square estimation

The ordinary least square (OLS) estimates of the parameters of Cobb-Douglas production function were obtained by grid search in the first step and then these estimates were used to estimate the maximum likelihood estimates of the parameters of Cobb-Douglas stochastic frontier production model. The ordinary least square

estimates showed the average performance of the sample companies that were presented in Table 1. From the analysis we observed that the coefficients of market return, market capitalization, book to market ratio and market value were statistically significant in the Dhaka Stock Exchange stock market. The result indicated that these input variables significantly affected to the individual company's return listed in the DSE market.

Table 1. OLS Estimates of the Cobb-Douglas Stochastic Frontier Production Function

Variables	Parameters	Coefficients	S.E	t-value
Constant	β_0	-0.4911[@]	0.3940	-1.247
Market Return	β_1	0.4553[*]	0.0535	8.507
Market Capitalization	β_2	-0.1548[*]	0.0374	-4.135
Book to Market Ratio	β_3	-0.0596[*]	0.0139	-4.281
Market Value	β_4	0.2305[*]	0.0335	6.884
Log likelihood function		-157.6330		

*, **, *** Significance level at 1%, 5%, 10% consecutively, @ means insignificant, S.E = Standard error

Maximum-likelihood estimates of Cobb-Douglas production function with time-variant and time-invariant situation

The maximum-likelihood estimates (MLE) for the parameters of Cobb-Douglas stochastic frontier production function with time-variant and time-invariant situations were presented in Table 2. The results showed that the maximum-likelihood estimate of the parameter for market return input is 0.4112 and 0.4551; for market capitalization input is -0.1467 and -0.1549; for book to market ratio input is -0.0750 and -0.0617; for market value input is 0.2806 and 0.2302 for the time-varying and time-invarying situation respectively. The MLE of market return and book to market ratio in time-invarying situation were found higher than time-varying situation; and the MLE of market capitalization and market value in time-invarying situation were estimated smaller than time-varying situation. However, the estimated values of the parameters of the Cobb-Douglas frontier production function obtained with the two different environments were almost similar. The log likelihood functional values for the two situations were relatively the same to each other. For the time-variant case, γ is estimated at 0.4770 which was significant and for the time-invariant case, γ is estimated at 0.0388 which was insignificant. This could be interpreted that 47 percent variations in output among the companies were due to the differences in technical efficiency for half normal distribution. It was evident from Table 2 that the estimates of σ was 0.1522 and 0.0871 for time-variant and time-invariant case were significantly different from Zero, indicated a good fit. The estimates for the parameters for the

time varying inefficiency model indicated that the technical inefficiency effects tend to increase over time since the estimates for the η parameter was observed negative.

For the time-variant and time-invariant environment, the maximum-likelihood estimates of the coefficients of market return, market capitalization, book to market ratio and market value were found significant at 1% level of significance. These results indicated that these input variables significantly affect the amount of return in individual companies listed in the DSE market.

Table 2. Estimates of Maximum-Likelihood of the Cobb-Douglas Production Function with Time-variant and Time-invariant situation

		Time-variant			Time-invariant		
Variables	Parameters	Coefficients	S.E	t-value	Coefficients	S.E	t-value
Constant	β_0	-1.6140*	0.4331	-3.727	-0.4359@	0.3923	-1.111
Market Return	β_1	0.4112*	0.0533	7.719	0.4551*	0.0530	8.591
Market Capitalization	β_2	-0.1467*	0.0402	-3.647	-0.1549*	0.0370	-4.183
Book to Market Ratio	β_3	-0.0750*	0.0151	-4.980	-0.0617*	0.0147	-4.191
Market Value	β_4	0.2806*	0.0393	7.145	0.2302*	0.0331	6.951
			Variance parameters				
Sigma-squared	σ^2	0.1522*	0.0303	5.028	0.0871*	0.0052	16.904
Gamma	γ	0.4770*	0.1067	4.473	0.0388@	0.0469	0.8280
Eta	η	-0.4657*	0.1051	-4.432	0	0	0
Log-likelihood		-152.3256			157.2972		

*, **, *** Significance level at 1%, 5%, 10% consecutively, @ means insignificant, S.E = Standard Error

Year-wise mean efficiency of companies

The year wise mean efficiency of 94 companies in DSE market was displayed in Table. From this investigation, the values of mean efficiency showed the range between 0.8232 and 0.9950 during the study period. The technical efficiency had decreased over the study period. The mean technical efficiency of the companies during the period 2000 to 2008 was 0.9448, which implied that 94 percent of potential output was being realized by the companies DSE market.

Table 3. Year-wise Mean Efficiency of Companies in Dhaka Stock Exchange

Year	Mean efficiency
2000	0.9950
2001	0.9921
2002	0.9874
2003	0.9801
2004	0.9686
2005	0.9507
2006	0.9234
2007	0.8824
2008	0.8232
Mean	0.9448

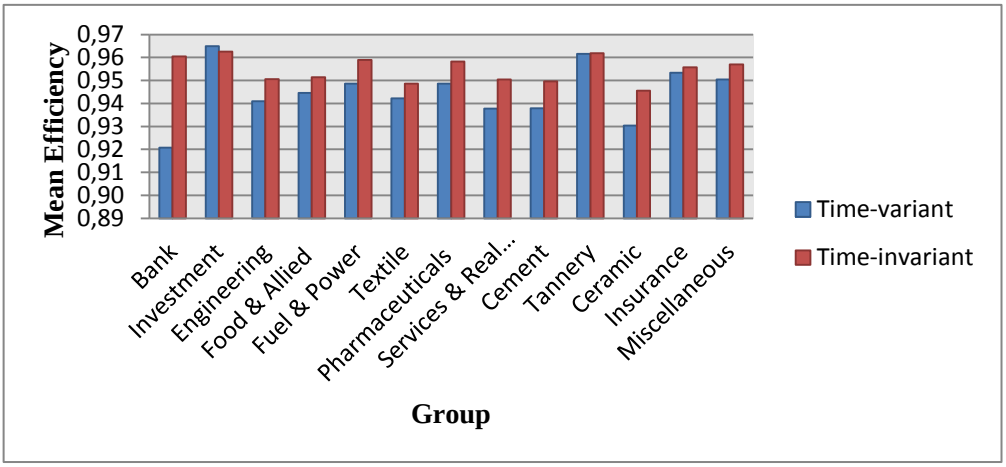
Group-wise mean efficiency of companies

Group-wise mean efficiency of both time-variant and time-invariant cases were given in Table 4 and Figure 1. For the time-variant situation, there was a variation in the technical efficiencies among the different groups in DSE market: it ranged from a low of 0.9207 for Bank-group, to a high of 0.9649 for Investment-group, while in case of time invariant environment; it ranged from a low of 0.9455 for Ceramic-group, to a high of 0.9625 for Investment-group. All groups, except "Investment" in DSE market with time-invariant environment showed higher technical efficiency than time-variant situation.

Table 4. Group-wise Mean Efficiency of Companies with Time-variant and Time-invariant in Dhaka Stock Exchange

	Mean Efficiency	
Group	Time-variant	Time-invariant
Bank	0.9207	0.9605
Investment	0.9649	0.9625
Engineering	0.9409	0.9506
Food & Allied	0.9445	0.9514
Fuel & Power	0.9486	0.9589
Textile	0.9421	0.9486
Pharmaceuticals	0.9486	0.9582
Services & Real Estate	0.9378	0.9504
Cement	0.9379	0.9495
Tannery	0.9616	0.9618
Ceramic	0.9304	0.9455
Insurance	0.9533	0.9557
Miscellaneous	0.9504	0.9569

Figure 1: Group-wise mean efficiency with time-variant and time-invariant environment



CONCLUSION

The results suggest that the variables such as market return, market capitalization, book-to-market ratio and market value have a significant influence on share returns. Through the several tests, it is observed that technical inefficiency effects associated with the companies of Bangladesh Stock Market are significant; the technical efficiency rate is found gradually decreasing over time in the stock market in Bangladesh.

The investment group gives highest technical efficiency and the bank group gives lowest technical efficiency in the situation of time-variant whereas in the context of time-invariant, the investment group also gives highest technical efficiency but the ceramic group gives lowest technical efficiency for the half normal distribution. Thus this study provides significant insights into the level of company's group-specific technical efficiency.

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