Journal of Global Business and Social Entrepreneurship (GBSE)
Vol. 1: no. 1 (2016) page 98–103 | gbse.com.my | eISSN 24621714|

YEAR OVER YEAR EFFICIENCIES OF BANK NEGARA MALAYSIA: DATA ENVELOPMENT ANALYSIS VERSUS STOCHASTIC FRONTIER ANALYSIS

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Abstract

This paper examines Bank Negara Malaysia (BNM) twelve year to year efficiency levels by employing two competing frontier analyses namely Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The data covers a 12-year time periods from 2000 to 2012 except 2010, and five variables are considered where Net Profit (NP) and Loans & Advances (LA) are the outputs, while total assets, risk reserve and total deposit are the input variables. The results show that DEA gives the lowest average efficiency level at 0.936, while LA Stochastic Frontier model estimates the highest average year wise efficiency at 0.992, and the NP Stochastic Frontier model is the second highest (0.934). With all three efficiency averages of more than 0.9, BNM is at the positive phase to increase its outputs, which are NP and LA by using the same inputs.

Keywords: *Efficiency Analysis, Data Envelopment Analysis, Stochastic Frontier Analysis, Bank Performance*

2016 GBSE Journal

Introduction

Bank Negara Malaysia (BNM) is the central bank of Malaysia. Its operations started on 26th of January 1959. BNM has to play major role in stimulating monetary and financial stability to boost up Malaysian economy. Besides being responsible for monetary policy and money issuance, BNM is also acting as a banker and advisor to the government and regulating the country's financial institutions. It also plays an important function in implementing initiatives to deepen and strengthen the financial markets, including the foreign exchange market (www.bnm.gov.my).

A question arises how far BNM is able to serve the country in meeting its desired goal. Its performance should be monitored closely and frequently but not by comparing it with other banks since its roles are different from other commercial banks. One way to measure the

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performance of BNM is by measuring its efficiency as its success indicator. This paper investigates its year wise efficiency levels by utilizing two competing frontier analyses namely Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). DEA is a non-parametric method, whereas SFA is its counterpart that is a parametric method. The data covers a 12-year time periods from 2000 to 2012 except 2010, compiled from the annual reports of BNM. Five variables are considered in this study where Net Profit (NP) and Loans & Advances (LA) are the outputs, whereas total assets, risk reserve and total deposit are considered as the input variables.

This paper is organized as follows. The next two sections provide discussions on the analysis methods used to measure the ten year to year efficiencies of BNM. Then followed by a section that explains about the data and the variable descriptions. The last two sections discuss the results and discussions, and the conclusions.

Data Envelopment Analysis (DEA)

DEA is a very popular method since being a non-parametric method, and DEA can be used without knowing the type of distribution underlying the data (Fukuyama, 1993; Favero and Papi, 1995). DEA measures the total efficiency of a unit, or known as decision making unit (DMU) by considering multiple outputs and inputs simultaneously. The definition of efficiency as a ratio of multiple outputs to multiple inputs is very suitable since many production systems are producing more than one output and using more than one input. This idea is basically initiated by Farell (1957) who defined efficiency as a ratio of one input to one input, but Charnes, Cooper and Rhodes extended the idea to multiple inputs and outputs and pioneered the idea of DEA with their original model with constant return to scale formulation (Charnes, Cooper and Rhodes, 1978).

$$Max \sum_{r=1}^{s} u_r y_{r0}$$

$$\text{Subject to: } \sum_{r=1}^{s} u_r y_{r0} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad (1)$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1, \quad -u_r \le -\varepsilon$$

$$-v_i \le -\varepsilon$$

where, y_{rj} and x_{ij} are positive known outputs and inputs of the *j*th DMU, and u_r and v_i are the variable weights to be determined by solving the above equation problem. For this study, the CCR model is used with Loans & Advances (LA) and Net Profit (NP) are used as output variables whereas Total Assets (TA), Risk Reserve (RR) and Total Deposit (TD) are used as input variables. DEA efficiency can also be defined as variable return to scale version, which is formulated as BCC (Banker, Charnes and Cooper, 1984).

Stochastic Frontier Analysis (SFA)

The SFA was introduced by Aigner, Lovell and Schmidt (1977). This method incorporates the measurement errors or stochastic noise (Hossain, Kamil, Baten, and Mustafa, 2012) which were 'neglected' by DEA, and these errors should be considered since they may

influence the shape and the position of the estimated frontier (Bauer, 1990, and Greene, 1993). The stochastic frontier production model is generally written as

$$\ln y_{it} = x_{it}^{'}\beta + v_{it} - u_{it}, \text{ where } i = 1, 2 \ldots N;\ t = 1, 2, \ldots T \qquad (2)$$

where y_{it} are outputs, x_{it} are vectors of explanatory variables, v_{it} are independently and identically distributed normal variables with zero mean and constant variance; and u_{it} are identically and independently distributed non-negative random variables used to capture technical inefficiency, which usually follow certain distribution such as half-normal, truncated normal or exponential.

Two SFA models are used in this study, the Empirical Loans & Advances (LA) and Net Profit (NP) Stochastic Frontier Models as given as follows:

Model1

Empirical Loans & Advances (LA) Stochastic Frontier Model

$$\ln(LA) = \alpha + \beta_1 * \ln(TA) + \beta_2 * \ln(RR) + \beta_3 * \ln(TD) + v - u \qquad (3)$$

Model 2

Empirical Net Profit (NP) Stochastic Frontier Model

$$\ln(NP) = \alpha + \beta_1 * \ln(TA) + \beta_2 * \ln(RR) + \beta_3 * \ln(TD) + v - u \qquad (4)$$

Where TA is the total asset, RR is the risk reserve and TD is the total deposit.

Data and Description of Variables

The data were collected from the annual reports of the BNM which is available online from BNM website at bnm.gov.my. As explained in previous sections, Loans & Advances (LA) and Net Profit (NP) are used as output variables whereas Total Assets (TA), Risk Reserve (RR) and Total Deposit (TD) are used as input variables, IMF fund, Foreign Security. Foreign Deposits, Gold and Foreign Exchange are used as explanatory variables. For this study, we consider 12 years from 2000 -2012. In the study, Net profit and Loans & Advances are considered as output variables whereas total assets, risk reserve and total deposit are considered as the input variables. Table 1 presents the descriptive statistics of loans & advances, net profit, total assets, risk reserve and total deposit during the study period. The following two sections illustrate the efficiency results from the two techniques.

Table 1: Descriptive statistics of outputs and inputs (in 000 RM)

	Loans and Advances	Net Profit	Total Assets	Risk Reserve	Total Deposit
Mean	10491606006.0	3777873625.1	303884451510.8	2537674647 8.83	1651412115 69.0
Minimum	8015270790.0	706055365.0	148908133501 .0	1396607942 4.00	8518619806 5.0
Maximum	12924727795.0	7669863825.0	476331018780 .0	4481834019 0.00	2486858541 02.0

Data Envelopment Analysis (DEA) Efficiency

Figure 1 describes the year wise total efficiency analysed by DEA method. From figure, it shows that BNM are found to be technically efficient in 2000, 2001, 2007, 2008, 2009 and 2012, but inefficient for five consecutive years, 2002 to 2006 with the minimum efficiency of score 0.77 in 2004. The average DEA technical efficiency in the study period is 0.926.

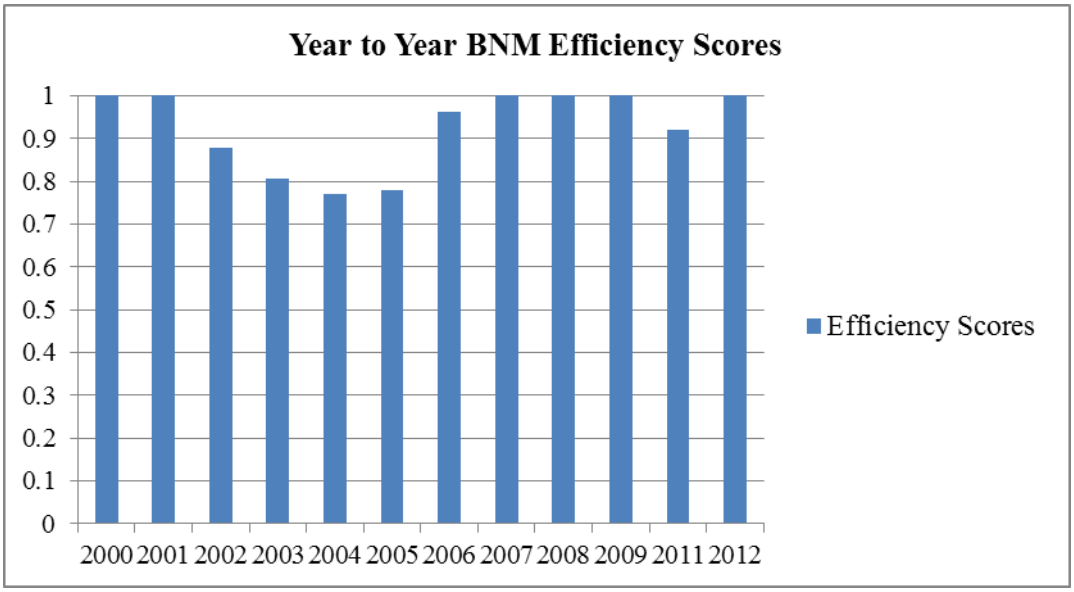

Figure 1: DEA Year Wise Technical Efficiency of Bank Negara Malaysia

Efficiency Results from Stochastic Frontier Analysis

In Model 1, Loans and Advances (LA) are considered as output and in Model 2, Net Profit (NP) is the output. Both models have the same inputs, which are Total Asset (TA), Risk Reserve (RR) and Total Deposit (TD). Table 2 shows the estimation of efficiency by Model 1 and 2. In Model 1, the TA and Total Deposit are significant at 5% and 1% level of significance whereas in Model 2, only Total Deposit is significant at 5% level of significance. The value of Gamma (γ) is positive and significant at 1% for Model 1, which implies that the specific technical efficiency is important to explain the total variability of the Loan and Advances or the output.

Table 2: Maximum Likelihood Estimation of Model 1 and Model 2

	Model 1: Loans and Advances is output			Model 2: Net Profit is output		
	Estimate	Std. Error	*z* value	Estimate	Std. Error	*z* value
(Intercept)	12.80***	0.998	12.821	-34.16***	7.81	-4.37
log(TA)	-0.85 **	0.41	-2.0865	0.68	0.72	0.94
log(RR)	-0.01	0.04	-0.3039	0.21	0.25	0.85
log(TD)	1.29***	0.44	2.9598	1.28**	0.73	1.74
σ^2	0.007*	0.003	1.6579	0.07***	0.03	2.68

γ	0.99***	0.04	23.7242			0.00
				0.00004	0.04	1
log likelihood value	19.70			19.70		

***, ** and * indicate 1%, 5% and 10% level of significance respectively

Figure 2 presents the year wise efficiency for the two models. Model 2 gives efficiency scores of Bank Negara almost of the same over the years and nearest to 1, while Model 1 shows a variation from year to year, where efficiency levels are above 0.9 except for years 2005, 2001, 2007, and 2011.

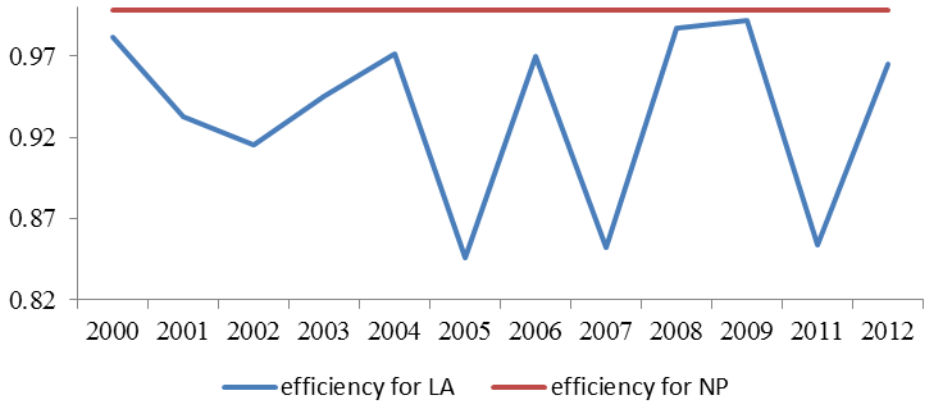

Figure 2: SFA Year to year efficiencies of BNM

Conclusion

This paper discusses the use of non-parametric and parametric methods to measure the year to year technical efficiency of Bank Negara in Malaysia. As a parametric method, SFA considers errors in the efficiency estimations. The results show that the central bank of Malaysia has the constant performance which is very near to one in using Loan and Advance as the output, whereas the performance of gaining Net Profit is less and varies throughout the study period. The use of SFA acts as a complement method to DEA, where DEA gives the year wise total efficiency levels of Bank Negara. These two methods are complementing each other and results obtained from both methods are more meaningful. As a whole, Bank Negara Malaysia are still at the positive state since there still opportunities for Bank M=Negara Malaysia to increase their outputs in the form of net profit and loans & advances by using the same inputs.

Acknowledgements

This research is supported by the Ministry of Education of Malaysia under the Research Acculturation Grant Scheme (RAGS) with S/O Code 12656, 2012-2015.

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