

Short Research Article

A Measure of Performance and Efficiency of Commercial Banks in Taiwan: Applying Data Envelopment Analysis and Malmquist Index

ABSTRACT

This paper examines the performance of commercial banks in Taiwan, in terms of their ability to provide maximum outputs by the given input utilization. The Data Envelopment Analysis (DEA) and Malmquist Index methods have been employed to determine the effects of variable returns on the operational performance and efficiency. The Model in the Study uses five input variables (i.e. numbers of branches, number of employees per branch, shares in total assets, share in total loans, and share in total deposits) and five output variables (i.e. ROA, ROE, net interest income/total assets, net interest income/total operating income, and non-interest income/total assets). Results of the DEA and Malmquist Index are presented and discussed in the final section.

Keywords: Bank, Performance, Data Envelopment Analysis, Malmquist Productivity Index

INTRODUCTION

Financial markets in Taiwan have remarkable transformation over the last two or three decades due to globalization. This paper examines the performance of commercial banks in Taiwan, in terms of their ability to provide maximum outputs. DEA approach has been applied to estimate efficiency and Malmquist Index has been used to examine changes in the operational performance. The observation period had been selected as five years between 2006 and 2010. This paper is organized as follows: section two reviews the relevant literature on banking industry using DEA and Malmquist Index. Section three introduces DEA and Malmquist Index in brief. Section four discusses methodology and sample. Section five presents findings and discussions. Conclusions are presented in the final section.

LITERATURE REVIEW

Banking sector has undergone significant changes in the past decades. Liberalization in financial market has been adopted by many countries worldwide. Facing extremely competition, commercial banks require evaluating their efficiency and performance. There are a variety of research have been studied in the field of banking performance using different methodologies, such as DEA or Malmquist Index to examine the operational performance and efficiency (Chang and Chiu, 2006; Pasiouras, 2008; Sufian, 2009).

A variety of techniques have been used to examine the efficiency and performance of commercial banks. It is found that the selection of technique have a crucial role in evaluating efficiency and operational performance. DEA technique allows an evaluation of the efficiency and performance

Comment [L1]: Let us assume this is Malmquist Index, granted. But see comment 11 below and draw distinction right there.

Comment [L2]: Insert.

Comment [L3]: Insert.

Comment [L4]: Insert.

Comment [L5]: Use upper case letter here to identify this study at hand from others..

Comment [L6]: Create a space after this word.

Comment [L7]: Number of employee is automatically one. Therefore insert 's' after employee.

Comment [L8]: See comment 6 above.

Comment [L9]: You need to briefly describe the results here. The reason for this is that an abstract should provide all the details of the paper briefly in a few words. One should have the gist of the entire paper by mere reading your abstract. One would also say that if the abstract is separated from this paper, it should speak for itself.

Comment [L10]: Keywords must be carefully looked at. When choosing keyword, we normally look at these words as an index to the paper. If any word given as keyword does not feature as an index, obviously the word does not serve the purpose as an index.

Comment [L11]: What is the difference between Malmquist Index and Malmquist Productivity Index? Clarify us here.

Comment [L12]: Insert.

Comment [L13]: Indicate how many decades if possible. If it is over just a decade then you have to remove that 's' after the word 'decades'.

Comment [L14]: Here you have to define the term in terms of its origins and indicate how it fits into this context.

Comment [L15]: Insert.

Comment [L16]: Become a bit more specific regarding the number of decades. See comment 13 above.

Comment [L17]: Briefly describe 'Liberalization'.

Comment [L18]: Provide an example or two of such countries.

Comment [L19]: Delete.

Comment [L20]: Delete.

relative to a best practice technology (Charnes et al., 1978; Sekhri, 2011). Efficiency is a wider perception and involves choosing optimum levels. Bank efficiency can be divided into scale, scope, technical efficiency and so on. As contrasting to parametric techniques such as regression or SEM, DEA technique does not assume that the same optimized regression equation relates to all DMUs.

Comment [L21]: Insert.

Comment [L22]: Delete.

Comment [L23]: Provide the full meaning on the first use and then use the acronym thereafter.

Comment [L24]: See previous comment just above.

Farrell (1957) published a paper entitled “the Measure of Productive Efficiency” to pre-estimate efficiency value with non-predetermined production function to replace predetermined function. This establishes the basic theory of the data envelopment analysis. Firstly, Farrell proposed the concept of production frontier to measure efficiency and with mathematical programming method to find the deterministic non-parametric efficiency frontier and efficiency production function. The concept of determinism refers to all the DMU at the same level and face the same production frontier. But, non-parametric efficiency frontier between the input and output need not predetermined specific production function. Farrell (1957) with the concept of the non-predetermined production function built mathematical programming model to evaluate agricultural technical efficiency among 48 states in USA. Its evaluation method mainly lies in the relative concept. To find the most efficiency sample from 48 states, use it to constitute the most efficiency frontier. For the other states, weighted average of its most efficiency sample for each unit production to find optimal sample combination. Take contrary of the sum of its coefficient. This inverse coefficient is called efficient. Farrell established a framework of the DEA with non-predetermined function to measure it. But this method only deals with the single output case. Charnes et al. (1978) based on the concept established by Farrell (1957) to create a mathematical model and formally named it as the DEA. It applies the envelope theory built by Farrell and Fieldhouse (1962) and deterministic nonparametric method built by Farrell (1957) to develop a method to measure relative efficiency for multiple outputs and multiple inputs.

Comment [L25]: Review the statement.

Comment [L26]: What contrary?

Comment [L27]: Delete.

DEA THEORY AND EMPIRICAL MODEL

This study used the Data Envelopment Analysis (DEA) to explore the operational performance of commercial banks in Taiwan. DEA is a non-stochastic and non-parametric programming to assess the comparative efficiency of Decision Making Units (DMUs) with ordinary inputs and outputs. As to the DEA theoretical basis, we can divide this into basic principle of the DEA and the Malmquist Index. This method can identify the most efficiency decision making unit (DMU) among all the decision units. It does not need to preset a weighted index, but can handle multiple inputs and multiple outputs. It also can offer the contribution of each kind of input and output to the relative efficiency. In addition, this method can offer improvement suggestions for the inefficiency decision units and with equality and objectivity to measure the efficiency (Sufian, 2012). The DEA estimate compares each of the commercial banks in the sample with the one that is the best practice DMU in this study.

Comment [L28]: This concept was not clearly defined. Also avoid repetition, see the abstract.

Comment [L29]: Insert.

Comment [L30]: This was also not initially clearly defined.

Comment [L31]: Delete.

Comment [L32]: Insert.

Comment [L33]: Delete.

Comment [L34]: Insert.

Comment [L35]: Delete.

Comment [L36]: Insert.

Comment [L37]: Delete.

Comment [L38]: Insert. It should here be noted that most of the work has already been done and past tense would thus be preferred.

Comment [L39]: Insert upper case.

This study will be divided into four parts to investigate the DEA model such as efficiency analysis, return to scale analysis, slack variable analysis, and sensitivity analysis. First, efficiency analysis; Farrell (1957) defines the overall efficiency as the product of technical efficiency and allocate efficiency. Afterwards Banker et al. (1984) decomposed the technical efficiency into the product of the pure technical efficiency and the scale efficiency. Second, return to scale analysis; With the DEA to calculate the sum of the aggregate parameter (λ) for each DMU, it can be identified which scale level stayed for the DMU. If $\Sigma \lambda > 1$, it shows that the

93 production of this DMU is over the optimal scale. It belongs to the increasing return to scale. If
 94 $\Sigma\lambda < 1$, it shows that the production of this DMU is below the optimal scale. It belongs to the
 95 decreasing return to scale. If $\Sigma\lambda = 1$, it shows that the production of this DMU is on the optimal
 96 scale. It belongs to the constant return to scale. In the BCC (Banker et al., 1984) model, it adds u_0 .
 97 If $-u_0$ (negative u_0) is greater than 0 (i.e. u_0 itself is negative), then it corresponds to the line of
 98 the production frontier belonging to the increasing return to scale (IRS). If $-u_0$ equals to 0, then it
 99 corresponds to the line of the production frontier belonging to the constant return to scale (CRS).
 100 If $-u_0$ is less than 0, then it corresponds to the line of the production frontier belonging to the
 101 decreasing return to scale (DRS).

102 Third, slack variable analysis; Slack variable analysis can provide the information of the resource
 103 utilization. It is not only for the basis of target setting, but also for understanding of how much
 104 improvement for the evaluated DMU is. For an inefficient evaluated DMU is called k. Its input
 105 set is (X_{ik}, Y_{rk}) . If the optimal solution is $(\theta^*, \lambda^*, S_r^{+*}, S_r^{-*}), (\lambda_1^*, \lambda_2^*, \dots, \lambda_n^*)$, then the projection
 106 of the (X_{ik}, Y_{rk}) on the efficiency frontier is would be as following:

$$107 X_{ik}^* = \theta^* X_{ik} - S_i^{-*}, i=1, \dots, m$$

$$108 Y_{rk}^* = Y_{rk} + S_r^{+*}, r=1, \dots, s$$

109 It can be found that the difference of (X_{ik}, Y_{rk}) to the compare object as follows:

$$110 \Delta X_{ik} = X_{ik} - X_{ik}^*, i=1, \dots, m$$

$$111 \Delta Y_{rk} = Y_{rk} - Y_{rk}^*, r=1, \dots, s$$

112 i.e. the evaluated DMU k can improve its efficiency by reducing input of ΔX_{ik} and increasing
 113 output of ΔY_{rk} .

114
 115 Forth, sensitivity analysis; the efficiency measured by the DEA is a relative efficiency. If the
 116 number of the evaluated DMU changes, its relative efficiency will be changed along. When input
 117 items changed, it has to rerun the DEA and to examine the efficiency value for the evaluated
 118 DMU. Thus any factor value changed it has to re-execute the programming model. Farrell (1957)
 119 proposed a method to measure efficiency. The main assumption is production technique fixed to
 120 measure the distance of the DMU to the production frontier. Use this production efficiency index
 121 as a criterion to evaluate firm operational performance. If add time factor into the model, it
 122 belongs to multiple period model. Production technique will change as time variation. Therefore
 123 on evaluating production efficiency, it should consider the variation of the production technique.
 124 Fare et al. (1992) defined Malmquist production index (MPI). It can solve the aforementioned
 125 problem. Productivity change can be decomposed into efficiency change (EC) and technical
 126 change (TC). Use distant function to calculate these two components of the MPI. Then use it to
 127 explore the reasons of the firm productivity change.

130 METHODOLOGY AND DATA ANALYSES

131 It is an advantage to employ DEA and Malmquist Index in measuring performance of the bank
 132 since the techniques do not need to use specified functional form such as guarantees, foreign
 133 exchange, trusts, credit cards, cash cards, securities, debentures, and proprietary dealing in
 134 futures. This paper aims to examine the long-term trend in efficiency changes of twelve
 135 commercial banks, which are subsidiaries of financial holding companies listed in Taiwan Stock
 136 Exchange (see Table 1).

Comment [L40]: Review sentence.

Comment [L41]: Review sentence.

Comment [L42]: What is BBC?

Comment [L43]: Review sentence.

Comment [L44]: Review sentence.

Comment [L45]: What is 'it' stand for?

Comment [L46]: Insert upper case.

Comment [L47]: Insert.

Comment [L48]: Insert.

Comment [L49]: Insert.

Comment [L50]: Delete.

Comment [L51]: Insert.

Comment [L52]: Insert.

Comment [L53]: Delete.

Comment [L54]: Review sentence.

Comment [L55]: Review sentence.

Comment [L56]: Review sentence.

Comment [L57]: Review sentence.

Comment [L58]: Insert.

Comment [L59]: Insert.

138 The data used in the study are from the reports of the Bank Sector Statistics published by the
139 Central Bank, Taiwan from 2006 to 2010. Table 2 shows that the variables used in the study
140 include inputs: (1) numbers of branches, (2) number of employee per branch, (3) share in total
141 assets, (4) share in total loans, and (5) share in total deposits and outputs: (1) ROA, (2) ROE, (3)
142 net interest income/total assets, (4) net interest income/total operating income, and (5) non-
143 interest income/total assets (Primorac and Zvonimir, 2005; Sakar, 2006; Sekhri, 2011). First, we
144 calculate simple correlation coefficients as a criterion to check productivity initially and use it to
145 analyze variable relationships. Second, based on the relationship between inputs and outputs to
146 find optimal production frontier, use it to evaluate the operational performance of commercial
147 banks in Taiwan. Based on the slack variable analysis provide the criteria to improve operational
148 performance. For all input and output variables standard deviation is a value comparable to the
149 variable mean.

Comment [L60]: Insert.

Comment [L61]: Use upper case.

151
152 The correlations between inputs and outputs are presented in the Table 3. There are strong
153 correlations between the input variables. For instance, IP1 (Number of branches) affect the IP3
154 (Share in total assets), IP5 (Share in total deposits). However, the correlation between inputs and
155 outputs is either too weak or not in existence. OP1 (ROA) and OP2 (ROE) are highly correlated.
156 Table 3 shows that all the coefficients with a positive between inputs and outputs. It indicated
157 that relational output quantity will increase as quantity of input increased. Therefore, it is not
158 necessary to remove the variables of input or output with a lower correlation coefficient.

Comment [L62]: Insert.

Comment [L63]: Delete.

Comment [L64]: Positive, what?

161 RESULTS

162 The DEA efficiency scores can be interpreted to illustrate that individual bank may increase its
163 outputs without changing the input utilization if the technical efficient is as good as the best
164 practice bank. The Table 4 shows that total efficiency indicated a steady improvement on the
165 commercial banks in Taiwan during 2006 to 2007. However, from 2009 to 2010, total efficiency
166 showed a decline. This showed that the operation of commercial banks in Taiwan is not on the
167 optimal scale. For resource consumption, there should be some rooms for improvement.

168
169 Regarding the change on the technical efficiency, the change rate in the period of 2007-2008 is
170 0.949, which shows that the technical efficiency has declined. Moreover, the following periods,
171 2008-2010 have declined further. For the change of scale efficiency in the period of 2006-2007 is
172 0.931 whilst the rate is 1.008 in the following period (2007-2008). This indicates that production
173 scale is more near constant return to scale. Regarding the change on the productivity, the rate
174 drops from 1.03 (2006-2007) to 0.774 (2009-2010). It indicates that productivity has constantly
175 declined during the five years (see Table 4).

Comment [L65]: Insert.

Comment [L66]: Insert

178 CONCLUSIONS

179 The paper aimed to use DEA and Malmquist Index to study the performance and efficiency of
180 commercial banks listed in Taiwan Stock Exchange. Two sets of results were found from the
181 period of five years between 2006 and 2010. Bank performance can be evaluated by these
182 efficiency scores so that banks with dreadful performance may identify and prioritize their
183 resources and enhance efficiency only by improving their outputs. We can identify relative
184 efficient and inefficient commercial banks and understand the result of each output variable under

Comment [L67]: Delete.

Comment [L68]: Insert.

Comment [L69]: Insert.

185 the efficiency performance analysis by the empirical results. We study how to achieve optimal
186 efficiency for the bank operation by changing inputs or outputs. In addition, those results are
187 expected to offer suggestions for commercial banks in planning its performance.

188
189 First of all, just 1(8.3%) bank shows an increase in total efficiency during 2005-2009, 4(33.3%)
190 banks remain steady, and 7(58.3%) banks demonstrate a decline. Second, regarding technical
191 efficiency, only 1(8.3%) bank shows an increase, 1(8.3%) bank keeps constant, and 10(83.3%)
192 banks show a decline. This indicates that most of the commercial banks in Taiwan are not in their
193 best operation. Finally, with regard to total factor productivity, all 12(100%) banks show a
194 decrease. It indicates the bank sector was deeply in financial crisis in 2008 and has not fully
195 recovered.

Comment [L70]: Insert.

Comment [L71]: Insert.

Comment [L72]: Insert.

196 197 198 REFERENCES

- 199 Banker, R., Charnes, A. & Cooper, W. (1984). Some Models for Estimating Technical and Scale
200 Inefficiencies in Data Envelopment Analysis. *Management Science*, 30, 1078-1092.
- 201 Chang, T. & Chiu, Y. (2006). Affecting Factors on Risk-Adjusted Efficiency in Taiwan's
202 Banking Indus. *Contemporary Economic Policy*, 24, 634-648.
- 203 Charnes, A., Cooper, W. & Rhodes, E. (1978). Measuring the Efficiency of Decision Making
204 Units. *European Journal of Operations Research*, 2, 424-444.
- 205 Charnes, A., Cooper, W. and Rhodes, E. "Measuring the Efficiency of Decision Making Units."
206 *European Journal of Operational Research*, Vol. 2, No. 6(1978): 429-444.
- 207 Färe, R., Grosskopf, S., Lindgren, B. & Roos, P. (1992). Productivity changes in Swedish
208 pharmacies 1980-1989: A non-parametric Malmquist approach. *Journal of Productivity*
209 *Analysis*, 3, 85-101.
- 210 Farrell, M. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical*
211 *Society (Series A)*, 120, 253-281.
- 212 Farrell, M. J., & Fieldhouse, M. (1962). Estimating Efficient Production functions under
213 increasing Returns to Scale." *Journal of the Royal Statistical Society (Series A)*, 125, 252-
214 267.
- 215 Pasiouras, F. (2008). International Evidence on the Impact of Regulations and Supervision
216 on Banks' Technical Efficiency: An Application of Two-Stage Data Envelopment Analysis.
217 *Review of Quantitative Finance and Accounting*, 30, 187-223.
- 218 Primorac, M. & Troskot, Z. (2005). Measuring the Efficiency and Productivity of the Croatian
219 Banks with Malmquist Index of Change of Total Factor Productivity. *Journal of Financial*
220 *Theory and Practice*, 29, 309-325.
- 221 Sakar, B. (2006). A Study on Efficiency and Productivity of Turkish Banks in Istanbul Stock
222 Exchange using Malmquist DEA. *Journal of American Academy of Business, Cambridge*, 8,
223 145-155.
- 224 Sekhri, V. (2011). A DEA and Malmquist Index Approach to Measuring Productivity and
225 Efficiency of Banks in India. *IUP Journal of Bank Management*, 10, 49-64.
- 226 Sufian, F. (2009). Sources of TFP Growth in the Malaysian Islamic Banking Sector. *The Service*
227 *Industries Journal*, 29, 1273-1291.
- 228 Sufian, F. (2012). Developments in the efficiency of the Malaysian banking sector: the impacts of
229 financial disruptions and exchange rate regimes. *Progress in Development Studies*, 12, 19-
230 46.
- 231

232

Table 1 Sample of Commercial Bank and its Financial Holding Company

DMU	Commercial Bank	Financial Holding Company
1	Hua Nan Bank (HNB)	Hua Nan Financial Holdings Co., Ltd.
2	Taipei Fubon Commercial Bank (TFCB)	Fubon Financial Holdings Co., Ltd.
3	Cathay United Bank (CUB)	Cathay Financial Holdings Co., Ltd.
4	E.SUN Commercial Bank (ESCB)	E. SUN Financial Holdings Co., Ltd.
5	Yuanta Commercial Bank (YCB)	Yuanta Financial Holdings Co., Ltd.
6	Mega International Commercial Bank (MICB)	Mega Financial Holdings Co., Ltd.
7	Taishin International Bank (TIB)	Taishin Financial Holdings Co., Ltd.
8	Shin Kong Bank (SKB)	Shin Kong Financial Holdings Co., Ltd.
9	Bank SinoPac (BSP)	SinoPac Financial Holdings Co., Ltd.
10	CITIC Bank International (CITIC)	Chinatrust Financial Holding Co., Ltd.
11	First Commercial Bank (FCB)	First Financial Holding Co., Ltd.
12	Taiwan Cooperative Bank (TCB)	Taiwan Cooperative Financial Holding Co., Ltd.

233

234

Table 2 Variable of Inputs and Outputs in the Model

Inputs		Mean	Std.
Input 1 (IP1)	Number of branches	158.017	1.579
Input 2 (IP2)	Number of employee (per branch)	106.792	153.969
Input 3 (IP1)	Share in total assets	29.459	0.568
Input 4 (IP1)	Share in total loans	18.341	0.347
Input 5 (IP1)	Share in total deposits	22.632	1.214
Outputs			
Output 1 (OP1)	ROA (Return on Assets)	0.018	0.002
Output 2 (OP2)	ROE (Return on Equity)	0.263	0.146
Output 3 (OP3)	Net interest income/total assets	0.421	0.912
Output 4 (OP4)	Net interest income/total operating income	1.430	2.049
Output 5 (OP5)	Non-interest income/total assets	0.006	0.003

235

236

Table 3 Correlations between inputs and outputs

	IP1	IP2	IP3	IP4	IP5
OP1	0.14	-0.19	-0.53	0.04	-0.53
OP2	-0.38	0.24	-0.93	-0.57	-0.86
OP3	0.41	-0.25	0.88	0.66	0.75
OP4	0.08	-0.17	-0.18	-0.33	0.25
OP5	0.88	-0.92	-0.15	0.22	0.47

237

238

Table 4 Malmquist Index Summary of Annual Means

Period	Efficiency change	Technical change	Pure technical change	Scale efficiency change	Total factor productivity change
2006-2007	0.889	1.158	0.931	0.955	1.03
2007-2008	1.021	0.949	1.008	1.014	0.969
2008-2009	1.022	0.831	1.012	1.01	0.849
2009-2010	0.983	0.787	0.992	0.991	0.774
Mean	0.977	0.921	0.985	0.992	0.9

239

240

241

Table 5 Banks ranking by total factor productivity change of Malmquist Index

DMU	Bank	Efficiency change	Technical change	Pure technical change	Scale efficiency change	Total factor productivity change
6	MICB	0.913	1.067	0.937	0.975	0.974
7	TIB	1	0.973	1	1	0.973
2	TFCB	0.959	1	0.983	0.976	0.959
12	TCB	0.994	0.949	1	0.994	0.943
8	SKB	1	0.935	1	1	0.935
10	CITIC	1	0.911	1	1	0.911
3	CUB	0.959	0.94	0.976	0.983	0.902
9	BSP	1.05	0.85	1	1.05	0.893
1	HNB	0.959	0.913	1.001	0.958	0.876
5	YCB	1	0.857	1	1	0.857
11	FCB	0.938	0.86	0.947	0.991	0.807
Mean		0.977	0.921	0.985	0.992	0.900
Number of Efficient ratio > 1		1(8.3%)	1(8.3%)	1(8.3%)	1(8.3%)	0(0%)
Number of Efficient ratio = 1		4(33.3%)	1(8.3%)	6(50%)	4(33.3%)	0(0%)
Number of Efficient ratio < 1		7(58.3%)	10(83.3%)	5(41.7%)	7(58.3%)	12(100%)

242