

Productivity Change Based on the Changes in Credit Risk of Taiwanese Commercial Banks: DEA Malmquist Productivity Measure

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Abstract

The operating efficiency of Taiwanese commercial banks is a key factor on Taiwan's economic development. However, the changes in credit risk of the banks have serious impact on productivity change. In this paper, we use financial ratios to assess credit risk of 34 Taiwanese commercial banks before and during the global financial crisis over the period 2007-08, and investigate the productivity change based on the changes in credit risk with the Malmquist productivity index (MPI) approach, which is calculated from efficiency scores based on data envelopment analysis (DEA). Then we apply Tobit regression to identify the key variables which significantly affect the efficiencies in credit risk and to analyze the correlation between the experience of M&As investment and productivity change. And according to earning per share (EPS) and MPI, we classify the 34 banks into four groups. We find that different groups of banks should have different strategies of credit risk management to survive in this changing environment. Furthermore, the increase of the ratio of total loans to total assets could not improve technical efficiency (TE) and pure technical efficiency (PTE) at the decision making units (DMUs) due to the increase of credit risk. Also, the experience of M&As investment could have poor help on efficiency/productivity change on credit risk at the DMUs.

Keywords: Credit risk, Financial ratios, Malmquist productivity index, Tobit regression

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1. Introduction

The notion of risk which matters is central to all industries. It is not just a question of what kinds of products will be produced, or how much it will cost. Most of the studies on bank performance in the literature employ objective functions focusing on the economics of cost minimization, profit maximization or managerial utility maximization, where the performance equation denotes a cost function, a profit function or a managerial utility function. However, the main deficiency of these researches is their negligence of risk. Recently, regulators have begun to consider the evaluation of credit risk to estimate the effectiveness of the capital requirement regime. For instance, Paradi et al. (2004) believed that the identification and quantification of credit risk is more important in improving the efficiency, accuracy and consistency of risk management initiatives. Furthermore, efficiency models are based on the fact that the elements of credit risk are important factors affecting the performance of a bank. Researchers in banks' strategic management have also considered credit risk assessment to be a major factor affecting key strategic decisions. The present author also contends that the changes of credit risk should impact productivity change of banks. Furthermore, concur with the recent global financial crisis in 2008, banking crisis in well-developed countries such as Taiwan, England and Japan has shown that property values and real asset values are very hard to be predicted and realized through liquidation. The weaker and more uncertain collateral values are, the more risky lending is likely to be. Therefore, the purpose of this paper is to measure the productivity changes based on the changes in credit risk of Taiwanese commercial banks

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before and during the global financial crisis over the period 2007-08, and to determine the effect of credit risk. Our sample consists of 34 Taiwanese commercial banks covering the period from 2007 through 2008. We employ the Malmquist productivity index (MPI) approach which is calculated from efficiency scores based on data envelopment analysis (DEA) to measure productivity change based on the changes in credit risk, and use Tobit model to identify the key variables which significantly affect the efficiencies in credit risk. And through our Tobit model, we also analyze the correlation between the experience of M&As investment and productivity change.

Credit risk is one of the oldest and most important forms of risk faced by banks as financial intermediaries. It is defined as the degree of value fluctuations in debt

instruments and derivatives due to changes in the underlying credit quality of borrowers and counterparties. And, it is also measured as the uncertainty of future credit losses around their expected levels. In the literature, there is a basic model for corporate default risks, which is called a structural model of credit risk. It has been introduced by Black and Myron (1973) and Merton (1974). While Merton's article on the pricing of risky debt was published, interest in pricing models for credit risk has been discussed extensively. About this setting, default of a firm occurs when the total market value of its assets falls below the value of its debts or a certain given threshold level. In order to manage this kind of risk, bank regulators select and monitor borrowers and create a diversified loan portfolio.

On the other hand, there are many researches on credit risk which relate on bankruptcy prediction. A pioneering contribution from the 1960s is Altman's (1968) study of bankruptcy prediction. Following Altman, a number of authors have

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estimated various types of credit risk models based on cross-sectional resampling techniques (e.g. Altman, 1973, 1984; Frydman et al., 1985; Li, 1999; Lopez and Saidenberg, 2000; Shumway, 2001), multivariate discriminant analysis (e.g. Deakin, 1972; Blum, 1974), logistic regression (e.g. Martin, 1977; Ohlson and James, 1980), and probit analysis (e.g. Zmijewski, 1984; Skogsvik, 1990). Recently, there has been a flurry of developments in the field of evaluating credit risk based on firm performance. The latest work is Psillaki et al. (2010) who investigated whether productive inefficiency measured as the distance from the industry's 'best practice' frontier is an important ex-ante predictor of business failure.

The literature on credit risk assessment is extensive and growing. A variety of analytical techniques have been used for credit risk assessment. They include statistical methods, models based on contingent claims and asset value coverage of debt obligations, neural networks, and operational research (OR) methods such as linear or quadratic programming and DEA. Psillaki et al. (2010) referred to the fact that the bulk of this literature has concentrated on the use of financial factors such as liquidity, profitability and capital structure in risk evaluation.

Traditionally, the application of financial ratios helps the evaluation of bank performance. Accounting ratios may be used in order to interpret financial accounts or management accounting data. Halkos and Salamouris (2004) pointed out that two main reasons for using ratios as a tool of analysis are to allow comparison among different sized bank and to control for sector characteristics permitting the comparison of individual bank's ratios with some benchmark for the sector.

Furthermore, Emel et al. (2003) noted that one of the fields in which formal or mathematical modeling of finance theory has found widespread application is risk

measurement. In the past, risk had been usually evaluated by a function of expected profit and its standard deviation. The method had been considered that the probability distribution depends on the parameter, such as Flannery (1981), Gizycki (2001), and Ennis and Malek (2005). However, a bank's financial information plays a vital role in decision making of credit risk-taking activities. Extensive literatures dedicated to the prediction of business failure as well as credit scoring concepts have emerged in recent years (e.g. Mingo, 2000; Brown and Wang, 2002; Carling, 2007). Financial ratios are among the most popular and widely used tools of financial analysis. They provide us with clues and symptoms of underlying conditions and have been found useful in predicting business failure (e.g. Huang et al., 2008; Zhao et al., 2009; Yeh et al., 2010). In general, financial ratio is an excellent tool in the evaluation of banks' credit risk and performance. Therefore, we employ financial ratios to assess credit risk and profitability of banks. In our DEA model, the ratios that assess credit risk are inputs, and the ratios that measure profitability are outputs.

Productivity growth is one of the major sources of economic development and a thorough understanding of the factors affecting productivity is very important. Current research studies on productivity change have applied the MPI approach, for example, Alam (2001), Ataullah et al. (2004), Guzman and Reverte (2008), and Liu (2010), which is evaluated from efficiency scores based on DEA linear programming approach. Originally, Malmquist (1953) introduced a quantity index, defined as the amount by which one consumption bundle must be radially scaled in order to generate the same utility level provided by some base consumption bundle. The MPI was first introduced in productivity literature by Caves et al. (1982). And Nishimizu and Page (1982) used a parametric programming approach to compute the index for

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the first time in the empirical context. This index estimates the change in resource use over time that is attributable to efficiency change and due to technological change.

And subsequently, Fare et al. (1989) decomposed productivity change into a part attributable to change of technical efficiency (TE) and technological change and used non-parametric mathematical programming models for its computation.

The Tobit model was first proposed by Tobin (1958), and refers to regression models in which the range of the dependent variable is truncated, censored or limited in some way. In econometrics literature, this model is called the "Tobit model" which is an extension of probit analysis developed by Tobin. In statistics literature, this model is called the "censored normal regression model". In the application of DEA approach, Lin (2008) indicates that the input and output variables are the variables

used to measure the efficiency of each route. There is no doubt that all variables will affect the efficiency measurement in such a way that the larger (smaller) amount of outputs (inputs) the higher efficiency score. If one selects the same variables in the Tobit regression model, it will surely be double-counted. Of course, it is interesting to find out the critical variable(s) appreciably affecting the efficiency.

The remainder of the paper is organized as follows. Section II presents the methodology used in the study. Section III describes the data of this study. Section IV discusses the research findings. Section V presents the conclusions from the results obtained.

2. Methodology

Financial ratios measuring profitability, liquidity, and solvency prevailed as the most significant indicators. This study combines financial ratios with MPI model to Productivity Change Based on the Changes in Credit Risk of Taiwanese Commercial Banks:

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evaluate the efficiency change based on the changes in credit risk of Taiwanese commercial banks over the period 2007-08. In order to understand that productivity change had been caused by the changes in credit risk due to the global financial crisis, we employ MPI which is evaluated from efficiency scores based on DEA linear programming approach. Then we apply Tobit regression approach to determine the effect of credit risk on MPI and analyze the correlation between the experience of M&As investment and productivity change. We describe the methodology as follows: MPI and Tobit regression.

2.1 Malmquist productivity index (MPI)

We define that $R x m$

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$+ \in$ denote an input vector and an output vector

of a decision making unit (DMU) in period t , $t = 1, 2, \dots, T$. The production possibilities set (PPS) is defined as

$PPS \{(y, x) \mid (y, x) \text{ can produce at time } t\}$ (1)

In Shephard's (1970) study, PPS_t is assumed to be closed, bounded, convex, and to satisfy strong disposability of inputs and outputs. The output distance function is

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In model (2), $Do(y,x)$ satisfies the inequality $Do(y,x) \leq 1$, with $Do(y,x) = 1$ if, and only if,

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 PF(y,x) = & \left\{ (\lambda, \theta) \in PPS, (\lambda, \theta) \notin PPS, \lambda > 1 \right\} \quad (3) \\
 & ox y y x y x
 \end{aligned}$$

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The PF_o is the output-oriented production frontier.

The distance function in model (2) is a within-period distance function, defined

using period t data and period t technology. And (y_t, x_t) denote the output and input vectors of DMU at time t . The output distance function for DMU at time t , relative to the technology existing at time $t + 1$, is defined as

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Fla.lore et al. (1994) decompose this MPI into sub-indices measuring change in efficiency and change in technology by rewriting model (7):

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where ΔTE_o is the technical efficiency change. It is defined as

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ΔSE_o is the scale efficiency change. It is defined as

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Liu (2010) consider that comparing efficiency across years tells only part of the story, and the changes in distance function values form 1 year to the next year could be due either to: (a) movement of banks within the input/output space, or to (b) technological changes, i.e., to movement of the boundary of the production set over time. In order to measure productivity change during the periods, we employ model (7) to calculate MPI. The method is output orientated DEA Malmquist. It is defined in model (7) measures distance from observed input/output vectors in one period to the technology in another period. Further, we use the formula (8) to understand the changes of the various elements that include ΔTE , ΔPTE , ΔT and ΔSE .

2.2 Tobit Regression

The Tobit model is an efficient method for estimating the relationship between an explanatory variable and truncated or censored dependent variable. Its derivation is based on the hybrid of probit analysis and multiple regression. It does this by estimating from a set of explanatory variables, the probability of a dependent variable being at or below (above) a limit. If above (below) the limit, the expected value of the dependent variable is estimated. In this way, Ekstrand and Carpenter (1998)

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discovered that it has the advantage of using all the information that either a probit (or logit) or ordinary least squares (OLS) separately would allow.

Additionally, Nahra et al. (2009) have an idea that the observation of the DEA scores reflects a censored distribution. Consequently, to analyze the determinants of efficiency with DEA scores serving as the dependent variable, a regression model other than OLS is required. The following formulation describes the Tobit model:

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$Y_1, \text{if } Y_1$

$Y_i, i = 1, 2, \dots, \text{number of units}$

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(13)

where Y^* is the actual efficiency/productivity change measure and X is a vector of variables proposed to describe variation in treatment unit efficiency.

3. The Data

Financial institutions bridge the needs of lenders (savers) and those of borrowers. They provide the flow of resources from one party to the other. Among financial institutions, commercial banks play a major role. They have the largest share of intermediation and are at the very core of a financial system. This study used financial ratio to assess the 2007–08 relative credit risk and financial performance of 34 Taiwanese commercial banks. We obtain the data from Taiwan Economic Journal (TEJ) database and annual report of our sample. This set should be as homogeneous as possible to be meaningful within the DEA relative efficiency measurement characteristic. The ratio of weighted outputs to weighted inputs constitutes the DEA performance index.

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Furthermore, selection of proper variables to define and to measure financial performance is always an extremely important decision. In this paper, we select input/output variables according to Pivotal Financial and Economic Indicators of Executive Yuan in Taiwan and literature review.

In most of literature, the application of financial statement analysis has helped the evaluation of bank performance. Whittington (1980) pointed out that ratio analysis has been used extensively in financial statement analysis for both normative and positive purposes. The normative approach compares a firm's ratio to a benchmark such as an industry average to judge its performance. The positive approach uses ratios to predict future performance such as earnings and also to predict bankruptcy and assess the riskiness of the firm. There are many studies that measure bank performance by observing the change in earnings-based financial ratios including the value of return on equity (ROE), return on assets (ROA), return on tier

1 capital, average profit per employee, and earnings per share (EPS). The five variables are used to determine if financial structure differences affect the relationship between the cash conversion cycle and operating performance. Therefore, we specify five outputs that represent profitability of our sample:

1. Return on equity (Y_1) = Income after tax / Average shareholders' equity
2. Return on assets (Y_2) = Income after tax / Average assets
3. Return on tier 1 capital (Y_3) = Income before tax / Average tier 1 capital
4. Average profit per employee (Y_4) = Income after tax / Total employees
5. Earnings per share (Y_5) = (Income after tax - Dividends of preferred shares) / Weighted average outstanding shares

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In addition, several articles have confirmed that the structure of loans, deposits and assets should impact credit risk in banks. For instance, Cebenoyan and Strahan (2004) found that banks that rebalance their loan portfolio exposures by both buying and selling loans to improve or operate their ability to manage credit risk. Lin (2009) observed that the factors of observable loans to total loans, allowance for doubtful accounts recovery rate, and interest-sensitive assets to liabilities ratio are significantly related to credit risk of the financial distress of banks in Taiwan. Therefore, we select three financial ratios to assess credit risk; the input set consisted of three main items:

1. Ratio of total loans to total assets (X_1) = Total loans / Total assets
2. Required reserve ratio (X_2) = Deposit reserve / Total deposits
3. Ratio of overdue loans (X_3) = Overdue loans / Total loans

In order to identify the key input variables which significantly affect efficiency/productivity change, we establish Y_* as ΔTE , ΔT , ΔPTE , ΔSE , and MPI, respectively, and ${}_iX$ as the average of the ratio of total loans to total assets (X_1), the average of required reserve ratio (X_2) and the average of the ratio of overdue loans (X_3), respectively in our Tobit regression model. Furthermore, in 34 banks, there are nineteen banks that had the experience of mergers and acquisitions (M&As) investment. It is 56% of our sample. We want to understand that if the experience of M&As investment could improve efficiency/productivity change over the study period. Therefore, we establish an environment variable, X_4 , to represent the experience of M&As investment. When $X_4 = 1$, it represents that the bank had the experience of M&As investment. And when $X_4 = 0$, it represents that the bank had no the experience of M&As investment. The models are specified as follow:

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ratio of total loans to total assets

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We apply model (14) to identify the key variables which significantly affect the efficiency change and MPI in credit risk and analyze the correlation between the experience of M&As investment and efficiency/productivity change over the period 2007-08.

4. Empirical Analysis

4.1 Descriptive Statistics of Inputs and Outputs

Table 1 gives the descriptive statistics of the variables used in the empirical analysis. It includes mean and standard deviation. In inputs, the standard deviation tells us that there are considerable differences in required reserve ratio (X_2) intensity among the banks in 2007 and 2008 with year in 2007 being the most X_2 intensive. In 2007, the higher means and standard deviation of the inputs compared with that in 2008. And in outputs, it shows that there are considerable differences in average profit per employee (Y_4) intensity among the banks in 2007 and 2008 with year in 2007 being the most Y_4 intensive. Similarly, there are higher means and standard deviation of the outputs in 2007 than the measurements of outputs in 2008. We

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consider that banks had a higher profitability in 2007. In this analysis, we obtain a result that there are considerable differences in all inputs and outputs intensity among the banks in 2007. However, they do not indicate the effects of credit risk changes on the profitability over the study period.

Table 1: Descriptive statistics of inputs and outputs

2007 2008

Variable Mean StDev Mean StDev

Ratio of total loans to total

assets (X_1) 64.509 10.540 63.619 9.590

Required reserve ratio (X_2) 20.912 17.866 20.609 11.844

Ratio of overdue loans (X_3) 2.007 1.033 1.856 0.924

Return on equity (Y_1) -2.999 24.143 -4.299 13.337

Return on assets (Y_2) -0.025 1.545 -0.377 1.171

Return on tier 1 capital (Y_3) -4.122 33.289 -5.496 18.713

Average profit per employee

(Y_4) 671.384 3735.533 -578.673 2182.938

Earnings per share (Y_5) 0.156 2.384 -0.150 1.621

4.2 Efficiency and Productivity Change

In Table 2, there are eleven banks with ΔTE greater than 1. They are Bank 2, 5, 8, 15, 17, 18, 24, 25, 29, 31 and 33. The result represents that these DMUs improve their TE over 2007 and 2008. Furthermore, there are nineteen banks with ΔT greater than 1. They are Bank 2, 3, 4, 5, 6, 8, 9, 10, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27 and 34. This means that these DMUs have their technological advances over the observation period. There are eight banks with ΔPTE greater than 1. They are Bank 5, 8, 15, 18, 24, 29, 31 and 33. This indicates that over the observation period, the PTE of these DMUs have been improving. And there are twelve banks with ΔSE greater than 1. They are Bank 2, 5, 6, 8, 14, 15, 17, 18, 25, 29, 30 and 32. The result represents that these DMUs improve their SE over 2007 and 2008. Finally, there are fourteen banks with an efficiency change value MPI greater than 1. They are Bank 2, 5, 6, 8, 9, 15, 17, 18, 24, 27, 29, 31, 33 and 34. This indicates that over the two years,

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the productivity of the fourteen banks has been improving. Specifically, the values of ΔTE , ΔT , ΔPTE , ΔSE and MPI of Bank 5, 8 and 18 are all greater than 1. It is a good signal of the operation performance for these three banks. On the other hand, the values of ΔTE , ΔT , ΔPTE , ΔSE and MPI of Bank 1, 11 and 28 are all less than 1. This means that the operation performance of the three banks has been declining. This is a warning message for the three DMUs.

Table 2: Efficiency change and Malmquist productivity index

Bank (DMU Code)	ΔTE	ΔT	ΔPTE	ΔSE	MPI
1	0.928	0.966	0.958	0.969	0.896
2	1.066	1.026	1.000	1.066	1.093
3	0.960	1.030	0.996	0.963	0.989
4	0.882	1.063	0.984	0.896	0.938
5	1.037	1.031	1.013	1.024	1.069
6	0.982	1.035	0.979	1.003	1.016
7	1.000	0.921	1.000	1.000	0.921
8	1.207	1.052	1.080	1.118	1.271
9	1.000	1.034	1.000	1.000	1.034
10	0.635	1.043	0.837	0.759	0.662
11	0.834	0.977	0.943	0.884	0.815
12	1.000	0.515	1.000	1.000	0.515
13	0.950	0.806	1.000	0.950	0.766
14	0.993	0.995	0.982	1.010	0.988

15 1.156 0.992 1.127 1.026 1.147
 16 0.889 1.038 0.916 0.971 0.923
 17 1.033 1.002 0.993 1.041 1.035
 18 1.065 1.019 1.023 1.041 1.086
 19 0.893 1.037 0.932 0.958 0.926
 20 0.907 1.031 0.957 0.948 0.935
 21 0.663 1.045 0.875 0.758 0.693
 22 0.851 1.034 0.888 0.959 0.880
 23 0.695 1.038 0.870 0.798 0.721
 24 1.183 0.994 1.328 0.891 1.176
 25 1.008 0.941 0.947 1.064 0.948
 26 0.974 1.022 0.977 0.998 0.995
 27 0.971 1.039 0.985 0.985 1.009
 28 0.936 0.983 0.955 0.979 0.920
 29 1.140 0.920 1.092 1.044 1.049
 30 0.937 0.987 0.893 1.049 0.925
 31 1.379 0.972 1.394 0.990 1.341
 32 0.980 0.967 0.942 1.041 0.948
 33 11.363 0.947 12.168 0.934 10.755
 34 1.000 1.054 1.000 1.000 1.054
 Ave. 1.035 0.981 1.066 0.970 1.015

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4.3 Matrix Analysis

In balance sheet, EPS represents the profitability of firm. In order to understand the relevance between the competitiveness of profitability and productivity change of the DMUs, we depict EPS and MPI of the Taiwanese commercial banks over the period 2007-08 in Figure 1. In Figure 1, we employ the horizontal axis to represent the individual mean of EPS at each DMU in 2007 and 2008 for measurement of the profitability competitiveness and the vertical axis to display MPI for measuring the productivity change of each bank. We utilize the total average values of EPS and MPI to determine the threshold values. From our database, we have the total average value of EPS 0.003 for the two years. And we obtain the total average value of MPI 1.015 in table 2. According to the threshold values 0.003 and 1.015, the 34 commercial banks can be classified into four categories as follows.

1. Banks with high EPS and positive productivity change on credit risk management: In total, there are eight banks, namely, Bank 2, 5, 6, 8, 9, 17, 18, and 34. These banks have an average EPS above 0.003 and an average MPI above 1.015. The

result shows that these banks should hold and gain the competition advantage of profitability and improve their efficiency/productivity over the evaluated periods. And this might indicate that these banks are right in their credit risk management. They should maintain and gain the greater competitive advantage of profitability and seek to find further improvements.

2. Banks with low EPS and positive productivity change on credit risk management:

They are Bank 15, 24, 29, 31 and 33. They have an average EPS below 0.003, but an average MPI above 1.015. Compared to other banks, although these five banks do not have the competition advantage of profitability, they have their substantial

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productivity improvement for the two years. We infer that if these banks continue to maintain the right strategy on credit risk management. In the near future, these banks will gain the competition advantage on profitability.

3. Banks with high EPS and negative productivity change on credit risk management:

Bank 1, 3, 4, 7, 10, 11, 12, 13, 14, 16, 19, 20, 22, 23, 28 and 30 have an average EPS above 0.003, but an average MPI below 1.015. At present, these sixteen DMUs should hold the competition advantage on profitability, but their MPI represent their productivity deterioration. We consider that these banks maintain the competitive advantage on profitability, but do not explore the opportunities to improve their efficiency/productivity. We recommend that these banks should reexamine their strategy on credit management. Otherwise, these banks may incur the profitability deterioration.

4. Banks with low EPS and negative productivity change on credit risk management:

In the case of Bank 21, 25, 26, 27 and 32, these DMUs have an average EPS below 0.003 and an average MPI below 1.015. The result clearly implies that these banks have less competitiveness on profitability and productivity deterioration than other banks. We regard that these banks should reexamine their actions and activities in their credit risk management policy.

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Figure 1: EPS and MPI

4.4 Tobit Regression Analysis

Table 3 presents Tobit results of ΔTE , ΔT , ΔPTE , ΔSE and MPI over the period 2007-08 on credit risk factors according to model (14). It should be stated that most of the estimated coefficients in all models are statistically significant and indicate that the models fit data well. In-depth analysis the relationship between the explanatory variable and dependent variable, we discuss the results as follows.

1. The relationship between the efficiency/productivity change and the ratio of total

loans to total assets (X_1): Table 3 shows that X_1 has a negative impact on ΔTE at the 0.05 significance level, has a positive impact on ΔT at the 0.05 significance level, and has a negative impact on ΔPTE at the 0.01 significance level. On ΔSE and MPI, there are the negative correlation and the insignificant relationships. That is, the increase of X_1 could deteriorate TE and PTE at the

-6.000 -4.000 -2.000 0.000 2.000 4.000

EPS

0.000

2.000

4.000

6.000

8.000

10.000

12.000

MPI

1

3

4

6

7

8

9

10

14

17

21

23

24

26

29

31

32

33

34

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DMUs. And the increase of X_1 could have the technological advances over the observation period. But the change of X_1 could not affect SE and productivity change. The results may show that the increase of X_1 (the increase of total loans

or the decrease of total assets) would raise the asset utilization to improve the technology, but enhance the formation of bad debts to deteriorate the technical efficiency in banking industry. The increase of total loans or the decrease of total assets may increase the organization cost to decrease the scale efficiency but it is not significant. Overall, the increase of total loans or the decrease of total assets may cause the productivity deterioration but the phenomenon is unapparent.

2. The relationship between the efficiency/productivity change and required reserve ratio (X_2): In Table 3, a negative relationship exists between required reserve ratio (X_2) and ΔT at the 0.01 significance level. And a negative relationship exists between X_2 and MPI at the 0.1 significance level. On ΔTE , ΔPTE , and ΔSE , there are the positive correlation and the insignificant relationships. In other words, the DMUs with a higher X_2 get the technological deterioration. It may be because the banks hold too much cash that comes from depositors, and drop in utilization of funds. But the increase of X_2 may reduce the generation of bad debts. It is guaranteed to the depositors. Therefore, it may improve the technical efficiency, but it is not significant. Furthermore, the increase of X_2 may increase the number of depositors and deposit amount. It may expand the scale of the organization to raise the scale efficiency, but the phenomenon is unapparent. In most cases, the increase of X_2 could not improve the productivity at the DMUs.

3. The relationship between the efficiency/productivity change and the ratio of overdue loans (X_3): On the ratio of overdue loans (X_3), the effect of X_3 has no significance on ΔTE , ΔT , ΔPTE , ΔSE and MPI, indicating that the change of X_3 could have poor impact on TE, T, PTE, SE and MPI at the DMUs. But, X_3 has a negative impact on ΔT , and has the positive impact on ΔTE , ΔSE , and MPI. It may be because the increase of X_3 raises the generation of bad debts. The banks can't withdraw the cash from the lenders on the maturity date, and cause the technological deterioration. However, the increase of X_3 may improve the utilization of funds, increase the interest income and expand the organization's business. Therefore, it may improve the technical efficiency, the scale efficiency, and productivity, but they are insignificant.

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4. The relationship between the efficiency/productivity change and the experience of M&As investment (X_4): Also, the experience of M&As investment (X_4) has no significance on ΔTE , ΔT , ΔPTE , ΔSE and MPI. The results indicate that the experience of M&As investment could not have any noticeable effect on TE, T, PTE, SE and MPI at the DMUs. On the correlation, a positive relationship exists between X_4 and ΔT . But the negative relationships exist between X_4 and

ΔTE / ΔPTE / ΔSE / MPI. This is the main reason may be that the activity of M&As increases the branches, labor, equipment...and so on. It improves the technology in banking. But the banks that had the experience of M&As investment may generate organizational conflict and produce more organizational costs. Therefore, the experience of M&As investment may not improve the technical efficiency and the scale efficiency. Overall, the experience of M&As investment may cause the productivity deterioration, but the phenomenon is unapparent.

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Table 3: Tobit regression estimates in 2007-08

	ΔTE	ΔT	ΔPTE	ΔSE	MPI					
Variable	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Constant	1.594***	0.000	0.900***	0.000	1.335***	0.000	1.212***	0.000	1.474***	0.000
% Ratio of total loans to total assets (X_1)	-0.010**	0.025	0.003**	0.020	-0.005***	0.004	-0.004	0.205	-0.006	0.161
% Required reserve ratio (X_2)	0.001	0.801	-0.004***	0.000	0.001	0.700	0.002	0.500	-0.007*	0.009
% Ratio of overdue loans (X_3)	0.021	0.494	-0.008	0.226	-0.003	0.775	0.019	0.418	0.012	0.687
The experience of M&As investment (X_4)	-0.067	0.223	0.018	0.280	-0.030	0.197	-0.067	0.116	-0.004	0.945
Log likelihood function	2.992	19.669	22.370	7.054	-0.019					

Note: ***, ** and * indicate that the coefficients are significantly different from 0 at the 0.01, 0.05 and 0.1 levels, respectively.

5. Conclusion

This study measures the changes in efficiency/productivity of the 34 Taiwanese commercial banks over the period 2007-08 before and during the global financial crisis. We employ MPI which is calculated from efficiency scores based on DEA linear programming technique to measure and decompose the productivity change. To further investigate the determinants of Taiwanese commercial banks efficiency about credit risk, we use ΔTE , ΔT , ΔPTE , ΔSE and MPI as the dependent variable, respectively in our Tobit regression model.

In order to analyze the productivity change based on credit risk of the DMUs before and during the global financial crisis, we utilize 2007 as a base year and

calculate MPI of the banks over the years from 2007 to 2008. The derived results show that the technical efficiency of 14 banks has been improving over the evaluated periods while 20 banks' technical efficiency has been declining. In most cases, the results of MPI indicate that productivity growth increased on average by 1.5% over the entire period. We decompose MPI into TE improved on average by 3.5% and T deteriorated on average by 1.9%, or PTE improved on average by 6.6%, SE deteriorated on average by 3.0% and T deteriorated on average by 1.9%. It is also Productivity Change Based on the Changes in Credit Risk of Taiwanese Commercial Banks:

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indicated that the DMUs have an improvement in technical efficiency but own downward shifts of technology and scale efficiency over the study period. An important outcome of this analysis lies with the results provided by Tobit regression, which indicates that the increase of the ratio of total loans to total assets could urge technical efficiency and productivity deterioration at the DMUs. And the increase of the ratio of total loans to total assets could have the technological advances over the observation period. The increase of the required reserve ratio could deteriorate the technology in banking. And the experience of M&As investment has insignificant impact on TE, T, PTE, SE and MPI at the DMUs.

In conclusion, we consider that the DMUs could improve the performance by credit risk management, although they had suffered the global financial crisis. And the different groups of banks should have different strategies of credit risk management to survive in this changing environment. But the experience of M&As investment could not have any noticeable effect on TE, T, PTE, SE and productivity improvement at the DMUs.

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