Impacts of Financial Development and Operating Scale on Bank Efficiencies in Taiwan

Ying-Hsiu Chen, Pao-Peng Hsu

Abstract—This paper adopts a two-stage data envelopment analysis to explore the impacts of financial development and bank operating scale on bank efficiencies. The sample comprises unbalanced panel data of 32 Taiwanese listed domestic commercial banks over the period 1998 to 2013. Empirical results show that pure technical efficiency is positively related to financial development, whereas the effect of financial development on scale efficiency is insignificant. Enlargement of bank operating scale improves bank efficiencies, but the efficiency gains are decreased gradually when the scale increases. Increases in capital adequacy ratio and market power of loans lead into a growth of bank efficiencies.

Keywords—Financial development, Operating scale, Efficiency, DEA.

I. INTRODUCTION

IN the country's economic activities, well-functioning financial intermediary institutions spur technological innovation by identifying and funding those entrepreneurs with the best change of successfully implementing innovative product and production processes [1]. In particular, banking industry is an important role of financial intermediary for loan. Through a well-functioning financial intermediary, the public savings can be effectively translated into various investments and loans to promote economic growth and social development [2], [3]. Therefore, many scholars such as [4]-[10] measured the efficiency performance of sample banks and its impact factors.

As financial liberalization, a majority of financial systems had relaxed restrictions of financial markets regulations and removed product-based barriers in financial service sectors. However, changes in deregulation that allowed establishment of private banks since 1991 in Taiwan lead to the over-banking problem which brought more degree of competition among banks and squeeze of bank profit margins. Therefore, this paper evaluates the empirical relation between the level of financial intermediary development and efficiency performance of banks in Taiwan.

Furthermore, in line with the move towards universal banking being consistent with the global trend of financial services liberalization, Taiwan financial institutions were encouraged to increase the size and scope of their banking activities with diversified financial services activities. In the extant literature, large banks are often claimed that they may possess scale economies to have lower average costs or higher average profits than most other banks, particularly as a justification for bank mergers. In contrast to these claims, large size sometimes frees managers from intense competition, causing a resource integration problem and increase of agency costs. There is a debate regarding the relationship between operating scale effect of bank performance issues.

The purpose of this paper is twofold. First, we estimate the efficiencies of Taiwanese listed domestic commercial banks by applying a version of DEA model. Second, we apply Tobit censored regression model to investigate the association of the efficiency estimates with financial development and the impact of bank operating scale on efficiency estimates in the case of firm-specific factors to be controlled.

The rest of the paper is organized as follows. Section II describes the theoretical model and model specification used for estimates. Section III briefly describes the empirical data and variable definitions. Section IV discusses the main empirical results, while the last section concludes this paper.

II. MODEL SPECIFICATION

The concept of efficiency in financial institutions has been discussed widely in the literature by utilizing both non-parametric and parametric techniques. The two procedures are commonly used namely stochastic frontier approach (SFA) and data envelopment analysis (DEA), which are involved in parametric and non-parametric methods, respectively. SFA and DEA differ in the assumptions they make regarding the shape of the efficient frontier and the existence of random error.

DEA has become popular in measuring efficiency and is based on the pioneering work of [11], proposing the frontier function to measure efficiency of decision making units (DMUs). DEA do not require any assumptions with respect to efficiency or the underlying functional form for the technology. For an introduction to DEA methodology with excellent illustrations see [12], [13].

This paper employs DEA with the variable returns to scale (VRS) setting developed by [14] (henceforth BBC). They suggested an extension of the constant returns to scale (CRS) DEA model by [15], to account for VRS situations. The BBC model for VRS and input-oriented envelopment problem can be expressed as the linear programming problem:

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$$\begin{aligned}
&\underset{\theta,\lambda}{Min.} \quad \theta \\
&subject\ to\ \theta x \geq X\lambda \\
&\qquad\qquad Y\lambda \geq y \\
&\qquad\qquad N1'\lambda = 1 \\
&\qquad\qquad \lambda \geq 0
\end{aligned} \qquad (1)$$

where θ is a scalar, λ is an N×1 vector of intensity variables, $x_i \geq 0$ is a K× 1 vector of inputs for the ith DMU, $y_i \geq 0$ is the ith DMU's M × 1 vector of outputs, X is an K × N matrix of input vectors in the comparison set, Y is an M × N matrix of output vectors in the comparison set, $N1$ is a N×1 vector of one, and note that $N1'\lambda = 1$ is convexity constraint in this VRS case. The problem is solved N times, once for each producer in the comparison set, and a value of θ is then obtained for each DMU with a value of 1 indicating a point on the frontier and hence a most technical efficiency DMU.

When all firms are not operating at optimal scale, the use of the CRS specification results in that measures of pure technical efficiency (TE_{VRS}) are confounded by scale efficiency (SE). In other words, scale efficiency is due to the choice of production scale problem, which a DMU is not operating under CRS, measuring the ray average productivity at the observed input scale relative to what is attainable at the most productive scale size. Scale efficiency is calculated residually as

$$SE = \frac{TE_{CRS}}{TE_{VRS}} \qquad (2)$$

where TE_{CRS} and TE_{VRS} are technical efficiencies under use of the CRS specification and pure technical efficiency, respectively, which are vary between 0 and 1.

In order to indicate whether a DMU is operating in an area of increasing returns to scale (IRS) or decreasing returns to scale (DRS), this can be determined by running an additional DEA problem with non- increasing returns to scale (NIRS) imposed. This problem is done by altering the DEA model in (1) by substituting the $N1'\lambda \leq 1$ restriction for $N1'\lambda = 1$.

In the second stage, using the efficiency measures derived from the DEA estimations as the limited dependent variable, the determinants of efficiency scores are investigated by Tobit censored regression model. Efficiency score are regressed upon explanatory variables as follows:

$$\begin{aligned}
E_{it} = &\beta_0 + \beta_1 FD_{it} + \beta_2 OS_{it} + \beta_3 OS_{it}^2 \\
&+ \beta_4 CAR_{it} + \beta_5 MP_{it} + \beta_6 t + \varepsilon_{it}
\end{aligned} \qquad (3)$$

where subscript i indexes the DMUs and t is the time period; E is efficiency score from first stage being pure technical efficiency or scale efficiency. FD denotes the level of financial development by assessing the means of indirect lending, which is measured as a ratio of domestic credit provided by banking sector to gross domestic product. OS is a proxy for operating scale which is computed as natural log of a bank's assets and its

squared term, OS^2, depicting the non-linear effect of asset scale.

CAR indicates the capital adequacy ratio computed as a ratio of core capital to risk weighted assets; MP represents loan market share of an individual bank, which is a proxy for assessing market power; t is the item of time trend and ε_{it} is a random error term.

III. EMPIRICAL RESULTS

A. Summary Statistics

The sample is an unbalanced panel of 32 Taiwanese listed securities firms during the period from 1998 to 2013, totaling 452 observations. Financial data are obtained from the Taiwan Economic Journal's financial database and from other official sources such as relevant publications of the central bank and the Ministry of Finance's Bureau of Monetary Affairs. All the nominal variables have been transformed into real terms by the Taiwanese consumer price index with base year 2011.

According the intermediation approach, banks are defined as financial intermediaries that invest capital and labour, transfer deposits into investments and loans, and earn interest and capital gains. Therefore, the inputs contain net physical capital (x_1), all kinds of deposits and borrowed funds (x_2) and number of employees (x_3), while the output entities comprise investments (y_1), which include government and corporate securities and stocks, and various short- and long-term loans (y_2) in this paper. The outputs and inputs are used to estimate pure technical efficiency or scale efficiency of the sample banks in the first stage.

TABLE I
SAMPLE DESCRIPTIVE STATISTICS

Variables	Symbol	Mean	Standard Deviation
Panel A			
Investments	y_1	117,314,718	136,493,832
Loans	y_2	342,302,387	403,300,879
Physical capital	x_1	13,821,780	12,843,978
Borrowed funds	x_2	588,280,017	572,256,411
Labour	x_3	3,285	2,387
Panel B			
Financial development (%)	FD	53.925	4.065
Operating scale	OS	19.864	1.019
Capital adequacy ratio (%)	CAR	11.527	9.623
Market power of loans (%)	MP	2.068	2.296
Number of observations		452	

Notes:
1. Variables of y_1, y_2, x_1 and x_2 are reported in thousands of New Taiwan's dollar.
2. Variable of x_3 is number of employees which its measured unit is thousands of persons.

Sample statistics of all variables are summarized in Table I. There is large variability in the input and output items in panel A of Table I. The loans are the main product of the overall banks, and the input item funds appear to be the most important factor of production. After the global financial crisis from 2008 to 2010, all output and input variables have significantly

reduced in substance. In panel B of Table I, the explanatory variables of Tobit censored regression model in (3) are have defined in the earlier section which are financial development, operating scale, capital adequacy ratio and market power of loans, respectively. These variables also present a higher degree of variation.

The average level of financial development is around 54%; this measure roughly increases per annum since 2005. The banks of higher government share have relatively high average values for operating scale and market power of loans, whereas the private banks have private relatively high average of capital adequacy ratio. The average market share of loans is only 2.07%, implying that the over-banking problem seems to exist subject to small market shares.

B. Evaluations of Efficiencies

For input-orientated measures, technical efficiency is measured by the ratio of optimal inputs to observed inputs, which reflects the ability of a bank to obtain minimal inputs from a given set of outputs. In addition, scale efficiency is due to the choice of production scale problem that a bank is not operating under constant returns to scale, and it measures the ray average productivity at the observed input scale relative to what is attainable at the most productive scale size. All of these efficiency measures are bounded by zero and one.

TABLE II
DESCRIPTIVE STATISTICS OF EFFICIENCY SCORES AND SCALE ECONOMIES

Pure Technical Efficiency (TE_{VRS})	Scale Efficiency (SE)	Measures of Scale Economies		
		CRS	DRS	IRS
0.742 (0.221)	0.823 (0.170)	17	375	60

Notes:
1. Number of total observations is 452.
2. Numbers in parentheses are standard deviation.

Table II reports the efficiency estimates and measures of scale economies, which the former involve pure technical efficiency (TE_{VRS}) and scale efficiency (SE) scores, and the latter is examined by number of observations in the area of increasing returns to scale (IRS). If the number of observations in the area of IRS greater than in others areas of decreasing returns to scale (DRS) and constant returns to scale (CRS), it implies the sample banks exhibit the characteristic of scale economies, which is the opposite of the decreasing or constant returns to scale.

The average TE_{VRS} and SE scores of all sample banks are 0.742 and 0.823, respectively. The mean TE_{VRS} score implies that the sample banks can reduce approximately 26% of inputs given the same outputs, and the mean SE score reveals that the sample banks can increase up to approximately 18% average productivity if they operate at constant returns to scale. In addition, TE_{VRS} score is much less than SE score indicates that technical inefficiency from inappropriate management constitutes the main source of operating inefficiency.

In terms of returns to scale characteristics, there are 375 observations to display IRS, accounting for 83% of whole

sample banks, and the observations belonging to CRS and IRS only account for 4% and 13% of all samples, respectively. This result implies that the representative bank exhibits decreasing returns to scale, suggesting that the sample banks have sizes bigger than efficient scale; that is, scale economies do not prevail in the majority of banks in Taiwan. Reduction of a bank's production scale could decrease its long-run average cost to promote increase in profitability and market power.

In order to analyze the volatility of efficiencies over time, the two efficiency scores are drawn on a time series graph and these results are illustrated in Fig. 1. The average TE_{VRS} and SE scores had significantly decreases per annum in substance since 2001 to 2006, especially in faster reduction of SE. After 2007, two efficiency scores gradually grew up and they were improved imperceptibly during 2011-2013.
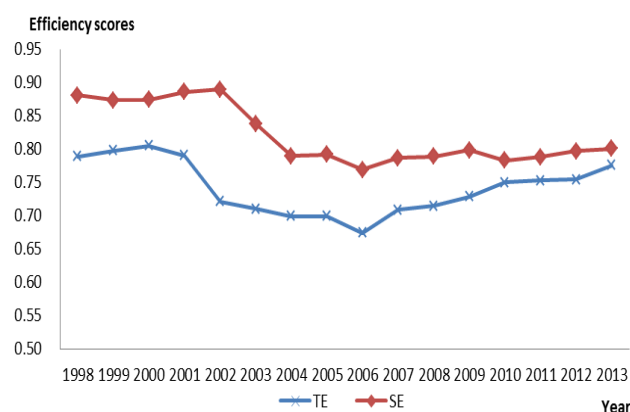

Fig. 1 Volatility of Efficiency Scores from 1998 to 2013

C. Results of Tobit Regression Analysis

Next, for examining the association of efficiency scores with potential determinants, this paper use the Tobit censored regression model by (3). The regression results are summarized in Table III. Accounting to Table III, the effect of financial development on TE_{VRS} is significantly positive for the sample banks, whereas the effect of financial development on SE is insignificant. The results indicate that the raise of financial development can help the sample banks to use fewer inputs to produce the same level of output, and to improve technical efficiency.

The relationship between efficiencies and operating scale appears to be significantly positive indicating the sample banks enlarge assets may lead to the problem of resource allocation causing a decrease in TE_{VRS} and SE. The effect of operating scale's squared term is significantly negative, which is likely to indicate the non-linear effect of asset scale on efficiencies, namely, the efficiency gains are decreased gradually when the scale increases.

TABLE III
TOBIT REGRESSION RESULTS

Independent Variables	Pure Technical Efficiency (TE_{VRS})			Scale Efficiency (SE)		
	Coefficient		Standard Error	Coefficient		Standard Error
Intercept	-8.067	***	3.266	-18.803	***	1.683
FD	0.009	***	0.003	0.001		0.002
OS	0.902	***	0.333	2.158	***	0.171
OS^2	-0.025	***	0.009	-0.060	***	0.004
CAR	0.006	***	0.001	0.001	**	0.001
MP	0.086	***	0.006	0.078	***	0.003
t	-0.003		0.003	0.005	***	0.002
Log likelihood	79.436			384.010		

Note: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

IV. CONCLUSION

This paper adopts a two-stage data envelopment analysis to explore the impacts of financial development and bank operating scale on bank efficiencies. The unbalanced panel data includes 32 listed domestic commercial banks in Taiwan over the period from 1998 to 2013. In the first stage, the efficiency estimate results show that the sample banks can reduce approximately 26% of inputs given the same outputs, and they can increase up to approximately 18% average productivity if they operate at constant returns to scale. Furthermore, scale economies do not prevail in the majority of banks in Taiwan.

In the second stage, the association of efficiency scores with potential determinants shows that pure technical efficiency is positively related to financial development, indicating that the raise of financial development can help the sample banks to use fewer inputs to produce the same level of output, whereas the effect of financial development on scale efficiency is insignificant. Enlargement of bank operating scale improves bank efficiencies, but the efficiency gains are decreased gradually when the scale increases. Finally, increase in capital adequacy ratio and market power of loans leads into a growth of bank efficiencies.

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