Japanese Banks: An Exploration of Efficiency Based on Data Envelopment Analysis[1]

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1. Introduction

After World War II, the financial sector in Japan faced restrictions and administrative guidance to stabilize the Japanese financial system. A distinct segmentation of business by banking categories existed such as segmentations between long-term financing and short-term financing, banking and trust as well as banking and securities. Financial sectors received deregulations after the 1980s. As a result, financial institutions could enter other banking categories due to the Financial Reform Act enacted in 1992. For example, banking and securities companies could enter into trust business activities through their subsidiaries. Additionally, regional and Tier II regional banks were able to engage in trust business activities. After 1998 following the revision of the Antimonopoly Law, it has become possible to establish financial holding companies, which are financial conglomerates with various types of financial companies, by holding their shares. After the 2000s, regional, Tier II and city banks integrated their management by using merger and holding company systems. Consequently, the number of banks has been decreasing compared to the beginning of 2000 (Table 1).

Through this deregulation, the Japanese government expected financial sector improvements, such as the promotion of international competition in city banks, improvement of profitability in regional and Tier II regional banks. Loukoianova (2008) pointed out that Japanese financial sector efficiency remains low in comparison to those in the United States and European countries. Consequently, it is important to show the causes of this situation and propose ways to improve it.

This paper estimates the productive efficiency of Japanese banks using Data Envelopment Analysis (DEA) to clarify whether Japanese banks are efficient with supplying financial services. Through this analysis, we can show that the productive efficiency in financial

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sectors by mergers which has been in progress.

Table 1 Changes in the Number of Japanese Banks

(at the end of fiscal year)

	2000	2005	2010	2014
City banks	9	6	6	5
Trust banks	8	7	6	4
Regional banks	64	64	63	64
Tier Ⅱ regional banks	54	47	42	41
Long-term credit banks	1			
Others*	5	2	2	2
Total**	136	126	119	116

* For 2000, Tokyo Sowa Bank, Niigata Chuo Bank, Kansai Sawayaka Bank, Shinsei Bank and Aozora Bank are included. For 2005, Shinsei Bank and Aozora Bank are included.

** The "Total" at 2000 does not include "Others'. On the other hand, the "Total" after 2005 includes "Others'.

Sources: Japanese Bankers Association, *Financial Statement of All Banks* (2000, 2005, 2010, 2014)

This paper is organized as follows: Section 2 reviews previous studies on productive efficiency. It specifically highlights the Japanese banking sector and its productive efficiency. Section 3 explains our DEA analysis, which represents a theoretical model for Japanese financial sector efficiency estimates. Section 4 describes data used in this paper. Section 5 shows the results of our analysis on productive efficiency as well as the interpretation of our results. Section 6 concludes the paper.

2. Literature Review and Study Focus

This section reviews previous studies on Japanese banking sector efficiency and explains our study's focus.

In Japan, productive efficiency in the banking sector is a traditional topic, and many empirical analyses exist concerning this subject. In empirical analysis, there are following two viewpoints: (1) *specification*, which is how to specify the cost function, and (2) *evaluation criteria* for determining efficiency.

Cost function specification consists of two types: (1) the *parametric model*, which specifies the functional form of cost function, and (2) the *non-parametric model*, which does not specify the functional form of cost function. In estimating the parametric cost function, there are two types of models: the *frontier cost function* and *ordinal cost function*. The difference between them appears in the specification of their error term. In the frontier cost function, the error term consists of an inefficiency indicator as well as observation error included in the error term of the ordinal cost function. For the non-parametric model, there are two types. One is based on the theory of index numbers, and the other non-parametric model is based on linear programming.

The evaluation criteria for efficiency has two types of comparisons among banks: one is based on an input-output relationship and the other deals with their average cost structure. Concerning efficiency, these criteria are crucially different. In the former comparison, we compare the efficiency among banks without considering the unique circumstances of each one. However, the latter compares the efficiency among banking categories while allowing the differences in efficiency among banks within a category.

The following reviews earlier studies on Japanese banking sector efficiency. They are based on the above classifications[2].

The empirical analysis using the frontier function from Tachibanaki et al. (1997) applies the Cobb-Douglas cost function, and Altunbas et al. (2000) use the Fourier cost function. In the empirical analysis using ordinal cost function, Kasuya (1986) analyzes the economies of scope in Japanese banking sector. Tachibanaki et al. (1991) analyzes the economies of scale in banking sector, as Kinoshita and Ohta (1991) looks at the target from 1981 to 1988. Additionally, Katagiri (1993) and McKillop et al. (1996) discover the economies of scope and economies of scale in city banks. Furthermore, Shinjo and Harimaya (2004) analyze the economies of scope and economies of scale in trust banks based on the Fourier cost function.

On the other hand, studies based on the non-parametric model are scarce in comparison to those centering around cost function. Yoshioka and Nakajima (1987) estimated the productivity index, such as the economies of scale, based on the theory of index numbers. Fukuyama (1993), Drake and Hall (2003) and Loukoianova (2008) analyzed productive efficiency based on DEA analysis in 1990, 1997 and 2005 respectively.

From previous studies on Japanese banking sector efficiency, the existence of the economies of scope cannot clearly be shown, except by Kinoshita and Ohta (1991) in city banks and Katagiri (1993) with trust banks. On the other hand, many researchers have found that

[2] There are many studies on the efficiency of banking sectors all over the world. For example, Aly et al. (1990), Elyasiani and Mehdian (1990) and DeYoung and Hasan (1998) analyzed the efficiency of banks in the United States. Bader et al. (2008) analyzed the international comparisons between commercial banks and Islamic banks. By the first half of the 1900s, Berger and Humphrey (1997) reviewed comprehensive literature on the efficiency of banking sectors all over the world.

economies of scale exist in all banks. In contrast, Drake and Hall (2003) revealed the decreasing returns to scale in large-scale banks.

From previous DEA analysis results, findings reveal that causes for inefficiency in the banking sector were due to technical inefficiency and the inefficiency evaluation in output relative to input, rather than inefficiency due to the economies of scale. In addition, city and trust banks are more efficient as compared to regional and Tier II regional banks. Notably, some research, such as Fukuyama (1993) as well as Drake and Hall (2003), shows that inefficiency appears in large-scale banks.

We have to investigate whether efficiency in the banking sector has changed recently after deregulation in 2000s. Particularly in Japan, it is important to clarify whether the mergers and integration of their management into Japanese financial sectors incited more efficiency.

This study analyzes and evaluates the efficiency of Japanese banks using cross section data from 2008 to 2013. Furthermore, we use the non-parametric approach of DEA analysis to exclude the effect of functional form from their results. Next, we compare the efficiency among Japanese banks to the results found by Drake and Hall (2003), which are similar to our analysis.

3. DEA Analysis

DEA analysis captures the efficiency based on the concept of linear programming. Various fields use this analysis, including the banking sector.

In general, efficiency is derived from the relationship between outputs and inputs used in the production process. Using DEA analysis, efficiency is shown as the comparison relative to the most efficient input-output relationship among sample.

Different concepts do exist for the efficiency of DEA analysis[3]. The CCR model, presented by Charnes et.al (1978), is commonly used for efficiency. The CCR model is defined under the constant returns to scale through the relationship between outputs and inputs. For instance, let n represent the number of banks. Then, the input-oriented efficiency score in bank 0, which is mathematically defined as a linear fractional programming problem, is as follows:

[3] Some following descriptions in our paper refers Cooper et al. (2007).

$$\max_{u_{r0}, v_{i0}} \theta_{0,CCR} = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{s} v_i x_{i0}}$$

Subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{r=1}^{m} v_i x_{ij}} \leq 1, (j = 1, 2, \cdots, n)$$

$$u_r \geq 0, (r = 1, 2, \cdots, s)$$

$$v_i \geq 0, (i = 1, 2, \cdots, m)$$

where: (1) u_r is the weight of output r, (2) v_i is the weight of input i, (3) y_{rj} is the amount of output r of bank j, (4) x_{ij} is the amount of input i of bank j, (5) n is the number of banks, (6) s is the number of output, and (7) m is the number of input. Under the simple condition that the weight of each input and output is more than zero, the score range is not less than zero and not more than one.

The BCC model presented by Banker et. al (1984) estimates efficiency excluding the assumption of the constant returns to scale. As Yoshioka and Nakajima (1987) pointed out, economies of scale exist, especially in Japanese banking sectors. The BCC model distinguishes itself by separating scale effect from technical efficiency. The input-oriented efficiency score in bank 0 is mathematically expressed as a linear fractional programming problem as follows:

$$\max_{v_i, u_r, v_0} \theta_{0,BCC} = \frac{\sum_{r=1}^{s} u_r y_r - v_0}{\sum_{i=1}^{m} v_i x_{i0}}$$

Subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj} - v_0}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, (j = 1, 2, \cdots, n)$$

$$u_r \geq 0 \ (r = 1, 2, \cdots, s)$$

$$v_i \geq 0, (i = 1, 2, \cdots, m)$$

where (1) u_r is the weight of output r, (2) v_i is the weight of input i, (3) y_{rj} equals the amount of output r of bank j, (4) x_{ij} is the amount of input i of bank j, (4) y_{r0} is the amount of output r in bank 0, (5) x_{i0} represents the amount of input i of bank 0, (6) n is the number of banks, (7) m is the number of inputs, (8) s the number of outputs, and (9) v_0 represents the indicator for the economies of scale with no restrictions on it.

By comparing the CCR and BCC score, there is no difference between them except for v_0. $v_0 = 1$ means the constant returns to scale, $v_0 > 1$ indicates the increasing returns to scale and $v_0 < 1$ means the decreasing returns to scale.

*Scale efficiency (*SE) is defined based on the CCR and BCC scores. From the definitional difference between the CCR and BCC scores, the indicator of scale efficiency SE can be defined using both indicators as follows:

$$\mathrm{SE} = \frac{\theta^*_{CCR}}{\theta^*_{BCC}}$$

where SE is not more than 1. The efficient under the BCC model with the constant returns to scale, the BCC score is 1. Since the BCC score θ^*_{BCC} composites the scale efficiency, the CCR score θ^*_{CCR} is sometimes called "overall technical efficiency," and the BCC score is also referred to as "pure technical efficiency" (Cooper et.al, 2007). Using these concepts, the previous relationship can be demonstrated as follows:

$$\theta^*_{CCR} = \theta^*_{BCC} \times \mathrm{SE}$$

This decomposition depicts the sources of inefficiency, which can be caused by inefficient operations or disadvantageous conditions displayed within the scale efficiency, or both.

4. Data

All the variables used in this study were taken from the "Financial Statement of All Banks" balance sheets and income statements during 2008-2013 from the Japanese Bankers Association. The variables used in this study are same as Drake and Hall (2003), where the banks are modelled as multiproducts and employ three inputs to produce three outputs.

In specifying inputs, we consider the standard intermediate approach where capital and labor inputs are used for intermediate deposits into loans and other earning assets. In our study, "Property, plant and equipment," the balance sheets substitute the capital input. Furthermore, “Deposits” in the balance sheets are used as intermediates. While “General and administrative expenses” in the income statement, which are dominated by personal expenses, represent labor input. In most DEA studies, it is very common that the number of employees is used as labor input. However, there are two reasons why we cannot use the number of employees. One reason is that we could not find data on the number of employees across our sample. The other explanation is that the employee numbers might lead to some bias against banks that hire high quality employees resulting in high staff costs. From a relative efficiency perspective, high quality employees are adequately productive because those banks will not be underprivileged.

Three outputs in our study consist of loans, trading, and other activities that include earning fee income. Stiroh (2000) found that efficiency estimates, in terms of US bank firms, are sensitive if there is exclusion of non-traditional activities in the output specification. The output by loans represents “Loans and bills discounted” in the balance sheets. Additionally, the output by trading is substituted by “Securities” in the balance sheets, and the output by other activities uses “Other income” in the income statement.

Risk and quality factors in the loan might be important to take them into account when measuring banking sector efficiency. However, we do not go through this issue in our analysis.

Table 2 presents basic statistics about the output and input variables from fiscal year (FY) 2008 to FY 2013. Overall, distribution of the input and output variables data is highly spread apart from one another.

Table 2　Descriptive Statistics of Data FY 2008-2013

(Unit: One hundred yen)

	Deposit	Labor input	Fixed capital	Loans	Securities	Other income
2008						
Maximum	100,208,977	1,095,432	915,904	73,786,503	39,558,840	276,777
Minimum	152	3,921	137	0	14,984	13
Average	4,882,050	56,351	52,796	3,762,556	1,852,158	8,337
Std. dev.	12,117,789	127,665	116,697	9,310,630	5,654,649	29,824
2009						
Maximum	103,976,222	1,080,498	886,516	69,106,624	52,068,380	284,363
Minimum	96	3,822	679	0	0	39
Average	5,101,849	57,824	54,107	3,735,868	2,230,893	7,884
Std. dev.	12,560,193	129,818	119,607	8,757,641	6,959,981	31,191
2010						
Maximum	105,854,679	1,039,395	872,747	64,981,715	58,303,309	232,695
Minimum	86	3,916	362	0	0	3
Average	5,280,391	57,355	54,311	3,756,520	2,452,951	5,547
Std. dev.	12,966,741	126,197	120,640	8,513,221	7,735,819	22,868
2011						
Maximum	106,680,877	1,054,269	864,836	69,386,000	63,452,246	240,241
Minimum	55	3,896	241	0	0	5
Average	5,363,128	57,119	53,601	3,823,670	2,624,710	7,852
Std. dev.	13,133,906	127,369	119,684	8,819,415	8,366,910	25,784
2012						
Maximum	120,153,990	1,146,190	1,425,385	80,947,236	63,334,714	218,421
Minimum	341,961	2,424	4,909	3,387	37,275	198
Average	6,220,196	63,082	73,401	4,489,620	2,956,881	11,480
Std. dev.	15,584,372	148,586	184,607	10,737,953	9,011,516	30,847
2013						
Maximum	119,636,522	1,123,952	863,197	79,495,010	56,790,753	311,462
Minimum	212,534	3,475	1,326	5,257	0	49
Average	5,947,809	57,221	55,460	4,316,500	2,572,101	13,458
Std. dev.	15,721,376	137,310	127,500	11,092,460	8,268,267	44,839

Source: Authors' calculation

5. Results and Discussion

5.1 Transition of the Efficiency of Japanese Banking Sector

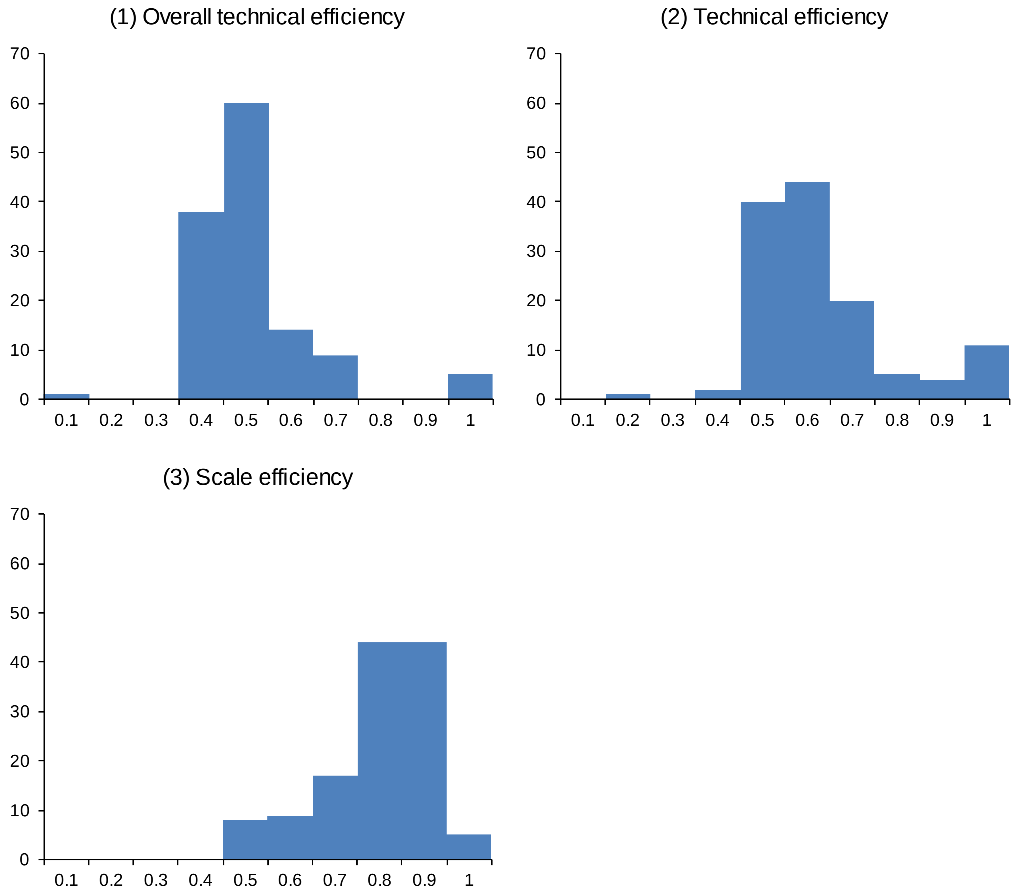
First, we display the tendencies of the CCR, BCC and SE scores of Japanese banking sectors from FY 2008 to FY 2013. Table 2 shows the basic statistics of these scores such as the average, standard deviation, maximum value, and minimum value. Figure 1 shows a histogram at FY 2008 in order to show the distribution of each score. For comparison, Table 2 shows the scores at FY 1997 estimated by Drake and Hall (2003).

Table 2 Transition of Efficiency Score (FY 2008-2013, All Samples)

	Overall technical efficiency	Technical efficiency	Scale efficiency	Overall technical efficiency	Technical efficiency	Scale efficiency
2008				1997 (Drake and Hall 2003)		
Average	0.562	0.673	0.845	0.724	0.781	0.928
Std. dev.	0.122	0.140	0.121	0.116	0.112	0.075
Maximum	1.000	1.000	1.000	1.000	1.000	1.000
Minimum	0.186	0.262	0.501	0.534	0.604	0.534
2009						
Average	0.635	0.724	0.876			
Std. dev.	0.131	0.130	1.014			
Maximum	1.000	1.000	1.000			
Minimum	0.177	0.312	0.568			
2010						
Average	0.642	0.723	0.888			
Std. dev.	0.124	0.134	0.921			
Maximum	1.000	1.000	1.000			
Minimum	0.137	0.291	0.470			
2011						
Average	0.602	0.681	0.884			
Std. dev.	0.146	0.157	0.931			
Maximum	1.000	1.000	1.000			
Minimum	0.152	0.295	0.516			
2012						
Average	0.787	0.853	0.923			
Std. dev.	0.122	0.094	1.297			
Maximum	1.000	1.000	1.000			
Minimum	0.168	0.612	0.274			
2013						
Average	0.711	0.760	0.937			
Std. dev.	0.143	0.146	0.979			
Maximum	1.000	1.000	1.000			
Minimum	0.152	0.161	0.943			

Source: Authors' calculation

Figure 1　Histogram of Efficiency Score at FY 2008



Note: The vertical axis in each figure shows the frequency. The horizontal axis represents the lower limit of each class and the width of each class is 0.1.
Source: Authors' own figure

The overall technical efficiency, which is CCR score, increases gradually from FY 2008 to FY 2013 except FY 2011. However, these time series variations may be caused by the Lehman shock in September 2008 and the Great East Japan Earthquake of March 2011. Furthermore, the standard deviation for the overall efficiency jumps in 2008 and 2011. This may indicate that the effect of great economic shocks on the Japanese financial market is different among banks and then appears in the disparity of efficiency among banks. In 2013, considering that the effects of Great East Japan Earthquake on Japanese financial markets disappear, the overall technical efficiency is 0.711, the pure technical efficiency score is 0.760 and the scale efficiency score is 0.937. These scores indicate that the inefficiency in Japanese banking sector occurs not by the scale diseconomy but by pure technical inefficiency, or, inefficiency is found within the input-output relationship. This is the same result as that of previous studies in Japanese banking sectors at 1997 estimated by Drake and Hall (2003).

Figure 2 is the histogram of three efficiency scores in order to view the variability of efficiency among Japanese banks. The variability of pure technical efficiency has right-skewed distribution, or long right-tailed distribution. On the other hand, the variability of scale efficiency has left-skewed distribution, or long left-tailed distribution. It can be said that variability of efficiency among Japanese banks is not distributed around the average but through skewed distribution.

5.2 Efficiency Comparison by Banking Categories

Table 3 represents the results in FY 2008 decomposed by banking categories except for "Others." Findings show that there is a gap in the average of efficiency scores of Japanese banks in comparison with Drake and Hall (2003), although there is a possibility that the effects of Lehman Shock in 2008 on Japanese banks differ. Furthermore, the efficiency score's standard deviation of Japanese banks was increasing. In particular, its gap is quite severe for banks with insufficient financial capabilities. As a consequence, it can be speculated that a realignment of Japanese banks has begun to unfold.

Secondly, we compare our result in 2008 by banking categories with those from 1997 estimated by Drake and Hall (2003). In city banks, the disparity of efficiency score in 2008 expand in comparison with that of Drake and Hall (2003), and the scale efficiency has no existence compared to other banking categories.

From our efficiency score results, trust banks became inefficient in comparison with Drake and Hall (2003), although the efficiency score of trust banks are highest among banking categories. This result may represent commercial banks entering into trust business activities by the deregulations in banking sectors after around 2000. In particular, entry of trust business activities by the other banking categories caused the competitive advantage of trust banks to diminish for trust business services.

In regional banks, findings are that overall technical efficiency diminished to the other banking categories. In particular, the score of overall technical efficiency in regional banks is lower than that in Tier II regional banks. Furthermore, since the standard deviation of the efficiency score in 2008 is unchanged compared to that in 1997, it can be said that the efficiency in regional banks became worse as a whole.

Tier II regional banks have inefficient cost structures compared to those for regional banks. The standard deviation of the efficiency index among them is increasing. Consequently, the gap in efficiency among Tier II regional banks expand drastically.

This result shows that the deregulation in financial sectors after the 1990s made apparent disparities in efficiency among banks. Particularly, in regional banks and Tier II regional banks, the disparities expand drastically. From a banking sector efficiency perspective, recent merger and integrations of their management by regional and Tier II regional banks have made further progress.

Table 3 Basic Statistics of Efficiency Scores by Banking Categories

	2008			1997 (Drake and Hall 2003)		
	Overall technical efficiency	Pure technical efficiency	Scale efficiency	Overall technical efficiency	Pure technical efficiency	Scale efficiency
All sample						
Average	0.562	0.673	0.845	0.724	0.781	0.928
Std. dev.	0.122	0.140	0.121	0.116	0.112	0.075
Maximum	1.000	1.000	1.000	1.000	1.000	1.000
Minimum	0.186	0.262	0.501	0.534	0.604	0.534
City banks						
Average	0.708	0.840	0.858	0.871	0.956	0.913
Std. dev.	0.150	0.165	0.154	0.046	0.057	0.044
Maximum	1.000	1.000	1.000	0.937	1.000	0.973
Minimum	0.526	0.602	0.587	0.800	0.858	0.822
Trust banks						
Average	0.758	0.843	0.910	1.000	1.000	1.000
Std. dev.	0.169	0.139	0.168	0.000	0.000	0.000
Maximum	1.000	1.000	1.000	1.000	1.000	1.000
Minimum	0.501	0.691	0.501	1.000	1.000	1.000
Regional banks						
Average	0.539	0.610	0.886	0.685	0.717	0.956
Std. dev.	0.072	0.078	0.075	0.078	0.072	0.047
Maximum	0.745	0.917	0.998	1.000	1.000	1.000
Minimum	0.432	0.500	0.531	0.567	0.604	0.731
Tier II regional banks						
Average	0.525	0.702	0.766	0.695	0.784	0.890
Std. dev.	0.048	0.120	0.122	0.084	0.082	0.088
Maximum	0.693	1.000	0.992	0.953	1.000	1.000
Minimum	0.449	0.497	0.514	0.534	0.651	0.651

Note: The statistics are calculated excluding “Others” in the banking categories, such as the Shinsei bank, Aozora bank, Seven bank, Orix trust bank, City bank and Norinchukin bank.

6. Conclusion

This study attempted to investigate the efficiency of city, trust and regional banks in Japan during FY 2008 in comparison with Drake and Hall (2003) using a non-parametric approach along with Data Envelopment Analysis (DEA). The results show that in the period of FY 2008, Japanese banks' efficiency has not improved since the results of Drake and Hall (2003). It seems that large Japanese banks exhibit diseconomies of scale. Most of the banks' inefficiency can be attributed to their technical efficiency rather than scale inefficiency. In addition, trust banks' efficiency seems worse than the efficiency score from Drake and Hall's (2003) analysis. These banks might have been affected by the government actions to tackle banks with loan problems after 2003. Moreover, most city banks exhibit decreasing returns to scale, which questions the reasons behind their merger and its effect on their scale efficiency. On the other hand, regional banks showed increasing returns to scale which imply that these banks could enhance their efficiency by scaling up their activities. From a banking sector efficiency perspective, recent mergers of regional banks may be desirable.

The impact of mergers on the efficiency of banks, well as the motives behind them, and efficiency in comparison with banks in the United States and European countries (Loukoianova, 2008) are future research topics that could be explored.

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