Management Efficiency in Japanese Regional Banks: A Network DEA
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Abstract
Data Envelopment Analysis (DEA) is a widely used method to evaluate bank’s management efficiency. To evaluate the management efficiency of Japanese regional banks, there is a limit in traditional simple DEA model. It is because the management situation of Japanese regional banks has been diversified. This study applies a slack-based measure network DEA (NSBM-DEA) model to evaluate the management efficiency of Japanese regional banks. The objective of this research is to evaluate overall and divisional efficiencies of Japanese regional banks. This study contributes to understand management efficiency of the divisions when regional banks evaluate their management efficiency.

Keywords: Management efficiency; Bank; Japanese regional bank; Data envelopment analysis (DEA); Network DEA; A Slack-based measure DEA (SBM-DEA); A slack-based measure network DEA (NSBM-DEA).

1. Introduction - Current state of the Japanese regional banks

Among the commercial banks in Japan, there are city banks and regional banks. There are traditional regional banks and second-tier regional banks in regional banks in Japan. However, their particular tasks and roles are the same. Therefore, they are treated as “regional banks” in the following. City banks support big-sized business and have their branches across the country. On the other hand, regional banks are essential to support small and medium-sized

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business, and have their branches primarily in areas where it takes their head office. Regional banks play an important role in supporting the regional economy. Share of the deposits amount of regional banks in 2012FY is 26% of the entire financial institutions of Japan. This is a large share comparing with 27% of city banks. Share of the loans and bills discounted amount of regional banks in 2012FY is 36% of the entire financial institutions of Japan. This is also a large share comparing with the 31% of city banks. These show that the regional banks are essential in supporting the Japanese economy.

Recently, the loan-deposit gap of Japanese regional banks has been increasing (Bank of Japan, 2014). The loan-deposit gap is deposits amount minus loans and bills discounted amount. The loan-deposit gap is becoming larger and larger in this century. It is because the increase in the deposit amount is larger than the increase in the loans and bills discounted amount. This means that Japanese regional banks are not being able to utilize deposits by means of loans and bills discounted effectively.

In addition to that, due to a decrease in lending rates, interest on loans and bills discounted of Japanese regional banks has been decreased. Hence, current income has been decreased. Along with that, fee-based business such as investment trust, and marketable securities investment such as national debts investment has been increasing. The management situation of Japanese regional banks has been diversified. Looking at the breakdown of current income of Japanese regional banks in 2012FY, 59% of those are the interest on loans and bills discounted, 15% are the fees and commissions, interest and dividends on securities are also 15%, and gains on sales of bonds are 5%. These four items mainly constitute the current income of Japanese regional banks. The management of Japanese regional banks is not limited to lending.

These years, the regional banks of Japan, due to the merger and holding company establishment, management integration has been accelerated. As the decrease of current income, it is intended to improve the management efficiency. By the management integration, the management situation would have been diversified.

From all of the background above, it is necessary to evaluate the management efficiency of diversified Japanese regional banks.

2. Previous research on DEA and objective of this study

There are various methods for measuring management efficiency of banks. Data Envelopment Analysis (DEA) is widely used to evaluate bank’s efficiency (Feith and Pasiouras, 2010). DEA is a nonparametric technique for evaluating and measuring the relative efficiency of decision making units (DMUs) by a scalar measure ranging between 0 (the worst) and 1 (the best). The first idea of multiple inputs and single output model was proposed by Farrell (1957). It was expanded with the concept of multiple inputs and multiple outputs by Charnes, Cooper, and Rhodes (1978).

Traditional DEA model deals with measurements of efficiency of DMUs regarding multiple inputs and outputs. One of the drawbacks of traditional DEA model is that it does not consider the linking activities among internal divisions, and treats all the operational processes as a black box. Therefore, it is also called “black box” model. However, in reality, each DMU has a network structure therein. The network structure is composed of several - divisions. They are related to each other. Individual divisions have their inputs and outputs respectively. Exchange of intermediate goods has been carried out among divisions. An intermediate output from one division becomes an intermediate input for another division.

Therefore, it is necessary to consider the network structure of DMUs. To solve this problem, network DEA (NDEA) model were introduced by Fare and Grosskopf (2000). NDEA model considers the internal structure and the linking activities among internal divisions of the DMUs. It accounts for divisional efficiencies as well as the overall efficiency in a unified framework. Then a slack-based network DEA (NSBM-DEA) model was proposed by Tone and Tsutsui (2009). The NSBM-DEA model is NDEA model that uses the slack-based measure approach for evaluating efficiency. A slack-based measure DEA (SBM-DEA) model was proposed by Tone (2000). SBM-DEA model deals directly with the inputs excess and the output shortfalls of the DMU in efficiency measurement.

There is little study which applies NDEA model to the bank. Avkiran (2014) applies the NSBM-DEA model in the context of banking. DMUs are domestic commercial banks in the United Arab Emirates and sub-DMUs (divisions) are the key profit center therein. It analyses the profit efficiency of a bank from a managerial accounting perspective. However, they do not focus on physical or functional divisional efficiencies, and do not consider the flow of the
business of banking. As mentioned above, to evaluate the management of recent Japanese regional banks, it is necessary to consider their business flow.

This study applies SBM-DEA model and NSBM-DEA model to measure the management efficiency of Japanese regional banks. Also the bank’s operational process must be divided into several divisions, considering the flow of the business of banking.

The objective of this research is to evaluate overall and divisional efficiencies for Japanese regional banks. This study contributes to understand management efficiency of the division when Japanese regional banks evaluate their management efficiency.

3. Research approach

3.1. Management efficiency models

This study uses both SBM-DEA model and NSBM-DEA model to measure the management efficiency of Japanese regional banks, and compares the results with each other.

SBM-DEA model is non-radial method that directly deals with slack of inputs and outputs. It is suitable for measuring the efficiency when inputs and outputs may change non-proportionally. Bank’s management situations are likely to change over times in real world. Therefore, non-radial efficiency measure is appropriate. The measure is invariant with respect to the unit of measurement of each input and output item. It is monotone decreasing in each input and output slacks. SBM-DEA model is not affected by the scale of the data (minimum and maximum value of the data). Efficiency is calculated only by the reference set. Formulations assuming variable-returns-to-scale and non-orientation are as follows:

Efficiency

\[
\min_{\lambda, s^-} \rho = \frac{1 - \frac{1}{m} \sum_{i=1}^{m} s_{i}^{-}}{1 + \frac{1}{s} \sum_{e=1}^{s} s_{e}^{+}}
\]

Subject to:

\[
x_i = \lambda x_i + s_i^{-},
\]

\[
y_o = Y_o - s_o^{+},
\]

\[\alpha \lambda = 1,\]

\[\lambda \geq 0, s_i^{-} \geq 0, s_o^{+} \geq 0,\]

Where:

\[i = \text{an input (m = number of input)},\]

\[r = \text{an output (s = number of output)},\]

\[s_i^{-} = \text{input slack},\]

\[s_o^{+} = \text{input slack}.\]

NSBM-DEA model is a network DEA model that uses the slack-based measure approach for evaluating efficiency. Formulations assuming variable-returns-to-scale and non-orientation are as follows:

Overall efficiency

\[
\rho^{*} = \min_{s^-, s^+} \frac{\sum_{k=1}^{K} w^k [1 - \frac{1}{m_k} (\sum_{i=1}^{m_k} s_i^{-} x_{io}^{k})]}{\sum_{k=1}^{K} w^k [1 + \frac{1}{r_k} (\sum_{e=1}^{r_k} s_e^{+} y_{eo}^{k})]}
\]

Divisional efficiency

\[
\rho_k = \frac{1 - \frac{1}{m_k} (\sum_{i=1}^{m_k} s_i^{-} x_{io}^{k})}{1 + \frac{1}{r_k} (\sum_{e=1}^{r_k} s_e^{+} y_{eo}^{k})} (k = 1, \cdots, K)
\]
subject to:

\[ \sum_{k=1}^{K} w^k = 1, \]
\[ x^k_i = X^k_i \lambda^k + s^k_i (k=1,\ldots,K), \]
\[ y^k_r = Y^k_r \lambda^k - s^k_r (k=1,\ldots,K), \]
\[ \epsilon^k_i = I(k=1,\ldots,K), \]
\[ w^k \geq 0, \lambda^k \geq 0, s^k_i \geq 0, s^k_r \geq 0, (\forall k), \]
\[ Z^{(k,h)} \lambda^h = Z^{(k,h)} \lambda^k, (\forall (k,h)), \]

where:

\[ k = \text{a division (K = number of division)}, \]
\[ i = \text{an input (I = number of input)}, \]
\[ r = \text{an output (O = number of output)}, \]
\[ w = \text{division weight}, \]
\[ s^k_i = \text{input slack}, \]
\[ s^k_r = \text{output slack}, \]
\[ (k, h) = \text{intermediate product link between division k and division h}, \]
\[ Z^{(k,h)} = \text{intermediate product}. \]

Division weights are nonnegative for all divisions and are 1 in total. The weight signifies the importance of divisions by setting exogenously numbers. The weight can be set freely. Under the variable return-on-scale assumption, every division has at least one efficient DMU. The last constraint implies free linking assumption where linking activities are free while maintaining continuity between inputs and outputs. Maintaining continuity means that an intermediate output from one division become an intermediate input for another division. Optimal input and output slacks to emerge from the objective function for divisional efficiency are entered into the objective function for overall efficiency. The overall efficiency of a DMU is the weighted sum of divisional efficiency. However, this overall efficiency is neither the arithmetic nor the harmonic mean of divisional efficiencies (Tone and Tsutsui, 2009).

3.2. Robustness of the efficiency regarding weights in NSBM-DEA

In NSBM-DEA model, weights of the divisions are the ratio of the each output against current income of the entire Japanese regional banks. However, every income ratio of division is different among banks. It cannot be said that there is validity to the results, when the result changes considerably with varying weights. Therefore, this study analyses the robustness of the weight. First, this study calculates the efficiency by changing the weight, then analyses the rank correlation, and compares with the original weight how much efficiency changes.

The ratio of the outputs of all banks has been plotted on a plane triangular graph. This study calculates the efficiency by using the weight of a bank that the outer periphery obtained by the convex method, and analyses the rank correlation between the original weight’s result and the changed weight’s result.

3.3. Business flow and variables

In NSBM-DEA model, this section determines divisions, inputs, outputs, links, and division weights.

The flow of the business of Japanese regional banks is to gather the deposits first, turn them to loans, and manage in the securities such as government bonds using the remaining funds. Considering the flow of the business of banking, bank’s operational process is divided into three divisions; deposit division, lending division, and marketable securities investment division. This study applies a three-division NDEA model.

Each divisional inputs and outputs are as follows. From the perspective of evaluating the management efficiency, “fees and commissions”, “interest on loans and bills discounted”, “sales of bonds and interest”, and “dividends on securities” are considered as outputs. It is because they mainly constitute the current income of Japanese regional banks. It is assumed that the activities of gathering deposits mainly depend on the number of branches. Then the deposit division has “interest on deposits” and “branches” as inputs, “fees and commissions” as an output. It is also assumed that the activities of lending mainly depend on the number of employees. Then the lending division has “employees” as an input, “interest on loans and bills discounted” as an output. The marketable securities investment division has “gains on sales of bonds” and “interest and dividends on securities” as outputs.

The flow of cash is defined as the link. Linking activity from deposit division to lending division is “deposits minus interest on deposits”, and lending division to marketable securities investment division is “<deposits minus interest on deposits> minus <loans and bills discounted minus interest on loans and bills discounted>”.


In SBM-DEA model, “Interest on deposits”, “branches”, and “employees” are inputs and “fees and commissions”, “interest on loans and bills discounted”, “sales of bonds and interest”, and “dividends on securities” are outputs. These inputs and outputs are same as those of NSBM-DEA’s each divisional one.

This study analyses all Japanese regional banks in 2012FY and 2013FY. Both SBM-DEA model and NSBM-DEA model are applied to 105 Japanese regional banks to evaluate their management efficiencies. Their data is collected by means of Nikkei NEEDS database and Japanese Bankers Association database.

In NSBM-DEA, the weights of the division are set based on the ratio of the each output against current income of the entire Japanese regional banks, with the proviso given profit structure of the entire Japanese regional banks. The ratio of each division is as follows; division1 0.158, division2 0.625, division3 0.217 in 2012FY, division1 0.166, division2 0.605, division3 0.229 in 2013FY.

4. Results and discussions

4.1. Management efficiency of Japanese regional banks

This study uses the non-oriented SBM-DEA model and NSBM-DEA model under the variable return-on-scale assumption for evaluating efficiency, and compares the result. Variable return-on-scale assumption is employed because it is more realistic assumption considering the banking industry. Non-oriented is employed because this assumption can analyse the result by not being prejudice on either the input or output.

Table 1 shows the results of the efficiencies. The efficiencies of the SBM-DEA models tend to be higher than that of NSBM-DEA models. In SBM-DEA model, 18 banks’ efficiencies are 1 in 2012FY, and 5 banks’ efficiencies are 1 in 2013FY. On the other hand, in NSBM-DEA model, only one bank’s overall efficiency is 1 in 2012FY, and only 2 banks’ efficiencies are 1 in 2013FY. Figure 2 shows every bank’s efficiency arranged in the order of the NSBM-DEA model’s overall efficiency. Even if a bank is efficient in SBM-DEA model, in fact, it has an inefficient division in NSBM-DEA model. Therefore, it is not efficient in NSBM-DEA model. Comparing each divisional efficiency in NSBM-DEA model, it is possible to get the information about which division is efficient or inefficient. For example, if some bank’s efficiency of the deposits division is bad compared to any other banks, there seems to be a surplus in “interest on deposits” and “branches”, or shortage in “fees and commissions” and “deposits”, or both.

Table 1. The results of efficiency

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>NSBM-DEA</th>
<th>SBM-DEA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Div1</td>
<td>Div2</td>
<td>Div3</td>
</tr>
<tr>
<td>2012FY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.352</td>
<td>0.493</td>
<td>0.504</td>
</tr>
<tr>
<td>Standard</td>
<td>0.156</td>
<td>0.205</td>
<td>0.247</td>
</tr>
<tr>
<td>Median</td>
<td>0.332</td>
<td>0.462</td>
<td>0.389</td>
</tr>
<tr>
<td>Efficient DMUs</td>
<td>1</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>2013FY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.266</td>
<td>0.488</td>
<td>0.626</td>
</tr>
<tr>
<td>Standard</td>
<td>0.167</td>
<td>0.209</td>
<td>0.294</td>
</tr>
<tr>
<td>Median</td>
<td>0.243</td>
<td>0.454</td>
<td>0.523</td>
</tr>
<tr>
<td>Efficient DMUs</td>
<td>2</td>
<td>6</td>
<td>27</td>
</tr>
</tbody>
</table>
Fig. 2. The results of efficiency (a) 2012FY; (b) 2013FY.

Fig. 3. The relationship between the overall efficiency and scale of the banks (a) SBM-DEA in 2012FY; (b) SBM-DEA in 2013FY; (c) NSBM-DEA in 2012FY; (d) NSBM-DEA in 2013FY.
Table 2. The results of efficiency

<table>
<thead>
<tr>
<th></th>
<th>NSBM-DEA</th>
<th>SBM-DEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Div1</td>
<td>0.584</td>
<td>0.821</td>
</tr>
<tr>
<td>Div2</td>
<td>0.018</td>
<td>0.616</td>
</tr>
<tr>
<td>Div3</td>
<td>0.821</td>
<td>0.886</td>
</tr>
</tbody>
</table>

Table 2 shows the correlation between overall efficiency in NSBM-DEA and each other efficiencies. The correlation between overall efficiency in NSBM-DEA and division3 efficiency is very high. This means that low overall efficiency in NSBM-DEA is somewhat due to division3 efficiency. The correlation between overall efficiency in NSBM-DEA and division2 efficiency is low. From the above, it is suggested that, there seems to be room for improvement in the management efficiency more in division3 than in division2.

Figure 3 shows the relationship between the overall efficiency and scale of the banks, using the total deposit amount as the scale of the bank. The plots of SBM-DEA (figures (a) and (b)) are scattered, there are no relationship between the two. However, the plots of NSBM-DEA (figures (c) and (d)) are approximately on above the quadratic function. Coefficient of determination is high, 0.615 and 0.488 respectively. It implies that the overall efficiency of the big or small-sized bank tends to be higher. That is to be said that, the efficiency of the medium-sized bank tends to be lower than that of the small or big-sized one.

4.2. Robustness of the efficiency

In NSBM-DEA model, the relative weight of each division is determined freely corresponding to its importance. This study uses the ratio of each output against current income of the entire Japanese regional banks. However, it is considered that the change of weight affects the efficiency ranking of banks. Therefore, this section analyses the robustness of the weight in NSBM-DEA model.

The ratio of the outputs of all banks has been plotted on a plane triangular graph. The efficiencies are calculated by using the weight of a bank that the outer periphery obtained by the convex method, and analyse the rank correlation between the original weight’s result and the changed weight’s result.

Spearman’s rank correlations are over 0.9 when banks are surrounded by the convex in Figure 4. With the exception of the 6 banks in 2012FY and 7 banks in 2013FY, rank correlations are very high. With the exception of the 4 banks in 2012FY and 5 banks in 2013FY, rank correlations are still over 0.8. As a result, there is considerable robustness in original weight’s result.

5. Concluding remarks

This study applies SBM-DEA model and NSBM-DEA model to measure the management efficiency of Japanese regional banks. The usefulness of the NSBM-DEA approach is confirmed to evaluate the profit structure of Japanese
regional banks. Overall and divisional efficiencies for Japanese regional banks were exactly calculated. By using NSBM-DEA, the information about the inefficiency of the bank’s in some division were given, which seems to be overall efficient in the SBM-DEA model. Especially, the medium-sized bank tends to be inefficient. Inefficient banks seem to have a necessity to improve their management efficiency especially in marketable securities investment division than in lending division.

Comparing each efficiency of divisions with that of any other banks, managers can distinguish their efficient divisions and inefficient divisions. For example, if a bank found that the efficiency of its marketable securities investment division was low compared with that of any other banks, the bank could recognize that it is necessary to improve the efficiency of its marketable securities investment division. Especially, this process must be more useful for the medium-sized bank.

Through this research, the managers can obtain more detailed information to monitor the management. This study contributes to understand management efficiency of the division when regional banks evaluate their management efficiency.

In this paper, it is assumed that the activity of gathering deposits mainly depends on the number of branches, and the activity of lending mainly depends on the number of employees. As an input, the deposit division has branches, and the lending division has employees. Of course, the role of branches is not limited to gathering deposits, and the role of employees is not limited to lending. One of the limitations of this study is that it cannot consider much realistic inputs of each division.

This study uses two years data independently. Comparing the results of the two years, of course, the results have somewhat different parts. In addition to that, the results of each year are independent. Comparing the results of efficiency of the first year with that of the second year directly is not possible. This is because each efficiency is calculated by each reference set in the DEA model. To analyse the time-series change by using the DEA model, it is necessary to employ the model that is possible to deal with time-series data. On top of that, a further study of the evaluation of the effectiveness of management integration of Japanese regional banks should be conducted.

References


